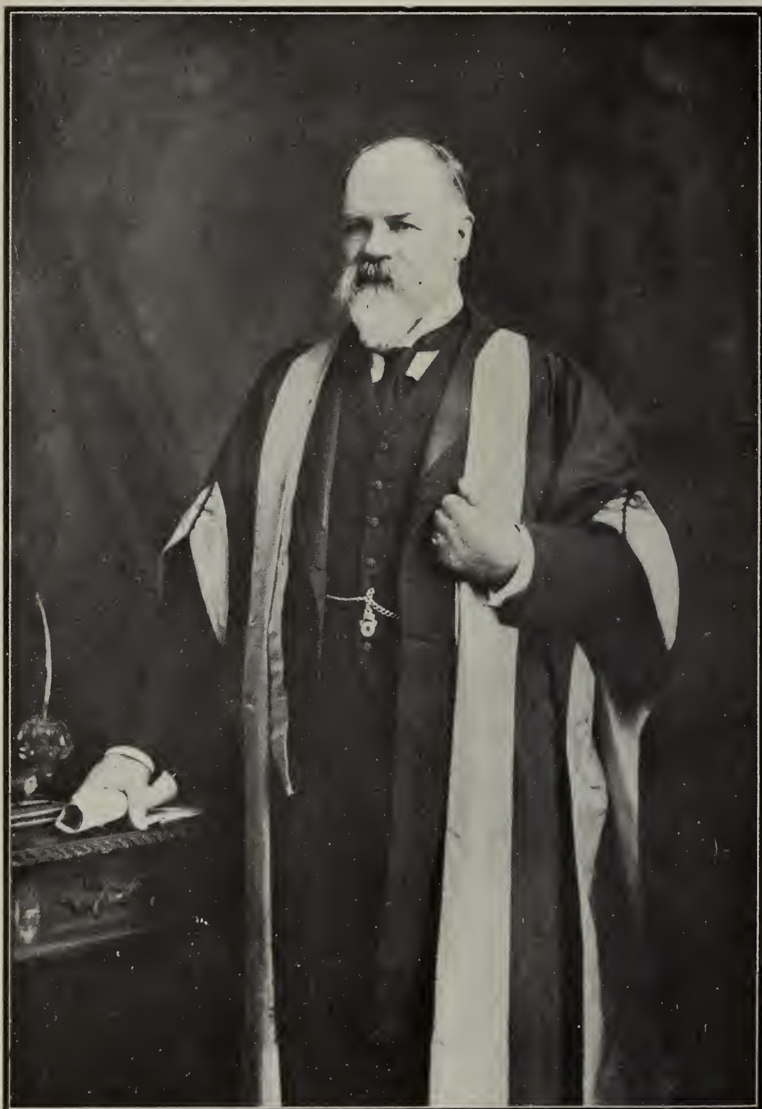

SIR WALTER L. BULLER, K.C.M.G., F.R.S.

Royal Society of New Zealand

TRANSACTIONS

AND

PROCEEDINGS

of the Royal Society of New Zealand

OF THE

NEW ZEALAND INSTITUTE

1906

VOL. XXXIX

(Twenty-second of New Series)

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BY

A. HAMILTON

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IN MEMORIAM.

By the death of **Sir Walter Lawry Buller, K.C.M.G., F.R.S., D.Sc.,** the scientific world has sustained a heavy loss, more especially in ornithological circles, for his beautiful and exhaustive works on the history of the birds of New Zealand are well and widely known.

Sir Walter was the descendant of an ancient Cornish family, and the eldest son of the late Rev. James Buller, a veteran missionary, and was born at Newark, in the Bay of Islands, on the 9th October, 1838. From early boyhood he displayed a natural taste for scientific pursuits, and made ornithology a life-long study.

He received his early training at Wesley College, Auckland, and on leaving school entered the banking profession in that city. There he won rapid promotion, but finding that his health would not stand the strain, and acting on medical advice, he took a year's rest at Wellington, devoting himself during that period principally to literary and scientific pursuits. During this time of enforced leisure he enjoyed the friendship of the late William Swainson, a celebrated ornithologist of his day, whose extensive collections in natural history, and valuable stores of information, were always at the command of his willing disciple.

He was appointed Native Commissioner in 1859 for the Southern Provinces, and during his location in Christchurch undertook and carried through to a most successful issue the experimental partition and individualisation of the Kaiapoi Reserve.

In 1861 he gained the first prize for an essay on "The Moral Welfare of New Zealand," offered by the Auckland Association, and open to the competition of all colonists under the age of twenty-six.

In the same year, by the desire of Governor Browne, he acted as honorary secretary of the Kohimarama conference of Native chiefs, and prepared the proceedings for publication.

Early in 1862 he was appointed Resident Magistrate in the Manawatu District.

In 1865 he was gazetted a Judge of the Native Land Court, and during that disturbed period he performed many special services in connection with Native affairs, for which he received on eight different occasions the official thanks of the Government.

As a volunteer on Sir George Grey's staff at the taking of the Weraroa Pa he received the New Zealand War Medal. On that occasion, declining the protection of a military escort, he carried the Governor's despatches, at night, through forty miles of the enemy's country, attended only by a Maori orderly—a piece of work which was mentioned in despatches as "an act of conspicuous personal courage, and a service which, in the Imperial Army, would have been rewarded by some special mark of distinction."

He was awarded by the Royal Commissioners the silver medal of the New Zealand Exhibition for an "Essay on the Ornithology of New Zealand," which was published by command, and afterwards reprinted with other essays in the "Transactions of the New Zealand Institute."

In 1866 he was appointed Resident Magistrate of Wanganui, which position he held till 1871, when he went to England as secretary to the Agent-General (Dr. Featherston). Before his return to the colony, three years later, he was called to the bar by the Honourable Society of the Inner Temple, and had produced his well-known work "A History of the Birds of New Zealand," every copy of this beautifully illustrated book having been subscribed for before the last page went to press, several crowned heads being amongst the subscribers.

He also took an active part in the Vienna Exhibition of 1872, and Dr. Featherston, in his official report to the Government, declared that the great success which had attended the New Zealand Court was mainly owing to his individual zeal and energy.

But it will be by reason of his researches in New Zealand ornithology that the name of Sir Walter Buller will be best remembered, and we believe it was his peculiar distinction to be the first native-born New-Zealander to gain recognition throughout the world for his exertions in the field of science, just as he was also, as we believe, the first native-born New-Zealander to receive the honour of a title from the hands of his Sovereign.

The University of Tubingen conferred on him the honorary degree of Doctor of Science, and he received decorations from the Emperor of Austria, the King of Wurtemburg, and the Grand Duke of Hesse; and the London *Daily Telegraph* in a leading article described the author of the "Birds of New Zealand" as "the Audubon of New Zealand."

On his return to New Zealand in 1874 Dr. Buller was admitted a barrister and solicitor of the Supreme Court, and for some years was actively engaged in the practice of his profession. He devoted himself largely to Native work, and on one occasion received from Mr. Justice Gillies the graceful tribute of being "the supreme advocate for the Maori race." In 1875 Dr. Buller was made a C.M.G., in recognition of his labours, and in 1876 he achieved the "blue riband of science" by election as a Fellow of the Royal Society.

In the midst of professional business he continued to make contributions to zoological literature, besides publishing some interesting papers on Maori subjects, and in 1882, at the invitation of the New Zealand Government, he prepared for official publication a "Manual of the Birds of New Zealand," illustrated by photo-lithographic prints from the plates in his larger work. In 1883 he received from the New Zealand Exhibition the gold medal for science and literature.

In 1886 he returned to England as New Zealand Commissioner at the Colonial and Indian Exhibition, and in the same year was promoted to the rank of K.C.M.G. In 1887 he was awarded the Galleian medal by the Royal University of Florence, and in 1888 he published a much larger edition of the "Birds of New Zealand" (two volumes).

Besides the honours already mentioned, Sir Walter Buller held the rank of Officier of the Legion of Honour, besides being Officier of l'Instruction Publique (Gold Palm of the Academy), Knight First Class of the Order of Francis Joseph of Austria, and Knight Commander of the Crown of Italy. For many years he represented the colony on the permanent governing body of the Imperial Institute.

Sir Walter Buller returned to New Zealand for a few years in the early nineties, living at Wellington, his country residence being near Levin, on the shores of the beautiful Lake Papaitonga—" the beauty of the south," as it has been called by the Maoris from time immemorial.

In addition to numerous papers on ornithological subjects contributed to the " Transactions of the New Zealand Institute," extending over a period of many years, Sir Walter wrote, in 1888, " Illustrations on Darwinism."

He returned to England in 1899, and the degree of Doctor of Science was conferred upon him by the University of Cambridge in the following year.

In 1906 he produced a " Supplement to the Birds of New Zealand," in two volumes, correcting the proof-sheets of this last great work during the illness which shortly afterwards terminated a life of remarkable strenuousness.

He died at Fleet, Hampshire, England, on the 19th July, 1906, where he was buried. A memorial service was afterwards held in St. Paul's Cathedral, London, in the Chapel of the Order of St. Michael and St. George, and a tablet is there placed to his memory in the Knights' stalls.

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Board of Governors.

EX OFFICIO.

His Excellency the Governor.
The Hon. the Colonial Secretary.

NOMINATED BY THE GOVERNMENT UNDER CLAUSE 4.

A. Hamilton; E. Tregear, F.R.G.S.; John Young; J. W. Joynt, M.A.

ELECTED BY AFFILIATED SOCIETIES UNDER CLAUSE 4.

Wellington: Martin Chapman; Professor T. H. Easterfield, M.A., Ph.D. Auckland: Professor A. P. W. Thomas, M.A., F.L.S.; J. Stewart, C.E. Napier: H. Hill, F.G.S. Christchurch: Professor Charles Chilton, D.Sc., F.L.S.; C. C. Farr, D.Sc. Westland: T. H. Gill, M.A. Nelson: L. Cockayne, LL.D. Otago: Professor W. B. Benham, F.L.S.; G. M. Thomson, F.L.S.

OFFICERS FOR THE YEAR 1907.

President: G. M. Thomson, F.L.S.

Hon. Treasurer: J. W. Joynt, M.A.

Editor of Transactions: A. Hamilton.

Secretary: T. H. Gill, M.A.

AFFILIATED SOCIETIES.	DATE OF AFFILIATION.
Wellington Philosophical Society ...	10th June, 1868.
Auckland Institute	10th June, 1868.
Philosophical Institute of Canterbury	22nd October, 1868.
Otago Institute	18th October, 1869.
Westland Institute	21st December, 1874.
Hawke's Bay Philosophical Institute	31st March, 1875.
Southland Institute	21st July, 1880.
Nelson Institute	20th December, 1883.
Manawatu Philosophical Society ...	16th January, 1904.

NEW ZEALAND INSTITUTE ACT.

The following Act reconstituting the Institute was passed by Parliament :—

1903, No. 48.

An Act to reconstitute the New Zealand Institute.

[*18th November, 1903.*

Whereas it is desirable to reconstitute the New Zealand Institute with a view to connecting it more closely with the affiliated institutions :

Be it therefore enacted by the General Assembly of New Zealand in Parliament assembled, and by the authority of the same, as follows :—

1. The Short Title of this Act is "The New Zealand Institute Act, 1903."

2. "The New Zealand Institute Act, 1867," is hereby repealed.

3. (1.) The body hitherto known as the New Zealand Institute (hereinafter referred to as "the Institute") shall consist of the Auckland Institute, the Wellington Philosophical Society, the Philosophical Institute of Canterbury, the Otago Institute, the Hawke's Bay Philosophical Institute, the Nelson Institute, the Westland Institute, the Southland Institute, and such others as may hereafter be incorporated in accordance with regulations to be made by the Board of Governors as hereinafter mentioned.

(2.) Members of the above-named incorporated societies shall be *ipso facto* members of the Institute.

4. The control and management of the Institute shall be in the hands of a Board of Governors, constituted as follows :—

The Governor ;

The Colonial Secretary ;

Four members to be appointed by the Governor in Council during the month of December, one thousand nine hundred and three, and two members to be similarly appointed during the month of December in every succeeding year ;

Two members to be appointed by each of the incorporated societies at Auckland, Wellington, Christchurch, and Dunedin during the month of December in each alternate year ;

One member to be appointed by each of the other incorporated societies during the month of December in each alternate year.

5. (1.) Of the members appointed by the Governor in Council two shall retire annually on the appointment of their successors; the first two members to retire shall be decided by lot, and thereafter the two members longest in office without reappointment shall retire.

(2.) Subject to the provisions of the last preceding subsection, the appointed members of the Board shall hold office until the appointment of their successors.

6. The Board of Governors as above constituted shall be a body corporate, by the name of the "New Zealand Institute," and by that name they shall have perpetual succession and a common seal, and may sue and be sued, and shall have power and authority to take, purchase, and hold lands for the purposes hereinafter mentioned.

7. (1.) The Board of Governors shall have power to appoint a fit person, to be known as the "President," to superintend and carry out all necessary work in connection with the affairs of the Institute, and to provide him with such further assistance as may be required.

(2.) It shall also appoint the President or some other fit person to be editor of the Transactions of the Institute, and may appoint a committee to assist him in the work of editing the same.

(3.) It shall have power to make regulations under which societies may become incorporated to the Institute, and to declare that any incorporated society shall cease to be incorporated if such regulations are not complied with, and such regulations on being published in the *Gazette* shall have the force of law.

(4.) The Board may receive any grants, bequests, or gifts of books or specimens of any kind whatsoever for the use of the Institute, and dispose of them as it thinks fit.

(5.) The Board shall have control of the property hereinafter vested in it, and of any additions hereafter made thereto, and shall make regulations for the management of the same, for the encouragement of research by the members of the Institute, and in all matters, specified or unspecified, shall have power to act for and on behalf of the Institute.

8. Any casual vacancy on the Board of Governors, howsoever caused, shall be filled within three months by the society or authority that appointed the member whose place has become vacant, and if not filled within that time the vacancy shall be filled by the Board of Governors.

9. (1.) The first annual meeting of the Board of Governors hereinbefore constituted shall be held at Wellington on some

day in the month of January, one thousand nine hundred and four, to be fixed by the Governor, and annual meetings of the Board shall be regularly held thereafter during the month of January in each year, the date and place of such annual meeting to be fixed at the previous annual meeting.

(2.) The Board of Governors may meet during the year at such other times and places as it deems necessary.

(3.) At each annual meeting the President shall present to the meeting a report of the work of the Institute for the year preceding, and a balance-sheet, duly audited, of all sums received and paid on behalf of the Institute.

10. The Board of Governors may from time to time, as it sees fit, make arrangements for the holding of general meetings of members of the Institute, at times and places to be arranged, for the reading of scientific papers, the delivery of lectures, and for the general promotion of science in the colony by any means that may appear desirable.

11. The Colonial Treasurer shall, without further appropriation than this Act, pay to the Board of Governors the annual sum of five hundred pounds, to be applied in or towards payment of the general current expenses of the Institute.

12. (1.) On the appointment of the first Board of Governors under this Act the Board of Governors constituted under the Act hereby repealed shall cease to exist, and the property then vested in, or belonging to, or under the control of that Board shall be vested in His Majesty for the use and benefit of the public.

(2.) On the recommendation of the President of the Institute the Governor may at any time hereinafter, by Order in Council, declare that any part of such property specified in the Order shall be vested in the Board constituted under this Act.

13. All regulations, together with a copy of the Transactions of the Institute, shall be laid upon the table of both Houses of Parliament within twenty days after the meeting thereof.

REGULATIONS.

The following are the new regulations of the New Zealand Institute under the Act of 1903 :—

The word "Institute" used in the following regulations means the New Zealand Institute as constituted by "The New Zealand Institute Act, 1903."

Incorporation of Societies.

1. No society shall be incorporated with the Institute under the provisions of "The New Zealand Institute Act, 1903," unless such society shall consist of not less than twenty-five members, subscribing in the aggregate a sum of not less than £25 sterling annually for the promotion of art, science, or such other branch of knowledge for which it is associated, to be from time to time certified to the satisfaction of the Board of Governors of the Institute by the President for the time being of the society.

2. Any society incorporated as aforesaid shall cease to be incorporated with the Institute in case the number of the members of the said society shall at any time become less than twenty-five, or the amount of money annually subscribed by such members shall at any time be less than £25.

3. The by-laws of every society to be incorporated as aforesaid shall provide for the expenditure of not less than one-third of the annual revenue in or towards the formation or support of some local public museum or library, or otherwise shall provide for the contribution of not less than one-sixth of its said revenue towards the extension and maintenance of the New Zealand Institute.

4. Any society incorporated as aforesaid which shall in any one year fail to expend the proportion of revenue specified in Regulation No. 3 aforesaid in manner provided shall from henceforth cease to be incorporated with the Institute.

5. All papers read before any society for the time being incorporated with the Institute shall be deemed to be communications to the Institute, and then may be published as Proceedings or Transactions of the Institute, subject to the following regulations of the Board of the Institute regarding publications:—

Regulations regarding Publications.

(*a.*) The publications of the Institute shall consist of—

(1.) A current abstract of the proceedings of the societies for the time being incorporated with the Institute, to be intituled "Proceedings of the New Zealand Institute";

(2.) And of transactions comprising papers read before the incorporated societies (subject, however, to selection as hereinafter mentioned), and of such other matter as the Board of Governors shall from time to time determine to publish, to be intituled "Transactions of the New Zealand Institute."

(*b.*) The Board of Governors shall determine what papers are to be published.

(*c*.) Papers not recommended for publication may be returned to their authors if so desired.

(*d*.) All papers sent in for publication must be legibly written, typewritten, or printed.

(*e*.) A proportional contribution may be required from each society towards the cost of publishing Proceedings and Transactions of the Institute.

(*f*.) Each incorporated society will be entitled to receive a proportional number of copies of the Transactions and Proceedings of the New Zealand Institute, to be from time to time fixed by the Board of Governors.

General Regulations.

6. All property accumulated by or with funds derived from incorporated societies, and placed in charge of the Institute, shall be vested in the Institute, and be used and applied at the discretion of the Board of Governors for public advantage, in like manner with any other of the property of the Institute.

7. Subject to "The New Zealand Institute Act, 1903," and to the foregoing rules, all societies incorporated with the Institute shall be entitled to retain or alter their own form of constitution and the by-laws for their own management, and shall conduct their own affairs.

8. Upon application signed by the President and countersigned by the Secretary of any society, accompanied by the certificate required under Regulation No. 1, a certificate of incorporation will be granted under the seal of the Institute, and will remain in force as long as the foregoing regulations of the Institute are complied with by the society.

9. In voting on any subject the President is to have a deliberate as well as a casting vote.

Management of the Property of the Institute.

10. All donations by societies, public Departments, or private individuals to the Institute shall be acknowledged by a printed form of receipt, and shall be entered in the books of the Institute provided for that purpose, and shall then be dealt with as the Board of Governors may direct.

Honorary Members.

11. The Board of Governors shall have power to elect honorary members (being persons not residing in the Colony of New Zealand), provided that the total number of honorary members shall not exceed thirty.

12. In case of a vacancy in the list of honorary members, each incorporated society, after intimation from the Secretary

of the Institute, may nominate for election as honorary member one person.

13. The names, descriptions, and addresses of persons so nominated, together with the grounds on which their election as honorary members is recommended, shall be forthwith forwarded to the President of the New Zealand Institute, and shall by him be submitted to the Governors at the next succeeding meeting.

14. The President may at any time call a meeting of the Board, and shall do so on the requisition in writing of four Governors.

15. Twenty-one days' notice of every meeting of the Board shall be given by posting the same to each Governor at an address furnished by him to the Secretary.

16. In case of a vacancy in the office of President, a meeting of the Board shall be called by the Secretary within twenty-one days to elect a new President.

17. The Governors for the time being resident or present in Wellington shall be a Standing Committee for the purpose of transacting urgent business and assisting the officers.

18. The Standing Committee may appoint persons to perform the duties of any other office which may become vacant. Any such appointment shall hold good until the next meeting of the Board, when the vacancy shall be filled.

19. The foregoing regulations may be altered or amended at any annual meeting, provided that notice be given in writing to the Secretary of the Institute not later than the 30th November.

TRANSACTIONS

TRANSACTIONS

OF THE

NEW ZEALAND INSTITUTE,

1906.

Art. I.—*The Fungus Flora of New Zealand.—Part II.*

By George Massee, F.L.S., Principal Assistant (Cryptogams), Herbarium, Royal Gardens, Kew.

[*Read before the Wellington Philosophical Society, 5th April, 1906.*]

Communicated by A. Hamilton.

Plates I and II.

Polyporeæ.

The one constant morphological feature of the present family consists in the hymenium, or spore-bearing surface, being developed over the entire inner surface of tubes or pits. In the most typical forms, included in such genera as *Boletus* and *Polyporus*, the tubes collectively forming the hymenium are frequently 2 cm. or 3 cm. long, and vary in different species from 0·5 mm. to 5 mm. in diameter. In the highest types the tubes are cylindrical, and are packed compactly side by side, as seen in a vertical section, whereas when viewed in the entire plant the pores or openings of the tubes only are seen. The form of the pores is circular when the tubes are cylindrical; in other instances the pores are polygonal, or sinuous, when somewhat elongated and wavy or flexuous.

In certain genera the tubes are so very shallow that they merely resemble circular, polygonal, or sinuous pits or depressions.

The bordering walls of the tubes, which bear the hymenium on their free surface, are called " dissepiments."

The elements of the hymenium consist of basidia and paraphyses, and in many instances large cystidia are also present in considerable numbers.

Texture, size, and form vary exceedingly in the present group. In *Boletus* the species are fleshy, soft, and putrescent, completely disappearing within one or two weeks after their first appearance. On the other hand, the species of *Fomes* are all perennial, hard, and woody, and form a new hymenial layer of tubes each year; consequently in old specimens the tubes are described as "stratose," each stratum of tubes corresponding to one year's growth.

As illustrating the variety of form included in the family, in *Boletus*, also in some species of *Polyporus* and *Polystictus*, there is an agaric type of structure, consisting of a pileus and central stem, pores replacing gills on the under surface of the pileus. In other genera the stem is lateral or altogether absent, the fungus being fixed by a broad base and forming bracket- or hoof-like horizontal projections. In other genera, again, as *Poria*, the entire fungus is quite thin, forming more or less extended patches firmly fixed to the matrix, and having the free surface completely covered with the hymenium. Some species are quite minute; others, again, are veritable fungal giants, certain species of *Polyporus* and *Fomes* numbering amongst the largest of known Fungi.

The family includes a considerable number of destructive parasites; species of *Polyporus*, *Fomes*, *Merulius*, and *Poria* being more especially destructive to forest and orchard trees; worked timber also suffers unless special precautions are taken.

Boletus alone, so far as is known, contains a few edible species, the members of the other genera being either woody or coriaceous. *Strobilomyces*, a genus closely allied to *Boletus*, contains several species from Australia, some of which may prove to be edible.

It is somewhat remarkable that no specimens representing the genera *Boletus* or *Strobilomyces* have as yet been recorded as occurring in New Zealand. It would appear highly improbable that representatives of these genera should be entirely absent, considering their comparative abundance in Australia.

Analysis of the Genera.

36. Polyporus. Pileus smooth, fleshy, flesh soft; tubes sharply defined but not separable from the flesh, not stratose.
37. Fomes. Pileus smooth, flesh thick, woody; tubes woody, stratose.
38. Polystictus. Pileus hirsute or silky, flesh quite thin; tubes short, not stratose.
39. Poria. Entirely resupinate; flesh usually very thin; tubes short.
40. Trametes. Pileus corky, sessile; tubes penetrating different depths into the flesh, not stratose.
41. Dædalea. Pileus corky, sessile; tubes elongated and sinuous, walls thick, elastic.
42. Favolus. Tubes elongated and lamellose, radiating from point of attachment of pileus.
43. Laschia. Stipitate or dimidiate; tubes as in *Polyporus*, but along with the pileus soft and subgelatinous.
44. Merulius. Resupinate, subgelatinous; pores very shallow, irregular, often reduced to irregular wrinkles or folds.

36. Polyporus, Mich.

Stem central, lateral, or absent; pileus fleshy, flesh soft and tough at first, becoming firmer, externally more or less glabrous, not sulcate nor zoned; tubes not separable from flesh of pileus, never stratose; pores rounded or angular, often more or less torn at the margin. Annual.

Polyporus, Micheli, Gen. Pl., p. 129 (in part).

Certain central-stemmed fleshy species of *Polyporus* closely resemble *Boletus*, but are at once distinguished by the tubes not being readily separable from the flesh of the pileus. *Fomes* differs in the woody consistency of the entire fungus, concentrically ridged pileus, and stratose pores. *Polystictus* is separated by the thin flesh and silky or hirsute, usually zoned, pileus.

The great majority of species grow on wood. A few central-stemmed species, leading up to the genus *Boletus*, grow on the ground.

I. *Stipitate; stem central, or nearly so.*

Polyporus arcularius, Fries, Hym. Eur., 526; Hdbk. N.Z. Flora, p. 607; Sacc., Syll. vi, no. 4903; Austr. Fung., p. 113.

Stipitate; pileus 2–4 cm. across, almost flat, or slightly depressed at the centre, margin more or less incurved, yellowish-brown, squamulose with small darker scales which are most persistent at the margin but eventually entirely disappear, flesh very thin; tubes very shallow; pores large elongato-hexagonal, elongated radially, pale-wood colour, entire, 1·5–2 mm. long by 0·5–1 mm. wide; stem central, 2–3 cm. long, slender, coloured like the pileus, squamulose, becoming bald.

On trunks, &c. New Zealand. Australia, Tasmania, Mauritius, Cape of Good Hope, Natal, India, Java, China, Formosa, Madagascar, Ceylon, central and southern Europe, United States, Brazil.

A very beautiful fungus; when in full vigour the margin is beautifully fringed, and the pileus dotted with minute squamules, as is also the stem; eventually, however, every part becomes bald. Distinguished by the large, entire, radially elongated pores.

Polyporus melanopus, Fries, Hym. Eur., p. 534; Sacc., Syll. vi, no. 4958; Austr. Fung., p. 115. Syn., *Polyporus leprodes*, Rost.

Pileus 5–10 cm. across, flattish at first, then becoming depressed or even irregularly funnel-shaped, rather thin, pliant when growing, delicately flocculose when young, whitish, then dingy yellowish-brown, margin often wavy or lobed; stem varying in position from lateral to being almost central, rather slender, short but variable in length, tapering upwards, blackish-brown ; pores very shallow, whitish, minute, decurrent for a short distance down the stem.

On dead wood, branches, and on the ground. New Zealand. Victoria, Queensland, Europe.

Distinguished from allied species by the black stem tapering upwards. The flesh is white, softish, and not at all woody. When growth is very vigorous the margin of the pileus is often beautifully waved and crisped, and under such circumstances the pores are often larger than usual.

II. *Stem lateral when present, often almost obsolete, but pileus attached by a narrowed base.*

Polyporus phlebophorus, Berk., Fl. N.Z., ii, p. 177, tab. cv, fig. 3 ; Hdbk. N.Z. Flora, p. 607 ; Sacc., Syll. vi, no. 4999.

Entirely pure white ; pileus about 2·5 cm. long and broad, irregularly fan-shaped, and narrowed behind into a very short, wrinkled, stem-like point of attachment ; glabrous ; cuticle subgelatinous, then becoming dry and cartilaginous ; pores very minute ; dissepiments thin, minutely toothed.

On decaying logs. Tarawera, Northern Island, New Zealand.

A very beautiful and distinct species, which does not appear to have been collected since the original specimens on which the species was founded were found by Colenso.

Polyporus xerophyllus, Berk., Fl. N.Z., ii, p. 178, tab. cv, fig. 2 ; Hdbk. N.Z. Flora, p. 607.

Pileus suborbicular or reniform, 2–3 cm. across, rufous-brown, marked with radiating wrinkles, minutely scabrid, or rough with raised points ; stem lateral, up to 0·1 cm. long, black, wrinkled, very minutely velvety ; hymenium whitish, pores very minute, dissepiments entire.

On dead wood. New Zealand.

An endemic species discovered by Colenso. Distinguished from allies by the black, minutely velvety stem and radially wrinkled pileus.

Polyporus grammocephalus, Berk., Hook. Lond. Journ., 1842, p. 148 ; Sacc., Syll. vi, no. 5005 ; Cooke, Austr. Fung., p. 117. Syn., *Polyporus emerici*, Kalchbr., Grev., x, pl. 145, fig. 125 ; *Polyporus russiceps*, Berk. and Broome, Journ. Linn. Soc. (Bot.), xiv, p. 48 ; *Polyporus incompletus*, Cesati, Myc. Borneo, p. 4 ; *Polyporus platotis*, Berk. and Broome, Linn. Trans., ser. ii, vol. i, p. 401 ; *Polyporus fusco-lineatus*, Berk. and Broome, Linn. Trans., ser. ii, vol. i, p. 401.

Pileus very thin, 2–3 mm. thick, obovate, irregularly circular or reniform, horizontal, margin sometimes more or less wavy, nearly flat, varying from pale-ochraceous through reddish-brown to umber, with very delicate lines radiating from the point of attachment to the margin, otherwise glabrous, 3–8 cm. broad; pores rather large, irregular, coloured like the pileus; stem usually lateral, very short, 3–4 mm. long by 2–3 mm. thick, scarcely discoid, sometimes quite central, at others almost absent.

On rotten trunks, fallen wood, &c. New Zealand. Queensland, New South Wales, New Guinea.

A very variable species in minor points, but characterized by the thin flesh, very short lateral stem, and the pileus streaked with very delicate, crowded, radiating ridges.

Polyporus borealis, Fries, Syst. Myc., i, p. 366; Hdbk. N.Z. Flora, p. 609; Cooke, Austr. Fung., p. 124; Sacc., Syll. vi, no. 5187.

Horizontal, subspathulate or reniform, either narrowed behind into a short more or less distinct stem, or thick and sessile, 4–10 cm. across, whitish then dingy-yellow, spongy then corky, compact, hairy; flesh thick, whitish, composed of parallel fibres; tubes 5–8 mm. long; pores unequal, flexuous; dissepiments thin, white, torn; spores hyaline, subglobose, 4 μ diameter.

On stumps and trunks of conifers, &c. Otago, Middle Island, New Zealand. Asiatic Siberia, Europe, United States.

Pileus often radiately wrinkled, rigid and more or less incurved when dry. When a stem is present the pores are more or less decurrent. Fleshy when young, becoming corky with age.

Polyporus colensoi, Berk., Fl. N.Z., ii, p. 178; Hdbk. N.Z. Flora, p. 607; Sacc., Syll. vi, no. 5016.

Main branches numerous, rather slender, springing from a common basal mass, and dividing into many smaller branchlets, each terminated by a small, fan-shaped, depressed pileus, brownish, nearly smooth; hymenium pale; pores shallow, large, often elongated, decurrent; dissepiments thin, edge acute, often toothed.

On trunks. Tarawera, Northern Island, New Zealand.

"Forming a mass more than 1 ft. across; main stems slender, distinct, somewhat elongated, repeatedly dichotomous. Pilei extremely numerous, flabelliform, expanded, depressed above, brownish, smooth, or nearly so, with a few raised lines. Pores pale, often very much elongated, decurrent; dissepiments thin; edge extremely acute, often toothed, sublamelliform. This is a noble species, and evidently differing from every form of *P. intybaceus* in its distinct dichotomous branches and the constantly acute dissepiments. Some of the figures of *Hydnum* *coralloides* give a better idea of the ramification of the species than any of those of *P. frondosus.*" (Berk.)

Polyporus lactus, Cooke, Grev., xii, p. 16; Sacc., Syll. vi, no. 5047; Cooke, Austr. Fung., p. 119.

Imbricated, much divided, rather thin, tough, tawny-orange or rusty above; pilei dimidiate, coalescing, entire, surface broken up into adpressed scaly zones, converging behind into a narrowed point of attachment, margin acute, sometimes tinged crimson or purple, 7–15 cm. broad; pores large, irregular in form, dissepiments thin, pallid; flesh thin, fibrous, orange-rusty.

On decaying trunks. Northern Island, New Zealand. Victoria.

Closely allied to the European *Polyporus giganteus*, differing in the bright colour of the pileus and flesh, and in the larger pores.

III. *Pileus sessile, attached by a broad base.*

Polyporus plebius, Berk., Fl. N.Z., ii, p. 179; Hdbk. N.Z. Flora, p. 608; Cooke, Austr. Fung., p. 126; Sacc., Syll. vi, no. 5247.

Pallid or pale-wood colour, imbricated, sessile, attached by a broad base, more or less semicircular, 3–8 cm. across, up to 1 cm. thick behind, becoming thinner towards the margin, which is sometimes rather thick and blunt, at other thinner and acute, not zoned, minutely pubescent when growing, usually even, sometimes with a groove or more or less rugged; flesh corky; hymenium concave; pores minute, $\frac{1}{6}$–$\frac{1}{8}$ mm. diameter.

On dead wood. Northern Island, New Zealand. Himalayas, Queensland, Victoria, Cuba.

The varieties indicated by Berkeley, depending on the acute or obtuse margin of the pileus, are not constant features, both occurring in the same group of specimens.

"In the New Zealand form the older parts are inclined to assume a spuriously laccate appearance." (Berk.)

Polyporus scruposus, Fries, Epicr., p. 473; Fl. N.Z., ii, p. 178; Hdbk. N.Z. Flora, p. 608; Sacc., Syll. vi, no. 5130; Cooke, Austr. Fung., p. 122.

Pileus sessile, attached by a broad base, semicircular or sometimes almost triquetrous, 1 cm. or more thick at the base and becoming thinner towards the acute margin; surface with raised concentric zones, rough with raised points as if minutely corrugated, brown, margin paler; flesh rather thick, orange-brown; tubes 2–5 mm. long; pores very minute, rounded, umber, often with a tinge of purple.

On dead wood. Northern Island, New Zealand. Victoria, New South Wales, Queensland, Western Australia, Tasmania, Pegu, Nepal, Island of Aru, United States, Mexico, Cuba.

Hard and woody, solitary or imbricated; known by the sulcate, rough pileus, and coloured flesh.

Var. *isidioides*. Syn., *Polyporus isidioides*, Berk., Hook. Lond. Journ. Bot., ii, p. 515; Fl. N.Z., ii, p. 178; Hdbk. N.Z. Flora, p. 608 (called by a slip *iridioides*); Cooke, Austr. Fung., p. 122; Sacc., Syll. vi, no. 5131.

Agreeing in habit and size with the type form; differing more especially in having the pileus rough, with elongated bristly nodules behind.

Although Dr. Cooke retains *Polyporus isidiodes* as a species in the "Handbook of Australian Fungi," after giving the diagnosis he says, "only a variety of *P. scruposus*," a statement with which I entirely agree.

Polyporus dichrous, Fries, Syst. Myc., i, p. 364; Sacc., Syll. vii, no. 5152; Austr. Fung., p. 123; Hdbk. N.Z. Flora, p. 608.

Thin, tough, soft, sessile, effuso-reflexed, often imbricated, 2–3 in. wide, sometimes much larger, slightly silky, white; pores very shallow, minute, rounded, cinnamon-colour, 4–5 in the space of 1 mm.

On trunks. Northern Island, New Zealand. Victoria, South Africa, Europe, United States.

Often covering a large extent of surface, more or less resupinate, with numerous free, spreading margins or lobes. Almost like a *Polystictus*, but soft and not zoned.

37. Fomes, Fries.

Pileus hard, covered with a rigid, crustaceous, zoneless, often concentrically grooved cuticle; tubes stratose. Perennial.

Fomes, Fries, Nov. Symb., p. 31. *Polyporus* of old authors.

The woody pileus with a cartilaginous cuticle not ornamented with coloured zones, and the stratose tubes, stamp the present genus.

I. *Stem lateral, sometimes very short.*

Fomes lucidus, Fries, Nov. Symb., p. 61; Fl. N.Z., ii, 177; Hdbk. N.Z. Flora, 607; Cooke, Austr. Fung., p. 128; Sacc., Syll. vi, no. 5305.

Pileus horizontal or oblique, flabelliform, subreniform, or irregular in form, laterally stipitate, 8–15 cm. across, corky, then hard and woody, sulcato-rugose, deep chestnut-red, or sometimes almost blood-red, polished, shining; tubes 1–1·5 cm. long, pores minute, whitish, then cinnamon; stem very variable in length, irregularly wrinkled, coloured and polished like the pileus; spores 7 × 5 μ, tinged brown.

On trunks, &c. Northern Island, New Zealand. Common in all tropical, subtropical, and temperate regions.

Very variable in size and form; the stem is sometimes almost or even quite central. The lacquered appearance of the pileus and stem is due to the exudation of a thick glutinous liquid which covers the surface, where it soon dries, giving to the surface a perfectly smooth and polished aspect.

II. *Sessile, attached by a broad base.*

Fomes igniarius, Fries, Syst. Myc., i, p. 375; Fl. N.Z., ii, p. 179; Hdbk. N.Z. Flora, p. 608; Sacc., Syll. vi, no. 5412; Cooke, Austr. Fung., p. 131.

Pileus at first irregularly globose, even, with a delicate brownish nap clothing the surface, then becoming hoof-shaped, rust-colour, changing to opaque dingy-brown, cuticle very hard, uneven, 6–18 cm. across; margin blunt, paler; flesh ferruginous, zoned, very hard; tubes 2–5 cm. long, very small, stratose, cinnamon, filled with white mycelium when old, general surface of hymenium convex; pores $\frac{1}{4}$–$\frac{1}{3}$ mm. across, rounded, at first hoary; spores subglobose, hyaline, 6–7 μ diameter; cystidia scanty, 10–25 × 5–6 μ.

On trunks of various trees, living and dead. Bay of Islands, Northern Island, New Zealand. Victoria, Queensland, New South Wales, South Australia, Western Australia, Tasmania, Ceylon, India, Siberia, Europe, United States.

Sometimes very large, thick, and in section more or less triangular, hence hoof-shaped. Allied to *Fomes fomentarius*, differing in being a perennial plant, very hard cuticle and flesh, and in the hyaline spores. A destructive wound-parasite, attacking many different species of trees, dissolving and destroying the heart-wood.

Fomes australis, Fries, Hym. Eur., p. 536; Hbdk. N.Z. Flora, p. 608; Sacc., Syll. vi, no. 5394; Austr. Fung., p. 130.

Normally bracket-shaped, sessile, dimidiate, concentrically zoned or irregularly wavy or tuberculose, glabrous, dark-brown, external crust exceedingly hard, 8–20 cm. across; flesh not very thick, brown, with a tinge of purple; tubes very long, stratose, brown, substance hard; pores at first whitish, then umber, very minute, about 4 in the space of 1 mm.; margin sterile, often slightly thickened.

On dead trunks, stumps, &c. Common in New Zealand, also widely distributed over southern tropical and subtropical regions.

A well-marked but at the same time exceedingly variable species. At times the surface of the pileus is marked with more or less deeply indented concentric furrows, at others only slightly concentrically zoned, whereas in other forms the pileus is irregularly rugged or tuberculated. The pileus is sometimes thin, almost semicircular, and bracket-like; at others it becomes elongated and almost cylindrical. Tubes distinctly stratose in thick specimens. The principal features are the very rigid woody cortex, almost too hard to cut with a knife, and the very minute pores.

Fomes hemitephrus, Cooke, Grev., xiv, p. 21; Sacc., Syll., vi, no. 5497. *Polyporus hemitephrus*, Berk., Fl. N.Z., ii, 179; Hdbk. N.Z. Flora, p. 608 (incorrectly written *hemitrephius*).

Pileus bracket-shaped, often with a boss near the point of attachment, usually with coarse concentric ridges, glabrous, brown, sometimes paler when young, when the rounded margin is whitish, hard, up to 12 cm. across; flesh 3–4 cm. thick, wood-colour, hard; tubes wood-colour, imperfectly stratified; pores very minute, rounded; hymenium concave, whitish.

On trunks of trees. Northern Island, New Zealand. Victoria, India, Gold Coast.

Allied to *Fomes fraxineus*, Fries.

Fomes salicinus, Fries, Syst. Myc., i, p. 376; Fl. N.Z., ii, p. 179; Hdbk. N.Z. Flora, p. 608; Cooke, Austr. Fung., p. 132; Sacc., Syll., vi, no. 5429.

Often broadly effused, woody, very hard, the greater portion usually resupinate, with a narrow, wavy, smooth, blunt, spreading free margin, cinnamon then greyish; pores minute, rounded, rusty-cinnamon like the flesh; spores $5 \times 3\ \mu$; cystidia plentiful $12–35 \times 6–8\ \mu$.

On trunks, living and dead, especially species of *Salix*. Dusky Bay, Middle Island, New Zealand. Queensland, South Africa, Europe, United States.

Pileus 1 ft. or more across; entirely resupinate, or on vertical trunks having the upper margin free and reflexed. Allied to *Fomes fomentarius* and *F. igniarius*, differing in not being hoof-shaped, but thinner in the flesh, and in being more effused over the matrix. Sometimes acts as a destructive wound-parasite.

Fomes hauslerianus, P. Henn., Hedw., 1896, p. 305.

Pileus rigid, somewhat woody, reniform or flabellate, radiately venosely rugulose, zoneless, at first covered with olive mealy down, then naked and blackish, 2·5–3 cm. long; margin thin, rigid, waved, crenate; stem short, lateral, olive-primrose; flesh pallid with a yellow tinge; hymenium greyish; tubes short; pores punctiform, minute; spores subglobose

On trunks. New Zealand; Auckland, Ohaupo.

38. Polysticus, Fries.

Pileus thin, coriaceus, cuticle fibrous, silky or hirsute, often with coloured zones; tubes short. Annual.

Polystictus, Fries, Nov. Symb., p. 54. *Polyporus* of old authors.

Often imbricated or growing in superposed tiers.

I. *Pileus stipitate, stem central.*

Polystictus oblectans, Berk., Hook. Journ., 1845, p. 51; Fl. N.Z., ii, p. 177; Hdbk. N.Z. Flora, p. 607; Austr. Fung., p. 138; Sacc., Syll. vi, no. 5545.

Entirely bright cinnamon-brown, stem usually darkest; pileus 2–5 cm. across, thin, coriaceous, depressed, margin often torn and wavy, zoned, strigosely silky, shining; pores very short, minute, dissepiments torn; stem central, 2–3 cm. long, 2–4 mm. thick, velvety.

On the ground. Northern Island, New Zealand. Victoria, Queensland, Western Australia, Tasmania, Ceylon, India, Brazil.

Polystictus cinnamomeus, Jacq., is closely allied to the present species, differing chiefly in the larger angular pores.

II. *Pileus sessile, attached laterally.*

Polystictus sanguineus, Fries, Epicr., p. 444; Hdbk. N.Z. Flora, p. 609; Sacc., Syll. vi, no. 5631; Austr. Fung., p. 141.

Pileus reniform or somewhat fan-shaped, sessile, or narrowed behind into a very short stem-like base, attached by an expanded disc, 3–10 cm. broad, glabrous and polished, sometimes concentrically zoned, vermilion, bleaching almost white when old; flesh thin, compact, 0·5 cm. or less thick, margin thinnest, frequently lobed or wavy; tubes very short; pores minute, rounded, 3 in space of 1 mm., deep and persistent vermilion.

On trunks, stumps, &c. New Zealand. Australia, Tasmania, Lord Howe Island, India, Java, Borneo, Philippines, Malacca, Sumatra, Friendly and Society Islands, South America, Central America, Cuba, United States

A showy fungus, superficially resembling *Polystictus cinnabarinus*. For distinction between the two see note under the last-named species.

Polystictus cinnabarinus, Fries, Syst. Myc., i, p. 371; Hdbk. N.Z. Flora, p. 609; Sacc., Syll. vi, no. 5711; Cooke, Austr. Fung., p. 146.

Pileus semicircular, somewhat narrowed behind at the point of attachment; convexo-plane, thickest behind, where it is 1–2 cm. thick, margin thin, 6–10 cm. broad; pileus corky, often slightly zoned or rugulose, at first downy, then glabrous, vermilion, bleaching almost white with age; flesh spongy or fibrous, red; tubes 2–3 mm. long; pores vermilion, roundish, 2, rarely more, in the space of 1 mm.

On dead trunks, &c. New Zealand. Australia, Tasmania, India, Ceylon, Sumatra, Cape of Good Hope, Europe, United States.

A beautiful fungus, superficially resembling *Polystictus sanguineus*. The latter, however, differs in the thinner substance of the pileus, which is glabrous and polished at all stages, is attached to the matrix by a distinct disc, and has smaller pores.

Polystictus versicolor, Fries, Syst. Myc., i, p. 368; Sacc., Syll. vi, no. 5741; Austr. Fung., p. 146. *Polyporus versicolor*, Fries, Hdbk. N.Z. Flora, p. 609.

Pileus thin, coriaceous, flat on both surfaces, often slightly depressed behind, upper surface densely velvety, shining, with variously coloured concentric bands, 3–10 cm. across; pores very short, minute, white, becoming tinged buff or cream-colour; dissepiments thin, becoming torn; pores about $\frac{1}{4}$ mm. across.

On trunks, stumps, branches, &c. Northern Island, New Zealand. Victoria, Queensland, New South Wales, Tasmania, Europe, America.

Distinguished by the silky shining pileus being marked with concentric zones of various colours.

Polystictus velutinus, Fries, Syst. Myc., i, p. 368; Fl. N.Z., ii, p. 178; Hdbk. N.Z. Flora, p. 609; Cooke, Austr. Fung., p. 147; Sacc., Syll. vi, no. 5763.

Horizontal, attached laterally by a more or less narrowed base, and imbricated, flat, or attached by a more or less central point and remaining flattened; thin, pliant when growing, then rigid, 4–10 cm. across; pileus velvety, indistinctly zoned, dull, dingy-white to pale yellowish-white, sometimes tinged brown; tubes very short; pores subangular, white, minute, often disappearing towards the margin; spores broadly elliptic-oblong, obliquely apiculate, 5–6 × 4 μ.

On trunks, stumps, &c. Northern Island, New Zealand. Victoria, Queensland, India, Borneo, Java, Philippines, Japan, Europe, Asiatic Siberia, United States, Cuba, South America.

Flaccid when young and growing, shrinking and curling inwards when dried; about 3–4 mm. thick. Allied to *Polystictus versicolor*, from which the present differs in the dull, opaque—not silkily shining—pileus, which is whitish, and not variegated with zones of deep colours.

Polystictus hirsutus, Fries, Syst. Myc., i, p. 367; Sacc., Syll. vi, no. 5760. *Polyporus hirsutus*, Fries, Hdbk. N.Z. Flora, p. 609.

Pileus thin, both surfaces almost plane, more or less semicircular in outline, often imbricated, upper surface generally whitish, sometimes tinged yellow, coarsely hispid or strigose, often concentrically zoned, 3–7 cm. across; pores roundish, small, about ⅓ mm., greyish-buff; spores narrowly elliptical, 4–5 × 2 μ.

On stumps, dead wood, &c. Middle Island, New Zealand. Victoria, Queensland, New South Wales, Europe, Siberia, United States.

Differs from *Polystictus versicolor* and *P. velutinus* in the coarsely strigose hymenium and the greyish pores.

Polystictus tabacinus, Mont., Flor. Juan Fernandez, no. 15; Fl. N.Z., ii, p. 178; Hdbk. N.Z. Flora, p. 609; Sacc., Syll. vi, no. 5876; Cooke, Austr. Fung., p. 151.

Pilei imbricate, entirely dark-brown, sessile, irregularly semicircular or shell-shaped, concentrically zoned, silky and shining, very thin, rigid, 2–6 cm. long, 2–4 cm. broad; tubes very short, rather small, the dissepiments becoming torn or toothed.

On dead wood. Northern Island, New Zealand. New South Wales, Mauritius, Island of Aru, Chili, Juan Fernandez.

A very beautiful fungus; flesh very thin, as is the whole fungus; pileus glistening with a silky sheen. Distinguished by the umber-brown colour of every part. Much incurved and very rigid when dry.

Polystictus sector, Fries, Epicr., p. 480; Sacc., Syll. vi, no. 5900.

Pileus 2–4 cm. across, wedge-shaped or fan-shaped, sessile, imbricated, thin, coriaceous, downy, becoming glabrous, zoned, striate, pale-brown; pores shallow, small, brown, sometimes with a tinge of purple, dissepiments thin.

On branches, &c. Northern Island, New Zealand. Tasmania, Cuba, Brazil.

Pileus sometimes almost triangular, narrowed behind, tomentose when young, margin fibrillose, often densely imbricated.

Polystictus adustus, Fries, Hym. Eur., 549; Sacc., Syll. vi, no. 5146; Austr. Fung., p. 123, Hdbk. N.Z. Flora, p. 607.

Effuso-reflexed or entirely resupinate, forming large patches 5–25 cm. across; flesh thin, whitish, flexible when moist; pileus greyish, downy, indistinctly zoned, often rugulose; tubes very short; pores minute, rounded, whitish, then dingy-grey or lead-colour, blackish when dry, averaging 3–4 to 1 mm. of space; margin sterile, whitish; spores colourless, $4–5 \times 2{\cdot}5\ \mu$.

On stumps, &c. New Zealand. Australia, Tasmania, India, Europe, United States, Cuba.

Very variable, sometimes entirely resupinate and resembling a *Poria*, at other times the margin becomes free. Distinguished by the grey pores and white margin. The pores become dark when bruised.

Polystictus catervatus, Berk., Fl. N.Z., ii, p. 180, tab. cv, fig. 1; Hdbk. N.Z. Flora, p. 609; Sacc., Syll. vi, no. 5918.

Usually densely crowded; pileus about 1 cm. across, fan-shaped or irregularly reniform, margin often lobed or torn, narrowing below into a short, slender, stem-like base, white, silkily fibrillose; pores very shallow, minute, irregular, white; dissepiments thin, edge minutely toothed.

On split stems of *Podocarpus spicata*, Mission Station; on bark, Wellington, New Zealand.

Very frequently the adjoining pilei grow together at the margin, and form a continuous membrane. Very thin and delicate, altogether white. An endemic species, and apparently rare.

39. **Poria**, Pers.

Entirely resupinate; flesh usually very thin, attached throughout to the substratum; tubes usually short.

Poria, Persoon, Syn., p. 542.

In all probability many species included under the present genus may prove to be nothing more than degraded resupinate conditions of species of *Fomes*, *Polystictus*, or *Polyporus*.

Poria vaporaria, Fries, Syst. Myc., i, p. 682; Fl. N.Z., ii, p. 180; Hdbk. N.Z. Flora, p. 610; Cooke, Austr. Fung., p. 155; Sacc., Syll. vi, no. 6035.

Broadly effused, thin, inseparable, the white mycelium penetrating the matrix; pores large, angular or sinuous, white, then cream-colour, forming a continuous stratum.

On dead trunks and branches. Northern Island, New Zealand. Victoria, Queensland, Western Australia, Malacca, Ceylon, Europe, North America.

Often broadly effused, or almost entirely covering fallen branches, inseparable from the matrix; flesh almost none; pores very variable, large, angular, or sinuous; often irregularly torn and more or less oblique, appearing as if sunk in the matrix, which is usually bark, whitish or pallid, becoming pale-ochraceous when dry. Pores often reaching 1 mm. in diameter. This species is sometimes destructive to worked wood, forming a white, spreading mycelium resembling the early stage of "dry rot."

Poria mollusca, Fries, Syst. Myc., i, p. 384; Sacc., Syll. vi, no. 5936; Austr. Fung., p. 153.

Effused, thin, soft, white, margin fibrillose and giving off radiating strands; pores very shallow, minute, angular, dissepiments very thin and unequally torn, occupying the central portion of the patch, or scattered here and there in groups, $\frac{1}{4}$–$\frac{1}{3}$ mm. diameter.

On rotten wood, and on heaps of dead leaves. New Zealand. Victoria, Europe, United States.

Sometimes broadly effused; known by the fringed fibrillose margin; the partitions of the pores are very thin, and usually toothed or torn. Sometimes tinged with yellow. At first forming a mere byssoid margin, which gradually acquires moderate, rigid, subrotund and angular pores.

Poria hyalina, Berk., in Hooker's Flora Tasm., ii, p. 255 (1860); Sacc., Syll. vi, no. 5938; Cooke, Austr. Fung., p. 153.

Resupinate, very thin, white, more or less hyaline, circumference sterile, membranaceous, margin not byssoid; pores very shallow, irregular in form, $\frac{1}{4}$–$\frac{1}{6}$ mm., dissepiments very thin.

On dead wood. New Zealand. Tasmania.

Very delicate, not thicker than paper; hymenium becoming much cracked, due to shrinkage during drying. The somewhat broad sterile border remains firmly attached to the matrix.

Poria leucoplaca, Berk., Fl. N.Z., ii, p. 180; Hdbk. N.Z. Flora, p. 609; Sacc., Syll. vi, no. 6092.

Entirely pure white, resupinate, thin; following the irregularities of the matrix, margin distinctly defined, every part covered by the small pores about $\frac{1}{3}$ mm. diameter, dissepiments rather thick, edge pulverulent under a lens; flesh almost none.

On dead branches. Northern Island, New Zealand. Malacca.

About 2 mm. thick, forming well-defined white crusts 2–10 cm. long.

Poria corticola, Fries, Syst. Myc., i, p. 385; Sacc., Syll. vi, no. 6093; Austr. Fung., p. 156.

White, then pallid, inseparable, often forming broad, thin, firm patches; not unfrequently more or less sterile (without pores); pores naked, very shallow, small, roundish.

On dead bark. New Zealand. Queensland, Victoria, South Australia, Europe, United States, Brazil.

Position uncertain.

Polyporus diffissus, Berk., Fl. N.Z., ii, p. 180; Berk., Hdbk. N.Z. Flora, p. 610.

Fleshy, red, at length separating from the matrix, pores small, dissepiments thin, the membranaceous edge minutely toothed.

In the charred inside of a *Fagus*. New Zealand.

"Resupinate, effused, fleshy, of a bright red, at length tearing away from the matrix and leaving part of the substance behind; pores small; dissepiments thin; edge membranaceous, slightly toothed. This is probably a resupinate form of some anodermeous species, which has not at present been observed. Its bright colour, however, makes it very remarkable, on which account it is inserted here, though the specimen is by no means in a satisfactory state." (Berk.)

No specimen exists at Kew, hence Berkeley's account, given above, cannot be supplemented. If this should prove to be a good species it would have to be known as *Poria difissa.*

40. Trametes, Fries.

Pileus corky or woody; tubes penetrating unequally into the flesh of the pileus; pores roundish or more or less elongated radially.

Trametes, Fries, Epicr., p. 488.

Trametes is intermediate between *Dædalea* and *Fomes*, differing from the former in the rounded or only slightly elongated pores, and from the latter in the tubes running up into the flesh of the pileus at different levels.

Trametes epitephra, Berk., Journ. Linn. Soc. (Bot.), xiii, p. 165 (1873); Sacc., Syll. vi, no. 6240; Austr. Fung., p. 159.

Imbricated; pileus hoof-shaped, with a few more or less prominent ridges, ashy-brown, coarsely velvety, becoming almost smooth with age, margin whitish, hard, 1–2·5 cm. broad; pores pallid, very much decurrent or running down the bark, more or less elongated, rather large; dissepiments very thick.

On trunks and decaying wood. New Zealand. Adelaide, South Australia.

Remarkable for the very thick dissepiments or walls separating the pores. Might with almost equal propriety have been placed in the genus *Dædalea.*

41. Dædalea, Pers.

Pileus woody or corky; pores elongated and irregularly sinuous; dissepiments or walls of tubes thick, flexible.

Dædalea, Persoon, Syn., p. 449.

Distinguished by the wide labyrinthiform pores, with thick, corky, and elastic walls.

Dædalea pendula, Berk., Fl. N.Z., ii, p. 180, tab. cv, fig. 4; Hdbk. N.Z. Flora, p. 610; Sacc., Syll. vi, no. 6394.

Imbricated; pileus 3–6 cm. broad and high, sessile, attached by the back and base, pendulous, irregularly cup-shaped, with the opening downwards, thin, flexible, strigose, reddish-grey; hymenium lining the cavity, pinkish-lilac, sparingly and vaguely scattered with tooth-like projections, and irregular shallow pores.

On dead wood. Ngawakatatara, New Zealand.

"Imbricated, coriaceous. Pilei 1½ in. long, pendulous, bursæform, pale reddish-grey, tinged with lilac, sparingly zoned, clothed with short, strigose, matted brown hairs; margin tomentose. Hymenium tinged with lilac and reddish-grey, sparingly porous, with irregular tooth-like dissepiments, which are finely setulose. This, if fully grown, is scarcely a *Dædalea* in its characters, having more the hymenium of a *Radulum;* but it is evidently allied to such species as *D. unicolor;* and though the dissepiments are irregular, there are very evident pores, while in some parts there are as evident teeth. The species is at any rate undescribed, whatever may be thought of the genus." (Berk.)

From the foregoing quotation it will be learned that the fungus under consideration is very imperfectly known, and, as it has not been collected since the type was found by Colenso, much remains to be learnt before its systematic position can be determined with certainty.

Dædalea confragosa, Pers., Syn., p. 501; Fl. N.Z., ii, p. 180; Hdbk. N.Z. Flora, p. 610; Sacc., Syll. vi, no. 6347.

Pileus sessile, horizontal, semicircular or subreniform, attached by a stout base, almost flat above, reddish-brown, indistinctly zoned, roughened, 4–12 cm. across; flesh pale-wood colour, corky, 1–2 cm. thick at the base, becoming thinner towards the margin; tubes elongated; pores rounded or more frequently elongated and sinuous, grey, then brownish; dissepiments thick, flexible.

On dead wood, more especially *Salix*. Bay of Islands, Northern Island, New Zealand. Europe, United States.

Variable in size; the pileus is sometimes rough with large irregular elevations, at others only scabrid.

42. **Favolus**, Fries.

Pileus thin, tough, dimidiate or substipitate; pores large, elongated, extending radially from the point of attachment of the pileus.

Favolus, Fries, Elench., p. 44.

The pores appear to be formed from radially arranged lamellæ or gills which anastomose and are connected by numerous lateral ridges. Perhaps most closely allied to *Cantharellus*, but more woody in texture.

Favolus intestinalis, Berk., in Hook. Journ. Bot., iii, p. 167 (1851); Hdbk. N.Z. Flora, p. 610; Sacc., Syll. vi, no. 6471.

Pileus thin, soft, irregularly reniform, margin variously undulate or lobed, attached by a very short lateral stem, which is sometimes almost obsolete, extending horizontally, 4–7 cm. long, upper surface very delicately pubescent when fresh; pores inferior, large, shallow, polygonal, up to 0·5 cm. across; spores broadly elliptical, hyaline.

On dead wood, among moss, &c. Northern Island, New Zealand. India.

Entirely white when fresh, becoming very thin, translucent, and dingy-ochraceous when dry. Berkeley writes as follows of this species, which was described from Indian specimens: "A very singular esculent species, looking like a piece of tripe. The substance dries up so completely that the pores are visible from the upper side, as in some other species."

43. **Laschia**, Fries.

Subgelatinous and tremelloid, thin, rigid when dry; under surface irregularly honeycomb-like in structure.

Laschia, Fries, Linnea, v, p. 533.

Distinguished by the flaccid subgelatinous texture, and the irregularly hexagonal indentations on the under fertile surface; there are frequently protuberances on the upper surface of the pileus corresponding to the indentations on the lower surface.

Laschia thwaitesii, Berk. and Broome, Journ. Linn. Soc. (Bot.), xiv, p. 58; Austr. Fung., p. 167; Sacc., Syll. vi, no. 6508.

Cæspitose; subgelatinous when moist; pileus convex, often oblique, thin, even, orange or yellowish-ochraceous, very minutely silky when young, 5–8 mm. across; pores rather large, irregular, yellowish; spores elliptical, obliquely apiculate, white, 6–7 × 4 μ; stem variable in length, up to 1·5 cm. long, sometimes very short, slender, whitish.

On dead stems of *Rhipogonum*. Pohangina River, New Zealand. Ceylon, Queensland.

A pretty and distinct species, growing mixed with *Marasmius subsupinus*, Berk., and sent to Kew, along with many other species, by Kirk. The pores are rather irregular, and in some specimens almost resemble gills connected by high transverse ridges. Differs from *Marasmius* in being subgelatinous when moist.

44. Merulius, Hall.

Resupinate, or with the margin more or less free and reflexed; substance usually somewhat soft and inclined to be gelatinous; pores very irregular in form, often formed from slightly raised, wavy, and anastomosing wrinkles.

Merulius, Hall., Helv., p. 150.

Differs from *Poria* in consistency and in larger and irregularly formed pores. Some species are destructive parasites; others, as *M. lacrymans* ("dry rot"), destroy worked wood.

Merulius corium, Fries, Elench., p. 58; Sacc., Syll. vi, no. 6532; Austr. Fung., p. 168.

Effused and resupinate, forming patches 3–10 cm. across, upper margin usually free and reflexed, substance very thin, flexible and tough; pileus whitish, silky; hymenium reticulato-porous, from pale-ochraceous to tan-colour, sometimes tinged lilac; spores oblong, 8–10 × 3–4 μ.

On trunks and branches. New Zealand. Australia, Tasmania, India, South Africa, Europe, United States.

Substance thin, often separable from the matrix. The hymenium is furnished with very slightly elevated ridges which anastomose to form an irregular reticulation that disappears towards the flat and sterile margin.

Hydneæ.

The sequence of general form is the same in the present family as in the *Polyporeæ*. In the highest types there is a more or less thick or fleshy pileus supported on a central stem; next we descend to species having a lateral stem; then the sessile bracket-shaped pileus; and finally to the resupinate condition where the entire fungus forms an incrusting more or less widely extending mass, inseparable from the matrix. The hymenium, instead of consisting of tubes having the inside lined with the hymenium as in the *Polyporæ*, consists of closely packed solid spines or teeth, the entire surface of which bears the hymenium.

In the genus *Hydnum* the spines are slender and pointed, or awl-shaped, and vary in length in different species from 3 cm. to less than 1 mm. In other genera, as *Radulum*, the teeth are more or less flattened, obtuse, and often very irregular in size and form, whereas in some of the simpler resupinate genera, as *Grandinia*, the teeth are very much reduced, the hymenium being densely covered with very minute warts or granules.

The spines or teeth are very often more or less fringed or feathered at the tip when seen under a pocket-lens

Representatives of the family are apparently rare in the Southern Hemisphere, the most highly developed species being most abundant in the forests of northern Europe.

Some of the large fleshy species are edible.

A few species are destructive parasites, attacking timber and fruit-trees.

Analysis of the Genera.

45. Hydnum. Spines rounded, acute, distinct from each other at the base.
46. Irpex. Teeth obtuse, springing from anastomosing ridges.
47. Phlebia. Hymenium covered with delicate radiating folds or wrinkles.
48. Grandinia. Hymenium crowded with very minute warts.

45. Hydnum, Linn.

Hymenium inferior in stipitate and dimidiate species, superior in resupinate forms, covered with acute spines or teeth that are perfectly free from each other at the base.

Hydnum, Linn., Gen. Pl., no. 968.

Distinguished from allies by the acute awl-shaped or spine-like teeth arising free from each other.

Hydnum clathroides, Pallas, Russ. Reis., p. 2, fig. 3; Hdbk. N.Z. Flora, p. 611; Sacc., Syll. vi, no. 6683

Entirely grey, very much branched, trunk divided from the base, branches fasciculate and anastomosing laterally to form an irregular network; upper surface of branches papillose, under surface densely crowded with filiform spines 2–3 mm. long.

On wood (*Knightia* sp.). Northern Island, New Zealand. Asiatic Russia.

Specimens imperfect, and identification hence doubtful; Native name, "pekepeke rione" (Coll.). Berk., in N.Z. Fl.

Hydnum coralloides, Scop., 2, p. 472; Sacc., Syll. vi, no. 6677; Cooke, Austr. Fung., 171.

Forming large tufts 5–12 in. across; white, becoming pallid with age; originating from a knob, which at once becomes divided into several tapering, crooked, pendulous branches which are ½ in. or more thick at the base, narrowing to about a line thick at the tip; spines springing from one side of the branches, pendulous, 3–8 lines long, awl-shaped, entire; spores hyaline, globose, 4–6 μ diameter.

On rotten wood, inside hollow trunks, &c. New Zealand. Queensland, Europe, Asiatic Siberia, United States.

"When old it forms tufts a foot or more in length, with flexuous angular branches, beset with incurved ramuli, bearing spines on the under side." (Cooke.)

Hydnum udum, Fries, Syst. Myc., i, p. 422; Sacc., Syll. vi, no. 6795; Cooke, Austr. Fung., p. 173.

Patches thin, effused, inseparable from the matrix, subgelatinous, flesh-colour then dull-yellowish; spines crowded, unequal, 2–3 mm. long, awl-shaped or compressed, simple or toothed, coloured like the subiculum.

On dead wood. New Zealand. Queensland, New South Wales, Tasmania, Europe, United States.

Sometimes forming dingily coloured subgelatinous patches several inches long. Yellowish towards the margin when dry, the central part pale-fawn or dingy flesh-colour.

Hydnum niveum, Pers., Disp., tab. 4, f. 6–7; Sacc., Syll. vi, no. 6815.

Entirely resupinate, inseparable from the matrix, very thin and delicate, pure white, becoming pallid when dry, patches 2–8 cm. long; margin delicately byssoid; spines crowded, very minute, equal, glabrous.

On dead wood. New Zealand. Europe.

A very delicate species, resembling a mere film; spines or teeth very delicate, but under a lens are found to be acute, very uniform in size, glabrous.

Hydnum scopinellum, Berk., Fl. N.Z., ii, p. 181; Hdbk. N.Z. Flora, p. 611; Sacc., Syll. vi, no. 6825.

Effused, white, subiculum interwoven; spines tomentose at the base, tips penicillate.

On dead wood.

"Widely effused; subiculum composed of delicate interwoven threads, which make the base of the aculei tomentose, tips penicillate."

The above is the account of the species as given by Berkeley, and as there is no specimen in Berkeley's herbarium I am unable to add to the description. The species is placed in the resupinate section.

46. Irpex, Fries.

Pileus dimidiate or resupinate ; teeth springing from irregularly arranged ridges or folds.

Irpex, Fries, Elench., p. 142.

The teeth are somewhat irregular in form, and not so uniformly spine-like and pointed as in *Hydnum*.

Irpex brevis, Berk., Fl. N.Z., ii, p. 181 ; Hdbk. N.Z. Flora, p. 611 ; Sacc., Syll. vi, no. 6887.

Sessile, more or less fan-shaped or sometimes attached by a broad base, dimidiate, horizontal or slightly pendulous, about 1 cm. long by 1·5–2·5 cm. broad, very thin ; pileus at first whitish, then brownish, more or less zoned and fibrillose ; teeth flattened, often irregularly divided, 2–3 mm. long, pale.

On dead bark, often growing among moss. New Zealand.

Apparently not uncommon, having been sent to Kew by Colenso on several occasions. An endemic species. Very variable in mode of growth. Sometimes several more or less fan-shaped pilei are crowded in an imbricate manner, at others they extend for a distance of several centimetres, attached by a broad base, the free portion overhanging and slightly drooping. The teeth are often decurrent for some distance below the free portion of the pileus. Finally the fungus is sometimes entirely resupinate, without a trace of free margin anywhere, the central portion being furnished with irregular plates or pores, almost resembling a *Poria*.

47. Phlebia, Fries.

Resupinate ; hymenium covering the entire free surface, somewhat gelatinous, everywhere covered with fine radiating wrinkles or folds.

Phlebia, Fries, Syst. Myc., i, p. 426.

Distinguished by the closely crowded series of corrugations or ridges radiating irregularly from centre to margin of the hymenium.

Phlebia reflexa, Berk., in Hook. Journ. Bot., iii, p. 168 (1851) ; Sacc., Syll. vi, no. 6964 ; Cooke, Austr. Fung., p. 176.

Densely imbricated or superimposed, reflexed, thin, free portion 2–4 cm. broad, flaccid and tough when moist, rigid when dry; pileus covered with a dense coat of short down, purplish-brown towards the margin, often greyish-white near the line of attachment, irregularly zoned; hymenium dark-brown, often tinged purple, corrugated behind, almost even towards the margin; spores subglobose, about 4 μ diameter.

On logs of *Fagus*, &c. Northern Island, New Zealand. Victoria, Queensland, New South Wales, New Guinea, China, Sikkim, Himalayas, Africa.

At first resupinate and spreading widely, but easily detached, then broadly reflexed and dimidiate, 4–6 cm. long, 2–4 cm. broad; very tough and pliant when moist. Distinguished from species of *Auricularia* by the hymenium being covered with short, irregularly arranged, radiating ribs, giving it a wrinkled or corrugated appearance.

48. Grandinia, Fries.

Resupinate; thin, incrusting, hymenium minutely papillose or granulose, covering the entire exposed surface.

Grandinia, Fries, Epicr., p. 527.

When examined under a low power of the microscope, the tips of the minute granules covering the hymenium are usually found to be indented.

Grandinia crustosa, Fries, Epicr., p. 528; Sacc., Syll. vi, no. 6973; Austr. Fung., p. 176.

White or with a pallid or yellow tinge, irregularly effused, sometimes for several inches, closely adnate, thin, crustaceous, rather mealy at maturity; warts crowded, subglobose, minute, often collapsing at the apex, unequal.

On dead bark, wood, and on other fungi. New Zealand. Victoria, Ceylon, Europe.

Thelephoreæ.

The fungi constituting this group show less differentiation and division of labour than is observable in the preceding groups. In the simplest forms the entire plant is resupinate or attached to the matrix at every point, and the upper surface is everywhere covered by the hymenium, with the exception of the silky or fibrous margin, which is the youngest or growing portion. When the fungus becomes partly free from the matrix or substance upon which it is growing, then the differentiation of the usually more or less membranous expansion is obvious. The under side, which is turned away from the light, is covered with the hymenium or spore-bearing portion, whereas the upper surface is completely sterile and usually more or less velvety or hispid. In many of the higher forms, as *Stereum*, *Hymenochæte*, &c., the sterile surface or pileus is brightly coloured and zoned.

The principal feature of the present group is the even surface of the hymenium, strictly confined to one side of the pileus, and the one-celled or non-septate basidia, as compared with the warts, spines, pores, or gills over which the spore-bearing surface is disposed in other groups. In some of the resupinate species of *Corticium* and *Coniophora*, where the flesh of the fungus is very thin, the hymenium often presents a warted or wrinkled surface, but on examination it will be found that this unevenness is due to the very thin substance of the fungus following the irregularities of the wood or other substance upon which it is growing.

Among the hymenial elements cystidia are very frequently highly differentiated, and are of importance in fixing the limits of genera. In *Peniophora* cystidia are very prominent, colourless, and the portion projecting above the general surface of the hymenium often coated with particles of oxalate of lime. In *Hymenochæte*, on the other hand, the cystidia are very thick-walled, rigid, and coloured brown. In the two genera just mentioned cystidia are so numerous in the hymenium, and project so much above the level of the basidia, that the surface presents a velvety appearance when seen through a pocket-lens.

In the most highly developed species there is a distinct central stem supporting a pileus which is usually depressed or funnel-shaped, thus resembling in general build an agaric, differing, however, in the absence of gills on the under surface of the pileus, which is quite even and more or less polished.

In some species of *Stereum* and *Lachnocladium* the pileus is cut up into numerous narrow strips or shreds, and superficially resembling certain species of *Clavaria*. In the last-named, however, the hymenium completely surrounds the branches, whereas in *Stereum* and *Lachnocladium* one side only of each narrow branch bears the hymenium, the opposite side being sterile and velvety or hairy.

Analysis of the Genera.

A. *Spores coloured.*

* Spores smooth.

49. Coniophora. Resupinate; surface dry and pulverulent.

** Spores warted or echinulate.

50. Thelephora. Substance dry and fibrous; hymenium often irregularly rugulose or nodulose.

51. Soppittiella. Subgelatinous, effused or variously incrusting twigs, grass, &c.

B. *Spores colourless.*

* Hymenium minutely setulose with projecting cystidia.

52. Peniophora. Cystidia colourless.
53. Hymenochæte. Cystidia coloured.

** Hymenium glabrous.

54. Corticium. Entirely resupinate; hymenium usually cracked when dry.
55. Stereum. Effuso-reflexed; pileus silky or strigose; hymenium even.
56. Lachnocladium. Erect, narrowed to a stem-like base; pileus cut up into many very narrow segments; fertile on one side only.
57. Craterellus. Large, erect, funnel-shaped. Terrestrial.
58. Cyphella. Minute, cup-shaped, mouth open. On plants.

49. Coniophora, DC.

Broadly effused, resupinate, margin determinate or indeterminate; hymenium powdered with the smooth coloured spores; cystidia absent.

Coniophora, DC., Flor. Fr., vi, p. 34.

Forming broadly expanded, minutely powdery expansions on bark or wood.

Coniophora sulphurea, Mass., Journ. Linn. Soc. (Bot.), xxv, p. 133; Cooke, Austr. Fung., p. 196. Syn., *Corticium sulphureum*, Fries, Epicr., p. 561; Sacc., Syll. vi, no. 7535.

Broadly effused, margin bright sulphur-yellow, often fibrillose and running out in cord-like radiating strands; hymenium thickish, compact, almost waxy, brownish with a yellow tinge, cracking when dry; spores broadly elliptical, brownish-yellow, 11–12 × 8–10 μ.

On wood, bark, dead leaves, &c. Northern Island, New Zealand. Tasmania, Ceylon, Europe, United States, Cuba.

Often sterile, and then very showy, as the mycelium and margin is clear yellow. Often extending for many inches.

50. Thelephora, Ehrh.

Varying from central-stemmed, through dimidiate, to resupinate; pileus usually fibrillose or strigose; hymenium usually wrinkled; spores coloured, warted, or echinulate. No cystidia.

Thelephora, Ehrh., Crypt., p. 178.

Differs from *Coniophora* in rough spores, which usually have a vinous or pale-purple tinge. *Stereum* differs in colourless spores.

Thelephora vaga, Berk., Fl. N.Z., ii, p. 182; Hdbk. N.Z. Flora, p. 611; Sacc., Syll. vi, no. 7181.

Resupinate, variously incrusting, dry, dingy-brown; mycelium byssoid, creeping, loose; spores vinous-brown, irregularly globose, minutely warted, 6–8 μ.

On wood, heaps of dead leaves, &c. Ashburton, New Zealand.

"It grows under pine-trees, chiefly *Pinus insignis*. I have observed it growing on bare soil, among beds of dead pine-leaves, which become matted into a mass, and also at the roots of *Dactylis glomerata*, growing under *P. insignis*." (W. W. Smith, Ashburton, New Zealand.)

51. **Soppittiella**, Mass.

Whitish at first, soft and subgelatinous, then becoming rigid, incrusting, form very variable; hymenium collapsing when dry and often tinged brown; spores coloured, spinulose.

Soppittiella, Mass., Brit. Fung. Fl., i, p. 106.

Distinguished by the soft substance when growing. Often creeping up living tufts of grass or other plants in an irregularly shaped fringed mass.

Soppittiella fastidiosa, Mass., Brit. Fung. Fl., i, p. 107 (1892). *Thelephora fastidiosa*, Berk., Outl., p. 268; Sacc., Syll. vi, no. 7161.

Whitish; forming broadly effused, incrusting, amorphous, or forming irregularly flattened branches; hymenium irregularly papillose, becoming rufescent with age or when bruised; spores broadly elliptical, rough, almost colourless, 6–7 × 4–5 μ. Smell of entire plant very fœtid, especially when bruised.

New Zealand. Europe.

White, becoming cream-colour, running as a thin soft film over everything in its way, sometimes forming free flattened branches. Silky or byssoid when young.

52. **Peniophora**, Cooke.

Resupinate, or with the extreme margin free and more or less raised; hymenium with projecting colourless spines or cystidia; spores colourless.

Peniophora, Cooke, Grev., vii., p. 20.

Differs from *Hymenochæte* in the cystidia being colourless; the projecting portions of the cystidia are often incrusted with particles of lime. *Corticium* differs in having no cystidia.

Peniophora velutina, Cooke, Grev., viii, p. 21, pl. 125, fig. 15; Sacc., Syll. vi, no. 7701.

Broadly effused, rather fleshy, inseparable, margin running out into long branching strands; hymenium minutely velvety, cream-colour, often slightly tinged with pink or buff; cystidia cylindrical or attenuated upwards, 60–80 × 10–15 μ; spores elliptical with a minute apiculus, 10 × 5 μ.

On wood and bark. New Zealand. Europe, United States.

Often forming patches 5–10 cm. long. When perfectly developed the hymenium bristles with projecting cystidia when seen under a lens; these are more cylindrical and less incrusted with lime than usual. In some specimens the hymenium is very much cracked, in others quite continuous. The marginal radiating strands of mycelium often extend for many inches and connect several distinct fertile patches.

Peniophora ochracea, Mass., Journ. Linn. Soc. (Bot.), xxv, p. 150. Syn., *Corticium ochraceum*, Fries, Epicr., p. 563; Sacc., Syll. vi, no. 7600.

Broadly effused, inseparable, magin radiato-byssoid, soon disappearing; hymenium ochraceous, sparkling with very minute crystals of oxalate of lime when fresh, cracked when dry; cystidia fusoid, 40–60 × 18–22 μ; spores elliptical, hyaline, 10 × 5 μ.

On dead bark and wood. New Zealand. Europe, United States.

Closely resembling in habit and general appearance, colour, and in the presence of sparkling atoms on the hymenium *Coniophora olivacea*, but distinguished by the cystidia and smaller colourless spores.

Peniophora papyrina, Cooke, Grev., viii, p. 20, pl. 124, fig. 9; Austr. Fung., p. 191, fig. 82; Sacc., Syll. vi, no. 7688. Syn., *Stereum papyrinum*, Mont., Hdbk. N.Z. Flora, p. 612.

Very broadly effused, margin usually reflexed, very thin, coriaceous, strigose, grey, concentrically grooved, margin acute, tawny; hymenium umber, becoming purplish, minutely velvety; setæ fusoid, 80–90 × 12–14 μ; spores subglobose, 6 μ diameter.

On bark and wood. Northern Island, New Zealand. Cuba.

Forming broadly effused, very thin patches, which follow the irregularities of the bark.

53. Hymenochæte, Lév.

Pileus with a central stem, dimidiate or entirely resupinate; hymenium minutely setulose with projecting coloured cystidia; spores hyaline or coloured.

Hymenochæte, Lév., Ann. Sci. Nat., ser. 3, 1846, p. 150.

Distinguished at once by the numerous brown cystidia projecting from the surface of the hymenium. These can be easily seen with an ordinary pocket-lens.

Hymenochæte tabacina, Lév., Ann. Sci. Nat., ser. 3, vol. v, p. 152; Sacc., Syll. vi, no. 7428; Cooke, Austr. Fung., p. 189; Mass., Mon. Thel., Journ. Linn. Soc. (Bot.), xxvii, p. 112; Mass., Brit. Fung. Fl., i, p. 117.

Subcoriaceous, thin, flaccid when moist, margin often reflexed, silky below, at length smooth, subferruginous, intermediate stratum and margin bright golden-yellow; hymenium cinnamon or rusty, usually with a tinge of purple, often cracked, minutely velvety; cystidia conico-acuminate, coloured, 80–130 × 10–14 μ; spores elliptical, olive, 5–6 × 3 μ.

On trunks, branches, &c. New Zealand. Victoria, New South Wales, Malacca, Europe, North and South America.

Distinguished by the golden-yellow margin of the hymenium and the coloured spores. Sometimes almost completely covering the under surface of fallen logs. When moist dirty ferruginous passing to mulberry-colour, rigid when dry, adnate, margin more or less free all round, often lobed, or free and reflexed above, rugulose. Hymenium often cracked when dry in lines radiating from the centre, or from several starting-points in broadly effused specimens.

Hymenochæte rhabarbarina, Cooke, Grev., viii, p. 148; Sacc., Syll. vi, no. 7467. Syn., *Corticium rhabarbarinum*, Berk., Fl. N.Z., ii, p. 184.

Effused, inseparable, hymenium minutely velvety, rusty-orange, margin paler, indeterminate, 8–12 cm. broad; setæ acuminate, 30–40 × 7–9 μ; spores pale-olive, oblong-ellipsoid, 8 × 4 μ.

On bark. Northern Island, New Zealand.

The present species proves to be a true *Hymenochæte*, having the hymenium furnished with projecting acute setæ or cystidia.

Hymenochæte kalchbrenneri, Mass., Journ. Linn. Soc. (Bot.), xxvii, p. 116; Cooke, Austr. Fung., p. 190.

Resupinate, rather dingy brown throughout, submembranaceous, broadly effused, loosely adnate to the matrix, margin rather well defined, wavy; hymenium minutely velvety; spores elliptical, hyaline, 7 × 5 μ; setæ cylindrical or subclavate, often rough, 80–90 × 6–8 μ.

On dead trunks. New Zealand. Victoria, Queensland.

There is sometimes a violet tinge on the hymenium. The entire plant is sometimes almost separable from the matrix.

Hymenochæte phæa, Mass., Mon. Thel., Journ. Linn. Soc., xxvii, p. 98 (1891); Cooke, Austr. Fung., p. 188. Syn., *Stereum phæum*, Berk., Hdbk. N.Z. Flora, p. 612.

Pileus dimidiate, sessile, thin, coriaceous, flexible, zoned, velvety, bay, concentrically grooved, the grooves forming corresponding ridges on the rust-coloured minutely setulose hymenium, 6–10 cm. broad; setæ scattered, conico-acuminate, 30–50 × 6–7 μ; spores subglobose, 4 × 3 μ.

On bark and wood. Northern Island, New Zealand. Tasmania.

Laterally attached, usually by a broad base, concentrically grooved, blackish-umber when dry; strigose with alternating dark and pale zones, margin crisped; hymenium umber.

Hymenochæte mougeotii, Mass., Sacc., Syll. vi, no. 7449; Austr. Fung., p. 189.

Broadly spreading, forming conspicuous blood-red or dull-red thin patches, sometimes there is an indication of a tinge of purple; closely adnate, margin determinate, dry, very minutely velvety under a lens, cracking when old and dry; cystidia conical, coloured, 30–75 × 5–8 μ; spores elliptic-fusoid, olive, 6–7 × 3·5 μ.

On dead trunks of pine and other wood. New Zealand. Victoria, Tasmania, Ceylon, India, central Europe.

Distinguished by the bright colour of the hymenium. The patches are sometimes 20–30 cm. long.

54. Corticium, Fries.

Entirely resupinate, or rarely with the extreme margin free; hymenium smooth, waxy, polished, becoming variously cracked when dry; spores colourless.

Corticium, Fries, Epicr., p. 556.

Forming resupinate inseparable patches on wood, bark, &c.

* *Hymenium dingy flesh-colour.*

Corticium nudum, Fries, Epicr., p. 564; Sacc., Syll. vi, no. 7609; Austr. Fung., p. 194.

Often forming thin patches 3–7 cm. long, waxy, margin determinate, glabrous; hymenium flesh-colour, becoming pale, cracked when dry, minutely pulverulent under a lens; spores elliptical, 12–13 × 4 μ.

On dead bark. New Zealand. Queensland, South Africa, Europe.

Distinguished by the pale-flesh-coloured minutely pulverulent hymenium.

Corticium polygonium, Fries, Hym. Eur., p. 655; Berk., Hdbk. N.Z. Flora, p. 613; Sacc., Syll. vi, no. 7611.

Closely adnate, inseparable, outline sharp, extreme margin byssoid, soon becoming hard and rigid, 5–10 cm. broad; hymenium dingy flesh-colour, primrose, usually much cracked or nodulose; spores narrowly elliptical, 14–16 × 5–7 μ.

On dead bark and wood. Northern Island, New Zealand. Europe, United States.

Usually extending under the form of small, distinct, *Tubercularia*-like pustules, which eventually usually become confluent, thick, separating from each other more or less when dry; giving the patch a cracked or tesellated appearance; sometimes continuous, and then the surface is more or less tuberculose; margin thin, adnate, byssoid; hymenium primrose, pinkish, black, or dingy-ochraceous.

** *Hymenium white at first, sometimes becoming pale-tan or pale-rose colour.*

Corticium auberianum, Montag., Crypt. Cuba, p. 372; Sacc., Syll. vi, no. 7552; Austr. Fung., p. 194.

Closely adnate, at first orbicular, several patches soon becoming confluent or growing into each other and forming broadly extended patches, 5–10 cm. long and broad, very thin, at first snow-white and minutely primrose, finally glabrous and tinged with dingy-yellow or grey, finely crooked when dry; margin persistently minutely floccose or fibrillose; spores elliptical, 6–7 × 4 μ.

On bark, &c. New Zealand. Australia, Patagonia, Cuba, United States.

Readily distinguished by the hymenium, which is snow-white and primrose when young. When the fungus is old it sometimes partly peels away from the matrix.

Corticium albidum, Mass. Syn., *Aleurodiscus albidus*, Mass., Grev., xvii, p. 55; Cooke, Austr. Fung., p. 193, fig. 83.

At first concave, rather fleshy, white, outside and margin tomentose, at first incurved then becoming extended and flattened, up to 6 mm. diameter, often confluent and forming rather large patches; hymenium white, minute mealy, cracking slightly when dry; spores elliptical, 10–12 × 9 μ.

On branches. Northern Island, New Zealand. Queensland.

This species was at first incorrectly determined as *Aleurodiscus oakesii.* The last-named is not known to occur in New Zealand.

Corticium scutellare, Berk. and Curt., Grev., ii, p. 4; Brit. Fung. Fl., i, p. 121; Sacc., Syll. vi, no. 7647.

Broadly effused, thin, quite inseparable from the matrix, margin indistinct, whitish, then dirty pale-tan-colour or tawny, waxy, smooth, very much cracked into polygonal portions, interstices white, silky; spores elliptical, $5 \times 3\ \mu$.

On wood, dead herbaceous stems, &c. Recognised by the brownish areolately cracked hymenium, and small spores.

Corticium leve, Pers., Disp., p. 30; Sacc., Syll. vi, no. 7530; Cooke, Austr. Fung., p. 194; Fl. N.Z., ii, p. 184; Hdbk. N.Z. Flora, p. 613.

Forming very thin patches from 5–10 cm. in diameter; hymenium smooth and with a more or less polished appearance, old-ivory colour often suffused with a flesh-colour or rosy tinge, becoming cracked when dry, the interstices silky, margin byssoid; spores elliptical, often slightly curved, $10–12 \times 6–7\ \mu$.

On dead wood and bark. Northern Island, New Zealand. Victoria, Queensland, Tasmania, Ceylon, Europe, North and South America.

Some forms of this species closely resemble, superficially, *Peniophora rosea*, but can at once be recognised under the microscope, or even under a pocket-lens, by the absence of projecting cystidia in the hymenium.

*** *Hymenium tinged green.*

Corticium viride, Berk., Fl. N.Z., ii, p. 184; Hdbk. N.Z. Flora, p. 613.

Olive-green, crustaceous, effused, cracked; margin very thin, membranous, scarcely byssoid, livid; spores large, elliptic or subglobose.

On dead bark and wood. Northern Island, New Zealand.

Effused, forming small confluent patches of a yellow olivaceous green, with a very thin, membranous, scarcely byssoid, livid margin; hymenium cracked; spores subglobose or elliptic, very large $\frac{1}{1750}$ in. long (= about $14\ \mu$). Analogous to *Hydnum viride.* When old it acquires a darker tinge. There is no specimen of this species at Kew.

Corticium terreum, Berk., Fl. N.Z., ii, p. 184. *C. terreum*, Hdbk. N.Z. Flora, p. 613.

Examination of the type specimen at Kew shows this to be an immature specimen of some *Thelephora*.

55. Stereum, Pers.

Pileus with a central stem, or dimidiate and imbricated ; pileus silky or strigose ; hymenium smooth ; spores colourless (rarely tinged with colour).

Stereum, Persoon, Obs. Myc., p. 35.

The leading features of the present genus are the smooth or glabrous hymenium, and the velvety or strigose pileus. Some species are destructive wound-parasites, attacking forest trees.

* *Pileus supported on a central stem.*

Stereum sowerbeii, Berk., Fl. N.Z., ii, p. 182 ; Hdbk. N.Z. Flora, p. 612 ; Mass., Brit. Fung. Fl., i, p. 129. Syn., *Elvella pannosa*, Sowerby, Fung., tab. 155.

White ; pileus funnel-shaped 2–2·5 cm. across, rough with projecting points, but not velvety, margin variously incised ; stem up to 1 cm. long, central ; spores elliptical, 5×3 μ, hyaline.

On the ground. Northern Island, New Zealand. Tasmania, Australia, Britain, United States.

A very beautiful species, snow-white, tinged with pale-buff when old, and of a waxy appearance when fresh ; sometimes with a distinct round stem $\frac{1}{2}$ in. or more in height, at others several plants grow close together, having their stems more or less confluent at the base. It has no relationship with *Cladoderris*, as suggested by Fries in Sum. Veg. Scand., p. 332.

** *Pileus attached laterally.*

Stereum lobatum, Fries, Epicr., p. 547 ; Sacc., Syll. vi, no. 7311 ; Hdbk. N.Z. Flora, p. 612 ; Austr. Fung., p. 184 (all in part). Syn., *Stereum luteo-badium*, Fr. ; *Stereum boryanum*, Fr. ; *Stereum ostrea*, Nees ; *Stereum sprucei*, Berk. ; *Stereum perlatum*, Berk.

Sessile, often imbricated or running on horizontally, pilei sessile sometimes fan-shaped and fixed by the narrow portion, horizontal, margin entire or variously lobed, thin, rigid, upper sterile surface tomentose or minutely velvety, orange or brownish, with darker concentric bands of colour, becoming glabrous towards the margin ; hymenium usually bright ochraceous, sometimes duller, and verging on a greyish tint ; 8–15 cm. across ; spores subglobose, 5–6 μ diameter.

On trunks, fallen timber, &c. Middle and Northern Islands. New Zealand. Widely distributed, especially in tropical and subtropical countries both in the Old and New World.

A variable species both in size, colour, and amount of rugosity of the pileus, but readily distinguished by the thin rigid substance; velvety zoned pileus, and smooth ochraceous or greyish hymenium.

Stereum lobatum, Fries, Epicr., p. 547; Hdbk. N.Z. Flora, p. 612; Sacc., Syll. vi, no. 7311; Austr. Fung., p. 184. Syn., *Stereum perlatum*, Berk., in Hook. Journ. iv, 1842, p. 153; *Stereum sprucei*, Berk., Journ. Linn. Soc., x, p. 331; *Stereum luteo-badium*, Fr., Epicr., p. 547; *Stereum boryanum*, Fr., Epicr., p. 547; *Stereum ostrea*, Nees, Nov. Act. Nat. Cur., xiii, p. 13, pl. 2.

Pileus thin, rigid, umbonato-sessile, coriaceous, tomentose, usually ochraceous and often zoned with bay, margin almost glabrous, 10–40 cm. across; hymenium smooth, even, pallid; spores subglobose, 5–6 μ.

On dead wood. Northern and Middle Islands, New Zealand. Tasmania, Victoria, New South Wales, Queensland, New Guinea, Philippines, India, Ceylon, Bourbon, Malay Peninsula, Java, Malacca, Surinam, Seychelles, southern United States, Mexico, Cuba, Brazil, Venezuela, Madagascar, Peru, Mauritius

A widely distributed and variable species, distinguished by its large size, thin substance, and pale dull-yellow hymenium. The margin is often variously lobed.

Stereum cinereo-badium, Klotzsch, Nov. Act., 19, tab. v, fig. 3; Hook., Fl. N.Z., ii, p. 182; Sacc., Syll. vi, no. 7337

Pileus dimidiate, sessile, robust, coriaceous, tomentose, margined, chestnut-brown, zones smooth, black; hymenium smooth, glaucous, flesh-coloured.

On dead wood. Northern Island, New Zealand. South America.

An imperfectly known species. There is no specimen in the Kew Herbarium from New Zealand or elsewhere

*** *Entirely resupinate, or with the margin only more or less free.*

Stereum illudens, Berk., in Hook. Journ., iv, p. 59; Sacc., Syll. vi, no. 7329; Austr. Fung., p. 185

Effused on the matrix, the upper part free, horizontal, margin usually crisped and wavy, substance very thin, coriaceous, rigid when dry; upper surface of pileus coarsely velvety, brown, often with paler zones, radially plicate, 2–6 cm. long, 2–3 cm.

wide; hymenium even, smooth, rufous or brown; spores elliptical, 6–7 × 4 μ.

On dead logs, branches, &c. New Zealand. Tasmania, Victoria, New South Wales, Queensland, Western and South Australia, Venezuela.

A characteristic Australasian species, distinguished by the dark, hairy, waved pileus and dark-coloured hymenium.

Stereum pannosum, Cooke, Grev., viii, p. 56.

Pileus coriaceous, becoming rigid when dry, effused, the upper portion free and reflexed, 3–6 cm. across, sterile surface dingy-grey, indistinctly zoned, hirsute; hymenium glabrous, dingy-grey, becoming primrose, cracked when dry; spores elliptical, 5–6 × 3–4 μ.

On dead bark. New Zealand. At present only known from New Zealand.

Effused, free margin often torn or split. Distinguished by the dingy-grey or dull-lead colouring of every part. *Stereum illudens* differs in brown tinge of every part, and *S. lugubre* in the blackish papillose hymenium.

Stereum lugubre, Cooke, Grev., xii, p. 85.

Coriaceous, rigid; pileus effused and reflexed, about 2·5 cm. deep, tomentose, zoned, cinereous, becoming pallid, zones darker; margin rather acute, pallid; hymenium somewhat papillose, smooth, naked, black.

On logs. New Zealand.

A very distinct species by its black obtusely papillate hymenium. Pileus about 1 in. deep, often densely imbricated and extending laterally several inches. There is no specimen of this species present in the Kew Herbarium, hence I am unable to supplement Cooke's original diagnosis, reproduced above.

Stereum rugosum, Fries, Epicr., p. 552; Fl. N.Z., ii, p. 183; Hdbk. N.Z. Flora, p. 612; Sacc., Syll. vi, no. 7336; Cooke, Austr. Fung., p. 187.

Broadly effused, sometimes shortly reflexed, coriaceous, becoming thickish and rigid, sterile surface at length smooth, brownish; hymenium pale greyish-yellow, primrose, becoming red when cut or bruised; spores cylindrico-elliptical, straight, 11–12 × 4–5 μ.

On bark and dead wood; sometimes growing on living trees and proving to be a very destructive parasite. Northern Island, New Zealand. Victoria, New South Wales, Western Australia, Europe, North and South America.

Very variable in form, wholly adnate, partly reflexed, or sometimes almost saucer-shaped and attached by a central point when young. Agrees with *Stereum sanguinolentum* in becoming red when bruised, but distinguished by the thicker rigid substance and in the larger straight spores. The hymenium is sometimes pale-yellow, at others greyish or livid

Stereum vellereum, Berk., in Hook. Fl. N.Z., p. 183; Hdbk. N.Z. Flora, p. 612; Cooke, Austr. Fung., p. 184; Sacc., Syll. vi, no. 7367.

Resupinate with the margin free, or fan-shaped, attached by a narrow base, and imbricated, thin, 2–5 cm. across, greyish, velvety, margin zoned and often lobed; hymenium ochraceous, even, glabrous; spores subglobose, 4–5 μ diameter.

On branches and twigs. Northern and Middle Islands, New Zealand. Victoria, Singapore, north-west Himalaya.

Usually growing on small branches, and then resembling *Hymenochæte tabacina* in habit, with broad, free, more or less lobed wings; substance thin; when growing on thick branches or logs, often imbricated and narrowed at the base. Resembling *Stereum hirsutum* in colour and habit, but thinner and with different spores.

Stereum hirsutum, Fries, Epicr., p. 549; Hdbk. N.Z. Flora, p. 612; Sacc., Syll. vi, no. 7288; Austr Fung., p. 185

Entirely resupinate, or more frequently with a free margin which is often more or less lobed or wavy; pileus coarsely strigose, 3–8 cm. broad, dingy-ochraceous, becoming pale and greyish, indistinctly zoned, thin and coriaceous; hymenium even, glabrous, naked, ochraceous or tan-colour; spores elliptical, 6 μ long.

On trunks and branches. Northern and Middle Islands, New Zealand. Tasmania, Victoria, Queensland, New South Wales, Western Australia, South Australia, Java, India, North and South America.

Very variable in form. When growing on a broad surface often wholly resupinate or with a very narrow free margin. On smaller branches there is often a broad, free, reflexed portion, or several such overlapping. Pileus coarsely velvety or strigose; hymenium usually bright ochraceous, often with varying shades of pink or grey.

Stereum ochroleucum, Fries, Hym. Eur., p. 639; Sacc., Syll. vi, no. 7283; Austr. Fung., p. 186. Syn., *Corticium ochroleucum*, Fries, Epicr., p. 557; Berk., Hdbk. N.Z. Flora, p. 613.

Coriaceous, thickish, separable from the matrix, sometimes entirely resupinate, at others more or less free round the margin, or almost entirely free and fixed by a broad effused base, flaccid, silky, dingy-ochraceous, 8–15 cm. broad; hymenium even, glabrous, pale-ochraceous, cracked when dry; spores broadly elliptical, $8 \times 6–7\ \mu$.

On dead wood and bark. Middle Island, New Zealand. Queensland, Tasmania, India, Europe, North America, Cuba, Venezuela.

Ochraceous, villose or strigose, often becoming bald when old; sometimes broadly effused and entirely adnate, in others the margin only free and upturned, in others again quite free and fixed by a narrow base. It is not unusual to meet with all transitions from entirely adnate to the flabelliform condition on the same trunk. Hymenium pale-ochre, smooth, cracked, especially when dry; the latter character separates it from *Stereum hirsutum*, and also from *Corticium*, which the adnate form resembles superficially.

Stereum latissimum, Berk., Fl. N.Z., ii, p. 183: Hdbk. N.Z. Flora, p. 613; Sacc., Syll. vi, no. 7419.

Forming broad, very thin, chalk-white patches, minutely subtomentose, margin abrupt.

On bark. Northern Island, New Zealand.

Forming patches many inches in length and breadth, very thin, following all the inequalities of the matrix, chalk-white; under the lens very minutely subtomentose; margin abrupt, by no means byssoid.

An imperfectly described species of which no type specimen is known to exist.

56. Lachnocladium, Lév.

Stipitate, much branched, branches narrow, one side tomentose and sterile, the other covered with the smooth hymenium; spores colourless.

Lachnocladium, Lév., in Orb. Dict., viii, p. 487.

Closely allied to *Stereum*, differing mainly in the much-divided pileus. Superficially resembling some species of much-branched *Clavaria*; differing in the tougher texture and in the hymenium being confined to one side of the branches.

Lachnocladium flagelliforme, Cooke, Austr. Fung., p. 179, fig. 79. Syn., *Clavaria flagelliformis*, Berk., Fl. N.Z., ii, p. 186; Hdbk. N.Z. Flora, p. 614; Sacc., Syll. vi, no. 8018.

Very much branched, divided to the base or nearly so, branches tufted, cylindrical, fastigiate, forked, tips acute and undivided ; spores hyaline, broadly elliptical, 5 × 3·5 μ. Entire fungus dingy-white or pale-brown, 4–5 cm. high.

On the ground, probably springing from buried twigs. Bay of Islands, Northern Island, New Zealand.

57. Craterellus, Fries.

Terrestrial. Plant altogether more or less funnel-shaped, hymenium covering the outside of the funnel, glabrous, smooth or rugulose.

Craterellus, Fries, Epicr., p. 531

Resembling superficially some species of *Cantharellus ;* the latter, however, are distinguished by the presence of narrow, thick, irregularly forked gills running down the outside of the pileus.

Craterellus insignis, Cooke, Grev., xix, p. 2 ; Sacc., Syll. ix, no. 880.

Erect, more or less tufted, sometimes grown together, 3–4 cm. long, about 2·5 cm. broad ; pileus fan-shaped, tan-colour, irregularly striate, margin lobed and wavy, flesh thin ; hymenium waxy, rugulose, darker than the pileus ; stem slender, expanding upwards into the pileus, tan-colour ; spores elliptical, tinged brown, 2·5–3 × 1·5 μ.

On dead trunks. New Zealand.

Resembling in general appearance some of the central-stemmed species of *Stereum,* but differing in the soft fleshy consistency

58. Cyphella, Fries.

Minute ; cup-shaped, mouth not contracted, often narrowed into a stem-like base ; hymenium internal ; outside velvety or downy.

Cyphella, Fries, Syst. Myc., ii, p. 201.

Minute, often clustered ; resembling in habit a small *Peziza.*

Cyphella densa, Berk., Fl. N.Z., ii, p. 184 ; Hdbk. N.Z. Flora, p. 614 ; Sacc., Syll. vi, no. 7837.

Gregarious, obliquely funnel-shaped, fawn-coloured, pendulous, attached by a short narrow stem-like base, very minutely pilose, flexible ; hymenium lining the inside of the funnel, smooth, even ; spores broadly elliptical, hyaline, 7 × 5 μ.

On living bark of *Corynocarpus.* Cape Kidnappers, Northern Island, New Zealand.

The pilei are obliquely funnel-shaped or more exactly resemble the head of any ordinary clay pipe, suspended by a very short stem. A very fine endemic species.

Cyphella filicicola, Berk. and Curt., Grev., ii, p. 5 (1873); Sacc., Syll. vi, no. 7898.

Scattered, sessile but attached by a narrowed base, more or less pendulous, obliquely funnel-shaped, often irregular in form, umber or brownish, externally minutely downy under a lens, 2–3 mm. long.

On dead fern-stems. New Zealand. Carolina, United States.

Shaped like the bowl of a smoking-pipe, and attached by a very short stem, or, rather, the narrowed base of the head of the pipe, the cavity pointing downwards.

Cyphella albo-violascens, Karst., Fung. Fenn. Exs., no. 715; Sacc., Syll. vi, no. 7817; Austr. Fung., p. 196.

Gregarious, sessile, 1–3 mm. diameter, globose and closed when young, then hemispherical, externally snow-white and densely downy; hymenium even, more or less tinged with violet; spores colourless, elliptical, usually slightly inæquilateral, $12–15 \times 8–9\ \mu$.

On wood, bark, twigs, &c. New Zealand. Australia, Cape of Good Hope, Europe, South America, United States.

Resembling a minute downy *Peziza*, for which it was mistaken by early authors. Often proliferous; hymenium and margin becoming blackish.

Clavarieæ.

An entire absence of differentiation into a sterile (pileus) and fertile (hymenium) surface respectively, and the even hymenium, are the characteristic features of the present group.

In the simpler forms the hymenophore is club-shaped, every portion of the club being fertile or covered with the hymenium. In other species the club becomes more or less divided, whereas in numerous species the fertile portion is broken up into numerous branches, the whole resembling a much-branched tree or coral in miniature.

The species are usually small, often brightly coloured, and with few exceptions grow on the ground. All the species are edible. Some of the minute species spring from sclerotia, and amongst these are parasites on various cultivated plants; but the injury caused by members of the *Clavarieæ* is practically a negligible quantity.

Analysis of the Genera.

59. Clavaria. Soft and fleshy, simple or much branched, branches terete, axils usually rounded.

60. Pistillaria. Minute, club-shaped, simple, rigid and horny when dry.

59. **Clavaria**, Fries.

Sporophore erect, club-shaped or fusiform, or variously and often excessively branched, axils of branches often rounded; spores colourless or coloured. Basidia two- or four-spored.

Clavaria, Fries, Syst. Myc., i, p. 465.

Usually terrestrial, rarely growing on wood. *Calocera* superficially resembles the branched species of *Clavaria*, but differs in the partly gelatinous consistency and different structure of the basidia. *Lachnocladium* differs in tough consistency and in the branches being flattened and having the hymenium on one side only.

* *Spores ochraceous or yellow.*

Clavaria flaccida, Fries, Syst. Myc., i, p. 471; Hdbk. N.Z. Flora, p. 615; Sacc., Syll. vi, no. 7972.

Slender, very much branched, entirely ochraceous, stem very short, branches crowded, repeatedly forked, upper axils rounded and the acute terminal branchlets converging; spores broadly elliptical, ochraceous, 4–5 × 3 μ.

On the ground in woods among moss, &c. Sometimes growing on masses of dead leaves, &c. Northern Island, New Zealand. Europe.

Varying from 2–5 cm. high; colour clear ochraceous without any tinge of brown; does not become green when bruised; terminal branchlets converging like callipers; mycelium whitish, creeping over leaves, &c.; stem sometimes 2 cm. long, at others almost obsolete.

Clavaria crispula, Fries, Syst. Myc., i, p. 470; Hdbk. N.Z. Flora, p. 615; Sacc., Syll. vi, no. 7991; Cooke, Austr. Fung., p. 201.

Pale yellow-brown or tan-colour, becoming ochraceous; stem rather slender, with downy rooting strands of mycelium, 4–7 cm. high; branches numerous, wavy, spreading, repeatedly dividing, terminal branchlets acute, spreading; spores pale-yellow, elliptical, 5 × 3 μ.

On the ground, at base of trunks, &c. Northern Island, New Zealand. Western Australia, Europe, United States, Brazil.

Stem thin; branches numerous, lax, rather wavy or flexuous.

** *Spores hyaline.*

Clavaria flava, Schæffer, Fung. Bavar., tab. 175; Sacc., Syll. vi, no. 7929; Cooke, Austr. Fung., p. 198. Syn., *Clavaria lutea*, Hook., Fl. N.Z., ii, p. 185; Hdbk. N.Z. Flora, p. 614.

Stem stout, short, white, breaking up into numerous rounded, tapering, crowded, even-topped, yellow branches, 8–14 cm. high ; spores elliptical, hyaline or with a slight tinge of yellow, 8–10 × 4–5 μ.

On the ground, in woods. New Zealand. Victoria, Queensland, Europe, United States.

Edible, as are all known species of *Clavaria*. Brittle ; stem often 2–3 cm. thick ; forming dense tufts of crowded branches ; yellow colour usually most pronounced at the tips of the branches.

Clavaria arborescens, Berk., Fl. N.Z., ii, p. 186 ; Hdbk. N.Z. Flora, 614 ; Sacc., Syll. vi, no. 8022.

Amethyst-colour ; stem slightly wavy, 2–3 cm. high, slightly thickened upwards, slender, dividing at the apex into a few main branches that bear short fastigiate branchlets at their tips ; spores hyaline, elliptical, 6 × 4 μ.

On the ground. Bay of Islands, Northern Island, New Zealand.

Berkeley considers this species as showing affinity with *Clavaria macropus*. To me it appears to resemble a slender form of *C. cinerea*.

Clavaria colensoi, Berk., Fl. N.Z., ii, p. 186 ; Hdbk. N.Z. Flora, p. 615 ; Sacc., Syll. vi, no. 8039 ; Cooke, Austr. Fung., p. 201.

Stem compressed, short, breaking up into several primary branches, which in turn become inflated at the apex and bear several slender secondary branchlets divided at the acute tips, 2–3 cm. high ; spores elliptical, 5 × 3 μ.

On dead wood and on the ground. Northern Island, New Zealand. Queensland.

All the branches have a tendency to become flattened, axils of branches rounded. The swollen apices of the branches are sometimes more or less excavated and the branchlets originate from the margin of the cup.

No account is given in the original description as to the colour of the plant. The following is Berkeley's description of this species : "About 1 in. high, attached to the soft decayed wood by a few short towy fibres, which, like the whole plant, are brown when dry. Stem mostly compressed, branched from the base or a little above it, repeatedly forked ; branches subfastigiate, delicate ; apices forked, very acute. Closely allied to *C. delicata*, but the brown fibres by which it is attached, and other points, forbid its association with that species, of which I have authentic specimens from Fries." (Fl. N.Z., ii, p. 186.)

Clavaria mucida, Pers., Comm., tab. 2, fig. 3; Sacc., Syll. vi, no. 8125; Cooke, Austr. Fung., p. 203.

Gregarious but not usually tufted, simple or sparingly branched, branches linear, tip sometimes cristate or divided into fine short branchlets, white or with a tinge of yellow or rose, surface even, 1-2 cm. high, slender; spores hyaline, averaging 6 × 3 μ.

On wet rotten wood. New Zealand. New South Wales, Europe, United States.

Clavaria contorta, Holmsk., Ot. i, p. 29.

Erumpent; in clusters of 2–5 specimens, simple, stuffed, variously twisted, contorted, and wrinkled, primrose, yellowish, often with a red or brown tinge, about 1 in. high; spores white, subglobose, about 4–5 μ diameter.

On fallen branches. New Zealand. Europe, United States.

Easily known by growing on wood, and in being erumpent, or bursting through the bark

Clavaria pusio, Berk., Fl. N.Z., ii, p. 185; Hdbk. N.Z. Flora, p. 614; Sacc., Syll. vi, no. 8017.

Stem slender, thickened upwards, where it divides into a few cylindrical acute branches equal in length to the stem and spreading at an acute angle, rarely divided, 1·5–3 cm. high; spores elliptical, hyaline.

On the ground. Northern Island, New Zealand.

The colour is brownish when dry, but it is probably paler or whitish when fresh.

Clavaria inæqualis, Flor. Dan., p. 74, fig. 4; Hdbk. N.Z. Flora, p. 615; Sacc., Syll. vi, no. 8069; Austr. Fung., p. 202.

Yellow, gregarious or fasciculate, fragile, stuffed, clavate, apex obtuse, simple or sometimes forked, 4–7 cm. high; spores elliptical, colourless, 9–10 × 5 μ.

Among grass and moss. Bay of Islands, Northern Island, New Zealand. Tasmania, New South Wales, Victoria, Europe, United States, Ceylon.

Scattered or in small loose tufts, clubs clavate or cylindrical; apex obtuse, sometimes forked or variously cut and divided, sometimes compressed, but not distinctly apiculate, and brown.

Clavaria misella, Berk. and Curt., Journ. Linn. Soc. (Bot.), x, p. 339; Sacc., Syll. vi, no. 8139.

Entirely white, simple or rarely with a single branch springing from near the base, slightly clavate, quite slender, 1–2 cm. high, base somewhat spongy; spores hyaline, subglobose, about 4 μ diameter.

Growing on living moss. Middle Island, New Zealand. Cuba.

Becoming opaque and remaining even when dry, which, in addition to the different spores, distinguish it from *Clavaria paupercula*, Berk. and Curt., a small species also growing on moss.

60. Pistillaria, Fries.

Minute, club-shaped, simple, becoming cartilaginous when dry.

Pistillaria, Fries, Hym. Eur., p. 686.

Very closely allied to *Clavaria*, if distinct as a genus. Differing mainly in minute size, and in becoming cartilaginous and rigid when dry.

Pistillaria ovata, Fries, Syst. Myc., i, p. 497 ; Hdbk. N.Z. Flora, p. 615 ; Sacc., Syll. vi, no. 8259.

Club obovate or ellipsoid, often more or less compressed, sometimes slightly lobed, white, hollow ; stem short, glabrous, pellucid ; entire plant 3–7 mm. high ; spores elliptical, 7–8 × 3·5 μ.

On dead leaves, herbaceous stems, &c. Northern Island, New Zealand. Europe.

Variable in size and form, but always minute ; distinguished by the short, polished, hyaline stem.

Tremellineæ.

The members of this group are characterized by the more or less gelatinous nature of the entire fungus when growing. During the process of drying the plant shrinks very much, and becomes hard and horny, expanding and becoming gelatinous again when soaked in water.

As representing the simplest structure presented by the *Basidiomycetes*, the basidia depart from what may be termed the normal or typical form in various genera. In *Dacryomyces* the basidium is cylindrical, with two much elongated and stout sterigmata at its apex. In this genus the spores are septate. In *Tremella* the basidium is stout and broadly clavate or obpyriform, with four stout sterigmata at its apex. When the sterigmata are just commencing growth the basidium, viewed from above, shows two apparent lines crossing at right angles, and the basidium has been spoken of as cruciate. This appearance is caused by the bases of the four incipient sterigmata. In the genera *Auricularia*, *Hirneola*, and *Septobasidium* the basidia are transversely septate, each cell bearing a single spore. This form of basidium agrees morphologically with the sporophores in the *Uredineæ*, with which, according to Brefeld, the *Basidiomycetes* are allied.

Analysis of the Genera.

* *Basidia subglobose, longitudinally quadripartite in a cruciate manner at maturity, and producing at the apex four elongated sterigmata.*

61. Exidia. Cup-shaped or variously lobed; spores sausage-shaped, curved; sterile surface minutely velvety.
62. Tremella. Brain-like or variously lobed and contorted; spores globose or ovoid.
63. Næmatelia. Firm, convex, with a central firm nucleus.

** *Basidia cylindrical or clavate, divided at the apex into two long sterigmata.*

64. Dacryomyces. Small, pulvinate, gyrose.
65. Guepinia. Irregularly cup-shaped or flabellate; hymenium on one surface only, the other sterile and silky.
66. Calocera. Erect, simple or branched, subcylindrical.

*** *Basidia elongated or fusoid, transversely septate, each cell producing one spore.*

67. Auricularia. Broadly attached, effuso-reflexed, upper surface sterile and strigose.
68. Hirneola. Cartilaginous, human-ear shaped, attached by a narrow point, sterile surface minutely velvety.
69. Septobasidium. Resupinate, not gelatinous but leathery.

61. **Exidia**, Fries.

Inflated, tremelloid, marginate or vaguely effused, often minutely papillose, black or dusky.

Exidia, Fries, Syst. Myc., ii, p. 224.

Forming irregular subgelatinous masses on dead wood and branches. The spores become 1–many septate on germination, each cell of the spore giving origin to a very short promycelium, bearing a cluster of strongly curved sporidiola.

Exidia albida, Bref., Unters. Mykol., vii., p. 94, pl. v, fig. 14; Sacc., Syll. vi. no. 8352; Austr. Fung., p. 207. Syn., *Tremella albida*, Huds.

Gelatinous, bursting through cracks in bark and wood, under the form of wavy or contorted heaps 1–3 cm. across; white at first, soon becoming dingy-yellow or brown; when mature primrose, with the dense mass of spores resting on the surface; spores oblong, slightly curved, 16–20 × 5–7 μ.

On dead branches, &c. New Zealand. Australia, Tasmania, Europe, United States.

Very soft and gelatinous, form irregularly lobed, soon deliquescing.

62. **Tremella**, Dill.

Gelatinous, tremelloid, immarginate, generally smooth (not papillose nor rugulose), variously lobed and contorted, often bright-coloured.

Tremella, Dill, Hist. Musc., p. 41.

Forming foliaceous variously contorted gelatinous masses oozing out of dead wood, branches, &c.; spores subglobose, continuous, on germination the germ-tube bears numerous broadly elliptical sporidiola. In some species dense racemes of conidia are produced in the substance of the gelatinous sporophore previous to or contemporaneous with the formation of basidiospores.

Tremella lutescens, Pers., Syn., p. 622; Sacc., Syll. vi, no. 8377; Cooke, Austr. Fung., p. 208.

Very soft and gelatinous, lobes crowded, entire, wavy, pallid then yellowish, 2–8 cm. diameter; spores subglobose, 12–16 μ diameter; conidia globose, 1·5–2 μ diameter.

On fallen and rotten trunks and branches. New Zealand. Victoria, New South Wales, Queensland, South Australia, Tasmania, South Africa, Europe, North America, Brazil.

The conidia are produced at the tips of densely corymbose branches buried in the gelatinous substance of the fungus.

63. Næmatelia, Fries.

Subgelatinous, convex, pallid, with a firm central white nucleus.

Nœmatella, Fries, Syst. Myc., ii, p. 227.

Readily distinguished by the presence of a firm, solid, white central nucleus, around which the subgelatinous sporiferous portion is spread, forming a convex body when extended. In some species the external gelatinous layer contracts and disappears when dry, the white nucleus alone being visible. The original structure, however, returns when the specimen is immersed in water.

Nœmatelia nucleata, Fries, Syst. Myc., ii, p. 227; Sacc., Syll. vi, no. 8450.

Sessile, depressed, gelatinous, more or less contorted, almost translucent, with a central, white, opaque, hard mass, 0·5–1 cm. across; spores broadly elliptical, hyaline, 7 μ long.

On damp rotten wood. New Zealand. Britain, southern United States.

Quite glairy and soft when moist; when dry the outermost gelatinous portion contracts, the white nucleus alone being visible.

64. Dacryomyces, Nees.

Gelatinous, homogeneous, more or less contorted, often bright-coloured; spores simple or septate.

Dacryomyces, Nees, Syst., p. 89.

Minute gelatinous fungi occurring on dead wood, often yellow or orange; spores cylindric-oblong, curved, often one or more septate at maturity or during germination, sometimes even becoming muriform. Chains of conidia resembling the basidiospores in form often occur in immense numbers in the substance of the fungus.

Dacryomyces deliquescens, Duby, Bot. Gall., p. 729 ; Sacc., Syll. vi, no. 8472 ; Cooke, Austr. Fung., p. 209.

Gelatinous, roundish or irregular and variously gyrose, yellow, almost translucent and subdeliquescent, basal portion root-like, emerging from the matrix, patches 1–4 mm. broad ; spores hyaline, cylindrical, obtuse, slightly curved, 3-septate, 15–17 × 6–7 μ.

On decaying wood. Northern Island, New Zealand. Tasmania, Europe, Siberia, United States.

Forming little gelatinous pale-yellow pustules on dead wood, often very abundant in rainy weather.

65. Guepinia, Fries.

Cartilaginous or subgelatinous, erect, substipitate, spathulate or expanded, one surface fertile, the other sterile and minutely velvety.

Guepinia, Fries, Elench., ii, p. 30.

Small, thin, and flexible; distinguished from others with similar basidia by the differentiation into a sterile and fertile surface respectively ; spores curved. Chains of conidia sometimes produced on the sterile side of the pileus.

Guepinia spathularia, Fries, Epicr., ii, p. 32 ; Fl. N.Z., ii, p. 185 ; Hdbk. N.Z. Flora, p. 614 ; Cooke, Austr. Fung., p. 210 ; Sacc., Syll. vi, no. 8520.

Cæspitose ; pileus erect, spathulate or irregularly flattened, thin, soft and tough, sterile side pale, pubescent, as is also the short rooting stem ; hymenium orange, wrinkled ; up to 5 cm. high, usually smaller ; spores elliptical, becoming septate, 10 × 6 μ.

On dead wood. Northern Island, New Zealand. Victoria, Queensland, New South Wales, Ceylon, Java, India, United States, Cuba, Brazil.

Very tough when growing, often springing out of cracks in wood, extending for some inches and growing more or less into each other, hence becoming very irregular in form. General form more or less battledore or fan shaped, with a stem 1–2 cm. long, especially when springing from cracks in the wood, a very common place of growth, and under such circumstances the plants are often closely crowded into rows following the crack for several inches. Altogether larger and differing from *G. pezizæformis* in the crowded habit.

Guepinia pezizæformis, Berk., in Hook. Journ., 1845, p. 60; Hdbk. N.Z. Flora, p. 614; Sacc., Syll. vi, no. 8518; Cooke, Austr. Fung., p. 210, fig. 96.

Bright orange-red, cartilaginous and elastic when moist, pileus obliquely saucer-shaped or almost flat, stem very short, minutely velvety, 3–4 mm. broad; hymenium slightly corrugated or wrinkled; spores elliptical, hyaline.

On dead wood. Bay of Islands, Northern Island, New Zealand. Tasmania, Queensland, Western Australia.

Usually more or less fan-shaped; rigid and contracted when dry. Growing solitary or scattered.

66. **Calocera**, Fries.

Cartilaginous, viscid, rigid and horny when dry, vertical, simple or branched; branches terete, often forked at the tips.

Calocera, Fries, Syst. Myc., i, p. 485.

Resembling the branched forms of *Clavaria* in habit and general appearance; differing in the cartilaginous structure and form of the basidia. Growing on wood. The spores are sausage-shaped and curved, becoming septate on germination and producing clusters of elliptical sporidiola.

Calocera viscosa, Fries., Syst. Myc., i, p. 486; Sacc., Syll. vi, no. 8147.

Irregularly branched, all branches of about uniform diameter, 2–3 mm., 3–7 cm. long, deep-orange, viscid, smooth and polished, very tough when growing, rigid and horny when dry, rooting base 3–5 cm. long, tough; spores cylindric-oblong, apiculate, slightly curved, $9–10 \times 4–5\ \mu$, hyaline.

On decaying stumps of pines, &c. New Zealand. Malacca, Europe, United States.

Superficially resembling a branched *Clavaria*, but differing in the tough consistency and different basidia.

Calocera stricta, Fries, Epicr., p. 581; Sacc., Syll. vi, no. 8163; Austr. Fung., p. 204.

Simple, solitary or gregarious but not crowded and confluent, linear, erect, apex subacute, 1–2 cm. high, 2 mm. thick, orange-yellow, tough when moist, rigid and remaining even when dry, orange or yellow, base with white down; spores elliptical, $7–8 \times 5–6\ \mu$.

On dead wood, especially of conifers. New Zealand. Victoria, Ceylon, Europe, United States, Cuba.

Distinguished from the closely allied *Calocera striata* in being firmer in structure, and hence not shrinking and becoming striate or wrinkled when dry.

Calocera furcata, Fries, Syst. Myc., i, p. 486 (1821); Sacc., Syll. vi, no. 8150.

Tufted, slender, 1–2 cm. long, often once or twice forked, yellow, viscid, branchlets acute, downy, and rooting at the base; spores hyaline, elliptic-oblong, slightly curved, 8–10 × 4–5 μ.

On rotten branches, &c. New Zealand. Europe.

Subgelatinous, slender, not becoming horny when dry, but adhering to the drying-paper. Stem simple, slightly pubescent, rooting, sometimes solitary.

Calocera cornea, Fries, Syst. Myc., i, p. 486; Sacc., Syll. vi, no. 8158; Austr. Fung., p. 204.

Clubs tufted, rooting, club-shaped, smooth, viscid, subulate, simple or rarely with a short branchlet, orange-yellow or sometimes pale-yellow, about 1 cm. high, 1–2 mm. thick; spores cylindric-oblong, 7–8 × 5 μ.

On naked wood. New Zealand. Australia, Europe, South America, United States.

Very rigid when dry. Frequently grows in rows, springing from cracks in dry hard wood.

67. Auricularia, Bull.

Effused or the upper portion reflexed; hymenium inferior, with raised ribs or folds, inflated and gelatinous when moist, collapsing when dry; sterile surface velvety or strigose.

Auricularia, Bull., Champ. Fr., p. 277.

Resembling species of *Stereum* in habit and appearance; differing in consistency and in structure of basidia. Spores oblong, curved, producing on germination a branched promycelium bearing several strongly curved sporidiola.

Auricularia mesenterica, Fries, Epicr., p. 555; Austr. Fung., p. 205; Sacc., Syll. vi, no. 8294.

Resupinate, upper margin free and reflexed, often very broadly effused, several specimens running into each other, subgelatinous and swollen when moist, rigid when dry, 3–10 cm. across; hymenium wrinkled and folded, smooth, brownish-purple; pileus coarsely velvety, zoned different colours, margin not deeply lobed; spores sausage-shaped, hyaline, smooth, continuous, slightly curved, 18–20 × 7 μ.

On trunks. New Zealand. Australia, Tasmania, Europe, South America, United States.

Often broadly effused and with numerous partly free imbricated pilei. Distinguished at sight from the species of *Hirneola* by the strigose zoned pileus.

68. Hirneola, Fries.

Substance thin, cartilagineo-gelatinous, soft and tremelloid when moist, rigid when dry; sporophore cup-shaped or human-ear shaped, fertile surface polished, sterile surface velvety.

Hirneola, Fries, Fung. Natal, p. 24.

Differs from *Auricularia*, its nearest ally, in not becoming bullately inflated when moist, the substance being no thicker when moist than when dry. Basidia rod-shaped or fusoid, transversely septate, each cell bearing a single sterigma which in turn bears an oblong curved spore.

Hirneola polytricha, Montag., Bel. Voy. Ind. Or., Crypt., p. 154; Austr. Fung., p. 206, fig. 90; Sacc., Syll. vi, no. 8311.

Hemispherical, then expanded, sessile but narrowed to a more or less central or oblique point of attachment, thin and elastic, rigid when dry; hymenium even, dark-brown with a purple tinge; externally even, minutely but densely velvety, greyish, becoming a rich yellowish-brown when dry; size variable, 4–12 cm. across; spores hyaline, colourless, smooth, sausage-shaped, slightly curved, 14–15 × 6–7 μ.

On trunks, branches, &c. New Zealand. Australia, Tasmania, Java, Ceylon, Tahiti, Madagascar, South Africa, South America, Cuba, Mexico, Chatham Islands, Lord Howe Island, Torres Straits.

Differs from *Hirneola auricula-judæ* in the absence of raised wrinkles on the pileus. A very widely distributed species, and one of the few fungi used on a large scale, and over a widely extended area, for food. Mr. T. Kirk gives the following account in the "Transactions and Proceedings of the New Zealand Institute," vol. xi, p. 454 (1878). "An Edible Fungus: *Hirneola polytricha* is collected and sent to China, where it is highly prized for food and medicine. In 1887 220 tons, valued at £11,318, were collected in New Zealand and exported."

Hirneola auricula-judæ, Berk., Outl., p. 289, pl. 18, fig. 7; Cooke, Austr. Hdbk., p. 206; Sacc., Syll. vi, no. 8312.

Hemispherical, then expanded and more or less resembling a human ear in shape, sessile, thin, soft and flexible when moist, rigid when dry, 3–8 cm. diameter; hymenium glabrous, uneven with anastomosing ridges and folds, dingy flesh-colour, then blackish or dark-brown; externally showing irregular wrinkles, minutely but densely tomentose, greyish-olive, often brownish when dry; spores smooth, hyaline, continuous, sausage-shaped, slightly bent, 20–25 × 7–9 μ.

On dead branches; in Europe most abundant on *Sambucus*.

New Zealand. Australia, Tasmania, Madagascar, South America, Cuba, Mexico, United States.

Distinguished from *H. polytricha* in having the pileus and hymenium wrinkled and veined. *Auricularia mesenterica* differs in the shaggy zoned pileus. Edible.

Hirneola hispidula, Berk., Exot. Fung., p. 396; Austr. Fung., p. 206; Sacc., Syll. vi, no. 8323.

Campanulate, then expanded, sessile, oblique, thin and flexible when moist, rigid when dry, 8–12 cm. across; hymenium dark-brown, even, or more or less veined; externally covered with a dense velvety pile, yellowish-brown or with an olive tinge, even or slightly veined; spores sausage-shaped and slightly bent, hyaline, continuous, smooth, 19–24 × 7–8 μ.

On dead wood. New Zealand. Australia, Mauritius, Ceylon, South America, Java, Hong Kong.

A large and fine species, somewhat variable in form and colour, sometimes narrowed at the point of attachment into a stem-like base. Hymenium sometimes with a purple tinge. Often growing in clusters of 2–6. Known more especially by the hairy pileus being almost hirsute, and the hairs longer than in other species.

69. Septobasidium, Pat.

Effused and resupinate, coriaceous, not moist or gelatinous; hymenium separating from the lower stratum; basidia transversely septate, curved, sterigmata borne on the convex side of the basidium; spores hyaline, continuous.

Septobasidium, Patouillard, Journ. de Bot., 1892, p. 63.

Superficially resembling *Thelephora*, but readily distinguished by the transversely septate basidia.

Septobasidium pedicellatum, Pat., Journ. de Bot., 1892, p. 63; Sacc., Syll. xi, no. 743. Syn., *Thelephora pedicellata*, Schweinitz, Syn. Carol., no. 108; Sacc., Syll. vi, no. 7188; Cooke, Austr. Fung., p. 180; Hdbk. N.Z. Flora, p. 611.

Resupinate; rather soft and elastic, densely fibrous, thick, basal layer composed of fascicles of hyphæ, tawny-cinnamon, margin whitish, radiating; hymenium paler, forming a thin separable pellicle which is often cracked irregularly; basidia curved, transversely septate, springing from a broadly pyriform basal cell; spores oblong, hyaline.

On branches of living and dead trees of various species. New Zealand. United States, Cuba, Brazil, Ceylon, India, Victoria, Queensland, Western Australia.

Forming effused patches often 8–12 cm. long, encircling branches; more or less felty and soft, hymenium often not developed. Very destructive when it attacks fruit-trees.

EXPLANATION OF PLATES I AND II.

PLATE I.

Fig. 1. *Tremella lutescens*, Fries; natural size.
Fig. 2. Basidia of same, in different stages of development; × 500.
Fig. 3. *Polyporus arcularius*, Fries; natural size.
Fig. 4. *Fomes australis*, Fries; a very small specimen; natural size.
Fig. 5. *Auricularia mesenterica*, Fries; natural size.
Fig. 6. Transversely septate basidium of No. 5; each cell of the basidium bears a single sterigma, with a sausage-shaped spore at its apex; × 400.

PLATE II.

Fig. 1. *Cyphella densa*, Berk.; natural size.
Fig. 2. Surface view and section of same; slightly ×.
Fig. 3. Spores of same; × 400.
Fig. 4. *Guepinia spathularia*, Fries; a group of plants; natural size.
Fig. 5. *Clavaria aborescens*, Berk.; natural size.
Fig. 6. *Pistillaria ovata*, Fries; natural size.
Fig. 7. *Poria hyalina*, Berk.; natural size.
Fig. 8. *Hirneola polytricha*, Mont.; natural size.
Fig. 9. *Craterella insignis*, Cooke; natural size.
Fig. 10. *Stereum illudens*, Berk.: natural size.
Fig. 11. Section of No. 10; natural size.

ART. II.—*Transpacific Longitudes.*

By OTTO KLOTZ, LL.D., F.R.A.S., Honorary Member, New Zealand Institute.

[*Read before the Wellington Philosophical Society, 5th April*, 1906.]

ON the 31st December, 1900, articles of contract were made by Her Majesty's Government, Canada, New South Wales, Victoria, New Zealand, and Queensland on the one part, and the Telegraph Construction and Maintenance Company on the other, for the construction and laying of the Pacific cable. The contract called for the completion of the whole cable on or before the 31st December, 1902. The cable was finished two months earlier, and, after undergoing the required test of a month, entered upon its commercial career on the 8th December, 1902. Thus was the project that had been advocated with persistence from some quarters for a quarter of a century an accomplished fact; the missing link of about eight thousand miles across the Pacific between Canada and Australia, in the world's metallic girdle, was now supplied.

Before laying a cable a survey is always made along the proposed route in order to select the most favourable ground, just as the railway engineer runs lines of levels before the final location of the railway. The cable engineer determines his levels by means of the sounding-line (piano wire), and at the same time obtains samples of the ocean-bed. It may be stated here that the direct route of the Pacific cable between the stations was departed from in order to avoid hills, craters, and hard or undesirable ground for the cable to rest upon.

From the survey the number of miles (nautical) required for the different sections was as follows: From Vancouver Island to Fanning Island, 3,654; from Fanning to Suva, Fiji, 2,181; from Suva to Norfolk Island, 1,019; from Norfolk to Southport, Queensland, 906; Norfolk to Doubtless Bay, New Zealand, 513.

The first section of the cable is about a thousand miles longer than any that had been laid before. This necessitated a considerable increase in copper for the conductor and in guttapercha for the dielectric. The working-speed of a submarine-telegraph cable depends on, and is inversely proportional to, the product of the total resistance of the conductor multiplied by the total electro-static capacity of the core, so that, other things being equal, the speed varies inversely as the square of the length of the cable. In the long section there were used 600 lb. of copper and 340 lb. of guttapercha per nautical mile; on the Suva–Fanning section 220 lb. of copper and 180 lb. of guttapercha; and on the remaining three sections the copper and dielectric were in equal proportions of 130 lb. each.

In the neighbourhood of Fiji, at a depth of 2,500 fathoms a temperature of 34·1° Fahr. was noted, being the lowest temperature taken during the survey. There is very little difference in the temperature of the ocean at great depths, say below 3,000 fathoms, over a great extent of the earth's surface, the temperature being only a few degrees above the freezing-point, or 32° Fahr.

The greatest depth, 3,070 fathoms (about three miles and a half), was found on the Fanning–Fiji section, where the bottom specimens consisted principally of radiolarian ooze. This ooze is found at the greatest depths, and was obtained by the "Challenger's" deepest sounding in 4,475 fathoms. The United States steamer "Nero" sounded in 5,269 fathoms (six miles), this being the deepest sounding recorded in the ocean, and the material brought from the bottom was radiolarian ooze.

Of the 597 samples of sea-bottom obtained on the Pacific-cable survey, 497 were such that they could be divided into distinct types of deposits. It was found that 294 samples referred to globigerina ooze, sixty-five to red clay, forty-three to radiolarian ooze, forty-five to coral mud or sand, twenty-seven to pteropod ooze, twelve to blue or green muds, and eleven to organic mud or clay.*

The pressure at a depth of 3,000 fathoms, in which a considerable portion of the Pacific cable is laid, is about 4 tons to the square inch. When the cable is being laid at such depths, it will be approximately twenty miles astern of the ship before it touches bottom.

Deep-sea cables last longer in the tropics than in the northern oceans. The reason is to be found in the fact that in the tropics marine life, from which globigerina ooze is derived, is more abundant than in the more northerly or southerly waters. It is the sun and the warmed surface-water that call into life these countless globigerina, which live for a short space, then die and fall to the bottom like dust, making such a good bed for the cable to rest in. In the arctic currents where the surface is cold the water does not teem with life in the same way as it does in the tropics, and consequently there is less deposit on the bottom of the ocean.

A submarine cable consists first of a core, which comprises the conductor, made of a strand of copper wires, or of a central heavy wire surrounded by copper strips as in the Pacific cable, and the insulating covering, generally made of guttapercha, occasionally of indiarubber, to prevent the escape of electricity. As far as cabling is concerned, this is really all that is necessary —an insulated conductor. This, however, would not, in the first place, be sufficiently heavy to lie in the ocean, and, secondly, would be too easily injured and destroyed by the many vicissitudes to which it would be subjected. For this reason a protection in the form of a sheathing of iron or steel wires surrounds the core, the nature, size, and weight of the sheathing being dependent upon the depth of the water and kind of ground over which it has to be laid. The deep-sea section, being the best-protected from all disturbing influences outside of displacement of the earth's crust by earthquakes or volcanic action, is naturally the one of the smallest dimensions ; and for the shore end, which is exposed to the action of the waves, to driftwood, to the grinding of ice in the more northerly latitudes, and to the danger of anchorage, especially of fishing-boats, the sheathing must be very heavy. So that, while the deep-sea cable is somewhat less than 1 in. in diameter, that for the shore end is nearly $2\frac{1}{2}$ in. in diameter. The action of the waves is limited to a depth of only about 13 fathoms, so that their influence on the cable, manifested by wear and chafing, is confined to the shore end.

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* Report of Sir John Murray.

The Pacific cable is equipped with the most modern apparatus at the various stations, and the cable is worked duplex—that is, messages are sent and received on the same cable at the same time.

Canada had carried longitude work from Greenwich across the Atlantic and thence to Vancouver. The completion of the British Pacific cable offered an opportunity for continuing the work across the Pacific in the interests of navigation and geography, besides tying for the first time longitudes brought eastward from Greenwich with those brought westward, making the first longitude girdle round the world.

In October, 1902, the Hon. Clifford Sifton, then Minister of the Interior, authorised the carrying-out of the transpacific longitudes, and the Governors of the South Seas, Australia, and New Zealand were respectively officially notified thereof. In preparing the programme for carrying out the work the climatic conditions of the various stations to be occupied were studied so that the most favourable times and seasons might be chosen. It was found that Suva, Fiji, was the governing factor, as it was by far the rainiest place of the series. The work was placed in my charge, and Mr. F. W. O. Werry, B.A., was associated with me as the other observer.

The instrumental outfit of the two observers was practically the same. Each observer was provided with a Cooke and Son astronomic portable transit, each of 3 in. clear aperture, the one of 34 in. the other of 36 in. focal length. Each transit was provided with reversing-apparatus. The transits of stars were observed over eleven threads in groups of three, five, and three respectively. The eye-piece attachment carried a micrometer (one revolution about a minute of arc with thread parallel to the transit threads) for latitude work; and the whole attachment was necessarily movable through 90°, so that the movable or micrometer thread becomes horizontal. The recording of transits was made, by means of a key, on a Fauth barrel chronograph. Each observer was provided with two sidereal box chronometers, one being a spare instrument in case of accident. There were, besides, dry cells, switchboards, and minor accessories to complete the outfit. I carried, too, a half-seconds pendulum apparatus and a Tesdorpf magnetic instrument, the latter similar to the ones furnished Drygalski, of the "Gauss," on his Antarctic expedition.

At each station—that is, at Fanning, Suva, Norfolk, Southport, and Doubtless Bay—a brick or cement pier was built, and an observing-hut covering the same. At Vancouver, which is used as a longitude reference point for the whole of British Columbia, we have a permanent transit-house.

Bamfield, on the west shore of Vancouver Island, is the eastern end of the Pacific cable, and was not occupied as an astronomic station, but simply as an exchange station—that is, for the comparison of the Fanning and Vancouver chronometers, to be described more fully later.

Longitude work consists in simply determining the accurate sidereal time for each of two places, the longitude of one of them being known, at an absolute instant, and then comparing such times: the difference between them will be the difference in longitude. The operation may be briefly stated: Each observer determines the error of his sidereal chronometer at a particular instant; then by means of the telegraph line or cable the two chronometers are compared, to be explained later; this comparison may be likened to an instantaneous photograph of both chronometers. Applying the respective chronometer corrections for the instant of comparison to the times thus shown by the two chronometers, we obtain the absolute local sidereal time for each place for the same instant; and, as before, the difference between these times is the difference of longitude.

Now, suppose we have a transit instrument with a single vertical thread, and that thread situate in the axis of collimation; furthermore, the axis of the telescope horizontal, no inequality nor ellipticity of pivots, and the pointing of the telescope truly in the meridian; then, if we record the transit of a star across the thread, and the time noted is free from personal equation, we obtain immediately the clock-corrections by comparing the observed time with the right ascension of the star for that time and day. The many conditions imposed in the last sentence show the many sources of error, the effect of which must be evaluated ere we obtain the desired quantity—the clock-correction; in other words, the true local sidereal time at a given instant.

We must therefore devise means for determining the instrumental errors, some of which are practically constant—inequality and ellipticity of pivots; while the others—level, azimuth, and collimation—are more or less variable from day to day. Careful readings, at the beginning and end of a season, of the former will evaluate them. For the latter we will speak of the level-corrections first. This quantity is determined directly by means of the striding-level placed upon the axis of the instrument. Readings should be taken as frequently as the intervals between stars admit. With sensitive levels, reading about a second of arc for divisions, great care must be exercised in allowing the level to come to rest. My own practice is not to take a reading until fully a minute has elapsed after placing the level, and as a light is necessary for reading at night, the reading should be taken quickly, for even a short exposure of the level to light will cause a change in the reading. I consider a six-minute interval between stars the minimum during which a deliberate reading (including reversal of level) for inclinations of the axis can be made. How to treat the various level-readings for one position of the instrument will depend upon circumstances. The readings may show a decided and unquestionable gradual change of level; in such a case the readings may be plotted and the level-reading for each star interpolated therefrom. If, on the other hand, the level-readings are confined within the errors of reading and small fluctuations, we may then take the mean of the various readings as the reading for that position of the instrument. The angular value of the level-reading expresses the angle between the vertical plane (in the case under consideration the meridian) and that described by the transit; the two great circles intersect each other in the horizon, where the level-correction is nil. The level factor, usually designated by B, is expressed by cos $(\phi-\delta)$ sec δ. This factor computed for each star, multiplied by the inclination of the axis, expressed in time, gives then the level-correction to be applied to the respective transits. Errors of level are measured directly, while those of azimuth and collimation with portable astronomic instruments are not directly measured, as is the case with the large transits in observatories. This leaves then the determination of three unknowns—the azimuth, collimation, and clock corrections; the minimum number of stars to determine which is three. With only three stars, however, there would be no measure of the accuracy of the observations, for one, and only one, value for each of the unknowns would satisfy the three observation equations; there would be no probable error. If the instrument is not in the meridian it is evident that the times of transit of stars north of the zenith will suffer a correction of opposite sign from those to the south. If the telescope is pointing west of north, north stars transit too late, and south stars too soon; and *vice versa* if pointing east of north. As polar stars move slowly they are well adapted for obtaining the azimuth-correction, and hence one polar star is included in each time set for each position of the instrument, and the general azimuth-factor is sin $(\phi-\delta)$ sec δ.

With the collimation-error, however, the correction for north and south stars is of the same sign for one position of the instrument; but when the instrument is reversed, then the error is of opposite sign, and the transits of stars are similarly affected. The effect of the collimation-error becomes therefore more apparent and is more accurately deduced when some stars are observed in one position of the transit, and others with the telescope or axis reversed.

The effect of the collimation-error on the times of transit varies directly as the secant of the declination of the star, hence the collimation factor is sec δ.

In order, therefore, to obtain a satisfactory time-determination—which is really the quantity sought—we observe more than the absolutely necessary three stars, and find the most probable value by the method of least squares.

In the programme of the transpacific longitudes it was arranged that (barring cloudy nights) on each night there should be two independent time-determinations; each determination to be derived from fourteen stars, divided into two groups of seven each, of which one was a polar. Furthermore, one group was observed clamp east, and the other clamp west. The six other stars of each group were "time" stars, and selected near the zenith and south (in the Northern Hemisphere) thereof. Instead of three we now have fourteen observation equations from which to deduce the three unknowns, already mentioned, by the usual method of forming the three normal equations. It is desirable to reduce the effect of azimuth and collimation on the derived clock-correction; we attain this by making the algebraic sum of the azimuth-factor as small as possible, and similarly with the algebraic sum of the collimation-factors.

In deducing the time-correction it evidently must signify the correction at some particular epoch, for every clock and chronometer has a rate. The epoch chosen is generally the mean of the various transits constituting a set, and the transit of each star is corrected for rate, as if all stars had been observed at that mean time. If, after having obtained the azimuth and collimation errors, we apply them with their respective factors to each transit and compare this corrected transit with the apparent right ascension corrected for aberration, we obtain the clock-correction of that transit or star, and the difference between this and the clock-correction of the normal equation gives us a residual. Each star thus furnishes a residual, and from them is found the probable error of a single observation as well as of the deduced clock-correction from all the stars. The average probable error of the latter is about 0·01 s. for good work.

A word about rate. Rate is one of the most difficult problems with which we have to deal in field longitude work. It is not the magnitude of the rate, although a small rate is very desirable, but the constancy: this is the crux. A chronometer may have an apparently constant daily rate, yet the hourly rate for the twenty-four hours may and does vary. Again, the rate is not the same when the current is on as when it is off; the former obtaining when observing and the latter the rest of the day. The rate deduced from two independent time-determinations of the same night, when the temperature is practically constant during the time of observation and the clock is in circuit with the battery (one cell) only during that time, is seldom, if ever, the same as that obtained from day-to-day observations.

In our programme we have two independent time-determinations for each night. Each set of transits is reduced to the epoch of the mean of the times of transit of the stars comprising that set. The rate which is applied for each transit to the mean epoch, and for which some magnitude must be assumed, is practically a vanishing quantity in the resulting clock-correction. The ideal time of exchange would be at that epoch when the effect of rate is eliminated. But, for various reasons, this is found to be impracticable. In the programme, then, of two independent time-determinations, for obvious reasons the exchange was arranged to take place about midway between the two epochs.

An interpolation between the two epochs gives the clock-correction at the instant required—that of the signals. This assumes that the rate is constant during the interval and is represented by a straight line. If extrapolation is necessary, as sometimes occurs, the rate-value has less weight. It is highly desirable that the temperature of the chronometer be kept as uniform as possible, and, if necessary, special provision made to attain this end.

We are supposed now to have made a complete time-determination, and are ready for exchange of signals—that is, of a comparison between the two clocks of the two stations.

As some of the exchanges were over land lines, I shall explain this method of exchange first, taking the case of Vancouver and Bamfield. Each of these stations was supplied with a switchboard. The portable switchboard has been in use many years and has given every satisfaction. On it are mounted a talking relay, a signal relay, and a pony or clock relay; the last is never on any circuit but that of the chronometer with one dry cell. Besides, there is an ordinary talking-key and a signal-key, the latter breaking circuit when depressed while the ordinary telegraph-key makes circuit. Along one edge of the board there is a row of binding-posts for connecting with the clock, chronograph, main line, and batteries, of which there are three dry cells for the chronograph, and, as stated, one for the chronometer. And, lastly, there is a three-point switch, by means of which the main line can be thrown on or off the points of the clock relay, and plugs to cut in or off any relay. While observing, the chronograph-circuit passes over the points of the clock relay, and, as the clock or chronometer breaks circuit every two seconds (omitting the 58th second so as to identify the minute), the points of the clock relay separate every two seconds, and hence record the clock-beats on the chronograph. In the chronograph-circuit is the break-circuit observing-key too, by means of which the transit of each star over the eleven threads is recorded.

It is customary when beginning the exchange to put the telegraph-line for a minute at each station over the points of the clock relay, whereby the circuit of the main line is broken by each chronometer every two seconds—that is, we let the clocks (chronometers) record simultaneously over the line, each chronograph thus obtaining the record of both clocks. From this record we immediately see the relative position of the respective minutes—in fact, of the seconds too—enabling one readily to identify corresponding arbitrary signals, by means of which the more accurate chronometer-comparison is made. Theoretically, the comparison by the chronometers recording directly over the line, as above, is as good as by arbitrary signals. The trouble lies in scaling or measuring the former. As, for an interval of a minute, the relative position of the two-second breaks of the two chronometers is the same, after having measured one such interval on the chronograph sheet the mind is involuntarily biassed: we know that all the others should be the same, and, consequently, we cannot measure, say, thirty, our minimum number, with that freedom of mind which would be the case if we did not know what measure to expect: hence the device of the arbitrary signals. In this case each chronometer records only on its own chronograph. One observer now sends by means of the signal (break-circuit) key twenty arbitrary signals; the chronograph-circuit, which always passes over the points of the clock relay, is now made to pass too over the points of the signal relay, which is on the main-line circuit. Hence a signal sent will be recorded on each chronograph, and each chronograph has its own chronometer-record for interpreting any signal, just as it interprets the transits while observing.

As the word implies, these arbitrary signals are intentionally made irregular, and will average about two seconds apart. The other observer now sends, similarly, forty signals, and again the former twenty more, so that the mean of the times of sending of the two observers about coincides, thereby eliminating differential rate of the two chronometers. It is customary when sending signals to give a rattle with the key at the beginning and end of each set. If there is no trouble on the line the whole exchange is over in five minutes. A few minutes are required for conversation about the condition of the sky. If the prospects are hopeless for the night for one, the other desists from further observations. The accuracy with which these comparisons are made is far beyond the accuracy that is possible in a time-determination: while the probable error of the latter is, say, 0·01 s., that of the former is generally less than 0·002 s.

The exchange on the cable is similar to that just described of arbitrary signals. The chronograph here is replaced by the paper fillet of the cable service. It is scarcely necessary to observe that nowadays signals (messages) on the cable are not read by means of deflections of a small mirror, interpreted on an opal glass scale by means of a reflected beam of light, but are read from the fillet of paper on which a siphon records in ink the deflections. As the current is very weak the siphon is not in direct contact with the paper, but, by an ingenious vibrating device, it deposits a tiny drop of ink at very brief intervals. A cable message looks like a profile of the Rocky Mountains, the ups and downs having an interpretation like the dots and dashes in the Morse system of telegraphy. From experience it is found impracticable to have the clock recording directly on the cable for interpreting signals sent or received. However, it is necessary to have a time-measuring scale on the fillet. We accomplish this by attaching another siphon to the frame of the cable instrument. This one is quite independent of the cable. It is actuated by a long vertical rod attached to the horizontal arm of an ordinary sounder, and connected to the siphon by a silk fibre. This latter siphon drags an ink-line on the fillet. The sounder is put in circuit with the clock, and hence every time the clock or chronometer breaks circuit the sounder makes a sharp break in the line on the fillet, and a time-scale is obtained close to and parallel to the zero-line of the cable-siphon. By projecting vertically these recorded clock-breaks on to the cable-siphon record, we can interpret in time the arrival or departure of a signal. We must know, however, the relative position of the two siphons. The signals are sent with one of the two cable-keys (on cables there are always two keys, one for sending positive and the other for sending negative currents). To the lever of the cable is adjusted another lever which is in the clock-circuit. It is so adjusted that the moment the cable-key makes contact—that is, sends a current into the cable—at the same moment the clock-circuit is broken, thereby both siphons record the event simultaneously, and the parallax between the two siphons is obtained. As a check on the value thus obtained for the parallax, a slight tap is given to the frame carrying both siphons, thereby disturbing both, and the parallax obtained. By the above arrangement, when sending signals we have two records on the fillet, one by the clock-siphon, the other by the cable-siphon. In receiving signals there is, of course, only the record of the cable-siphon, the other siphon recording only the chronometer-beats, which, on the fillet, measure about 1 in. for the two seconds. The speed of the fillet may be varied to any degree. It will be seen that a comparison of clocks by this means is simply a matter of careful linear measurement. Were the records at the two stations instantaneous, then the two records would be identical; but such is not the case. Each signal arrives late at the distant station, and therefore the two records will differ by twice the time of transmission, assuming that the time of transmission is the same in each direction, an assumption which we cannot avoid. On the long section of the cable between Bamfield and Fanning, about four thousand two hundred statute miles, the time of transmission was a third of a second, equivalent to about twelve thousand statute miles per second.

In the first longitude-work by cable before the introduction of the recording-siphon, instead of arbitrary signals, the clock-beats were sent by hand at intervals generally of ten seconds, and the time of arrival of the signal, as indicated by the reflecting-galvanometer, was noted by the "eye and ear" method. The uncertainties and "personal equation" in this method of exchange and comparison of clocks are apparent.

We have now explained briefly how the clock-correction is obtained for a given instant, and how the comparison of the two clocks is made. The application of the clock-corrections respectively to the times of exchange gives apparently the local sidereal time for each place at the same instant. Each value is, however, affected by a small correction—the personal equation of each observer. As the quantity sought is the difference between the local sidereal times, the absolute personal equation of each observer is unimportant; it is the difference between the two personal equations that affects the difference of longitude. On land lines, where the ready means of transportation is good, it has been customary (up to the present, when, by the introduction of the registering-micrometer, the personal equation is eliminated) for the observers to exchange stations, the mean result of the two differences of longitude being free from personal equation: this is on the assumption that the personal equation of the observers remains constant during the longitude campaign. On this assumption, if there is a series of stations odd in number, and the observers occupy alternate stations, it will be seen that the odd-numbered stations will be free from personal equation, and the even-numbered ones affected by it. Now, between British Columbia and Australia, and also between British Columbia and New Zealand, the number of stations is odd—*i.e.*, there are three intermediate stations, Fanning, Suva, and

Norfolk; hence Southport (Queensland), Doubtless Bay (New Zealand) and Suva (Fiji) are free from personal equation.

Personal-equation observations were, however, made at Ottawa by the two observers using the same clock and determining its correction at the same time on the same stars with the two transit instruments, and the resulting difference of personal equation, 0·124 s., applied to Fanning and Norfolk.

Southport was connected with the observatories at Sydney and at Brisbane, and similarly Doubtless Bay with the observatory at Wellington. Personal-equation observations were made between the respective observers.

It was on the 29th September, 1903, that the first satisfactory clock exchange was had with Sydney, and so this night may be considered as the one when for the first time longitude from the west clasped hands with longitude from the east, and the first astronomic girdle of the world was completed. The immediate reasons for the first telegraphic connection in longitude between Australia and the prime meridian, Greenwich, were (1) with a view of confirming the position of the eastern boundary of the Colony (now State) of South Australia, 141° E.; (2) for obtaining the longitude of stations to be occupied for observing the transit of Venus in 1882. To attain this end connection was made astronomically between Sydney, Melbourne, Adelaide, Port Darwin, and Singapore. A connection was made, too, between Sydney and Wellington. All Australian and New Zealand longitudes at present rest on the position of Singapore as accepted in 1883, which then, quoting from the Government report for 1886 of South Australia, "had twice been telegraphically determined—first in 1871 by Dr. Oudeman, of Batavia, and Mr. Pogson, of Madras, and more recently by Commander Green, United States Hydrographic Department." The determinations of the latter were accepted. It may be remarked that at this time the Thomson (Lord Kelvin) recording-siphon had not yet been introduced, and that the clock exchanges between Port Darwin and Singapore over the cable were made by use of the deflecting mirror or reflecting galvanometer, already spoken of, a method involving more or less uncertainty in noting by "eye and ear" the movement of the mirror and the instant of time of its occurrence.

Singapore was dependent in position upon Madras, the initial meridian for the great trigonometrical survey of India.

For over a century observations have been taken from time to time to determine the longitude of Madras. The early ones, before the advent of cables and telegraphs, were dependent mostly on lunar observations, some on Jupiter's satellites. In 1891 the Survey of India had not adopted the then best value, so that at the International Geographic Congress held at Berne in that year the question arose, why the known error in longitude of 2′ 30″ was not corrected on the Indian maps and charts. This gave rise to a discussion in India, and the whole longitude work was reviewed, with the result that a determination *de novo* was decided upon, carrying the work directly from Greenwich *via* Potsdam, Teheran, Bushire, and Karachi, where connection was made with the three arcs of the great trigonometrical survey between Karachi and Madras. This work was carried out by Captain (now Major) S. G. Burrard, R.E., and Lieutenant Lenox Conyngham, R.E., in 1894–6. The resulting longitude of Madras was 5 h. 20 m. 59·137 s. ± 0·022 s.

In 1903 a redetermination of Greenwich–Potsdam was carried out by Professor Dr. Albrecht and Mr. Wanach. Stations were exchanged and observations made with a Repsold registering-micrometer. The exchange of stations was made to test the elimination of personal equation by means of the registering-micrometer, and the result was highly satisfactory, the weighted mean of the one result agreeing with the weighted mean of the other to the third place of decimal of a second of time. It may be stated here that the introduction of the registering-micrometer in longitude-work marks a distinct epoch in that class of work, not only in assuring greater accuracy in the results, but also in very materially reducing the cost of longitude-work of the first order by saving of time and money in doing away with the necessity of exchange of stations. Since the completion of the transpacific longitude-work, the two Cooke transits used in that campaign have been provided with the registering-micrometer made by Saegmueller, of Washington, and the longitude work of 1905 was carried out with that attachment.

From the 1903 determination by Albrecht we have for the longitude of Potsdam 0 h. 52 m. 16·051 s. ± 0·003 s. This value is 0·098 s. greater than that of Burrard obtained in the series of 1894–6 referred to above.

In the reduction (1885) of the Australian longitudes, the longitude of Madras was accepted as 5 h. 20 m. 59·42 s., and the derived value of Sydney was 10 h. 4 m. 49·54 s.

In making the comparison between the longitude of Sydney as brought from Greenwich eastward with that brought westward, the best and most recent available data are utilised for the longitude of Madras.

Taking, then, Albrecht's value for the arc Greenwich–Potsdam, and the values of Burrard for the arcs Potsdam–Madras, we obtain for the longitude of Madras 5 h. 20 m. 59·235 s. ± 0·021 s.

As there have been no new determinations of the various arcs from Madras to Sydney, the values given in the report of May, 1885, by Ellery, Todd, and Russell, on Australian longitude, are used. Adding the latter to the above-accepted value, we obtain for Sydney 10 h. 4 m. 49·355 s. ± 0·088 s. The Canadian value is 10 h. 4 m. 49·287 s. ± 0·058 s. Difference, 0·068 s. = 1·02″ = 84 ft. for the latitude of Sydney—that is, the first girdle of the world closed within 84 ft.

New Zealand.

The longitude of Wellington is discussed in the report of 8th August, 1884, of the Surveyor-General of New Zealand, and in Appendix No. 1 of that report Mr. C. W. Adams fully describes and tabulates the result of the determination for the difference of longitude between Sydney (Australia), and Wellington. The time-determinations of this series are of a high order, and deserve every confidence. At the time (1883) the siphon recorder had not been introduced on the cable, so that the clock-beats were sent by hand and the deflections of the reflecting-galvanometer were noted by eye. As Mr. Adams says in the above appendix, "I received them at Wellington by reflecting-galvanometer, but, instead of noting each signal by 'eye and ear,' I simply tapped the key and recorded each signal on my chronograph"—that is, as soon as the motion of the light-spot had impressed itself on the brain, the key was tapped to record the event. Although many trials were made for "the loss of time in receiving signals," and the results are inconsistent amongst themselves, yet the lack of self-recording cable-apparatus is the weak point in the 1883 determination for difference of longitude. The range for difference of longitude for the 1883 determinations is satisfactory, but of course may involve constant errors without affecting the range. As we shall presently see, the inter-agreement between the difference of longitude between Sydney and Wellington obtained in 1883, and that in 1903, when the siphon recorder was used, is remarkably close.

As Mr. T. King, observer at Wellington, has so fully given the evolution of "the longitude of the Colonial Observatory, Wellington," in the "Transactions of the New Zealand Institute," vol. xxxv, 1902, pp. 436–47, it is not necessary here to cover the same ground.

As has already been explained, the determination of the longitude of Southport (Australia) and Doubtless Bay (New Zealand) is free from personal equation, and, so far as the Canadian work is concerned, these two places are necessarily better determined than places dependent upon them. In other words, Doubtless Bay is better determined in longitude in the Canadian arcs than is Wellington; for Wellington to be as well determined as Doubtless Bay would mean perfect observations and perfect exchange of time-signals between the two places, which is of course impossible, no matter how good the work.

Upon my arrival in Wellington in November, 1903, I was very cordially received by Sir James Hector and Mr. T. King. Sir James, by the way, we Canadians claim as a kinsman, for we have not forgotten the very valuable work he did nearly half a century ago in the Rocky Mountains in connection with the Palliser expedition. The Hon. Mr. Richard J. Seddon, Premier, who had been officially notified of my coming, offered every facility for the successful issue of the work, and Sir Joseph Ward, Postmaster-General, kindly placed the telegraph-lines at my disposal. Mr. King and I discussed the work in hand—the connection of Doubtless Bay and Wellington. The star programme, the routine of observing and exchange of time-signals were followed as already explained. Mr. King in his time work always observes by "eye and ear," and this method he followed too in the longitude work, including the personal-equation observations, while I, as usual, recorded my observations on the chronograph.

The main consideration was the installation of electric apparatus to enable the exchange of time-signals between the two stations. After explaining to Mr. J. K. Logan, Superintendent of Government Telegraphs, what was required, the electrician, Mr. Buckley, and Mr. Chisholm installed the necessary batteries and relays at the observatory, a description of which, furnished me by Mr. Logan, follows later. A brief *résumé* of the apparatus at the Wellington Observatory may be given.

The observatory was established in 1869, and is used for time service only. It is situate on the summit of the hill within the old cemetery, and overlooks the city, harbour, and surrounding country. The building has two rooms—a clock-room and a transit-room.

Clocks.—In the former are three mean-time clocks, and one sidereal—Dent No. 39720—having electrical attachment making contact or circuit every second except the 60th in order to identify the minute. The clocks are all mounted on brick and cement bases, and are fastened to substantial braced frames.

Transit.—The transit is by Troughton and Simms, and is mounted on a rather high stone pillar. It has an aperture of $2\frac{3}{4}$ in., and a focal length of 32 in. The reticule has seven threads at equal equatorial intervals of about 17 seconds of time. There is a sensitive striding-level, and one oil-lamp for illuminating the field. The single small setting-circle reads to minutes, and the reversing of the telescope is done directly by hand.

Meridian Mark.—The meridian mark, placed thirty-five years ago, which also serves for testing collimation in the daytime, is a 3 in. iron bar set in cement, and shows well above the sky-line of the Tinakori Range to the north.

Chronograph.—The chronograph is of the Morse pattern and records on a tape. It is provided with two styles, side by side. The one records, embossing by make-circuit, the second-beats of the sidereal clock, while the other similarly records the signals by the transit-key, also the clock or arbitrary signals received (from Doubtless Bay) when making a comparison of the clocks for the determination of the difference of longitude. The transit and arbitrary signals on the tape are readily interpolated and expressed in time from the embossed dots or records indicating the seconds of the local sidereal clock.

Electric Apparatus.—Mr. J. K. Logan, Superintendent of Government Telegraphs, has furnished the following description and diagram of the arrangement especially installed at the Wellington Observatory for the differential longitude work with Doubtless Bay, as this was the first time that an automatic exchange of clock-signals had been made with the observatory. (The Wellington clock made contact (circuit) every second, while the chronometer at Doubtless Bay was arranged to "break" circuit.)

Two British Post Office polarised relays, the coils of each of which were joined in parallel, giving a resistance of 150 ohms for each relay, were connected in multiple through three Leclanché cells to the terminals of the clock. 120 Leclanché cells, with the copper earthed, were joined to one of the local terminals of one of these relays, and, by adjustment, the tongue of this relay was made to bear against the stop connected to that terminal. The terminal connected with the tongue was then joined to the copper terminal of a Siemens relay of 500 ohms resistance. The line was connected to the Z (zinc) terminal of the Siemens relay through a switch arranged to disconnect it from the time-recording instruments and connect it to the speaking (Morse) instruments when required. The local terminals of the second British Post Office polar relay were connected through eight Leclanché cells to the terminals of the magnet-coils of the back style of the chronograph. The local terminals of the Siemens relay were conducted through eight Leclanché cells to the terminals of the magnet-coils of the front style of the chronograph. At every make of the clock the tongue of the Post Office relay that was connected to the back style of coils made contact and caused the style to emboss, thus registering every clock-beat. The other Post Office relay at every beat of the clock broke contact at its tongue; the line-current was thus broken and a signal recorded at Doubtless Bay. As this line-current passed through the Siemens relay at the observatory, and while passing held the tongue of that relay open against the bias given to it, at every break of the current the tongue, by reason of that bias, moved across and closed the local circuit, thereby recording marks on the front style. When signals were to be received from Doubtless Bay, the observatory battery of 120 cells was cut off, battery being applied to the sending end. At every break of the current at Doubtless Bay the Siemens relay tongue moved to close the circuit and the breaks were recorded by the front style, marks being made at the same time by the observatory clock with the other style. Arbitraries were received from Doubtless Bay in the same way. When arbitraries were being sent from the observatory it was arranged, by means of a two-way switch, to cut off the clock from one Post Office relay—*i.e.*, the one the tongue of which was in the main-line circuit. This relay was then worked by the closing of a key, the line current being broken at the tongue of the relay in the same way as when the clock was operating the relay. This break was recorded at Doubtless Bay and also on the front style at Wellington by the movement of the tongue of the Siemens relay, at the same time the clock was recording on the back style. It is desired to indicate that for received signals the tongue of the Siemens relay had to move to close the circuit, and the front style then to move to mark the tape. The signals of the observatory clock had to cause the Post Office relay tongue to move to close the circuit, and the back style then to move to mark the tape. The record of the outgoing signals either from the clock or by arbitraries was got after the clock or the key had caused the Post Office polar relay tongue to break the circuit, which in turn caused the Siemens relay tongue to move to close the circuit of the front style, and which style had then to move to impress the tape. The line was 704 miles long, Wellington to Doubtless Bay, and was of 11½ copper throughout, 200 lb. to the mile."

No repeaters were used.

As it was impracticable for the observers to exchange stations it was decided to observe for personal equation at Wellington, and this was done.

I took train to New Plymouth, thence by steamer to Onehunga, and Auckland, and thence by the "Clansman"—the connecting-link between the world and Ultima Thule—to Doubtless Bay. Here, close to the cable-station, the pier and observatory were built. The foundation—a cubic yard—of the brick pier (22 in. by 27 in.) was in compact sand, and hence very satisfactory. The telegraph-line was led directly into the observatory and there connected with the switchboard. It may be remarked that another pier was built in another building where gravity observations were made with the Mendenhall half-seconds pendulum; magnetic observations were also taken.

A triangulation has been carried over the North Island by the Survey Department of New Zealand, and by instructions of the Surveyor-General, Mr. J. W. A. Marchant, the District Surveyor, Mr. V. J. Blake, made a connection of the triangulation from Station 20 on the west side of the entrance to Mangonui Harbour to the observatory, and by that means obtained the position of the observatory in terms of the New Zealand initial station and meridian. At Doubtless Bay the superintendent of the cable-station, Mr. C. L. Hertslet, rendered invaluable services both in the cable and land-line exchange of signals. His thorough knowledge of the circuits quickly overcame any difficulties or mishaps that arose.

Six independent determinations of difference of longitude between Doubtless Bay and Norfolk were obtained, and the same number between Doubtless Bay and Wellington.

We will now deduce the longitude of Doubtless Bay, giving the various transpacific arcs determined in 1903.

Stations.	Difference of Longitude.	Probable Error.	Longitude. Time.	Longitude. Probable Error.	Longitude. Arc.	Longitude. Probable Error.
	H. M. S.	S.	H. M. S.	S.	° ′ ″	″
Vancouver ..	..	..	8 12 28·368 W.	±0·050	123 7 5·520	±0·75
Vancouver – Fanning	2 25 5·406	±0·021	..	..	..	..
Fanning ..	..	..	10 37 33·774 W.	±0·054	159 23 26·610	±0·81
Fanning–Suva	1 28 43·837	±0·008	..	..	..	..
Suva ..	..	..	11 53 42·389 E.	±0·055	178 25 35·835	±0·82
Suva–Norfolk ..	0 42 1·243	±0·011	..	..	..	..
Norfolk ..	..	..	11 11 41·146	±0·055	167 55 17·190	±0·82
Norfolk – Doubtless Bay	0 22 15·000	±0·021	..	..	..	..
Doubtless Bay ..	..	..	11 33 56·146	±0·060	173 29 2·190	±0·90

The geographic position of Station 20 was furnished by Mr. Marchant, Surveyor-General.

We have then—

	°	′	″
Longitude, Station 20	173	31	37·1
Station 20 to Station A (by Mr. Blake)	0	2	24·1
Station A	173	29	13·0
Station A to observatory (by Mr. Blake)	0	0	3·66
Observatory	173	29	9·34

or, 11 h. 33 m. 56·623 s. The Canadian value is 11 h. 33 m. 56·146 s. Difference, 0·477 s., or 7·15″, or 595 ft. for the latitude of Doubtless Bay.

It may be remarked that the position of Station 20 is dependent upon the initial station, Mount Cook, at Wellington, through a chain of triangles about seven hundred miles long. From the roughness of the country it was expedient to carry on a network of triangulation for land survey and settlement purposes, and the refinements of a primary triangulation were not aimed at. In the closing for Wellington it will be found that the difference is 0·038 s., or 0·57″, and of the same sign as the above, making thereby the difference between the telegraphic determination, Wellington–Doubtless Bay, and the one obtained by triangulation 0·439 s., equivalent to 549 ft. at the latitude of the latter.

In the following table is given the deduction of each difference of longitude, Doubtless Bay–Wellington. Column 1 gives the date; column 2 the direction in which the arbitrary signals were sent; columns 3 and 4 the respective sidereal times at the two stations of the mean of the times of the signals sent; column 5 is the comparison of the scalings of the same signal—that is, each signal is measured on the two chronographs and expressed in time to the hundredth of a second of the respective clock; there would be at least thirty such signals, and each signal would show the "difference" between the two clocks at that instant, plus or minus the "transmission-time," according to the direction sent, westward or eastward; the "difference" given in column 5 is the mean of the thirty individual differences. If the two clocks had no rate, or the same rate, then the difference between the comparison of signals sent in the two directions would give twice the transmission-time; when, however, the clocks had different rates, we must introduce the correction "relative rate" of column 6 to one of the comparisons (the later one is taken to correspond to the sign of the rate) in order to make it comparable with the other. Column 7 has been explained. The difficulties encountered with rate have already been adverted to. They become very apparent when deducing the transmission-time, especially when that quantity is very small, as in the present instance. When we are dealing with transmission-time of a third of a second, as is the case between Fanning and Bamfield, one or two hundredths of a second variation affects but little the various transmission-times; but it is very different when the transmission-time falls near the limit of certainty of the rate. The relative rate of the 18th December was deduced as the others from the best available data, and the result shows a negative value of a hundredth of a second for transmission-time. This, however, does not affect the difference of longitude. Columns 8 and 9 give the deduced clock or chronometer corrections respectively at the two stations for the same instant, the mean of the times of the two exchanges. With the three data then—the difference between the two clocks at an absolute instant, and the respective clock-corrections for that instant—we obtain column 10, the difference of longitude, each with its respective probable error deduced from the probable error of the respective clock-corrections.

We have then the following values :—	H.	m.	s	s.
Dec. 6—Difference of longitude ..	0	5	9·231	0·027
,, 7 ,, ..	0	5	9·200	0·018
,, 11 ,, ..	0	5	9·225	0·032
,, 12 ,, ..	0	5	9·156	0·021
,, 17 ,, ..	0	5	9·210	0·032
,, 18 ,, ..	0	5	9·199	0·020
Weighted mean	0	5	9·198	0·007
Personal equation	0	0	0·257	0·045
Difference of longitude	0	5	8·941	0·045
Doubtless Bay longitude	11	33	56·146	0·060
Wellington longitude	11	39	5·087	0·075

Date.	Direction.	Sidereal Time Welling-ton.	Sidereal Time Doubtless Bay.	Difference.	Relative Rate.	Transmission Time.	Chronometer Correction Welling-ton.	Chronometer Correction Doubtless Bay.	Difference of Longitude.
1903.		H. m.	H. m.	H. m. s.	S.	S.	S.	M. s.	M. s.
Dec. 6	Wellington to Doubtless Bay	3 20·67	3 15·96	0 4 42·655	+0·347	0·019	..	..	..
	Doubtless Bay to Wellington	2 44·47	2 39·74	0 4 43·039	..	..	..	..	..
	Mean..	3 2·57	2 57·85	0 4 42·847	..	..	−5·189	−0 31·573	5 9·231
„ 7	Wellington to Doubtless Bay	3 27·24	3 22·77	0 4 28·059	+0·096	0·018	..	..	..
	Doubtless Bay to Wellington	3 16·17	3 11·70	0 4 28·191	..	..	..	..	..
	Mean..	3 21·70	3 17·23	0 4 28·125	..	..	−3·180	−0 44·255	5 9·200
„ 11	Wellington to Doubtless Bay	3 31·66	3 28·2	0 3 38·167	+0·076	0·026	..	..	..
	Doubtless Bay to Wellington	3 23·39	3 19·76	0 3 38·296	..	..	..	..	..
	Mean..	3 27·53	3 23·89	0 3 38·232	..	..	+1·119	−1 29·874	5 9·225
„ 12	Wellington to Doubtless Bay	3 41·72	3 38·32	0 3 24·142	..	..	..	..	..
	Doubtless Bay to Wellington	4 1·58	3 58·18	0 3 24·018	+0·171	0·024	..	..	..
	Mean..	3 51·65	3 48·25	0 3 24·080	..	..	+3·530	−1 41·546	5 9·156
„ 17	Wellington to Doubtless Bay	4 5·70	4 3·27	0 2 25·720	..	..	..	..	..
	Doubtless Bay to Wellington	4 26·16	4 23.73	0 2 25·659	+0·144	0·041	..	..	..
	Mean..	4 15·93	4 13·50	0 2 25·690	..	..	+3·702	−2 39·818	5 9·210
„ 18	Wellington to Doubtless Bay	3 52·85	3 50·61	0 2 14·365	+0·083	−0·010	..	..	..
	Doubtless Bay to Wellington	3 42·20	3 39·95	0 2 14·428	..	..	..	..	..
	Mean..	3 47·53	3 45.28	0 2 14·397	..	..	+4·582	−2 50·220	5 9·199

Based on the present value of Sydney, 10 h. 4 m. 49·54 s., and the 1883 value, Sydney–Wellington, 1 h. 34 m. 15·77 s., gives the longitude of Wellington (N.Z.I. report, 1902, p. 442) 11 h. 39 m. 5·31 s. This requires the correction of −0·185 s., the same as applied to Sydney for the adopted value of Madras, dependent upon the work of Professor Albrecht and Major Burrard. We have then for the value of Wellington *via* Madras–Sydney, 11 h. 39 m. 5·125 s.

The Canadian value is 11 h. 39 m. 5·087 s. Difference, 0·038 s., or 0·57″, or 43 ft.

We have at Wellington, then, another closing of the girdle of the world, as we had the first at Sydney.

The weakest link, yet good, in the longitude of Wellington is the personal equation of the two observers; all the other links are very strong. The observations therefor were made with the same (Wellington) instrument, as it was impracticable to build another pier and mount my Cooke transit there.

A final word in closing. Gratifying as the above closing-error is, it is questionable whether one would be justified at the present time, with our improved methods, in making a circuit of the globe in longitude, with the number of stations necessary therefor, in expecting *à priori* a closing-error of less than one-tenth of a second.

The task that Canada set out to perform, to bind Australia, New Zealand, and the Pacific islands to Canada by the "all-red line," thereby completing the first astronomic girdle of the world, has been successfully accomplished.

Art. III. — *Notes on the Flesh-eating Propensity of the Kea* (Nestor notabilis).

By W. B. Benham, Professor of Biology, University of Otago.

[*Read before the Otago Institute, 12th June, 1906.*]

Plate IV.

At a meeting of the Philosophical Institute of Wellington, last session, statements were made to the effect that the mutton-eating habit attributed to the kea (*Nestor notabilis*) was a myth: at any rate, this was the inference drawn from the reports of the meeting published in the New Zealand Press; and a paragraph founded on this report appeared in *Nature* for the 28th December, 1905.*

Since this alleged change of habit is of very great interest to biologists, and has received world-wide currency from the account given by Wallace in his "Darwinism" (p. 75), from which it has been copied into many books discussing evolution, it was very startling to be informed that the flesh-eating habit was non-existent in fact, and had only existed in the imagination of certain sheepowners and their shepherds. Biologists have for years been using this alleged change of habit as an illustration of the fact that variation in habit, as well as in structure, occurs in nature; and to be told now that the change of habit is quite mythical is extremely disconcerting.

But what evidence did those who deny the existence of the habit bring forward? And on what evidence is the allegation of the habit founded?

Although I am unable to answer the first question, this is of little consequence, since I am able to give the evidence of some of the many witnesses to the existence of the habit.

As a matter of fact my attention had been called to the subject in conversation with an Australian colleague during the meeting of the A.A.A.S. in Dunedin in 1904; and as a result of that conversation I proceeded to make inquiries of various people in the South Island who were reputed to have had experience of the attacks of the kea on their sheep. And although I made these inquiries to satisfy my own doubts, yet, in view of the importance of ascertaining and establishing the truth (or otherwise) of the matter, I have come to the conclusion to put on record the letters containing the personal

* Immediately on reading this I forwarded a brief note to *Nature* (12) summarising the facts of the present communication.

experience of a few persons living in Otago at the time the attacks were first noticed.

These letters were in answer to a series of questions which I put to my correspondents, and these answers entirely support the generally accepted opinion that in certain parts of the South Island certain keas have acquired the habit of attacking sheep and of devouring their flesh. These letters, in short, merely confirm the statements contained in Buller's "Birds of New Zealand," which were founded on the statement of men living in the same localities as some of these same folk to whom I have written. A good account of the matter has already been given by Mr. Huddlestone in 1891 (6).

The history of the matter is, briefly, as follows :—

In or about the year 1867 it was observed that on certain sheep-runs in Otago, in the neighbourhood of Lake Wanaka, sheep were wounded in a rather mysterious manner. It was noticed in the case of sheep killed for food that a healed wound occurred sometimes in the loin or sides ; when shearing, too, similar healed and even open wounds were found in or about the region of the loins ; also, when mustering, sheep were seen with more or less pronounced wounds, raw and bleeding, and even with entrails hanging out of large holes in the side of the abdomen.

It was on Mr. Henry Campbell's station at Lake Wanaka that the first efforts seem to have been made to trace the origin of these injuries, but similar facts had been noticed on other stations. Mr. Campbell gave instructions to his shepherds to keep a good look-out for the animal that caused the wounds :* so poisoned mutton-fat was laid out in suitable and likely places, and men were set to watch. It was found that keas were attracted and devoured the mutton more or less greedily, and were poisoned thereby ; and the suspicion that they were the enemy was soon turned to certainty by the observation of Mr. James MacDonald, at that time (1868) head shepherd, and now a sheep-farmer at Dipton in Southland.† He saw a kea

* It was by some supposed to be a disease. It has even been suggested that the damage attributed to the kea has, in part at least, been caused by gulls (*Larus dominicanus*). These birds are known to peck at the eyes of lambs, but I am not aware whether they have ever been detected eating sheep or attacking them while alive.

† Mr. John Campbell writes that he believes he was the first to detect the true cause—he states that this was in 1870 ; but as MacDonald had already reported the occurrence in 1868, there seems either a confusion of dates or Mr. Campbell's memory has played him false as to his being the discoverer, for he states, "The kea was not suspected of attacking sheep in any way in 1868, and not for two years afterwards." But MacDonald's name is referred to by two or three of my correspondents as being the first to discover the cause of the wounds.

at work on the back of a sheep. I will quote from his letter to me:—

"I do not know whether I was the first to see the kea attack sheep, but I was the first to report it to Mr. Henry Campbell of Wanaka Station. . . . .

"In 1868 my orders were to go all over the run after the snowfall and see that the sheep were evenly [distributed] over the ground, that no hill or spur had more sheep on it than it could well carry. While I was at this work, the snow [being] about 2 ft. deep, I went out to the tops: in a small basin under the top, on the west side, facing a rocky country that we called 'skay,' there was a mob of sheep snowed in and unable to get out. There I saw the kea at work. He would come down from the rocks, settle on a sheep's loin, and peck into the sheep, which would run through the mob; but [the bird] stuck to the sheep all the time till he got a piece out of the sheep, then he would fly to the rocks. I watched the bird at this work and did not disturb him till I was fully satisfied. . . . . Then I went down to the station and reported to Mr. Campbell. He could not credit me, and all hands on the station [refused to] believe that the birds would do it; so I was ordered to go to another hill, called the Black Hill, and Mr. Campbell came with me, and some more men, and at the first mob we came to Mr. Campbell and the rest saw [the keas] at work with their own eyes."

The announcement, first published in the *Dunstan Times*, was received with incredulity and ridicule by Mr. H. Campbell's fellow-sheepowners. But not for long; soon other sufferers noticed the kea at work, and those who had laughed laughed no more.

So serious was the trouble that on Mr. H. Campbell's station men were engaged as "kea-shooters," one of whom—Mr. John King, of Pembroke—has been good enough to give me a good deal of information, and to send me the names of several of the gentlemen whose letters are printed below; and on their replies to my questions the present communication is founded.

There can be no doubt, it seems to me, that sheepowners have suffered very considerable loss from the attacks of keas; but whether the numbers of sheep killed by them as given by various persons are the correct ones or are exaggerated I have no means of ascertaining. Sir Walter Buller (13) gives instances, so that I need not repeat them. But it will be noticed that Mr. Dougald Bell believes that the kea kills 5 per cent. of the sheep in the region of Lake Hawea, and records the loss of twenty-five during last season. But, seeing that several people attribute their heavy financial losses to the kea, it seems improbable that the exaggeration would be very great. Surely we may credit these men, directly concerned as they were, with sufficient intelligence to investigate the facts with enough care to convince themselves that the losses were due to keas.

It has been suggested that it was in the interests of shepherds and so forth to exaggerate the loss, so that the bonus on kea-beaks might be kept high. I should imagine that 'cute men of business, and Scotchmen to boot, would scarcely be so befooled by their men.

The Kea seen at Work.

I have been asked by incredulous folk, "Has any one ever seen a kea at work on the sheep?" I was at one time unable to answer this question, till I investigated the subject, but thanks to my correspondents I am now in a position to say, Most certainly; on plenty of occasions have the birds been seen on the backs of sheep, and shot while at work pecking away at the wool and flesh. (See letters at end of this article.)

Several people—viz., Reischek(5), Fraser, Bell—have examined the crop of the bird and found wool and mutton therein.

I will quote from some of my correspondents' letters in answer to my questions :—

J. Campbell writes, "I was coming down the Matatapu when I saw a mob of sheep rushing about as if a dog was disturbing them. When I got nearer I saw a flock of birds hovering over the sheep. These were keas. I stopped and watched for a few minutes, and presently I saw a sheep singled out from the others and make towards some rocks with a kea planted on its back. By running under rocks and rubbing against them the sheep got the bird off its back; but the same [bird] or another was soon on again. This went on for some time till the sheep became exhausted."

A. Fraser writes, "I have seen the kea attacking the sheep and also eating into a sheep when the latter was stuck in deep snow. I have opened scores of keas' crops and found wool and meat therein."

J. H. King says, "I have often seen the birds at work on a sheep, and have shot them while on the sheep's back. I have seen a flock of twenty or thirty birds attack a mob of sheep in high precipitous country. The kea would harass them until one bird would suddenly alight on a sheep's back, holding on to the wool of the rump. The sheep so attacked would separate from the mob and rush frantically about: it would either go over a bluff or drop down from exhaustion.

The kea, which had still held on, was joined by several others, and they soon destroyed [? devoured]* the sheep."

Again, *Mr. Cameron* writes, "When 'snow-raking'—that is, taking sheep from high country—keas would gather round the sheep in great numbers, attack one or more quite close to us shepherds. A sheep would get frightened, run out of the flock with one or half a dozen [!] keas on its back, kill or wound it severely before they would let go."

The majority of my correspondents give a similar account of the facts, and several of them—Messrs. Bell, Cameron, King, McGregor, McKenzie—state that they have often seen keas on the sheep's back; and most of them give details as to occasions on which they have shot the birds while at work.

It must be borne in mind that some of my informants are and always have been managers, and so are less likely to have had the opportunity of witnessing the attacks than the shepherds; and, further, as Mr. Ford states, the attacks are frequently, if not usually, made during the night, and therefore, unless specially watched, their attacks are rarely witnessed. Nevertheless, all the men to whom I wrote have actually seen the bird at work. My correspondents are all, I believe, trustworthy witnesses, and I see no reason to doubt the truth and accuracy of their statements.

Area of Country affected.

The kea is confined to the South Island, and occurs only in the high mountainous parts—*i.e.*, along the Southern Alps and other high ranges. But it is not throughout this country that the kea has been a nuisance to sheepowners. In travelling through Marlborough or in North Canterbury my inquiries met with a negative reply—indeed, some of the men to whom I put the question scoffed at the idea of the bird doing serious damage to sheep. From further inquiries, however, I find that it has been known for some years that along the eastern flanks of the Alps in Mackenzie country, Canterbury down to Earnslaw, near Lake Wakatipu in Otago, various sheep-stations have suffered loss from the attacks of the bird. Thus, I have records from Mount Cook Station and Ben Ohau Station, in the first-named district; while the Wanaka, Hawea, and Wakatipu districts yield abundant evidence of the existence of carnivorous keas. And one of my correspondents (Mr. King) gives the Takitimo Mountains as the southern limit. Further, during the present year the farmers of Amuri County, in North

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* Throughout this article words or phrases in square brackets are interpretations or paraphrases of mine.

Canterbury, met in conference at Culverden and decided to petition the Government to increase the bonus on kea-beaks.

In the *Otago Daily Times* for the 16th February, 1906, we read that "the keas have been very numerous in the mountainous parts of Amuri County during the last two years. They have descended on the Amuri highlands from the mountains, and several landowners stated that the losses of sheep attributed to these birds had increased from about 7½ to 8 per cent. last year to 15 per cent. this year. Musterers brought reports of having seen sheep killed by keas," &c., &c.—a repetition of the course of events well known in Otago. While from the same newspaper for the 22nd March, 1906, one learns that on the West Coast, too, the kea is at work: "At Mahitahi, Bruce Bay, in South Westland, Mr. T. Condon lost last year 150 sheep, which he believed to have been killed by keas. He had seen the bird at work on the sheep. . . . . There has been no complaint of the birds attacking the settlers' flocks in the more northern sections of the Coast—as, for instance, round the Franz Josef Glacier."

But even within the limit of distribution of the kea many stations seem to be free from its attacks. Thus, Buller (13) quotes H. Campbell as stating that, in 1868, when he was suffering from the attacks at Wanaka, the keas were not attacking the sheep at another station owned by him, some thirty miles away, "at the same altitude (4,000 ft. to 5,000 ft.), in the same district, and where the birds are plentiful"; and my own inquiries quite bear out this evidence of the sporadic distribution of the habit.

Is every Kea carnivorous?

I put this question to my correspondents, and the replies render it impossible to give a definite answer: for whereas Messrs. Bell, Cameron, Ford, and Holmes believe that every kea in a district indulges in the habit—as "the old birds teach the younger directly they are fledged," writes Ford—there are some of my informants who take the opposite view, that "only the more daring birds" attack sheep (McGregor); that "the habit is peculiar to individual keas in a flock" (McKenzie); and this view is held by Mr. Green of the "Hermitage," Southern Alps; and I am inclined to share the latter opinion, for if every kea in the district were to become carnivorous the loss to sheep-owners would be much greater than it is.

There are many stations, as I have stated, in the area occupied by the kea whose owners have apparently no fault to find with the bird, and even in those districts where they are most troublesome it is probably only certain birds that are the victims of this craving for flesh. It is—as some of my correspondents put it—only the more daring and older birds that attack the sheep. Just as, in India, there are only certain tigers that, unprovoked, indulge in human flesh—the "maneaters"—so, amongst the keas, we must recognise certain "sheep-eaters," though whether their number is on the increase seems unascertained.

The Kea is still at Work.

It will be seen from the letters that the kea is still at work in, at any rate, certain districts, whereas in some of those stations at which they were formerly a pest the birds at present appear to be less addicted to the habit. This may be owing to the fact that on certain stations it is no longer profitable to keep sheep (see King's letter), or because possibly the "sheep-eaters" have migrated to other regions. At any rate, at Hawea, D. Bell "shot three keas attacking living sheep on the 12th January, 1906—shot one on the sheep's back. I shot eight keas during the term we were mustering in January, and their crops were full of mutton." And he says that "they kill sheep now as much as ever." Other evidence from Makarora is to the same effect: "The sheep still come in more or less wounded, and even with the entrails hanging out, and when killed for food, as many as one in four present healed wounds in the back" (Ford). But one thing seems certain, that the birds now go more thoroughly to work, and make a more complete "job" of it than in old days. Then the sheep were usually merely wounded. True, the wounds may have been serious, and some of the sheep died of their wounds. But nowadays the carcase is devoured, the bones are left picked clean. Mr. D. Bell sent me the arm-bones (humerus) of sheep from which the keas had actually extracted the marrow. In each of the four bones sent, a more or less triangular hole had been neatly made by the kea, just below the "head." (Plate IV.)

Mr. King writes, "One thing has been noticed lately by those who were among the sheep in high country—viz., that the keas when they kill a sheep now pick the carcase clean, leaving nothing but the skeleton, the skin almost turned inside out."

Mr. Bell also refers to this increase in the damage done to individual sheep. It has been suggested by Taylor White(8) that originally the bird merely sucked the blood, but that it soon discovered that the flesh itself is good to eat, and, as we learn, now recognises the "importance of being thoroughly in earnest" by devouring the entire carcase.

It will be remembered that Wallace states that the bird showed a marked preference for the "kidneys," and it is very popularly supposed that it makes a special effort to obtain these organs; but, as the majority of my correspondents point out, this is an error. It is a mere accident that the bird, in certain cases, makes its first attack in the region of the kidney, for it is on the rump that the bird finds it most convenient and safest to settle, and naturally pecks at one side or the other of the backbone, working through to the underlying kidney. But, as a matter of fact, the bird will commence the attack at that part of the sheep which is most prominent: if a sheep be lying on its side in a gully or elsewhere the kea commences at the side of the abdomen.

The eclecticism of the kea is in that exaggerated, as has already been pointed out years ago by Huddlestone and by Taylor White; but such a legend dies very hard indeed.

The Method of Attack.

The method of attack is varied. It may be (*a*) on the moving sheep; (*b*) on a fallen sheep; (*c*) on a snowed-up sheep.

Perhaps the best account of the first method is that contained in Mr. R. McKenzie's letter: "I have seen a kea attack and hang on to a living sheep. The bird flew on to a sheep's back, and commenced driving its beak through the wool into the flesh—not necessarily just over the kidney, as is supposed to be the custom. The frenzied sheep jumped and ran about in any direction for dear life, then, separating itself from the mob, made a direct line down a steep slope, and in its mad career finally dropped over a precipice, until which moment the bird held on with its claws, its wings slightly extended as if to steady itself or to be ready to fly off at any moment. The instant the victim left *terra firma* the bird relaxed its hold, but was observed to fly almost straight down as if bent on securing the sheep. Both were then lost to view."

Similar statements occur in other letters (Bell, Cameron, McGregor), and have been made to me by shepherds and others orally.

(*b*.) A sheep will sometimes, in coming down hill, roll over and perhaps lodge in a gully or elsewhere, and be unable to rise. The kea will then attack. I quote from a letter to the *Otago Witness*, November 22, 1905, written by Mr. J. A. Wraytt, of Garston: "When travelling along the bridle-track down the east side of Lake Wanaka I saw a sheep some 50 yards below, kneeling down with its head poked under a shelf of rock. There was a kea on its back, and about half a dozen sitting on the rocks close by. On going down to the spot I found the sheep, which was or had been a strong, fat one, with most of the wool stripped off its back and lying around in small tufts. There was a large hole through the sheep's loins, into which the kea kept diving and filling its mouth. The others had apparently had their fill, as their heads were drenched with blood."

(*c.*) Frequently when the sheep are snowed up, and weakened no doubt by want of food, they will fall victims to the birds. Thus Mr. E. Cameron writes, "A snowslide carried a sheep with it. I happened to be on the hill about the time it happened. It was all covered with snow but its nose and one hind leg, but still alive. The uncovered leg was eaten to the bone—not a scrap left on it—with half a dozen keas fighting over it."

The kea is known to be a very fearless bird, and we have a record in Mr. King's letter: "One man, who has had a good deal of experience in the high country, tells me that on one occasion, at Lake Ohau, in the Mackenzie country, he saw two keas attack a mob of sheep standing in the yards at the woolsheds of that station. Shearing was going on at the time, and this was seen by all the shearers present. The birds were shot."

The sheep do not necessarily die from the attack, for, as mentioned, the animals are frequently observed to present healed wounds when being shorn; and cases are known in which part of the intestine has been actually torn away, and the broken end has adhered to the edges of the hole in the body-wall, so as to form a new exit for the dung. Such a case is recorded in Buller's work, and one of my correspondents—Bell—states that he has met with two instances of it.

The sheep that are selected by the keas as victims are apparently always those in good condition, and with long wool, especially such as have missed a shearing; whereas a newly shorn sheep, or one in poor condition, is never attacked. One readily understands the choice of a well-covered sheep, as it affords a firm foothold for the bird.

Period of the Attacks.

The attacks are most frequent in the spring and winter—when presumably the natural food of the bird is scarce, or covered with snow—but by no means are they confined to these seasons. Further, it may be noted that the night-time is the period during which much of the damage is done, though the bird is not absolutely or entirely nocturnal.

Any one who has spent a few days in the region of the Southern Alps knows that the birds may frequently be seen during the day; and many people who have spent a night in the Ball Hut on the side of the Tasman Glacier will recall their noisy habits in the early morning, before the dawn.

The Normal Food.

The kea, like other parrots, is normally a vegetarian, though it includes insects in its diet. At any rate, so it appears from the few reliable statements that exist.

According to that accurate observer, the late Mr. Thomas H. Potts (1), the kea gathers "its subsistence from the nectar of hardy flowers, from the drupes and berries of dwarfed shrubs that contend with a rigorous climate and press upwards almost to the snow-line of our alpine giants. To these food-resources may be added insects found in the crevices of rocks, beneath the bark of trees," &c.

Mr. Potts also states (2) ("Out in the Open," quoted by Buller in "Birds of New Zealand," i, p. 168, footnote) that when the snow covers these subalpine shrubs, and insect-life is dormant, the kea is forced to go lower and lower down the mountains to take shelter in gullies, where it feeds on the hard, bitter seeds of the kowhai [*Sophora tetraptera*], small hard seeds in the fruit of *Pittosporum*, the black berries of *Aristotelia fruticosa* (the "native currant"), as well as on the fruit of the pitch-pine and the totara.

The most detailed bill of fare is that given by Huddlestone (6): it includes the grub of such insects as the weta (*Deinacrida*) and cicada, which are to be found in the ground. "Besides grubs, they fed on the berries of various alpine shrubs and trees, such as the snowberry, *Gaultheria*, *Coprosma*, *Panax* [= *Nothopanax*], the little black seed in a white skin of *Phyllocladus alpinus*, the *Pittosporum* with its hard seed in a glutinous mass like birdlime, and the red berry of the *Podocarpus* [*nivalis*], also on roots of various herbaceous plants—*Aciphylla squarrosa* and *A. Colensoi*, *Ranunculus lyallii*, celmisias, &c."

My own observation, while in the Southern Alps this year, adds to the list the orange berries of the low-growing heath *Leucopogon fraseri*. Two birds were feeding on these berries within two yards of where I was sitting: they eat the juicy part of the berry, putting out the skin and usually the "seed" also, which I found afterwards on the ground, though now and then I heard the bird crack the seed, so that occasionally, at any rate, it swallows this.

Both Potts and Huddlestone refer to it eating the "hard seeds" of *Pittosporum* and *Podocarpus*; but I wonder whether this is habitual; why should they neglect the juicy covering?

Mr. Cameron writes, "The food of the kea is berries, roots of spear-grass (*Aciphylla*) and cabbage-tree [*Cordyline*], and snow-grass [*Danthonia* sp.]".

Several of my correspondents note the fact that keas eat "roots," though they are not in agreement as to what the roots are. Mr. Taylor White (8) suggests—though on what evidence does not appear—that the bird feeds on "lichens which cover the rocks in high mountainous regions." This, it seems to me, would be a very innutritious diet, and it is little likely that, in the presence of a fairly abundant choice of juicy berries and other fruits, the bird would touch so poor a food. But it appears from his article that there were no berry-bearing subalpine shrubs in the locality he was acquainted with. Certainly around the "Hermitage," in the Mount Cook district, the subalpine scrub is abundant, and lichens would, one imagines, be the last resort of the bird.

Mr. McGregor writes, "I have watched a kea picking grubs out of a dead tree, and frequently noticed them picking into the earth for roots, with their beaks." But none of the above observers, or, so far as I can ascertain, any one else, seems to have examined the crops of any of the birds in an untroubled district —where, that is, the carnivorous habit has not shown itself— so that it is difficult to determine with absolute certainty the whole range of the normal diet of the bird.

THE ORIGIN OF THE CARNIVOROUS HABIT.

The above being its normal food, how has it come about that the bird has taken to eating mutton? Various suppositions have been put forward. One of these may at once be disposed of. It has been suggested that the kea mistook a sheep lying down for the plants termed by settlers the "vegetable sheep" (*Raoulia mammillaris* and *R. eximia*)! Thus Mr. (now Judge) F. R. Chapman wrote some years ago (7), "It is said that the keas tear them (the plants) up with their powerful beaks, and that these birds learnt to eat mutton through mistaking dead sheep for masses of *Raoulia*."

Now, as a matter of fact, these large species of *Raoulia* do not occur in the Wanaka district, nor on the Southern Alps in the neighbourhood of Mount Cook. None of my correspondents, all of whom know the country round Wanaka well, mention the plant as providing any sort of food for the kea. I think that Mr. Chapman must have been misled. Further, it is extremely doubtful (see later) whether the keas devour "dead" sheep—*i.e.*, such as are found lying on the hills, that may have died of "natural causes"—one, in short, that the birds have not killed themselves.

This "vegetable sheep" business is another myth that ought to be eliminated from the history of the habit.

There can be no doubt that the origin of the habit is traceable to the kea's natural curiosity: its bump of inquisitiveness is very highly developed, and it will investigate any unusual object—turning it over, pecking at it, and so forth.

It is very easy to imagine a kea coming across a fallen still-living sheep or one partially covered by snow, proceeding to pluck at the wool, and so coming down to the skin; then its beak would nibble at the flesh, and the bird would soon find that blood is a good sort of juice to swallow.

Or, as some have suggested (*e.g.*, Mr. McGregor), the bird inquired into the fresh skin of a sheep hanging on a fence, or was attracted by a carcase, newly killed, suspended from a gallows: either of these possibilities seems probable, though only one or two of my correspondents refer to this matter, in reply to my query. It does not seem certain, however, that a kea will feed on a sheep that has died from "natural causes" on the hills. Mr. T. White and several of my correspondents state that they have never seen them thus feeding. At the same time, one of my correspondents refers to the bird devouring the carcase of deer that have been shot and left on the hills; and Buller refers to a dead foal being similarly eaten; and it is also stated that the corpse of a man who fell over a precipice was found torn to pieces by keas. Reischek (5) made the ingenious suggestion that the birds acquired the habit from finding and feeding on maggots which had appeared on the carcase of a sheep which had died on the hills, and "having thus acquired a taste for fat, became emboldened to attack live sheep."

But these are all suppositions, and if it be true that the bird does not in fact touch a dead sheep, these suppositions cannot be true.

Whether the habit is related in any way, originally, to a scarcity of food does not seem at all clear; the answers are all rather vague, and there is a diversity of opinion on the matter. Thus Mr. King writes, "I do not think that scarceness of the natural food had much to do with the attacks. I have been told that the kea attacks sheep in the West Coast in the low country close to the bush, where food would be plentiful." But that this scarcity has occurred is certain. The burning-off of the alpine scrub and the bush in gullies, as has occurred in many districts, would deprive the bird of its normal food during the whole year; while elsewhere, when the normal food is covered by snow in winter-time, the bird would be compelled to seek a new diet, or migrate, or die. The kea has met the problem by adopting the first of these three alternatives; and as, at the same time as the burning occurred, the sheep were introduced into the district, a new source of food was at once open to it. And the suggestion that the kea, on the disappearance, temporary or permanent, of its normal food, would proceed to investigate a fallen sheep, or one snowbound—weakened perhaps from cold or absence of food—seems quite in accordance with the bird's general habit of inquiry and its catholicity of diet.

The change of diet is not so abrupt as at first appears, since part of the bird's food consists of flesh in the form of insects, and possibly there is not a great amount of difference in taste between a good, fat, juicy weta or beetle grub and a piece of raw sheep, while the ease with which a whole flock of birds can obtain a full meal must be a distinct improvement upon the more wearisome task of digging in the earth and probing rotten logs for a small mouthful as a reward.

The observations of birds kept in captivity are few, and not entirely in agreement. Dr. DeLautour (as quoted by Buller from the *Field*) noted that his bird—which was the first living specimen to be exhibited in the Zoological Gardens in London—ate only the flesh and would not touch the fat, preferred mutton to beef, and was not averse to pork. Reischek states that a kea he had in captivity preferred meat to vegetables.

I had a caged kea under observation for a week, through the kindness of Mr. Harry Buckland of Waikouaiti. We fed it normally on various vegetables, such as carrots and parsnips, and on fruits, such as apples and bananas, all of which it seemed to like. We tried it with mutton flesh and fat, and so long as we watched it the bird neglected the meat, though it ate it during the night. On two occasions we presented it with a saucer containing cut-up vegetables, mutton—lean, fat, and kidney. It went to work at once on the vegetables. On one occasion it did not eat the mutton so long as daylight lasted, but during the evening we found that it had devoured the flesh, later on the fat, and next morning the pieces of kidney had disappeared. On the second occasion—on which it had not been fed during the earlier part of the day—it again attacked the vegetables first, later the flesh, then the fat, and lastly, during the night, the kidney. Of course, this bird may not have developed a carnivorous habit before its capture, some three months previously, for, as I have pointed out, only some keas exhibit the taste for mutton. Moreover, it must not be supposed, I think, that even a bird that has once developed the habit eschews vegetable diet thereafter; it is likely that its diet will be a "mixed" one.

Nor is the kea alone in evincing a liking for flesh; its near ally the kaka (*Nestor meridionalis*), normally a honey and grub eater, has been observed to devour mutton. Travers (3) states that "They are fond of raw flesh, and I have seen them hovering in front of a sheep's pluck hung on a tree . . . . eating fragments which they tear off, giving preference to the lungs."

At the time that Wallace referred to this new food-habit of the kea it was the only case of the sort known. But a closely analogous instance has been described for an African starling, the "rhinoceros-bird" (*Buphaga*), which formerly fed upon ticks and insects infesting the skin of herbivora. But a few years ago the cattle-plague decimated the herds of wild and domestic cattle, antelopes, &c., and it is now found that the bird, thus deprived of its natural food, has become carnivorous. It pecks holes in the skin of healthy beasts, and even eats their ears off, causing wounds from which the animals frequently die—at any rate, causing considerable damage (9).

Correspondence and Inquiries.

I wrote letters containing a series of questions to some fifteen persons, whose names had been given to me by various people as likely to have first-hand acquaintance with the bird and its depredations. These fifteen persons are, or have been, actively engaged in connection with sheep-runs in the neighbourhood of Lakes Wanaka, Hawea, and Wakatipu, and elsewhere. I have received replies from ten, which replies are embodied in the present article.

To these ten gentlemen I am extremely obliged for the courtesy and readiness with which they gave me every information I asked for :—

Dougald Bell, now owner of Hawea Lake Station, has had thirty-three years' experience of sheep-farming in the district round Lakes Wakatipu, Hawea, and Wanaka. His first observation was in the Hunter Valley (Hawea) in 1874; his last, in 1906, at Lake Hawea.

Ewan Cameron, of Pembroke, was shepherding on the Crown Range in 1868; and has had experience of kea-attacks on the Matukituki, and Matatapu, and right branch of the Shotover.

John Campbell, now of Cromwell, at one time shepherd at Wanaka West.

William Ford, at one time shepherd on Mr. H. Campbell's station, has ever since been sheep-farming in the Wanaka district.

Alexander Fraser, now Stock Inspector in Nelson, was at one time sheep-farming in the Wanaka and Hawea districts (1871–83), and suffered severe losses of sheep from kea-attacks.

M. Stuart Holmes, now of Kakanui, has been sheep-farming since 1874, and was at one time manager of Lake Wanaka Station (1881–82).

John King, of Pembroke, was at one time engaged as "kea-shooter" on H. Campbell's station in the "seventies," and has had a long experience in that district.

James MacDonald, now a farmer at Dipton, Southland, at one time head shepherd on Henry Campbell's station at Wanaka.

Robert McGregor, of Hawea Flat, speaks of the attacks at Triplet Peaks, Lake Hawea, from 1877 to 1883.

Roderick McKenzie, now of Birchwood, Southland, was part owner in 1889 to 1891 of Hawea Lake Station.

In addition to these correspondents, I have received information of kea-attacks from Mr. James W. R. Green, now porter at the Hermitage Inn, Southern Alps. He had been employed as rabbiter at Mount Cook Station, and has shot keas while attacking sheep. And from some other sources I have obtained information.

In addition to answering a series of questions which I sent them, several of the above gentlemen wrote letters containing their personal experiences, which appear to be of sufficient interest to entitle them to be placed on record.

1. *Mr. Dougald Bell.*

"Hawea Lake Station, 20th February, 1906.

"In reply to yours of the 20th November *re* keas killing sheep . . . . I can safely say that they kill 5 per cent. of the flocks in all the country that is infested with keas. As a matter of fact, this season in my small flock [number not given] during the time we were mustering I personally counted twenty-five sheep killed by keas; I also shot three keas killing a live sheep. I shot one of them on the sheep's back, tearing away at the kidney-fat and meat. [The majority of my correspondents do not lay stress on this, and no doubt Mr. Bell merely means that the bird was tearing away at this region.] After I shot the keas, the sheep, a big, strong, half-bred wether, which was holed all along the back and ribs, managed to get up and walk away, but he would be sure to die, as he was too much holed and worried to live. I shot eight keas during the time we were mustering in January last, and they were all full of mutton in their stomachs [crops].

"There is another matter I should like to point out to you about keas: when they have eaten all the flesh off the bone, then they tackle the shoulder [*i.e.*, humerus] and leg bones, and take all the marrow out of the bone by chipping the bones with their beaks until they obtain an entrance. I am sending you four shoulder-bones, some old, and some fresh ones killed last winter. [One of these is here figured.]

"There is also another point: Two sheep came in during mustering at Hawea Lake—a ewe and a wether—which had been attacked by keas some time during the season. Each had holes in their backs, and the main gut had been cut through and pulled up through the backs; the gut had grown to the [skin of the] back and [a new anus had been formed] which caused a black streak down each flank where the droppings fell out. One of these cases happened in the year 1887 and the other in 1899. It was in the month of January that they mustered in each case, and brought into the station for shearing when [the above facts were] noticed.

"I have had thirty-three years' of experience with keas, and so know a little about them. I first came up here in 1873. When the keas first started to attack sheep they used to pull a tuft of wool off the back of the sheep over the kidneys for a while before killing [I presume he means that they merely tasted the flesh and left the sheep], but now it is very different, as nearly every sheep they tackle they kill outright.

"There is a lot of country in this locality that could be stocked with sheep if it were not for the keas: but it is not safe to put sheep on it, as the birds would kill half of them."

2. *Mr. Ewan Cameron.*

"Pembroke, 28th September, 1905.

"The first notice of keas killing sheep in Wanaka was in 1868 by James McDonald, head shepherd for Mr. Henry Campbell, owner of Wanaka Station at that time . . . . Mr. Campbell wrote a letter to the *Dunstan Times* describing the destruction that keas were causing among his sheep, with the result that all the people in that part of the country laughed at him.

"In that year I was shepherding in the Crown Range, and after reading Mr. Campbell's letter I saw at once what was killing my sheep. The place of attack is nearly always on the loin, behind the last rib; they [keas] tear down to the kidney, pull out the entrails, and sometimes leave the sheep without killing it. It is a common thing for sheep to come into the yards with their entrails hanging over the side; also with new wounds, or old ones healed up.

"[As an instance of the ferocity of the keas, I may mention that] One season, at the head of the Matukituki, I had four hundred sheep that did not come in at the proper time for shearing. I put them in a safe place after snowfall at the beginning of winter: when I went to shift them on the 1st September [I found that] the keas had killed two hundred of them: a good many were devoured, and some not touched but with the usual wound above the kidneys.

"Rose Bros. had a run on the Matatapu, a continuation of the same range I was on. They mustered their sheep (about three thousand) in the beginning of winter, left them in a large mountain paddock at night, and next morning found thirty-five killed.

"They [the keas] do most of the damage at night. On another occasion, on my own run, a snowslide carried a sheep with it. I happened to be on the hill about the time it happened, and saw the sheep still alive but covered with snow except its nose and one hind leg: the uncovered leg was eaten to the bone, not a scrap [of flesh] left on it, and half a dozen keas fighting over it."

3. *Mr. John Campbell.*

"Cromwell, 13th August, 1906.

"I have much pleasure in telling you what I know of this wonderful bird. I first saw the kea in the Wanaka Lake district in '68. . . . . I was shepherding at this time on what was then called 'Campbell Station' (Wanaka West), and often killed numbers of keas when out on the mountains towards nightfall. . . . . As regards their attacks on sheep, I think I was the first to see the kea on a sheep's back. The shearers often drew our attention to a scar on the sheep's back opposite the kidneys, and being on the same place on each sheep, some thought it was a disease (for some were found dead wounded in the same way). The kea was not at all suspected until some time afterwards.

"I was coming down the Matatapu (boundary between Wanaka and Wanaka West Stations)* when I saw a mob of sheep rushing about as if a dog was disturbing them. When I got nearer I saw a flock of birds hovering over the sheep. These were keas. I stopped and watched for a few minutes, and presently I saw a sheep get singled out from the others and make towards some rocks with a kea planted on its back. By running under rocks and rubbing against them the sheep got the bird off its back, but the same one or a fresh one was soon on again. This went on for some time till the sheep was exhausted. I

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* In a second letter he writes, "It was late in the year '70 when myself and mate, David Kinnard, were coming home from Glencoe to Glendhu on Wanaka Station. We saw sheep on the hill-top disturbed as by dogs. I went to the top, but Dave would not come up."

then went down and drove away the birds and examined the sheep, which had the wool and flesh torn by the birds in the same spot as that previously noticed by the shearers. This solved the mystery, and when I related the story to the station-manager and fellow-workers they were greatly surprised to learn that the kea was the culprit. . . . .

"I am convinced that the chief reason why the bird attacks the sheep in that particular spot is because it is the only place that it can perch for any length of time without the sheep putting it off." [He does not believe in the keas seeking after the kidney-fat.]

4. *Mr. Alexander Fraser.*

"Nelson, 2nd August, 1905.

"In reply to yours of the 22nd ultimo, I was engaged sheep-farming in the Hawea and Wanaka Lake district between 1871 and 1883. Suspicion arose in the first-named period that keas were attacking sheep, suggestion being that they learnt it from picking at sheep-skins and carcases hung on gallows. I lost some thousands of sheep from keas. I have seen the kea attacking the sheep, and also eating into a sheep when the latter was stuck in deep snow. I have opened scores of keas' crops and found wool and meat therein. I have laid poison in dead sheep in snow, gone back later and found dead keas; also have often poisoned keas with mutton suet [poisoned, I presume]. The natural food originally of the kea was berries, and grubs and insects it dug out of the ground. The burning of the alpine country probably diminished its natural food. They breed inside broken rock. Never found a nest. Keas are very numerous between the above dates, though shot and poisoned by the thousand."

5. *Mr. John King.*

"Pembroke, 22nd July, 1905.

[Part of this letter has already been quoted above, and many of the facts contained in it are incorporated in the general account. It continues :] "I have seen sheep snowed up on the ranges, and on one occasion I counted twelve dead out of about fifty, and numbers of keas sitting about on the rocks gorged, very much after the manner of vultures. On another occasion I was with Mr. Campbell and some of his shepherds who had a large mob of sheep in front of them taking them across some hilly country, when we noticed two keas hovering over the sheep. Presently one swooped down on a sheep not 30 yards from where we were. This sheep immediately left the others and rushed past me. I was carrying a gun at the time, and shot the bird on the sheep's back. I could recount many instances where I have seen the keas at work, but probably what I have written may suffice."

6. *Mr. R. McKenzie.*

"Birchwood, Southland, 23rd October, 1905.

[I have quoted portion of Mr. McKenzie's letter on page 78, describing one method of attack, as being a very clear account.]

"The habit of attacking sheep I firmly believe to be peculiar to individuals in a flock. I also believe the reputed slaughter by keas of hundreds or even scores of sheep in a single night to be gross exaggerations. On one occasion, during a snowstorm, when two or three hundred sheep had been hemmed in for a few days, I found three or four sheep killed and mostly eaten up by the birds. . . . .

"With regard to the bird digging in over the kidney, I believe this to be accidental rather than by design or instinct, for as the maddened sheep tries to escape by running away—always down-hill—the bird hangs on to the highest part (that is then the rump just over the kidney) of the sheep, and begins operations there."

LITERATURE.

(1.) Potts, 1871 : *Nature*, iv, 489.
(2.) Potts, "Out in the Open."
(3.) Travers, 1872 : Trans. N.Z. Inst., iv, 210.
(4.) Menzies, 1878 : Trans. N.Z. Inst., xi, 376.
(5.) Reischek, 1885 : Trans. N.Z. Inst., xviii, 98.
(6.) Huddlestone, 1891 : N.Z. Journ. Sci. (n.s.), 198.
(7.) Chapman, 1891 : N.Z. Journ. Sci. (n.s.), 203.
(8.) Taylor White, 1895 : Trans. N.Z. Inst., xxvii, 273.
(9.) Lankester, *Nature*, lxii, 366.
(10.) *Otago Daily Times*, March 22, 1906.
(11.) *Otago Daily Times*, Feb. 16, 1906.
(12.) Benham, 1906 : *Nature*, lxxiii, 559.
(13.) Buller, "History of New Zealand Birds," i.

EXPLANATION OF PLATE IV.

Outline of humerus of sheep which has been opened by a kea.—*a*, *a*. The surface of this bone has been picked away, exposing the cancellar structure. *b*. The cavity of the shaft exposed by the removal of a somewhat triangular piece of bone.

All the four humeri had been opened by the kea at this spot, in order, no doubt, to get at the marrow.

Art. IV.—*Notes on the Distribution of Ores in Horizontal Zones in Vertical Depth.*

By Professor James Park, M.A.Inst.M.E., M.Inst.M. and M., F.G.S., Director Otago University School of Mines.

[*Read before the Otago Institute, 8th August,* 1905.]

It has been clearly demonstrated by mining operations in the United States, England, and elsewhere that while in many veins the metallic sulphides are intimately mixed without any definite arrangement, in other veins, particularly those of lead, zinc, and iron, there is a more or less orderly distribution in horizontal zones in a vertical direction: that is, there are certain horizontal zones each of which is characterized by a dominant sulphide.

This arrangement of the metallic contents of a vein in more or less horizontal zones was noticed in Cornwall many years ago; and no better example could be found than that presented by the celebrated Dalcoath Mine, which commenced as a tin-mine, at a lower depth yielded nothing but copper, and again below that, tin.

In the great lead- and zinc-mining region of Ozark, in the lower Mississippi Valley, the vertical distribution of the ores, according to Bain,* is as follows :—

(1.) Oxidized zinc and lead ores, with galena.
(2.) Blende, with a little galena.
(3.) Iron-sulphide predominates, and increases with depth.

Spurr,† in his report on Monte Cristo mining district, in Washington, states that the quartz, pyrite, chalcopyrite, pyrrhotite, blende, galena, realgar, stibnite, and calcite show a marked tendency to aggregate themselves in horizontal zones in the order named above.

Rickard mentions the orderly distribution of ores in Colorado.‡ Weed states that in the Castle Mountain district, in Montana, the order appears to be galena on top, passing into highly zinciferous ores below, and these into low-grade pyrite.§

* H. F. Bain, U.S. Geol. Survey, Twenty-second Annual Report, Part II, p. 161.

† J. H. Spurr, *loc. cit.*, p. 841.

‡ J. A. Rickard, Trans. Inst. Min. and Met. London, Vol. vi, 1899, p. 196.

§ Weed and Pirsson, Bull. 139, U.S. Geol. Survey, 1896.

At the Broken Hill mines in New South Wales the general distribution of ores in vertical depth has been as follows :—

(*a*.) Oxidized ores of lead and silver.
(*b*.) Galena with blende.
(*c*.) Blende with galena.

Weed, in his paper on "Ore-deposition and Vein-enrichment by Ascending Hot Waters,"* appears to support the hypothesis which assumes that the distribution of ores in horizontal zones is the result of primary concentration by ascending hot solutions.

The eruption of igneous magmas is often succeeded by intense solfataric action, of which notable examples are found in the Yellowstone Park in the United States, and in the volcanic region of the North Island of New Zealand. The ascending waters slowly circulating in contact with the heated rocks below become superheated, and in their upward course dissolve various substances, which they carry with them along the line of least resistance—that is, towards the hot-spring pipe or vent. Many substances insoluble in normal conditions are rendered easily soluble in the presence of heat and pressure. The underground water will therefore possess its greatest solvent power where the greatest heat and pressure are attained, which will naturally be at the greatest depth. With loss of heat and pressure the less soluble substances held in solution will be precipitated—that is, those substances whose dissolution was effected under extreme heat and pressure. As the waters ascend they will continue to lose heat and be relieved of pressure, with the result that the dissolved minerals will be precipitated in the inverse order of their solubility. When the hot waters reach the surface the only substances in solution, in most cases, will be the extremely soluble alkaline sulphates, carbonates, and silicates. An obvious result of this process of vein-filling will be an impoverishment of the veins at great depths, due to the migration of the valuable minerals from below to the zones of precipitation above. It is a notorious fact that hot springs seldom deposit metallic sulphides at the surface. The great mushroom-capped veins of the Hauraki region and Great Barrier Island, in New Zealand, are composed of siliceous sinters, chalcedonic and crystalline quartz, manifestly the result of long-continued solfataric activity. The overhanging mushrooms of quartz are almost devoid of gold and metallic sulphides ; but the necks in all cases contain gold, and sulphides of silver and iron.

* W. H. Weed, Amer. Inst. Mining Eng., Vol. xxxiii, 1903.

Had denudation removed the mushroom caps, the sulphide-bearing necks would now be exposed at the surface.

The well-known Martha Lode, at Waihi, consists of chalcedonic and crystalline quartz, apparently the result of hydrothermal activity, which at one time probably manifested itself at the surface. There is no overhanging cap.

At the outcrop the quartz is almost pure silica, containing no sulphides excepting a trace of argentite associated with free gold containing about one-third its weight of silver. Above water-level the ore is clean, and free from oxidized products.

In many places both above and below water-level the joints in the veinstone are discoloured with films of manganese and iron oxides, which appear to owe their origin to the infiltration of meteoric water from the wall-rock, and not to the oxidation of contained sulphides.

Between the adit level and No. 1 level there began to appear small limonite-crusted cavities in the thin veins of crystalline quartz which traverse the main lode. At No. 1 level there are detached branches of iron-pyrites in the quartz, and at No. 2 level the sulphide ore forms a rib two or three feet thick.

The lode is being worked to a depth of 750 ft. below adit level; and although there has been an increase in the proportion of iron-pyrites, there has been no decrease in the gold and silver values.

A greater measure of denudation than the lode has already suffered would have exposed the sulphide ore at the surface.

In the study of vein-filling it is always well to bear in mind that veins which outcrop at the surface may have been truncated to a greater or less degree by denudation.

After their formation, some veins, through movement of the walls, have been brecciated and recemented by circulating mineralised waters. Such waters, ascending through the crushed vein-matter, would deposit their metallic contents as sulphides through the reaction of primary sulphides contained in the ore.

In this way a secondary concentration of sulphide ore may be effected by ascending waters. The common belief, however, is that secondary enrichment is in the majority of cases the result of the transference of material from the oxidized portions of a vein to a lower level through the agency of descending waters, from which the metallic contents are precipitated by the reducing action of organic matter or primary sulphides.

ART. V.—*Notes on the Formation of Zones of Secondary Enrichment in certain Metalliferous Lodes.*

By Professor JAMES PARK, M.A.Inst.M.E., M.Inst.M. and M. (Lond.), F.G.S., Director Otago University School of Mines.

[*Read before the Otago Institute, 8th August,* 1905.]

IT has been noted in many parts of the globe that masses of ore of exceptional richness often occur in the oxidized portion of the ore-body—commonly in that portion lying at the boundary of the oxidized and unaltered sulphides.

Microscopic investigation has proved that these rich masses are not of primary but of secondary origin. Their genesis is supposed to be due to the migration of the valuable contents of the upper part of the vein to, and their concentration in, the lower part of the oxidized zone.

In some cases the processes of dissolution, migration, and redisposition may have taken place over and over again, each cycle resulting in an increasing degree of concentration.

The veins in which secondary enrichment are most often seen are those of gold, silver, copper, lead, and zinc.

Gold-ores, in the zone of weathering, are often augmented in value by the long-continued disintegration of the vein and the enclosing rock, whereby the gold set free from its matrix is permitted to concentrate at the outcrop.

Extensive areas of the Australian Continent have been subject to subaerial denudation since the close of the Palæozoic period ; and it is doubtless due to this cause that so many notable examples of mechanical enrichment of gold-bearing veins have been found in Victoria and Western Australia.

The migration of gold, copper, silver, lead, and zinc from the upper to the lower parts of the veins is effected by descending surface waters in the zone of vadose circulation. The processes involved in the migration are chemical dissolution and electro-chemical deposition.

Chemical processes may operate in various ways to cause secondary enrichment, as follows :—

(*a*.) By the removal of worthless metals, thereby leaving the valuable contents in a purer form.

(*b*.) By removal of worthless metals, and their replacement by valuable metals removed from a higher part of the vein.

(*c.*) By deposition of valuable metals on primary sulphides in those portions of the vein subject to the influence of circulating surface waters. In this case the primary sulphides may form the nuclei for the deposit of the secondary sulphides.

Manifestly the first operation in the process of secondary enrichment is the chemical weathering and oxidation of the metallic contents of the vein.

The oxidation of base sulphides can be seen in operation every day. In a mass of mixed sulphides of iron, copper, zinc, and galena, the iron will be the first to be affected, from its affinity for oxygen. Iron-pyrites is decomposed and forms ferrous sulphate, which is changed into $Fe(OH)_3$, $Fe_2(SO_4)_3$, and H_2SO_4. The H_2SO_4 attacks fresh iron-sulphide and forms ferrous sulphate, liberating H_2S, which at once combines with free oxygen to form H_2SO_4. The ferrous sulphate changes to the ferric sulphate, which attacks gold and sulphides of copper, lead, zinc, and silver. The process of dissolution is necessarily slow, on account of the extreme dilution of the solutions.

For many years it was believed that the only secondary enrichment that could take place was the formation of rich bonanzas of carbonate ores and chloride of silver, in the zone above water-level. But careful investigation has shown that primary sulphides have been enriched by the deposition of secondary sulphides even in places below the present water-level.

It was proved experimentally by Skey* in 1870 and Liversidge† in 1893 that gold is more readily precipitated from its solutions by metallic sulphides than by organic matter. Furthermore, Skey showed that sulphides of the base metals were readily precipitated from their alkaline sulphide solutions in a solid coherent form in the presence of iron-pyrites, galena, blende, stibnite, &c.

The descending acid solutions formed in the zone of oxidation will attack the constituents of the rocks through which they percolate, producing alkaline silicates and sulphides.

Gold dissolved by ferric sulphate would be also carried down and deposited as leaf, scale, or wire gold in cracks in sulphide ore, thereby causing local enrichment.

It is maintained by some writers that secondary sulphides have been found below water-level. The evidence on this question is not quite conclusive. Changes of water-level may have taken place since the secondary sulphides were deposited.

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* Skey, Trans. N.Z. Inst., Vol. iii, 1879, p. 226.

† Liversidge, Proc. Roy. Soc. N.S.W., Vol. xxvii, 1893, p. 287.

The property possessed by silica, clay, and porous substances of absorbing metals from dilute aqueous solutions may be an important factor in the formation of zones of secondary enrichment in the oxidized portions of metalliferous lodes. In this we may have the explanation of the rich kaolin ores of silver at Broken Hill, of the concentration of gold in the talcose clays of the lode-formations of Kalgoorlie, and of the copper-bearing shales of Europe and America.

The researches of Emmons,* Weed,† and others have thrown much light on the secondary enrichment of vein deposits, and much still remains to be done before safe generalisations can be formed.

IMPOVERISHMENT OF VEINS IN DEPTH.

T. A. Rickard, when discussing Professor Posepny's paper on "The Genesis of Ore-deposits," states that the general non-persistence of ore in depth is a fact capable of proof.‡ He contends that since heat and pressure are the two factors which increase the solubility of mineral substances, the deep region will favour solution the most, while the shallow zone will favour precipitation owing to the decrease of heat and pressure.

There is much in favour of this contention, and many examples could be adduced in its support in all parts of the globe.

Moreover, progressive poverty in depth below a certain point must be the natural corollary of the general law governing the orderly distribution of ores in horizontal zones in vertical distance through the agency of ascending waters.

In some cases impoverishment in depth is determined by the prevailing geological conditions. Ore-veins which are confined to a single overlying formation often die out or become exhausted on reaching the underlying rock.

A notable example of this is afforded by the hydrothermal veins of the Thames, Tapu, Coromandel, and Kuaotunu mining districts in the Hauraki mining region of New Zealand, where the gold-bearing veins are contained in altered andesites which rest on a highly eroded surface of Lower Mesozoic slaty shales and sandstones.

Mining operations have in all cases shown that when the veins which occur near the borders of the andesite-flows reach the basement rock they die out completely, or end in small strings which soon disappear in depth.

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* S. J. Emmons, Trans. Am. Inst. M.E., Vol. xx, 1900.

† W. H. Weed, Bull. Geol. Soc. Am., Vol. xi, 1900, p. 179; and Trans. Am. Inst. M.E., Vol. xx, 1900, p. .

‡ T. A. Rickard, "Genesis of Ore-deposits": Discussion, p. 190.

The principle of secondary enrichment precludes the continuance of the enriched portion of the vein downward in vertical distance.

When the values of secondary enrichment are added to ore already of a payable quality, the result is a rich shoot or bonanza; but when, as often happens, the secondary values are added to lean ore, then the net result is to render the lean ore just profitable. Hence below the zone of enrichment the ore will be lean and unprofitable.

Absorption of Metals by Clays in relation to Secondary Enrichment.

It has been noted in many mines that the ore in the zone of secondary enrichment is commonly associated with, or contained in, a matrix consisting of clay or other finely divided mineral matter. Of this there are no better examples than the kaolin silver-ores of Broken Hill and the talcose gold-ores of Kalgoorlie.

Clays and clayey matter are the natural products of the alteration of rocks and ores in the zone of oxidation, hence their presence calls for no comment. But the frequent occurrence of rich ores in a clayey matrix in the zone of oxidation in certain lodes has led to much speculation as to the relation existing between the clay and its metallic contents.

It has been suggested by some writers that this association is not accidental, nor the result of paragenesis, but due to some quality of the clay. That clay and finely divided matter possess the property of absorbing or extracting metals from their aqueous solutions has long been known; and with this knowledge in mind it has been contended that the clayey matter acting as a porous filter in the lower part of the zone of oxidation has absorbed the metals from the descending solutions, thereby effecting a concentration of the valuable contents.

There is much to be said in favour of this view, but it has still to be determined whether clayey matter is a primary or merely a contributing cause in the formation of zones of secondary enrichment.

Walter Harvey Weed* early in 1905 described some experiments made by himself and others in the laboratory of the United States Geological Survey on the absorptive property of clays, &c. The results obtained confirmed the researches of W. Skey

* W. H. Weed, "Absorption in Ore-deposition," Engineering and Mining Journal, Feb. 23, 1905.

in 1869, and of E. Kohler* in 1903, who found that clays and porous substances such as gelatinous silica, carbonaceous and colloidal matter, possess the power of extracting metals from their dilute aqueous solutions. As the subject is one having an important bearing on the concentration of metals in the zone of oxidation, and perhaps also in bed-impregnation and vein-filling, it may be of interest to notice more fully the experiments made by Skey in the New Zealand Government Laboratory in 1869, 1871, and 1874. Skey, it should be noted, was one of the pioneers in this department of research, and it is a tribute to the marvellous ability and skill he displayed in his research-work to find his determinations so fully verified by investigators of later date.

In 1869 he proved experimentally† that finely pulverised massive quartz, rock-crystal, and silica possess the power of absorbing or extracting the oxide of iron from its acetate solution. He also found that prepared silica especially manifests this property if ignited at a low temperature; and, besides, takes oxides of copper and chromium from their acetate solutions. The more finely divided the silica the more apparent is the absorption.

In 1871 Skey‡ found that when a weak ammoniacal solution of copper containing a little caustic potash is poured upon a filter of Swedish paper (cellulose), the liquid which passes through the paper is quite or nearly colourless, and the filter is found to have retained all, or nearly all, the copper of such solution.

In 1874 he showed that clay possesses the property of absorbing and fixing natural petroleum in such a way as to form a substance resembling natural oil-shale, the oil being chemically combined with the clay.§ He does not appear to have tried to ascertain the absorptive power of clay upon solutions of the metals, but his discovery that silica and porous substances, such as cellulose, possess the property of absorbing metals from their solutions has an important bearing upon the chemistry of ore-deposition.

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* E. Kohler, Zeitschrift für Praktische Geologie, 1903, p. 49 *et seq.*

† W. Skey, "On the Absorptive Properties of Silica, and its Direct Hydration in Contact with Water," Trans. N.Z. Inst., Vol. ii, p. 151: Wellington, N.Z., 1869.

‡ W. Skey, "Absorption of Copper from its Ammoniacal Solution by Cellulose in Presence of Caustic Potash," Trans. N.Z. Inst., Vol. iv, 1871, p. 332.

§ W. Skey, "Notes on the Formation and Constitution of Torbanite and similar Minerals," Trans. N.Z. Inst., Vol. vii, 1874, p. 387.

Art. VI. — *Notes on the Origin of the Metal-bearing Solutions concerned in the Formation of Ore-deposits.*

By Professor James Park, M.A.Inst.M.E., M.Inst.M. and M. (Lond.), F.G.S., Director Otago University School of Mines.

[*Read before the Otago Institute, 8th August,* 1905.]

Ore-deposits may be divided into two genetic classes—namely. those deposited by metal-bearing solutions, and those formed by direct magmatic segregation in an igneous magma. The former include the majority of ore-deposits of economic value; the latter are comparatively rare and unimportant.

It is manifest that the waters concerned in the formation of ore-deposits of the first class must be either (*a*) meteoric and descending, or (*b*) magmatic and ascending.

Descending waters are believed to gather their mineral contents from the rocks through which they percolate. They are said by Van Hise and other writers to descend to great depths by gravitative stress, and to move laterally towards open channels and fissures, where they deposit mineral matter. In this we find the basis of the theory of *lateral secretion*.

Hot ascending solutions are held to be genetically connected with igneous masses—that is, they are either directly magmatic, or they are liberated from sedimentaries in the form of gases and aqueous vapour. In this conception we have the fundamental basis of the theory of *ascension of solutions*.

Theory of Lateral Secretion.

According to this theory it is assumed that meteoric waters percolating through the country rock, by the aid of carbon-dioride and alkalies dissolve out certain constituents, which are afterwards deposited in fissures and cavities.

The origin of the theory is unknown, but it is certain that Delius, in 1770, Gerharde, in 1781, and Lasius, in 1789, were supporters of it, the latter basing his argument upon a careful examination of the veins of the Hartz Mountains.*

In 1847 Professor Bischof, of Bonn, a distinguished geologist and chemist, in his fascinating "Text-book of Chemical and Physical Geology," discusses the chemical processes which take place when meteoric waters and different kinds of aqueous

* Georg. Lasius, "Observations on the Hartz Mountains," Hanover, 1789: "Ores and Minerals," Vol. ii.

solutions come in contact with rocks. His work created a new scientific basis of research in this branch of economic geology. He contended that ores were obtained by leaching from the rocks traversed by the veins, and suggested the possibility of the vein-constituents being found in the adjacent rocks.

In 1855 Forchhammer, the famous chemist of Copenhagen, found traces of lead, copper, and zinc in the roofing-slates of North Wales, a discovery which was held to afford conclusive proof of the origin of ore-veins by processes of lateral secretion.

In 1873 Professor F. Sandberger, of Wurzburg, dissatisfied with the meagre results obtained from the examination of sedimentary rocks, directed his attention to a systematic chemical investigation of the rocks traversed by ore-veins, and of the vein-stuff itself, in different mining centres in the Black Forest. In clay-slate he discovered copper, zinc, lead, arsenic, antimony, tin, cobalt, and nickel; in sandstone, lead and copper. Titanic and phosphoric acids were found to be present everywhere in small quantity.

Sandberger's results showed that a close relationship existed between vein-contents and the country rock; but he was by no means satisfied as to the origin of the heavy metals. He accordingly extended his investigation to an examination of the constituents of igneous rocks. He crushed large samples of rock and separated the constituent minerals by solutions of different densities. Large samples of the individual crystallized silicates thus isolated were subjected to careful analysis. In this way he found all the usual elements formed in metalliferous veins. Thus, in olivine he found iron, nickel, copper, and cobalt; in augite, copper, cobalt, iron, nickel, lead, tin, and zinc; and in the micas, many base metals. Gold, mercury, and tellurium were not sought for.

In 1880 Sandberger announced his belief that the mineral contents of veins were derived not from some unknown depth, but from the immediate wall-rock.

Gold-bearing veins are common in slates and sandstones of marine origin; and, as sea-water, according to the announcement of Sonstadt* in 1872, contains somewhat under a grain of gold to the ton, it is held by the exponents of lateral secretion that the sea is therefore the source of the gold in veins traversing marine sedimentaries. It is maintained that when sediments are deposited on the floor of the sea they must necessarily entangle a certain proportion of sea-water, and that when these sediments become consolidated the gold must remain in them.

* Confirmed by Professor Liversidge in 1893 and Sir William Ramsay, F.R.S., in 1905.

The theory of lateral secretion received a new impulse from the researches of Sandberger. It seemed competent to explain the origin of many ore-veins, and, although strongly opposed by Professor Stelzner of Freiburg and Professor Posepny of Przibram, it found much support in America, in a more or less modified form.

Thus, Emmons,* discussing the manner in which he considers the Leadville ore-deposits were produced, summarises his views on ore-formation in general as follows :—

(1.) Ore-deposits have been deposited from solution, rarely in open cavities, most frequently by metasomatic interchange.

(2.) Solutions do not necessarily come directly upwards, but simply follow the easiest channels of approach.

(3.) The material was derived from sources within limited and conceivable distance, very often the older intrusive rocks.

Emmons, while supporting the principle of lateral secretion, disclaims the narrow views of Sandberger, who limits the source of the vein-contents to the wall-rock in immediate contact with the vein.†

In the critical discussion which followed the publication of Professor Posepny's paper on the genesis of ore-deposits, in 1893, Blake and Winslow reaffirmed their belief that the zinc and lead ores of Wisconsin were formed by lateral secretion.‡

Becker,§ while strongly dissenting from Posepny's view that metasomatic replacement was incapable of producing such pronounced ore-bodies as those at Leadville, makes a clear statement of the supposed operation of metasomatic processes. He says, "Replacement, like solution, must occur along fissures or channels, and metasomatic ore-bodies will present analogies in form to the open spaces of caves of solution."

Rickard|| discusses the problem of ore-formation from a wide standpoint, and is not a dogmatic supporter of the extreme doctrines of either ascension or lateral secretion. He affirms that there is no ground for the belief in the existence of a reservoir of water at great depth, and maintains that all ascending water must at one time have been descending water.

This last can only be true in regard to meteoric waters. So far as the existence of deep-seated water is concerned, his view

* S. F. Emmons, "The Genesis of certain Ore-deposits," Trans. Am. Inst. M.E., Vol. xx, p. 125.

† "The Genesis of Ore-deposits," New York, 1901, p. 199.

‡ *Loc. cit.*, p. 188.

§ *Loc. cit.*, p. 206.

|| *Loc. cit.*, pp. 190 and 211.

is not in accord with the hydro-fusion theory of modern petrologists.

Rickard, who possesses a personal knowledge of the goldfields of Australia and New Zealand, discusses the probable origin of the veins of the Thames Goldfield, in the latter country, and in the main agrees with Captain Hutton that they were formed by processes of lateral secretion by thermal waters.

Professor J. Le Conte* in a carefully prepared thesis combats the extreme views of both Posepny and Sandberger. He makes an earnest attempt to combine what is true in each, and reconcile their differences. It is manifest, however, that he leans favourably to the side of lateral-secretion processes, although not defined as such. He considers both sides right and both wrong. Ascensionists, he thinks, are right in deriving metals mainly by ascending solutions from great depths, but wrong in imagining these depths to be an exceptionally metalliferous barysphere, and wrong in not allowing subordinate contributions by lateral currents from the wall-rock higher up. The lateral-secretionists, on the other hand, are right, he thinks, in deriving metals by leaching from the wall-rock, but wrong in not making the thermosphere the main source.

Le Conte succinctly summarises his views in the following terms :—

(1.) Ore-deposits, using the term in its widest sense, may take place from many kinds of waters, but especially from alkaline solutions ; for these are the natural solvents of metallic sulphides, and metallic sulphides are usually the original form of such deposits.

(2.) They may take place from waters at any temperature and pressure, but mainly from those at high temperature and under heavy pressure, because, on account of their great solvent power, such waters are heavily freighted with metals.

(3.) The depositing waters may be moving in any direction —up-coming, horizontally moving, or even sometimes down-going—but mainly up-coming, because by losing heat and pressure at every step such waters are sure to deposit their contents abundantly.

(4.) Deposits may take place in any kind of water-way—in open fissures, in incipient fissures, joints, cracks, and even in porous sandstones, but especially in great open fissures, because these are the main highways of ascending waters from the greatest depths.

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* J. Le Conte, "The Genesis of Ore-deposits," p. 270.

(5.) Deposits may be found in many regions and in many kinds of rocks, but mainly in mountain regions and in metamorphic and igneous rocks, because the thermosphere is nearer the surface, and ready access thereto through great fissures is found mostly in these regions and in these rocks.

Professor C. R. van Hise, in a classic paper on "Some Principles controlling Deposition of Ores,"* defines his views in the following sentences :—

(1.) That the greater number of ore-deposits is the result of the work of underground water.

(2.) That the material of ore-deposits is derived from rocks within the zone of fracture.

(3.) That by far the major part of the water depositing ores is meteoric.

(4.) That the flowage of water underground is caused chiefly by gravitative stress.

(5.) That the waters which perform the first work in the genesis of ore-deposits are descending waters.

(6.) Lateral secretion is therefore an essential step in the first concentration of ore-deposits.

(7.) That sulphide ores are generally deposited by ascending waters in trunk channels.

(8.) That the majority of ore-deposits, if not all, are partly deposited in pre-existing openings, and are partly replacements of wall-rocks.

It is manifest that he attaches too little importance to the genetic connection existing between ore-deposits and eruptive processes, and places too much dependence upon the formative power of meteoric waters.

Professor Kemp† contends that mining operations in America show conclusively that mines become drier with increasing depth ; and deep mining in South Africa, Australia, and New Zealand adds confirmation to this view. The dryness of mines in depth seems to destroy the foundations of Van Hise's main contention respecting the underground circulation of meteoric water.

Van Hise admits that there are ore-deposits which have a direct igneous origin, but thinks they are of limited extent. In his rejoinder to Kemp he somewhat modifies his former concep-

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* "The Genesis of Ore-deposits," p. 282 ; also Trans. Amer. Inst. M.E., Vol. xxx, 1901, p. 27.

† J. F. Kemp, "The *Rôle* of Igneous Rocks in the Formation of Veins," "The Genesis of Ore-deposits," 1901, p. 681.

tion with respect to the action of meteoric waters, and admits that the *rôle* of igneous intrusions may be very considerable.*

It has been suggested by the opponents of lateral secretion that the metals contained in the silicate minerals of eruptive rocks are not primary but secondary constituents. According to their view, lateral secretion is only a process of concentration.

ASCENSION OF SOLUTIONS.

According to this theory it is assumed that the material which fills a lode has been brought in solution from great depths, and not derived from the rocks in the immediate vicinity of the lode.

In his classic memoir on "The Genesis of Ore-deposits," the late Professor Posepny, an ardent supporter of the ascension hypothesis, laid great stress upon the occurrence of sulphur and cinnabar at Sulphur Bank, California, impregnating a decomposed basalt, and still mildly in process of formation from gaseous emanations and hot mineral waters.

Similar conditions exist at Steamboat Springs, in Western Nevada, where we have an example of a mineral vein in process of formation. The matrix is banded siliceous veinstone, containing iron and copper sulphides, sulphur, and metallic gold.

Sandberger, who was an equally strenuous supporter of *lateral secretion*, objected to this view on the ground that he knew of no spring which deposited mineral incrustations on the walls of their channels. He regarded the Sulphur Bank and Steamboat Springs phenomena as exceptional.

Becker, who made a special examination of the deposits at Sulphur Bank and Steamboat Springs, strongly opposed the views of the extreme ascensionists. And with regard to the origin of the deposits he expressed the following views: "The evidence is overwhelming that the cinnabar, pyrite, and gold of the quicksilver-mines of the Pacific Slope reached their present positions in hot solutions of double sulphides which were leached out from masses underlying the granite, and the granite itself."† Further on he says, "I regard many of the gold-veins of California as having an origin entirely similar to that of the quicksilver-deposits."

Becker's views postulate a new hypothesis lying midway between the ascension and lateral-secretion theories, and now

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* C. R. van Hise, "The Genesis of Ore-deposits," New York, 1901: Discussion, p. 763.

† G. F. Becker, "The Geology of the Quicksilver-deposits of the Pacific Slope," U.S. Geol. Survey, Vol. xiii, 1888, p. 449.

receive more general support than the extreme views of Posepny and Sandberger.

According to the definition of lateral secretion by the latter, the descending waters became charged with mineral matter by leaching the rocks in the region of vadose circulation. On the other hand, Posepny assumed that the ascending waters became charged at great depths by coming in contact with a deep-seated repository of metalliferous matter, the existence of which is necessarily hypothetical.

The modification suggested by Becker leans towards the ascension theory, and differs only from lateral secretion in assuming a deeper source for the mineral contents of the vein-matter.

Summary.

From the data recorded in the preceding papers we may deduce the following conclusions respecting the genesis of ore-deposits :—

(1.) That the majority of ore-deposits are genetically connected with igneous rocks.

(2.) That circulating underground water and gases are the principal agents concerned in the dissolution, primary concentration, and deposition of vein-matter.

(3.) That ore-deposits do not necessarily occupy pre-existing fissures and cavities.

(4.) That ore-deposits were in many cases formed by metasomatic replacement.

(5.) That vein-filling waters are ascending waters, in most cases probably of magmatic origin.

(6.) That the mineral contents are derived from rocks contiguous to the zone of fracture or zone of metamorphism.

(7.) That the principal agents of dissolution are water and gases aided by heat and pressure.

(8.) That precipitation from the ascending waters takes place in orderly horizontal zones in accordance with the natural laws governing solution and precipitation.

(9.) That secondary enrichment is in the majority of cases due to the migration of mineral contents from a higher to a lower level, through the agency of descending meteoric waters.

The theories of lateral secretion and ascension of solutions are based on the fundamental assumption that the mineral matter filling cavities was deposited from circulating waters. Their differences lie principally in the different conceptions as to the direction and operation of the circulating liquids.

1. The lateral-secretion theory supposes—

(*a.*) That the filling of cavities was the work of descending meteoric waters;

(*b.*) That the filling-matter was principally obtained from the adjacent rocks by a process of leaching by thermal waters.

2. The ascension theory assumes—

(*a.*) That the filling of veins was effected by deep-circulating waters, ascending through open or partially open fissures;

(*b.*) That the mineral and metallic contents were derived from a deep-seated mineralised zone.

Many writers assume that ascending and descending waters are merely units in what may be termed a hydraulic circuit, the interchange being caused by gravitation assisted by capillary, and the difference of temperature of the ascending and descending waters. Much of the movement, it is claimed, is necessarily lateral and towards channels filled with ascending waters.

It was maintained by Professor Posepny and Dr. Raymond that descending waters were merely oxidizing, and incapable of depositing sulphides. This contention has, however, been successfully disproved by Emmons, Becker, Van Hise, and other American geologists, who have shown the existence of secondary sulphides both above and below water-level, or in what may be termed the zone of vadose circulation.

Professor Daubree always maintained that metallic sulphides could not be deposited without the agency of organic matter; but Skey, as far back as 1870, proved experimentally that from its solution of carbonate of soda, potash, and ammonia, gold is reduced by sulphides, but not from its solutions in alkaline sulphides.* He found that 1 grain of iron-pyrites was able to reduce 8·5 grains of gold.

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* W. Skey, Trans. N.Z. Inst., Vol. iii, 1870, p. 226.

Art. VII.—*Notes and Descriptions of* Lepidoptera.

By E. Meyrick, B.A., F.R.S.

Communicated by G. V. Hudson, F.E.S.

[*Read before the Wellington Philosophical Society, 3rd October,* 1906.]

The following notes on new and interesting forms are based mainly on material received through the kindness of Messrs. G. V. Hudson and A. Philpott, principally collected in the southern parts of the South Island. It is evident that the fauna is still far from being exhausted. I think that good results might be especially obtained by (1) searching for, and particularly breeding, the more minute forms, which require close observation, and (2) collecting at high altitudes earlier, and perhaps also later, in the year.

Caradrinidæ.

Leucania temenaula, n. sp.

♂. 34–36 mm. Head and thorax greyish-ochreous mixed with brownish. Antennæ serrate, fasciculated. Forewings elongate-triangular, costa almost straight or subsinuate, termen bowed, waved, oblique; greyish-ochreous, mixed with whitish-grey and brownish; subbasal, first, second, and subterminal lines obscurely pale or whitish, inconspicuous, more or less partially dark-edged interiorly, sometimes with some black irroration; orbicular and reniform more or less distinctly whitish-edged and laterally dark-margined, orbicular round, reniform trapezoidal; claviform small, whitish, dark-edged, touching first line, sometimes obsolete; median line obsolete; three pale dots on costa posteriorly; a terminal series of dark-fuscous crescentic marks. Hindwings fuscous, with dark-fuscous terminal line; cilia whitish, base fuscous-tinged.

Rakaia (Fereday), Dunedin (Hudson); three specimens. A distinct though inconspicuous species, allied to *moderata*, but lighter and less uniform in colouring, spots more distinct, termen rather more oblique, hindwings much less dark posteriorly.

Leucania pachyscia, n. sp.

♀. 32–40 mm. Head and thorax grey-whitish mixed with dark fuscous, thorax sometimes with blackish anterior angulated bar. Forewings elongate-triangular, costa almost straight, termen bowed, waved, oblique; whitish, sprinkled with brownish and black scales; subbasal line partially margined with dark fuscous; first and second lines indicated by dark-fuscous interior margins; spots indicated by partial dark-fuscous margins, orbicular roundish, reniform trapezoidal, claviform suboval; median shade more or less marked, formed by dark-fuscous suffusion; subterminal line indicated by well-marked thick dark-fuscous anterior margin; a terminal series of dark-fuscous crescentic marks: cilia whitish, with distinct bars of blackish irroration. Hindwings whitish-fuscous, with suffused fuscous terminal fascia; cilia whitish, base more or less infuscated.

Mount Arthur (4,700 ft.) and Lake Wakatipu, in January; two specimens. Easily known by the whitish ground-colour and strong dark præsubterminal shade.

Hydriomenidæ.

Chloroclystis halianthes, n. sp.

♂. 26–27 mm. Head, palpi, and thorax fuscous mixed with whitish and dark fuscous, shoulders partially suffused with red; palpi $2\frac{1}{4}$. Antennæ biciliated with long fascicles. Forewings triangular, costa posteriorly arched, termen little bowed, oblique, subsinuate above tornus; pale fuscous mixed with white and dark fuscous, sometimes partially suffused with pale red, appearing purplish-tinged; normal fasciæ formed of blackish irroration; median band broad, anterior edge hardly curved, below middle sometimes largely suffused with white and partially with pale red, posterior edge running from before $\frac{3}{4}$ of costa to tornus, very obtusely angulated below middle, followed by well-marked pale double second line; fifth and sixth fasciæ little marked, below middle obsolete through contraction of area: cilia fuscous mixed with whitish, distinctly barred with dark fuscous. Hindwings with termen tolerably evenly rounded, hardly prominent on vein 3; pale-grey, towards dorsum sprinkled with black and white.

Lake Wakatipu (Hudson); two specimens. Of the New Zealand species of this genus that have fasciculate antennæ in ♂, *muscosata*, *antarctica*, and *bilineolata* are green-tinged species, *dryas* a clear brown species, *plinthina* and *aristias* are red-tinged species: *halianthes* is really red-tinged, but appears purplish, and is allied to the two latter, but larger than either, darker, and easily known by the grey hindwings (in the other two whitish) and differently formed median band of forewings. Probably it varies considerably, like several of the others.

Asaphodes stephanitis, n. sp.

♂. 26–27 mm. Head and thorax yellow-ochreous, with a few blackish scales. Forewings triangular, costa gently arched, termen bowed, oblique, slightly waved; clear light yellow-ochreous; fasciæ formed by dentate striæ of blackish irroration, first and second separated by a suffused whitish line, second obsolete except on extremities; third reduced to a single curved stria, preceded by a white line, and followed by white suffusion above and below middle; fourth of three striæ, posterior edge with acute short triangular projection in middle, followed by a strong white line; fifth of two striæ, posterior sometimes very thick and suffused, followed by white subterminal line, sometimes partially obscured; sixth of one stria following subterminal line, terminated above by an oblique subapical suffusion; a blackish terminal line: cilia white, barred with blackish irroration. Hindwings light ochreous-yellow; terminal line and cilia as in forewings.

Invercargill, on sandhills (Philpott); two specimens received from Mr. Hudson. Recalls a small *Xanthorhoe clarata*, but the resemblance is only superficial.

Xanthorhoe dionysias, n. sp.

♂. 28 mm. Head, palpi, and thorax pale-ochreous tinged with brown-reddish. Forewings somewhat elongate-triangular, costa gently arched, subsinuate in middle, termen rather bowed, oblique, not waved; pale greyish-ochreous, towards costa suffusedly tinged with reddish-ochreous; basal area indistinctly striated with dark fuscous irroration; median band defined anteriorly by two curved similar striæ, posteriorly by three curved dark striæ enclosing two lines, first pale, second slightly tinged with reddish-ochreous; within median band are two suffused striæ connected by a transverse dark-fuscous discal dot, first obsolete in middle; terminal area irrorated with dark fuscous; an interrupted dark-fuscous terminal line: cilia pale-greyish-ochreous, barred with dark-fuscous irroration. Hindwings elongate, termen rounded, faintly waved; pale greyish-ochreous, thinly irrorated with grey; a blackish discal dot; a cloudy grey postmedian line; cilia pale greyish-ochreous mixed with grey.

Old Man Range, Dunedin (Lewis); one specimen received from Mr. Hudson. A distinct species, probably allied to *aegrota*, but not very nearly.

CRAMBIDÆ.

Crambus apselias, n. sp.

♂ 28–30 mm., ♀ 23 mm. Head ochreous-white, face rounded. Palpi 4½–5, brownish-ochreous, internally and at base beneath white, in ♀ very slender. Antennæ in ♂ filiform, shortly ciliated. Thorax brownish-ochreous, with ochreous-white central stripe. Abdomen whitish-ochreous. Forewings very elongate-triangular, costa posteriorly moderately arched, apex round-pointed, termen sinuate, oblique; shining brassy-ochreous; a moderate white longitudinal median streak from base, split into three branches posteriorly, and two similar detached branches above these; very indistinct narrow streaks of whitish suffusion towards costa between veins, in ♀ more suffused; two or three broader and sometimes confluent streaks of white suffusion towards dorsum between veins: cilia in ♂ whitish, on lower half of termen more or less suffused with ochreous, in ♀ white. Hindwings fuscous-whitish, in ♂ more fuscous-tinged towards apex; cilia in ♂ ochreous-whitish, in ♀ white.

Invercargill, in December; two specimens taken by myself, and three others received from Messrs. Philpott and Hudson. Closely allied to *ramosellus*, from which it is very easily separated by the entire absence of the black terminal dots and of the blackish inferior edging of the white median streak.

Crambus conopias, n. sp.

♂. 26 mm. Head white, with a central ochreous line, face forming a moderate conical projection. Palpi 5, brownish-ochreous, white at base and internally. Antennæ filiform, simple. Thorax light ochreous, with suffused whitish dorsal stripe. Abdomen whitish-ochreous. Forewings very elongate, narrow, somewhat dilated posteriorly, costa slightly arched, apex tolerably acute, termen hardly sinuate, oblique; pale brownish-ochreous; a moderate white longitudinal median streak from base to termen, posterior extremity angularly produced upwards on termen, margined with blackish suffusion above from $\frac{1}{3}$ to near termen, and beneath almost from base to middle; veins posteriorly marked with some dark-fuscous scales; median and second lines indicated by angulated series of ill-defined dark-fuscous longitudinal marks on veins, obsolete near costa; terminal blackish dots on veins: cilia white, somewhat mixed with brownish-ochreous. Hindwings fuscous-whitish, more infuscated posteriorly; cilia white.

Dunedin (Lewis); one specimen received from Mr. Hudson. Apparently more allied to *ramosellus* than to any other New Zealand species, but very distinct by the frontal cone; there would seem to be undoubted affinity to the European *inquinatellus*.

Tauroscopa glaucophanes, n. sp.

♀. 29–31 mm. Head and palpi ochreous-whitish mixed with blackish, palpi $3\frac{1}{2}$; a naked dark-grey space between eye and palpi. Thorax dark grey suffused with light bronzyblue-greenish, and mixed with ochreous-whitish and pale ochreous. Forewings elongate, moderate, slightly dilated, costa gently arched anteriorly, almost straight posteriorly, apex obtuse, termen rounded, somewhat oblique; dark grey, more or less mixed suffusedly with ochreous-whitish or whitish-ochreous, with a brassy-blue-greenish tinge; first and second lines pale, angulated, margined with darker shades, but sometimes almost wholly obsolete: cilia grey mixed with ochreous-whitish. Hindwings grey, lighter towards base, suffused with darker towards termen; cilia grey, tips whitish.

Lake Wakatipu, 4,000–5,000 ft. (Hudson); two specimens. Larger than the other two species, with the forewings much less triangular, rather oblong, and otherwise quite distinct.

PYRAUSTIDÆ.

Scoparia xysmatias, n. sp.

♂. 19 mm. Head dark fuscous. Palpi 2½, dark fuscous, lower longitudinal half ochreous-whitish. Antennæ very minutely pubescent. Thorax dark fuscous, sprinkled with ferruginous scales. Forewings elongate, gradually dilated, costa almost straight, apex obtuse, termen faintly sinuate, rather oblique; dark fuscous, irregularly strewn except on margins with yellowish-ferruginous scales, and partially suffused with black, especially about margins of first and second lines and towards dorsum anteriorly; first and second lines represented by straight undefined series of whitish scales surrounded with yellowish-ferruginous suffusion, strongly converging towards dorsum; a small spot of white scales in middle of disc, followed by a black spot; a well-marked black fascia beyond second line; a few white scales indicating subterminal line: cilia ochreous-whitish, with dark-fuscous basal and grey median lines. Hindwings without hairs in cell; dark grey sprinkled with blackish; cilia ochreous-whitish, with dark-grey basal line.

Old Man Range, Dunedin (Lewis); one specimen received from Mr. Hudson. Probably intermediate between *hemicycla* and *ergatis*, but very distinct.

Scoparia autochroa, n. sp.

♂. 21–23 mm. Head and thorax brown, face dark fuscous. Palpi 2¾, pale brownish mixed with dark fuscous, base whitish. Antennæ dark fuscous, ciliations ⅔. Abdomen fuscous. Forewings elongate-triangular, costa hardly arched, apex obtuse, termen little rounded, somewhat oblique; brown sprinkled with rather dark fuscous: cilia pale brownish, with rather dark fuscous subbasal line. Hindwings without hairs in cell; fuscous; cilia light greyish-ochreous, with fuscous subbasal line.

Invercargill, in open swampy situations, in November (Philpott, Hudson); three specimens. Very distinct, of somewhat doubtful affinity, possibly nearest *encapna*.

Scoparia choristis, n. sp.

♂. 17 mm. Head and thorax fuscous, somewhat whitish-sprinkled. Palpi $2\frac{1}{4}$, fuscous, basal area white beneath, edged with dark fuscous. Antennal ciliations $\frac{1}{2}$. Forewings elongate-triangular, costa posteriorly moderately arched, termen slightly sinuate, rather oblique; white, thinly sprinkled with fuscous; base suffused with fuscous, with a few black scales, and a short very oblique black streak from base of costa; first line white, undefined anteriorly, posteriorly edged by a black streak from $\frac{1}{3}$ of costa to $\frac{2}{5}$ of dorsum, rather curved near costa, followed by an undefined band of fuscous suffusion; discal spot 8-shaped, faintly outlined with fuscous; second line slender, white, from beyond $\frac{3}{4}$ of costa to dorsum near tornus, edged anteriorly with fuscous irrorated with black, subsinuate inwards near costa and outwards near dorsum and very obtusely angulated above middle; terminal area fuscous mixed with blackish, subterminal line represented by some whitish suffusion towards apex, and an oblique suffused white bar below middle; a terminal series of cloudy whitish dots. Hindwings without hairs in cell; light grey with brassy reflections, paler towards base; cilia whitish, with two pale-grey shades.

Kaitoke, Wellington, in November (Hudson); one specimen. Very similar to *colpota*, but immediately distinguished by quite different form of second line, especially by the peculiar outward sinuation near dorsum; also allied to *periphanes*, in which, however, the lower half of second line is straight and oblique.

Scoparia asaleuta, n. sp.

♀. 21–23 mm. Head, palpi, and thorax prismatic bronzy-grey, suffusedly irrorated with white; palpi $2\frac{1}{4}$. Antennæ dark grey, suffusedly ringed with white. Abdomen pale ochreous, sprinkled with grey. Forewings very elongate, narrow, posteriorly dilated, costa subsinuate in middle, slightly arched posteriorly, apex obtuse, termen nearly straight, hardly oblique, rounded beneath; iridescent pale ochreous mixed with dark bluish-grey, wholly suffused or densely irrorated with white except dark markings as under—viz., an undefined subbasal fascia; a nearly direct fascia representing first line, dilated posteriorly above middle; an 8-shaped discal mark; a broad terminal fascia, on which the second and subterminal lines appear as whitish shades confluent in middle and sometimes partially obsolete : cilia whitish-ochreous, tips whitish, with narrow basal and broader postmedian grey shades. Hindwings without hairs in cell ; pale greyish-ochreous, with suffused dark-grey terminal fascia ; cilia ochreous-grey-whitish, with grey basal line.

Lake Wakatipu (Hudson) ; two specimens. An elegant species, intermediate between *cataxesta* and *tetracyla* ; to the naked eye obviously bluish-tinged.

Scoparia augastis, n. sp.

♂. 28–29 mm. Head fuscous, crown mixed with whitish. Palpi 3, fuscous, base white. Antennæ fuscous, ciliations ½. Thorax light fuscous. Abdomen pale greyish-ochreous. Forewings very elongate, gradually dilated, costa posteriorly gently arched, apex obtuse, termen faintly sinuate, rather oblique ; rather light fuscous, more or less irrorated finely with whitish ; costa and all veins marked by more or less distinct somewhat darker fuscous lines : cilia whitish, with two fuscous lines, anterior interrupted. Hindwings with long hairs in cell ; very pale brassy-ochreous ; cilia whitish, with very faint greyish subbasal line.

Invercargill, in March, on flowers of *Senecio* after dark (Philpott) ; three specimens. Very distinct, perhaps nearest to the Australian *nephelitis*.

Pterophoridæ.

Platyptilia campsiptera, n. sp.

♂. 17 mm. Head and thorax yellowish-white, metapleura with an oblique black streak, frontal cone of scales moderately long. Palpi 3½, white, apical ⅔ externally irrorated with dark fuscous. Abdomen pale whitish-yellow, with a black lateral dot near base, and a few black lateral scales posteriorly. Legs white, banded with dark fuscous. Forewings cleft from ¾, upper segment rather narrow, apex produced, pointed, lower segment much broader, posteriorly dilated ; whitish, tinged with pale yellow ; costa towards base shortly strigulated with fuscous irroration ; a small triangular fuscous spot irrorated with dark fuscous on costa before fissure, not reaching across first segment, and a smaller similar mark on costa between this and apex : cilia ochreous-whitish, spotted with fuscous round lower angle of first segment, and upper angle and termen of second, with a small black scale-tooth on dorsum at ⅔. Hindwings reddish-fuscous ; cilia whitish, slightly reddish-tinged, with a blackish basal mark on lower half of termen of first segment, and mere traces of black scales in middle of dorsum of third segment.

Humboldt Range, Lake Wakatipu, at 3,600 ft. (Hudson). Mr. Hudson writes : " In this species the second digit of the forewing is held almost at right angles pointing downwards from the first digit during life ; after death the digit assumes the normal position." This would appear to be a very singular characteristic, which would repay further investigation. The species is allied to *deprivatalis*, but very distinct.

Platyptilia deprivatalis, Walk. 946.

This name supersedes *Haasti*, Feld. ; I have examined the types.

TORTRICIDÆ.

Epagoge, Hb.

This genus, which differs from *Capua* only by the absence of the costal fold in ♂, has not been hitherto known from New Zealand, but is well represented in Australia.

Epagoge cyclobathra, n. sp.

♂ ♀. 16–18 mm. Head, palpi, and thorax rather dark fuscous. Abdomen pale grey. Forewings elongate, suboblong, costa moderately arched, apex obtuse, termen hardly rounded, rather oblique ; fuscous, slightly purplish-tinged, sprinkled with dark fuscous, towards middle of costa suffused with dark ashy-fuscous, towards termen mixed with reddish-ochreous and strigulated with dark fuscous ; basal $\frac{2}{5}$ whitish-ochreous, marked with several deeper ochreous striæ, outer edge curved ; within this patch an irregular dark-fuscous streak from base of dorsum along costa to $\frac{1}{4}$, thence proceeding as a curved transverse streak to submedian fold : cilia grey, with dark fuscous median line. Hindwings light grey ; cilia whitish-grey, with darker subbasal line.

Invercargill, in December and January (Philpott) ; two specimens.

Trachybathra, n. g.

Antennæ in ♂ moderately biciliated. Palpi moderate, porrected, rough-scaled above and beneath. Thorax smooth. Forewings with rough scales at base, in ♂ with costal fold ; 2 from $\frac{2}{3}$, 7 and 8 stalked, 7 to termen, 11 from middle. Hindwings with vein 4 absent, 6 and 7 stalked.

Allied to *Capua*, from which it differs by the rough basal scales of forewings, and the absence of vein 4 of hindwings.

Trachybathra scoliastis, n. sp.

♂. 18 mm. Head, palpi, and thorax brownish irrorated with grey-whitish and dark fuscous. Abdomen fuscous. Forewings elongate, hardly dilated, costa slightly bent before middle, apex obtuse, termen faintly sinuate beneath apex, bowed, oblique; pale brownish, partially suffused irregularly with whitish, costa and dorsum strigulated with dark fuscous; outer edge of basal patch indicated by a blackish line in disc, obsolete towards extremities; an irregular incurved fuscous streak marked with black from $\frac{2}{5}$ of costa to below middle of disc, followed by whitish suffusion; an irregular dark-fuscous spot above tornus, and some dark-fuscous strigulæ towards lower part of termen: cilia grey-whitish mixed with dark grey. Hindwings fuscous, strigulated with darker; some undefined ochreous-yellowish suffusion in centre of disc and towards costa in middle; cilia pale grey, with dark-grey subbasal line.

Lake Wakatipu (Hudson); one specimen.

Pyrgotis tornota, n. sp.

♀. 18 mm. Head and thorax pale ochreous sprinkled with dark ferruginous. Palpi $2\frac{1}{2}$, whitish-ochreous, irrorated wit dark ferruginous. Abdomen pale whitish-ochreous. Forewings elongate, posteriorly somewhat dilated, costa strongly arched towards base, faintly sinuate in middle, posteriorly almost straight, apex obtuse, termen concave, little oblique; reddish-brown, suffusedly mixed with pale leaden-grey, and strigulated with whitish-yellowish; a few minute dots of blackish scales, especially on dorsum; a moderately broad curved darker streak, suffusedly irrorated with yellow-ochreous, from $\frac{1}{3}$ of costa to below middle of disc, thence curved evenly upwards, confluent towards costa with a round similar blotch on middle of termen, so that the ground-colour appears to form a narrow whitish-edged projection upwards between them: cilia reddish-brown, darker towards apex, tips whitish-ochreous. Hindwings whitish, with a few grey strigulæ on dorsal half; cilia whitish.

Invercargill, in August (Philpott); one specimen. The whitish hindwings are a special characteristic.

Adoxophyes conditana, Walk.

I have received from Mr. Philpott three examples of a curious melanic form of the male of this species, stated to be common near Invercargill. The forewings are mainly suffused with dark purplish-grey irrorated or strigulated with blackish, except some small variable whitish spots towards middle of dorsum and sometimes towards apex and termen; whilst the hindwings are densely irrorated with blackish. I at first thought it a distinct species, but after careful comparison with my long series of varieties of this extraordinarily variable species am satisfied that it is only a melanic southern form; I have not however, yet seen the corresponding females. Several other species from Invercargill show the same tendency to melanism, which should be borne in mind when considering insects from that region.

Cacoecia acrocausta, n. sp.

♂. 19–21 mm. Head and thorax brownish-ochreous or yellow-ochreous. Palpi 3, fuscous, externally suffused with ferruginous. Antennal ciliations $1\frac{1}{2}$. Abdomen whitish-ochreous, beneath ferruginous, and tuft mixed with dark grey. Forewings elongate-triangular, costa slightly arched, apex obtuse, termen rounded, little oblique; whitish-ochreous or yellow-ochreous, with scattered blackish-grey strigulæ, basal $\frac{3}{4}$ more or less tinged or suffused with brown; costal edge ferruginous: cilia whitish-ochreous, on upper half of termen dark grey, on costa yellowish-ferruginous. Hindwings ochreous-whitish, strigulated with pale grey, more distinctly towards base; cilia ochreous-whitish.

♀. 22 mm. Head and thorax whitish. Palpi $3\frac{1}{2}$, ochreous-whitish, externally fuscous-sprinkled. Forewings more elongate than in ♂, ochreous-whitish, sprinkled with very pale fuscous; central fascia indicated by an undefined grey very zigzag shade; a small grey spot towards termen in middle: cilia whitish-ochreous, becoming fuscous on upper part of termen. Hindwings as in ♂.

I took a male and female together at Christchurch in September, but had not ventured hitherto to describe them; I have now received four additional males from Mr. Philpott, taken at Invercargill, where the species is common in October and November. It is allied to *excessana*, but quite distinct.

Cacoecia orthropis, Meyr.

Examples from Invercargill sent by Mr. Philpott have the forewings much greyer than Christchurch and Wellington specimens, and the hindwings are also grey; they appear to constitute a geographical form only, and to afford an instance of the tendency to a darker colouring mentioned above.

Tortrix molybditis, n. sp.

♂. 12 mm. Head and palpi rather dark fuscous, palpi 2. Antennal ciliation 1. Thorax dark glossy leaden-fuscous. Abdomen dark fuscous. Forewings elongate, posteriorly dilated, costa gently arched, apex obtuse, termen straight, rather oblique; rather dark glossy leaden-grey; markings blackish-fuscous; four small spots on costa alternating with principal markings; a stria marking outer edge of basal patch, strongly angulated in middle; a small spot of pale-yellowish projecting scales on dorsum near base; upper half of central fascia well marked, lower half obsolete; a small triangular costal patch, from near which proceed two irregular striae to tornus and lower part of termen, edged with a few pale-yellowish scales: cilia dark fuscous, tips paler. Hindwings dark fuscous; cilia pale-greyish, with dark-grey basal line.

Wellington (Hudson); one specimen. Very distinct; has some superficial resemblance to *Dipterina hemiclista*, but easily distinguished by the short antennal ciliations.

Eurythecta paraloxa, n. sp.

♂. 12–13 mm. Head and thorax whitish-ochreous, more or less suffused with ferruginous, with a few black scales. Abdomen dark fuscous, apex pale ochreous. Forewings elongate, rather narrow, costa somewhat arched anteriorly, apex obtuse, termen somewhat rounded, oblique; vein 7 present; ochreous-whitish, more or less suffused with yellow-ochreous, palest on costa; markings yellow-ochreous or ferruginous, variably mixed with dark fuscous; basal patch darkest towards outer edge, which is oblique, rounded-prominent in middle, more or less excavated beneath this; central fascia moderate, anterior edge nearly straight, posterior edge irregularly prominent below middle, so as to appear concave on upper half; four small spots on costa posteriorly, first three sometimes confluent into a small triangular blotch; an irregular blotch along termen: cilia ochreous-whitish, more or less distinctly barred with dark fuscous. Hindwings dark grey; cilia grey.

Invercargill, common on sandhills in January (Philpott); three specimens. This species differs from the other two in having vein 7 of forewings present; but as it possesses the other characteristic structural points of the genus, and is obviously nearly allied in all respects, it seems unnecessary to form a new genus for its reception. The genus is a development of *Proselena*, and the present species is an early form of it.

Prothelymna niphostrota, n. sp.

♂. 15 mm. Head whitish. Palpi, thorax, and abdomen pale fuscous. Forewings elongate, costa moderately arched, apex obtuse, termen slightly rounded, oblique; white; basal patch pale fuscous, marked with spots of blackish irroration; dorsal half from this to tornus marked with coarse grey strigulæ irrorated with black; an oblique grey patch on middle of costa; a smaller dark-grey spot on costa at $\frac{3}{4}$; a grey apical patch, marked with coarse blackish-grey strigulæ, and extended as an irregular subterminal stria to tornus: cilia whitish, round apex greyish-tinged and spotted with blackish irroration. Hindwings pale grey, veins partially dark grey; cilia grey-whitish.

Invercargill, in January (Philpott); one specimen. This, the second known species of the genus, is easily known from the other by the white ground.

Phaloniadæ.

Heterocrossa iophaea, n. sp.

♀. 18–19 mm. Head, palpi, and thorax dark fuscous irrorated with whitish, face and palpi internally pale ochreous, palpi 4. Abdomen grey, two basal segments whitish-ochreous. Forewings elongate, narrow, costa gently arched, apex round-pointed, termen almost straight, oblique; dark fuscous irrorated with whitish, sometimes more or less mixed with pale ochreous; a series of small dark spots along costa; tufts brownish-ochreous suffusedly edged with black and posteriorly margined with whitish, viz., two near base sometimes surrounded with ochreous suffusion, a transverse angulated series beyond $\frac{1}{4}$, and five arranged round middle of disc, enclosed space sometimes blackish; a more or less defined angulated dark subterminal line: cilia rather dark fuscous irrorated with whitish. Hindwings grey; cilia whitish-grey.

Invercargill, amongst bush, from October to February (Philpott); four specimens. Much the darkest species of the genus.

Heterocrossa gonosemana, Meyr.

Further material has convinced me that *epomiana*, Meyr., is only a variety of this species, and must sink accordingly.

Gelechiadæ.

Gelechia acrodactyla, n. sp.

♂. 15–17 mm. Head whitish-ochreous. Palpi ochreous-whitish; basal joint, lower third of second joint, and subapical ring of terminal joint dark fuscous. Antennæ serrulate, pubescent, pale ochreous dotted with dark fuscous. Thorax whitish-ochreous, tinged or irrorated with brownish. Abdomen grey. Forewings elongate, narrow, costa gently arched, apex obtuse, termen rounded, rather strongly oblique; whitish-ochreous, irregularly irrorated with brown; plical and first discal stigmata rather large, blackish, plical rather before first discal; brown irroration forms a suffused costal patch beyond middle, and a narrow terminal fascia; cilia whitish-ochreous, with dark-grey subbasal line. Hindwings over 1, grey; cilia pale whitish-ochreous, with grey subbasal line.

Invercargill, amongst bush, local, in November (Philpott); three specimens. Allied to *achyrota*, but, apart from other characters, *achyrota* has two blackish rings on terminal joint of palpi, *acrodactyla* only one.

Œcophoridæ.

Borkhausenia armigerella, Walk.

Specimens sent by Mr. Philpott from Invercargill, in conjunction with the material already possessed, appear to show conclusively that *actinias*, Meyr., is only a strongly marked form of this species, and the name should therefore be reduced to a synonym.

Borkhausenia perichlora, n. sp.

♂. 21–22 mm. Head whitish-ochreous mixed with fuscous. Palpi whitish-ochreous, irrorated throughout with rather dark fuscous. Antennæ dark fuscous. Thorax dark fuscous, apical half of patagia yellow-ochreous. Abdomen grey. Forewings elongate, costa gently arched, apex round-pointed, termen very obliquely rounded; ferruginous-brown, towards costa somewhat paler and more ochreous; a yellow-ochreous streak along dorsum from base to near tornus posteriorly whitish, upper edge triangularly indented before middle, with some blackish scales in indentation: cilia ferruginous-ochreous. Hindwings light grey, margins narrowly whitish; cilia whitish.

Invercargill, abundant among *Leptospermum*, in November and December (Philpott); three specimens. At first sight very similar to *basella*, but with termen of forewings more oblique, and easily distinguished by the fuscous-mixed head, uniformly infuscated palpi, and whitish cilia of hindwings.

Borkhausenia basella, Walk. (*Incurvaria basella*, Walk. 492; *Œcophora ademptella*, ib. 698.)

♂. 18–21 mm. Head ochreous-yellow. Palpi ochreous-yellow, second joint except apex, and subbasal and subapical rings of terminal joint dark fuscous. Antennæ dark fuscous. Thorax dark brown, apex of patagia and a posterior spot ochreous-yellow. Abdomen fuscous. Forewings elongate, costa moderately arched, apex obtuse, termen almost straight, oblique; ochreous-brown irrorated with darker, with a slight purplish gloss; costal edge finely ochreous-yellow except towards base; a whitish-yellowish streak, partly suffused with deep ochreous-yellow, along dorsum from base to $\frac{3}{4}$, upper edge broadly triangularly indented before middle, with a blackish dot in indentation: cilia brown, irrorated with darker. Hindwings and cilia fuscous-grey.

Wellington (Hudson); six specimens. Distinguished by the uniform dark colouring and pale dorsal stripe; *phegophylla*, Meyr., is very similar, but much brighter-coloured, and has terminal joint of palpi wholly yellow, without dark fuscous rings; *politis*, Meyr. (of which I have both sexes) is much more mottled in appearance, with dark stigmata and subterminal line always apparent, and (though occurring in the same neighbourhood) truly distinct, since the antennal ciliations of ♂ are appreciably longer, obviously over 1, whilst in *basella* they are only 1.

Borkhausenia pronephela, n. sp.

♂. 16–17 mm. Head and thorax ochreous-yellowish. Palpi light yellowish, lower half of second joint dark fuscous. Antennæ dark fuscous. Abdomen grey. Forewings elongate, rather narrow, costa moderately arched, apex obtuse, termen rounded, rather strongly oblique; yellow-ochreous; a pale yellow dorsal streak from base to near tornus; basal third of wing suffused with brown or dark fuscous except on dorsal streak which is indented by the dark colouring before middle, indentation partially whitish-edged and containing a blackish mark; two ill-defined fasciæ of fuscous suffusion from middle of dorsal streak and tornus respectively, meeting on middle of costa; stigmata cloudy, dark fuscous, plical beneath first discal; some dark fuscous scales indicating an angulated subterminal line: cilia yellow-ochreous mixed with fuscous, with a fuscous postmedian shade. Hindwings grey; cilia whitish-grey.

Invercargill, on outskirts of bush, in December (Philpott); three specimens. A distinct species, intermediate between the *basella* and *griseata* groups.

PLUTELLIDÆ.

Glyphipteryx metasticta, n. sp.

♂ ♀. 11–12 mm. Head and thorax bronzy-fuscous sprinkled with dark fuscous. Palpi ochreous-whitish, with two rings on second joint, and two rings and an anterior streak on apical portion of terminal joint blackish. Antennæ dark fuscous. Abdomen fuscous. Forewings elongate, rather narrow, costa moderately arched, apex round-pointed, termen very obliquely rounded; 7 and 8 stalked; in ♂ ochreous-fuscous, sometimes partly suffused with bronzy-ochreous, in ♀ dark fuscous with a cloudy whitish streak along dorsum and posterior half obscurely marked with undefined whitish strigulæ, partly edged with blackish; second discal stigma round, blackish, sometimes with a smaller similar dot before and above it; two or three short whitish strigulæ from costa posteriorly, in ♂ very undefined, in ♀ longer and blackish-edged: cilia fuscous, on termen white with a blackish basal line. Hindwings and cilia rather dark grey, darker in ♀.

Invercargill, in damp situations on sandhills, in October (Philpott); three specimens. A distinct species, allied to the following.

Glyphipteryx aulogramma, n. sp.

♀. 15–16 mm. Head and thorax light shining bronzy-ochreous. Palpi ochreous-whitish, second joint with two black subapical rings, terminal joint with black anterior line. Antennæ and abdomen dark fuscous. Forewings elongate, narrow, costa gently arched, apex acute, termen faintly sinuate, very oblique; 7 and 8 stalked; light shining bronzy-ochreous; costal edge whitish towards middle; a whitish-ochreous streak along submedian fold from $\frac{1}{4}$, variably extended posteriorly, and sometimes undefined whitish streaks on veins posteriorly, the interspaces sometimes fuscous-tinged; five silvery-grey-whitish fuscous-edged diversely oblique streaks from posterior half of costa, and two from about tornus, first costal connected with first tornal by some black scales, second tornal partly black-edged and subconfluent with fourth costal in a straight line: cilia ochreous-whitish. Hindwings dark grey, posteriorly blackish-irrorated; cilia grey, round costa and apex grey-whitish.

Invercargill, in damp situations on sandhills, in October (Philpott); two specimens. Allied to *transversella*, Walk., but a much less brilliant insect.

Simaethis exocha, n. sp.

♂. 20 mm. Head, palpi, and thorax grey-whitish mixed with blackish. Antennæ pale grey, ringed with blackish. Abdomen fuscous, segmental margins mixed with whitish. Forewings elongate, moderate, posteriorly rather dilated, costa gently arched, apex obtuse, termen faintly sinuate, oblique; 7 and 8 connate; olive-fuscous, costa and dorsum broadly suffused with dark fuscous; basal area irrorated with whitish except a narrow fascia preceding first line; first line whitish, acutely angulated near costa, followed by a very irregular fascia of whitish irroration, which sends a triangular projection above middle to centre of disc; second line white, sharply defined, running from middle of costa to $\frac{3}{4}$ of disc, thence acutely angulated to beyond middle of dorsum, somewhat sinuate inwards towards costa and dorsum; an evenly broad fascia of white irroration from $\frac{1}{5}$ of costa to $\frac{4}{5}$ of dorsum, resting on second line in discal portion, terminating in a white spot on costa, and edged with a white line from this to angle of second line: cilia grey mixed with whitish, and indistinctly barred with dark fuscous irroration. Hindwings grey, darker posteriorly; indications of a cloudy whitish dot towards termen below middle; cilia grey mixed with whitish, with dark grey basal line.

Humboldt Range, Lake Wakatipu, at 3,600 ft. (Hudson); one specimen. This large and interesting form is allied to *combinatana*, Walk., but very distinct.

Art. VIII.—*The Increase of Nitrogen in certain Soils due to Nitroculture.*

By A. M. Wright, F.C.S. (Berlin), M.Am.C.S.

[*Read before the Philosophical Institute of Canterbury, 14th November,* 1906.]

This paper is the record of an attempt to determine what increase of nitrogen takes place in soils which have grown a leguminous crop, with and without the aid of nitro-culture, and with and without the addition of sulphate of potash and superphosphate.

The nitro-culture was obtained from the United States Department of Agiiculture, the experiments being carried out with the garden-pea grown on various soils.

Three soils were experimented with, about 1,500 grams of soil being used in each pot.

The following are the conditions under which each soil was treated and cultivated:—

Experiment 1. The crop grown without fertiliser or nitro-culture.

Experiment 2. The crop grown with 1 gram sulphate of potash added to the soil.

Experiment 3. The crop grown with 1 gram sulphate of potash and 1 gram superphosphate added to the soil.

Experiment 4. The crop grown with the seed inoculated with nitro-culture.

Experiment 5. The crop grown with the soil inoculated with nitro-culture.

Experiment 6. The crop grown with the seed inoculated with nitro-culture and 1 gram sulphate of potash added to the soil.

Experiment 7. The crop grown with the seed inoculated with nitro-culture and 1 gram of sulphate of potash and 1 gram superphosphate added to the soil.

The following tables show the increase or decrease of nitrogen in each soil when the various experiments were completed. The original percentage of nitrogen in each soil is shown at the top of each table. All determinations are calculated to the water-free sample.

TABLE I.

Soil A.

Original N. = ·188 per cent.

Experimont No.	Percentage of Nitrogen.	Increase or Decrease.
1	·175	− ·013
2	·180	− ·008
3	·190	+ ·002
4	·212	+ ·024
5	·211	+ ·023
6	·218	+ ·030
7	·222	+ ·034

TABLE II.

Soil B (peaty).

Original N. = ·332 per cent.

Experiment No.	Percentage of Nitrogen.	Increase or Decrease.
1	·334	+ ·002
2	·336	+ ·004
3	·340	+ ·008
4	·360	+ ·028
5	·392	+ ·060
6	·367	+ ·035
7	·381	+ ·049

TABLE III.

Soil C.

Original N. = ·088 per cent.

Experiment No.	Percentage of Nitrogen.	Increase or Decrease.
1	·081	− ·007
2	·082	− ·006
3	·092	+ ·004
4	·113	+ ·025
5	·114	+ ·026
6	·116	+ ·028
7	·120	+ ·032

Table IV.

Soil C + 10 grams Starch.

Original N. = ·088 per cent.

Experiment No.	Percentage of Nitrogen.	Increase or Decrease.
4	·121	+ ·033
5	·146	+ ·058
6	·135	+ ·047
7	·142	+ ·054

From these experiments it would appear that there is a decided increase of nitrogen when the seed is inoculated with the nitro-culture; further, the increase is greater when sulphate of potash and superphosphate are added to the soil.

Except in the case of peaty soil (Table II), and when combined carbon was added (Table IV), there does not appear to be any special increase of nitrogen by inoculating the soil; and from the results presented in Table II, experiment 5, it is probable that the cellulose in the soil-humus is utilised to promote the growth of the organism and the increase of nitrogen.

The experiments presented here indicate that to a certain extent nitro-culture can be utilised to assist the replacement of the nitrogen removed by crops from the soil.

For permission to publish this paper I have to express my thanks to the Management of the Christchurch Meat Company (Limited), in whose laboratory most of the work was carried out.

Art. IX.—*Notes on New Zealand Echinoderms; with Description of a New Species.*

By H. Farquhar.

Communicated by A. Hamilton, Director Colonial Museum.

[*Read before the Wellington Philosophical Society, 1st August,* 1906.]

These notes will serve to clear up some points which were doubtful at the time when my "List of New Zealand Echinoderms" was published (Proc. Linn. Soc. N.S.W., 1898, p. 305); to describe a new ophiuran discovered by my colleague Mr. Arthur Haylock, who has made a fine collection of New Zealand echinoderms; and to correct several omissions in the "Index Faunæ Novæ-Zealandiæ."

Although it is stated in the preface to the "Index" that I revised the Echinoidea, star-fishes, and Hydrozoa, I am not entirely responsible for the lists of these groups. When the late Captain Hutton was compiling the work, in reply to his request I sent copies of my papers to him, and some notes on the nomenclature of several species, and I offered to revise the lists when compiled, but I did not see them until the book was published.

Ophiuroidea.

Ophionereis schayeri.

This species, which is abundant near Wellington, Nelson, and Auckland, is very widely spread. Professor Kirk, of Victoria College, found it at the Chatham Islands; Mr. Haylock obtained specimens at the East Cape and at the Kermadec Islands; Dr. Ludwig has determined specimens from Juan Fernandez as our species (Zool. Record, 1898, Ech., p. 67); this or a very nearly allied form was described by Mr. E. A. Smith in the Proceedings of the Zoological Society, 1877, p. 92, from the Galapagos Islands, under the name *Ophionereis albomaculata;* and it occurs freely on the eastern coast of Australia. This is one of the two New Zealand littoral ophiurans which extend northwards into the Indo-Pacific region, the other being *Ophiomyxa australis.* I have found young specimens on the roots and stems of seaweed (*Lessonia* and *Macrocystis*), and it probably came to New Zealand across the Tasman Sea on floating seaweed. The southern branch of the Pacific Equatorial Current, which strikes the north-eastern coast of Australia and is diverted thence southwards and eastwards across the Tasman Sea, assisted by the prevailing westerly winds, has apparently been the means of adding many species to our littoral marine fauna. Our hydroid fauna especially shows the effect of this commingling of Australian forms with those which are peculiarly New-Zealandian.

The distribution of this sea-star appears to indicate a very great amount of vitality. From New Zealand (probably *via* the Chatham Islands) it has spread right across the South Pacific Ocean and up the western coast of South America in the line of distribution of the great sea-tangle of the Southern Ocean, *Macrocystis pyrifera*, a line of distribution followed by a considerable number of other southern forms, as pointed out by Professor D'Arcy Thompson in the Proc. Roy. Soc. Edin., vol. xxii, p. 313. The holothurian *Colochirus brevidentis* is in the same category if Ludwig's identification of specimens from Juan Fernandez is correct. Professor Kirk also found *Ophiomyxa australis* at the Chatham Islands.

Amphiura elegans.

I have followed Professor Bell in retaining Leach's specific name *elegans* (Catl. Brit. Ech., p. 119), although Lyman preferred that of Delle Chiaje—*squamata* (Chg. Rpts., vol. v, p. 136). This is an exceedingly interesting little species, on account of its remarkable geographical distribution, being widely diffused in the temperate seas of both hemispheres. It occurs freely on seaweed in rock-pools near Wellington, and I found great numbers on seaweed in rock-pools at Gisborne, as noted by me in the Linnean Society's Journal (Zool.), vol. xxvi, p. 191. It also occurs in deeper water among sand and gravel, Mr. H. Suter having dredged up a quantity of specimens in Lyttelton and Akaroa Harbours.

Ophiactis nomentis, n. s.

The disc is roundly subpentagonal in form, somewhat swollen above, constricted above the arms, and the edge thick and rounded between the arms; about 9 mm. in diameter. The arms increase slightly in width to a short distance from the disc and then taper evenly to a fine extremity; they are about 46 mm. in length, and the greatest width is 2 mm. The disc is closely covered above with small, rounded, irregular, imbricating scales, somewhat elongated towards the edge of the disc, armed with small, bluntly pointed, smooth spinelets, thickly placed at the edge of the disc between the arms, and a few scattered irregularly around the radial shields and sometimes towards the middle. The radial shields are seed-of-pear-shaped, 2 mm. long and a little less than 1 mm. wide, separated their whole length by a narrow wedge of small elongated scales. One rounded leaflike mouth-papilla on each side of the base of the mouth-angle. Mouth-shields round, with a very slight peak without. Side mouth-shields triangular with re-enteringly curved sides, meeting or almost meeting within. The teeth are short, stout, and wedgelike, the uppermost one being often rounded and leaflike. The upper arm-plates are transversely oval, much broader than long, covering the whole of the upper part of the arm; some of them are usually split into two or three pieces in adult specimens. The under arm-plates are circular, slightly truncated within. The side arm-plates, which do not meet, bear four short, stout, blunt, divergent arm-spines, and one round, leaflike tentacle-scale. The colour of dried specimens is brownish-grey above, the arms being banded or variegated with darker grey, and yellowish-white beneath. In life the disc is reddish, becoming bright-red towards the edge of the disc between the arms.

A number of specimens were dredged up by Mr. Haylock at Cape Maria van Diemen, between the little island on which the lighthouse stands and the mainland, in about 4 fathoms of water, among seaweed and stones.

Ophiopeza danbyi.

This species is given in the "Index" without a reference. It was described by me in the Linnean Society's Journal (Zool.), vol. xxvi, p. 189 (1897), from a specimen collected by Mr. Danby at the Kermadecs, which is now in the Canterbury Museum.

A number of echinoderms are given in the "Index" which are not in my "List." The reason of this is that Captain Hutton included the species found at the Kermadec Islands and "Challenger" Stations Nos. 170 and 170A. These may be included in our fauna, as the Kermadecs are part of this colony, and their land fauna and flora are essentially New-Zealandian.

Asteroidea.

Gnathaster miliaris.

1846. *Astrogonium miliare*, Gray. Proc. Zool. Soc., p. 80.
1866. " " Synopsis of Starfish, p. 10.
1872. *Pentaceros rugosus*, Hutton. Proc. Zool. Soc., p. 812.
1872. *Astrogonium rugosum*, Hutton. Cat. Ech. N.Z., p. 7.
1876. *Pentagonaster miliaris*, Perrier. Révis. Stell. Mus., p. 220.
1878. " " Archiv. Mus. Hist. Nat., 2e série, vol. 1, p. 84.
1889. *Gnathaster miliaris*, Sladen. Chger. Rpts., vol. xxx, pp. 286, 750.
1897. *Gnathaster rugosus*, Farquhar. Jrn. Linn. Soc. (Zool.), vol. xxvi, p. 194.

Having compared Gray's description and figure and Hutton's description of this species, and of his supposed new species (*N. rugosus*) with Perrier's original description of *Goniodon dilatatus*, and with Hutton's type specimens in the Colonial Museum, I have come to the conclusion that Hutton's *N. rugosus* is *N. miliaris*, Gray; and the specimens identified by Hutton as Gray's species are specimens of Perrier's *Goniodon dilatatus*. The synonymy of Gray's species *G. miliaris* will therefore stand as above.

Goniodon dilatatus.

1872. *Astrogonium miliare*, Hutton (non Gray). Cat. Ech. N.Z., p. 7.

1876. *Pentagonaster dilatatus*, Perrier. Archiv. Zool. Expér., vol. v, p. 33.

1889. *Gnathaster dilatatus*, Sladen. Chger. Rpts., vol. xxx, pp. 286, 750.

1894. *Goniodon dilatatus*, Perrier. Stellérides du Travailleur, p. 244.

1901. *Goniodon dilatatus*, Loriol. Notes pour servir à l'Etude des Echinodermes, ix, p. 43.

My late friend Mr. A. Reischek kindly sent a copy of Perrier's original description of this species to me, which may not be accessible to New Zealand naturalists. It runs thus : " Espèce remarquable par sa forme rappelant un peu celle du *Pentagonaster pulchellus*, bien que les plaques marginales soient disposée tout autrement. Le corps est plat, les bras courts, larges, dilatés au sommet en forme de spatule, et terminées par un bord arrondi. R = 2r, $d = 90$ millimètres. Les deux faces dorsale et ventrale sont uniformément couvertes de granules assez gros et bien distincts les uns des autres. L'ensemble des granules correspondant à chaque ossicule dorsal est nettement séparé des granules voisis, de sorte que les ossicules sont parfaitement distincts les uns des autres ; sur la face ventrale, au contraire, il est difficile de distinguer les limites des ossicules squelettiques. Les plaques marginales augmentent graduellement de largeur depuis le sommet de l'arc interbrachial jusque vers le sommet des bras, les dernières seules diminuant de nouveau. La longueur de toutes ces plaques demeure au contraire sensiblement constante. C'est à l'élargissement graduel des plaques marginales qu'est due la form spatulée des bras ; l'aire limitée par les plaques, qui sont au nombre de dix-huit, présente comme d'habitude la forme d'un pentagone à côtés concaves. La plaque madréporique est grande et subcentrale. Sur la face ventrale les piquants ambulacraires sont disposés sur trois rangs dont le niveau supérieur dépasse à peine celui de la granulation générale. Les piquants du premier et du seconde rang sont un peut plus gros que ceux du troisième, dont les dimensions transversales sont identiques à celles des granules ventraux."

Asteropsis imperialis.

This species is given in the " Index " without a reference, and wrongly spelt " *Asterospis*." It was described by me in the Linnean Society's Journal (Zool.), vol. xxvi, p. 193. The unique type specimen, which is from the Kermadecs, is in the Canterbury Museum.

Asterias rodolphi.

This Kermadec species is also given in the "Index" without a reference. A few notes were added by me in the Linnean Society's Journal (Zool.), vol. xxvi, p. 192, to M. Perrier's brief original description, which runs thus: "Very like *A. gracialis*, L., from which it differs chiefly in the number of rays, which is seven, and the position of the ventral spines near the ambulacral spines, which form a triple and not a double series as in the European species": Ann. Mag. Nat. Hist., ser 4, vol. xvii, p. 34 (1876). The type, which is in the British Museum, was collected by Macgillivray during the voyage of H.M.S. "Herald" in 1854.

Cribrella ornata.

Professor H. B. Kirk found this species in abundance at the Chatham Islands. He also observed *Asterias calamaria* and *Asterias scabra* at the same place.

Echinoidea.

Echinobrissus recens.

This extremely interesting little echinoid occurs in Tasman Bay; specimens may be found on the beach at "The Sands," near Richmond, after northerly gales. It also occurs pretty freely in the channel at the entrance of Port Nicholson. Mr. Haylock has collected a good many specimens on the beach between Day's Bay and Pencarrow Light, some of them being quite fresh with the spines on. The spines on the abactinal surface are short, slightly tapering, with rounded tips, and longitudinally striated, 1·6 mm. long; those on the actinal surface are longer and finer, the longest, 3·5 mm., being near the mouth. There is a specimen in the Canterbury Museum from the Chatham Islands, and one from Stephen Island. It also occurs in Foveaux Strait.

The genus *Echinobrissus* attained its maximum development in the later Jurassic and early Cretaceous periods, when its forms were numerous and widely diffused. Two species occur in the Australian Tertiaries, and one (*E. papillosus*) in the New Zealand Eocene. If this species occurs in Madagascar, as stated by Agassiz in the "Revision," its distribution is not so remarkable as would appear at first sight, for it is evidently a very old form, and in far distant times—probably before the Cretaceous—Madagascar was much nearer to New Zealand zoologically than it is now. This is shown by the relationship between the extinct *Dinornithidæ* of New Zealand and the extinct *Æpiornithidæ* of Madagascar. Our fern-bird belongs to a genus (*Sphenœacus*) found only in New Zealand and South Africa, with a near relation in Madagascar; and the beetle *Sternaulax* and the marine shell *Littorina mauritiana* occur in New Zealand and Madagascar, the latter being also found in Australia. (See Introduction to the Index Faunæ N.Z., p. 6.)

Centrostephanus rodgersii.

Strongylocentrotus erythrogrammus.

New Zealand specimens of both these species are in the Colonial Museum at Wellington, as noted by me in the Linnean Society's Journal (Zool.), vol. xxvi, p. 189. These are omitted from the "Index," although *Strongylocentrotus tuberculatus*, which is noted as a New Zealand form on the same page, is retained. *C. rodgersii* ranges from New Caledonia to Tasmania and New Zealand, and *S. erythrogrammus* occupies the same area, with extensions to Japan and Chili. *S. tuberculatus* was found at the Kermadecs by Mr. Haylock.

Sphærechinus australe.

This species, which is given in my "List" and omitted from the "Index," occurs in Australia, Tasmania, Mauritius, and the Society Islands. It is recorded by Agassiz as from New Zealand, and is one which we might expect to find here; as, however, it is not known to New Zealand naturalists, it may be omitted from our list, at any rate for the present.

Holopneustes inflatus.

I gave this species in my "List" on the authority of Mr. Agassiz (Rev. Ech., pp. 136, 483; and Chger. Repts., iii, p. 274), but as it is not known here it may be correctly omitted from the "Index." Dr. Ramsay says, "Three species—*H. inflatus*, *H. porosissimus*, and *H. purpurescens*—are somewhat doubtfully recognised by Agassiz, and without a large series of specimens it is almost impossible to distinguish the varieties: it is quite likely that they all belong to one species. As *Holopneustes* occurs on the east and south coasts of Australia, it is not unlikely to occur in our seas. Some dredging operations have recently, I believe, been carried on in the neighbourhood of Dunedin, and some of the species now omitted from our list may have been rediscovered, but I do not know what echinoderms were obtained.

Echinus margaritaceus.

Peronella rostrata.

Metalia sternalis.

These three species are omitted from the "Index." I included them in my "List" on Mr. Agassiz's authority (Chger. Repts., iii, pp. 274, 275). *Echinus margaritaceus* is widely spread in southern seas, having been found at the Straits of Magellan, Juan Fernandez, Kerguelen Land, and Heard Island, and we may expect to find it in our southern waters; but as it is not known to New Zealand naturalists it may be omitted for the present. *Peronella rostrata* is a Zanzibar form which does not occur here. We have a species of *Peronella*, however, specimens of which are in the Otago Museum, from the West Coast Sounds. Two species of *Peronella* occur in Australian waters, *P. decagonale* and *P. peronii*. The former appears to be confined to the Indo-Pacific region, and the latter ranges from the Philippine Islands to Tasmania. Being unacquainted with these, I cannot identify our species. *Metalia sternalis* is a tropical form, widely diffused in the Indo-Pacific region, and does not, I think, occur in our seas.

Brissopsis luzonica.

I do not know of the occurrence of this species here. It is a tropical form, widely spread in the Indo-Pacific region, and I do not think it belongs to our fauna. It is given in the "Index," although I marked it "doubtful" in my "List" for both New Zealand and Australia.

Salmacis.

We have a species of *Salmacis* in New Zealand, but I do not think it is *S. globator*, which is given in my "List" and in the "Index." Specimens are in the Otago Museum from Stewart Island, and one denuded test is in the Colonial Museum. I believe it belongs to Bell's *S. alexandri* ("Alert" Report, p. 118), which is a very variable form, and occurs freely in Port Jackson (Catl. Ech. Aust. Mus. (1891), p. 50).

Phyllacanthus dubia.

A specimen of *Phyllacanthus*, which I take to be *P. dubia*, was found by Mr. Haylock at the Kermadec Islands. This is an Indo-Pacific species, having been found also in New Caledonia, North Australia, the Red Sea, Zanzibar, and the Bonin Islands.

Art. X.—*Note on the Bipolarity of Littoral Marine Faunas.*

By H. Farquhar.

Communicated by A. Hamilton, Director, Colonial Museum.

[*Read before the Wellington Philosophical Society, 1st August,* 1906.]

The littoral marine fauna of New Zealand, in common with the land fauna, consists of several distinct elements. In all or nearly all the groups which have been worked up we find two comparatively small elements, which are nevertheless more interesting than the other parts of our fauna—namely (1) an autochthonic element, consisting of species which are peculiarly Neozelandian in type, and, having no relations in any other parts of the world, are entirely distinct from all other forms; these have arisen in the New Zealand area in extremely remote geological times; and (2) a representative element, consisting of species which are identical or closely allied to species inhabiting the northern temperate or Arctic regions. The latter are known as bipolar forms. The autochthonic element is stronger in the land fauna, but it is also well marked among our marine animals; and, although only a faint trace of the northern element is found among our terrestrial animals, it is much more strongly marked in the marine fauna.

The bipolar forms are thought by some naturalists to be the remnant of a fauna which was cosmopolitan in very early times, when a more equable climate probably obtained all over the world.

Of Hydroida we have six littoral species in New Zealand identical with European forms: *Obelia geniculata, Sertularia operculata, Sertularella polyzonias, Plumularia setacea, Antennularia antennina*, and *Tubiclava fruticosa*. *Campanularia caliculata* var. *makrogona*, which occurs freely in Wellington harbour, is a distinct species, for it always has the large type of gonangia figured by Bale in the Proc. Linn. Soc. of New South Wales, 1888. It is closely related to the European species *C. caliculata*, which occurs in Australia. *Aglaophenia filicula* occurs here and at the Azores; and almost all the genera are European.

The sea-anemone *Actinia tenebrosa*, which is only found between tide-marks, is the southern representative of, and closely allied to, *A. equina*. The genera are almost all common to both regions. Two New Zealand species known to me are entirely distinct from all others—namely, *Halcampactis mirabilis*, and a very beautiful, large, undescribed species with large kidney-shaped lumps on the body-wall, giving it somewhat the appearance of a bunch of grapes, for which a new genus will have to be established.

The two lime-sponges, *Leucosolenia clathrus* and *Leucosolenia cerebrum*, have been found here by Professor Kirk; the former occurs in the English Channel and the latter in the Adriatic.

Of echinoderms, *Amphiura elegans* (*A. squamata*) is widely spread in the North Atlantic; *Stichaster insignis* is the southern representative of the far northern form *S. albulus*—the two species are remarkably near, and both increase by subdivision; and *Cribrella compacta* is a near ally of *C. occulata*. The little heart-shaped sea-urchin *Echinocardium australe* extends into the North Pacific, but this has a great bathymetric range, having been obtained from a depth of 2,675 fathoms off Japan. It is very closely related to the Atlantic species *E. cordatum*. The only genus of echinoderms peculiar to New Zealand is *Ophiopteris*, with but one species, *O. antipodum*.

The large gephyrean worm *Echiurus neozelanicus*, which occurs freely in Wellington harbour, is nearly allied to its congener *E. unicinctus* of Japan. *Priapulus caudatus*, which occurs along the coasts of Greenland, Norway, and Great Britain, and in both the North and Baltic Seas, was found by the "Southern Cross" Expedition in the Antarctic off Cape Adair. Mr. Shipley says, "The genus, too, seems also bipolar in its distribution. *P. bicaudatus* lives in the North Sea and Arctic Ocean, and is represented in habits and its two tails by M. de Guerne's *Piapuloïdes australis* from the neighbourhood of the Magellan Straits" (Rpt. "Southern Cross" Collections, p. 285). Mr. A. Willey, in his report on the Polychæta of the "Southern Cross" Expedition, says, "Perhaps the most interesting feature of the collection is the addition of the characteristic northern maldanid, *Rhodine loveni*, Magn., to the Antarctic fauna. Besides this, two other genera not hitherto recorded in the south are represented by species slightly different from their northern congeners—namely *Gatlyana* (= *Ngchia*) *cristata*, n. sp., and *Malmgrenia crassicirris*, n. sp. (p. 262).

The stalked ascidian *Boltenia pachydermatina*, which is abundant at low water on our southern coasts, in the colder water of the Antarctic Drift, occurs also on the coasts of Greenland.

Eighteen species of New Zealand Bryozoa are identical or closely related to European forms—namely, *Scrupocellaria scrupea*, *Bugula neritina*, *B. avicularia*, *Membranipora membranacea*, *M. pilosa*, *M. lineata*, *M. solidula*, *Microporella ciliata*, *M. malusii*, *Mucronella variolosa*, *Retepora cellulosa*, *Membraniporella nitida*, *Hippothoa flagellum*, *Schizoporella hyalina*, *Crisia denticulata* var., *Idmonea serpens*, *Entalophora raripora*, and *Diastopora patina*. I have obtained these names by comparing Hutton's revised list of New Zealand species (Trans. N.Z. Inst., xxiii, 102) with Miss Jelly's "Synonymic Catalogue," assuming that those with a reference to Hinck's "British Marine Polyzoa," Fleming's "British Animals," or Johnston's "British Zoophytes" are European forms. Some of them are probably cosmopolitan. Tenison-Woods described a fossil bryozoan, *Fasciculipora ramosa*, from New Zealand Tertiary beds so nearly allied to a species from the Lower Pliocene of Europe that if it had been found in the same locality it would have been regarded as a mere variety ("Palæontology of New Zealand," pt. iv, p. 31). *Smittia landsborovi* occurs in the Arctic Ocean, European Seas, and the Antarctic off Cape Adair.

Our marine crustacean fauna has evidently a considerable amount of affinity with that of northern Europe. Myers, in the introduction to his "Catalogue of New Zealand Crustacea" (1876), says, "The remarkable resemblance between the carcinological fauna of New Zealand and that of Great Britain has been adverted to by Dana and other authors, and is sufficiently striking." This generalisation was quoted by Dr. Chilton in his presidential address to the Philosophical Institute of Canterbury, 1904, on "Arctic and Antarctic Faunas," which has not been published. Nearly all the species of the genus *Gnathia* are European, and one species, *G. polaris*, occurs in the Antarctic off Cape Adair. I hope Dr. Chilton will presently give us an account of the New Zealand species which are identical with and nearly related to northern forms, as he and Mr. G. M. Thomson have worked up this group. The character and affinities of our terrestrial Crustacea are extremely interesting. Mr. Thomson kindly gave me an account of these some time back, which I embodied in a continuation of my paper on "The New Zealand Zoological Region" (*Nature*, vol. lxi, p. 246). This continuation was never published, and unfortunately both Mr. Thomson's and my own notes were lost in the confusion of changing residence from Wellington to Auckland and then back to Wellington again.

The following list of marine Mollusca which occur in New Zealand and the north temperate region has been kindly furnished to me by Mr. H. Suter: *Crepidula crepidula*, Mediterranean, Atlantic; *Tritonium costatum*, Mediterranean, West Indies, Africa, Brazil; *Tritonium rubicundum*, Great Britain, Mediterranean, India to Japan; *Venericardia corbis*, Mediterranean, Pliocene fossil in Italy; *Trivia europœa*, *Kellia suborbicularis*, and *Thyasira flexuosa*, Atlantic; *Cassidea pyrum*, *Lima bullata*, and a variety of *Cassidea labiata*, Japan; *Ancilla rubiginosa*, Japan, China, Malacca, Madagascar; *Mytilus edulis* and *Saxicava arctica*, cosmopolitan. Mr. Suter says the above list is probably far from complete.

Of shore fishes we have six species which are identical with those of the European seas—namely, *Trachurus trachurus*, *Zeus faber*, *Conger vulgaris*, *Scymnus lichia*, *Echinorhinus spinosus*, and *Acanthias vulgaris*. Our species of *Cyttus* and *Polyprion* are representatives of the North Atlantic forms; and the southern mackerel *Scomber australasicus* is either identical with or very closely allied to *Scomber colias*. The genus *Argentina*, which is characteristic of the seas of northern Europe and the Mediterranean, is represented in New Zealand waters by *A. decagon*.

These facts show that there is a good deal of evidence in the character of the littoral marine fauna of New Zealand which makes for the support of the bipolar theory.

Professor D'Arcy Thompson, in his critical review of Sir John Murray's paper, maintains "that an actual community of forms is not proven, save for a very few forms, some peculiar to the extreme depths of the sea, and others that inhabit the surface of the ocean in colder latitudes while represented in the deeper and colder waters of tropical seas" (Proc. Roy. Soc. Edin., xxii, p. 312). The forms enumerated by me, with the exception of *Echinocardium australe* and perhaps one or two molluscs, are, however, essentially littoral species, which do not extend into deep water, and do not appear to be represented in the intervening seas.

I have gathered together these scraps, which are, no doubt, far from complete, and if they contain any mistakes I hope they will be corrected by others.

If there is anything of value in the bipolar theory, and in view of the fact that there are immense differences in the variation of species—some forms remaining unchanged or changing very little through vast geological periods, while others are unstable and change very rapidly—we should expect to find a few species in the Antarctic and sub-Antarctic regions identical with those of the corresponding northern regions, a considerable number of representative species and the genera for the most part common to both areas, with a few genera in all the groups peculiar to each area of distribution in both regions; and this is, I think, what we find in a comparison of the New Zealand littoral marine fauna with that of the North Atlantic. Near alliance of species is probably more favourable to bipolarity than actual identity.

I know little or nothing of the North Pacific fauna, but a comparison on the same lines would be extremely interesting. Then we need an Australian naturalist to give us an account of the character and affinities of the Australian marine fauna. And when our Tertiary fossils have been worked up, a comparison with those of the northern temperate and sub-Arctic regions will perhaps shed a little more light on this exceedingly interesting problem.

Art. XI.—*The New Zealand Plateau.*

By H. Farquhar.

Communicated by T. King.

[*Read before the Wellington Philosophical Society, 3rd October,* 1906.]

Plate V.

At the time when the "Challenger" Reports were published only a very few deep-sea soundings had been made with the improved sounding apparatus in the neighbourhood of New Zealand, and the New Zealand Plateau was only approximately sketched on the map published with the reports. But since the "Challenger" Expedition a great deal of sounding-work has been done in the South Pacific by H.M.S. "Penguin" and other vessels, in connection with the laying of the Pacific telegraph-cable from British Columbia to New Zealand and Australia; and a line of soundings was run by Sir James Hector from the Bluff southward to the Macquarie Islands, north-eastward to the Chathams, and westward to Lyttelton. The contour of the sea-bed surrounding this country is therefore fairly well known, and we can now map out the Plateau correctly, except at one or two points.

The map now published is compiled chiefly from the Admiralty chart of the Pacific Ocean with the latest additions, and a map of the Pacific, showing soundings, published by the India-rubber, Guttapercha, and Telegraph Works Company.

This great Plateau forms a very irregular area. It extends far to the south and south-east beyond the outlying islands (Auckland, Macquarie, Campbell, Antipodes, Bounty, and Chatham), but the boundary-line has not been certainly fixed here and may extend a little beyond that marked on the plan.

North-westward the Plateau extends in an immense submerged ridge, which may be called the "Lord Howe Island Ridge," and joins or almost joins the New Caledonian Plateau. The deep channel which runs along the south-western side of New Caledonia may extend northwards between the D'Encrecasteaux and Chesterfield Reefs, thus cutting off the New Caledonian Plateau from that of New Zealand by a narrow channel; but this is not very probable, and a few soundings are needed here to decide the point.

This great ridge is the most striking feature of our Plateau, and it has profoundly affected the character and distribution of the fauna and flora of New Zealand—a great stream of life having come in this way.

At the southern extremity of the Lord Howe Island Ridge, and lying to the north-westward, there are two smaller ridges, that lying farthest north being the extension of what is now known as the Auckland Peninsula. Between these ridges lie two valleys or depressions, in which, no doubt, large rivers flowed at the times of elevation.

The great backbone ridge of New Zealand, with its divergent ranges, must have presented a truly grand appearance during the periods of elevation—the beginning of the Tertiary era and early Pliocene—when the land stood five or six thousand feet higher than now, with its vast snowfields and glaciers grinding out the great valleys and fiords, and forming the moraines which lie scattered about the country.

North of the main body of the Plateau and east of the Lord Howe Island Ridge a large depression known as the "Gazelle Basin" lies between New Zealand and the Fiji Islands, and further eastward again, beyond the Kermadec Ridge, the "Aldrich Deep" culminates near the Kermadecs at a depth of over 5,000 fathoms, plumbed by Captain Aldrich. Its western boundary is an immense mural escarpment, running southward from the Tonga Islands past the Kermadecs, and down the eastern side of the North Island towards Cook Strait, where it turns abruptly eastward to the north of the Chatham Islands. On the west our Plateau is separated from Australia by the "Thomson Deep," which is evidently one of the great primordial depressions of the earth's crust, and accounts for the fundamental difference between the animals and plants of Australia and New Zealand. Eastward from the Australian coast-line the sea-bed rapidly plunges down to a great depth (2,600 fathoms), and then rises gradually in a long undulating slope to New Zealand.

The evidence of the former great extension of New Zealand, and of the vast changes that have occurred in this region, as seen in the geology and in the character and relationships of the fauna and flora, has been admirably discussed by the late Captain Hutton in the "Transactions of the New Zealand Institute," and in the introductions to the "Index Faunæ" and "Animals of New Zealand," and by Messrs. Laing and Blackwell in the introduction to their beautiful "Plants of New Zealand." And if these works are studied with the map of the Plateau as now developed the relations and reasons of most of the observed facts may be understood.

ART. XII.—*On the Occurrence in New Zealand of* Platalea regia, *Gould.*

By TOM IREDALE.

[*Read before the Philosophical Institute of Canterbury, 11th July,* 1906.]

IN vol. ix of our Transactions, Dr. (now Sir) Walter Buller recorded the first occurrence of *Platalea regia*, Gould, in the colony. That specimen was shot in April, 1875, near the mouth of the Manawatu River, and is now in the collection of birds in the Colonial Museum. In vol. xxviii Sir Walter Buller stated that he had been informed by Mr. Townson, of Westport, that another specimen had been shot, on the Buller River, about January, 1892, and was preserved in Dr. Gaze's collection.

I have now to put on record another occurrence of this fine bird, making the third in a space of thirty years. The specimen, which I now exhibit, was shot on a lagoon near Greytown North, in the Province of Wellington, in the month of May, 1905. This specimen is an immature bird.

As the bird was set up as you now see it when I heard of it, I can only give you the words of the man who shot it. He said, "I was coming home by the side of the lagoon from rabbit-shooting when the bird rose from a hollow just in front of me. I shot it, and was surprised at the bird when I picked it up. I took it along to a friend of mine who dabbles in bird-stuffing, and he set it up for me. I found that it had been seen for some weeks previously flying about the lagoon, and several attempts had been made to stalk it, but all had been unsuccessful owing to its wariness. It had even been christened 'the white hawk.'"

Art. XIII.—*New Zealand Ctenophores.*

By W. B. Benham, D.Sc.

[*Read before the Otago Institute, 14th August, 1906.*]

Plate VII.

Hitherto the only member of that group of "melon-jelly-fish" that has been attributed to our seas is a pleurobrachid, named *Cydippe dimidiata*, Lesson.* This was obtained in the Tasman Sea—or, as it was termed, "the channel between New Zealand and New South Wales"—in 1770, by Banks and Solander, during Captain Cook's first voyage. It was originally named by them "*Beroe biloba*," but by Lesson† was placed in his genus *Eschscholthia* and described by him as *E. dimidiata*. It had been figured previously by Eschscholtz‡; and Chun, presumably judging from this figure, identifies it as a member of the genus *Cydippe*.§ It has not been studied further, and nothing more is known of it than the short account given by Lesson. I think that it may well be removed from our list.

During the last few years I have collected or received a few specimens of ctenophores which belong to two genera—*Beroe*, Browne, 1756; and *Euplokamis*, Chun, 1880—for each of which I propose, though with considerable diffidence, owing to lack of recent literature, a new specific name, though I recognise that these may be found superfluous.

Beroe shakespeari, n. sp.

I received a number of individuals, well preserved in formalin, from Mr. R. Shakespear, the Curator of Little Barrier Island, to whom my thanks are given for his kindness and thoughtfulness in presenting them to me.

The specimens, some of which have a faint roseate hue, are subglobular, but slightly compressed in the transverse or infundibular plane, so that the "sagittal" diameter is rather greater than the "transverse."

The fifteen individuals vary from 27 mm. to 62 mm. in height, and from 20 mm. to 50 mm. in diameter across the base, being

* Lesson, Ann. Sci. Nat. (Zool.), 1836, ser. 2, vol. v, p. 254.
† Lesson, Hist. Nat. Zoophytes, Acalephes, 1843, p. 102.
‡ Eschscholtz, Syst. der Acalephen, 1829, pl. ii, fig. 2.
§ Chun, Fauna u. Flora des Golfes v. Neapel. Ctenophoren, p. 287 (1880).

rather greater than this near the equator. One or two have a more oval form, the diameter being proportionally smaller, but in the majority the vertical and horizontal diameters are approximately equal.

The mouth does not occupy the whole of the base—*i.e.*, it is not relatively so large as in the two well-known Mediterranean species, *B. ovata* and *B. forskalii.* In the present species the oral moiety of the body is somewhat contracted, sloping downwards and inwards, so as to be nearly horizontal around the mouth.

The costæ, even in the largest individuals, do not extend down to the margin of the mouth. This I supposed at first to be related to the immaturity of the specimens, but I find that the largest ones contain fully developed spermatozoa in the meridional canals and young ova, so presumably they are practically full-grown, or at any rate adult. These gonads are limited to the meridional canals, and extend down to their lowest limits. The costæ taper off to a fine point orally, about two-thirds of the total height of the body. The eight costæ are not absolutely equidistant; the pair at each end of the sagittal plane run at first parallel with each other and are closer together than are the other costæ; they then diverge rather suddenly, so that at the equator the distance separating the pair of subsagittal costæ is only slightly less than that between other pairs. Thus, in the largest specimen, the distance between the pair of subtransverse costæ at the equator is 12 mm., and between the subsagittals 10 mm. But at their origin these distances are 4 mm. and 1·5 mm. respectively.

The subcostal or meridional canals give off, right and left, branched cœca, which do not anastomose but terminate in slight dilatations; and to some extent those of one canal interdigitate with those of a neighbouring canal—as in *B. ovata.* The two stomodæal canals also give origin to a few fine outgrowths which take a horizontal direction on the wall of the stomodæum and branch slightly; these open into a series of inwardly directed branches from the meridional canals. These canals and branches are readily seen in the specimens, and I injected them in one large individual in order to confirm the observation. The four meridional and the stomodæal canal of each side open into a semicircular marginal canal at the edge of the mouth; but the two marginal canals do not meet at the ends of the sagittal plane. This fact is also in agreement with Chun's observations.

I have obtained specimens of this species of *Beroe* from the following localities: (*a.*) Little Barrier Island (Shakespear); 1906. (*b.*) Off D'Urville Island, off the north coast of the

South Island (G. M. Thomson); 1900. (*c.*) Tauranga, on the east coast of the North Island (which is without date, and was collected during my predecessor's time).

The lot (*a*) include forms varying in size from 27 mm. to 62 mm. in length; the largest I take to be adults. The lots (*b*) and (*c*) are quite young, attaining a length of 9 mm., 6 mm., and even less. They exhibit a series of stages of growth corresponding to some of those figured and described by Agassiz* for *B. roseola*, on pp. 36, 37.

The youngest of my specimens has costæ extending only a short way down the body (*cf.* fig. 52 of Agassiz); the meridional canals are relatively wide, have no branches, and open below into a semicircular canal (*cf.* figs. 57 and 58 of Agassiz); but in the former figure no marginal canal has appeared, while in the latter there are already indications of cœca which are absent in my specimens.

In the lot (*a*), even in the smallest, the meridional canals are provided with branched cœca, though the branches in the smaller individuals (20–25 mm. in length) are not so much ramified as in the older. (This measurement was taken after transference from formol to alcohol, in which the specimens shrink somewhat—losing about 20 per cent. of their former size). In all of them the costæ extend more than half-way down.

Remarks. — The question arises, Is a new specific name required for this form? Chun (p. 306) has pointed out in his memoir the immense amount of synonymy—both generic and specific—that occurs in the family Beroidæ, and comes to the conclusion that, at any rate in the Northern Hemisphere, not more than three species exist—namely, *Beroe ovata*, *B. forskalii*, and *B. cucumis*. But he acknowledges that the forms that have been gathered in the Pacific Ocean, and figured by older authors, are insufficiently described to enable him to decide as to their validity or otherwise.

More recently, a species *B. australis* has been described by Agassiz and Mayer† from Fiji, which, however, is quite distinct from the present form, and appears nearly related to *B. forskalii*.

But from each of the three species from the Northern Hemisphere the present one differs in the following points: From *B. forskalii* in form and sundry details which serve to distin-

* Agassiz, N. American Acalephæ, Ill. Catal. Mus. Harvard, 1865.

† Agassiz and Mayer, "The Acalephs of Fiji," Bull. Mus. Harvard, 32, 1899, p. 177.

guish this from *B. ovata*. From *B. cucumis* (= *B. roseola*, Agass.) in the presence of network of canals on the wall of the stomodæum—just that feature which most distinctly separates the North Atlantic form from *B. ovata*.

We are reduced, then, to a comparison of our New Zealand species with *B. ovata*, which, though it descends into the tropical and even the southern regions of the Atlantic, does not appear to have been met with eastward of Africa. From *B. ovata* our species differs in its more globular form, for even in the individuals in which the horizontal diameter is least in relation to the vertical (*e.g.*, 60 mm. × 40 mm.) the proportions are very different from those of *B. ovata*, in which the length is more than twice the breadth; secondly, the approximation of the upper ends of the subsagittal costæ; thirdly, in the cessation of the costæ before the lower margin is reached (which may possibly be due to the specimens being not yet fully grown); fourthly, in the fact that the mouth is not at the widest part—that the lower margin of the bell is directed inwards, so that the mouth is smaller, relatively, than in *B. ovata*. It may be that in life the mouth of our species is capable of a certain amount of mobility and distension.

Reference should perhaps be made to Agassiz's* "*Idyiopsis clarkii*" from South Carolina, which in its more rounded form (see fig. 63, p. 39, *loc. cit.*) certainly resembles our species. Agassiz emphasizes the short vertical axis, the compressed body, the prominent costæ, and depressed intercostal regions as distinctive of the genus, which later authors include in *Beroe*. But though there is a certain degree of resemblance, it is not probable that the same species would occur in the Atlantic and the Pacific. In "*Idyiopsis clarkii*" the polar area is, from Agassiz's figure, much more compact than in the present species.

The only Pacific species, besides *B. australis*, is *Beroe macrostoma*, Peron,† which was obtained south of New Guinea during the voyage of the "Coquille." Its shape is, however, like that of *B. ovata*, but Chun states that it is insufficiently described for identification. At any rate it is quite unlike our New Zealand species.

Euplokamis australis, n. sp.

The body is cylindrical, though slightly narrower at the aboral pole; the mouth is situated on a short and probably mobile tube, considerably narrower than the body.

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* Agassiz, Illust. Cat. Harvard Mus., 1865, p. 39.

† Peron, Voy. de la Coquille, Zool., p. 105, pl. xv, 2.

The characteristic features upon which this genus was founded are (1) the great extent of the costæ and the large size of the costal plates; (2) the tentacles issue from the tentacular sheath very high up the sides.

The present species differs from *E. stationis*, described by Chun, p. 283, in a few very evident characters. The "tentacle-base" is about one-third the length of the body, and extends considerably below the level of the "infundibulum"; the tentacillæ or accessory filaments do not roll up into spirals, and I am unable to detect the transversely striated muscle within them which Chun describes for *E. stationis*.

Localities.—(*a.*) A single individual: off the north coast of the South Island, near Farewell Spit (G. M. Thomson). (*b.*) Several young ones: Otago Harbour (Cottrell).*

The largest individual is 20 mm. in length, with a greatest diameter of 12 mm. rather below the equator, while near the aboral pole its diameter is 8 mm.

The specimen preserved in formalin exhibited the internal anatomy well (see Plate VII, fig. 1). The gonads are present, but the gametes not fully developed. The long "infundibular canal," large "infundibulum," the radiating canals from it, are all shown. Those from Otago Harbour are young ones, and in them the enormous breadth of the costæ and the great size of the individual costal plates can be seen.

These young ones measure, on an average, 5 mm. × 3 mm. The costæ almost touch one another, and each is made up of 12 plates. In these young ones the aperture of the tentacle-sac is much nearer the apex, and the length of the tentacle-base is about half the length of the animal, and its lower end reaches nearly to the lower end of the costa: this is perhaps due to unequal contraction of the parts: these had been fixed in corrosive sublimate and preserved in alcohol, which causes the jelly to shrink to a much greater extent than does formalin.

Remarks.—A comparison of the figures and description of *E. stationis* with those of our species makes it evident that there are considerable differences between them. But since the publication of Chun's monograph on the Mediterranean ctenophores two other species belonging to this genus have been described. *E. cucumis*, Mertens, has been redescribed by Vanhoffen,† to whose account, however, I have not access. It was obtained near Unalaschka, in the Behring Sea. The short account given by Mertens is referred to by Chun (footnote, p. 284), where it is

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* I have also a specimen, 9 mm. in length, from Port Jackson.

† Vanhoffen, "Ctenophoren," in Nordische Plankton, 1903.

stated that the tentacle-base is situated in the neighbourhood of the stomodæum. *E. californiensis* has been described by Torrey,* whose account of it I have been unable to obtain. It was captured off San Diego, on the coast of California. It is possible that our New Zealand species is identical with it.

In addition, there is an earlier species, *E. elongata*, of Quoy and Gaimard,† which was placed by them in the genus *Beroe*, then by Lesson (*loc. cit.*, p. 103) in the genus *Janira* (as *J. quoyi*), but has been by Chun recognised as a *Euplokamis*, who resuscitated the original specific name.

This species was taken in the Atlantic, off the coast of Africa; in it the tentacle-base is more than half the length of the body.

From this species, also, mine is evidently quite distinct.

EXPLANATION OF PLATE VII.

(Figs. 1–4 refer to *Beroe shakespeari;* figs. 5–7 refer to *Euplokamis australis.*)

Fig. 1. *Beroe shakespeari*, natural size of preserved specimen: *a*, canals containing gonads; *b*, costæ; *c*, mouth. The apex is retracted.

Fig. 2. The same, view of apical pole (natural size), showing the compression of the animal, and the apical approximation of the subsagittal costæ (*d*).

Fig. 3. A younger individual (natural size).

Fig. 4. A very young specimen (enlarged), showing short costæ, wide canals, without the cæcal outgrowths.

Fig. 5. *Euplokamis australis*, adult individual (× 2½), showing, by transparency, the internal anatomy. The tentacles are partially retracted.

Fig. 6. A young specimen (× 4). The costæ are wide; the tentacles, almost fully protruded, issue much nearer the apex than in the adult.

Fig. 7. A portion of a young one bisected to show the great length of the tentacle-sac at this stage as compared with adult (perhaps due to differences of preservation). *b*, the tentacle-base.

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* Torrey, Univ. California Publications, 1904, vol. ii, p. 46.

† Quoy and Gaimard, "Voy. Astrolabe," iv, p. 37, pl. vi, Mollusques; and Atlas, pl. 90, figs. 9–14.

Art. XIV.—*On the Presence of another Australian Frog in New Zealand.*

By George R. Marriner, F.R.M.S., Assistant, Biological Laboratory, Canterbury College.

[*Read before the Philosophical Institute of Canterbury, 14th November,* 1906.]

Our New Zealand fauna can only boast of one amphibian—namely, the indigenous frog, *Liopelma hochstetteri*—which was rare at the time of its discovery, but now is rarer still, if not almost extinct, only being found occasionally on the Coromandel Peninsula.

About the year 1868 several batches of the common green Australian frog, *Hyla aurea*, were liberated in different parts of New Zealand, as Christchurch, Wellington, &c.: these have increased so much that they are now to be seen in hundreds in many parts of the country.

Since the introduction of *Hyla aurea* there is only one other recorded instance of the introduction of frogs into New Zealand—namely, in 1898, when the Agricultural Department liberated another kind of Australian frog in this country.

Mr. T. W. Kirk, Government Biologist, writing in his report, says, under the heading of "Climbing-frogs," "A consignment of six dozen of these insect-destroyers was also obtained and liberated at suitable spots in the following districts: West Coast (North Island), Wellington Province, Wairarapa, Hawke's Bay, and Auckland. This frog is similar to the ordinary common frog, so common in many parts of New Zealand, except that it has a very considerable advantage over that species in that its toes are provided with suckers, which enables the animal to climb trees and houses in search of insects. In Sydney I have seen these frogs at the top of a wall four stories high." Unfortunately, Mr. Kirk does not mention the name of the frogs, and so far I have been unable to obtain it.

As late as 1904 Captain F. W. Hutton included only *Hyla aurea* in his list of naturalised amphibians, inserted at the end of the "Index Faunæ Novæ-Zealandiæ" (page 348). However, for the last thirty years there has been living and increasing in Westland, especially around Greymouth, another species of Australian frog, which, though well known to the residents, was not thought to be very different from the common green frog of Canterbury. My brother, Mr. F. G. Marriner, was the first person to draw my attention to the presence of this amphibian around Greymouth. He told me that the frogs in the district had a peculiar whistle, which, when a large number joined in chorus, could be heard for some distance.

This at once aroused my interest, and through the kindness of Mr. H. West, Greymouth, I received five live specimens on the 3rd February, 1906.

On inspection I found that they were small frogs from $1\frac{1}{4}$ in. to $1\frac{1}{2}$ in. in length, and of a brown colour; and in order to get them properly named I forwarded two live ones to Mr. J. J. Fletcher, of Sydney, who has done much work on Australian frogs.

He described it as *Hyla ewingii*, D. and B., var. *calliscelis*, and stated that it was included in the British Museum Catalogue of Batrachia (1882), page 406; he also informed me that it is one of the commonest frogs of eastern Australia and Tasmania.

On the 1st March I received about forty more from Mr. H. West, and so had a good opportunity of noticing any variation that might occur between different individuals. When exposed to light they are of a light-brown or even a very pale brown colour; there is usually a broad dark band running down the middle of the back, with two lighter broad bands on each side. The under-surface is lighter, and on the ventral surface of the thighs there is a yellow streak. When buried in the earth, or not exposed to a bright light, they go to dark reddish-brown colour—almost to a dark chocolate; and if one is buried with only a part of its body exposed to bright light, the buried portion turns a dark reddish-brown colour, and the exposed portion, no matter how small it may be, keeps its very light colour, the line of demarcation being very definite.

In the specimens that I received the male seems to be about $\frac{1}{4}$ in. smaller than the female, but otherwise they seem to be the same externally. The average size of my specimens was about $1\frac{1}{2}$ in., but one specimen was about 2 in. in length. The head is large, eyes prominent, and snout short; hind feet are webbed, but fore feet are not so; all the digits have suckers at their tips.

The frogs in my case seem to be more strictly nocturnal than *Hyla aurea*, for they seldom come out in the daytime, except in wet weather. I kept a large number among some grass in a bell jar for some days; at night-time they could be seen climbing all over the sides of the jar, but in the daytime they were almost all invisible. Since then I have kept them in a glass aquarium, with a dish of water and turf, but I seldom see them out in the daytime. Mr. H. West tells me that they are best caught at dusk or later, when they crawl over the grass, &c., and can be located by their peculiar cry, which somewhat resembles a whistle when compared with the hoarse croak of *Hyla aurea*.

Arboreal Habits.

Hyla ewingii is a true climbing-frog, but according to Mr. J. J. Fletcher it has, at least in Australia, altogether or nearly lost the arboreal habits of a tree-frog. In Westland, however, it still seems to do a fair amount of climbing.

Mr. A. P. Harper, of Greymouth, in a letter to me, gives the following account of their climbing propensities: "I have personally seen these frogs (*Hyla ewingii*) crawling over blackberry bushes at a height of from six to eight feet above the ground, and also in the middle of a patch of berry, five yards by three at least. They even crawl along the thorny stems. I have also seen them on the *macrocarpa* and in the branches of the natural creepers on a dead tree-stem. The highest these frogs climb above the ground is, I should say, about eight feet. On one old tree-stem covered with creepers, ferns, &c. (as one so often sees here) there are nearly always some singing-frogs. It is just above a pool which exists in wet weather only. I rather think they climb when the pools are dry, but I am not sure."

Several that escaped from me on the 9th March I afterwards found clinging to the top of grass-stems about two feet from the ground. Whether the abundance of bush in Westland has stimulated the frog to make use of a power which it has almost lost in Australia is difficult to decide. At any rate, the frog's environment in Westland would certainly be conducive to tree-climbing, and the abundance of undergrowth and creepers would make it very easy work.

Breeding Habits.

Hyla ewingii evidently extends its breeding season into the autumn, for on the 1st March two lots of spawn were laid in the aquarium.

On the 11th and 12th most of the eggs hatched out, and the tadpoles, dark-blue in colour, after swimming about for a little time, finally fastened themselves to the water-weeds or to the sides of the aquarium.

After about three weeks of normal development the tadpoles had grown to about 17 mm. in length.

On the 22nd March I put five into an aquarium, which I shall call A; it was out in the open, about 2 ft. by 2 ft. by 1 ft. in size, and held 4 cubic feet of running water. Five others I put into an aquarium (B) situated in a hothouse. The tank was 2 ft. 8 in. by 15 in. by 7½ in., and held about 2⅓ cubic feet of standing water. During the autumn they were always visible swimming about in the aquarium, but when the cold weather came they all disappeared. However, in aquarium B, whenever warm weather prevailed a solitary tadpole would appear from time to time, but in the coldest part of the winter no tadpoles were visible. It seems to me that when tadpoles remain as tadpoles all the winter, they must either bury themselves in the mud or else hide away among the water-weeds at the bottom of the aquarium, for I could never see any sign of them during the cold weather.

In the spring two tadpoles appeared in tank B, and only one in tank A, though no doubt several crayfish, which were living in the same aquarium, were partly responsible for the smallness of the number of survivors in the latter. Though the aquariums had plenty of water-weeds and submerged rocks, there was no place where the tadpoles could find a shallow landing-place where they would need their limbs for crawling, and the result has been that neither the lungs nor the limbs have been developed.

In autumn they would often come to the surface and take in large mouthfuls of air, as most tadpoles do, but since the winter they seem to have no inclination to come to the surface, but act to all intents and purposes similar to fish.

It has been stated that not only will tadpoles keep as tadpoles when reared under such conditions, but that they will increase in size in proportion to the size of the tank in which they are kept. Though three specimens are not sufficient to prove anything, yet the tadpoles in my aquariums do seem to uphold this fact. All of them were about 17 mm. in length when put into the tanks, and now the two in the tank holding $2\frac{1}{3}$ cubic feet of water are only 25 mm. and 30 mm. respectively, while the one in the tank holding 4 cubic feet of water is now 45 mm. in length.

Distribution.

It seems almost certain that these frogs first made their appearance at Greymouth, whence they have extended inland and south.

From Greymouth they have spread either naturally or artificially up the Grey River for at least twenty-four miles to Ahaura, and very likely further, but so far all the places where I have found them to be present are on the south bank of the river, and none on the north, though it is not at all unlikely that they are on the opposite bank also.

At Brunnerton, eight miles from Greymouth along the river, they are plentiful, and seem to be increasing. No other kinds of frogs are said to be found there.

At Stillwater, nine miles from Greymouth and a mile past

Brunnerton, according to Mr. Mallock there are both the green and brown kinds present, though the latter are more numerous and are increasing.

At Ahaura, twenty-four miles up the river, only the brown frogs are present, and these appear to be increasing.

At the centre of their dispersion, Greymouth, they are said to exist in very large numbers, and seem to be increasing.

The only other place where I have them recorded is Hokitika, twenty-two miles south of Greymouth, and there is no reference to them being found in between these towns, so that it is very unlikely that they travelled overland—indeed, rumour says that they were brought by an unknown person from Greymouth.

At Hokitika *Hyla ewingii* is now very scarce, if not quite extinct. Mr. James King, of Hokitika, says that ten years ago the big green frog (I suppose *Hyla aurea*) was introduced, and perhaps this has something to do with the decrease of the brown ones. From what I have seen of the *Hyla aurea* it would find the small brown frog very eatable, and if it does not stop at eating its own kind there is very little chance of it sparing the small strangers. It is evident that they have not extended in any direction from Hokitika, for I have no place outside of that town where they are known to be present.

Its Introduction.

The next question is to find out how this frog came to New Zealand.

I thought that at first it might be an indigenous frog, but there seems to be no evidence whatever to support this theory. There is no record of it in the early days of settlement, and at all the places where it has been found its origin can be traced directly or indirectly to Greymouth.

As the frog was so common on the east coast of Australia I thought that probably it came over among the ballast of some ship trading between that continent and Greymouth, but this theory was upset on making further inquiries in Westland.

Several of my correspondents say that these brown frogs, *Hyla ewingii*, were brought from Tasmania by a Mr. W. Perkins in 1875, and through the kindness of Mr. T. Eldon Coates, of Greymouth, I received the report which is generally accepted in that town. He states that a Mr. W. Perkins, who was a barrister in Greymouth for some time, brought some of these frogs from Tasmania in a glass bottle in 1875. They were liberated in a drain in Alexandra Street, Greymouth, whence they have spread to the surrounding country. They have remained in great numbers in and about the spot where they were originally liberated. The main facts of this account I have also received from several other Greymouth correspondents.

These frogs cannot, as some have thought, be the ones liberated by the Agricultural Department in 1898, because they were never liberated on the west coast of the South Island at all; besides, the two could never have been confused, owing to the difference in size, colour, and general appearance.

Several of my correspondents have known *Hyla ewingii* around Greymouth for twenty or even thirty years. Mr. H. West has written to say that he remembers them twenty years, and Mr. West, sen., for about thirty years.

The presence of this frog in Westland in 1875 may somewhat explain a mystery which has never been cleared up: In 1875, before the Westland Institute, Mr. F. E. Clarke read a paper on "Notice of a Tadpole found in a Drain at Hokitika." He explained that he had found one in a drain which was being cleaned out by some labourers. After discussing the amphibian he writes, "No frogs or frogs' spawn having been introduced nearer to the west coast of New Zealand than Nelson and Christchurch, it is puzzling to conjecture in what manner the little stranger arrived in a territory having a climate so thoroughly congenial to its kith and kin."

Mr. Clarke was evidently unaware that about three years before he wrote his paper *Hyla ewingii* had been introduced into Greymouth, and they could easily have been brought from Greymouth as adults by some unknown person, or else perhaps the spawn was carried across the intervening twenty-four miles by some water-fowl. At any rate, there is not so much of a mystery about the occurrence, when frogs were not more than twenty-four miles away, as it would have been when they were no nearer than Nelson, about a hundred and fifty miles as a crow flies.

As this frog can climb well, I think it would be worth while introducing it into Canterbury and other parts of New Zealand in order to deal more effectively with the insect pests, as the common green frog is unable to reach insects that do not come near the ground. Already several of my specimens of *Hyla ewingii* have liberated themselves, and if not destroyed by birds might establish themselves around Christchurch.

In closing I should like to express my thanks to all those who have supplied me with information, and especially to Mr. H. West for the trouble he has taken in procuring live specimens for me.

Art. XV.—*Maori Numeration: Some Account of the Single, Binary, and Semi-vigesimal Systems of Numeration formerly employed by the Maori.*

By Elsdon Best.

[*Read before the Auckland Institute, 3rd October, 1906.*]

Maori numeration is a subject which appears to have received little attention from writers who have dealt with the customs of the Native race, and of what has been placed on record a certain proportion thereof is certainly erroneous and misleading. The following notes, albeit somewhat brief and incomplete, will serve to give the reader some idea of the system of numeration which obtained among the Tuhoe Tribe of Maoris prior to the arrival of Europeans in New Zealand.

There were, in former times, two different methods of numeration in use among the Maori people, single and binary. Some profess to see in the dual system a primitive method of enumeration which obtained in times long past, before the arrival of the race in Polynesia. From information obtained in this district of Tuhoeland, it would appear that the binary system was used in counting game, &c.: that is to say, such items were counted, or tallied, in pairs—hence the term used (*topu*) in this method is equivalent to our word "brace."

The systems of numeration of primitive peoples are often quoted by anthropologists as a sign of the grade of culture to which such peoples have attained. Thus we read of tribes of so low a culture as to have no system of counting beyond five, or even three. It will be seen that the Maori, a barbarous people, had evolved, or borrowed, a very good system of numeration, and doubtless quite elaborate enough for their purposes. Some writers have stated that the Natives of New Zealand did not count above one hundred, any number above that not being counted with precision, but simply styled as "numberless," or "a great many," "a multitude." It does not, however, appear to have been so, although it is probable that the statement given would be correct if applied to thousands instead of hundreds. Albeit the term *mano* has been used to define "a thousand" in modern times—*i.e.*, since European settlement in these isles—yet it is not clear that it was so used in ancient times. I am inclined to think that the word *mano* may have been originally used as the term *tini* is at the present time—viz., to imply a great number, a multitude. The Ngati-Kahungunu Tribe have an expression—*mano tini ngeangea*—which is used to denote a great number. It appears to equal our expression "in countless numbers"—like unto the sands of the sea-shore, or leaves in the Vale of Vallombrosa. Both *mano* and *tini* are used separately, or together, to denote a great number, a myriad; hence *mano* does not necessarily imply a specific number, as a thousand. The word *ngeangea* is probably an intensive. Ellis expresses his astonishment at the completeness of the Polynesian system of enumeration in these words: "The precision, regularity, and extent of their numbers has often astonished me."

The Native terms for the numerals were as given below:—

Numerals.

Cardinals.

Tahi = one.	Ono = six.
Rua = two.	Whitu = seven.
Toru = three.	Waru = eight.
Wha = four.	Iwa = nine.
Rima = five.	Ngahuru = ten.

Of these terms the first nine are still used, but the word *ngahuru* is no longer employed in counting, being replaced by the term *tekau*, which latter appears to have been used in pre-European times to denote twenty—but of which more anon.

To the above terms various prefixes are applied. When using any of these expressions for numbers in conversation, or when enumerating articles, the term *ko* is prefixed to the first, which thus becomes *kotahi*. From two to nine inclusive the prefix is *e*. To *ngahuru* no prefix is applied as a cardinal, but as an ordinal *tua* is so employed: *tua-ngahuru* = tenth. *Tekau*, the modern term for ten, never bears a prefix, the ordinal being expressed by the use of the definite article: *te tekau* = the tenth. Thus we have the cardinal numbers as follows

Ko-tahi = one	E-ono = six
E-rua = two	E-whitu = seven
E-toru = three	E-waru = eight
E-wha = four	E-iwa = nine
E-rima = five	Ngahuru, *or* tekau = ten

as used in Maori. These terms are often used when counting. But an ancient, and more correct, style of actual enumeration is by prefixing *ka* to the numerals. Probably, however, *ka* is not a true prefix in this case: for my own part, I do not so regard it. In Williams's Maori Dictionary we find "*ka* = a verbal particle, denoting the commencement of a new action or condition, or a state of things new to the speaker." Here we have the key to the matter—in this wise: when, in counting a number of articles, a person says "*ka wha*," the expression means that that number is attained, the counted items have become four; *ka rima* = they have become five, a new state of things is attained. Hence I should write this method of counting as follows,—

Ka tahi	Ka ono
Ka rua	Ka whitu
Ka toru	Ka waru
Ka wha	Ka iwa
Ka rima	Ka ngahuru, *or* ka tekau,

and not look upon *ka* as a true prefix.

Ordinals.

The ordinal numbers are formed by prefixing *tua* to the numerals.

Tua-tahi	= first.	Tua-ono	= sixth.
Tua-rua	= second.	Tua-whitu	= seventh.
Tua-toru	= third.	Tua-waru	= eighth.
Tua-wha	= fourth.	Tua-iwa	= ninth.
Tua-rima	= fifth.	Tua-ngahuru	= tenth.

These terms are usually written without the hyphen, as *tuatahi*, *tuarua*, &c.

Again, we often hear Natives using the definite article before the cardinals to express the ordinals, and dropping the prefix *tua*: as, *te rima* = the fifth; *te ono* = the sixth; &c.

The prefix *toko* is used only in speaking of persons. It is prefixed to the numerals two to nine inclusive, and not to one or ten. Thus, in speaking of persons, the numerals are thus used (see Table No. 3):—

Kotahi	= one.	Tokoono	= six.
Tokorua	= two.	Tokowhitu	= seven.
Tokotoru	= three.	Tokowaru	= eight.
Tokowha	= four.	Tokoiwa	= nine.
Tokorima	= five.	Tekau	= ten.

During a residence of eleven years' duration among the Tuhoe Tribe, once only have I heard *toko* prefixed to *tahi*. *Toko* was not prefixed to *ngahuru*, but the term *ti-ngahuru* was applied to persons only.

Toko is also prefixed to the interrogative numeral *hia*: *Tokohia nga tangata* = How many persons? And also to the words *iti* (few, a small number), *maha* (many), *ouou* (few), and a few others, but only when speaking of persons: *He tokomaha nga tangata kua tae mai* = Many persons have arrived.

Tekau (ten) is often preceded by *kotahi* (one) in these days, hence *kotahi tekau* (one ten) is the usual method of denoting that number. It would seem, however, that this has only obtained in late times—*i.e.*, since *tekau* has been adopted to express ten, which figure has now become the basis of Maori numeration. *Kotahi tekau* (one ten) is quite a natural use when *rua tekau* (two tens) is used for twenty, and *toru tekau* (three tens) for thirty, and so on. It prevents any misunderstanding as to how many tens are meant. But in former times, when *tekau* was used to denote twenty, it was not preceded by *kotahi*.

Another prefix to numerals is the word *taki*. This, as Williams's Dictionary states, "gives a distributive force to numerals": hence *takitahi* = singly; *takirua* = by twos, two at a time; *takitoru* = by threes; and so on. Again, it is used before other words, "denoting that what is said applies to each one individually," to quote the same authority: *Ka takiomaoma ki te ngaherehere* = Every one of them fled to the forest.

We will now give the modern system of Maori numeration, such as has been used since the early days of European settlement. The old system has been retained up to nine, but *ngahuru*, the ancient term for ten, has been rejected, and *tekau* substituted for it. This *tekau* is now the multiple of Maori numeration. Observe:—

Tekau	10.
Tekau ma tahi	11 (ten and one).
" rua	12 (" two).
" toru	13 (" three).
" wha	14 (" four).
" rima	15 (" five).
" ono	16 (" six).
" whitu	17 (" seven).
" waru	18 (" eight).
" iwa	19 (" nine).
Rua tekau	20 (two tens).
" ma tahi	21 (two tens and one).
Toru tekau	30 (three tens).
Wha tekau	40 (four tens).
Kotahi rau	100.
" ma tahi	101 (one hundred and one).
" kotahi tekau	110 (one hundred one ten).
" kotahi tekau ma tahi ..	111 (" one ten and one.)
" e rua tekau	120 (" two tens).
E rua rau	200.
Kotahi mano	1000.
Kotahi mano e toru rau e wha tekau ma tahi	1341.

And so on.

Here we note that ten has become the common multiple of Maori numeration. Apparently this change was made in order to assimilate the Maori system of numeration to that of the invading race. I can find no proof among the Tuhoe people that this system given above was used in pre-European days: hence it would appear that ten was not used as a multiple in former times.

It might be claimed that two was a multiple in the ancient

Maori system, but it resolves itself into a custom of counting by pairs, or braces; and it was not used in all cases—counting singly was also common. Persons were not counted in pairs, or braces, as was game, &c. These Natives would never have used *ka wha pu* to denote eight persons. But in one way a semi-binary system was used in counting persons; and this brings us to another prefix—viz., the word *hoko*. *Hoko*, as a prefix to numerals, is said by Williams to signify ten times the subjoined numeral; but when applied to persons the Tuhoe Tribe give it the value of twenty times the subjoined numeral, or ten times in pairs, whichever way you please to take it. Thus *hokorua* applied to persons signified forty; *hokotoru* = sixty; and so on. This system is similar to that of Aitutaki, described by Mr. J. T. Large at page 260, vol. xi, of the "Journal of the Polynesian Society." He says, in the first place, that *okotai takau* (the aspirate is not used in the Cook Islands) stood for twenty, &c., and then states, "A correlative system of enumeration was also used indifferently with the above. This was distinguished by the prefix *oko*: for instance, *okorua* was twenty doubled, or forty; *okotoru* was sixty; and so forth, up to *okoiva*, which was 180; but it seems to have been confined to those limits." This is exactly the Tuhoe case. From *hokorua* = forty, up to *hokoiwa* = 180, this system of counting obtained; but I have never heard *hokotahi* used to denote twenty, although it would seem that it was probably so used. Mr. Tregear looks upon *hoko* as a causative prefix, as *hokowhitu* = to make seventy.*

It is probable that the prefix *hoko* was here used in both ways—viz., as signifying ten times the subjoined numeral, and also ten times doubled. Thus *hokorua* might mean either twenty or forty. In these cases the Maori could make his meaning clear by adding a word of explanation—either *takitahi* (singly) or *topu* (double—*i.e.*, pairs). Thus *hokorua takitahi* would mean ten times two singly = twenty, and *hokorua topu* would be ten times two in pairs, or doubled = forty.† This point is not, however, yet quite clear. We have seen the value of the prefix *hoko* as given by Williams's Maori Dictionary—a most reliable work—but, still, my informants of the Tuhoe Tribe will not admit that *hokorua* signified twenty, and *hokotoru* thirty, and so on, but always double those figures, which would give the prefix *hoko* the power of multiplying the subjoined numeral twenty times, not ten times. A confirmation of this comes from the east coast. The Rev. H. W. Williams, of Gisborne, informs me that he was told by

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* "Journal of the Polynesian Society," vol. i, p. 56.

† Most of the old Natives state that *hoko* multiplied by twenty the subjoined numeral in former times.

Mohi Turei, of the Ngati-Porou Tribe, that *hokorua* signified forty, and *hokotoru* = sixty, but that eighty was *hokorua topu*. This last term is very singular. Judging from the value of *hoko* before *rua* and *toru*, then eighty should be *hokowha*, as used by the Tuhoe people. It was surely a very strange break, or change, in this system of numeration to jump from *hokotoru* for sixty to *hokorua topu* for eighty. I cannot help thinking that this is an error. If, however, it was really the case that *hokorua topu* = eighty, then it is a proof that *hoko* really multiplied by twenty the subjoined numeral. Only one local authority has informed me that the *hoko* system was used in both ways, singly and doubly: as *hokorua takitahi* = twenty, and *hokorua topu* = forty, and so on. This would mean that Williams's Dictionary is correct that *hoko* multiplies by ten, and that *hokorua topu* simply means ten times two doubled, and not twenty times two. Anyhow, Vaux's statement was correct when he said that *hoko* was used for multiples of ten.*

An examination of the Native methods of enumeration given in this sketch will show that several systems were employed—viz., counting singly, and the binary system of counting in pairs. There were also some differences in counting persons, and different words for various by-terms pertaining to enumeration: for example, the words *kehe*, *taukehe*, and *tautahi* all denoted an odd number. The terms *paepae* and *tuma* both mean an odd number in excess, as an incomplete ten or hundred. Tuhoe use the former word, and in this manner: *kotahi rau, hokorua te paepae* (one hundred, forty the excess) for 140. *Tauhara* and *tauwhara* are also terms for an odd number. By "an odd number" I do not necessarily mean the odd numbers three, five, seven, &c.; the terms are also used to denote (as in preserving birds) an incomplete ten. If eighty-three, or eighty-five, or eighty-six birds were put into a calabash, that vessel would be said to contain *hokowha* (eighty), *ka whakarerea nga tauwhara* (the odd ones are omitted).

The verb "to count" in Maori is *tatau*. Counting singly, as we do, would be described as *tatau takitahi*, and the dual method as *tatau topu*. *Pu* and *topu* bear much the same meaning—a pair, couple, brace. *Takitahi*, as we have seen, means—by ones, singly, once told.

It is possible that the last migration of Polynesians to New Zealand brought with them a somewhat different system of numeration to that in use among the original peoples, the descendants of Toi and the old-time tribes of these isles. They were certainly more advanced than the latter in some

* Trans. N.Z. Inst., vol. viii, p. 38.

arts—*e.g.*, in cultivation. If so, this would explain some singular discrepancies and confusion noted when examining the methods of numeration employed by the Maori.

Before giving longer tables of the Maori systems of numeration, we offer a few remarks on some of the terms already quoted.

Rima = five. This term is said by many writers to be a survival of the primitive method of counting on the fingers. *Ringa* is the Maori word for hand, but *linga* and *lima* bear the same meaning in various Polynesian dialects: in Tahitian, *rima* = five, and also the hand; Hawaiian, *lima* = five, also the hand; Rarotongan, *rima* = five, also the hand; &c.* The Maori still counts on his fingers in certain cases, as when repeating a genealogy, in order to count the number of generations from a certain ancestor.

Ngahuru.—This is the old Maori word for ten, now replaced by the term *tekau*. This word, recognisable under various letter-changes, is in use over a wide area in the Pacific: Rarotongan, *ngauru* = ten; Hawaiian, *anaulu* = ten days; Samoan, *gafulu* = ten. (See Tregear's Dictionary for many other comparatives.) *Ngahuru* is misspelt in Thomson's paper in the fifth volume of the "Transactions of the New Zealand Institute," as also are many other Maori words. *Ngahuru pu* (= twenty) in Maori is literally ten pairs. Only once have I encountered this word in a different form among the Maori of New Zealand, and that was when an old man of the Tuhoe Tribe gave me the term *tekau mahangahuru* (or *tekau maha ngahuru*) as the ancient expression for thirty, in single counting. This is somewhat puzzling, and needs confirmation from other authorities.† *Tekau* was twenty, and presumably the most likely term for thirty would be *tekau ma ngahuru* (twenty and ten), as there existed no special terms for thirty, fifty, seventy, and ninety in the Tuhoean system, according to my informants. But I have noted in various works that *angahuru* is supposed to have been an ancient term for ten in Polynesia (*cf.* Hawaiian *anaulu* above; though Tregear's example has *anahulu*). Hence I have thought that the expression above quoted should perhaps be written *tekau ma hangahuru*, which appears more natural when bearing in mind various Polynesian resemblances. Mr. J. T. Large states that the ancient term for ten at Aitutaki was *ngaungauru*. *Hagavulu* is used for ten in the New Hebrides.

An old-time Maori proverb is this: "*Ngahuru kei runga, ngahuru kei raro*"; which the late Sir George Grey translated

* Compare our use of the term "digit."

† Confirmation obtained from two tribes, 23rd December, 1905.

thus: "Never mind, I've ten teeth in my upper jaw and ten in my lower; hard or not, a hungry man can eat it." It was used in reference to hard or tough foods.

For my own part, I but seldom theorize anent matters Maori. I am too busy at field work—*i.e.*, collecting information from original sources. But I have a lone theory, and it concerns the word *ngahuru*, as used to denote ten. This I will proceed to give—*hai kata ma te marea*—though it leave me theoryless.

When a Maori proceeds to count on his fingers in the ancient manner he holds up his left hand open, fingers straight, in front of him. In beginning to count he takes hold of the top of the little finger of the left hand with the thumb and forefinger of the right. As he counts "one" he turns down the little finger until it touches, or nearly so, the palm of the hand. He then in like manner takes hold of the top of the next finger and turns that down as he counts "two," and so on until he reaches "five," when he turns the thumb in. Observe now the cream of my theory. All the fingers of the left hand have now become *huru*, or *hurua*—contracted, drawn in (from the verb *huru* = to contract, or draw in). This is one *huru*, or *ringa huru;* but it will not bear the plural of the definite article—*i.e.*, *nga*—as a prefix. But he proceeds with his counting up to ten, which he tallies on the fingers of his right hand in the same manner as he did on the left, using the thumb and forefinger of the left hand to turn down the fingers of the right, but keeping the other three fingers of the left hand still closed on the palm. On completing the ten (*ngahuru*) he holds up both hands, with all fingers closed, as he repeats the word *ngahuru*. Here is where the plural comes in. Both hands (all the fingers thereof) are *huru*, or *hurua*—contracted; hence *nga huru*, or *nga ringa huru*—two contracted hands, ten fingers are *huru*'d. I want you to be careful of this theory, and treat it with all respect. I shall not make up any more: it is too exhausting.

John Fraser states in his excellent paper on Polynesian numerals that *ngahuru* and allied terms originally meant "the whole"—that is, the whole of both hands: hence ten. Judging from some of the terms quoted by Fraser, it would appear that *huru* alone meant ten: as in the Samoan *e lua fulu* (*e rua huru*) for twenty—literally, two *huru;* also in *e fa ga fulu* (*e wha nga huru*) for forty—literally, four *huru*. In the Polynesian isle of Bukabuka the term *katoa*, a word signifying "all," is used to denote ten.

Another form of the word for ten is *tingahuru*. This form was used only when speaking of persons. A person asks, "*Tokohia te whakareka?*" (How many persons are there of the invitation party?) and one might answer, "*He tingahuru*" (There are ten), or "*He ti-ngahuru pea taua ope whakareka.*" It is difficult to say what was the origin of this *ti* before the ordinary word for ten. *Ti* is a causative prefix in Maori, as in *tiwaha*, *tirama*, &c. Vaux states that the causative prefix *whaka* is placed before "ten" in order to form the ordinal, just as *tua* was used. He gives as examples *tua-iwa* and *whaka-tekau* (*tekau* for ten)—ninth and tenth. I have never heard *whaka* so used, but it may be employed thus by tribes with which I am not acquainted. (Yes; see Maunsell's Grammar.)

Tekau.—This term, as already observed, is now applied to ten, but the old men of the Tuhoe Tribe agree that in pre-European days it was applied to twenty only, never to ten. They also state that no decimal system, or multiples of ten, were in use among the Natives prior to the arrival of Europeans in these isles. Nor was any quinary system in use, although there was a vigesimal method of numeration, as we shall presently see.

In regard to the change made by Europeans in Native systems of numeration, we have on record cases of such made by early missionaries in Rarotonga, the Hawaiian isles, and elsewhere. Many writers have been misled by the modern system of counting among the Maori people of New Zealand, and have treated it in their essays as though it were the ancient system of the land, by which the value of their remarks or researches has been much impaired. I cannot prove that among all the Maori tribes of New Zealand *tekau* = twenty, but it was certainly so used among the Tuhoe, Ngati-Awa, and Ngati-Porou Tribes. In counting by pairs or braces the term *ngahuru topu* (ten pairs) was used for twenty.

We shall see that there are three main points to explain in Maori numeration, if not three systems—viz., counting singly, the binary, and the vigesimal or semi-vigesimal methods—not to speak of the modern system, or the changes made when speaking of persons. The binary or dual method was not used in counting persons, although the vigesimal system was, where *hokorua* = forty, and *hokotoru* = sixty.

As to *tekau* for twenty: In the far-distant Paumotu Group we find that twenty is *rari takau*—literally, "one *takau*," *rari* meaning "one" or "alone." In Tahitian, *taau* = twenty; Tongan, *tekau* = twenty, also *fakakau* = to put in scores or twenties; Marquesan, *tekau* = twenty; Mangaian gives *takau* = ten pairs; in Mangareva, *takau* = a double ten, *takao* = twenty. This is good evidence in favour of the Maori statement that *tekau* was originally used for twenty. Mr. J. T. Large states that at Aitutaki Island twenty was expressed by the term *okotai takau* (*okotai* is *hokotahi* in the New Zealand dialect).

It seems probable that *tekau* was originally *te kau*, two distinct words; and it is the opinion of several Maori scholars that *kau* represents an original Polynesian word meaning "collection, assemblage." (See Tregear's Dictionary.)

The late Mr. A. S. Atkinson mentions, in a pamphlet published by him in 1893, that both Archdeacon Maunsell and Bishop Williams—two excellent Maori scholars—agreed in saying that among some tribes *ngahuru* meant ten, and *tekau* eleven: Bishop Williams saying that they counted by elevens, the eleventh being a tally; and he compares our "baker's dozen." Thompson, in his paper on "Barata Numerals,"* gives *tekau* for eleven, but does not quote any authority, except as to spelling. At page 137 he gives the Maori numerals one to ten, where he spells *tahi* (one) "*tahai*," *toru* appears as "*torou*," *wha* as "*t'fa*," *ono* as "*oné*," *ngahuru* as "*anga hourou*." After that, small wonder that he made "eleven" of *tekau:* we should be thankful that he made it nothing worse.

At page 61, vol. i, of the "Transactions of the New Zealand Institute" Mr. Phillips gives *tekau ma ngahuru* as meaning twenty, which is obviously an error, that term meaning thirty in Maori.

I have not been able to obtain locally any confirmation of the above remark concerning *tekau* as having been used for eleven, or of any system of counting by elevens; but it is possible that some tribes did so use the term. Many customs differed to some extent among various tribes.

The Vigesimal System of Enumeration (Table No. 1).

It appears to me that at some period of their history the Maori must have used a vigesimal numerical method—a system of counting by scores, or twenties. I shall include in this paper a table showing the method so far as I have been able to ascertain it from my local Native friends. It will be observed that there was a special term (*tekau*) for twenty, but none for thirty; a special term (*hokorua*) for forty, but none for fifty; a special term (*hokotoru*) for sixty, but none for seventy; and so on. Thirty was twenty and ten; thirty-one was twenty, ten, and one; and so on to thirty-nine. Forty was again a special term, then forty and one, then forty and two, and so on to forty-nine. Fifty was forty and ten; fifty-one was forty and ten and one, &c. (See Table No. 1.)

In the "Journal of the Polynesian Society," vol. x, p. 101, Professor Cyrus Thomas gives a short paper on the vigesimal system of enumeration. In it he observes that traces of a

* Trans. N.Z. Inst., vol. v, p. 131.

former system of vigesimal numeration have been observed in Oriental lands—in south-eastern Asia, Cambodia, and Malaysia—but long overlaid by the decimal system. The Cambodia system, as given by Aymonier, much resembles that of the Maori. There are characters for each of the nine digits, for twenty, and for a hundred (and presumably for ten). "The character for twenty is distinct, and not two tens. In order to indicate thirty-seven, there is first the character for twenty, then for ten, and last for seven." All this is the same as the Maori system. He goes on to say that forty is two twenties, sixty is three twenties, &c., there being a separate character for a hundred. "A mingling of the two systems is apparent in some of the examples given by Aymonier," &c. Now, this is just the Maori case. We note how the vigesimal and the *topu* or binary methods are sometimes confused by Natives, not in the special terms for scores so much as in the intermediate items. Doubtless, however, much of this confusion arises from the fact that these old-time methods of the Maori have been laid aside in favour of the decimal system introduced by Europeans, albeit the latter system is expressed in purely Maori terms. The older generation of living Natives can only recall the old-time numerical terms by an effort of memory; indeed, some have forgotten many of them. The younger generation know practically nothing of these matters. It is when an old Native is repeating tribal traditions, &c., that one hears quotations from the old numerical systems, but seldom under other circumstances.

Professor Thomas states that among the Maya people "The numbers from one to eleven had specific names, but from twelve to nineteen [were formed] by the addition of units. There was a specific name for twenty, four hundred, and four thousand. Numbers from twenty to four hundred were formed mostly by twenty as the multiple, and units." He notes some confusion, however, and evidence of the quinary and decimal systems.

In vol. xi. of the "Polynesian Journal" Mr. Large mentions a vigesimal system used by the Natives of Aitutaki, which is practically the same as that of the New Zealand Maori, the same terms being used, although the Cook Islands dialect has lost the *h* and aspirated *w*, the *w* having become *v*. In that system *okorua* = forty, *okotoru* = sixty, and so on.

In the same volume Mr. Percy Smith states that the Natives of Niue counted fish by twenties, *te kau* (or "two tens") being the term used, though it would appear that *tekau* was a specific term for twenty, and not "two tens." Was *kau* = ten, and *te* a plural, or "two," that *tekau* should be given as = two tens? Elsewhere it appears to be a special term for twenty. *Tekau* does not appear in the Niue vocabulary published by the Polynesian Society, neither does *te*; *kau* is given as meaning "company, troop." *Kau* is probably the root of the word, *te* being the definite article.

Since writing the above I have unearthed a long-buried copy of Maunsell's Maori Grammar, 3rd edition, 1882. I quote a few remarks therefrom to show how numeration differed in some districts, the result, perhaps, of tribal isolation. He explains the modern method of numeration by multiples of ten, but states in a note that "It should be here noticed that this is the new mode of reckoning brought in by Europeans, and now fast spreading over the land. The old mode is not so convenient, but it is often heard; 240 would, according to it, be thus expressed: *kotahi rau ma rua*—literally, one hundred and two. *Rua* here stands for (twice ten) twenty doubled. 250 would run thus: *kotahi rau, ma rua pu, tautahi*—one hundred and two double, and a *tautahi* (odd one)." Now, the above was the method of counting in the Waikato district. Observe that it was the dual system, couples or pairs being always implied, while *ma rua*, "and two," is made to serve for "and twenty" (couples understood). In the second illustration he gives the term *pu*, signifying "pairs," or "twice told," or "doubled"—thus, one hundred, and two pairs (for twenty doubled); this "two pairs," or "two doubled," being perhaps an abbreviation, though noticeable all over the Island. The term *tautahi* is used in a similar manner among Tuhoe. It is usually applied to a single odd number—*e.g.*, *e waru pu, tautahi*, for eight brace (or couples) and an odd one = seventeen. In Maunsell's example, however, it stands for ten, or an odd ten.

Maunsell, in giving the modern system, stated that *hokorua* is used for twenty, but explains in a note, "The Maori mode of counting has always heretofore been by pairs: thus *hokorua*, twenty, stands for twenty pair—*i.e.*, forty—and so on. When they wish it to be understood singly they postfix *takitaki* to the numeral adjective—*i.e.*, *hokorua takitaki* = twenty." This *takitaki* may be a misprint for *takitahi*, the term in general use to denote "singly," or "by ones." Here we have evidence that *hokorua*, *hokotoru*, &c., really mean twenty, thirty, &c., but that the term *topu* or *pu* (pairs) is understood, unless the expression *takitahi* be added, in which case hearers understand that counting singly is meant. Thus evidence accumulates to show that Maori numeration was dual in its character, and that the term *topu* (or *pu*) was by no means always used when employing that system, but was understood to be implied; also, that it was necessary to use the term *takitahi* to show that single numeration was meant.

Maunsell goes on to say that among the Ngapuhi Tribe *ngahuru* was used for ten and *tekau* for eleven, while in the centre of the Island *ngahuru* and *tekau* both represent ten. Judging from Polynesian comparatives, the use of *tekau*, both for ten and eleven, seems to be of local origin, though it may, strictly speaking, have meant ten pairs. He also gives a variation in the form of the distributive prefix, or a plural form thereof, where *tataki* is used for *taki*, the example being, *Kia tataki rua pu nga utu i te tangata* (Let each man have four payments). In speaking of the ordinals he gives three ways of expressing such—(1) By *tua* prefixed to the cardinal, as *tua toru* = third; (2) by *whaka* prefixed, as *whaka-tekau* = tenth; (3) by the simple cardinal with the definite article, as *te wha* = the fourth. The first and third of these modes have been given as in use among the Tuhoe Tribe, but *whaka* I have not heard so used. Was it used before ten only, or might it be used before any of the digits?

Having now (7th January, 1906) obtained some further information anent Maori numeration, I proceed to add the same to above notes.

Tekau.—Several old Natives of the Tuhoe and Ngati-Awa Tribes confirm the statement that *tekau* was formerly used to denote twenty, and was not used for ten. As *kau* seems to have been a Polynesian word meaning "collection" or "assembly," then the expression would probably have been originally *te kau* = the whole, or the assembling of the ten fingers and ten toes, *te* being the definite article singular.

Table No. 1: This shows the ordinary mode of counting singly, as formerly used. It includes, in a singular way, a vigesimal system—that is to say, it is partially vigesimal. It has the special term for ten which, however, was not used as a multiple. It has a special term for twenty, but none for thirty; a special term for forty, but none for fifty; for sixty, but none for seventy; and so on. Thirty was "twenty and ten." Thirty-one was "twenty, ten, and one"; and so on to thirty-nine. Forty was a distinct term (*hokorua*), and then another twenty was commenced. It will be observed that the vigesimal system was never carried beyond 180 (*hokoiwa*), or nine twenties, except in conjunction with the *rau* (hundred): *e.g.*, *kotahi rau, hokowhitu*, for 340—*i.e.*, one hundred twice told and seventy couples. A common form, however, was to abbreviate such terms: as *kotahi rau ma whitu*, or *he rau ma whitu*, for 340; *kotahi rau ma rua*, for 120 doubled; and so on.

I have consulted a great many Natives as to the value of the prefix *hoko*, and the majority state that this prefix conveyed the meaning of twenty times the subjoined numeral. Some, however, maintain that it merely implied ten times the subjoined numeral when the word *takitahi* (single, or singly) was added: as *hokorua takitahi*=twenty; *hokotoru takitahi*= thirty; and so on.

Confirmation has been received regarding the term *tekau maha ngahuru* for thirty, not only local, but also from the Ngati-Awa Tribe. I am unable to account for the syllable *ha*.

Table No. 2: This gives the dual system of numeration formerly in use among the Maori people, the counting by pairs, which was a common custom. This form of binary numeration was used only for game, baskets of food, and so forth, but was not applied to the *genus homo*. I have remarked above that the binary method was not used when counting persons. This remark needs some explanation. Certainly the dual method of numeration, as given in Table No. 2, was not used for persons, but another form of counting in pairs* was used for persons. Apart from the matter as to whether the prefix *hoko* multiplied the numeral ten or twenty times, there were other expressions used which doubled the number given. We have seen that *kotahi rau ma whitu* (one hundred and seventy) was used for 340. This was certainly applied to persons, as in giving the numbers of a war-party. This, and *hokowhitu* for 140 men, were such common terms that the word *topu* does not seem to have been employed to denote the fact that the number given meant so-many couples. But with other numbers the evidence seems to be in favour of the term *topu*, or *takitahi*, having been used: as *kotahi rau takitahi* (one hundred, singly, or once told), and *E wha rau topu taua ope* (That party consisted of four hundred [persons] twice told, or doubled). These expressions are used when speaking of persons, and seem to have been so used formerly. Many of my old Native friends say, "*Kaore i takirua te tatau mo te tangata*"—*i.e.*, persons were not counted in pairs. I believe they mean that, when actually counting a number of persons, the system given in Table No. 2 was not used. And it certainly was not. A person would not have counted persons in this manner—*ka tahi pu* (two), *ka rua pu* (four), *ka toru pu* (six), &c.—as he would in counting game, &c.; nor would he have said *ka toru pu, tautahi*, for seven persons. He would count them singly, and for seven persons he would have used *tokowhitu* (see Table No. 3). But if he had counted, say, 240 persons, and was asked how many there were, he would have replied, "*Kotahi rau, hokorua*"—one hundred (*topu* understood) and a *hokorua;* or "*Ko tahi rau ma wha*"—one hundred and forty (*topu* understood). In

* Or not exactly in pairs, as in Table No. 2, but the doubling of stated numbers, a "twice-told" mode.

stating numbers between one hundred and another, the terms *ma rua, ma toru, ma wha*, &c., were used to imply "and twenty," "and thirty," "and forty," and so on, though, strictly speaking, the expressions mean "and two," "and three," &c. Another ancient method of stating 240 was *kotahi rau, hokorua te paepae*—one hundred (*topu* understood), the excess a *hokorua*.

But to return to Table No. 2: In this is shown the method employed in counting by pairs—*i.e.*, the terms used for every number from 2 to 102, and a few of the leading figures from that number up to 1,000, which the reader will have no difficulty in following. But it must be mentioned here that a person engaged in counting a number of articles by the dual method would not make use of all these terms; he would not count the odd numbers, where the expression *tautahi* is employed. The terms for odd numbers are merely inserted to show what words express such numbers. Such are used only to express the total when that total contains an odd number. Observe: A fowler visits his bird-snares every morning in order to collect the birds. Having completed his round, he proceeds to count the birds taken. This he does by taking up two birds at a time and laying them aside. For the first brace he counts "*Ka tahi pu*"; for the second, "*Ka rua pu*"; for the third pair, "*Ka toru pu*"; for the fifth, "*Ka rima pu*"; for the tenth brace, "*Ngahuru pu.*" Here the word *ka* is dropped, but it is sometimes resumed for eleven brace, as *ngahuru pu, ka tahi pu*, and so on; *ngahuru pu, ka iwa pu*, for thirty-eight. It is not usual to use *ka* before *hokorua, hokotoru*, &c., but it is sometimes resumed after them: as *hokorua, ka tahi pu*, for forty-two; *hokorima, ka whitu pu*, for 114, &c. Indeed, I am inclined to believe that this was the more correct way of expressing numbers when actually engaged in counting.

Suppose our friend the fowler has taken seventy-seven birds: he goes on counting by the brace (*pu*) up to seventy-six—*hokotoru, e waru pu* (or *ka waru pu*); then, casting the remaining bird on the heap, he says, "*tautahi*" (an odd one). The number of birds taken is expressed by *hokotoru, e waru pu, tautahi* (sixty, eight brace, odd one).—*Q.E.D.*

The singular feature of this system of counting is the combination of the dual and vigesimal systems. It is purely dual up to twenty, but from the number twenty-two onwards to thirty-nine the numbers hinge upon twenty—as "ten brace, one brace," "ten brace, two brace," and so on—until the next twenty (*i.e.*, forty) is reached, where we note the special term *hokorua*, which again has pair after pair added to it until sixty (another special term) is attained, and so on to 199.

For 200 we find a new term employed—viz., the *rau*, or hundred, doubled. Upon this new base the *pu* and *hoko* systems are built up until 400 is attained, when we find the term *rua rau* (two hundred—brace understood) employed. The same system is repeated until 600 (*toru rau*), and so on. In actual counting, a person would probably say "*Ka rua rau, ka toru rau,*" &c., and not "*E rua rau, e toru rau.*" But if simply stating a number, not counting, he would probably use the particle *e*: "*E hia nga kete riwai i a koe?*" (How many baskets of potatoes have you?) and the answer would be, "*E rua rau,*" or "*Hoko toru,*" or whatever the number might be. But if the questioner used the verbal particle *ka*, then the answer would be preceded by that term: "*Ka hia au manu?*" Answer, "*Ka rua rau,*" or "*Ka wha pu,*" &c.

We have seen that *paepae* was used to imply an excess number. For instance, in counting by the dual system, 460 would often be given as *e rua rau, hokotoru te paepae* (two hundred—*pu* or *topu* understood), the *paepae* being sixty. This term for an excess number seems to have been used between hundreds only—*i.e.*, for numbers between 100 and 200, between 200 and 300, and so on. It is said to have been used in counting objects (game, &c.) only, and not in counting persons. The word *paepae* means the odd or excess numbers stretching forward towards the next hundred. *Pae* means "a step; direction; perch; to lie across; lie ready for use," &c. *Whakapae* = to lay across. *Paepae* and *paewai* = threshold. *Paepae* is the step towards the next hundred. Of these numbers between hundreds an old Native remarked, "*E pae tonu ana, kia tae ki te rau, kua kore e kiia he pae*" (They are all in the *pae* stage; when the next hundred is attained, the term *pae* is not applied). But it is again employed when the next hundred is commenced.

Another common expression for an excess number is *tuma*. Thus *ngahuru tuma* means "ten and an excess"; and it may be used for any number from eleven to nineteen inclusive. *Kotahi rau tuma* stands for one hundred and an excess, and may be used for any number from 101 to 199 inclusive. Such usage is equivalent to our expressions "twenty odd" and "one hundred odd," &c. These illustrations are from the single method of counting. Maunsell gives an illustration from the dual method—viz., *e rua mano ma wha, hokorima te tuma*, for 4,900; but literally it is "two thousand and four, *hokorima*"—the words "hundred doubled," or "hundred pairs," are omitted after the word "four," but are understood. In the modern system of counting by multiplying by ten we often hear the word *tuma* for the excess numbers between tens. But then, ten was not a multiple in the ancient system, nor was *tekau* used for ten. As old Tutaka expressed it, "*Tekau* as a term for ten is a modern usage. It was the white man and his books that made it known to us."

Makere is another term used to imply an excess number. *Ngahuru makere* (ten odd) seems to bear the meaning of "ten onwards," and may be used in relation to any number from eleven to nineteen inclusive. When explaining to me the meaning of the expression *ngahuru tuma*, a Native said, "*Mo te tekau makere tena karanga*" (That term is used to denote ten onwards). Here, of course, *tekau* is used with its modern meaning of ten.

And again, we have the word *rerenga* used in a like manner. *Rerenga* is a verbal noun (*rere* = to run, flow, &c.). *Kotahi tekau, e whitu te rerenga*, means "one ten, the balance or excess being seven." This, again, is the modern *tekau* = ten. Again, *kotahi rau me nga rerenga* stands for "one hundred and the balance" (or excess over 100).

The terms *tauwhara* and *tauhara* bear a similar meaning of excess numbers. When explaining to me the ancient binary system of counting, a Native said, "Game was so counted in former times, when the birds or rats were taken from the snares, but when they were potted in calabashes the odd numbers were omitted, and eighty-five birds would be styled a *hokowha* (eighty). (*Kia maoa rawa nga manu, kia uru ki te ngutu iti, ka whakarerea nga tauwhara.*)

Still again, we have the terms *kehe* and *taukehe* as meaning odd numbers. *Taukehe* is sometimes used in place of *tautahi*, when counting by the dual method: hence *ka rua pu, taukehe*, would be used for five; *ngahuru pu, taukehe* = twenty-one; and so on. *Kehe* is often used to express an odd number. When looking at a hut in course of erection a Native said to me, "*E he ana nga heke, kua kehe*" (The rafters are wrong, there is an odd one). It is a Native custom to always put an even number of rafters on either side of a roof. It is a sign of bad luck to put an odd number.

Williams's Maori Dictionary gives the following words not used among the Tuhoe Tribe: *Hara* = excess above a round number—*kotahi rau, e iwa nga hara*. *Hemihemi* = excess over a definite number—*kotahi rau ma whitu, hemihemi* (one hundred and seven and over).

Whakamoe (or *whakamoe mătă*) is an expression employed to denote the counting of game in braces, laying aside each brace as counted—*Kai te whakamoe a Turei i nga manu o te taha.*

In counting *koko* (tui) birds prepared for preserving, a *pu* or brace consisted of four birds (I am not a Milesian)—*i.e.*, they were set aside by fours, but the four were only called one *pu*. Possibly this was on account of the smallness of the bird. (*Mo te koko, kia makiritia, ka penei te karanga, he pu koko, mo te wha takitahi tena karanga*).

Although I have given in Table No. 2 that form of dual numeration which I believe was generally used in this district, yet some of my authorities differed from it in their accounts; for instance, one man gave a different method of counting from twenty-two to thirty-eight inclusive. Observe :—

20.	Ngahuru pu.		
22.	Ngahuru ma	tahi	(ten and one; "pu" understood).
24.	"	rua	(" two; "brace" understood).
26.	"	toru	(" three ").
28.	"	wha	(" four ").
30.	"	rima	(" five ").
32.	"	ono	(" six ").
34.	"	whitu	(" seven ").
36.	"	waru	(" eight ").
38.	"	iwa	(" nine ").
40.	Hokorua.		

Here we see pairs added to ten pairs until thirty-eight was reached, after which it was the same as Table No. 2—pairs added to twenties.

Another differed in his term for twenty only. He used *tekau* instead of *ngahuru pu*, and added pairs to it as in Table No. 2—*tekau, kotahi pu* (twenty-two), *tekau, e rua pu* (twenty-four), &c. This man is one of those who maintain that persons were always counted singly. He says that, when speaking of persons, *hoko* multiplies the subjoined numeral by ten only—*hokorua* = twenty, *hokotoru* = thirty, &c.—while it multiplies the numeral by twenty in counting game, &c. Another old Native, a man of much knowledge, also maintains that *hoko* was used in both ways—*i.e.*, *takitahi* and *takirua*—which supports Williams's Dictionary. Thus *hokorua takitahi* would be twenty, while *hokorua topu* would stand for forty. This latter (Native) authority states that if in stating a number a person simply said "*Hokowha*," he would be asked, "*Hokowha aha?*" (Forty what?) and the reply would be "*Hokowha takitahi*," or "*Hokowha topu*," as the case might be. Also that, in using the dual method, the terms *hokorua, hokotoru*, &c., should really be followed by *pu*, but that it is usually omitted. Again, he states that prefixes were often omitted—*e.g.*, *ngahuru pu, tahi pu* (twenty-two); *ngahuru pu, rua pu* (twenty-four), &c.—when counting.

When, in counting his bag, a fowler found he had taken, say, 105 or 107 birds, he would often wait until he had made the number up to, say, 110 before returning home, to abolish the *taukehe*.

One of my old Native authorities is confident that in former times the Tuhoe people counted up to 1,000 readily, but did not carry the system beyond that number. Still, it is clear that they could express any number up to 2,000 by the use of the term *topu*—as *E whitu rau ma rima topu* = seven hundred and fifty pairs = 1,500; *kotahi mano topu* = one thousand pairs = 2,000. Higher numbers were, he says, expressed by such terms as *tini*, &c. (see *ante*).

The words *nui* and *maha* mean "many," the latter being prefixed by *toko* when applied to persons. *Iti* is sometimes used as = "few," though, strictly speaking, its meaning is "small" (*tokoiti*) when applied to persons. *Tokohinu* = some. *Ouou*, *ruarua*, and *torutoru* are also used for "few," and are sometimes, not always, given the prefix *toko*—*i.e.*, when speaking of persons. The two last expressions are, it may be observed, formed by doubling the words *rua* (two) and *toru* (three). In Williams's Maori Dictionary we find *rūrŭa* = both equally. (*E tika rurua ana raua* = They are both equally correct.)

We have seen that *măno* is used for 1,000—a specific term for that number; also that it is employed with a more vague sense—"numberless," or "multitudinous"—though often coupled with other expressions, as *mano tini* or *mano raua ko tini*, *mano tini whaioio*. The last is sometimes merely *tini whaioio*. Williams gives *hea* = multitude, majority; and *mano tuauriuri* = very many. The numeration terms *ngera*, *makehua*, *maioio*, *rea*, given by Maunsell, I have not heard used, nor yet the expression *tini whakarere*. They are probably peculiar to tribes of the Waikato, or northern districts. *Tini makehua* is a peculiar term. I cannot refrain from thinking *makehua* allied to *makahua*, a generic term for stones. Tylor, in his "Anthropology," gives some account of the origin of numeration and ciphering, showing how many people reckoned with stones used as counters; as also the origin of the Latin *calculare*, and our word *calculate*, from *calculus* = a pebble.

As observed, none of the Maori terms for the digits seem to have any connection with the names of the fingers, although the word for five (*rima*) is apparently an old-time Polynesian word for hand. The names of the fingers are *takonui* (thumb), *takoroa* (forefinger), *manawa*, *mapere*, *toiti*. These are termed the *tokorima a Maui* (the five of Maui). The prefix *toko* is employed because the five were persons—*i.e.*, the personifications of fire. For these were the Fire Children of Mahuika, the Maori fire-goddess, who were destroyed by Maui when he obtained fire for man. If, when offering food to a Native, you apologize for the lack of knife and fork, he will say, "Never mind, I have the *tokorima a Maui*."*

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* Sometimes simply *tokorima*. Ex., "*E aurakina nei e oku tokorima*."

It is a very ancient myth, and curious withal, that of the origin of fire—that is to say, of the Fire Children. "It was in an age long past away, before man was, that the thought came to the son of Tangotango [*i.e.*, to the sun] that he would send his child to the lower world to convey to his descendants there a great boon, the blessing of fire. Hence he said to his child, to Auahi-tu-roa, 'Go you to convey a boon to our descendants in the world.' And his son asked, 'How shall I give it?' The sun replied, 'Give them fire' [*tokorima*]. So Auahi-tu-roa descended to the earth. He came to Mahuika, younger sister to Hine-nui-te-Po [goddess of Hades], and ere long she gave birth to five children, whose names were Takonui, Takoroa, Manawa, Mapere, and Toiti. Those children were the Fire Children." Here we see how fire originally came from the sun. But this is digression. Return we to our numeration.

Williams gives a word I have not before met with, *makiu* = very numerous. Ex., "*Tuauriuri whaioio, makiu, makiu.*"

The modern method of adding units to 100 is by means of the conjunction *ma : kotahi rau ma whitu*—one hundred and seven. But in the old system of single counting this phrase seems to have stood for 170. *Kotahi rau ma rua* = one hundred and twenty (literally, one hundred and two). This method was used between hundreds, to express the odd tens, and is the only item in Tuhoe numeration of pre-European days that is decimal in its nature.

An ancient way of adding units to hundreds was by using the particle *e*—*kotahi rau, e whitu*, for 107. *Kotahi ma whitu* was not only an exact term for 170, but also a vague expression employed for any number of persons between 100 and 200. *Rau ma whitu* was used in the same manner, applied to a war-party, or company of travellers. It simply meant between 100 and 200. In like manner the term *hokowhitu* was used in the same vague way, when applied to a company of people. As my informant put it, "*Kia eke rawa ki te rau, katahi ka karangatia.*" It was only when the hundred was attained that the term was altered.

In that very singular work, "Te Ika a Maui," by the Rev. R. Taylor, are some curious remarks anent Maori counting. He says, "The old Maori way of counting was evidently at first by the fingers up to ten, then a shake of both hands was given, which signified one ten—this was called a *nga huru*, or the entire ten fingers; one hand being shaken implied five, or the half; ten shakes of the two were 100; and so on. Thus *kotahi* was one finger; *ka rua*, two, &c.; *ka tekau*, ten: then a shake of the hands was given

—this was *nga huru,* the whole ten fingers; *tekau ma tahi,* eleven; *tekau ma rua*, twelve, &c.; *rua tekau*, twenty; and so on to *kotahi rau,* 100, and *kotahi mano*, 1,000: beyond that all numbers were *mano tinitini*. . . . Unless they added *takitahi* (once told) to these shakes they meant double: thus *kotahi rau* would signify 200, unless they said *kotahi rau takitahi* (a hundred once told). *Pu* also signifies counting by pairs, unless qualified by the word *topu:* thus *kotahi pu topu* is simply two, but *e rua pu* is two pairs, or four; *ngahuru* (ten) is thus twenty. The word *hoko* signifies the doubling of twenty: *nga hoko rua*, forty; *nga hoko toru*, sixty; *nga hoko tekau*, two hundred . . . *kotahi rau hoko whitu*, one hundred doubled and seven twenties. *Topu* also signifies a pair doubled, or four."

The items in the above which arrest our attention are: The shaking of the hand, or hands, to show that five, or ten, is complete; and the use of *tekau* for ten, which the reverend author seems to imply was an ancient custom. It would be interesting to know what tribe these notes were obtained from. His remarks on the terms *pu* and *topu* are peculiar. I cannot see how *topu* qualifies *pu*. *Pu* means a pair, and requires no qualification. *Kotahi pu topu* sounds very tautological, while *hoko* scarcely signifies the doubling of twenty, but the multiplying by that number.

We may note that the Maori had no knowledge of ciphering, or any form of abacus, so far as we know. They possessed, apparently, one only mnemonic aid to memory in their genealogical staves. This was a piece of hardwood about 1 in. in diameter and 3 ft. or so in length. It had on one side a series of square-edged notches cut in it, the pieces of wood left between the notches being about ½ in. or ¾ in. These represented each a generation. These staves were, if necessary, used in a boustrophedon manner. They were but a crude aid to memory, and their use does not appear to have been very common.

The word *mutu* is sometimes used after a round number to show that no excess exists—*e.g.*, *kotahi rau mutu* (one hundred and no excess).

Ngahoro is another term used to imply an excess number: thus *hokorua ngahoro* is equivalent to *hokorua makere*, &c., and means a *hokorua* and an excess number. If *hokorua* is used in the *topu* sense, then the above expression may be used for any number from forty-one to fifty-nine inclusive.

Table No. 3: In this table we see the old-time Maori method of enumerating persons. The prefix *toko*, used only when speaking of persons, has already been noted, as also the terms *tingahuru* and *tekau*.

Although the *topu* or binary system of counting, as given in Table No. 2, was not applied to persons, yet the double *hoko* and *rau* methods were. Thus *hokorua* was usually employed to denote forty persons, *hokotoru* for sixty, and on to *hokoiwa* for 180. The single *hoko* system appears to have been sometimes employed when stating an excess over a round number (see Table No. 3 for examples). The single *rau*, or hundred, seems to have been seldom applied to persons, 100 being expressed by *hokorima*. But 200 was *kotahi rau topu*—*i.e.*, one hundred doubled, or one hundred pairs. The word *topu* was not actually used, as a rule, but was left to be inferred. Thus 140 was termed a *hokowhitu*; 340 was a *rau hokowhitu.*

I have given many terms in Table No. 3, so that the reader may know the exact terms for precise numbers; but it must be here explained that the Maori usually gave round numbers for persons, and seldom expressed exact numbers between twenties. He would use the term *hokorua makere* for any number between forty and sixty, and would not specify the excess unless under peculiar conditions—*e.g.*, in answer to a question. In like manner the expression *kotahi rau tuma* might be used for any number between 200 and 300, unless he employed the *takitahi* method, in which case it might stand for any number between 100 and 200. The table shows the forms employed to express the excess numbers, when required. The number 101 might also be expressed by *hokorima, kotahi te tuma*; 102 by *hokorima, tokorua te tuma*; and so on to 119 = *hokorima ngahuru ma tahi te tuma* (or *paepae*); 122 might be given as *hokoono, tokorua te tuma*, and so on; 130 as *hokoono, he ti ngahuru te tuma*; 131, *hokoono, ngahuru ma tahi te tuma*, and so on. The different terms used to denote a given number are perplexing in the extreme. Possibly different methods, or different expressions, were formerly used among different tribes, and the modern Maori has confused them.

If the single *hoko* and *rau* terms are used, then the system of numeration may be termed decimal; but if the double *hoko* method be employed (as *hokorua* = forty, &c., and *kotahi rau* = 200), then the system is vigesimal.

Regarding the numbers eleven to nineteen in Table No. 3, these were given to me by Te Puia, of Tuhoe, as—eleven, *ti ngahuru, kotahi*; twelve, *ti ngahuru, tokorua*; thirteen, *ti ngahuru, tokotoru*; nineteen, *ti ngahuru, tokoiwa*. He also gave—fifty-one as *hokorua, ngahuru takitahi, kotahi*; fifty-two as *hokorua, ngahuru takitahi, tokorua*; fifty-three as *hokorua, ngahuru takitahi, tokotoru*; and so on to *hokotoru* = sixty.

The Ngati-Awa Tribe, according to Matutaera Hatua, objected to applying the *topu* system of counting to persons because it interfered with their *kawa tapu.* Probably this was on account of food-supplies being counted by the *topu* or binary system. As almost all local authorities agree that persons were counted singly, and not by the *tatau topu*, I feel certain that the double *hoko* and *rau* methods (*hokorua* = forty, &c.; *kotahi rau* = 200) are not viewed by Natives as being binary in their nature, but that that expression is applied only to the system of counting in pairs, as given in Table No. 2; and, moreover, that the vigesimal (or double *hoko*) method was a system of numeration known to, and used by, the Polynesian peoples in times long past away. Thus, the reader will bear in mind that the vigesimal system, as given in Table No. 3, seems to have been that in common use for enumerating persons. The variant forms, as *kotahi rau takitahi* for 100, *kotahi rau ma rua* and *kotahi rau, hokorua takitahi te paepae*, for 120, &c., do not seem to have been so much used, at least according to evidence now obtainable.

In regard to Table No. 1, it seems probable from the evidence of many Natives that the terms *hokorua makere, hokotoru makere*, and so on, were also much more commonly used than a perusal of that table would lead one to suppose. I have given the definite terms between twenties, in order to place my notes on record, and to render the table complete; but a Native would very often say *hokorua makere* for any number from forty-one to fifty-nine inclusive. This is equivalent to our system of counting by scores, when we say, "Three score odd," &c.

A singular form obtains among some of the Waikato Natives, of expressing the numbers twelve to nineteen in the numeration of persons, as—*tekau ma tokorua*, for twelve; *tekau ma tokotoru*, for thirteen; and *tekau ma tokoiwa*, for nineteen.

Puihi Maru-tawhao, an old man of Tuhoe, has given me the following notes lately: The *pu koko* (see *ante*) consisted, in this district, of six birds. These were, presumably, considered equal to two pigeons or *kaka*. Both the single and double *hoko* systems were formerly used here—*e.g.*, *hokorua takitahi* stood for twenty, and *hokorua topu* for forty. He says that *hokotahi* was not here used. Fish, as well as birds, were counted in pairs—*i.e.*, the binary method was employed; but baskets of *kumara*, &c., were counted singly.

And here endeth such notes as we have collected anent the systems of enumeration employed by the Tuhoe Tribe in days of old. They are not remarkable for clearness, but represent, nevertheless, much work in collection, and close questioning of many persons.

Table No. 1.

Tatau Takitahi (Single Method of Numeration).

1. Kotahi.
2. E rua.
3. E toru.
4. E wha.
5. E rima.
6. E ono.
7. E whitu.
8. E waru.
9. E iwa.
10. Ngahuru.

11. Ngahuru ma tahi (ten and one).
12. „ rua („ two).
13. „ toru („ three).
14. „ wha &c., &c.
15. „ rima
16. „ ono
17. „ whitu
18. „ waru
19. „ iwa
20. Tekau.

21. Tekau ma tahi (twenty and one).
22. „ rua („ two).
23. „ toru („ three).
24. „ wha &c., &c.
25. „ rima
26. „ ono
27. „ whitu
28. „ waru
29. „ iwa
30. Tekau maha ngahuru (twenty and ten).

31. Tekau, ngahuru ma tahi (twenty, ten and one).
32. „ „ rua („ „ two).
33. „ „ toru &c., &c.
34. „ „ wha
35. „ „ rima
36. „ „ ono
37. „ „ whitu
38. „ „ waru
39. „ „ iwa
40. Hokorua topu (forty, *or* ten twos doubled), *or* hokowha takitahi.

41. Hokorua ma tahi; *or* hokorua, kotahi te tuma.
42. „ rua; *or* „ e rua „
43. &c., &c.
44.
45. *Or simply* hokorua makere.
46.
47.
48.
49.

50. Hokotoru, ngahuru takitahi (forty, ten single; *or* ten twos doubled and ten single).
51. " ngahuru ma tahi (forty, ten and one; *or* ten twos doubled and one).
52. " " rua
53. " " toru
54. " " wha
55. " " rima
56. " " ono
57. " " whitu
58. " " waru
59. " " iwa

or hokorua makere (sometimes "te tuma" (the excess) added to terms for fifty to fifty-nine inclusive).

60. Hokotoru topu, *or* hokoono takitahi.
61. Hokotoru ma tahi; *or* hokotoru, kotahi te tuma
62. " rua; *or* " e rua "
63. " toru; *or* " e toru "
64. " wha; *or* " e wha "
65. " rima; *or* " e rima "
66. " ono; *or* " e ono "
67. " whitu; *or* " e whitu "
68. " waru; *or* " e waru "
69. " iwa; *or* " e iwa "

or hokotoru makere.

70. Hokotoru, ngahuru takitahi
71. " ngahuru ma tahi
72. " " rua
73. " " toru
74. " " wha
75. " " rima
76. " " ono
77. " " whitu
78. " " waru
79. " " iwa

Sometimes the words "te tuma" (the excess) are used after each term; *or* hokotoru tuma (sixty and excess) used for any number from sixty-one to seventy-nine, *or* hokotoru makere is so used.

80. Hokowha topu, *or* hokowaru takitahi.
81. Hokowha ma tahi; *or* hokowha, kotahi te tuma
82. Hokowha ma rua; *or* hokowha, e rua te tuma
83. &c., &c.
84.
85.
86.
87.
88.
89.
90. Hokowha, ngahuru takitahi
91. Hokowha, ngahuru ma tahi
92. " " rua
93. " " toru
94. " " wha
95. " " rima
96. " " ono
97. " " whitu
98. " " waru
99. " " iwa

Te tuma sometimes added; *or* hokowha tuma (*or* makere, *or* ngahoro) used for any number from eighty-one to ninety-nine.

100. Hokorima topu; *or* kotahi rau takitahi.
101. Hokorima ma tahi; *or* hokorima, kotahi te tuma; *or* kotahi rau, kotahi.

102. Hokorima ma rua; *or* hokorima, e rua te tuma; *or* kotahi rau, e rua.
103. Hokorima ma toru; *or* hokorima, e toru te tuma; *or* kotahi rau, e toru.
104. Hokorima ma wha; *or* hokorima, e wha te tuma; *or* kotahi rau, e wha.
105. Hokorima ma rima; *or* hokorima, e rima te tuma; *or* kotahi rau, e rima.
106. Hokorima ma ono; *or* hokorima, e ono te tuma; *or* kotahi rau, e ono.
107. Hokorima ma whitu; *or* hokorima, e whitu te tuma; *or* kotahi rau, e whitu.
108. Hokorima ma waru; *or* hokorima, e waru te tuma; *or* kotahi rau, e waru.
109. Hokorima ma iwa; *or* hokorima, e iwa te tuma; *or* kotahi rau, e iwa.
110. Hokorima, ngahuru takitahi te tuma.
111. „ „ ma tahi „
120. Hokoono topu; *or* kotahi rau ma rua.
121. Hokoono ma tahi; *or* hokoono, kotahi te tuma.
122. „ rua; *or* „ e rua „
140. Hokowhitu topu; *or* kotahi rau ma wha.
160. Hokowaru topu; *or* „ ono.
180. Hokoiwa topu; *or* „ waru.
190. Hokoiwa, ngahuru takitahi; *or* kotahi rau ma iwa.
191. „ ngahuru ma tahi.
199. „ „ iwa.
200. E rua rau (takitahi).
201 to 219. E rua rau tūmā. (The excess number stated if necessary.)
220. E rua rau, hokorua takitahi; *or* e rua rau ma rua.
221. E rua rau, hokorua ma tahi te paepae (*or* tuma), &c.
230. „ hokotoru takitahi te paepae (*i.e.*, two hundred, thirty once told the excess); *or* e rua rau ma toru.
240. „ hokowha takitahi te paepae; *or* e rua rau ma wha.
250. „ hokorima „ *or* „ ma rima.
260. „ hokoono „ *or* „ ma ono.
300. E toru rau (takitahi).
400. E wha „ „
1000. Kotahi mano.

Table No. 2.

Tatau Topu (the Binary or Dual System of Counting, used when counting Game, Fish, etc.).

1.
2. Ka tahi pu (one brace or pair).
3. „ tautahi (one brace (and an) odd one).
4. Ka rua pu (two brace).
5. „ tautahi (two brace (and an) odd one).
6. Ka toru pu (three brace).
7. „ tautahi.
8. Ka wha pu (four brace).
9. „ tautahi.
10. Ka rima pu.
11. „ tautahi.
12. Ka ono pu.
13. „ tautahi.

14. Ka whitu pu.
15. ″ tautahi.
16. Ka waru pu.
17. ″ tautahi.
18. Ka iwa pu.
19. ″ tautahi.
20. Ngahuru pu (ten brace).
21. ″ tautahi (ten brace (and an) odd one).
22. ″ kotahi pu (ten brace, one brace).
23. ″ ″ tautahi (ten brace, one brace, odd one).
24. ″ e rua pu (ten brace, two brace).
25. ″ ″ tautahi (ten brace, two brace, odd one).
26. ″ e toru pu.
27. ″ ″ tautahi.
28. ″ e wha pu.
29. ″ ″ tautahi.
30. ″ e rima pu.
31. ″ ″ tautahi.
32. ″ e ono pu.
33. ″ ″ tautahi.
34. ″ e whitu pu.
35. ″ ″ tautahi.
36. ″ e waru pu.
37. ″ ″ tautahi.
38. ″ e iwa pu.
39. ″ ″ tautahi.
40. Hokorua.
41. Hokorua, tautahi.
42. ″ kotahi pu.
43. ″ ″ tautahi.
44. ″ e rua pu.
45. ″ ″ tautahi.
46. ″ e toru pu.
47. ″ ″ tautahi.
48. ″ e wha pu.
49. ″ ″ tautahi.
50. ″ e rima pu.
51. ″ ″ tautahi.
52. ″ e ono pu.
53. ″ ″ tautahi.
54. ″ e whitu pu.
55. ″ ″ tautahi.
56. ″ e waru pu.
57. ″ ″ tautahi.
58. ″ e iwa pu.
59. ″ ″ tautahi.
60. Hokotoru.
61. Hokotoru, tautahi.
62. ″ kotahi pu.
63. ″ ″ tautahi.
64. ″ e rua pu.
65. ″ ″ tautahi.
66. ″ e toru pu.
67. ″ ″ tautahi.
68. ″ e wha pu.
69. ″ ″ tautahi.
70. ″ e rima pu.
71. ″ ″ tautahi.
72. ″ e ono pu.

73. Hokotoru, e ono pu, tautahi.
74. „ e whitu pu.
75. „ „ tautahi.
76. „ e waru pu.
77. „ „ tautahi.
78. „ e iwa pu.
79. „ „ tautahi.
80. Hokowha.
81. „ tautahi.
82. „ kotahi pu.
83. „ „ tautahi.
84. „ e rua pu.
85. „ „ tautahi.
86. „ e toru pu.
87. „ „ tautahi.
88. „ e wha pu.
89. „ „ tautahi.
90. „ e rima pu.
91. „ „ tautahi.
92. „ e ono pu.
93. „ „ tautahi.
94. „ e whitu pu.
95. „ „ tautahi.
96. „ e waru pu.
97. „ „ tautahi.
98. „ e iwa pu.
99. „ „ tautahi.
100. Hokorima.
101. „ tautahi.
102. „ kotahi pu.
110. „ e rima pu.
120. Hokoono.
121. „ tautahi.
122. „ kotahi pu.
140. Hokowhitu.
160. Hokowaru.
180. Hokoiwa.
200. Kotahi rau (*i.e.*, one hundred ; brace, "pu," understood).
210. „ e rima pu.
220. „ ngahuru pu.
240. „ hokorua.
260. „ hokotoru.
280. „ hokowha.
300. „ hokorima.
301. „ „ tautahi.
302. „ „ kotahi pu.
400. E rua rau (*i.e.*, two hundred ; brace, or pairs, "pu," understood).
401. „ tautahi.
402. „ kotahi pu.
403. „ „ tautahi.
500. „ hokorima.
600. E toru rau.
700. „ hokorima.
800. E wha rau.
900. „ hokorima.
1000. E rima rau (*i.e.*, five hundred, "pu" understood).
2000. Kotahi mano ("pu" understood).

Table No. 3.

Tatau Tangata (Enumeration of Persons).

1. Kotahi.
2. Tokorua.
3. Tokotoru.
4. Tokowha.
5. Tokorima.
6. Tokoono.
7. Tokowhitu.
8. Tokowaru.
9. Tokoiwa.
10. Tingahuru.
11. Tingahuru ma tahi (*or abbreviated to* ngahuru ma tahi).
12. „ rua (ten and two).
13. „ toru (ten and three).
14. „ wha &c., &c.
15. „ rima
16. „ ono
17. „ whitu
18. „ waru
19. „ iwa
20. Tekau, *or* hokorua takitahi.
21. Tekau ma tahi (twenty and one).
22. „ rua („ two).

&c., &c. (see Table No. 1).

30. Tekau, maha ngahuru.
31. „ ngahuru ma tahi.

&c., &c. (see Table No. 1).

40. Hokorua topu, *or* hokowha takitahi.
41. „ kotahi te tuma ; *or* hokorua makere.
42. „ tokorua „ *or* „
43. „ tokotoru „ *or* „
44. „ tokowha „ *or* „
45. „ tokorima „ *or* „
46. „ tokoono „ *or* „
47. „ tokowhitu „ *or* „
48. „ tokowaru „ *or* „
49. „ tokoiwa „ *or* „
50. „ ngahuru takitahi *or* „
51. „ ngahuru ma tahi te tuma ; *or* hokorua makere.
52. „ „ rua „ *or* „
53. „ „ toru „ *or* „
60. Hokotoru topu, *or* hokoono takitahi.
61. Hokotoru kotahi te tuma ; *or* hokotoru makere.
62. „ tokorua „ *or* „
70. „ ngahuru takitahi *or* „
71. „ ngahuru ma tahi te tuma ; *or* hokotoru makere.
80. Hokowha topu, *or* hokowaru takitahi.
100. Hokorima topu, *or* kotahi rau takitahi.

The numbers 101 to 119 would usually be given as kotahi rau (takitahi), tuma = one hundred and an excess; *or* hokorima tuma takitahi.

120. Hokoono topu ; *or* kotahi rau ma rua ; *or* kotahi rau, hokorua takitahi te paepae.
140. Hokowhitu topu ; *or* kotahi rau ma wha ; *or* kotahi rau, hokowha takitahi te paepae.
170. Kotahi rau ma whitu (takitahi) ; *or* kotahi rau, hokowhitu takitahi te paepae ; *or* hokowaru makere.

180. Kotahi rau ma waru (takitahi); *or* kotahi rau, hokowaru takitahi te paepae; *or* hokoiwa topu.
190. Kotahi rau ma iwa takitahi; *or* kotahi rau, hokoiwa takitahi te paepae; *or* hokoiwa topu, he tingahuru te paepae.
200. Kotahi rau topu; *or* e rua rau takitahi.
220. Kotahi rau topu hokorua takitahi te paepae; *or* e rua rau ma rua, takitahi.
230. Kotahi rau topu, hokotoru takitahi te paepae; *or* e rua rau ma toru, takitahi.
240. Kotahi rau topu, hokorua te paepae; *or* kotahi rau ma rua topu.
250. Kotahi rau topu, hokorima takitahi te paepae.
260. Kotahi rau ma toru topu; *or* kotahi rau, hokotoru.
300. Kotahi rau ma rima topu; *or* kotahi rau, hokorima.
340. Kotahi rau ma whitu; *or* kotahi rau, hokowhitu.
400. E rua rau topu.
500. E rua rau ma rima topu; *or* e rua rau, hokorima.
600. E toru rau topu.
700. E toru rau ma rima topu; *or* e toru rau, hokorima.
800. E wha rau topu.
900. E wha rau ma rima topu; *or* e wha rau, hokorima.
1000. E rima rau topu.
1100. E rima rau ma rima topu; *or* e rima rau, hokorima.
1200. E ono rau topu.
2000. Kotahi mano topu.

TABLE No. 4.

THE MODERN DECIMAL SYSTEM ADOPTED DURING THE FIRST HALF OF THE NINETEENTH CENTURY, BUT WHICH WAS UNKNOWN IN ANCIENT TIMES.

1 to 9. Same as Table No. 1.
10. Tekau (kotahi tekau = one ten, to be explicit).
11. Tekau ma tahi (ten and one).
12. 〃 rua (〃 two).
13. 〃 toru (〃 three).
14. 〃 wha (〃 four).
15. 〃 rima &c., &c.
16. 〃 ono
17. 〃 whitu
18. 〃 waru
19. 〃 iwa
20. E rua tekau (two tens).
21. E rua tekau ma tahi (two tens and one).
22. 〃 rua (〃 two).
23. 〃 toru (〃 three).
24. 〃 wha &c., &c.
25. 〃 rima
26. 〃 ono
27. 〃 whitu
28. 〃 waru
29. 〃 iwa
30. E toru tekau (three tens).
31. 〃 ma tahi (three tens and one).
32. 〃 ma rua (〃 two).
40. E wha tekau (four tens).
50. E rima tekau (five tens).
60. E ono tekau (six tens).
90. E iwa tekau (nine tens).

100.	Kotahi rau.	
101.	Kotahi rau ma tahi (one hundred and one).	
102.	"	ma rua (" two).
110.	"	kotahi tekau (one hundred, one ten).
111.	"	" ma tahi (one hundred, one ten, and one).
115.	"	" ma rima.
120.	"	e rua tekau.
121.	"	" ma tahi.
199.	"	e iwa tekau ma iwa.
200.	E rua rau.	
201.	"	ma tahi.
202.	"	ma rua.
250.	"	e rima tekau.
300.	E toru rau.	
400.	E wha rau.	
500.	E rima rau.	
1000.	Kotahi mano.	
1001.	"	ma tahi.
1100.	"	kotahi rau.
1101.	"	" ma tahi.
1102.	"	" ma rua.
1906.	"	e iwa rau ma ono.
2000.	E rua mano.	
3000.	E toru mano.	
10000.	Kotahi tekau mano.	
100000.	Kotahi rau mano.	

Art. XVI.—*Two New Species of Leech in New Zealand.*

By W. B. Benham, D.Sc., University of Otago.

[*Read before the Otago Institute, 13th November,* 1906.]

Plates VIII and VIIIa.

Up to the present time two species of leech have been described from this region—the first by Dendy and Olliver in 1900, and three years later I added a second species. Since that date I have been trying to obtain leeches—which undoubtedly occur in our streams in various parts of the Island—but with only limited success. In the present communication I give an account of the anatomy, internal and external, of two new species, and add a short description of the internal anatomy of *Hirudo antipodum.* The four leeches now known to occur in New Zealand are here systematically arranged.

Order RHYNCHOBDELLIDA.

Fam. GLOSSOSIPHONIDÆ.

Microbdella, Moore, 1900.

M. novæ-zealandiæ, Dendy and Olliver.

Placobdella, Blanchard, 1893.

P. maorica, n. sp.

Order ARHYNCHOBDELLIDA.

Fam. HIRUDINIDÆ.

Hirudo, Linné, 1758.

H. antipodum, Benham.

H. mauiana, n. sp.

Placobdella maorica, n. sp.

A single specimen of this small aquatic leech was forwarded to me by Professor Chilton, who had received it from Mr. T. Horan, of Ruapuke Island, in Foveaux Strait. It was preserved in alcohol, and was a good deal contracted.

Shape and Dimensions.—The form is oval, much arched dorsally, concave ventrally. The head was curved downwards. The posterior end was also bent downwards, so that the hinder sucker was hidden when the animal was viewed from above. The lateral margins were similarly inflexed, rounded (fig. 1).

The total length measured along the curved dorsum was 9 mm.; the transverse diameter, 4 mm.; the widest part being about the middle of the body. The posterior sucker measured 1·75 mm. across, and the margins inflexed. Probably in life the animal would be about an inch in length.

Colour and External Features.—The colour is a uniform pale-greyish brown in spirit, without any trace of pattern or coloured spots, but under a dissecting-lens one or more rows of minute brown dots were visible in each annulus. Certain of the annuli (see below) carry four papillæ, regularly arranged so as to form four longitudinal rows along the dorsal surface.

As for the "segmental sensillæ," on which Whitman (16, 19) laid so great a stress in his valuable work on the land-leeches of Japan, and which have since been utilised for the purpose of plotting out the segments, I was unable to recognise any definite organs. Oka (14) and Castle (8) have also found a difficulty in applying this method to some members of the family Glossosiphonidæ.

There is a single pair of eyes on the 3rd annulus. They are not quite symmetrical, as that on the left side is slightly more anteriorly placed than the right eye. Possibly this ocular annulus is double; but in the following enumeration of somites and annuli I have refrained from a too detailed analysis, as it is extremely difficult on a preserved and strongly contracted specimen, especially when only a single individual is at hand, to be certain of the difference between annuli and "wrinklings," even in longitudinal sections. Consequently I neglect the apparently double nature of certain annuli, and regard each as single. In front of the eyes are two annuli, both of which are strongly bent so as to be V-shaped in this individual. The ocular annulus is thus the 3rd; the 4th shows indications, especially laterally, of being double; the 5th is the first complete one, and forms the posterior margin of the anterior sucker: this also presents an indication of being double.

There appear to be 70 annuli—possibly 71 or even 72; but the posterior region is so much contracted that I did not find it possible to distinguish annuli certainly from the wrinklings on the base of the sucker.

The anus is on the 69th annulus.

The papillæ above referred to are on annuli 6, 9, 12 &c., 63, 68, 69, and I believe on 70 and 71, which are at base of the sucker and form its dorsal surface here. There are, thus, normally three annuli to a somite. In the greater part of these annuli there are four papillæ—a pair dorsally and a pair dorso-laterally placed. They are nearly equidistant from each other, but the space between the dorso-lateral and the margin of the leech is about half that separating the dorsal from the dorso-lateral (figs. 2, 3). Owing to the great contraction of the two extremities I was unable to detect the outer papillæ on annuli 6, 9, or 68, 69.

Turning now to the ventral surface, the anterior sucker is bounded posteriorly by the 5th annulus. The mouth lies rather low down on the anterior lip, and was only recognisable in sections. The true form of this anterior sucker is concealed by the contraction of the leech, the upper lip being curved downwards so as to reduce the opening to a narrow crescentic slit.

The male pore is a rounded prominence (? due to contraction) between the 25th and 26th annuli (*i.e.*, 21st and 22nd post-oral). The female pore, detected only in sections, lies two annuli behind—*i.e.*, between the 27th and 28th.

Following Castle (8), who finds in the Glossosiphonids, examined by him with great care, that the anterior sucker is always contained in the somite iv, we have the male pore between somites xi and xii, while the female pore is between annuli *b* and *c* of somite xii. It is the presence of these two annuli between the pores that is used as one of the characters of *Placobdella* by Blanchard (4, 6).

Internal Anatomy

The internal anatomy was studied by means of longitudinal sections.

The Alimentary Tract (fig. 4).—The mouth is small, situated far down on the anterior lip of the sucker, in front of the eyes, and probably in the 2nd annulus. It leads into the usual pharyngeal sac, which extends backwards into about somite ix. In it lies the long, muscular, club-shaped pharynx, which was somewhat displaced laterally, and undulating. It commences as a very narrow tube just behind the brain, but increases considerably in diameter as it passes backwards, so that in somite x it is four or five times its previous diameter. Opening into the posterior end is a pair of groups of salivary glands, each group consisting of a bunch of numerous large gland-cells, each of which is prolonged into a long narrow neck, as described by Castle for several species. The bunch of cells is, however, more compact than in the species described by him, each bunch being confined to a single segment—to the eleventh. The short œsophagus leads into the crop, which is produced laterally into seven pairs of cæca in somites xiii to xix, the first and last of which are larger than the rest. The first, arising in somite xiii, passes forwards into somite xi; it is sacculated, overlies the ductus ejaculatorius, and is indented by its coils. The last similarly passes through about four segments, and is also sacculated. Each of the others is confined to its own segment.

A feature that I do not see noted in the description of other members of the family is a median gland surrounding the crop in somite xi; it consists of cells similar to the pharyngeal-gland cells, closely wrapped round the tube.

The stomach, occupying somites xxi to xxiv, is produced into four pairs of simple pouches, each enveloped as usual by a great dilatation of the dorsal blood-vessel. These gastric pouches are not strictly metameric: they are much crowded in the specimen, and lie partly over one another. They appear to belong to somites xxi, xxii, xxiii, xxiv.

The intestine follows, and passes to the dorsally situated anus.

The *nephridia* were not traced out fully, nor was the total number enumerated; the funnels have a form typical for Glossosiphonids.

The Generative Organs (fig. 5).—There are six pairs of testes (really testicular sacs), lying immediately behind the six anterior enteric cæca, and partially below them (probably due to curvature and the contracted condition of the individual); they lie in the annuli 31, 34 &c., to 46—*i.e.*, in the posterior annulus of somites xiii to xviii. They are compressed by the neighbouring organs, but are more globular towards the margins of the body. They contain only a few sperm-morulæ, as the spermatozoa had already been discharged into the seminal vesicles.

The six testes on each side are connected by short vasa efferentia with a dorsally situated vas deferens, which runs forwards into segment xiii and then bends backwards along the floor of the body in a very undulating course, to somite xvi; here each vas deferens opens into the seminal vesicle of its side.

The vasa efferentia open by ciliated funnels into the testes through the anterior wall, except in the last, where the funnel perforates the posterior wall.

The seminal vesicle may be regarded essentially as a cylindrical sac, but as it passes forwards it is much constricted and folded by the enteric cæca and by the vertical muscles, so that in reality its outline is very complex. It commences in somite xvi and passes forwards into somite xii, where it communicates with the narrow, muscular-walled ductus ejaculatorius. This is cylindrical, a good deal coiled in somite xi, and opens mesially into a pyriform or subspherical glandular sac, which may be termed "the spermatophoral sac"; it is transversely placed and opens with its fellow into a shallow, broad, common atrium, which in its turn communicates with the exterior between somites xi and xii.

Whitman (19) has described and figured the spermatophores of *Placobdella parasitica* (*Clepsine plana*), and discussed the question of the "hypodermic impregnation," giving an account of the structure of the different regions of the sperm-duct, with which account the present species closely agrees.

The ductus ejaculatorius, when it issues first from the seminal vesicle, is lined by a low epithelium; further along this becomes a layer of high glandular cells, which reduce the lumen of the tube.

In the "pyriform sac," in which Whitman believes the spermatophore is formed, the epithelium becomes still taller, and the lumen almost obliterated; the cells are much vacuolated in the specimen under consideration.

The seminal vesicle is distended with spermatozoa; the wall consists of a thin connective-tissue coat (staining blue in picronigrosin) lined with a low columnar, almost cubical, epithelium.

In segment xviii, on the left side of the body, situated just below the sixth enteric cæcum, is a mass of spermatozoa, not enclosed by any wall, but free in the body cavity: this mass is quite isolated from the seminal vesicle and from the testicular sac. It has, no doubt, arrived here by migration from the surface, as suggested by Whitman; and, in addition, I note a smaller mass dorsally above the gut.

The ovary (or ovarian sac) is a comparatively small lobulated sac, of short extent, occupying only two segments, xiii and xiv;

it has a thick wall, chiefly of connective tissue (staining blue in picronigrosin). In it is the usual coil of germ-cells, the true ovary or germarium. This "egg-cord" consists of very minute cells, only a few of which exhibit the characters of ova. I imagine, from this fact, and from the unusually short extent of the sac, that the ova have recently been discharged, and that when fully developed the sac would be longer.

The sac narrows to form a duct, which opens to the exterior in common with its fellow, at the hinder part of somite xii.

Hirudo mauiana, n. sp.

The opportunity of studying this, the second species of Gnathobdellid leeches to be recorded as occurring in New Zealand, I owe to Mr. H. Suter, who sent me nine specimens. They were obtained by Mr. Alfred Suter in water pumped up from a depth of 28 ft. in the grounds of the Farmers' Co-operative Freezing-works, at Penrose, Auckland. Probably, however, they are not truly subterranean, but live normally in some swampy region, or in ponds in the neighbourhood, and had been carried in some way into the well. The first individual to be obtained was thoughtfully sent to me alive, in October, 1905, and I was able to make a careful study of the coloration.

Colour.—The greater part of the dorsal surface is a dark olive-brown, paler and greener along the median line. This median band is bordered on each side by a linear streak of light yellowish-green. On each side the dark ground-colour is traversed by a well-defined band of light dusky-yellow, about midway between the median band and the margin of the body, which is reddish-orange. Except for the two admedian linear streaks and the marginal orange, there are thus seven nearly equal bands of colour—five dark and two yellow (fig. 6). The latter taper at each end, ceasing anteriorly at the level of the last pair of eyes, and posteriorly a few annuli in front of the sucker. The ventral surface is a uniform orange-red, which passes upwards round the margin on to the upper surface to form the marginal band just mentioned.

This individual was killed by adding alcohol gradually to the water, so that it retained its extended condition: it was then preserved in formol. When examined a year later the olive-brown had become a dark-grey, the admedian pale-greenish lines are now much paler—in fact, a dirty-white—and the conspicuous yellow bands are also dirty-white. The sucker is dark along the middle, but pale-yellowish along the right and left sides. The remaining eight individuals preserved in alcohol exhibit the same pattern.*

It will be evident, then, that the colour pattern is quite different from that of *H. antipodum* (2), though we do not know with certainty what are the true colours of this leech when alive. But as there are differences of greater importance in the internal anatomy, the distinctness of the two species is considerable.

Dimensions.—The living leech when fully extended — *i.e.*, with both its suckers adhering to the table-top — measured 85 mm., and when contracted 25 mm., with a diameter of 7 mm. in the latter condition. The length when killed and preserved is now 70 mm.; the greatest breadth, which is a little behind the middle of the body, is 5 mm., but this is only slightly greater than the diameter elsewhere; and thickness 3 mm. The sucker, about 4·5 in diameter (fig. 7).

Of the remaining eight, the measurements are as follows (Nos. 2–5 were killed in alcohol, Nos. 6–9 in corrosive sublimate):—

Measurements in Millimetres.

No.	Length.	Breadth.	Sucker.
1	70	5	4 × 4·5
2	64	9	4·5 × 5·5
3	59	6	4·5 × 5·5
4	50	5·25	4 × 5
5	50	5	4 × 4
6	49	5·5	3·5 × 4
7	48	5	3·5 × 4
8	48	5	3·25 × 3·75
9	39	5	3 × 3·5

The sucker is not quite circular, having the transverse diameter slightly greater than the longitudinal.

It will be seen that the specimens vary from rather less than 2 in. to nearly 3 in. in a preserved state, with a breadth of approximately ¼ in. No. 2 on the list is distended, probably with blood.

The leech is long and narrow, with a moderate sucker.

External Anatomy.—This was studied in specimen No. 1 when freshly killed.

There are the usual five pairs of eyes, on the annuli charac-

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* Four, killed in corrosive sublimate, show the olive-brown as dark-brown, the yellow bands as pale-primrose, the belly dirty-white. Four were killed in alcohol: in these the olive bands are now dark bluish-grey, the yellow bands are very pale yellowish-brown. In all the median band is paler than the two lateral dark bands.

teristic of the genus—viz., 1, 2, 3, 5, 8 (following Whitman and Blanchard, but Moore counts the preocular region as the first annulus. I have, however, made no attempt to analyse the annulation). The eyes are situated at the edge of the dark pigmented region.

I find no distinct preocular annulus, nor can I detect in any of the specimens, fresh or preserved, any segmental "sensillæ"—hence my inability to define the limits of the somites, which no doubt agree with other species.

The total number of annuli is 102. The male pore is situated on the extreme posterior margin of annulus 30, so that in a contracted specimen it appears to be between 30 and 31; the female pore is between annuli 35 and 36: or, counting the ventral annuli only, they lie respectively between the post-oral annuli 24 and 25, and 29 and 30—in other words, in a position typical for the genus.

The seventeen pairs of nephridiopores occupy the usual position.

The lower lip is formed by annuli 5 and 6, fused more or less; while the 4th also comes down the side of the sucker, and part of the way across the ventral surface, but is here indistinguishably united with the 5th.

Internal Anatomy.

This was examined only by means of dissection of other individuals; not of No. 1.

The alimentary canal has the usual structure. The anterior sucker leads to the mouth, and is grooved dorsally (fig. 8).

The three jaws are nearly semicircular; the oral margin being, however, rather straighter than the aboral or outer margin, which meets it at an angle. The denticles are set along this margin only, very small externally, and increasing gradually towards the angle; the second and third, at the oral end of the series, being of much greater size (fig. 9). There are forty-eight to fifty of these denticles.

In *H. medicinalis*, it may be mentioned, the denticles are set along the entire margin, and though gradually increasing in size as the median plane is approached, they are not so large as those in the present species, and are much more deeply imbedded in the jaw.

The *genital organs* (fig. 10) differ in several details from the typical species. There are, as usual, ten testicular sacs (or testes) on each side, communicating by short vasa efferentia with the delicate vas deferens running along the body-wall at their outer side. At its anterior end this duct becomes enlarged, and closely convoluted to form a whitish mass, the "epididymis" (or seminal vesicle); when the duct leaves this it dilates to form a large ovoid muscular sac, from the anterior end of which a narrow duct passes transversely, to open into a median, globular, gland-covered "prostate," from the posterior end of which the long, curved, muscular "penis-sac" (cirrus-sac) passes backwards, then bends forwards ventrally to open to the exterior at the male pore, just behind the sixth ganglion.

The most striking point in which this species differs from *H. medicinalis* is the presence of the ovoid muscular sac, which no doubt corresponds to the comparatively narrow muscular "ductus ejaculatorius" of that species.

The female organs consist of the usual pair of small ovarian sacs, each of which communicates by a narrow oviduct with the anterior end of a large gland-covered sac (the albumen-gland), from the hinder end of which a comparatively wide "uterus" passes backwards, then curves forwards ventrally and becomes the "vagina," which opens by the female pore just behind the seventh ganglion. The "uterus" is readily distinguishable from the vagina by the different character of the wall, the latter having distinct circular muscles surrounding it.

In one specimen opened both the male and female duct lie on the right side of the nerve cord; in the second, the male is on the right and the female on the left side.

Remarks.—There is a superficial resemblance to a leech from New South Wales—*H. australis*, Besisto (3)—in which olive-brown and yellow bands alternate; but an examination of the coloured figures given by Becker (1) and by Schmarda (15) show essential differences in the arrangement of these bands.* In it the yellow predominates over the darker tint, which, according to Schmarda and Besisto, is nearly black in life. The median dark band is quite narrow, bordered on either side by a slightly broader yellow band: this is followed successively on each side by two dark separated by two light bands of approximately equal breadth, much greater than that of the median and admedian bands; but the outer dark band is narrower than either of the yellow bands.

It is true that coloration alone may be insufficient to distinguish two leeches, for a considerable range of variation is known to occur in *H. medicinalis*—the best-studied species of *Hirudo*; nevertheless, Grube states that all the specimens studied by him exhibit the same pattern; and all my New Zea-

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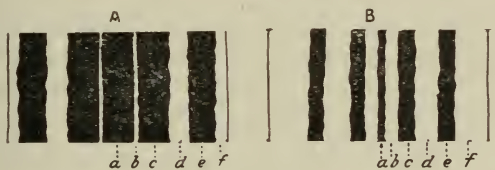
* I have followed the synonymy given by Grube (10), who identifies *H. quinquestriata*, Schmarda, with *H. australis*, Besisto. Blanchard, however, refers to Schmarda's species as belonging to his genus *Linnobdella* (5, p. 29), and does not refer to Besisto's specific name.

land specimens agree with one another and in pattern, which differs from that of *H. australis*. It may be suggested that here we have two well-marked "local varieties" of one and the same species. Possibly this is the case; but if we turn to measurements we find that *H. australis* is a broader leech, and has a larger sucker.

The contrast with the present species is perhaps best rendered evident by a comparison of the two following diagrams:—



EXPLANATION OF TEXT FIGURES A AND B.

Colour pattern of (A) *Hirudo mauiana* and (B) *H. australis* (copied from Schmarda). In both the various bands are lettered — in A, *a* is olive-green; *b*, greenish-yellow; *c*, *e*, olive-brown; *d*, bright-yellow; *f*, reddish-orange: in B, *a*, *c*, *e* are very dark olive (nearly black); *b*, *c*, yellow; *f*, brownish-orange.

Grube gives the measurements of two individuals (presumably preserved), and Schmarda gives the dimensions of another (apparently living). Taking a medium-sized individual (Grube's) and comparing it with a specimen from New Zealand of corresponding length, we have,—

	Length. Mm.	Breadth. Mm.	Sucker. Mm.
H. australis ..	72	16	10
H. mauiana ..	70	5	4·5

Of internal structure we know nothing, excepting the jaws, of which Schmarda says that each jaw bears forty-eight to fifty denticles; and he shows them arranged along the entire margin, to increase in size towards one end, and to be of much greater size than in *H. mauiana*.

If Grube's synonymy be correct, I believe I am justified in creating a new species.

Hirudo antipodum, Benham.

My previous article (2) dealt only with such external features as seemed to be diagnostic of the species. I have now to give a brief account of the internal organs, as seen on dissection of a small specimen 25 mm. in length. The alimentary tract agrees in the main with *H. medicinalis*, though I was able to detect only ten cæca, of which the anterior two are very small. The crop was partly filled with blood, the four posterior cæca being distended therewith ; the three or four preceding cæca contained more or less blood, but there was none in the anterior cæca.

The pharynx appears to occupy a greater proportion of the body than usual ; its hinder end reaches to a point at about one-third of the total length of the body, and covers both the median genital organs.*

I have already, in my previous note, called attention to the edentulous condition of the jaws.

The genital organs (figs. 11, 12) differ considerably from the typical species—and, indeed, from any other species of *Hirudo*, so far as I can ascertain. There are only seven testicular sacs on each side ; the vas deferens is relatively wide as it passes along the series, but anteriorly, in front of the testicular sacs, it becomes narrow, then presents the usual convoluted region, forming an epididymis or seminal vesicle, whence a narrow muscular "ductus ejaculatorius" passes transversely to a median gland-covered muscular sac of nearly spherical form, which opens directly to the exterior by its ventral surface. There is no narrow "cirrus-sac" such as occurs in other species of *Hirudo*. The filiform cirrus (which is protruded in one specimen) is contained within this globular sac, which may be termed "atrium." It corresponds to prostate + penis-sac.

The female organs are also different from the type. The ovarian sacs are conspicuously large—larger, indeed, than the "albumen gland," alongside which they lie. The muscular vagina is a short U-shaped tube, which, as it approaches the body-wall below the gland, becomes greatly dilated, so that its diameter is nearly as great as that of the overlying gland.

Remarks.—It may be necessary to form a new genus for this species, but at present I have not sufficient literature at my disposal to allow me to do so with surety.

The only other leech, so far as I am aware, in which the number of testes is so small as seven pairs is *Philobdella*, Verrill —which, however, is possessed of characteristic and unique "copulatory glands," opening on to pits which appear to serve as adhesive organs in copulation. Moreover, the genital pores are separated by less than one somite ; the annulations of the body in *P. gracile*, Moore (12), at any rate, being more complex than in *Hirudo*. There are also other differences. In *Limnatis*, however, the number of testes is eight pairs, according to Moquin-

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* In *H. medicinalis* the hinder end of the pharynx is at a point well in front of the genital organs, about one-seventh the total length, and in *H. mauiana* this point is at about one-sixth the length.

Tandon; who, however, according to Blanchard, has confused *Limnatis nilotica* with *Hæmopis sanguisuga*, and describes it under the latter name (*loc. cit.*, pl. vi).

In this leech the vas deferens is described as of large size and sinuous; the testes are also relatively large; the prostate + penis-sac is pyriform, as the penis-sac is very short and straight. In all these respects *H. antipodum* agrees with *Limnatis nilotica*, which has a very wide distribution over Asia, south Europe, and north Africa. But Blanchard (1894), in defining *Limnatis*, says, "Jaws with more than a hundred very acute denticles, and ornamented with papillæ; anterior lip with a ventral groove." In each of these points my species disagrees.

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EXPLANATION OF PLATES VIII AND VIIIa.

Placobdella maorica.

Fig. 1. Ventral view of a much-contracted specimen (much enlarged). The head is bent downwards and shows the eyes. A short distance behind the tip of head is the male pore.

Fig. 2. Diagrammatic view (or analysis) of the dorsal surface of the anterior end. The annuli are numbered on the left and the somites on the right side.

Fig. 3. Similar analysis of the hinder end of the body: *a*, anus; *s*, posterior sucker.

Fig. 4. Diagram of the alimentary system, showing segmental positions of the parts (scale half that of figs. 2 and 3). Some of the somites are numbered. The outline of the anterior sucker is indicated by the broken line. c^1, c^7, first and last cæca of the crop; *cg*, the enveloping gland of crop; *cr*, crop; *gl*, pharyngeal glands; *i*, intestine; *mo*, mouth; *ph*, pharynx in the pharyngeal sac; *st*, stomach; t^1, t^6, the first and last testicular sacs, in true position.

Fig. 5. Plan of the genital organs (on same scale as figs. 2 and 3): *at*, atrium; *d.ej.*, ductus ejaculatorius; *od*, oviduct; *ov*, ovary; *s*, spermatophoral sac; *s.v*, seminal vesicle; t^1, t^6, the first and last testicular sacs.

Hirudo mauiana.

Fig. 6. Anterior end ($\times 4$), showing pattern and position of eyes.

Fig. 7. Ventral view of entire leech ($\times 1$).

Fig. 8. Ventral view of under-surface of the anterior end ($\times 7$). The lower lip has been slit through, and the cut edges turned aside. The sucker has been stretched lengthwise. *b.w*, body-wall; g^1, first ventral ganglion exposed; *j*, jaw; *m*, muscles of jaw; *or*, anterior or oral sucker.

Fig. 9. One of the jaws ($\times 40$, camera drawing).

Fig. 10. The anterior portion of the genital organs ($\times 4\frac{1}{2}$). The median organs are represented as turned aside. *alb*, albumen gland; *ep*, epididymis; g^6, the sixth ganglion of the ventral chain; *ms*, muscular (? spermatophoral) sac; *n.c*, nerve-cord; *ov*, ovary; *p*, penis-sac; *pr*, prostate; t^1, first of the ten testicular sacs of the left side; *ut*, uterus; *v.d*, vas deferens; *vg*, vagina.

H. antipodum.

Fig. 11. The genital organs ($\times 4$): *alb*, albumen gland; *at*, atrium (= prostate + penis sac); *ep*, epididymis; g^6, g^8, the sixth and eighth ganglia; *n.c*, nerve-cord; *ov*, ovary; t^1, t^7, first and last testicular sacs; *v.d*, vas deferens.

Fig. 12. The median portion of the genital organs turned aside ($\times 8$): ♂ the atrium (penis-sac) penetrating body-wall to open externally; ♀, the vagina (*vg*) penetrating the body-wall to open externally. Other letters as before.

ART. XVII.—*On a New Species of Pennatulid* (Sarcophyllum bollonsi).

By W. B. BENHAM, D.Sc., Professor of Biology in the University of Otago.

[*Read before the Otago Institute, 14th August,* 1906.]

Plate VI.

THIS species is the only representative of the "sea-pens" or "sea-feathers" belonging to the "pinnate" division of the pennatulids that has as yet been recorded from the coastal waters of New Zealand, though the more delicate rod-like form (*Virgularia gracillima*) has been known for some years.* The present specimen was dredged by Captain Bollons, of the Government steamship "Hinemoa," in Doubtful Sound, on the west coast of the South Island, in a depth of 40 fathoms of water; and I have to thank Mr. Hamilton, the Director of the Colonial Museum, to which it was presented, for the opportunity of examining and describing it.

Class ACTINOZOA.

Order PENNATULACEA.

Fam. PENNATULIDÆ.

Sarcophyllum bollonsi, Benham, Zool. Anz. xxxi, p. 66.

The "vane" of the feather is only slightly longer than the "peduncle," or naked portion of the stem. It has a rounded outline, the broadest region being near the apex, which is rounded. The "pinnæ" are only slightly sickled-shaped; they are rather thick, fleshy, and bear a single row of autozooids (polyps) in an undulating line along the metarachidian ("dorsal") margin. The prorachidian (or "ventral") edge is curved near the free end. The basal margin, or line of attachment to the stem (rachis), is short. There are thirty pairs of pinnæ, which (in the present specimen) meet across the rachis, with the exception of the last four on each side. The siphonozooids form a conspicuous cushion-like thickening on the proximal portion of the prorachidian margin, and this cushion extends on to the lower surface of the pinna as a very distinct "zooid plate," and for a much less extent passes over on to the upper surface. The "zooid plate" on the under-surface extends across the

* Dendy, Trans. N.Z. Inst., xxix, 256.

pinna close to the rachis, and reaches the metarachidian ("dorsal") margin.

The Axis.—The peduncle, which is nearly as long as the rachis (or upper portion of the axis) is distinctly swollen immediately below the "vane"; the free end or apex is rounded. The rachis is quite narrow on the metarachidian (dorsal) surface, being 6 mm. wide in the middle of the vane. At the distal extremity this surface bears a cushion of siphonozooids, extending between the uppermost five pinnæ, and occupying the whole of the surface. The prorachidian (ventral) surface is smooth, and presents no features of importance.

Dimensions.	Mm.
Total length	155
Length of vane	80
Length of peduncle	75
Breadth of peduncle	14
Breadth at swollen region	21
Breadth of rachis in middle of vane ..	14
Breadth of vane (greatest)	70
Length of prorachidian, edge of pinna ..	32
Greatest breadth of pinna	21
Height of pinna (in middle of vane) ..	18
Length of basal margin	8
Number of pinnæ	30

Remarks.

The colour of the specimen appears to have been pale-red in life, as traces of a reddish tint existed on the pinnæ when first received by me. The specimen had been well preserved in strong alcohol, but had undergone a slight amount of flattening at each end owing to having been put into a jar just too small for it.

I supposed at first that this pennatulid was a member of the Australian species, *S. grande*, Gray (*S. australe*, Köll.), but fortunately specimens of this species were available in the Museum, and by the kindness of Professor Haswell I have been able to study Kölliker's description and figures, and a careful comparison has satisfied me that I am justified in forming a new species for the present specimen. The two differ in—(*a*) the general form of vane; (*b*) the proportions of vane and peduncle; (*c*) the form of pinna, which is much more sickle-shaped in *S. grande*; (*d*) the number of rows of autozooids; (*e*) the size and arrangement of the spicules in the pinnæ; (*f*) the form of the large "calcareous bodies" in the deep tissues of the peduncle; (*g*) the form and extent of the cushion of siphonozooids on the pinnæ; and (*h*) the arrangement of the siphonozooids on the rachis.

I propose to give a more detailed account of the species in another place.

EXPLANATION OF PLATE VI.

Fig. 1. *Sarcophyllum bollonsi* (natural size); only on one side are the zooids indicated on the edges of the pinnæ: *a*, peduncle; *b*, vane; *c*, pinnæ (dorsal margins).

Fig. 2. Apex of the colony, with pinnæ pushed apart to show the siphonozooids: *a*, apex; *b*, pinnæ; *c*, siphonozooids; *d*, rachis.

Fig. 3. A single leaflet or pinna seen from below: *a*, cushion of siphonozooids; *b*, base of attachment to axis; *c*, ventral margin; *d*, dorsal or polypigerous margin, with polyps (autozooids) diagrammatically represented.

Art. XVIII.—*Recent Observations respecting the Origin of the Vegetable Caterpillar.*

By G. V. Hudson, F.E.S.

[*Read before the Wellington Philosophical Society, 6th June,* 1906.]

In the "Transactions of the New Zealand Institute" for 1903, page 170, Mr. Alfred Philpott states that he has practically reared *Porina dinodes* from a healthy larva which precisely agreed in structure with larvæ attacked by the *Sphæria* fungus and popularly known as "vegetable caterpillars." Since this time two additional facts have come under my notice indicating that "vegetable caterpillars" belong to several distinct species of Hepialid larvæ, and throwing considerable light on the origin of these remarkable objects.

Several years ago the late Mr. N. J. Tone, who was then Secretary to the Wellington Acclimatisation Society, called me into his office to see a specimen of vegetable caterpillar which he had found in the trunk of a tree and had kept in the same position as it had occupied when he discovered it. On examination I at once recognised the insect as a larva of *Hepialus virescens*, and the portion of the tree-trunk with the burrow in which this larva was situated precisely agreed with the usual habitat of that species. I informed Mr. Tone at the time that his discovery was one of extreme interest, and urged him to prepare a note on the subject for this Society. This he stated he intended to do, but did not carry out his intention before his death. I now place his observation on record to save it from probable oblivion. In connection with this discovery it is perhaps remarkable that the vegetable caterpillar was originally identified by the early New Zealand naturalists as the larva of *Hepialus virescens*, but apparently without any definite evidence, and that this chance identification has proved, in one instance at least, to be correct.

In June, 1905, Master Comyn Caldwell, a son of Mr. Robert Caldwell, of Karori, brought me two Hepialid larvæ, one very recently dead and infested with the *Sphæria* fungus, being in fact a vegetable caterpillar of recent formation, the other an identical larva unaffected by the fungus—alive, and very healthy. Both the larvæ were found in the earth, close together, amongst the roots of some native shrubs in some bush on Mr. Caldwell's property, through which a footpath was being cut at the time. I at once imprisoned the living larva in a jar of earth covered with turf, hoping to rear the perfect insect and thus ascertain the actual species of *Porina* to which the larva was referable. This I fortunately succeeded in doing, the moth emerging during the following November. I have much pleasure in exhibiting this evening the vegetable caterpillar found by Master Caldwell, together with the female specimen of *Porina enysii* reared from the living larva of the same species.

As vegetable caterpillars have, so far as I know, always been found in the ground, with the exception of the specimen found by Mr. Tone, we may, I think, now reasonably conclude that the caterpillars found in the North Island mostly belong to *Porina enysii*, and those in the southern portion of the South Island to *Porina dinodes*.

The appearance of the *Sphæria* in the larva of *H. virescens* is no doubt very rare, but clearly occurs, and it is probable that all the larvæ of the *Hepialidæ* in New Zealand are liable to attack.

In further illustration of these notes I exhibit male and female specimens of *Hepialus virescens* from Karori, male specimens of *Porina dinodes* captured by Mr. Alfred Philpott of Invercargill, and a fine specimen of vegetable caterpillar given to me by Mr. Leonard Hill, and probably specifically identical with the one which has been proved to be the larva of *Porina enysii.*

Art. XIX.—*Notes on the Entomology of the Routeburn Valley.*

By G. V. Hudson, F.E.S.

[*Read before the Wellington Philosophical Society, 18th August,* 1906.]

During January, 1905, and 1906, in company with my wife and little daughter, I spent a few days entomologizing in the Routeburn Valley. On each occasion the weather was unfavourable, and the collection obtained is probably very incomplete. It is, however, as far as it goes, very interesting, and is, I believe, the only collection of insects which has been made in the locality.

The Routeburn Valley is best reached from Kinloch, a small settlement on the western side of the head of Lake Wakatipu. The first ten miles of the journey may be performed by horse and trap, a fair road skirting the foot of the Humboldt Range, along the western side of the Dart River. About two miles after leaving Kinloch a good view is obtained of Mount Bonpland and its glacier, as well as of a fine waterfall on the slopes of the Humboldts, and before leaving the Dart Valley the traveller cannot fail to be struck by the great snow-clad mountains and glaciers at the head of the valley. About nine miles from Kinloch the Routeburn Station is reached, the road having left the Dart and turned up the Routeburn Valley, which is here fairly wide and flat, and is partially under cultivation. About a mile beyond the station the road gives place to a bridle-track, which follows the Routeburn into the forest, and it is at this point that the characteristic scenery of the locality may be said to begin.

The eight miles of track now traversed before reaching the Routeburn Hut is certainly without exception the finest country I have ever seen. The beeches constituting the principal trees in the forest are very large, and the undergrowth consists of small totaras and several interesting shrubs. The forest is interspersed with numerous picturesque grassy openings. The edges of these openings are fringed with lacebark-trees (*Plagianthus betulinus*), and from these trees swarms of the beautiful pale-yellow *Venusia undosata* fly out when disturbed. The stream itself is large, very rapid, running over a beautiful bed composed of blue rock, shingle, and boulders, and is as clear as crystal. The valley is bounded by vast forest-clad hills and precipitous cliffs, frequently traversed by fine waterfalls and backed by stupendous snowy mountains. Some four miles past the Routeburn Station the first crossing is reached. The valley here is wide and flat, the river making a double bend. The ford is fairly good, but can only be undertaken on horseback, unless the river is very low. After passing the ford the "zigzag" is soon reached, the track ascending some 800 ft. in following the river through an extremely narrow gorge, bounded on the opposite side by overhanging cliffs between 1,000 ft. and 2,000 ft. above the river. After this the valley widens out somewhat, and the track descends gradually until it reaches the vicinity of the Routeburn Hut. The valley is now much wider, and the stream again has to be crossed. Here it is, however, considerably shallower than at the first ford, and can generally be traversed on foot.

Just before the second ford the hut may be seen about three-quarters of a mile away. Some two or three hundred yards before the hut is reached a track may be seen branching off on the western side. This is the track to Lake Harris. It is well to take special notice of this track, as visitors without a guide have often attempted to reach the lake by following the stream above the hut. In going to Lake Harris it is necessary to *return* from the hut to the junction of the two tracks, and no other route should be attempted.

The accommodation at the Routeburn Hut, although plain, is quite satisfactory. The hut consists of three rooms furnished with wooden bunks, tables, shelves, and forms, visitors supplying, of course, their own blankets and provisions. As this is a Government hut, and free to every one, it is at times liable to be rather crowded. The view from the hut is very beautiful, comprising — Conical Hill, a fine bush-covered cone rising about 1,500 ft. from the river-valley; the left-hand branch of the Routeburn, a level grass-covered valley between great bush-clad mountains, the lower edges of the bush being fringed as usual with groves of lacebark-trees; and lastly, Mount Cosmos, with its glaciers and snowfields. This great mountain is so close that I was able to see, by means of a small telescope, numerous crevasses and many other details near the top. The final spur of this mountain has a very remarkable curved outline, which, when once seen, is not likely to be forgotten. A large waterfall is visible from the hut on the western side of the left-hand branch of the Routeburn, and in wet weather a second waterfull appears quite close to the first one. Behind and above the hut are great quantities of a very beautiful fern (*Aspidium aculeatum*), which grows in great tufts, often over 5 ft. in height. The forest is also very thickly interspersed with lacebark-trees, especially near the banks of the river. The asparagus fern is very common along the track just before reaching the hut.

On ascending the Lake Harris track, more and more extensive views are unfolded of this wild and interesting region, and the collecting between elevations of about 2,500 ft. and the end of the bush at about 3,600 ft. is extremely good. One very large mountain-torrent is crossed about half-way up the bush-line. On 23rd January, 1906, just before crossing this stream, we were caught in a passing snowstorm. The snow was seen descending from a perfectly clear sky for fully five minutes after the clouds which had shed the snow had passed over. This interesting phenomenon was probably caused by a very strong south-west wind blowing in the upper regions of the atmosphere and driving the clouds across at a great rate, thus not allowing time for the relatively light snowflakes to fall through the calmer air near the surface of the earth until after the clouds had disappeared. At the bush-line itself the river passes over a number of fine waterfalls, and in places is divided into several branches which reunite after flowing through very precipitous ravines. A gorge is then traversed, and the open country above 3,600 ft. fairly reached. This country, although rough, is tolerably accessible, and should yield excellent collecting in calm sunny weather, as even during periods of fitful sunshine and strong wind many interesting species were found. Two or three miles of this class of country are traversed before Lake Harris is reached.

This lake is situated solemnly between vast, almost perpendicular snow-clad mountains, and resembles in general appearance an artificial reservoir, the outlet flowing over a solid rocky dam, the bed of the lake having apparently been hollowed out of the rock by glacial action. Lake Harris was, unfortunately, the limit of our expeditions, the weather being so unsettled during each of our visits (two days in 1905, and seven in 1906) that more extended trips could not be undertaken. I had intended to have scaled the Lake Harris saddle and descended into the Hollyford Valley by way of the Martin's Bay track, but had to abandon this proposed expedition on account of the weather.

The bush round the Routeburn Hut is rich in birds, and by means of my small telescope I obtained many interesting views of the following species, amongst others: Kea, grey duck, paradise duck, sparrow-hawk, red-fronted and yellow-fronted parakeets, and several species of wrens. Rabbits also were fairly abundant, but as yet they do not appear to have committed very serious depredations on the native flora. On the Humboldt Range, at the head of Lake Wakatipu, the rabbits have unquestionably very much injured the alpine flora since I first visited that locality in 1894.

For several days prior to our departure from the Routeburn the hills around were considerably obscured by smoke. The weather having been frequently wet for fully a week before, and the winds westerly, I was at a loss to account for the origin of the smoke, seeing that under the circumstances bush-fires could hardly have been raging on the south-west coast. On my return to civilisation I learned that extensive fires had occurred in Queensland at that time, and there is little doubt that the prevailing north-west winds had carried the smoke from these fires on to the south-west coast of New Zealand.

The following is a list of the insects taken at the Routeburn, with general remarks on the class of locality where each species occurred :—

Vanessa gonerilla.

A few specimens of this well-known butterfly were seen on the wing. A number of young larvæ were also observed feeding on the small nettle (*Urtica incisa*) in the forest.

Chrysophanus boldenarum.

Fairly common on the shingle near the river during the few sunny intervals experienced. The males were entirely suffused with glistening purple, with the black spots very small; the females pale yellowish-brown.

Chrysophanus salustius.

A few in open spaces near the river, probably rare owing to the prevalence of cloudy weather; a small pale-coloured form.

Physetica cærulea.

One specimen taken flying over a grassy flat near the river, in hot sunshine.

Leucania purdii.

At "sugar." One specimen only.

Leucania propria.

At "sugar." Rare.

Ichneutica ceraunias.

One small very dark male specimen taken flying wildly in hot sunshine in the open country near Lake Harris, at about 3,800 ft.

Melanchra vitiosa.

At "sugar." One specimen.

M. agorastis.
At "sugar." One very fine specimen.

Melanchra asterope.
At "sugar." Two specimens.

M. rubescens.
At "sugar." Two specimens.

Paradetis porphyrias.
Two taken and several seen amongst ferns, Lake Harris track, at about 2,800 ft.

Chloroclystis antarctica.
Several very beautiful varieties of this, or a closely allied species, were found amongst undergrowth at about 2,800 ft.

Chloroclystis nereis.
On rocks above bush-line, Lake Harris track, at about 3,800 ft.

Chloroclystis halianthes.
One specimen, near Lake Harris. This is one of the largest species of the genus.

Hydriomena hemizona.
This extremely rare species, of which I had previously only taken two specimens, one of which furnished the type for the original description, was fairly common in certain restricted spots in the forest, both on the Lake Harris track and on the main track. The insect was generally disturbed from amongst foliage on overhanging banks, usually in dense forest. In all I secured ten specimens, which formed a very welcome addition to my collection.

H. rixata.
Common in forest round the hut. Specimens of this insect from the South Island are much duller than those from the North Island, and the characteristic green markings are absent.

H. callichlora.
One specimen of this extremely rare species occurred on the Lake Harris track, at about 3,000 ft.

H. purpurifera.
Fairly common in forest round Routeburn Hut and on Lake Harris track to about 3,000 ft. A most beautiful insect, and a

very fine series secured. The hindwings are paler and less ochreous than in specimens captured at Castle Hill, West Coast Road.

Venusia xanthaspis.

One specimen of this rarity was taken on Lake Harris track, and another seen. Both were disturbed from foliage growing in front of dripping rock-facings.

V. undosata.

The commonest lepidopteron at the Routeburn. Disturbed in hundreds from lacebark foliage everywhere up to about 3,000 ft. The specimens are very pale-yellow, much paler than those from Nelson and other more northern localities.

Xanthorhoe semifissata.

Common in forest round the hut. A very large and finely marked form.

Xanthorhoe orophylla.

Found on the open country near Lake Harris, at about 3,900 ft.

X. cataphracta.

Found on the open country near Lake Harris, at about 3,900 ft. Some very large specimens.

X. clarata.

Very abundant in the open country both near the hut and on Lake Harris track, 2,300 ft. to 4,000 ft.

X. prasinias.

In forest near the hut. A few specimens only.

X. beata.

Common in the forest near the hut. Many very finely marked specimens.

X. adonis.

In forest, Lake Harris track. Four specimens at about 2,600 ft.

X. ægrota.

A few specimens on the edge of the forest near the hut.

X. chionogramma.

One specimen only, Lake Harris track, at about 3,600 ft.

X. cinerearia.

A large slaty-grey variety was common on the river-bed near the hut. A very beautiful variety of the small form (*invexata*) also occurred.

Dasyuris callicrena.

This very fine species was abundant on the Lake Harris track in the open country above 3,500 ft.

Notoreas zopyra.

On stony places in the river-bed near the hut.

N. brephos.

On stony places in the river-bed near the hut.

Selidosema productata.

A few good varieties in the forest at about 2,500 ft.

Sestra humeraria.

Common in the forest round the hut; a very pale form.

Gonophylla fortinata.

One large specimen at "sugar," and another seen. This insect is specially attached to *Aspidium aculeatum*, the most abundant fern at the Routeburn.

Diptycophora leucoxantha.

Two specimens only in forest. Both specimens have the central spot orange-yellow, and are larger than usual.

D. helioctypa.

Extremely abundant, flying in clouds over all the grassy openings near the river.

Crambus vitellus.

Common, as usual.

C. flexuosellus.

Common, as usual.

C. canopias.

One specimen only.

Mecyna(?).

Two specimens.

Scoparia philerga.
Several.

S. chlamydota.
Common amongst lacebark near the hut.

S. hemicycla.
One specimen, in forest, at about 2,500 ft.

S. minusculalis.
One specimen only.

S. encapna.
On stones, Lake Harris track, in hot sunshine, at about 2,800 ft.

S. paltomacha.
A few specimens only.

S. micropthalmia.
Fairly common, Lake Harris track.

S. melanægis.
One specimen, 2,300 ft.

S. thyridias.
This very interesting species was common in the forest round the hut. The bare patch in the disc of the forewings is natural, and not the result of abrasion, and Mr. Meyrick informs me that the same structure occurs in some of the Hawaiian species of *Scoparia*.

S. psammitis.
Extremely abundant in all the openings along the river-valley up to about 2,500 ft.

S. crypsinoa.
A few only.

S. axena.
A few only.

S. octophora.
Common in the river-bed near the hut.

S. sabulosella.

Very common, as usual.

S. trivirgata.

Lake Harris, above the bush-line, 3,500 ft., common. A very large pale variety.

S. cyameuta.

Fairly common near the hut.

A number of other species of *Scoparia* were also taken (not yet identified), several of which are probably new to science.

Musotima nitidalis.

Fairly common amongst ferns, as usual. A large pale-coloured variety.

Stenoptilia charadrias.

This little plume was extremely abundant amongst a species of tauhinu (*Cassinia*) growing on a restricted spot near Lake Harris track, at an elevation of about 2,800 ft.

Pyrgotis pyramidias.

This beautiful little *Tortrix* was very common in the forest round the hut, and many fine specimens were secured. It is usually a very scarce species.

Heterocrossa.

Two or three species of this genus were observed.

Gymnobathra calliploca.

A few taken.

Several species of *Œcophora* and allied genera were also found, but have not yet been determined. Two very fine "daddy-long-legs" (*Cirozodia plumosa* and *Macromastix montana*) occurred on the Lake Harris track, at about 3,800 ft.

Beetles were not specially worked for, but several *Carabidæ* and two or three species allied to *Adelium* were common in the forest under logs and stones. In finer weather, no doubt, many interesting *Diptera* and *Coleoptera* would be found, especially on the high country round Lake Harris.

Art. XX.—*The Influence of the Earth's Rotation on the Course of the Rivers on the Canterbury Plains.*

By F. W. Hilgendorf, M.A., D.Sc., Lincoln College.

[*Part of an Address delivered to the Canterbury Philosophical Institute, 1st November,* 1905.]

Plate X.

William Ferrel, in 1859, published a paper in the *Mathematical Monthly* announcing the law now known as "Ferrel's law": "If a body move in any direction on the earth's surface, there is a deflecting force arising from the earth's rotation which deflects it to the right in the Northern Hemisphere and to the left in the Southern." The application of this law to the explanation of the course of the trade-winds is familiar to everybody, and it must also apply to streams. There are, of course, many other factors which come into play to decide the course of the stream, and the question is one that has aroused considerable discussion.

G. K. Gilbert, writing on "The Sufficiency of Terrestrial Rotation for the Deflection of Streams," in the "American Journal of Science," vol. xxvii (1884), says he started by considering the rotation of the earth quite unnoticeable, owing to greater differences due to hardness of rocks, slope, &c., but nevertheless, on giving the matter full consideration, is now compelled to write supporting the contention that the terrestrial rotation is sufficient to cause deflection. In a discussion in the French Academy of Science, Bertrand demonstrated that a river flowing in S. lat. 45°, with a velocity 3 metres per second, would exert on its left bank $\frac{1}{63529}$ of its weight, and he regarded this as too small for consideration. Henry Buff pointed out that the influence of rotation combined with that of gravity would be to heap the waters up on the left side, make them a little deeper there, and so increase the velocity slightly, so that the terrestrial rotation increases the transporting, and therefore corrading, power on the left bank. It is true, however, that he regarded this as of less effect than the wind-waves on the same surface. It has been held by others that the influence of the rotation merely amounts to a slight change in the direction of gravitation—that a river flowing down an incline to the sea will flow not straight down, but slightly to the left, and that that is all. The river will take up this course, adjust itself to it, and then nothing further will happen. Gilbert himself held this opinion for some time, but saw fit to abandon it.

A stream flowing straight has a symmetrical cross-section, the swiftest current in the centre. Admit a curve and centrifugal force comes into play; and since this force varies as the square of the velocity, it throws the swifter strands of the stream towards the outer bank; corrasion results there, a deposit is formed on the inner bank, and the eccentricity, so far from correcting itself, goes on increasing until quite other forces come into play.

Now, Ferrel proves that the deflective force of the earth's rotation (be its apparent effect large or small) varies as the velocity of the stream; and this is the main point of the argument. If it varies as the velocities, it must exert a selective action on the various strands of water moving at different velocities. It moves over to the left bank* the strands of water moving most quickly. Now, in water moving round a curve, with the outside to the left, the centrifugal force moves the water to the left as the square of the velocities, and the rotational force moves the water to the left as the velocities, and these two forces act in concert, and their effects are summed. If the curvature has its outside to the right, the centrifugal force tends to move the thread of greatest velocity to the right, but the rotational force tends to move it to the left, and the two forces are opposed. Gilbert expresses this by means of the following equation :—

v = Velocity of stream;
r = Radius of curvature of stream-course;
n = Angular velocity of earth's rotation;
l = Latitude of locality:

$$\frac{\text{Total displacement of velocity to left}}{\text{Total displacement of velocity to right}} = \frac{v + r \sin l}{v - r \sin l}$$

Giving the values derived from the study of the Mississippi,

n = 0·000072924 rad. per second,
v = 8·4 ft. per second,
r = 8,000 ft.,
l = 37°,

we have, were it in Southern Hemisphere,

$$\frac{L}{R} = 1{\cdot}087$$

—that is, the selective movement of velocities to left bank is nearly 9 per cent. greater than to right bank.

Let me refer now to the law that the transporting-power of a stream varies as the sixth power of its velocity. It is a matter

* All streams are supposed to be in the Southern Hemisphere.

of experiment. A stream running 1 ft. a second is, we suppose, able to move a stone 2 lb. in weight. Increase the velocity to 2 ft. a second: instead of now being able to lift a stone 2 lb. in weight, it can lift one of actually 64 lb. weight, 64 being 2^6.

Now, consider these accumulated facts: The effects of the terrestrial rotation are unceasing and cumulative. It is allowed to cause an extra pressure on the left bank; it is allowed to increase depth of water and so increase the velocity on left bank; it is allowed, in a river of the rate of flow and S. latitude (altogether neglecting the size) of the Mississippi, to cause a selective motion of velocities towards left bank of curves of 9 per cent., and then the transporting-power of stream varies as sixth power of velocities, so that even if the velocity on the left bank be very slightly greater the difference in corroding-power will be very appreciable. Consider these accumulated facts, and we may believe that the rotation of the earth may well have some slight effect on the course of a river—slight, of course, is agreed, but not so slight as to be unappreciable in favourable circumstances.

Gilbert, in the paper mentioned above, describes an actual case where he believed that the terrestrial rotation had most evidently determined the course of several streams. On the south side of Long Island, New York, a number of streams flow down a plain of gentle slope and essentially homogeneous formation. Each of these valleys is bordered on the right side by a bluff from 10 ft. to 20 ft. high, while its gentle slope of the left side merges imperceptibly with the general plain. The stream in each case follows closely by the bluff at the right, and there seems no reasonable doubt that these peculiar features result from the influence of terrestrial rotation.

Thus much I read at a time when I had seen the Canterbury rivers only while crossing them on the main line of railway. But thinking over them, I remembered that the Rangitata and Waitaki had steep and high banks on their left sides, and very sloping or unnoticeable banks on their right. I also thought then that the Canterbury Plains were homogeneous in structure, and had several streams running across them, so that if the rotation of the earth did have a deflecting influence on the courses of rivers, we should on these plains see it as well as anywhere. To be able to detect the influences of the earth's rotation we need an even slope through a homogeneous structure. Where rocks of different hardness occur, or where the slope is not regular, we can expect the influence of the earth's rotation to be partially or wholly obscured. I started a year ago to take measurements of the height of the banks of the rivers, and the distance of these banks from the right and left side of the stream. In the course of the measurements I have visited, I think, all the chief streams of Canterbury, with the exception of the Selwyn and Hinds. When I say "visited them," I mean I have travelled up and down both their right and left banks from the mountains to the sea, taking a section of the river under observation about every four miles. The rivers and streams thus examined were the Ashley, Waimakariri, Rakaia, north and south branches of the Ashburton, the Rangitata, Orari, Opihi, Otaio, Makikihi, Waihao, and Waitaki. My outfit consisted of a bicycle, to get from place to place, with a tested cyclometer to determine the distances I had travelled up or down the river when taking each section; a pedometer, tested to record one mile for each 2,000 paces I walked, and which was very useful for determining the width of terraces; a chain tape measure and ball of string, to determine the height of the most important terraces; and, finally, a couple of levels to find out when, standing on one bank, I was at the same elevation as the top of the opposite bank of the stream. One of these levels was a small dumpy, and the other a small builder's level screwing into a stick, for the rougher observations. My method of work was to choose a road as near the banks of the river as possible, and every four miles or so make expeditions on foot to the river-bank; then, having found the first terrace, to walk to the stream, recording the heights of the escarpments and the breadths of the terraces as I went. This observation was supplemented at a later date by a corresponding observation on the other side of the river, at a point as nearly as possible opposite the first. Early in the course of the investigation I found that the conditions obtaining on the plains were not as favourable as I had imagined. The Rakaia and Rangitata do not flow down a perfectly even slope, but my observations on these rivers are included with the others. On the other hand, it will be noticed that no section of the Waimakariri is given, as it was evident that the two disturbing factors mentioned—namely, want of uniformity of texture of the plains and want of uniformity of slope—are particularly obtrusive in this case. For the first nine or ten miles of its course the river is continually held or deflected by the fan of the Kowhai and Rock Ford; by the abutments of Eagle Hill, which run down into the river; by the Gorge Hills, and by Brown's Rock. After a few more miles the river, which used to run through Prebbleton and down to the sandhills at Halswell, is entirely thrown out of its course by its own fan striking against the Port Hills, and its present bank is about nine miles from its old southernmost one. Owing to the magnitude of the disturbing factors, then, the Waimakariri was unsuitable for the purposes of the investigation.

The results of the investigation in the case of the other rivers will be best seen by examining the generalised section of each river shown on Plate X, figs. 1–6. These sections have been prepared in the following manner: The heights of all the escarpments on the left bank were added, and divided by the number of sections across the river: this gives the height of the left bank. The same thing was done with those on the right. Then the width of all the terraces from the first escarpment on the left bank to the river-bed were added, and divided by the number of sections taken, and this gives the breadth of the left bank, and a similar calculation that of the right bank. The average width of the bed was also taken, and the black spot in the bed shows the average position of the main body of water in the stream. It will be seen that the general result shows to a very marked degree that the left bank is much more abrupt than the right—that is, that the rivers have corroded that bank to which the influence of the earth's rotation tends to deflect them.

It may be pointed out that if the Waimakariri had been used in the investigation, it would have given very exaggerated results of the same nature as those shown by the other rivers, as in its lower course its first terrace on the right bank is about nine miles from the present bed of the stream.

The Rakaia is the only river observed that has higher banks on its right bank than on its left. Von Haast concludes—and is, I believe, generally supported by other geologists—that the Ashburton was at one time much the biggest of the three rivers now known as the Rangitata, Ashburton, and Rakaia—or, indeed, that these rivers were one, and emptied themselves in the position now occupied by the present Ashburton. This joint river deposited upon the plains a huge fan, whose front edge stretched southwards past the present Rangitata and northwards past the present Rakaia. This fan is still fairly evident, especially in the cliffs along the Ninety-mile Beach, which cliffs rise from 10 ft. at the mouth of the Rakaia to 60 ft. at the Ashburton, and fall away to 20 ft. or less at the Rangitata.

Standing on the right bank of the Rakaia with my level, it was only by looking backwards up the plain that I could find a point on the left bank as high as that on which I stood, for I was standing on the fan of the old Ashburton; and the same was true while standing on the left bank of the Rangitata. On the opposite side of the river, and in a direction at right angles to its flow, there was no land as high as that on which I stood, for here, too, I was on the old Ashburton fan, but on its southern edge. Now, the presence of the fan will easily account for the height of the right bank of the Rakaia, if we can find any reason why the river should have corroded this higher bank rather than run down beside this bank.

The Rakaia when it first became independent was running through its present gorge in a direction that would carry it well into Lake Ellesmere, along the line where the Ashburton fan overlay the general seaward slope of the plains. This would give the river a course from gorge to sea of about forty-five miles, while its present course from gorge to sea is thirty-eight miles, and the shortest possible course is thirty-five. Now, the shorter the course is, the greater is the fall per mile, the greater the velocity, and the greater—by the sixth power—the corrasion. Suppose the river formed a delta at its mouth: one arm would flow southward into the sea, and the other north; but the one flowing south would have a shorter distance to go for the same fall, would corrade more rapidly, and would become the master stream. Thus the continual tendency of the stream's mouth would be to move southward so as to reach the position in which it would have the least distance to go to pass through the fixed amount of fall from the gorge to the sea. I believe this conclusion is valid, and my belief is strengthened by Von Haast's reference to an apparently well-known law—namely, "that rivers that unite tend to do so by the shortest line." If this statement is a true one it should also apply to rivers that reach the sea: they endeavour to do so by the shortest line. At the same time, I must confess that in my working models of this system of fans and rivers the stream that represented the Rakaia corraded the fan and shifted its mouth southwards in a less marked degree than I had anticipated.

This consideration, if accurate, then, explains the only exception to the general truth—that the rivers flowing through the plains have eaten into their left bank more than their right bank. The Rangitata was in the same position as the Rakaia in regard to the Ashburton fan—namely, it ran down the side of it; so that we may neglect the presence of this fan altogether, for its influence on one bank of one river is counterbalanced by its influence on the other bank of the second. I have therefore prepared an average section of the larger rivers of Canterbury, including all but the Waimakariri (fig. 8). If it is considered that the fan of the Ashburton has too great an effect to be negligible on the courses of the Rangitata and Rakaia, we will reject those rivers, and take an average section of those remaining—viz., the Ashley, Opihi, Ashburton, and Waitaki (fig. 7). I have omitted the Waihao, Makikihi, and Otaio owing to their small size; but these streams show the same peculiarities in a very marked degree. In either case, it will be seen that the average left bank is steeper than the average right, and that the average position of the main stream is nearer the left bank. This renders it probable that the rotation of the earth has had a deflecting influence upon the courses of the rivers running through the Canterbury Plains.

Note 1.—Gilbert says he would not expect to see the influence of the terrestrial rotation marked in rivers that are flowing rapidly and corrading their beds vertically; but even in this case there must be certain curves in the course of the stream with differential corrasion on the opposite banks.

Note 2.—Some of the Canterbury rivers, notably the Ashley, flow almost due east, and in such cases the influences of the rotation must be much less marked. But again, the curves in the course of the river must occur, and even if the general course of the river is due east, in its curves it will flow more or less north or south, and so again present favourable conditions for the effect of the terrestrial rotation to make itself apparent.

EXPLANATION OF PLATE X.

In all cases the east side of the river appears on the right-hand side of the section, following the convention in map-drawing. The arrangement has the disadvantage, in southwards-flowing rivers, that the left bank is on the right-hand side of the observer. He should imagine himself looking up the stream.

Each ordinate represents 4 ft., the abscissæ 200 yds. The black dot in the bed of the stream represents the position of the main body of water.

Each ordinate in figs. 7 and 8 represents 10 ft., the abscissæ 200 yds.

Art. XXI.—*Notes on Protective Resemblance in New Zealand Moths.*

By Alfred Philpott.

[*Read before the Philosophical Institute of Canterbury, 1st November, 1905.*]

These notes have been put together with a view of forming a base for future work. There is, I am afraid, but little that is new in them, but I have preferred to risk repetition in order to give them some measure of completeness.

By far the greater number of our native moths are protectively coloured; one can easily gauge from this fact the severity of their struggle for existence. Many of our birds live entirely or in part on insect food. The fantails (*Rhipidura*) and bell-birds (*Anthornis*) take them on the wing; creepers (*Mohua* and *Finschia*), warblers (*Gerygone*), and wrens (*Xenicus*) search for them while at rest on the tree-trunks or branches; while the parrakeets (*Cyanorhamphus*) and kakas (*Nestor*) prey on the larval forms of those species which inhabit decayed wood. It is therefore not a matter for surprise that our *Lepidoptera* should have developed the principle of protective colouring to such an extent and to such perfection as is exhibited by several forms.

Though I have dealt with the *Lepidoptera* only, I feel sure that other groups of our insects would well repay study in this direction; the *Coleoptera* especially would yield some interesting examples.

Nyctemera annulata.

This species is a very striking example of "warning colours." The larvæ and pupæ are as conspicuous as the perfect insect, and I know of no instance of either being eaten by birds or preyed upon by other insects. It was at one time thought that a disease which affects cattle grazing in districts overrun by *Senecio jacobæa* and its allies—the food plants of the larvæ—had its origin in the animals inadvertently eating the larva along with its food plant. It is now known that the *Senecio* itself contains a poisonous substance. Still, there can be no doubt of the nauseous, if not poisonous, qualities of the insect. The larvæ are avoided by poultry, and if picked up with other food are at once rejected. The moths may be often seen entangled in spiders' webs, but I do not remember ever having seen one that had been attacked by the spider.

Metacrias strategica.

This moth, in common with *erichrysa* and *huttoni*, is probably also decked in "warning colours." If it were edible it would fall an easy prey to birds, particularly when fluttering in the grass in search of the apterous female. A hidden female will soon attract dozens of males, and such a gathering would form a fortunate chance for any passing insectivorous bird. The females, which are covered with a thick coat of yellowish hair-scales, do not leave their pupal birthplaces under logs, &c., and are therefore not in much need of protective colouring. They are, however, very inconspicuous, and might easily be passed over for a fragment of dry earth. They move about very little, and this also would be in their favour if inconspicuousness were aimed at. It would be of great interest to find one sex protected by "warning colours" and the other by protective resemblance, but in the absence of adequate observation and experiment nothing definite can be said on the point with regard to the present species. Some apterous females are considered to mimic spiders, but, except in the case of immunity from attack by other spiders, it is difficult to see in what manner such mimicry would benefit them.

Orthosia.

Mr. Meyrick states that the members of this genus are almost all autumnal, and that "their yellow and ferruginous colouring is doubtless adapted to the autumn tints of falling leaves." This is strikingly true of *O. immunis*, but *O. comma* appears in November. Its variegated and speckled appearance would harmonize well with the dead and decaying leaves which are to be found in the bush at all seasons.

Xanthia purpurea.

This moth resembles in colour a much darker dead leaf than *Orthosia immunis* imitates, and the greyish dots and strigæ resemble those minute patches of mould which are often found on decaying leaves in damp situations.

Leucania.

It is difficult to see how the grey colouring of *moderata* and its allies can be of value, but the ochreous and brownish hues of *atristriga*, *propria*, *unica*, &c., bear considerable resemblance to faded leaves of grass, and as the larvæ all feed on *Gramineæ* this must be of some importance to the perfect insect. In some species, as in *toroneura* and *neuræ*, the resemblance is further enhanced by the veins being outlined in blackish; in others, as *propria* and *acontistis*, the same end is gained by brownish or black basal and discal streaks. The light-yellow forms, such as *sulcana*, *semivittata*, and others appear to be rather conspicuous insects; on dead, dry herbage, however, they would be far from noticeable, and in this connection the black dots which are scattered over the wings have probably some use in assisting to render the resemblance still more natural, dried herbage being often covered with such spots.

Melanchra.

The markings of the species of this genus are, as Meyrick observes, "usually very similar, and the colouring dull and adapted to conceal insects which are accustomed to hide amongst dead leaves or refuse." Several forms, however, seem to have a tendency to rest on trees; for instance, *mutans* is often found thus situated, and on rough brownish bark is extremely inconspicuous. *Vitiosa* is also hard to detect under similar circumstances, and on moss-grown trunks *plena* and *insignis* are alike unnoticeable. Such species as *lignana*, *pelistis*, *composita*, and *steropastis* would be well protected about the roots of grass, while the uniform brown colour of *infensa* blends admirably with the underside of dead bark, and in this position I have several times found it. The strikingly contrasted black and green colouring of *exquisita* might be quite inconspicuous on a lichen-grown trunk, but the insect is so rare as almost to lead one to think that its striking appearance has had an adverse effect on the species in the struggle for life. *Octans* is also exceedingly rare, but two examples having been taken so far. In this instance, however, the rarity of the species in collections is probably due in great measure to the perfection of its resemblance to its environment. The type specimen was found on a rough limestone rock, and its presence was only revealed by the closest scrutiny.

Bityla defigurata.

In common with *Melanchra infensa*, this species has a liking for resting under pieces of dead bark; in fact, I have several times found small colonies hibernating under one flake of bark. Its uniform dark-brown colour is very suitable for such a resting-place; and *B. sericea* would also be protected in a like situation.

Rhapsa scotosialis.

This is a dead-leaf-mimicking species. The light and dark points on the forewings help to carry out the resemblance. The moth is slow and feeble of flight, and if pursued often drops to the ground and remains motionless.

Tatosoma and Chloroclystis.

Nearly all the species of these two genera are more or less greenish in colour. They are spring and summer insects, and frequent bush. It is worth noticing that in *Tatosoma*, where the hindwings are small and covered by the forewings when the insect is at rest, the hindwings exhibit no protective colouring, but are pale dull-yellowish or grey. In *Chloroclystis*, however, where the hindwings are exposed in repose they partake in a marked degree of the colour and markings of the forewings. This interesting fact is noticed by Mr. Hudson* when speaking of *Elvia glaucata*, the beautiful white-and-green lichen-mimicking species. The tendency of some forms of the genera

* "New Zealand Moths and Butterflies," p. 46.

under notice—such as *T. agrionata* and *Topea* and *C. plinthina*—to have patches of white amid the green of their wings may perhaps be explained by supposing that such patches serve to represent the effect of the rays of light which glance through apertures in the foliage. *C. lichenodes*, according to Mr. G. V. Hudson,* "frequents forests, resting with outspread wings on lichen-covered tree-trunks, where its wonderfully protective colouring may be seen to great advantage. The remarkable brown patches on the wings have undoubtedly been acquired for this protective purpose." I should think it probable that *maculata* and *inductata* also frequent lichens, but both are rare, and their habits little known.

Hydriomena.

This large genus exhibits considerable diversity of colour and markings, and several of the species, viewed apart from their natural environment, appear to be very conspicuous insects. *H. purpurifera* is one of the most striking, but the conspicuous white fasciæ of the forewings become quite inconspicuous when the insect is resting amongst foliage. *H. siria* is a most peculiar form. It frequents grassy bush tracks, and flits about somewhat after the manner of a butterfly, calling to mind, with its bright-orange colouring, a small specimen of *Chrysophanus sallustius*. It is improbable that there is any significance in this resemblance, but the fact is worth noticing.

Asthena schistaria, Venusia verriculata, and Xanthorhoe gobiata.

These represent a peculiar and interesting style of marking. In each form both fore- and hind-wings are crossed by numerous fine lines. Of course, each species rests with the hind-wings exposed. In *V. verriculata* so perfectly do the lines of the forewings correspond with those of the hindwings that it is difficult to notice the overlapping edge. The abdomen also is crossed with fine lines: thus there is no break from the costa of one forewing to the costa of the other. According to Mr. Fereday as quoted by Mr. Hudson,† *verriculata* frequents the cabbage-tree (*Cordyline australis*), resting on the dead leaves which always hang in numbers from this tree, and always sitting across the leaf, so that the lines across the wing are continuous with the veins of the leaf. I do not know if *A. schistaria* and *X. gobiata* are also attached to the cabbage-tree, but faded leaves of the flax-plant (*Phormium*) or the toitoi (*Arundo*) would answer the purpose equally well.

* "New Zealand Moths and Butterflies," p. 44.
† "New Zealand Moths and Butterflies," p. 53.

Venusia undosata.

This beautiful moth is attached to the pepper-tree (*Drimys colorata*); the lemon-coloured forewings of the typical form with their dark-brown costal borderings harmonize in a remarkable manner with the leaves of this plant. There are, however, a great many striking variations of this insect, one in particular having developed a most inconspicuous drab colour.

Xanthorhoe.

In this genus a noticeable case of colour-development to suit environment occurs. *X. orophyla* is almost exactly similar in markings to *X. semifissata*, but while *semifissata* is pinkish-brown, *orophyla* is bluish-grey. While *semifissata* frequents open forest districts, *orophyla* is found on the mountain-ranges, and its colour is well adapted to the rocky nature of its habitat. It is, I think, probable that *X. orophyla* has been developed from *X. semifissata*, and this is the more likely as some forms of *semifissata* vary in the direction of the grey colour of *orophyla*. *X. clarata* presents a case of the protective colouring being chiefly developed on the undersides of the wings. This form is very conspicuous and striking in the cabinet, but when resting with folded wings amongst the tussock and rough herbage of its natural surroundings it is far from easy to see. The insect folds its wings over its back, and the undersides are covered with dark elongate dots on an ochreous ground, a type of marking very suitable to its ordinary environment. In *X. bulbulata* we have an instance of "contrast colours." The bright-orange hindwings, conspicuous in flight, are in strong contrast to the dull-grey forewings, and when the insect suddenly drops into a tussock and closes its wings it is hidden at once; that which on the wing appears to be a bright-yellow insect is instantaneously transformed into a dull and inconspicuous grey one.

Notoreas.

The members of this genus, with *Lythria* and *Dasyuris*, are for the most part protected by "contrast colours." The genera, however, contain forms, such as *N. perornata*, in which the fore- and hind-wings are alike brilliant; and others, as *N. omichlias*, in which almost all trace of bright colours has been lost, and the insect is admirably protected by its resemblance to the general hue of its environment. There is still, however, much to be learned of the habits of these mountain forms, and future investigations may throw considerable light on their economy.

Selidosemidæ.

This family exhibits some of the most striking "dead leaf" resemblances to be found. Foremost among these stands *Drepanodes muriferata.* Mr. Hudson has observed that when disturbed this insect accentuates its resemblance to a dead leaf by keeping its wings extended and motionless, and allowing itself to fall to the ground as a dry leaf falls. I have not had much opportunity of observing *muriferata*, but can state that similar tactics are often adopted by its ally *Sestra humeraria*—in fact, one can never be quite certain until after close examination whether moth or falling leaf has been observed. In the genus *Epirranthis* all stages of dead and decaying leaves are represented, the irregular margins of the wings aiding the resemblance. The same remark applies to *Selidosema panagrata* and *dejectaria*, but *Selidosema productata* seems to be particularly protected when resting on tree-trunks, its blotched black-and-white colouring being eminently suitable to such trees as the matai (*Podocarpus spicata*). *Gonophyla azelina*, though one of the handsomest of New Zealand moths, is one of the most inconspicuous when at rest amongst the stems and dead leaves of forest ferns, a position in which it is most often found.

Pyralidina.

Turning to the group *Pyralidina*, we find the members of the genus *Crambus* admirably protected both in form and colour. As a general rule the forewings are of some ochreous shade, with one or more longitudinal white lines. In repose the wings are folded back upon the body, and the position assumed is almost invariably in line with the stalks and linear leaves of the rough herbage which these moths commonly frequent. Thus when *siriellus* or *simplex* has been observed to alight in a patch of tussock-grass, it often requires much patient search before the moth can be discovered. The system of marking by longitudinal lines is also continued in the smaller and darker forms, such as *æthonellus* and *corruptus*, and is still in evidence in *Orocrambus.* In *Scoparia* several forms are attached to tree-trunks as resting-places; the coloration of such forms as *philerga* and *submarginalis* is well suited to such a situation. Another section containing such forms as *octophora*, *sabulosella*, and their allies frequents red tussock and vegetation of a like character; these, as might have been expected from their habitat, are dull-greyish ochreous forms. Yet another section has developed the linear arrangement of marking, as in *Crambus*, but here the ground-colour is light and the lines dark. *S. trivirgata* is a good example of this group, and the effect of the colour-arrangement seems to be equally successful, *trivirgata* being a very abundant insect and widely distributed.

Tortricina.

The members of this group find their chief protection in their resemblance to dead leaves. *Cacoœcia*, *Ctenopseustis*, *Pyrgotis*, *Adoxophyes*, and other genera mimic the tints of the faded leaves of many of our small-leaved shrubs. The genus *Strepsicrates*, however, seem to rely more on their resemblance to twigs; and some species of *Heterocrossa*, notably *gonosemana*, are well protected on rough mossy bark. The lovely white wings of *Nymphostola galactina*, with their delicate tracery of green veins, might be mistaken for the petals of some bush flower, and as the moth appears in midsummer this is probably the end aimed at.

Tineina.

In the *Tineina* several species of *Trachypepla* exhibit a curious form of colouring. The head, thorax, and anterior portion of the wings are white, the remaining portion being dark-coloured. *T. euryleucota* I have several times taken from *Leptospermum* bushes when the white buds were just unfolding, and have been struck with the resemblance between such buds and the moth as it sits at rest with closed wings. Mr. Meyrick, however,* inclines to the opinion that "*euryleucota*, with *leucoplanetis* and *conspicuella*, mimics the droppings of birds." The remaining forms of *Trachypepla* evidently mimic moss and lichens, and the illusion is strengthened by the surface of the forewings having a rough, irregular appearance, caused by a number of patches of raised scales. This method has also been adopted in *Lysiphragma*, the object in this case being to create a resemblance to the rough bark of the broadleaf (*Griselina littoralis*), under which the larvæ feed, and on which the mature insect is often found. *Megacraspedus calamogonus* frequents the seed-heads of *Arundo conspicua*, on which its larva feeds. It is well protected both in form and colour.

Elachistidæ.

Several genera are remarkable for the position assumed in repose. In *Stathmopoda* the posterior legs are erected over the back with the tarsi directed more sideways: *Thylocoseles* holds the posterior legs out behind, but bent, after the manner of a grasshopper. Other genera have adopted like unusual positions; and Mr. Meyrick suggests that the attitudes are assumed in order to deceive enemies by their unnatural appearance.

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* Trans. N.Z. Inst., xvi, 13.

Art. XXII.—*Note on the Occurrence of* Phyllitis fascia (*Muell.*), *Kuetz, in New Zealand.*

By Robert M. Laing, B.Sc.

[*Read before the Philosophical Institute of Canterbury, 8th August,* 1906.]

Chief synonymy: *Ulva fascia* (Lyngb., Hydr., p. 28); *Laminaria fascia* (Muell., Fl. Dan., p. 768); *Laminaria cuneata* (Suhr.).

The discovery in New Zealand of such a typical and well-known seaweed as *Phyllitis fascia* is perhaps worthy of a special note. In September, 1904, I obtained at Akaroa, below the public gardens in the bay, on boulders just beneath low-tide mark, a brown alga which I at once recognised as being new to New Zealand. I sent specimens of it to Major Reinbold, of Itzehoe, who, in the absence of sporangia, identified it somewhat doubtfully as belonging to the genus *Phyllitis*. I afterwards gave duplicates to Professor Setchell, of the California University, and he was fortunate enough to find plurilocular sporangia upon them, and was able to identify the plant unhesitatingly as *Phyllitis fascia*. I have also compared it myself with European herbarium material, and find it inseparable from northern examples of the species. It is rather strange that it has not been found hitherto in New Zealand, and that now it has only been obtained from Akaroa. It is probable, however, that it will be found in other parts of the colony, unless, indeed, it should have been brought here by some strange chance on the bottom of a whaler or other Home vessel in the early days. I append, for the benefit of New Zealand students, a description of the plant. *Phyllitis fascia* is apparently unknown in Australia, but has been found at Cape Horn and the Falkland Islands. The plant, therefore, should perhaps be added to the list of our subantarctic species. I have deposited a specimen for reference in the Canterbury Museum.

The genus *Phyllitis* is placed by Oltmanns in the family *Ectocarpaceæ*, under the section *Scytosiphoneæ*.

Fam. ENCOELIACEÆ (Engler and Prantl).

Section SCYTOSIPHONEÆ.

Genus Phyllitis (Kuetz.).

Thallus ribbon-shaped or discoid, tapering towards the base into a short filiform stem, sometimes hollow in places, consisting of parenchymatous tissue, with large walled cells internally, and sometimes beset externally with slender filaments. Paraphyses always wanting. The reproductive organs appear first in spots on the surface of the thallus, but finally almost completely cover it, and consist of unilocular and plurilocular sporangia.

Phyllitis fascia.

Root a minute disc. Stem very short, cylindrical at the base but immediately becoming flattened, and gradually expanding into a thin linear lanceolate or obovate frond, 10–30 cm. long and 1–4 cm. broad, sometimes very obtuse at the apex, but at other times more acute. The margin waved, and occasionally notched. The surface smooth, and not shining. Colour at first olive-green, but gradually becoming more yellow as the plant advances in age, finally attaining to a beautiful greenish-golden hue. (The species is scarcely distinguishable from P. *cæspitosa*, J. Ag.).

General Distribution.—Coasts of the North Atlantic and Mediterranean, Alaska, North-western America, Cape Horn, Falkland Islands, New Zealand, Japan, and Formosa.

P.S. (February, 1907).—Since writing the above I have collected a specimen of this plant at Wellington Heads; and it has also been recorded from the coast of New South Wales.

Art. XXIII.—*On the Occurrence of* Fredericella sultana *in New Zealand.*

By Arthur Dendy, D.Sc., F.L.S., Professor of Zoology in King's College (University of London).

Communicated by Dr. Chilton.

[*Read before the Philosophical Institute of Canterbury, 6th June,* 1906.]

The specimen upon which the identification of this New Zealand fresh-water polyzoon with the well-known and widely distributed *Fredericella sultana* is based was found growing on a dead leaf in a pond in the Acclimatisation Society's Gardens at Christchurch, on the 13th September, 1898. I made a sketch of the fully extended zooid in the living condition, and satisfied myself that the lophophore was not hippocrepian, but that the tentacles (about twenty-two in number) were arranged in the manner figured and described by Allman* for *Fredericella sultana.* The much-branched tubular cœnœcium is of a pale-

* "Monograph of the Fresh-water Polyzoa," London, Royal Society, 1856.

brown colour, and incrusted with diatoms. It differs from that figured by Allman for the British form in being more slender, and in the suppression (complete or partial ?) of the ridge-like keel—which, however, does not appear to be very prominent even in British specimens.

The only difference which I could detect in the zooid itself was in the form of the epistome, which in the New Zealand specimen was bluntly rounded at the apex, while Allman's figure (pl. ix, fig. 7) shows it as being gradually sharp-pointed. This may be due to difference in the state of contraction, and in any case can hardly be regarded as of specific importance. The specimen contains no statoblasts, and, pending the examination of these in the New Zealand form, the specific identification may be considered as somewhat doubtful.

Fredericella sultana has been recorded from various parts of Europe and from Australia,* while Kræpelin† regards the three American species‡ of Leidy and Hyatt as doubtfully identical with this species.

It is interesting to note that Jullien§ regarded *Fredericella sultana* as being a monstrous form of *Plumatella lucifuga*, but Kræpelin does not agree with this view, and maintains the genus.

Hutton, in his "Catalogue of the Marine Mollusca of New Zealand,"|| records the occurrence of *Plumatella aplinii*, Macgillivray, in the Malvern Hills. As he states that he only examined dried specimens, however, this identification must be regarded as doubtful. Hamilton, in 1879,¶ described a form from near Napier, which he identified (somewhat doubtfully) with *Plumatella repens*. He examined the living animal and the statoblasts, so that it seems tolerably certain that the genera *Plumatella* and *Fredericella* both occur in New Zealand, as they do also in Europe and Australia (Whitelegge). Hamilton has also recorded** the occurrence near Dunedin of *Paludicella ehrenbergi*; so that we have in New Zealand at least three of the common genera of fresh-water *Polyzoa*, while none of the species can, in the present state of our knowledge, be regarded as endemic.

* Whitelegge, Proc. Linn. Soc. N.S.W., viii (1883), pp. 297, 416.

† Kræpelin, "Die Deutschen Süswasser - Bryozoen," Festchrift des Naturwissenschaftlichen Vereins, Hamburg, 1887.

‡ *F. regina*, Leidy (Proc. Acad. Nat. Sci. Philadelphia, vol. v, 1851); *F. walkottii* and *F. pulcherrina*, Hyatt (Communications Essex Institute, vols. iv and v, 1865–6).

§ Jullien, "Monographie des Bryozoaires d'Eau douce": "Bulletin de la Société Zoologique de France," vol. x, 1885.

|| Wellington, 1873, p. 104.

¶ Trans. and Proc. N.Z. Inst., vol. xii, 1879, p. 302.

** Trans. N.Z. Inst., vol. xxxv, 1902, p. 263.

Art. XXIV.—*On the Radio-activity of certain Soils.*

By J. H. Howell, B.A., B.Sc.

[*Read before the Philosophical Institute of Canterbury, 3rd October,* 1906.]

As is well known, radio-active substances are in many cases found present in the water of mineral springs and in the deposits formed by them; and it has been suggested, since the radio-active products are powerful germicides, that the therapeutic properties of such springs may be due to their presence. In some cases experiments have seemed to show that this is at any rate a partial explanation. An examination of the mineral waters of New Zealand would therefore be interesting; and with that end in view small quantities of the deposits from a number of the Te Aroha springs were collected. Subsequently, in order to get comparative data, the radio-active properties of the light volcanic soil of Mount Eden, Auckland, of the heavy subsoil of the same district, and also of Parnell clay, were investigated.

The radio-activity of the Te Aroha deposits was at first tested in a simple electroscope of the following type:—

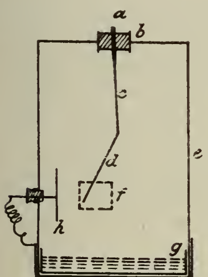

Fig. 1.

a, Small brass screw; *b*, plug of sulphur; *c*, thin copper wire; *d*, gold leaf of about 1 mm. in width observed by a microscope with micrometer eyepiece and 1 in. objective; *e*, brass cylindrical electroscope, 2 in. in diameter; *f*, glass window; *g*, copper cap containing deposit; *h*, earthed copper plate.

The electroscope was charged by touching the head of the screw with an insulated sewing-needle which had been charged by a replenisher, and the rates of leak were determined by a large number of observations taken alternately with and without the deposit. Although the results seemed on the whole to indicate the presence of radio-active substances, the irregularities were too great to allow any definite conclusions to be drawn. It was therefore decided to modify the apparatus so as to diminish as far as possible any leak over the insulation and also to allow the use of a much larger quantity of the deposit.

The apparatus used in the remaining experiments was as follows :—

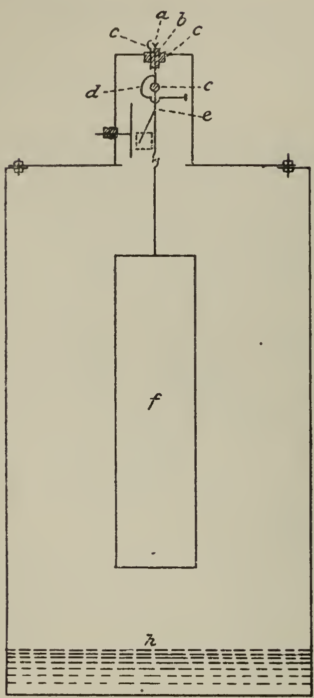

Fig. 2.

a, Brass rod with mercury cup ; *b*, brass guard-tube with connecting wire ; *c*, sulphur ; *d*, iron-wire spring ; *e*, brass ribbon ; *f*, copper-gauze cylinder ; *g*, tin can, 14 in. by 7 in. ; *h*, deposit.

The brass rod and guard-cylinder were first charged as before, while the wire from the guard-tube was dipped into the mercury, and the rod and cylinder were made to share their charge with the insulated lower system by momentarily making connection by attracting the steel spring with a magnet. The guard-cylinder was then disconnected. In all experiments the charge given was such that the initial divergence of the leaves was practically the same.

The Te Aroha deposit that had given most promise of radio-activity in the preliminary experiments was that from No. 1 Spring, and through the kindness of Dr. Kenny a good supply of this was obtained. All leaks are expressed in micrometer divisions per ten minutes. The leak through the air due to the influence of the can alone was tested on three successive days, the leaks being as follows :—

First Day.—4·2, 4·7, 4·5, 4·0, 4·5 : average, 4·25.

Second Day.—3·7, 4·2, 3·7, 3·7, 4·2 : average, 3·9.

Third Day.—4·8, 5·0, 4·8, 4·8, 4·8 : average, 4·85.

On the third day, after the above experiments had been carried out, the Te Aroha deposit was placed in the instrument and the following leaks were observed : 11·5, 11·0, 10·3, 10·3, 9·8, 8·7, 9·7, 9·0 : average, 10·0. Leak due to deposit only, 10 – 4·85 = 5·15/ten minutes.

Fourth Day.—The deposit being left in the meanwhile, the following leaks were observed : 9·7, 10·2, 11·0, 10·7 : average, 10·4. On removing the deposit and wiping out the can, the leak due to the influence of the can only was found to be 2 in ten minutes, which gives as leak due to deposit only 8·4 per ten minutes. The surface of the can had meanwhile become covered by an amalgam with mercury, and it is interesting to note the falling-off in the leak due to the can alone.

Fifth Day.—Can only 1·5. Deposit replaced, 8·0, 7·3, 8·2, 10·0: average, 8·4. Effect due to deposit only, 6·9, which is less than the effect of the previous day but greater than the initial effect.

VOLCANIC SOILS.

A. *Light Volcanic Soil.*—For purposes of comparison similar experiments were done with some of the light volcanic surface soil common in the Mount Eden district of Auckland, an approximately equal volume being taken.

The leaks per ten minutes obtained over a period of four hours were 12·0, 12·7, 17·7, 22·0, or an average of 15·9, while those due to can alone were 2·2, 1·8, or an average of 2·0.

The Te Aroha deposit was placed in the can on the same day, when the leaks were 10·0, 9·7, while on the following day the leaks due to the Te Aroha deposit were 9·0, 9·2, and to the can alone 1·8.

The experiments indicate that the light volcanic soil contains substances of greater radio-activity than the Te Aroha deposit, though the explanation of the rapid rise in the rate of leak is not obvious.

B. *Volcanic Subsoil.*—Beyond the boundary of the light volcanic district, what is locally known as "heavy volcanic soil" is found, and about 10 in. below the surface the volcanic ash forms a very hard "pan," which is attacked better with the pickaxe than with the spade. Some of this subsoil from a depth of about 15 in. was taken, the leak due to the can alone having just previously been found to be 1·5 per ten minutes. The following were the leaks due to the subsoil: 40·8, 38·0, 40·0, 40·8, 40·0, 36·0, 49·3, 37·8, 35·7, 37·2, 45·0, 45·0, 36·7, 40·0, 41·7, the average of fifteen readings being 40·3.

On the morning of the second day, the subsoil being left undisturbed overnight, the following leaks were observed: 52·5, 52·3, 45·5, 51·7, 56·7, 46·7, the average being 50·9. Later on in the same day the leaks were 57·2, 57·2, 58·2, 55·0, 55·0, 60·0, or an average of 57·1.

On the third day, the subsoil still being in the can, the leaks were 52·2, 53·8, 58·7, 50·8, 56·7, or an average of 54·4.

On the fourth day, in the morning the soil was taken out and the can well cleaned; the leaks with can only were now 9·5, 8·7, or an average of 9·1. At night the leak due to can only was 2·8.

C. *Parnell Clay.*—The effect of Parnell clay, a surface soil formed by the weathering of volcanic rock, was next observed, a measured quantity of about one-third the previous quantities being taken. The leaks obtained on the first day were 8·8, 9·8, 7·7: average, 8·8. Second day, 7·7, 7·7, 8·7: average, 8·0. Third day, 9·3, 11·0: average, 10·1. Fourth day, 7·7, 7·7.

An equal quantity of volcanic subsoil was then taken, when the leaks observed were 29·5, 28·7, 35·0, 37·0, or an average of 32·5. As an average of fifteen readings with about three times the quantity of soil was 40·3, the rate of leak would not be appreciably affected by small variations in the quantities taken, and it is therefore sufficient for purposes of comparison if approximately equal amounts are tested. On the fifth day the subsoil gave 30·0, 32·3, 34·7—average, 32·3; and on the following day 32·3, 33·3, 31·7, 29·5—average, 31·7. The subsoil was then left in the can for sixteen days, at the end of which the leaks obtained were 46·0, 46·5, showing an increase of 50 per cent.

No further experiments could be carried out at the time, but it is hoped shortly to continue and extend them in order to determine the nature of the radio-active substances. In future experiments the apparatus will be modified in several respects in order to try to get rid of the irregularities which have so far occurred; and by conducting the experiments over a longer period with the same material more accurate information will be gained as to the rate of growth and decay of the induced radio-activity

The results so far obtained indicate the presence of radio-active substances in small quantities in the deposit from No. 1 Spring, Te Aroha, and in larger quantities in both surface soils, while the hard volcanic subsoil is about six times as active. The difference between the surface soil and the subsoil is what would be expected if radium were present, for the heavy emanation gas produced by the disintegration of this element would more or less be imprisoned in the subsoil, and the subsequent soil-products, themselves radio-active, formed by the subsequent disintegration would accumulate there. On the other hand, in the case of the loose surface soil, the emanation would for the most part escape and the further products be lost.

Art. XXV.—*On Introduced Birds.*

By J. Drummond, F.L.S.

[*Read before the Philosophical Institute of Canterbury, 6th December,* 1905.]

My excuse for entering the controversy as to whether small birds are man's friends or his enemies lies in the fact that I have lately collected a great deal of information dealing with the position that has arisen in New Zealand since acclimatisation was commenced in this colony, over forty years ago.

The introduction of old birds to a new country cannot fail to interest naturalists, who will welcome all additions to their knowledge of the subject. Besides that, the small English birds have brought about a serious problem in this country, as in all other countries where they thrive, and I feel sure that agriculturists in New Zealand, as well as in other countries where acclimatisation is contemplated, will be glad of some means of ascertaining the results brought about here.

The best plan of collecting the information is to pass from district to district, interviewing farmers and old settlers, and making observations. To do that, however, both time and money are necessary. The next best plan is to send throughout the colony a large number of circulars containing questions bearing on the subject. This was the plan I adopted, and, through the kindness of the Biological Branch of the Agricultural Department, which undertook to print the circulars and send them out to farmers, observers, and others who would be likely to give intelligent replies to the twenty-nine questions contained in the circulars, I have collected a great deal of evidence.

How Acclimatisation Began.

Acclimatisation began in New Zealand when the Maoris brought their dog and their rat from Polynesia. The rat, which is a rather engaging little animal—for a rodent—is not plentiful now, except in some densely wooded districts; and the dog, which was a sorry specimen of his order, is quite extinct; but for five or six hundred years both thrived exceedingly well, and they stand first on a long list of animals that have been introduced into this country with a success which, in several cases, is far too marked.

The first European animals were introduced by Captain Cook. He let three pigs loose in Queen Charlotte Sound in 1773. He extracted from the Maori to whom he gave them a promise that they would not be killed. He believed that in time the pigs would stock the whole island. The Maori kept his word, and the navigator's belief was fulfilled. In later years the "Captain-Cooks," as they were called, afforded splendid diet for the Maoris and the early European visitors. It was these "Captain-Cooks," by the way, that began the disastrous attack on the native fauna. To them is attributed the work of banishing the tuatara from the mainland to a few small islands on the sea-coast.

By the time civilisation had sent out its advance guards of pioneers the pigs had increased so largely as to become a nuisance. They multiplied astonishingly, and enormous numbers assembled in the uninhabited valleys far from the settlements. At Wangapeka Valley, in the Nelson Province, Dr. Hochstetter, in 1860, saw several miles ploughed up by the pigs. Their extermination was sometimes contracted for by experienced hunters, and Dr. Hochstetter states that three men in twenty months, on an area of 250,000 acres, killed no fewer than twenty-five thousand pigs, and pledged themselves to kill fifteen thousand more.

When civilisation had fairly established itself, bringing many species of its domestic animals and several species of its domestic pests and vermin, there began a short, sharp, but bitter struggle between the new fauna and the old one which had possessed this country for ages. The result was never in doubt. The old fauna, which may be regarded as aristocrats of the animal kingdom, had absolutely no chance against the shrewd, vulgar, hard-headed, cunning, practical, greedy, and ferocious invaders, who were inured to hardship and had walked hand in hand with adversity through many generations. The incident was a specially dramatic one in respect to the avifauna. The native birds were driven completely away—not altogether, or even chiefly, by the newcomers, but by influences that the latter had been taught by experience to combat.

Sentiment, necessity, and utility played parts in connection with the acclimatisation of birds, and it was necessity and utility, not sentiment, that carried most weight. About forty years ago the country was smitten with a blasting plague of insects, which crawled over the country in vast hordes. The gathering of the caterpillars was a sight that caused consternation to agriculturists. They came not in regiments and battalions, but in mighty armies, devouring crops as they passed along, and leaving fields as bare as if the seed had not been sown.

In the Auckland District one settler kept a paddock closed up for a short time in order to place some young stock in it, but when he completed his purchases he was astonished to find that the grass in the paddock had disappeared. It had been devoured by caterpillars. In the same province a settler who was driving his dray along a road drove through a colony of caterpillars which happened to be crossing the road at the time. They were present in such countless numbers that the wheels of his dray were in a puddle, caused by the crushing of the insects. A Press Association telegram published in the leading New Zealand newspapers about that time stated that the morning and evening trains between Waverley and Nukumaru, on their way to Wanganui, were brought to a standstill owing to countless thousands of caterpillars being on the rails, which had to be swept and sanded before the trains could continue their journeys. In the neighbourhood of Turakina, in the Rangitikei District, an army of caterpillars, hundreds of thousands strong, was overtaken by a train as the insects were crossing the rails to reach a field of oats. Thousands of them were crushed under the wheels of the engine, and the train suddenly stopped. It was found that the wheels had become so greasy that they revolved without advancing, as they could not grip the rails. The guard and the engine-driver placed sand on the rails, and a start was made. It was found, however, that during the stoppage the caterpillars had crawled in thousands over the engine and all over the carriages, inside and outside.

A Hawke's Bay gentleman who filled in one of the circulars states that caterpillars have covered his paddocks so thickly as to give colour to the pasture, even from a distance, and it was considered worth while to drive a mob of sheep backwards and forwards over the insects in order to destroy them. At Dunsandel, in North Canterbury, crops of oats of 60 or 70 bushels were completely threshed by the caterpillars. Their numbers increased in proportion to the quantities of food they consumed. They marched from field to field in grand processions, leaving behind them the abomination of desolation.

A Dunsandel farmer says: "I have been forty years in Canterbury. I have seen some bad work by the small birds, but I have also seen some bad work by the caterpillars. I once saw the caterpillars coming out of one man's paddock and crossing the road into another man's paddock. I made all haste to tell the man, and we got about sixteen hundred sheep on the road and killed the insects. The road was black with them, and as warm weather came on the smell was something awful."

Dr. C. Morton Anderson, of Christchurch, also gives his testimony. He states that twenty-five years ago an old farmer in the Amberley district, North Canterbury, showed him a splendid crop of wheat and said that he had seen just as fine a crop, twenty years previously, destroyed by caterpillars.

It was clear to the settlers that if this disastrous condition of affairs continued it would be useless to attempt to carry on agriculture and horticulture, as operations in that direction would mean that insects, not men and women, would be fed. The armies of the insects had to be fought back. In places large ditches were dug to stop the creatures' progress.

Some of the native birds performed good service by eating the insects. Prominent among these birds were gulls, terns, kingfishers, oyster-catchers, native larks, white-eyes, fantails, bell-birds, and grey warblers. At first the kingfishers seemed to increase rapidly with agriculture, and were regarded for a time as the agriculturist's best friends. The native birds, however, will not dwell with men, and when the native bush was felled in the vicinity of settlement they retreated further back, and only visited the insect-laden fields occasionally. As a means of adequately dealing with the insect pests they are not worth considering.

The settlers then turned their attention to the insect-eating birds they had known in the Old Country. Acclimatisation societies were formed, and steps were taken to introduce English birds. In Europe the insect-eaters have their retreats in the winter, when insects are absent; in New Zealand there are no winter retreats. It was therefore concluded that the introduced birds would have to possess three qualifications: they would have to be able to eat both insects and seeds, otherwise they would not be able to live in the winter, when the "children of the summer" were absent; they would have to be non-migratory, otherwise the time and money spent on their acclimatisation would be wasted; and they would have to be prolific breeders, so that they should multiply rapidly and soon overcome the insect pests.

In weighing the evidence against the small birds it must never be forgotten that that rapid increase was one of the principal qualifications set down by the early colonists as necessary for success. The sparrow fills all these requirements, and it is not surprising to learn that this little bird, which is now heartily cursed in many countries, and outlawed in several, with a price upon its head, should be among the first to be introduced to the new land of insects and trouble.

As far as I have been able to learn, it was to Canterbury that the first sparrows came, but their advent, it is stated, was purely accidental, and their introduction was not contemplated on that occasion. The story is that the acclimatisation society ordered twelve dozen hedge-sparrows from England. The order was placed with Captain Stevens, of the "Matoaka," who submitted it to a bird-fancier at Knightsbridge. Either the fancier or the captain blundered, and the latter took on board thirteen dozen house-sparrows, which are generally known by the common name of "sparrow." He was very attentive to them on the voyage out, believing that they were the valuable hedge-sparrows which the colonists were anxious to secure. Most of them died, however, and when he reached Lyttelton, in February, 1867, only five were left. The officers of the society, realising that a mistake had been made, refused to accept the strangers. The captain then took them out of their cage, and, remarking that the poor little beggars had had a bad time, set them at liberty. They flew up into the rigging and remained twittering there for some time. The members of the society had gone down below to look at other birds. When they reached the deck again the sparrows had flown. The birds stayed about Lyttelton for three weeks; then they disappeared, and when next heard of had been seen at Kaiapoi, about twenty miles distant, where, at the end of 1869, they were reported as being "particularly numerous." The Otago society liberated three sparrows in 1868 and eleven in 1869. Other consignments were brought out later on, until the colony was well stocked. Sir Walter Buller frankly pleads guilty to having been accessory to the importation of sparrows to Wanganui. He, on behalf of the acclimatisation society there, advertised in the London newspapers offering a reward of £100 for a hundred pairs of sparrows delivered alive. Both advertisements and importations were successful.

Previous to that, in 1868, the Canterbury society introduced small numbers of birds, including skylarks and goldfinches. In shipping offices in London the society circulated lists of the sums of money it was willing to give for different species of birds, which it was intended should be brought out by emigrants from England; but that system was not successful, and it was not until definite arrangements were made with agents and captains of vessels that any satisfactory results were achieved. It was Captain Stevens who brought the first hedge-sparrow to the colony, and, it is claimed, to the Southern Hemisphere. It came in the "Matoaka," together with the first house-sparrows. It was the only survivor of a consignment. For a long time it was an object of interest in the society's grounds in Christchurch, many people journeying to the gardens to see the stranger.

The sight of the introduced birds seemed to fall in with the early colonists' desire to make Canterbury as like England as possible. Their minds were full of the place they had left. The Old Country was their Holy Land, and anything that reminded them of it and its associations was given a hearty welcome.

The blackbird, the skylark, and the song-thrush were introduced for sentimental reasons. The song of the skylark was listened to with a delight that can hardly be expressed in words. It sent a thrill of pleasure through the whole settlement. The bird was a "blithe spirit," which poured out the fullness of its joy "in profuse strains of unpremeditated art." It showered a "rain of melody" on the toiling colonists, and awakened the sweetest thoughts of home and of childhood's happy hours. The colonists had absolutely no suspicion that their charming little feathered friend, the gay and debonnair "embodiment of joy," the gentle singer of the field, who had come to sing to them the old songs of Merry England, would soon be ranked as a feathered pest, second to none but the sparrow.

The blackbird was another treasured reminder of the Old Country; and it is now another "feathered friend" that is heartily cursed up hill and down dale. There is some doubt as to when it was first introduced into New Zealand. Old settlers in Otago have an impression that it is indigenous, and was in the colony before civilisation came. It is probable, however, that early settlers in Otago mistook some of our own dark-plumaged birds for the English blackbird, and were led into a misapprehension. A statement has been made that the blackbird came up into Canterbury from Otago, making its first appearance in the former province in 1856. No Canterbury settler with whom I have spoken on the subject has been able to confirm that statement. The first record in regard to Canterbury is in 1865, when Captain Rose brought a pair to Lyttelton in the "Mermaid." In the same year the Otago Acclimatisation Society liberated a pair in Dunedin. In 1867 Captain Stevens brought forty-six to Lyttelton in the "Matoaka," and six more were liberated in Dunedin. Others followed, a few being acclimatised every year for a considerable time, Messrs. R. and C. Bills bringing out quite a large number. There was a great rage for blackbirds in Christchurch at one time. A single bird kept in a cage by Mr. T. H. Potts, at Governor's Bay, in Lyttelton Harbour, was the subject of much attention, and extortionate prices were paid for a mate for an odd bird.

The blackbird soon became naturalised. Colonists only smiled when it took a little fruit. There was plenty of fruit, they said, but there were only a few blackbirds; and they looked upon the bird's depredations as they would look upon the little failings of a favourite child. As the years went by, and the blackbird increased in numbers, it began to take the lion's share of cherries, strawberries, pears, apples, and other fruit. Gardeners then began to look upon it as an ugly, sooty intruder and a greedy nuisance, and its company was found to be not half as desirable as had been anticipated.

The acclimatisation of nearly all the other small birds was the object of the same keen interest. The fact that the familiar shrill note of the robin redbreast was heard in Hagley Park, Christchurch, in 1880 was carefully recorded; and when a single nightingale, which had come out with the robins, died through an unnatural moult, deep regret was felt far and wide. The acclimatisation of both robin redbreast and the nightingale was unsuccessful in Canterbury, but the failure may be attributed to the fact that they were not given a good chance. An attempt to introduce the robin at West Taieri also failed.

Some of the birds spread from one district to another. In that way, Canterbury got from Otago its cirl-buntings and goldfinches, and some of its starlings, which were rather rare in Canterbury in 1880, but were very abundant there ten years later. The first were liberated in Dunedin in 1867, and in both Otago and Southland they are present in great numbers. The blackbirds and the goldfinches have covered an extraordinarily wide area, having taken up their residence on the lonely Auckland Islands, three hundred miles south of the mainland. The redpoll, on the other hand, is almost confined to North Canterbury and the country along the sea-coast of Otago, but it is found in a few northern districts. At first the song-thrush did not succeed anywhere except at Cheviot, between Christchurch and Kaikoura, but it is now found all over the colony. I have been able to obtain absolutely no trace of the Java sparrow, which was introduced into Nelson and Auckland, or of the grass-parrakeet, introduced into Canterbury. The bullfinch was liberated in Nelson, but I have heard nothing further about it, except from Mr. H. Guthrie-Smith, of Tutira, Hawke's Bay, who says that he has seen it in his district, while another correspondent says he saw one at Rissington, another district in Hawke's Bay.

THE SPARROW.

The case against the sparrow has been made out so often and so strongly that it is not necessary for me to state it in general terms here. The bird's troubles began about 1730, when Frederick the Great of Prussia caught a few sparrows eating some of his favourite fruit. He immediately placed a price on the head of each sparrow in his kingdom, ordered a crusade against the whole finch family, and set about the work of extermination with the same hearty goodwill that he brought to bear upon his troubles with the powers and principalities around him. At the end of two years he found that his trees were bare of either leaves or fruit, but were alive with caterpillars. He retracted his decree, and was glad to pay large sums of money to import consignments of sparrows from other countries. In England in recent years the sparrow has been condemned by Miss E. A. Ormerod, and by the English Board of Agriculture. Even at the recent Ornithologists' Conference in England it was severely dealt with.

Everybody knows that it does great harm to crops and gardens. There are few farmers in New Zealand or any other country that do not regard it as one of their greatest enemies. The report of its ravages cannot be greatly exaggerated, as plain facts and figures are supplied, and corroborative evidence is not wanting.

In New Zealand, as in England, it refuses to go out into the woods and get an honest living in the straightforward but laborious manner adopted by our own birds. It clings to civilisation and cultivation, and insists on inflicting upon man its most unwelcome company. Whatever change it has made in its habits since it came to this new land have been for the worse. It has become less of an insect-eater than it used to be, and more of a grain-eater. It has swarmed into the gardens and orchards. No vegetable, fruit, or crop of any kind is proof against its enormous appetite. Its sole object in life seems to be to eat, breed, and be merry. Its cunning is unsurpassed. It has a wonderful knowledge how not to fall into a trap. Its impudence knows no bounds. Above all, it has an extraordinarily robust constitution, and it enjoys such continuously good health that no disease, evidently, is strong enough to materially lessen its numbers.

One of the inquiries in the circular was made with the object of ascertaining the number of young a pair of sparrows will breed in a season. I thought that if I could obtain reliable information in that respect from people residing in different parts of the colony, a rough estimate might be formed of the rate of the sparrow's increase in this country. The question was, "Can you state the number of young birds a pair of sparrows will rear in one season?" As might be expected, the replies make a very mixed assortment of statements, observations, conjectures, and guesses. Large numbers of the correspondents admit that they cannot supply the answer. Others put me off with general statements, such as "Their name is legion," "As many as they can," and, "Judging from the visible increase in this district, about a million."

I have been supplied, however, with plenty of good evidence, based on careful observation, to show that the sparrow is astonishingly prolific in this country. The number of eggs that may be taken from a female is almost without limit. At one place, where an experiment was made, egg after egg was removed until fifty from one bird had been counted.

At Temuka, four broods of young, totalling thirteen birds, have been hatched in one nest, and in quick succession. In the Waikato district, four broods of five birds each are quite common. Mr. W. Hooton, secretary of the Farmers' Union at Rangi-iwi, in the Waikato, states that sparrows there generally breed four times in the season. In North Tauranga, on the east coast of the North Island, three broods of six each are common. At Balcairn, Woodside, and West Taieri, in the South Island, the reports state there are three broods in the season. Mr. W. Harding, chairman of the Ashburton branch of the Farmers' Union, gives the number in his district as thirty-five, which is also the number given by the Ashburton County Council. Mr. A. H. Shury, of Ashburton, says that a pair will rear five broods of five birds each, and the first brood will rear at least one.

Mr. James Smaill, an observer at Inch-Clutha, in Otago, says that breeding goes on all through the season, whole nestfuls being killed off by the cold in the severe weather. From twenty-five to thirty are the figures supplied for West Oxford, and at Riccarton there have been recorded three broods of five each. In a nest under a verandah the unfledged young ones evidently helped in the hatching of the eggs, so that the nest was never empty of unfledged young, while fully fledged birds seemed to rise out of the nest uninterruptedly right through the season.

From the nature of the evidence submitted, I should say that twenty-five young is a fair average for one pair in one season.

If allowance is made for natural decrease, which certainly cannot be very great in the case of the sparrow, the average might safely be put down at twenty. I feel sure that that is well within the mark. If those twenty were equally divided into males and females, and if all of them, together with the original parent birds, lived for five years, the single pair in that time would have increased to no fewer than 322,102. The increase is shown by the following table :—

Year.	Pairs Breeding.	Pairs of Young.	Total Pairs.	Total Number of Birds.
First	1	10	11	22
Second	11	110	121	242
Third	121	1,210	1,331	2,662
Fourth	1,331	13,310	14,641	28,882
Fifth	14,641	146,410	161,051	322,102

If the process was continued at the same rate for five more years, and if all the birds lived, the single pair, at the end of ten years, would be represented by 51,874,849,202 sparrows. When figures are placed together in that way, of course, they are absurd. The increase assumed would never be reached, even by rapid breeders like sparrows. I may add that an American ornithologist, on whose system the table has been drawn up, states that it is no unusual thing for a pair in the latitude of New York to rear twenty or thirty young in a year, and, assuming the annual product of a pair to be twenty-four, and that they all lived, he works out the progeny of that pair for ten years at 275,716,983,698. It is only fair to state that he points out that the actual increase must be only a small fraction of that total, which is based on assumptions that are never likely to be realised. His investigations show that it is probable that the large colonies at Galveston (Texas), Salt Lake City, Utah, and San Francisco have resulted wholly, or at any rate to a large extent, from the few pairs originally introduced at those places; but he finds that it is impossible to apply the same remark to most of the other centres of abundance in the United States.

The evidence I have been able to gather seems to point to the fact that the five sparrows liberated by Captain Stevens in Lyttelton in 1867 must have been responsible for large numbers of the sparrows that spread over Canterbury in the following years. If there was only one pair in that little consignment, it must by this time have produced sufficient progeny to stock a large portion of the South Island.

I have endeavoured to ascertain whether the rates of increase are affected by the different climatic conditions in this colony, but these birds seem to have such remarkably strong constitutions that they thrive equally well in the cold of Otago and Southland and the warmth of Auckland. All the information supplied points to the fact that they are more numerous in the southern provinces than in the northern ones, and breed as rapidly in one as in the other. It is true that they are sometimes found dead in large numbers in the severe winters of the south, but this is more likely to be attributed to lack of food than to the severity of the climate. Wherever there is close settlement, in fact, sparrows are found in countless numbers, and in the enjoyment of the very best of health. It is stated that in America they do not increase as rapidly or as steadily in cold climates as in temperate ones, but I certainly cannot say that that is the case in New Zealand.

It is interesting to note that the first sparrows were taken to the United States in 1850, seventeen years before Captain

Stevens liberated the historical five in Lyttelton. The first pairs in America were liberated in Brooklyn, but they did not succeed very well, and a second attempt had to be made, a large shipment being sent from England in 1853. The birds were carefully watched, fed, and protected. Into some districts they were transported; into others they went voluntarily, and formed colonies. By 1875 there were many large colonies in different parts of the country, and a bulletin issued by the United States Department says, "From that time to the present the marvellous rapidity of the sparrow's multiplication, the surpassing swiftness of its extension, and the prodigious size of the area it has overspread, are without parallel in the history of any bird. Like a noxious weed transplanted to a fertile soil, it has taken root and has become disseminated over half a continent before the significance of its presence has come to be understood."

Exaggerated reports of the benefit the bird had conferred upon settlers in the districts in the United States into which it had been first introduced helped largely to foster its increase. Many people in the United States went to the expense of purchasing and shipping sparrows to considerable distances in the belief that they were insectivorous birds and must prove beneficial wherever they could be naturalised. In this way a sparrow "boom" was started, and the price of sparrows in New York went up to such a point that many people desirous of obtaining the birds found it cheaper to club together and import them direct from England.

I directed special inquiries to ascertain if possible the manner in which the sparrow in New Zealand regulates its diet. It would be interesting to know the proportions of grain and insects it consumes, and whether, if a dish of insects and a dish of grain were placed in front of it, it would take the insects before the grain.

Large numbers of farmers in this country have come to the conclusion that the sparrow has entirely lost its insectivorous habits, and has become a grain-eater pure and simple. They say that while there is a speck of grain about or a seed of any kind the sparrow will not trouble about the insects, unless it is to feed the young. Some attempts have been made to put the sparrow's weakness in this respect to an actual test. One correspondent states that when insects were placed round a sparrow's nest the bird left them alone, and flew to an adjacent wheat-field or a garden of sweet young vegetables. So far as the replies to my circular are concerned, there has been only one case of this kind, and against it there are the statements of many correspondents that the sparrow still eats many insects, although this is often qualified by another statement that it does so only when there is no grain available.

A reliable correspondent at Ashburton estimates that one sparrow will eat 100 grains of wheat in twenty-four hours, and that the progeny of one bird, during the three months of harvest, will consume three-quarters of a bushel of wheat, and will also shake large quantities to the ground. These estimates are not altogether guesses, but are based on intelligent investigations. A Waikato farmer says, "Bother the sparrows! they eat or destroy everything you do not want them to." A farmer in the Wairarapa sums up his views in the following words: "If all the sparrows were dead we would never miss them; they are a tax on the farmer to the extent of an extra bushel of seed per acre." A member of the Farmers' Union at Aponga, Whangarei, declares that he doubts if the sparrows ever touch insects, as he has never seen them doing so.

The fifth question in the circular was, "Do you think that the introduction of any of the small birds was a mistake?" There are very few correspondents who, in replying to this, have not named the sparrow and emphasized his inclusion in the condemned list by strong and harsh words.

Mr. A. Burrows, a dairy farmer, of West Oxford, North Canterbury, says: "I once made a small box for sparrows and placed it in a position where I could watch them. After a week had passed a pair built a nest in the box and reared five young. For the first week they fed them on insects, bringing as many as six moths and 'long-legs' at a time. A short distance away there was a paddock of wheat getting ripe. They started upon that. They made a journey about once in every five minutes, bringing each time a grain of wheat, making, for both birds, 24 grains an hour—that is assuming that they took only one grain at a time. If they worked eight hours a day the total would be 192 grains. I do not know how long they would have continued, as I killed the young ones before they were ready to fly. There was nothing but wheat in the crops of them all. I sowed 4 lb. of timothy seed on half an acre of land, well worked to test its capacity. After sowing I bush-harrowed it well and rolled it hard. I could not keep the sparrows off. They worked it all up again, as though it had never been harrowed, and very little came up. I shot some of the sparrows, and found that they had as much as half a teaspoonful of seed in their crops. I tried poisoned wheat, but they would not touch it. Last winter I raked the snow off the grass and put poisoned wheat down. The sparrows were plentiful, but did not touch it; but in an hour there were five larks, three chaffinches, one grey linnet, and one thrush dead. Dead gulls, blackbirds, pheasants, and hedge-sparrows, poisoned by wheat, have been brought to me."

Some of the replies give an idea of the intense enmity the sparrow has created for himself in New Zealand. One correspondent refers to him as "that bird brigand, the sparrow." A resident of Mataura, in Southland, says that he is a greater nuisance than the rabbit. Another farmer says that the man who first introduced the sparrow should be smitten with all the plagues of Egypt; and another thinks that hanging is the only punishment that will fit the crime of introducing "this pestiferous little beast, which has done no good to any one, and much harm to everybody."

Of the hundreds of correspondents who have filled in the circular, there are only six who raise their voices in the sparrow's favour. I give their opinions in full. Mr. G. Wilkinson, Chairman of the North Cape County Council, writing from Mangonui, says: "I feel sure that sparrows do a lot of good, and if their numbers were greatly reduced the country would be overrun with insects again." Mr. W. E. Draper, of Waerenga, Waikato, looks upon the sparrow as "the best agricultural scavenger we have." "It is true," he adds, "that he eats a little, but he does not destroy what he won't eat. When I watch him and see what quantities of dirty slugs he eats I am satisfied that I am not paying too high a price for the return made. I am also satisfied that a great deal of the damage attributed to the sparrow is committed by the lark." Mr. G. M. Thomson, F.L.S., a Dunedin naturalist, says that though the sparrow is very destructive to grain-crops when they are ripening, it eats a number of insects throughout the year, as well as the seeds of weeds. He also states that "it is a common sight to see sparrows chasing moths and other insects on the wing, and lighting down on the roads to strip their wings off; in gardens they destroy germinating seeds, especially peas, disbud gooseberries, and pick the primrose-flowers as they open; but here again they do a lot of good in keeping down insect life." Mr. R. H. Shakespear, curator of the bird sanctuary at Little Barrier Island, says that sparrows are destructive to a certain extent, but in the winter they destroy a good many insects. He doubts if they are as destructive as they are thought to be, and says that probably one characteristic balances the other. Mr. Shury, of Ashburton, states that a pair of sparrows have been observed to feed their young thirty-six times an hour in a fourteen-hour spring and summer day, and he has calculated that they feed their young with 3,400 worms and caterpillars in one week. Mr. H. A. Nevins, writing from Tinui, Castle Point, says: "Sparrows do a great deal of good; I have known them to clear a field of peas of caterpillars, which, before the birds became numerous, would have destroyed all the peas."

In 1878, Mr. T. W. Kirk, F.L.S., Government Biologist in New Zealand, read an interesting paper before the Wellington Philosophical Institute, in which he stated that the balance of a mass of information he had collected was against the sparrow. In 1897, in the "Report of the Department of Agriculture," he stated that he had made more extensive investigations, with the result that the evidence against the bird was overwhelming, "and would crush, as with a weight of shame, any less hardened criminal."

That is the case for and against the sparrow as far as my inquiries have gone. The mass of evidence is entirely against the bird, which stands condemned on the almost unanimous vote of the farming community of the colony. It is proclaimed a public nuisance, and the mitigations of its offence are evidently so slight that they are deemed hardly worth considering.

Whatever the sparrow may do in these times, however, there is no doubt that it did good service to the agriculturist and horticulturist of New Zealand in former days, when the insects were on the war-path and when the people were liable to be eaten out of house and home. A new generation has arisen, and only the sparrow's faults are remembered. We do not know how we would fare if the sparrow was dismissed from the land, and the safest plan seems to be to keep it in check as far as possible.

The Blackbird

The blackbird is a pest of the orchard rather than of the field. It devours all kinds of fruit, from currants and strawberries to apricots, apples, cherries, and plums. Its wholesale depredations in this respect outweigh much of the good it does by eating insects. Its name is generally linked with that of the sparrow and the skylark in answer to the question as to whether the introduction of any English birds was a mistake.

Amongst other things, the blackbird is accused of having been the means of spreading the blackberry throughout the West Oxford (North Canterbury), Mangonui, and other country districts. Mr. J. Speight, of Shirley, near Christchurch, who was a passenger by the "Matoaka" in 1867, and had blackbirds as his shipmates, says that they are almost useless in Canterbury now, and that they seem to have forgotten the art of breaking snails' shells in order to get at the snails, a practice in which they display considerable skill in England.

A large majority of those who replied to my circular are distinctly in favour of banishing the blackbird, if that is possible, as they look upon it as no friend, but an enemy. One of the correspondents, at Waihou, Piako County, reports that the blackbird, in conjunction with the thrush, has practically put a stop to the growing of grapes, plums, peaches, gooseberries, apples, or pears on a small scale, and this gentleman sees absolutely no good in the bird—a view which is taken by many other people in New Zealand.

OTHER SMALL BIRDS

I have already classed the skylark, placing it next to the sparrow in respect to destructiveness. It is often seen pulling up springing wheat, and it is specially troublesome in the gardens where early seeds, such as turnips and cabbages, are sown, pulling the young plants out of the ground as they are just shooting above the surface.

Very few of the correspondents have a good word to say for the song-thrush, which is placed fairly high in the list of mistakes. An observer at Rissington, Hawke's Bay, however, sends the following story of the thrush: "For about thirty days in the year, until well into January, a thrush has come to my farm morning after morning. Over an area of about 300 square yards he collects worms, and flies with them to his mate, taking sometimes two or three at a time. I have watched him frequently, and from 7.30 a.m. to 8 a.m. he takes fifty worms. I think I underestimate it in putting it at two hundred worms a day. He also takes slugs and insects."

The greenfinch is described sweepingly as the farmer's greatest enemy when grain is ripening. It is very plentiful in the open country, where it is seen in large numbers. The first greenfinches of which I have been able to secure any information were liberated in Christchurch in 1863, where a pair were purchased at auction for five guineas. They soon nested, but the only occupant at first was one little greenfinch. Before the warm summer days had passed, however, a second family of five was reared, and in the following winter a flock of eight was seen daily. In the next year, late in the autumn, more than twenty were flushed from a little patch of chickweed, and it was not long before the birds had spread so widely that their note became a well-known sound in Canterbury. It is stated that in the Central Otago district the greenfinch is the worst offender of all in the orchards, as it attacks the trees while they are still in flower and just as the fruit is forming. In some orchards in that district, it is reported, the birds have taken nine-tenths of the fruit-crop. The chaffinch and the redpoll have appeared at Tutira, in Hawke's Bay, within the past two years. Mr. Guthrie-

Smith states that both came from the north. The former is now nesting everywhere on the run, but the latter is much rarer.

The goldfinch feeds largely on seeds, and it does not seem to have aroused much enmity. Some farmers say that it does more good than harm, as it destroys large quantities of thistle-seed.

The redpoll is regarded as a harmless bird for the most part, but it has not spread very far. In the North it is reported to be destructive on grass-seed burnings.

The yellowhammer is classed with the sparrow in descriptions of the damage done to seed in the newly-sown bush burns in the North Island. Mr. S. I. Fitch, of Dallington, near Christchurch, who took a keen interest in birds when a boy in Yorkshire, states that the song-thrush, the greenfinch, and the goldfinch are more numerous in New Zealand than he ever knew them to be in England.

The house-mynah attacks fruit as well as insects, being specially fond of cherries.

The chaffinch joins other birds in their attacks upon seeds and berries.

The lapwing seems to have had a hard struggle at first against this climate. It was not tried in the South Island until quite recently, and it was thought that attempts to introduce it into the North Island had failed. The information supplied, however, shows that its acclimatisation has been successful in several northern districts, where it is highly praised, the experiment of its introduction having given great satisfaction. This bird is credited with having killed large numbers of the wireworm and grubs in the spring, and absolutely no charges are made against it. In January, 1904, thirty lapwings were liberated in the Upper Kokotahi district, Westland, but nothing has been heard of them yet.

Praise of the little hedge-sparrow is almost unanimous. It is found in fairly large numbers in Canterbury and in some districts of Otago. It is regarded as a faithful friend of the farmers, who regret that it has not spread as rapidly at its impudent and hardy namesake.

The cirl-bunting has established itself in several districts. It seems to have created neither good impressions nor bad ones.

Rooks have been introduced successfully, but they generally remain in one district, and do not spread far. They are fairly plentiful in Canterbury, and in some districts of the North Island, where it is said they do much good and scarcely any harm. Their acclimatisation has not been very successful in Hawke's Bay, although there are several colonies of them there. This bird, however, is not without its enemies, and colonial farmers with a Home experience say that its introduction may prove to be one of the mistakes of acclimatisation.

Nothing is said against the Australian magpie, which is sometimes described as a useful immigrant. It has taken up its residence in a number of districts, where it seems to thrive very well. Many years ago a pair of these birds came over to Streamlands, in the Rodney County, from the Island of Kawau, when it was owned by Sir George Grey. They nested in a kauri-tree about a hundred yards from a settler's house, and from that spot they spread throughout the whole county. They have now completely disappeared from Streamlands.

There is hardly any limit to the good words said of the starling. It is frequently described as the only introduced bird worth having. It is found in nearly all parts of the colony, and its arrival in a new district is welcomed by all who are engaged in agriculture. Large numbers of farmers erect nesting-boxes in order to encourage it to come about their farms. Besides eating insects, it does a great deal of good by destroying larks' eggs and eating the ticks on sheep. Many farmers look upon this bird as being the only true insectivorous bird introduced into this colony. Somewhat alarming stories are told by quite a large number of correspondents, however, about the starling having taken to devouring fruit and even grain. Mr. Edgar Stead confirms the report in regard to this bird's fruit-eating proclivities. In a conversation with me he predicted that it will become one of the greatest nuisances orchardists and gardeners have ever known. I have no absolute proof that it has actually taken to eating grain, but this is a phase of the starling's life that is well worth watching. If even the starling turns from insects to fruit and grain, it may be asked if there are any birds that are likely to remain loyal to their reputations as insect-eaters exclusively. It may be pointed out here that the starling has given rise to something more substantial than suspicion in Australia, where the gravest possible charges are made against it, and these charges are evidently based upon evidence that cannot be discounted. According to the report of the American Consul at Melbourne, starlings have increased to myriads in Australia, and they have become very injurious to the fruit-crops, so that the regulations passed for their protection have been repealed, and it is urged that steps should be taken for their systematic destruction. "The fruit destroyed by them," the Consul says, "includes peaches, pears, cherries, apples, figs, apricots, plums, grapes, and strawberries. Both vine- and fruit-growing are seriously threatened if the pest is not suppressed. As many as ten cases of apples have been destroyed by this bird in less than half an hour." Another charge is made against the starling in Australia. It is stated that valuable native insect-eating birds, such as kingfishers, diamond-birds, tree-swallows, and tree-creepers, are being turned out of their nesting-places in tree-hollows by swarms of starlings, "and before long," the report continues, "these birds, so useful to the farmers, will be driven out of the country." The starling in Australia is supposed to raise five broods in the year, and it multiplies with amazing rapidity—much more rapidly, evidently, than in New Zealand. Before leaving the starlings, I should like to point out that Mr. W. W. Smith, in a letter to the *Lyttelton Times*, a few years ago, reported that they killed off large numbers of humble-bees, which the birds captured in order to give to their young. "Like the native tui," Mr. Smith writes, "the starling now frequents the flax flats and sucks the honey from the richly mellifluous flowers of the plant. It is quite probable that the eating of the bees' honey-sac by the starling developed a taste for honey in these birds. Both the starling and the tui are birds of high intelligence. Their newly acquired habits are important as illustrating how the penchant for fresh food is developed in some species." These facts point to the great need for caution when fresh importations are being considered.

The Small Birds as a Company.

A mass of evidence is brought forward against the company of small birds as a whole, apart from individual species. Most of the information on this point is supplied in reply to the eighteenth question on the circular, which is as follows: "Generally speaking, have the introduced birds done more good than harm or more harm than good?" A typical reply is from Wairere, Wairarapa North: "As with most aliens, it would be better if they had stayed at home." The same sentiment is expressed in other words many times. One correspondent says that the introduction of English birds, taking them together, was "a terrible mistake." Another says, "For goodness' sake don't make it worse by importing any more of them." A fruit-grower at Patutahi, Poverty Bay, declines to give his views, as the space left in the circular for the reply to the question is far too limited to enable him to say all that he wants to say.

The Lower Hutt, in the Wellington District, is a market-gardening centre, and the following catalogue of grievances, together with the general sweeping statement, seems to show that small birds are particularly numerous there: "One acre of cabbage and cauliflower plants destroyed entirely last year; vegetable-garden seeds picked out, necessitating netting; currants entirely eaten up; cannot ripen one gooseberry; raspberries saved with the greatest difficulty by picking twice daily; impossible to grow wheat, quarter-acre picked absolutely clean last year; oats pulled out when about 2 in. high, and have to sow double quantities to allow for destruction; whole treefuls of the best sorts of plums destroyed; the destruction, in short, is so great as to seriously interfere with cropping arrangements, to bar several valuable lines, and to render gardening, both domestic and market, simply heartbreaking."

At Ellesmere (Canterbury) and Fendalton, one of the suburbs of Christchurch, it is impossible to grow barley of good malting sample, as the farmer cannot sow it at the right season, or the birds will take the whole crop.

Farmers in the Lincoln district, North Canterbury, generally agree to sow their wheat at about the same time, so that the birds' attacks will be fairly divided. "If one of us had an early crop," a farmer of that district says, "all the birds would concentrate their efforts upon it, and they would have it eaten up very soon; but when we act in concert the birds bestow their attentions over the whole area, and one farmer does not have to bear the whole of the brunt."

The replies to the eighteenth question, in fact, leave no doubt whatever that a vast majority of the classes of the community most interested in the doings of the birds firmly believe that their introduction was a disastrous mistake, that they do immeasurably more harm than good, and that their banishment, if it was possible, would be exceedingly desirable. The consensus of opinion is expressed in too clear, concise, and emphatic a manner to leave any shadow of doubt as to the strong antagonism felt towards English birds. Many farmers, however, modify their condemnation by expressing an opinion that if the birds could be kept in check they would be converted from enemies to friends. I cannot help thinking that that is the proper attitude to adopt. The birds are far from being altogether bad. A forgetful generation may have a short memory, but great services given in the past cannot be ignored when the birds are on their trial.

Attempts have been made to estimate the damage done by the birds and to place a value on it. At a conference of local bodies held in Christchurch to consider the best means of dealing with the nuisance, the damage was set down at 5s. an acre on cultivated land. If the average throughout the colony was only half that sum the total loss must be enormous, as last year the total area under crops in the colony was 1,494,722 acres, 661,926 acres being in grain-crops. Besides that total, there were 17,176 acres in garden and 27,482 in orchard.

How to Check the Small Birds.

Some of the inquiries were directed towards ascertaining what steps have been taken to keep the birds in check, and what success has been achieved in that direction. The plan most favoured is the laying of poisoned grain and the payment for heads and eggs. This plan seems to have been fairly effective when combined action is taken, but it has often failed where there is lack of combination. The natural increase is checked by this means, but there are few instances of any material diminution in numbers having been made. In the orchard in the North Island the gun is used. At the bird sanctuary on Little Barrier Island, the nests of blackbirds, thrushes, sparrows, and finches are destroyed when opportunities occur, and it is thought that this probably keeps the English birds in check on the island.

In several districts heads and eggs are paid for, and poisoned wheat is distributed free by local authorities. In other districts netting is resorted to. Mr. J. Wolfe, a Lincoln (North Canterbury) farmer, states that the system of purchase has the desired effect to a great extent. He also informed me that he was the first to use strychnine poison in his district, having commenced to do so twenty-six years ago, and he has been poisoning ever since, with good results.

A very miscellaneous lot of suggestions are offered as to the best means of checking the nuisance. A gentleman in Temuka has prepared a scheme providing for legislation to compel all landowners to produce a certain number of sparrows during the winter months. Several farmers suggest that long nets, such as bird-catchers use, could be brought into requisition by capable men with effect. The Government is recommended to give a bonus for the production of a poison that will be readily eaten by the birds, and one correspondent thinks that a bonus should be given for the best trap. There is a strong feeling in favour of the introduction of English owls and other birds of prey, and the introduction of English bats, frogs, and toads is also favoured. A practical observation is that the towns ought to be compelled to do more than at present, as they are breeding-places from which the birds swarm into the country districts. Among the most novel suggestions are the systematic employment of armies of small boys at nesting, and the use of electric wires stretched round fields of crops, the wires to be charged with electricity in order to give the birds severe shocks. The most practical scheme, and the one that is evidently more acceptable than any other, is thorough and systematic poisoning. The whole operation, it is urged, should be controlled by the Agricultural Department, which should be armed with compulsory powers, so that it could compel all farmers in one district to act in unison. This is the scheme favoured by the officers of the Department, and it is likely that an attempt will be made to bring it into operation.

PHEASANTS AND QUAIL.

The common pheasant (*Phasianus colchicus*) and the ring-necked pheasant (*Phasianus torquatus*) have had a strange and eventful history in this country. At first their acclimatisation was a notable and almost an unqualified success. They succeeded wherever they were introduced, increasing very rapidly and rearing healthy and hardy broods of young. One of the first successes was achieved by Sir Frederick Weld in 1865, when he established the common pheasant in Canterbury. Other importations into that province followed, the acclimatisation society bringing out fairly large numbers. In 1868 it bred forty birds and sold them to members for £2 a pair. In the tussock-covered land of Canterbury they thrived specially well, and the large Cheviot Estate, then held by the Hon. W. Robinson, was soon stocked with them. Mr. Robinson spared no expense in preparing for their reception when he arranged for a consignment, supplied by the society. He erected large commodious aviaries, ordered that all the native cats on the estate should be killed, nearly extirpated the wekas, and had the hawks destroyed at the rate of six a day. The society continued to import pheasants for a considerable time. It bred about a hundred birds in a year, and obtained a fairly good income by selling them to the owners of large estates. It seemed as if pheasants would, in a few years, spread throughout both Islands and become thoroughly naturalised. After this had gone on for some time the birds received a decided check. Their numbers neither increased nor decreased. Then they began to decrease rapidly and, apparently, almost simultaneously in many districts. Their complete failure, taking the colony as a whole, is now beyond doubt. In Canterbury and other provinces where they were once exceedingly plentiful they are never seen at all. "Once plentiful, but decreasing or disappeared," are the words generally written against them in the circulars. This result, which is very regrettable from the sportsman's point of view, is attributed to the laying of poison for rabbits, to the depredations of stoats, weasels, and wild cats, to bush fires, and, in a lesser degree, to the pheasants' food-supplies being eaten by the smaller introduced birds. It is stated that the wekas, as well as the stoats and weasels, eat pheasants' eggs. The birds are decreasing as rapidly in districts where there is plenty of cover as in districts where there is little or none. The destruction done by bush-fires is shown by the following statement from a farmer at Mangahao, Pahiatua, Wellington District: "When sowing grass-seed after bush-fires seven years ago I came across thousands of nests with the remains of eggs and the charred bones of the pheasants that had been sitting on them. They were very plentiful here once, but now, when one is seen, half the town and country is after it to shoot it."

In large numbers of cases the decrease has been almost simultaneous with the arrival of stoats and weasels, which seem to have set about the work of extirpation without any unnecessary delay. A rather striking remark is made by a farmer at Ruatutiri, who says that there are only a few pheasants in his district now, and those that are there are "only old cock birds."

The reports received show that pheasants now exist in numbers worth counting in only the North Island. The Poverty Bay district, on the east coast of the North Island, is the only district in which they are reported as "numerous," and there they seem to be working towards the interior. In the few districts where they are at all plentiful they are regarded by agriculturists as a thorough nuisance. A farmer at Parua Bay describes them as "the greatest curse settlers have to contend against." At Hokianga they are "ruination to the farmer and the gardener." They destroy young grass, pull up maize and eat it, and attack potatoes, carrots, beans, peas, barley, wheat, and many kinds of fruit. A strong testimony is given against them by Mr. W. E. Draper, of Waerenga, who classes them with both species of introduced quail in the following condemnation: "I am a large grower of fruit, such is strawberries, grapes, peaches, plums, and so on. The ravages committed by the pheasants and quail are a serious matter for me. I cannot offer strawberries for sale with a piece pecked out of one side, nor does it suit me to find the ground between the rows sprinkled with half-ripe berries bitten off. The birds perambulate a row of vines and completely destroy every grape on a row 5 or 6 chains long. When I sow a field of clover the soil is scratched and the seed eaten. If a stop is not put to the increase of these pests no man in his sober senses will embark on fruit-culture in country districts infested by them. My opinion is that it is little better than criminal folly to keep a close season for these birds. I have counted twenty-five pheasants on about an acre of potatoes on the lake-side, and I have put up nineteen on my own place when traversing a distance of 30 chains. Up to about nine years ago I supplied strawberries up to the middle of June. The berries come now as before, but they are all destroyed by the pheasants and the quail, especially the latter.

In former years I have sold in March, April, and May from 10 cwt. to 15 cwt. of strawberries. Now they are all destroyed."

The two species of quail introduced, the swamp-quail (*Synœcus australis*) and the Californian quail (*Callipepla californica*), have been hardly more successful than the pheasants. They never increased so rapidly, however, and their failure is not so marked. The Californian quail is still plentiful in some of the North Island districts, where farmers write against its name, "No good." At Te Puke, in the Maketu district, quail live largely on clover, taking both the seed and the young plants in the bush clearings. Stoats and weasels, cats, poison, and bush-fires are their enemies.

In regard to the Californian quail a farmer at Ngatimaru says: "I have noticed that this bird wants fairly large tracts of land. It is also better if the land is hilly and broken, with bush and scrub here and there. It seems to get on very well on land where there is plenty of bush. On other land it does well for a time and then its numbers are decreased, for what reason I do not know, unless it is on account of the cats, which I think are largely to blame."

A farmer in the Motu district, in the Auckland Province, says that quail need more protection, and he suggests that private owners should proclaim their properties private sanctuaries, and every third year should be a close one.

The Two Swans.

There is a very striking contrast between the white swan and the black swan in respect to their acclimatisation in New Zealand. The black swan is near the top of the list of successes, while the white swan has increased slowly and with obvious difficulty, and has sometimes quite failed to establish itself. The black swan, in fact, has shown much greater adaptability than the other species, whose first attempts at incubation in Christchurch and other places were utterly ineffective. The black swan settled down at once to its new conditions. It was introduced into Canterbury partly with the object of destroying watercress in the Avon, which runs through Christchurch. In a few years the birds had increased largely, but in 1867 many of them forsook the Avon and made long and rather notable migrations to the wild country on the West Coast, and to Otago, and even Marlborough. Less than twenty were liberated on the Avon at first by the Christchurch City Council. These birds did the work desired from them, as they cleared a pathway through the watercress for the current. In 1880 there were hundreds of black swans in the Avon and Halswell Rivers, as well as the Heathcote, as many as five hundred sometimes being counted on small areas. They achieved the same success in Otago, where about sixty were liberated from 1866 to 1870.

Black swans are now found in thousands on lakes, estuaries, and lagoons in many parts of the colony, from the extreme north to the far south. They keep much to the wild regions. In some places they wage a deadly war on the native ducks, taking their food-supplies from them and persecuting them relentlessly.

Further Introductions Suggested.

A rather striking aspect of the inquiries is that there is not the same consensus of opinion against the introduction of more English birds as there is against those we have already. Further introductions are suggested with quite as much confidence as characterized the first introductions, forty years ago.

The twenty-eighth question on the circular was, "Do you think that any other English birds could be introduced advantageously? If so, state the species you favour." Only a few of the correspondents are opposed to further introductions, although several sound a warning that English birds are liable to change their habits on coming to a new land and living under new conditions.

It is clear, however, that sentiment must still be reckoned with. This is shown by the fact that many more votes have been cast in favour of robin redbreast than in favour of any other bird that can be thought of. He heads the list of suggested importations of the future. The fact that jenny wren is not very far down in the list may be taken as further evidence that sentiment in regard to the birds of the Old Country is not dead. It is expected, however, that robin redbreast will be useful as well as ornamental. The swallow comes next to him, then several kinds of martins, then the plovers, the swift, and the wagtail, in that order. The cuckoo is a general favourite. Other birds named are the stonechat, shrike, snipe, more lapwings and hedge-sparrows, flycatcher, tits, titmouse, whitethroat, nightingale (which, by the way, has only one vote), water-ousels, storks, American flycatcher and kingbird, goatsucker, grouse, partridge (French and English), jackdaw, blackcock, nightjar, woodpecker, winchat, wheatear, pipit, wryneck, crow, and butcher-bird.

I supply this list for what it is worth, and to give some indication of the feeling on the subject. The advisableness of introducing any of the birds named is a matter that should be gone into with great care when definite steps in regard to further importations are contemplated, and it could hardly be discussed here. The facts brought to light in respect to acclimatisation in

New Zealand are sufficiently striking to guard against thoughtless action. It might be advisable to forbid the importation of any more foreign birds without the sanction of a committee of experts, which could be appointed.

Conclusion.

My inquiry has not put an end to the controversy, which is one of those things that will continue as long as small birds and farmers exist. The lines of demarcation are too faint, and too hard to define, to enable it to be said with any certainty that the introduction of small birds into this colony was a mistake. The question rests largely upon speculative opinion, and absolute settlement need never be looked for.

A great deal of the evidence I have collected is confusing, and a little of it is obviously the outcome of prejudice and bitter enmity. There is, however, less of this than I expected.

For the most part the conclusions arrived at by the hundreds of correspondents who have returned the circulars are based upon actual observations extending over thirty or forty years. Many of those who went to the trouble of filling in the circulars are in the advantageous position of having known the small birds both at Home and in the colonies, and they are in a good position to make comparisons and note changes that have taken place in the birds' habits. In some cases considerable trouble has been taken, the circulars being accompanied by long letters. By the adoption of this system of seeking information many men have been reached who would never have imparted their knowledge in any other way. Several of the correspondents have been good enough to commend the system. They have expressed their willingness to supply more detailed information, if desired, and they suggest that the idea should be applied to other subjects that interest the agriculturist.

The evidence has been weighed carefully, and in forming conclusions I have endeavoured to be just to men and birds alike. The summary of the results, at any rate, is impartial, and I think I am justified in claiming that on the prominent points of the controversy a consensus of expert opinion throughout the colony is now placed at the disposal of all who wish to have it.

I have to thank Mr. T. W. Kirk for the trouble he took in distributing the circulars, collecting them through his Department, and forwarding them on to me.

The following is a list of birds that have been naturalised and established in New Zealand: Song-thrush (*Turdus musicus*), blackbird (*Turdus merula*), hedge-sparrow (*Accentor modularis*), sparrow (*Passer domesticus*), greenfinch (*Ligurinus chloris*), chaffinch (*Fringilla cœlebs*), goldfinch (*Carduelis elegans*), red-poll (*Linota*] *rufescens*), yellow-hammer (*Emberiza citrinella*), cirl-bunting (*Emberiza cirlus*), starling (*Sternus vulgaris*), house-mynah (*Acridotheres tristis*), Australian magpie (*Gymnorhina leuconota*), skylark (*Alauda arvensis*), rook (*Corvus frugilegus*), white swan (*Cygnus olor*), black swan (*Cygnus atratus*), swamp-quail (*Synœcus australis*), Californian quail (*Callipepla californica*), pheasant (*Phasianus colchicus*), ring-necked pheasant (*Phasianus torquatus*), lapwing (*Vanallus cristatus*).

Art. XXVI.—*Results of Dredging in Hauraki Gulf; with Descriptions of Seven New Species.*

By Henry Suter.

[*Read before the Wellington Philosophical Society, 3rd October,* 1906.]

Plate IX.

When returning from dredging in 110 fathoms off Great Barrier Island, the results of which were published in last year's Transactions, some dredging was also done in about 25 fathoms, on rocky bottom, one mile south-west off Channel Island, commonly known as "The Watchman," and the following is an account of the different species of *Mollusca* obtained :—

1. **Cylichna thetidis**, Hedley.

Mem. Austral. Mus., vol. iv, 1903, p. 395, fig. 111 in text.

A few immature shells. This is an addition to our fauna.

2. **Drillia lævis**, Hutton.

Cat. Mar. Moll. N.Z., 1873, p. 12.

One empty shell.

3. **Drillia buchanani**, Hutt., subsp. **maorum**, E. A. Smith.

Drillia (?) *maorum*, E. A. Smith, Ann. Mag. Nat. Hist. (4), vol. xix, 1877, p. 497.

One empty shell.

4. **Daphnella protensa**, Hutton.

Trans. N.Z. Inst., vol. xvii, 1885, p. 317.

One empty shell.

5. **Daphnella conquisita**, n. sp. Plate IX, fig. 1.

Shell small, fusiform, thin, fragile, semitransparent, spirally lirate. Sculpture consists of narrow, sharply rounded and elevated spiral ribs, narrower than the grooves, 4 on the spire-whorls, 10 on the body-whorl, the interspaces radiately microscopically finely striate. Colour light-fulvous. Spire elevated, higher than the aperture. Protoconch formed by 2 smooth and convex whorls. Whorls 6, regularly increasing, slightly shouldered, flatly convex, base contracted. Suture impressed and margined below by a small thread on the penultimate whorl only. Aperture oblong-oval, margins nearly parallel, produced below into an open, slightly flexuous canal, truncated at the base. Sinus obsolete. Outer lip sharp, inside smooth, convex above, concave on the canal. Columella sinuous, slightly produced in the middle, without any callosity.

Altitude, 6 mm.; diameter, 2·2 mm.

Type to be presented to the Colonial Museum.

A very well characterized species, in sculpture approaching *D. lacunosa*, Hutt., which, however, has smooth grooves.

6. **Murex zelandicus**, Q. and G.

Voy. "Astrolabe," Zool., vol. ii, 1833, p. 529, pl. 36, figs. 5–7.

One live young specimen.

7. **Murex octogonus**, Q. and G.

Voy. "Astrolabe," Zool., vol. ii, 1833, p. 531, pl. 36, figs. 8–9.

A few specimens, one of them alive.

8. **Trophon curtus**, Murdoch.

Trans. N.Z. Inst., vol. xxxvii, 1905, p. 228, pl. 8, fig. 22.

Two dead shells of this small species were obtained.

9. **Trophon pusillus**, n. sp. Plate IX, fig. 2.

Shell small, fusiform, fairly solid, imperforate, with nodulous ribs. Sculpture formed by spiral and radiate rounded ribs, produced into oval nodules at the points of intersection; there are 11 longitudinal ribs on the last whorl, but slightly narrower than the interspaces, 2 spiral ribs on the upper whorls succeeding the protoconch, 3 on the penultimate, and 10 on the last whorl. From the base of the fourth whorl minute and close radiate striæ are beginning to ornament the whole surface of the shell, most of the nodules remaining partly smooth. Colour yellowish-white. Spire conical, a little shorter than the aperture. Protoconch mammillate, smooth, consisting of 3 strongly convex whorls. Whorls 6, lightly shouldered, base concave. Suture impressed, undulate. Aperture elongately pyriform, produced into a comparatively long canal, which is subtruncate and slightly deflexed to the right. Outer lip broken off. Columella straight, obliquely truncate below, terminating in a sharp point on reaching the left margin of the canal; inner lip forming a rather narrow callosity with a longitudinal furrow parallel to the margin.

Altitude, 6 mm.; diameter, 3·5 mm.

Type to be presented to the Colonial Museum.

Three specimens only were dredged. This species is near *T. curtus*, Murd., but may at once be distinguished from it by the microscopic axial striation and the long canal.

10. **Columbella choava**, Reeve.

Conch. Icon., sp. 239, 1858.

Two immature empty shells.

11. **Siphonalia nodosa** (Martyn).

Buccinum nodosum, Martyn, Univ. Conch., vol. i, 1784, fig. 5.

Four examples, two of which were alive.

12. **Megalatractus maximus** (Tryon).

Siphonalia maxima, Tryon, Man. Conch. (1), vol. iii, 1881, p. 135, pl. 54, fig. 355; Hedley, Mem. Austral. Mus., vol. iv, 1903, p. 374, pl. 38.

Two live specimens, one of them about half-grown. The larger specimen is decollated, has 7 whorls, and a length of 145 mm. Kesteven has published a paper on the anatomy of *Megalatractus*—which, however, I have not seen yet—and has assigned the above species to this genus. This is a very interesting addition to the New Zealand fauna. The protoconch of this shell was figured in last year's Transactions (pl. 24, fig. 28).

13. **Cominella huttoni**, Kobelt.

Jahrb. d. Deutsch. Mal. Gesellsch., 1878, p. 233.

Three empty shells.

14. **Vulpecula rubiginosa** (Hutton).

Columbella (*Atilia*) *rubiginosa*, Hutton, Cat. Mar. Moll. N.Z., 1873, p. 20.

Two empty shells.

15. **Marginella allporti**, Ten.-Woods.

Proc. Roy. Soc. Tasmania, 1877, p. 28.

One dead shell. This is another addition to the list of New Zealand molluscs.

16. **Ancilla mucronata**, Sowerby.

Spec. Conch., part i, 1830, p. 8, figs. 47–48.

Six empty shells.

17. **Ancilla bicolor**, Gray.

Jukes, Voy. "Fly," vol. ii, 1847, p. 357, pl. 1, fig. 4.

A few young and empty shells.

18. **Odostomia angasi**, Tryon.

Man. Conch. (1), vol. viii, 1886, p. 362, pl. 79, fig. 68.

Two dead shells.

19. **Odostomia vestalis**, Murdoch.

Trans. N.Z. Inst., vol. xxxvii, 1905, p. 227, pl. 8, fig. 20.

One empty shell.

20. **Odostomia marginata**, Murd. and Sut.

Trans. N.Z. Inst., vol. xxxviii, 1906, p. 297, pl. 25, fig. 37.

Several dead shells.

21. **Odostomia fastigiata**, n. sp. Plate IX, fig. 3.

Shell small, subcylindrically acuminate, imperforate, smooth, with a distinct columellar plait. There is no sculpture, except distinct incremental lines. Colour white. Spire high, slowly tapering towards the small globular apex, more than three times the height of the aperture. Protoconch heterostrophe, subcentral, smooth, the apex tilted up and globular, one whorl. Whorls 7, first slowly increasing, the last about half the length of the whole shell; base narrowly rounded. Suture distinct, but superficial. Aperture vertical, ovate, truncated above by the body-whorl. Outer lip very little curved, broken off; basal lip narrowly convex. Columella with a distinct blunt plait above, slightly concave below.

Altitude, 4·5 mm.; diameter, 1·5 mm.

Type to be presented to the Colonial Museum.

One specimen only. This species stands nearest to *O. vestalis*, Murd., but it is more cylindrical, has no microscopic spiral striation, and the suture is not submargined.

22. **Turbonilla zealandica** (Hutton).

Chemnitzia zealandica, Hutton, Cat. Mar. Moll. N.Z., 1873, p. 22.

A few specimens only.

23. **Struthiolaria tricarinata**, Lesson.

Ann. des Sci. Nat. (2), vol. xvi, 1830, p. 256.

Eight empty specimens.

24. **Serpulus sipho** (Lamarck).

Serpula sipho, Lamarck, Anim. s. Vert., vol. v, 1818, p. 626.
(*Vermetus novæ-hollandiæ*, Rousseau.)

One dead shell.

25. **Turritella rosea**, Q. and G.

Voy. "Astrolabe," Zool., vol. iii, 1834, p. 136, pl. 55, figs. 24–26.

Only one empty specimen.

26. **Turritella fulminata**, Hutton.

Cat. Mar. Moll. N.Z., 1873, p. 29.

A number of young empty shells.

27. **Turritella carlottæ**, Watson.

Journ. Linn. Soc., Zool., vol. xv, 1880, p. 222.

Eight specimens, all empty.

28. **Triphora infelix**, Webster.

Trans. N.Z. Inst., vol. xxxviii, 1906, p. 307, pl. 38, fig. 6.

One specimen only turned up.

29. **Newtoniella stiria**, Webster.

Trans. N.Z. Inst., vol. xxxviii, 1906, p. 307, pl. 38, fig. 5.

One young shell.

30. **Cerithiopsis crenistria**, n. sp. Plate IX, fig. 4.

Shell small, turriculate, imperforate, thin and semitransparent, ornamented with numerous nodules, aperture small, terminating in a short and widely open canal. Sculpture formed by 2 low spiral ribs, which are crossed by equidistant radiate costæ, 12 on the last whorl, not reaching to the suture; the crossing-points of the two kinds of ribs are raised to very distinct nodules, first round, oval on the later whorls. Colour very light-brown, shining. Spire high, turriculate. Protoconch of a lighter colour, $1\frac{1}{2}$ whorls, top flattened, radially striate and on the periphery with a row of elongated small nodules. Whorls 9, the second has a slightly greater diameter than the third; sides biangulate, nearly straight; base flat, depressed round the canal. Suture very distinctly impressed, margined below by a small thread. Aperture subquadrate, produced into an open and short canal, which is a little turned to the left and backward. Outer lip sharp, but little convex, basal lip concave. Columella slightly concave, the inner lip spreading as a very thin, narrow, and whitish glaze over it.

Altitude, 8 mm.; diameter, 3 mm.

Type to be presented to the Colonial Museum.

One specimen was found, and I do not think it is adult. Our other species, *C. sarissa*, Murd., is smaller and more subulate, it has three spiral threads, and the nodules are less prominent.

31. **Rissoa impressa**, Hutton.

Trans. N.Z. Inst., vol. xvii, 1885, p. 321; Plioc. Moll. of N.Z., 1893, pl. 8, fig. 64.

One specimen. This species was hitherto only known as fossil from the Pliocene.

32. **Rissoina parvilirata**, n. sp. Plate IX, fig. 5.

Shell small, oblong, imperforate, white, microscopically spirally lyrate, base subtruncate. The sculpture consists of close fine spiral grooves, visible only under a lens, the interspaces being broader. Colour pure-white, shining. Spire conical, a little higher than the aperture. Protoconch minute, smooth, with globular apex. Whorls 4, the last large, occupying three-fourths of the whole length, slightly flattened below the suture, slightly convex. Suture superficial, submargined above. Aperture vertical, pyriform, truncated at the base. Outer lip strong, descending nearly straight, then turning at a narrowly rounded angle toward the almost straight basal lip. Columella concave and truncated below. Inner lip forming a strong but narrow callus on the body-whorl, broadening above, where it joins the outer lip; on the columella it is much narrower, covering only the inner half of it.

Altitude, 3 mm.; diameter, 1·5 mm.

Type to be presented to the Colonial Museum.

Only a few specimens were amongst the dredgings. It is a very well characterized species. It has also been obtained off Otago Heads, and in sand at Narrow Neck, Devonport.

33. **Calyptræa novæ-zeelandiæ**, Lesson.

Voy. "Coquille," Zool., vol. ii, 1830, p. 395.

A few empty shells.

34. **Calyptræa scutum**, Lesson.

Voy. "Coquille," Zool., vol. ii, 1830, p. 395.

Many dead shells with the septum mostly broken off.

35. **Crepidula crepidula** (Linné).

Patella crepidula, L., Syst. Nat., ed. 10, 1758, p. 1257.

A few dead shells.

36. **Crepidula aculeata** (Gmelin).

Patella aculeata, Gmel., Syst. Nat., ed. 13, 1788, p. 3693.

A few shells.

37. **Trichotropis inornata**, Hutton.

Cat. Mar. Moll. N.Z., 1873, p. 26.

One empty shell only.

38. **Natica zelandica**, Q. and G.

Voy. "Astrolabe," Zool., vol. ii, 1832, p. 237, pl. 66, figs. 11–12.

One empty shell.

39. **Trochus tiaratus**, Q. and G.

Voy. "Astrolabe," Zool., vol. iii, 1834, p. 256, pl. 64, figs. 6–11.

Three young dead shells.

40. **Calliostoma pellucidum**, Valenciennes.

Voy. "Venus," Moll., pl. 4, fig. 2, 1846.

Two live examples.

41. **Cyclostrema subtatei**, n. sp. Plate IX, figs. 6–8.

Shell minute, subdiscoidal, spirally lyrate, broadly umbilicated. Sculpture formed by broad and shallow spiral grooves, slightly broader on the periphery, leaving between them narrow and sharply raised ridges, 10 on the last whorl. Colour white. Spire very low. Protoconch flatly convex, smooth, formed by one whorl. Whorls 3, the last large and descending a little, flat near the suture, rounded at the periphery; base convex. Suture not much impressed. Aperture circular, peristome continuous, solid. Umbilicus wide and perspective.

Altitude, 1·5 mm.; diameter—maj., 2·5 mm.; min., 2 mm.

Type to be presented to the Colonial Museum.

One specimen only was gathered. I fully agree with my friend Mr. Hedley that this species is nearly allied to *C. tatei*, Angas, from South Australia, but the latter is larger, has a more elevated spire, the spiral ridges are less numerous, more distant on the upper side, and the interstices are ornamented with close fine and oblique radiate striæ, a feature totally wanting in our species; there are only faint incremental lines. I found this shell also in sand from Lyall Bay.

42. Emarginula striatula, Q. and G.

Voy. "Astrolabe," Zool., vol. iii, 1834, p. 332, pl. 68, figs. 21–22.

Fragments only.

43. Acanthochites rubiginosus (Hutton).

Tonicia rubiginosa, Hutton, Trans. N.Z. Inst., vol. iv, 1872, p. 180.

Three intermediate valves.

44. Lepidopleurus inquinatus (Reeve).

Chiton inquinatus, Reeve, Conch. Icon., pl. 23, fig. 154, 1847.

One live specimen.

45. Myodora subrostrata, E. A. Smith.

Proc. Zool. Soc., 1880, p. 584, pl. 53, fig. 6.

One left (flat) valve.

46. Saxicava arctica (Linné).

Mya arctica, Linné, Syst. Nat., ed. 10, 1758, p. 1113.

A few dead shells.

47. Corbula zelandica, Q. and G.

Voy. "Astrolabe," Zool., vol. iii, 1835, p. 511, pl. 35, figs. 12–14.

A few shells and valves.

48. Corbula macilenta, Hutton.

Cat. Tert. Moll. N.Z., 1873, p. 18.

A few shells and valves.

49. Psammobia zelandica, Deshayes.

Proc. Zool. Soc., 1854 (1855), p. 319.

A few valves.

I am now quite certain that the late Captain Hutton was quite right in omitting *Psammobia affinis*, Rve., from our list.

50. Protocardia (Nemocardium) pulchella (Gray).

Cardium pulchellum, Gray, in Dieffenbach's Travels in N.Z., vol. ii, 1843, p. 252.

A few valves.

I think this species answers to the requirements of the diagnosis of *Protocardia*, sect. *Nemocardium*. Copying from Dr. W. H. Dall, Trans. Wagn. Free Inst. Sci., vol. iii, part v, p. 1078, they read as follows :—

Genus *Protocardia*, Beyrich. Zeitschr. f. Malak., 1845, p. 17. —Shell globose with a posterior area sharply distinguished by sculpture from the rest of the surface ; closed ; hinge normal, with no lunule or escutcheon.

Sect. *Nemocardium*, Meek, Pal. Upper Missouri, 1876, p. 172. —The posterior area spinose or tuberculate, the remainder of the surface finely radially striate or finely reticulate ; the anterior laterals springing from the umbonal cavity.

51. Macrocallista multistriata (Sowerby).

Cytherea multistriata, Sowerby, Thes. Conch., vol. ii, 1851, p. 628, pl. 136, fig. 177.

A few valves.

52. Dosinia lambata, Gould.

Proc. Boston Nat. Hist. Soc., vol. iii, 1850, p. 277.

One valve.

53. Chione mesodesma (Q. and G.).

Venus mesodesma, Q. and G., Voy. "Astrolabe," Zool., vol. iii, 1835, p. 532, pl. 84, figs. 17–18.

Many valves were dredged.

54. Chione oblonga (Hanley).

Venus oblonga, Hanley, in Wood's Index Test., Suppl., 1828.

One valve only.

55. Mactra scalpellum, Reeve.

Conch. Icon., pl. 19, fig. 106, 1854.

A few valves.

56. Zenatia acinaces (Q. and G.).

Lutraria acinaces, Q. and G., Voy. "Astrolabe," Zool., vol. iii, 1835, p. 545, pl. 83, figs. 5–6.

Fragments only.

57. Tellina angulata, Hutton.

Trans. N.Z. Inst., vol. xvii, 1885, p. 322.

Fragments only were obtained.

58. Leptomya lintea (Hutton).

Tellina lintea, Hutton, Cat. Mar. Moll. N.Z., 1873, p. 67.

A few valves.

59. Diplodonta zelandica (Gray).

Lucina zelandica, Gray, in Yate's N.Z., Appendix, 1835, p. 309.

A few valves.

60. Loripes concinna, Hutton.

Trans. N.Z. Inst., vol. xvii, 1885, p. 323.

Again a few valves only.

61. Divaricella cumingi (Adams and Angas).

Lucina (*Cyclas*) *cumingi*, Ad. and Ang., Proc. Zool. Soc., 1863, p. 426, pl. 37, fig. 20.

Valves only.

62. Venericardia difficilis (Deshayes).

Cardita difficilis, Desh., Proc. Zool. Soc., 1852 (1854), p. 103, pl. 17, figs. 16–17.

A number of valves were obtained.

63. Venericardia lutea (Hutton).

Cardita lutea, Hutton, Man. N.Z. Moll., 1880, p. 159.

Numerous valves.

64. Pecten medius, Lamarck.

Anim. s. Vert., vol. vi, 1819, p. 163.

One empty shell.

65. **Pecten convexus**, Q. and G.

Voy. "Astrolabe," Zool., vol. iii, 1835, p. 443, pl. 76, figs. 1–3.

A few fragments only.

66. **Pecten zelandiæ**, Gray.

Dieffenbach's Travels in N.Z., vol. ii, 1843, p. 260.

A good number of small valves.

67. **Ostrea reniformis**, Sowerby.

Conch. Icon., 1871, fig. 57.

Valves of young specimens.

68. **Modiolus australis**, Gray.

King's Voy. Intertrop. Coasts Australia, vol. ii, 1827, p. 477.

One damaged valve only.

69. **Modiolaria impacta** (Hermann).

Crenella impacta, Herm., Spengler in Naturforscher, vol. x, 1776, pl. 6, fig. 8.

A few valves.

70. **Pectunculus laticostatus**, Q. and G.

Voy. "Astrolabe," Zool., vol. iii, 1835, p. 466, pl. 77, figs. 4–6.

One valve only.

71. **Anomia furcata**, n. sp. Plate IX, figs. 9–10.

Left valve circular to oval, sometimes irregular, convex, thin, semitransparent, radiately costate and with distinct concentric ridges. Beak distinct, nearly smooth, and more or less central; one specimen (fig. 10) has a deep posterior notch, another example has three deep posterior notches, and two shallow ones on the anterior end. The dorsal margin is either straightened or flatly convex. The sculpture consists of narrow, nodulous radial riblets, obsolete in some places, and mostly bifurcating towards the margin. The concentric ornamentation is formed by fine, close, and slightly undulating lines of growth, interspersed with distant stronger ridges. Colour whitish-yellow. Interior of the same colour and somewhat pearly, with a sharp and smooth margin. There is a well-marked transversely elongate ligamental fossette. The upper byssus adductor scar is long, tongue-shaped, the lower small and oval, and the valve adductor scar is of about the same size and triangularly oval. Pallial line entire, simple.

Dimensions of a left valve: Height, 16·5 mm.; length, 16 mm.; diam., 3 mm.

Type to be presented to the Colonial Museum.

Only a number of left valves were obtained, of which one only showed the muscle-scars distinctly.

72. Nucula nitidula, A. Adams.

Proc. Zool. Soc., 1856, p. 51.

A few valves.

73. Leda bellula, A. Adams.

Proc. Zool. Soc., 1856, p. 49.

A few valves.

Note. — Having sent a few valves of our supposed *Leda bellula*, A. Ad., to Mr. E. A. Smith, I.S.O., of the British Museum, he most obligingly compared them with the type, and wrote to me: "These valves are very like but *not quite the same.* They are more inequilateral—that is, the posterior half is *rather* longer in proportion to the anterior, the transverse sculpture is finer, and the posterior escutcheon *decidedly broader.*"

A number of years back Mr. R. H. Shakespear, of Little Barrier Island, dredged in about 20 fathoms between this and Tiri-Tiri Island, and the material was kindly handed over to me for examination by Mr. T. F. Cheeseman, and the following is the result of the examination:—

1. Mangelia flexicostata, *Suter.*
2. Murex octogonus, *Quoy and Gaimard.*
3. ,, *subsp.* umbilicata, *Ten.-Woods.*
4. Columbella choava, *Reeve.*
5. Cominella maculata, *Martyn.*
6. ,, huttoni, *Kobelt.*
7. Vulpecula hedleyi, *Murdoch.*
8. Marginella albescens, *Hutton.*
9. ,, mustelina, *Angas.*
10. ,, allporti, *Ten.-Woods.*
11. Ancilla bicolor, *Gray.*
12. Eulimella cœna, *Webster.*
13. Odostomia impolita, *Hutton.*
14. ,, rugata, *Hutton.*
15. Turbonilla zealandica, *Hutton.*
16. Turritella kanieriensis, *Harris.*

17. Triphora ampulla, *Hedley.*
18. ,, infelix, *Webster.*
19. Seila terebelloides, *Martens.*
20. Bittium exile, *Hutton.*
21. Rissoa subfusca, *Hutton.*
22. ,, cheilostoma, *Ten.-Woods.*
23. ,, micans, *Webster.*
24. ,, agrestis, *Webster.*
25. Rissoina olivacea, *Hutton.*
26. ,, rosea, *Hutton.*
27. ,, parvilirata, *Suter.*
28. Calyptræa scutum, *Lesson.*
29. Trichotropis inornata, *Hutton.*
30. Natica zelandica, *Quoy and Gaimard.*
31. Scala levifoliata, *Murdoch and Suter.*
32. Crossea labiata, *Ten.-Woods.*
33. Leptothyra fluctuata, *Hutton.*
34. Cantharidus sanguineus, *Gray.*
35. Gibbula fulminata, *Hutton.*
36. Cyclostrema subtatei, *Suter.*
37. Cuspidaria trailli, *Hutton.*
38. Corbula zelandica, *Quoy and Gaimard.*
39. ,, macilenta, *Hutton.*
40. Psammobia stangeri, *Gray.*
41. Protocardia pulchella, *Gray.*
42. Chione mesodesma, *Quoy and Gaimard.*
43. Mactra scalpellum, *Reeve.*
44. Divaricella cumingii, *Adams and Angas.*
45. Cardita calyculata, *Linné.*
46. Venericardia australis, *Lamarck.*
47. ,, corbis, *Philippi.*
48. Lima bullata, *Born.*
49. Pecten zelandiæ, *Gray.*
50. Barbatia decussata, *Sowerby.*
51. Pectunculus laticostatus, *Quoy and Gaimard.*
52. ,, striatularis, *Lamarck.*
53. Nucula strangei, *A. Adams.*

EXPLANATION OF PLATE IX.

Fig. 1. *Daphnella conquisita*, Suter. 6 mm. by 2·2 mm.
Fig. 2. *Trophon pusillus*, Suter. 6 mm. by 3·5 mm.
Fig. 3. *Odostomia fastigiata*, Suter. 4·5 mm. by 1·5 mm.
Fig. 4. *Cerithiopsis crenistria*, Suter. 8 mm. by 3 mm.
Fig. 5. *Rissoina parvilirata*, Suter. 3 mm. by 1·5 mm.
Figs. 6–8. *Cyclostrema subtatei*, Suter. 1·5 mm. by 2·5 mm.
Figs. 9–10. *Anomia furcata*, Suter (after two specimens). 16·5 mm. by 16 mm.

Art. XXVII.—*Notes on, and Additions to, the New Zealand Molluscan Fauna.*

By Henry Suter.

[*Read before the Wellington Philosophical Society, 3rd October,* 1906.

1. Siphonaria diemenensis, Quoy and Gaimard.

Voy. "Astrolabe," Zool., vol. ii, 1833, p. 327, pl. 25, figs. 1–12. (= *denticulata*, Q. and G., 1833 = *scabra*, Reeve, 1856).

Specimens from the Kermadec Islands are in my collection. They differ but slightly from Tasmanian examples, an opinion also shared by Mr. C. Hedley, of Sydney, to whom I sent the shells for examination.

Both species of Quoy and Gaimard are enumerated in Captain Hutton's Catalogue, 1873, but our large *S. obliquata*, Sow., was taken for *diemenensis*, and *S. zelandica*, Q. and G., for *denticulata*. In his "Révision des Coquilles de la Nouvelle Zélande et des Îles Chatham," 1878, *S. diemenensis* (= *denticulata*, C.M.M.) is again on the list, with the remark, "Il existe, au Muséum colonial, des exemplaires de cette espèce, mais la localité est douteuse." In the Manual, 1880, the species *diemenensis* and *denticulata* are omitted, and the same is the case in Hutton's article on the New Zealand *Siphonariidæ*.*

2. Bulla adamsi, Menke.

Having a few specimens of a (to me) unknown *Bulla*, obtained at Cape Maria van Diemen, and no literature for naming them at my disposal, I availed myself again of Mr. Hedley's never-failing kind help, and the specimens were returned with the name "(?) *B. adamsi*, Mke." To make quite sure about the species I sent examples to Mr. E. A. Smith, of the British Museum, and with his usual courtesy he informed me that he considered them as small examples of *B. adamsi*, which may only be a form of *B. ampulla*, L., judging from the shells.

3. Mitromorpha striata, Hutton, sp.

Bela striata, Hutton, Cat. Tert. Moll. N.Z., 1873, p. 5. *Daphnella striata*, Hutton, Proc. Linn. Soc. N.S.W., 1886 (1887), p. 214; Pliocene Moll. N.Z., in Macleay Mem. Vol., 1893, p. 52, pl. 7, fig. 33.

One specimen was dredged by Captain J. Bollons in 37 fathoms off Cuvier Island, and kindly presented to me. It

* Trans. N.Z. Inst., vol. xv, p. 141.

is smaller than Pliocene specimens usually are, being 16 mm. high, but otherwise it cannot be separated from the fossil form. This species appears first in the Upper Miocene of New Zealand.

4. **Ancilla depressa**, Sowerby.

Ancillaria depressa, Sow., Thes. Conch., vol. iii, 1859, p. 63, pl. 211, fig. 3. *A. lata*, Hutton, Trans. N.Z. Inst., vol. xvii, 1884 (1885), p. 325; Pliocene Moll. N.Z., 1893, p. 44, pl. 6, fig. 15; Suter, Trans. N.Z. Inst., vol. xxxviii, 1905 (1906), p. 332.

I am under obligation to Mr. J. H. Ponsonby, of London, for copies of the diagnosis and a beautifully coloured figure from the Thesaurus, which leave not the least doubt about the identity of the two species. Sowerby's name has priority. Reeve treats *A. depressa* as a synonym of *A. australis*, Sow., but the two are quite distinct.

5. **Heliacus variegatus**, Gmelin.

One specimen, kindly identified for me by Mr. C. Hedley, was dredged by Captain J. Bollons in 37 fathoms off Cuvier Island, but without the characteristic operculum. This is a highly interesting addition to our fauna. The shell is usually known as *Torinia variegata*, but Harris has shown* that *Torinia*, Gray, is only a list name, and that *Heliacus*, d'Orbigny, 1842, should be used.

6. **Neojanacus perplexus**, n. gen. et n. sp.

Genus (?), Murdoch and Suter, Trans. N.Z. Inst., vol. xxxviii, 1905 (1906), p. 301, pl. 27, figs. 52–54.

Since describing this curious shell I examined the specimen several times carefully, and it struck me that it looked very much like *Crepidula* (*Janacus*) *crepidula*, L. (= *unguiformis*, Lam.) without a septum; I first thought that this had been broken off, but examination under a powerful lens revealed no trace of fracture, the under-surface being everywhere smooth and polished.

Amongst shells dredged by Captain J. Bollons in 18 fathoms, Port Pegasus, Stewart Island, I found to my great surprise a number of specimens of the very same shell in different stages of growth, quite young examples being oval in shape; none had the animal attached to the shell, and the anatomy, therefore, still remains unknown. I sent a few specimens to Dr. W. H. Dall, of the U.S. Nat. Museum, and I am indebted to him for the following information: "The shell from Stewart Island is very curious. It is certainly not a *Crepidula*, the fea-

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* Cat. Tert. Moll., part i, p. 245.

tures which recall that genus being evidently adaptive in both groups. I should suspect a relation to *Capulus* — that is, that it might be some form of *Capulus* which had taken to living inside shells, as the *unguiformis* (*Janacus*) type of *Crepidula* has done. I have described, under the name of *Hyalopatina*, a curious shell which recalls this, but has a more central nucleus. I took it to be related to *Umbrella*, or something of that sort, but have only the one specimen without the animal. It is finely radiately sculptured, and nearly flat. Whether this and your shell are nearly related I cannot pretend to say, but conchologically there are points of resemblance. You will find *Hyalopatina* figured on plate 30, fig. 5, of Proc. U.S. Nat. Mus., No. 1264." The shell was described by Dr. Dall as *Hyalopatina rushii*.*

Fresh specimens of our shell show a dextral spiral smooth protoconch, and a horse-shoe-shaped muscle-scar. The surface is concentrically striated, but there is no radiate sculpture. For this new shell I propose the generic name *Neojanacus*, and place it in the family *Capulidæ*. I need hardly say that for the present the diagnosis of the species must also be that of the genus. It is to be hoped that the anatomy of the two conchologically related genera *Hyalopatina* and *Neojanacus* may be investigated some day, and their true systematic position settled.

Type (from 110 fathoms, off Great Barrier Island) in the Colonial Museum.

7. **Scala corulum**, Hutton.

Scalaria corulum, Hutton, Trans. N.Z. Inst., vol. xvii, 1884 (1885), p. 332, pl. 18, fig. 22; Pliocene Moll. N.Z., 1893, p. 67, pl. 8, fig. 72.

In sand collected by Miss Marjorie K. Mestayer, of Wellington, I found one specimen of this minute shell. It is slightly smaller than Pliocene examples. The number of molluscs of our Pliocene found recent is rapidly increasing!

8. **Crossea cancellata**, Tenison-Woods.

Proc. Roy. Soc. Tasm., 1877 (1878), p. 122; Tate and May, Proc. Linn. Soc. N.S.W., 1901, p. 380, pl. 23, fig. 1 (= *Delphinula johnstoni*, Beddome, 1882).

A specimen, kindly identified for me by Mr. C. Hedley, has been in my collection for a number of years, and was obtained in Whangaroa Harbour. It represents a conical variety of the species. This brings the number of New Zealand species of *Crossea* up to three.

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* Bull. Mus. Comp. Zool., Harvard College, vol. xviii, p. 61.

9. **Schismope atkinsoni**, Tenison-Woods, sp.

Scissurella atkinsoni, T.-Woods, Proc. Roy. Soc. Tasm., 1876 (1877), p. 149. *Schismope carinata*, Watson, "Challenger" Rep., Zool., vol. xv, 1886, p. 119, pl. 8, fig. 6.

I have one specimen from Whangaroa Harbour, which agrees with shells in my collection from South Australia, and my identification was confirmed by Mr. C. Hedley. The species is recorded from Tasmania, South Australia, Victoria, and New South Wales.

10. **Haliotis varia**, Linné.

Syst. Nat., 12th ed., 1767, p. 1256. *Haliotis viridis*, Proc. Zool. Soc., 1846, p. 56. *H. semistriata*, Reeve, Conch. I.c., f. 51.

Some years ago I bought a few specimens of a (to me) unknown *Haliotis* from Mr. E. Craig, Auckland, who told me that they were collected south of Whangarei. The best specimen I sent to Mr. E. A. Smith for naming, and with his constant obligingness he wrote to me, "It seems to me inseparable from *H. varia*, L., of which *H. viridis*, Reeve, is in my opinion a synonym. Of course it is difficult to say for certain, having only one shell, and that in rather worn condition." Since then I have acquired a fine specimen, which perfectly agrees with Reeve's figure in Conch. Icon., and description.

11. **Onithochiton undulatus**, Q. and G., n. var. **subantarcticus**.

At the Auckland and Campbell Islands there occurs a very constant colour variety, chocolate-brown, which certainly deserves a varietal name. Sometimes one or several intermediate valves are transversely banded with white. The girdle is always buff-coloured.

Type, from the Auckland Islands, in my collection.

12. **Dosinia lambata**, Gould.

Dosinia carpenteri, Römer, Monogr. Dosinia, 1862, pl. 10, fig. 2; Hutton, Man. N.Z. Moll., 1880, p. 150.

Römer's species I consider to be a synonym of *D. lambata*, as already stated in 1902.* Some time back I sent a specimen of the latter to Professor Lampert, of the Kgl. Naturalien Kabinet, Stuttgart, asking him to be good enough and compare it with the type of *D. carpenteri*. According to news received the two are identical, Gould's name having priority.

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* Trans. N.Z. Inst., vol. xxxiv, p. 222.

13. Chione stutchburyi, Gray.

Venericardia zelandica, Potiez and Michaud, Gal. des Moll., vol. ii, 1844, p. 166.

Mr. C. Hedley pointed out* that the description of Potiez and Michaud was evidently meant for *Chione stutchburyi*, Gray. As the species of the French authors has, as far as I know, never been figured, I sent a perfect specimen of *C. stutchburyi* to the museum of Douai, where the type of *V. zelandica* is kept. The curator, Mr. E. Gosselin, most courteously sent me excellent photos of the type and my own specimen for comparison. The only difference is in the sculpture, my specimen being younger and perfect, whereas the Douai type shows the sculpture less perfect, such as we usually find the species in muddy sand bottom. I am very glad to thus be able to confirm Mr. Hedley's opinion.

14. Venerupis carditoides, Lamarck.

V. exotica, Lam., is the same, and has priority.

The Rev. Mr. Webster's list of "Shells to be added to Fauna List"† (with locality only, no other information given) contains the above species, locality Takapuna. I am fully convinced that Webster is mistaken, though I have not seen his specimen. For years and years collecting has been going on at Takapuna reef, yet there is no record that this species, which inhabits the shores of Tasmania and southern Australia, has ever been found there, or in any other part of New Zealand; and the species is not so small that it might be easily overlooked—in fact, it is much larger than any of the New Zealand species of the genus. I am pretty sure that if Webster examines his specimen carefully he will find it to be *Tapes costata*, Q. and G. Should it, however, prove to be the species he mentions, then it is simply a dropped shell. It is not a very rare occurrence to find foreign shells dropped on our shores; in some instances they may be ballast shells. One of the most striking instances may be mentioned here. A specimen of the African fresh-water genus *Lanistes* was found on the bank of the River Avon, near New Brighton, and sent to England. Mr. H. A. Forbes, Liverpool, asked me to look out for this shell in the River Avon, but I did not, being already fully acquainted with the molluscan life of that river.

In my opinion, *V. carditoides* should not be added to our fauna list.

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* Trans. N.Z. Inst., vol. xxxviii, p. 73.
† Trans. N.Z. Inst., vol. xxxvii, p. 280.

15. Diplodon websteri, Simpson.

It is the opinion of the Rev. Mr. Webster* that I was not correct when I stated that I considered the above species as a *D. menziesi* in which the nodulous sculpture is developed to the highest degree. But we do find very interesting stages of nodulous development. My assertion is based on facts, and not on imagination. Webster seems to overlook the fact that we have a form of *Diplodon* which stands very near *D. websteri*—this is *D. aucklandicus*, Gray, which is considered by Simpson as a synonym of *D. menziesi*, and I have already stated that I accept his treatment of the two species.† In fact, the *aucklandicus* form of *D. menziesi* and *D. websteri* are found living together! I have specimens of the former with the nodules so much developed that they approach Simpson's species very closely. The hinge, thickness of the valves, and brilliancy of the nacre are very variable in the genus, greatly influenced by the surroundings—the condition of the bottom, the quality, quantity, and mode of movement of the water. I consider *D. websteri* as a good subspecies of *D. menziesi*.

16. Rochefortia donaciformis, Angas, sp.

Mysella donaciformis, Angas, Proc. Zool. Soc., 1878, p. 863, pl. 54, fig. 13. *Rochefortia donaciformis*, Angas: Hedley, Proc. Linn. Soc. N.S.W., 1902, pl. 1, figs. 10–14.

A few valves were obtained by Captain J. Bollons when dredging in 18 fathoms, Port Pegasus, Stewart Island. They fully agree with the diagnosis, the figures, and with specimens in my collection from South Australia.

17. Lima sydneyensis, Hedley.

Lima brunnea, Hedley, Proc. Linn. Soc. N.S.W., 1901, p. 21, pl. 2, figs. 7–9; *non* Cooke, 1886. *L. sydneyensis*, Hedley, *l.c.*, 1904, p. 200.

Mr. A. Hamilton, Director of the Colonial Museum, sent some shells, collected by the late Mr. C. Traill, to Mr. C. Hedley, and he wrote, under date the 9th July, 1904, that the above-named species was amongst the lot—one of the rarest shells in Port Jackson. It is at the special request of Mr. Hedley that I publish this note.

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* Trans. N.Z. Inst., vol. xxxviii, p. 311

† Trans. N.Z. Inst., vol. xxxvii, p. 234.

ART. XXVIII.—*Notes on the Natural History of the Kea, with Special Reference to its Reputed Sheep-killing Propensities.*

By GEORGE R. MARRINER, F.R.M.S., Assistant, Biological Laboratory, Canterbury College.

[*Read before the Philosophical Institute of Canterbury, 8th August,* 1906.]

INTRODUCTION.

THE kea (*Nestor notabilis*) (O, D), or mountain-parrot, is found only in the Middle Island of New Zealand, where it lives among the peaks and valleys of the Southern Alps. When discovered by Mr. William Mantell (O) in 1856 the kea's chief food seemed to consist of insect-larvæ and berries; however, as early as 1868 it was suspected not only of eating meat, but of becoming a bird of prey of no mean order. Rumours were heard to the effect that the bird attacked and killed sheep for the sake of the kidney and the kidney-fat, which formed its special delicacies.

The first recorded instance, which was published in the *Daily Otago Times* (J, *c*), runs as follows: "For the last three years the sheep belonging to a settler, Mr. Henry Campbell, in the Wanaka district (Otago), appeared to have been afflicted with a new kind of disease. The first appearance of this supposed disease is a patch of raw flesh on the loin of the sheep, about the size of a man's hand. From this, matter continually runs down the sides, takes the wool completely off the part it touches, and in many cases death is the result. At last a shepherd noticed one of the mountain-parrots sticking to a sheep and picking at a sore, and the animal seemed unable to get rid of its tormentor. The runholder gave directions to keep watch on the parrots when mustering on high ground. The result has been that during the present season, when mustering high up on the ranges near the snow-line, they saw several birds surrounding a sheep, which was freshly bleeding from a small wound on the loin; on other sheep were noticed places where the kea had begun to attack them, small pieces of wool having been picked out."

Though this record casts grave suspicion on the kea, it does not by any means absolutely prove that it was the culprit. In the first instance, the bird was only picking at a sore on a sheep's back, just as to-day starlings are commonly seen in the same position; and to say that this fact proves that the sheep was killed by the kea is putting more weight on the evidence than is justifiable. In the second instance, the shepherds saw several keas "surrounding" (notice, not "attacking" or "pecking ") a wounded sheep, and with the uncertainty which existed at that time as to the true culprit it might easily have turned out that some other animal had wounded the sheep, and the keas had only been attracted by its struggles. It seems from later investigations that the sheep had been killed by the keas, but the record here is only on circumstantial evidence, which can never, by itself, satisfactorily prove a scientific theory. In the third instance, these shepherds jumped to the conclusion that because the other sheep had some wool pulled out the keas must have done it. This shows that when men are anxious to prove a point almost anything is taken as conclusive evidence, even though there is not the slightest reason for doing so.

This early record, though not conclusive, is very important, because it points out in what direction the true sheep-killer may be discovered; but before taking this supposition as correct a very exhaustive examination should have been made for several years, to see if further researches confirmed the evidence of these men. However, though nearly fifty years have passed since the record was first published, there has not been one genuine attempt to inquire into the case, and up to the end of 1905 this is the only definite case recorded where a man actually saw a kea picking at a live sheep. Of course, many articles have been written, both in magazines and scientific works, but I cannot find one writer who says that he ever saw a kea attack a sheep, nor is the name of any man given who said that he had seen the bird at work.

It has been since proved that there were, and are at the present time, many men who have been eye-witnesses to the birds' depredations, but from the available records in 1905 not one could be found. It seems a great pity that men of scientific standing should publish in their books, on such paltry evidence, as though it were an undoubtedly proved fact, that the kea had become not only carnivorous, but a bird of prey. I think I am justified in saying that, up to 1905, all the literature that had been published stating the kea was guilty of the crime has been giving to the world as a fact a statement which has never been satisfactorily proved.

If there is anything that wants to be most conclusively proved it is a scientific fact, and as long as investigators continue to publish as true half-proved theories, only error and confusion can be the result. As might be expected from such unsatisfactory evidence, later investigations do not always uphold these hasty conclusions jumped at by early writers.

It is rather surprising to find that no one questioned the weight of the evidence until 1900, when Dr. L. Cockayne, the retiring President of the Canterbury Philosophical Institute, while reading a paper "On some Little-known Country in the Waimakariri District," made the following statement: "I have never seen it [the kea] attack sheep, nor have I ever met with any one—shepherd, musterer, or mountaineer traveller—who has done so; the most that my inquiries have elicited is that sheep are found from time to time with holes in their backs, and that keas have been seen hovering around sheep." A very warm discussion followed, and from that time people have been looking into the evidence. The result has been that there are more people who disbelieve the kea's guilt to-day than there were ten years ago. Dr. Cockayne and his supporters do not state that the kea is innocent, but that at the present time the recorded evidence is not strong enough to condemn the bird.

Let us glance through the most conclusive recorded evidence, and see on what grounds the bird's guilt has been declared proved. The late Mr. T. H. Potts (N) condemns the kea from what appears to be hearsay evidence only. He writes, "Through the kind offices of Mr. Robt. Wilkin the writer has been greatly assisted with valuable notes, acquired by sheep-farmers, owners of stations, shepherds, &c." Unfortunately, Mr. Potts does not state that any of his informants ever saw a kea at work, or whether the notes were merely the sheep-station rumours, of which a bookful could be collected to-day. Again, he does not seem to have seen the bird attacking sheep, but as his guarantee mentions the names of several men, but there is nothing to show that even these men were eye-witnesses.

In 1878 the Hon. D. Menzies (Q), writing a paper on the kea, is certain of the kea's guilt, but he also does not give his authority, which, however, is evidently some shepherds.

Sir Walter Buller (J, *a*, *b*, *c*; R) gives a complete description of the bird, and also an illustration of a kea attacking a sheep, but again no eye-witness is mentioned, with the exception of a shepherd, who said that a kea attacked some sheep while he was driving them. There is no name given, and so we do not know who the man was or anything about him.

In 1884 Reischek (T, *a*) wrote an article giving his actual experience with the kea, but though he saw them eating the carcases, and also found wool and fat in their crops, he never saw one attack a sheep.

Mr. F. F. C. Huddlestone (M), in 1891, wrote an account of his experience in kea country, and condemned the bird, but in his account he never states that he saw the sheep attacked by one.

In 1894 Mr. Taylor White (V) accused the bird, but yet does not seem to have been an eye-witness, but bases his conclusions on hearsay, for he says, "One day my brother John came home and said that he knew what caused the holes in the back of the sheep: it was done by the kea. This surprised me greatly, but I soon afterwards had evidence of the fact myself, for when some of these birds had once found out that blood of the sheep was good for food, others were initiated into the performance." What Mr. White and his brother saw is not stated, and I think that if a kea had been seen attacking a sheep it would be almost certain to have been mentioned in the paper. I have since had a letter from Mr. Taylor White stating that he has never seen a kea kill a sheep.

In February, 1906, at a meeting of runholders held at Culverden, some strong remarks were made about the loss of sheep caused by the kea, and the Wellington Philosophical Society was ridiculed for upholding the statement that at the present time the recorded evidence against the kea was not sufficient to condemn it. However, in spite of all their talk, only one speaker was reported to have seen the kea attacking sheep. The rest all spoke from hearsay; and I have since received a letter from the reported eye-witness, stating that the newspaper had misrepresented his remarks, for he had never said any such thing at the meeting. This meeting was the means of leading many people to believe in the kea's guilt, and yet, when the evidence was sifted, not one man saw the kea do it.

This is the pith of the recorded evidence up to the end of 1905, and not one writer brought forward a reliable instance where a sheep had been seen to be attacked and killed by the kea.

The strongest evidence against the bird was the circumstantial, which may be classed as follows:—

1. *Against the Kea.*

(*a.*) The account of the Wanaka shepherds.

(*b.*) Only where keas were known to live were the sheep wounded after the kea's method, and that where they were unknown no instance of this special kind of sheep-killing had been seen.

(*c.*) If sheep had been killed, and the birds in that place were shot, the killing at that spot ceased.

(*d.*) Keas had been seen to fly off the bodies of sheep, and wool and fat had been found in their crops.

(*e.*) Some keas in captivity would eat meat, fat, skins, &c.

This evidence may be sufficient to satisfy the general public, but it is inadequate to prove it conclusively as a scientific fact.

2. *For the Kea.*

(*a.*) The lack of recorded eye-witnesses.

(*b.*) In many places where keas were known to live, no sheep had been killed after the kea's method.

(*c.*) Many keas in captivity would not eat meat, &c.

(*d.*) Many of the men who accused the bird were paid for exterminating them, and they would naturally wish the story to be believed.

It was suggested to the writer by Dr. Cockayne that in order to get some evidence that might be depended on all the men who had seen the kea attack sheep should be requested to send in an unexaggerated account of what they had seen, and when this eye-witness evidence had been sifted and arranged some real facts about this interesting bird might be obtained and published.

In response to several requests, kindly published for me by the newspapers, I have received a large amount of evidence from men who live, or have lived, in kea country—namely, musterers, shepherds, head shepherds, managers of stations, runholders, and station-owners. These, it is true, are not trained scientific observers, nevertheless they all live in contact with fact, and it seems to me that we are sure to get nearer to the truth by taking the experiences of men who have spent most of their lives in kea country than those of men who judge the birds mostly from caged or preserved specimens.

To make the evidence as reliable as possible, the following precautions have been taken: (1.) Nothing but accounts from the eye-witnesses themselves have been taken. (2.) Evidence without the writer's name and address has been cast out. (3.) All details, as year, station, &c., have been received in each case, when possible. (4.) The witnesses, if necessary, have been cross-examined by post. (5.) All accounts of keas attacking sheep have been forwarded with a written statement that, if necessary, the writer will be willing to swear to his evidence before a Justice of the Peace. (6.) The accounts that have been received will be filed and presented to the library of this Institute, for further reference. In spite of all these precautions, I am aware that inaccuracies may creep in; but I think that when fifty or sixty eye-witnesses agree in the main facts of the case we may take it for granted that we are somewhere near the truth.

To some people this question will never be satisfactorily proved until some man of scientific standing has actually seen the kea killing the sheep. In order to satisfy these doubters, I should suggest that some sheep should be fenced in on some station where keas are plentiful, and by getting some one of scientific standing to keep watch, the keas' method of attack could be witnessed in surroundings that are quite natural. In this way, no forcing or starving of the bird would be needful. However, I think I am justified in saying that, as far as human evidence can be relied on, I have conclusively proved that the kea has not only taken to meat-eating, but that it does actually attack and kill sheep for the sake of the meat.

In order to have evidence from both sides I invited accounts from men who believed the kea to be innocent, but I only received one reply. The writer did not want his name published, and told me not to take much notice of what the Stock Inspectors told me, for the whole thing was a bogey. He promised to send me down the names of a number of reliable men who would give me satisfactory evidence to support his side. However, as his list included two Inspectors, and as four other names were marked as doubtful, I did not deem it wise to continue this kind of investigation.

Meat and Vegetable Eating.

If keas, both in captivity and in their wild state, have never been known to eat meat or fat, then this fact would cast grave doubts on the belief that they are the culprits. On the other hand, if the birds, though they are not naturally carnivorous, have been known to eat meat and fat and even relish it, then we have some reason to believe that these parrots may be guilty of sheep-killing. Many people still believe that these birds are not meat-eaters, but though in some cases this is true, most of the men who have kept keas, or have seen them feeding in the open, say emphatically that they like a meat diet.

There are other birds besides these mountain-parrots that have taken to eating meat, though not naturally carnivorous. Many cockatoos are fond of picking meat from bones, and the white-eye (*Zosterops cærulescens*) can be often seen in winter eating meat and fat.

Sir W. L. Buller (J) tells of a number of parrots that took to killing and eating their fellows.

Mr. C. C. Lake, Christchurch, writes saying, "I was given a kea when in Fairlie some two or three years ago, and although I had him several months prior to his death, I can honestly say that never once did I see him refuse meat in preference to anything else."

Mr. R. Urquhart, Mount Algidus Station, Canterbury, when writing on this question, says, "It is a strange thing, for we have nine keas in a cage, and I can honestly say that they have had nothing but meat to eat for the last two years."

Mr. Fred Daw, Miller's Flat, Otago, writes of an experience of his when on the Red Mountains, Southland: "The bird [kea] not only made a hole in the tent, but started eating the fat which was hanging on the ridge-pole."

Mr. George Rutherford, Dalethorpe, Canterbury, states, "I have had a kea on the chain here this last four months, and he seems as lively now as the first day we got him, and his only diet is kidneys, liver, and warm fat. He won't eat much cold fat. He seems very fond of raw carrots, and eats them every day."

Dr. L. Cockayne writes as follows: "In the summer of 1897–98 I was camped for some weeks on Arthur's Pass, at an altitude of 2,800 ft. During a part of that time three keas lived round the camp, frequently perching on the beech-trees and at times climbing over the tents. These birds fed greedily on any meat which was thrown to them, picking bones and so on. They were by no means friendly with one another, one being especially the 'cock of the walk' and driving away the others when they came after the food. These particular birds were extremely tame, and would actually perch upon the long ends of wood jutting from our fire." Dr. Cockayne adds the following to the above and his other statements about the kea: "All the above is written from memory, and therefore I do not vouch for its accuracy. Observations of animals and plants should be entered in a note-book at the time of observation, otherwise they can only be accepted with caution."

Others testifying to the keas eating meat are Messrs. W. N. Ford, J. Morgan, J. McIntosh, John McGregor, A. Watherston, H. T. Heckler, P. Dunbar, &c. Without going into the evidence of these men, I think enough has been said to prove that many keas, whether wild or tame, will eat meat and even relish it. Not only does the kea eat meat, but twice it has been seen acting the cannibal.

Mr. J. Morgan, Lake Coleridge Station, writes, "When going up to the Big Basin, Forks, Mesopotamia, one day, a mob of keas came and settled close to me. I knocked one over and cut off its beak and let it roll down the snow-slips to the bottom of the basin. Immediately the mob swooped down on it and started pulling the feathers out as it was rolling down. I was rather curious to see if they would eat their dead mate, so when going back I went and saw the bird. The mob of keas were still there, kicking up a great fuss, and all that remained of their dead mate was the head and bones, which were picked clean. It could not have been more than three-quarters of an hour since I killed the bird until I saw it again 'stripped.' I have seen the same on more than one occasion since, though I never investigated it the same as the above."

Some of my correspondents have written to say that the keas under their observation prefer vegetables, insects, &c., to meat. These instances are not very numerous, but are, I think, worth while recording.

Mr. A. J. McKay, Geraldine, writes, "I had a kea sent me from the Mackenzie country, and I observed its habits very closely. He would eat flies, spiders, and caterpillars of any description, and was fond of vegetables such as peas and beans in the pod. I tried him with kidney-fat (sheep) and the kidneys themselves, but he would hardly deign to put his beak into them."

Mr. Gully, Nelson, writes, "I beg to acknowledge your letter, and in reply beg to inform you that we have a live kea in the gardens here. It eats bread-and-milk, sugar, apples, dock-leaves, &c., and since its confinement has preferred a vegetable diet, eating no meat."

Dr. F. W. Hilgendorf, Agricultural College, Lincoln, gives me the following account of a kea that lives near Malte Brun, Mount Cook: "A plate of meat which was put on a platform was pulled over the edge immediately by the kea, without tasting the meat, and this we could never get him to eat, although he would pick up crumbs of bread."

Mr. C. V. Rides, of the Christchurch Acclimatisation Gardens, gives the following account of two keas in the aviary, which shows that these birds often like both the vegetable and the meat diets. He says, "We have two keas here, which we have had in a cage for about eighteen months with a hawk, with which they agree very well. Although these birds will and do eat meat, always preferring the fat and suet, they are equally fond of all kinds of fruit, such as apples, plums, cherries, elderberries, green peas, bits of cabbage-stumps, &c., not caring for wheat or maize, such as other parrots are fed on. When dead rats are put in for the hawk the keas never attempt to pull them to pieces. I do not think that the information concerning these birds in captivity is of much value as regards their native life; I notice that most birds in confinement lose character to a large extent. Even the wild ducks prefer cakes and buns to the usual wheat and maize, &c."

From what has been said it can be seen that many, if not most, keas in captivity will eat meat; a few keep to both diets, as no doubt the wild keas do, and others seem to abhor meat and keep to a vegetable or insectivorous diet.

These accounts may at first seem very contradictory, but I think the explanation is that all keas have not acquired the taste for meat; and very likely, if a bird is captured before it has got the taste for meat, it is not likely to acquire it as long as it has a plentiful supply of ordinary food.

Carcase-eating.

At the St. Louis Exhibition, according to Mr. Guthrie, of Burke's Pass, the New Zealand Tourist Department represented the kea as follows: "The kea, a species of parrot that fastens itself to the back of the sheep, picks out the fat surrounding the kidneys, leaving the animal to die a lingering death." From the accounts that I have received, this description is very erroneous, for the kea does not only eat the kidney-fat, but in many instances the whole carcase is devoured. People who kill the birds by poisoning state that often the difficulty is to find a carcase with enough flesh on to poison. Mr. Guthrie says, "My experience is that the kea prefers putrid meat to fresh. In shooting them, before dying they generally disgorge, and in the hundreds I have seen, over 90 per cent. disgorged putrid meat."

Mr. Morgan writes as follows: "Some writers say that this bird won't eat dead sheep, but they will, and seem to enjoy them. They will get on a dead sheep and clean every bit of flesh off the bones."

Mr. Ford, of Pembroke, Lake Wanaka, says, "I was engaged for some time in destroying the keas by arsenic and strychnine mixed. I would go out on the hill in the afternoon and wait about until the sun got weak, as then the keas would gather and make in the direction to where they had mutton. I would then follow them up and always find one or more dead sheep killed by them. I would poison the carcases thoroughly, but the trouble was to find a carcase with sufficient flesh to poison, as they devour the sheep completely, leaving nothing but wool and bones. Cases when I have found sheep partly eaten, on coming to them next day I would pick up as many as twenty-eight dead keas near the carcase."

So sure are the men that the keas eat the dead sheep that for the purpose of killing the birds they often camp near a carcase. Mr. E. Cameron, Pembroke, Lake Wanaka, says, "The way we used to do if we did not find a dead sheep on the ground was to kill one and camp near it at night. Often as many as fifty keas would come and eat it, and they are that tame that every one could be shot." From this and other evidence which I have received there seems little doubt that the birds will eat almost the whole of the carcase, and they certainly do not confine themselves to the kidney-fat.

This naturally leads up to the question as to whether the kea's beak, filthy from a recent gorge of decaying meat, does not sometimes cause blood-poisoning in the next live sheep it attacks, and so a very small scar might be sufficient to cause death. Mr. Guthrie, writing on this question, says, "I visited the camp daily for some time and found newly killed sheep almost every day. Some would be lying dead in the camp without any outward sign of a wound, but on skinning them there would be a spot of bruised blood on the spinal cord. Others would be torn and bleeding from a wound over the kidneys, generally black and swollen, just as if the sheep had died from blood-poisoning."

Mr. Turton, of Peel Forest, Canterbury, writes, "Others you find with a hole so small that you could scarcely get your finger in—merely a scratch—but they would mope about, and die in a few days. If you skin these sheep, as I have done, you will find that it is as black as ink, and smells something vile. The bird's bill is, in my opinion, poisonous to sheep."

It seems as if in some cases blood-poisoning is caused, but it certainly is not always so, as is proved by the number of sheep which come into the sheds every year marked with kea-scars, but otherwise quite healthy.

Why so few Keas are seen attacking Sheep.

It has often been asked, If the kea does so much damage to the flocks, how is it that so few people have ever seen the bird at work ? The answer to this question is easily found by studying the habits of the bird. It is largely nocturnal, being especially lively in the early morning and the evening, and, if we may take the circumstantial evidence, it appears to do most of its work at night.

Mr. Reginald Foster, "Hasledon," Christchurch, discussing this subject in a letter to me, says, "I fear, however, that it will be difficult to obtain the evidence of eye-witnesses, because the keas work in the night and very early in the morning. . . . The work is done, too, pretty high up on the ranges, where the musterer or shepherd perhaps does not reach until 8 or 9 o'clock in the morning."

Mr. R. Guthrie, in writing to the *Timaru Herald*, says, "In my opinion the kea, which is of nocturnal habits, does chiefly all its mischief at night or on very dull, foggy days, and never shows its true character in sunshine."

Mr. J. Logan, of Double Hill Station, Canterbury, writes, "The reason why there are not more eye-witnesses to the ravages of the kea is that the time of its attack is at night or on foggy days."

Messrs. R. Urquhart, W. N. Ford, and many others give similar evidence.

It can be seen from what these men say that, owing to the time when the kea does the killing, and the distance from the homestead of the places where the sheep are found dead, it is not surprising that so few men have seen the bird actually attacking the sheep.

Attacking Sheep.

Among my numerous correspondents, over thirty state that they have seen the keas actually attacking sheep. These witnesses do not consist only of musterers and shepherds, but in many instances they are either managers of the sheep-stations or the station-owners themselves. Summing up the different accounts, the bird's mode of procedure seems as follows: They may attack in ones or twos or in numbers, but usually one or two birds do the killing and the others share the spoil. The keas do not, as some people think, attack the sheep that are in poor condition, but always seem to choose the pick of the flock. The bird settles on the ground near its quarry, and after hopping round for some time it leaps on to its prey, usually on the rump. If it cannot get a firm grip with its feet the movement of the sheep causes it to fall off, but it persists until it has firmly perched itself on the sheep's back. Then the kea begins its operations by tearing out the wool with its powerful beak, and at last gets its beak into the flesh. The sheep, which for some time has been moving uneasily about, gives a jump as the beak pierces the flesh, and then begins to run wildly about in vain efforts to rid itself of its tormentor. When, however, the sheep finds it cannot dislodge its enemy it seems to become terrified by pain and fright, and rushes blindly about, usually at a high speed. Sometimes the sheep tears round the flock until it is played out and cowed, when it sinks to the ground and lies with its neck stretched out, a picture of misery. If snow is on the ground, the poor beast flounders about until it gets into a snow-drift, and then it becomes an easy prey to the relentless birds. At other times the terrified sheep, as if making a last despairing attempt to get rid of its enemy, rushes madly forward in one direction, usually downhill, at a terrific speed, quite oblivious of rocks and pitfalls, the kea meanwhile holding on and balancing itself with outstretched wings. Very soon the sheep strikes a rock or stumbles and rolls over and over down the hill, only to get on its feet again and repeat the performance time after time. When the beast stumbles the kea rises on its wings, and settles down again on to the sheep when it has regained its feet. This awful race is continued until, bruised by its numerous falls, utterly exhausted by its death-struggles, and maddened with pain, the terrified animal stumbles to rise no more, and becomes an easy prey to the kea. The blind rushes often end even more tragically: the sheep in its blind rush often comes to a precipice, and, with the same mad impulse that brought it so far, it leaps over the edge and is dashed to pieces on the ground below. In this case the kea leaves go its hold as soon as the sheep begins to fall, but follows the unfortunate animal in the descent, to satisfy its hunger on the result of its labours. Some writers think that many inexperienced keas kill sheep in this way, even though they may not have intended to.

I will now give some typical accounts from men who have seen the bird at work:—

Mr. Don. Finlayson, late of Glenthorne Station, Canterbury, writes, "In December, 1898, in company with Walter Grieve (now manager for Mr. F. W. Cordy, Hororata), when walking along the edge of Lake Coleridge, at the foot of Mount Oakden (on the Acheron Run), we saw a kea rise suddenly about a chain ahead of us. We walked to the place and found a sheep lying with a hole torn in its back. The sheep was so severely injured that we had to kill it. When mustering in the same year on Totara Hill, up the Wilberforce River, I was walking quietly along, and coming to the edge of a slight depression in the ground, there right at my feet a kea rose from the body of a sheep. I examined the sheep. It was a merino wether, perfectly sound, but had been so severely injured by the kea (a hole had been torn in the sheep's loin, the kidneys were protruding, and some of the fat had been eaten) that I had to kill it."

Mr. Charles W. Symonds, Christchurch, writing of his experiences while living on the border-line of Canterbury and Otago, says, "While mustering, I have on many occasions actually seen the kea on the sheep's back (loin), and generally three or four keas would be flying round the sheep, which would be running at the tail of the mob. The sheep would run until it was thoroughly exhausted and had to lie down from exhaustion and fright."

Mr. R. McKenzie, Blackmount Station, writes, "Seeing your request *re* the kea in the local paper, I write to say that I have seen the kea at work on the sheep's back. The latter was driven frantic by the bird's attack, ran wildly in any and every direction, eventually making a bee-line down a steep slope, and, as if blind, took a 'header' over a precipice, more than 100 ft. high, and was dashed to pieces on the rocky and shingly bottom. The kea hung on to its prey until the moment the unfortunate animal left *terra firma*, when the bird relaxed its hold, but flew down almost on the very track of its prey, when it was lost to view by the writer and a shepherd who was there also."

Mr. Donald Burnett, Sawdon Station, Burke's Pass, writes, "It was in the afternoon ; I was mustering in Boundary Gully, Mount Cook Station, at the time, and had a mob of sheep in hand, and was about 2 chains away, when a kea—one of several that were flying around—settled on a sheep. The beast at first gave a jump or two and then made downhill at a great rate. When the sheep got into motion the bird spread out its wings, and as the pace became faster the wings came together at the perpendicular. The sheep continued its race until both were lost to view, after going some distance through the storm."

Mr. Thomas Wilson, of Alford Forest, Canterbury, writes, "Some years ago a kea rode a sheep into the woolshed on the Double Hill Estate ; I was an eye-witness, and closed the door. The kea was caught, and I killed the sheep, which was badly picked on the back, and the entrails were pulled out just over the kidneys."

Mr. J. Sutherland, of Benmore Station, Otago, writes, "In 1887 I was keeping a boundary where keas were numerous, and on several occasions I saw them attack sheep. I saw a sheep running down the hill with a kea hanging on. I followed after it and found the sheep lying in the gully with the kea tearing away at it. I drove it off. The sheep was not dead, but the wool and the skin was torn and a hole was made in the sheep's back, just above the kidneys, a wound from which it would have died ; however, I killed it to put it out of pain."

Mr. H. E. Cameron, of Longslip Station, Otago, writes, "One day while mustering in the summer-time of 1895 I saw a kea on a sheep's back, clinging to the wool and digging his beak into its back, and a number of others flying about. I went down to the sheep with some other men. Some entrails had been pulled through a hole in its back, and we had to kill the sheep. I was camped at the foot of Davies Saddle (Longslip Station) one foggy day, and at 3 o'clock heard a great screaming of keas, so I went out to see what they were at. On going down the creek a short distance I saw a sheep coming down the face of the hill as fast as it could, with a kea on the hips, and twelve more birds following and screaming. The sheep when it got to the foot of the hill ran under a bank, and the others watching as if waiting for a feed. I went up to the sheep, after throwing stones at the birds. When I got up to the sheep it had two holes in its back ; the kidney-fat had been eaten, but the kidneys were lying bare in the sheep. The entrails were pulled out through the hole in the back. The sheep was not dead, but had to be killed."

Mr. J. H. Bond, of Templeton, gives his experience while on the Mount Algidus Station: "I saw a kea settle on a sheep and begin to tear away at its back while I was within a few chains. The sheep bolted downhill into a gully, and stood up to its belly in the snow at the bottom, from 3 to 4 chains off. It looked to me as if the kea then drove its beak deep into the flesh; the sheep gave a big jump and stood still. When I went to examine the sheep it had a bad wound just over the kidney, quite fresh in appearance."

Mr. Hugh McKenzie, of Etalvale Station, Nightcaps, writes, "In 1884, on Lorne Peak Station, Wakatipu, in the month of July, there came a heavy fall of snow. One morning early myself and two other men went out to look up the sheep; at 10 a.m. we sighted a mob. As we got within about a quarter of a mile of them we could make out a number of keas flying about the sheep, making a great noise screeching. We at once hastened on to the sheep, which were stuck on a point of a spur about 3,000 ft. in altitude. At a distance of 300 to 400 yards we saw two sheep floundering in the snow with a kea perched on the rump of each sheep and at work on the loins. These sheep would be distant from the mob about 80 yards, and fully 20 yards from each other. As we sighted them, however, notwithstanding our singing out and hurrying up to the sheep, neither kea quit his position until we were within 20 yards of them. They, however, did not damage these sheep enough to cause death, as we came just in time."

Mr. J. Morgan writes, "On Mesopotamia Station, in July, 1905, one afternoon at 2 p.m., the kea settled on the snow alongside the sheep, and then hopped on to the sheep's back. The kea then started to pull a tuft of wool out above the loins, and then another, &c. Then it inserted its beak; at this the sheep ran into the mob, and the kea just flew off, and when the sheep was quiet again it once more got on to its back and started to use its beak again. At this the sheep plunged downhill into the snow. The kea went through the same performance again. All this occurred inside of five minutes. Of course we did not let the kea kill the sheep."

Mr. A. S. Smith, of Fairlie, writes, "The first occasion on which I actually saw a sheep killed was one time while mustering. I noticed two sheep that had been passed some little distance, and while in the act of hunting a dog for the sheep a kea flew down to the back of a sheep, which made headlong down the hill with the bird all the while on its back. After running some little distance the beast stumbled and fell. Then the bird rose to its wings until the sheep got up and continued its race downhill, evidently much terrified. The bird then flew on to the sheep's back again while it ran. This occurred, I should say, three or four times before the bottom of the gully was reached. When I went to investigate I found the sheep not quite dead, but bleating with evident pain, it would appear on account of a hole in its back, close up to the shoulder."

Mr. A. Wilson, of Pembroke, Lake Wanaka, writes, "I have seen them attack a sheep at midday, when it was quietly feeding, and it would rush away as fast as it could go, until it either tripped itself or fell down exhausted, when the keas that followed it would start picking the wool off the loins. I have followed sheep under these circumstances and found the keas picking them until I drove them away and set the sheep on to its feet again. I have also found sheep actually able to walk about a little, even though they had portions of their intestines pulled out through the hole in the loins and hanging down their sides. These, of course, we killed."

Mr. H. Heckler, of Lumsden, Southland, writes, "I was keeping boundary up the Gladstone Gorge, after snow muster, and was gathering stragglers off the high country, when I ran across about twenty keas. Two of them were on a sheep's back. The balance were flying round him (a stray wether) making a terrible noise. The sheep was going at full speed down the spur. I watched where he ran to and followed him down for about three miles. When I got down the sheep was dead, with two holes (one on each side of the backbone) in him, and most of the mob of keas were picking out the kidney-fat. I crawled to the rock where the poor sheep was lying, and the keas were so busy at work that I killed three with my stick."

Mr. Andrew Watherston, Ree's Valley Station, Glenorchy, writes of his experience in 1904 as follows: "I was looking out a mob of wethers, and found that the keas had been killing them, and there were eight dead. As it came on a dense fog I had to return to my hut. Early on the following morning I went out to the wethers again. Arriving where the sheep were camped, some time before sunrise, I could hear the keas calling, and following up the sound I got to where there were about forty of them. They had about three or four hundred wethers rounded up. The sheep were huddled close together, and the keas were flying over them and alighting on their backs. When the keas started to pick the back of the sheep it would start to run round and round the mob; the kea would rise, but as soon as the sheep stopped the bird was on its back again. This continued for a little time; the sheep, apparently getting sulky, lay down with its neck stretched out and its lower jaw resting flat on the ground, when it showed no further resistance, but allowed the kea to pick away at its back. I never saw a sheep, after it once sulked, to show any further resistance. I shot nineteen keas and left the mob, but on looking round I found that they had killed thirty-eight wethers, most of them being quite warm and in splendid condition."

Many more such instances could be cited, but enough has been said to show the method and the results of the kea's attack on sheep.

The Kidney Theory.

It has always been supposed that the kea attacked the sheep for the sake of the kidneys, and the first man to dispute this, so far as I know, was Mr. F. F. C. Huddleston, of Nelson (M, N). Dr. Alfred Russell Wallace, in his book entitled "Darwinism" (G), after describing the method of the kea's attack, says, "Since then it is stated that the bird actually burrows into the living sheep, eating its way down to the kidneys, which form its special delicacy." From the evidence of men who have seen many sheep killed and wounded by keas, this statement appears to be erroneous, and of the many correspondents that have communicated with me only one states that the bird eats the kidneys; and later on the same writer says, "I have shot many keas by the dead sheep, and they vomited up fat." It appears as if, even in this instance, the bird eats the fat rather than kidneys.

Mr. T. Toms, of Richmond Station, Lake Tekapo, says, "I have not examined many sheep that have been killed by keas, but in the ones that I have examined I have always found the same result—the fat has been torn away and the kidneys left. Of course, the kidneys have been found mauled, but they were not sufficiently torn to give the impression that the kea had been eating them.

In three other accounts—namely, in those of Messrs. Donald Finlayson, H. E. Cameron, and C. W. Symonds—the fat was also eaten and the kidneys left exposed and untouched. Now, if the kidney itself was a special delicacy, as Dr. Wallace's book states, the keas, I think, would have eaten the kidneys as soon as they were exposed.

Mr. McKay, of Geraldine, had a kea which would not touch sheep's kidneys. He says, "I repeatedly tried him [the kea] with kidney-fat and the kidneys themselves, but he would scarcely deign to put his beak into them."

One reason why people suppose the kea to be fond of kidneys is that the keas nearly always attack the sheep on the loin just near these organs, and, as they eat their way through the flesh and fat, people have jumped to the conclusion that they must be after the kidneys.

In looking through the authentic accounts of about fifty eye-witnesses, I cannot find any evidence to support the kidney theory. The reason for the keas always tearing open the sheep above the kidneys can be explained, I think, by the way the bird attacks sheep. All my correspondents with three exceptions say that, from what they have seen, the kea always settles on the rump. Mr. R. Guthrie thinks that they only settle on the shoulders when the sheep is stuck in the snow, but I have an instance where the shoulders were eaten and the sheep was not caught in the snow.

The reasons for the keas always settling on the hind quarters are as follows: Firstly, the rump of the sheep is its widest part, and so it makes a firm platform for the kea to settle on and to get a firm hold. Several witnesses say that it is almost impossible for the kea to keep on a sheep's back unless he perches on this part. Mr. Guthrie says, "It is almost impossible for a kea to stick on a sheep's back while pecking it in any other position than behind the kidneys, facing the head. I have seen them trying to hang on to a sheep's back, but unless they were in the position described they could not stick on for ten yards." Secondly, when flying after a sheep, the rump is the nearest and handiest part to settle on, and as the birds often have to alight on the sheep while it is running, it is no wonder that the rump is that part chosen. Though keas seem fond of mutton-fat, I do not consider that this is the only reason why they make for the loin. It naturally follows that when perched on the sheep's hind quarters the bird will commence to pick the sheep's back at the handiest part: this, without doubt, will be the part that is under the kea's nose—namely, the loin. Again, the loin is very easy to tear open, owing to the absence of ribs, and this again would commend itself to the bird.

To me it seems that the preceding reasons do more to influence the kea when attacking than the presence of the kidney-fat. Even the first-recorded accounts of sheep-killing mention that the bird attacked the loin, and the only way to explain this is that the kea found the loin the easiest and handiest part to attack. I can hardly believe, as some people do, that by some kind of instinct the kea knew where the kidney-fat was to be found in the live sheep. This latter idea is somewhat upset by the fact that cases have been seen where the flesh around the backbone has been eaten, and the kidney and the kidney-fat left almost untouched.

The kea appears to eat whatever part of the sheep comes first—first the skin and flesh, then on to the kidney-fat. In some cases they do not even eat all the kidney-fat, but begin to pull out the intestine, and several sheep have been found alive with these organs protruding. Mr. A. Wilson says, "One day I came suddenly upon two or three keas, busy picking at the loin of what I supposed to be a dead sheep. There was a hole right through the sheep's back, and the birds were putting their heads right through to the inside of the sheep and pulling out portions of the intestine, but I cannot say if they ate them or not. I then went over, and to my surprise I found that the sheep was not dead, so I killed it to put it out of pain."

It is evident that these birds do not mind what part they attack as long as they get something to eat, and when a sheep is buried in the snow they go for the handiest part. Mr. E. Cameron says, "A snow-slip carried some sheep with it. I found the sheep stuck in the snow, where it landed, still alive, with its hind leg eaten to the bone, and half a dozen keas tearing away at him."

I think that the theory about the bird killing the sheep for the kidney alone is entirely wrong, and I doubt very much if the kidneys are in any way the source of attraction. The birds certainly do not leave the sheep to die a lingering death while their hunger is unappeased, unless they are disturbed.

As to the kidney-fat theory, though this has some evidence to support it, I think that it is mostly because these parts are easiest to get at. The very fact that the keas eat all parts of a carcase except the wool and bones rather weakens this theory.

How the Habit was acquired.

We now come to the interesting question as to how the kea acquired the habit of killing sheep and eating the carcases. This can never be completely answered, but there are several theories which are well worth considering, as they throw a certain amount of light on the reason for the bird's change of diet.

1. *The "Vegetable Sheep" Theory.*—This is certainly the most popular, though it has very little to recommend it. The supporters of this theory suppose that the kea had been in the habit of tearing open the "vegetable sheep" (*Haastia pulvinaris* and *Raoulia eximia*) in search of grubs, which are supposed to live in these peculiar plants. They are found especially in the northern half of the Middle Island, at an altitude of from 4,600 ft. to 6,000 ft., and in external appearance they somewhat resemble a sheep, growing as they do in the form of cushions, often as large as sofas, and the whole surface having a woolly appearance. It is supposed that when the

sheep first wandered into the keas' domains the birds mistook them for the woolly-like plants, and, with the idea of digging out the grubs, they began to tear open the skin of the sheep. In this way the keas are supposed to have acquired the method of killing the sheep and eating the flesh.

This all sounds very feasible, but on further investigation it is found that the true facts do not support the theory.

Firstly, where the keas were first known to attack sheep—namely, around Lake Wanaka—the "vegetable sheep" do not, according to Dr. Cockayne, grow to such a size that they might be mistaken for sheep; in fact, *Raoulia eximia* does not occur there at all, and many mosses, &c., are often as conspicuous as the Otago species of *Raoulia*. The true "vegetable sheep" (*Haastia pulvinaris*) does not even come as far south as Canterbury, and *Raoulia eximia* does not go farther south than Mount Ida in Central Otago, its only known Otago habitat. Therefore it appears that where the kea first acquired the habit of killing sheep the "vegetable sheep" is practically unknown.

Secondly, I have never found any grubs in the "vegetable sheep," though I have pulled many up, and I have read and heard of no one who has seen grubs in these plants of such a size or numerous enough to attract the kea. The only supposed reference that I can find is in an article by the Hon. Dr. Menzies, M.L.C. (Q), in 1878. He says, "They suppose that these birds [keas] formerly fed chiefly on berries and the large white grubs abounding in the mossy vegetation on the hills." Whether Dr. Menzies, or the shepherds from whom he received his information, mistook the "vegetable sheep" for a lichen or moss, as many people do, I cannot say.

Thirdly, when keas first attacked sheep, and up to the present day, they seemed to confine their attacks to the shoulder or rump, the latter in preference. Now, if the keas were in the first instances looking for grubs, then they would almost be sure to work right along the whole length of the back; but in the accounts that I have seen this is certainly not the case.

Fourthly, if the keas feed on these grubs that are supposed to live in the "vegetable sheep," one would expect to hear of the plant being found in a partly torn-up condition. However, I can find no instance of the plants being seen in this condition, and, though I have been upon the ranges where keas and "vegetable sheep" are both numerous, I have always found the plants intact.

It seems to me that unless further evidence is forthcoming to support this theory it must be left out of consideration.

2. *The Curiosity Theory.*—Some writers think that it is nothing but the kea's insatiable curiosity and destructive-

ness that has got it into the habit of sheep-killing. Taking into account the bird's love of investigating anything that is at all strange, it is suggested that when the sheep first appeared in the birds' domains they became at once the centre of attraction. The keas would, no doubt, walk round the sheep and inspect it, and finally hop on to the animal's back. When the sheep commenced to run the bird would most likely fall off, but by repeated attempts it would at last find the way to hold on. Once on the sheep's back, the kea most naturally would begin to pull out the wool and finally find his way down to the flesh. In this way he would soon find out how to get food from a living sheep.

Again, if a number of sheep were half buried in the snow, their position would be quite strange enough to attract the keas, and with their natural love of tearing they would soon find their way to the animal's flesh.

It seems to me that this theory has much in its favour, and may account to some extent for the bird's change of diet.

3. *The Hunger Theory.* — The supporters of this theory suggest that it was the lack of ordinary food that caused the kea to attack sheep. They say that when the ground was covered with snow and frozen hard the birds would have a difficulty in finding sufficient food. Being pressed by hunger, they would visit the meat-gallows at the homesteads and feed on the meat, skins, offal, &c., and in this way they would soon acquire a liking for meat. Having once acquired the taste, they would next take to eating dead sheep or sheep caught in the snow, and finally take to tackling the live animals.

4. *The Maggot Theory.*—This is a slight modification of the hunger theory, and was first suggested by Dr. Menzies (Q) in 1878. He says, "They suppose that these birds formerly fed chiefly on berries and the large white grubs abounding in mossy vegetation on the hills, and that after the country was stocked they—first by feeding on maggots and insects on dead sheep, and afterwards on dead animals—acquired not only the taste for meat, but also a discrimination of the choice parts. By-and-by they attacked living sheep, and their upper mandible enabled them quickly to tear open the skin."

Reischek (T, *a*), in 1885, supports this theory, and says, "My opinion is that these birds became carnivorous through being numerous when sheep were introduced, and feeding on maggots which soon appear on carcases of sheep dying on the runs, and have thus probably acquired such a liking for the fatty matter that it has emboldened them to attack live sheep."

This theory seems to have much in favour of it, especially when we remember that the kea is naturally insectivorous.

Again, the very fact that birds seem fond of dead carcases rather supports this theory.

It is, of course, impossible to say which theory is nearest the truth, but I think that there is no doubt that the main factors that caused the keas to change their diet and become birds of prey are expressed in the last three theories.

The Time of Attack.

It would be unwise to say in what month of the year the keas are most destructive to the flocks, because all the sheep that are killed are not found, and naturally when musterers are out on the ranges they will see more results of the keas' work than when they remain on the homestead. From the records that I have received, they seem to attack mostly in the winter and the spring, and frequently at midsummer.

There are several reasons which may account for their attacking in winter. Firstly, when the ground is covered with snow, or frozen hard, the birds will have much difficulty in finding sufficient food, and hunger, no doubt, would make them ferocious. Secondly, the sheep are made an easier prey owing to the depth of the snow, and often they are buried in it, so as to be almost unable to move, and so would give the birds very little trouble.

In early spring the climatic conditions are, if anything, intensified, and the ordinary food is scarcer still. Besides, it is the kea's nesting-time, and the extra work of sitting, and the feeding of the young birds, would make the parents more hungry and daring. During the late spring, when their ordinary food would be more accessible, they appear to kill less sheep, and do not become very much of a nuisance again until about the middle of summer.

The reason why the keas find this season a good time for depredations is uncertain, but may be accounted for as follows: Firstly, owing to the snow having melted, the sheep are able to roam in the kea's domain. Secondly, the sheep have favourite places for sleeping, and, if anywhere near, they make for them night after night. These spots are called "camps," and no doubt the keas are always sure of finding a good supply of sheep in the "camps" whenever they intend to attack. Thirdly, at shearing-time the sheep are confined to small paddocks, and so have less chance of getting away from the kea. They do not, however, confine their attacks to these seasons only, but have been known to kill sheep all the year round, though autumn seems the time when they attack least: whether it is due to the quantity of their ordinary food, that would be plentiful at this season, or not, is hard to decide.

The time of day when they attack sheep is also uncertain, and, speaking generally, they have been known to attack at all hours; but the evening, night, and early morning appear to be their favourite times.

Why night-time should be their favourite time may be accounted for in several ways. Firstly, the sheep are said to make for the same sleeping-grounds or camp for several consecutive nights, and the birds would be sure of finding plenty of sheep together during the hours of darkness. Secondly, being partly nocturnal in their habits, they have an advantage over the sheep, and at night there is less chance of their being seen or disturbed.

If attacking in daylight they seem to choose dull or foggy days, but this is not always the case, as I have heard of several instances of attacks being made in bright sunshine. However, in these cases there has always been snow on the ground, and the helplessness of the sheep, or the lack of food, may have made them more daring.

Number of Sheep killed.

It is impossible to work out anything like a correct estimate of the damage done to the flocks of sheep by the keas, owing to the uncertainty of the results sent in. For instance, where every sheep that is missing is put down as the work of these birds the damage is exaggerated, and in cases where sheep are killed by the keas and their remains are never seen there will be an underestimation of the loss. Again, if we take the number of birds killed in a certain time we go wrong, because the birds seem to kill at irregular intervals, and when percentages are given we have to find out whether it is made out on one flock, one station, or one district. Often when a percentage is given on a week's or a month's damage, unless it is very clearly stated, it is sometimes taken for the annual loss, and in this way very erroneous results have been published. Some people quote the damage to the stations at 30 and 40 per cent., but I think that this is very wide of the mark. A rough idea of the number killed, even in a short time, can be seen by the following accounts:—

Mr. J. Morgan writes as follows: "In spring, 1894, Mesopotamia Station, Rangitata Gorge, we found a lot of strong wethers dead, and on skinning some we found a small puncture through the skin above the loins, and the flesh torn about under the skin. On going over a block about a mile long and a quarter wide we found close on three hundred dead sheep. The next night a man went out and shot a few birds—in all, during two days, he shot sixty-three keas—and we lost no more sheep on this spot. On another occasion, when taking hoggets out in the spring, we put them through a gate at dark. When we went in the morning we found seven of the sheep dead, about their camp. The following night we shot eight keas at this place, and, although we took out several mobs of sheep the same way afterwards, no more were killed."

Mr. P. E. Challis, of Parawa, Southland, states that he has seen nineteen sheep attacked in one evening.

Mr. A. Watherston reports that one evening he found some keas attacking the sheep, and eight of them were killed. On going out at daybreak next morning he found that during the night thirty-eight had been killed, and the keas were still attacking them. The carcases of the sheep were in most cases still warm; and out of about sixteen hundred sheep about three hundred were killed. This loss works out to about 18 per cent. for the winter.

Mr. W. N. Ford says that around Lake Wanaka the losses in the year are about 26 per cent. of the sheep, and about half of these are put down to the keas.

If the birds always kill on an average twenty or thirty a night the loss would be tremendous, but it seems that they make special raids, and then are quiet for some time. Many of the keas must either kill for the love of killing, or else to have a number of dead sheep on which to feed for some time. Many are killed and left almost untouched. However, from evidence, it seems that they come back afterwards and feed on them until the carcases are devoured.

In most of the kea-infested country the annual damage is, I should say, well under 5 per cent. A few stations may lose as much as 10 per cent., and I doubt if any station loses as high as 20 per cent.

Attacking other Animals.

Though the sheep are the favourite animals for the kea to attack, they do not seem to confine themselves to them alone, for I have instances sent me where they have attacked horses, dogs, and rabbits.

Mr. Guthrie gives the following account of an attack on a horse: "The pack-horse was tethered on a piece of flat ground about 10 chains from the camp. After we had tea I strolled over to where there was a large flock of keas, on a little knoll above the pack-horse. This would be about an hour before dusk. One or two flew down on to the horse's back. He was an old, stiff-built cobby horse of a very sluggish nature. He took no notice of the keas when they flew on and off his back for some time, giving him an occasional peck. At last an old fellow perched on his back and started operations in a most serious manner. He soon had the old horse showing more life than he had ever done before; in fact, before he got the kea dislodged he was almost mad. When I got down to him he was in a heavy sweat, and the blood was trickling slightly over his loins. On examination I found a nasty wound that took a long time to heal, as it became very dirty. Ever after, the horse would go almost frantic when there were any keas about."

Two of my correspondents record cases where the keas have settled on dogs, and also cases of where rabbits have been killed by these birds.

Nesting Habits.

As well as the evidence that I have received, there have been several notes about the kea's nesting habits, which I think are worth while putting on record. Their breeding season has been recorded as beginning in August, but this seems to be too late in the year.

Mr. J. McIntosh, Burke's Pass, says, "They nest at all times from May onwards. I have seen eggs from May on to September."

Mr. Turton states that he has seen them early in July, and Messrs. Huddleston and Ford in August.

The late Mr. Potts (N, A) says, "It breeds in the deep crevices and fissures which cleave and seam the sheer facing of almost perpendicular cliffs, that in places bound, as with massive ramparts, the higher mountain-spurs. Sometimes, but rarely, the agile musterer, clambering amongst these rocky fastnesses, has found the entrance to the 'run' used by the breeding pair, and has peered with curious glance, tracing the worn track till its course has been lost in the dimness of the obscure recesses beyond the climber's reach. In these retreats the home or nesting-place generally remains inviolate, as its natural defences of intervening rocks defy the efforts of human hands unless aided by the use of heavy iron implements that no mountaineer would be likely to employ." This account, while giving a very vivid and clear idea of the kea's nest, is not quite correct, for, though the birds usually choose such inaccessible positions, they are influenced a good deal by the nature of the country in which they live.

From the evidence that I have received it seems that when they are unable to find such positions as described by Mr. Potts they will build in any place that comes handy, and their nests have been found in caves, under heaps of rocks, in cairns of stones, in banks, in rabbits' burrows, and even on the flat.

The nest is just a small hollow lined with a few bits of grass, and sometimes even these are absent. Most of the nests are connected with the exterior by a long "run," which is made up of the natural crevices and fissures in the rocks, but Mr. R. Urquhart this year found in a cave a nest which was quite easy to get at owing to the absence of this long passage. Mr. F. F. C. Huddleston gives an account of a nest that he once found, and, from the number of keas found in it, seemed to indicate that it was a sort of breeding colony, for he says that twenty keas came out of it. However, none of my other correspondents mention anything of this kind, so that it must at least be a very rare occurrence.

One of my correspondents states that he has found nestlings in June, but this, like the finding of kea-eggs in May, seems to be rather the exception than the rule. From the accounts that I have received, it is evident that the eggs may be laid as early as the end of June or the beginning of July, and young birds may be expected towards the end of the latter month.

Mr. R. Urquhart found four young birds in a nest on the 21st of August, and as they were about three weeks old when they were found, the eggs must have been laid towards the beginning of July.

The young keas, from all accounts, seem to remain a long time in the nest. Mr. J. McIntosh found some young ones in September and took them out of the nest in December, so they must be nearly full-grown before they leave their parents.

Through the kindness of Mr. R. Urquhart, I received two live kea nestlings, and so was able to see for myself how helpless they are even at an advanced stage of development. The birds were about two months old when I received them, and though they were about the size of an ordinary pigeon, they were quite unable to move about or swallow their food. Their wings were fairly strong, and were flapped sometimes, though rarely, when food was brought to them, but though their legs were large they seemed quite devoid of muscular action, and were never used. Indeed, so helpless were they that when being photographed they would not move from the position in which they were first placed.

As there are very few descriptions of young keas on record, I have inserted the following from my diary:—

"*22nd September*, 1906.—Received two young live keas from Mr. R. Urquhart. Since their capture, a month previous, they have been fed with thin strips of sheep's kidney, which has to be poked down their throats with a small stick. Their cry somewhat resembles that of their parents, but is weaker and very plaintive. They possess a very disagreeable odour, even when kept in clean apartments.

"Head: Bill—Upper mandible large, and black in colour with the exception of a slight tinge of yellow on the top of the arch. It is not so long as the bill of an adult bird, nor so pointed. Lower mandible of a yellow colour with the exception of a black tip. Wattle round the nostril plentiful and of a light-yellow colour. Mouth large, and on each side of the head at the angle of the jaws there is a large mass of light-yellow material, resembling wattle in appearance, and forming a kind of sac to keep the food from falling out of the sides of the mouth.

"Body: Most of the body, except under the wings, is covered with young feathers, which, like those in the adult bird, are dark-green often fringed with black. The large feathers of the tail and wings are just coming out of their quills. Legs large, dark-grey in colour, with black claws; very weak, and at present useless. The body and head are still covered to a certain extent with long grey down, but this is fast disappearing.

"*24th September*, 1906.—The larger bird can swallow small pieces of kidney if placed well in the mouth; the other has still to be fed with the aid of a stick. Both seem to enjoy the kidney, and even though they have had nothing else to eat they seem strong and healthy.

"*28th September*, 1906. — Both caught a chill by being left outside. Smaller one died, and I have chloroformed the other."

I think it is a noteworthy fact that the kea, though living in a region where the cold and severity of the winter is especially felt, builds its nest, lays its eggs, and hatches its young during the most severe months of winter. During this season its domain is swept by a succession of severe storms, and often the ground is covered for months with several inches of snow. That birds in warm countries do often nest in the winter months is not altogether unknown, but for a bird to rear its young in winter at an altitude of 3,000 ft. or 4,000 ft., in a country where even at sea-level the other birds seem to find it unwise to nest until the spring weather comes, is at any rate remarkable.

It has been suggested that the taste for meat has now become hereditary to the young keas, for when they are given raw meat they eat it readily. The two forwarded to me by Mr. R. Urquhart fed greedily on sheep's kidneys. Mr. W. N. Ford found some kea chicks only a few days out of the shell, and with their eyes still closed, and he kept them for six weeks feeding them on sop and raw meat. This would appear at first sight as if the taste for meat was hereditary; but as pieces of meat have been found outside the nest, it is most likely that the old birds teach the young to be carnivorous. Again, the fact that young birds will eat meat does not prove conclusively that they have inherited the taste. Other instances are known where animals have instantaneously taken to food that they could never have tasted before.

By the kindness of Dr. Cockayne and Mr. E. Jennings of the Dunedin Museum I am able to publish the following interesting incident: While on a tour of the Southern Islands of New Zealand in the Government Steamer "Hinemoa" in 1904, a specimen of the flightless duck of New Zealand (*Nesonetta aucklandica*) was captured and brought alive to Dunedin. From the time of its capture it was fed solely on bread-and-milk, which it seemed to take to very readily. Now, this duck is found only on the Auckland Islands, where it feeds on small crustaceans and other small animals, &c., which are found among the rocks of the sea-shore and the kelp where this bird swims. These islands are uninhabited, and are practically never visited by any shipping except the Government steamer "Hinemoa," which pays them an annual visit. It can almost be taken for certain that this particular bird had never before seen bread, much less tasted it, and yet, when caught, it at once took to this strange food, which was so entirely different from its natural supply. This instance, I think, shows that even if birds take to new food readily, it does not prove that the taste is of necessity hereditary.

HABITAT.

That the kea is found in the mountainous country of Canterbury, Otago, and Westland is a well-established fact, but whether it lives among the snow-capped peaks and the glaciers or lower down near the forest-line is a question that has never been satisfactorily settled. The generally accepted opinion is that the bird's stronghold is far up among the snow-capped peaks, and a recent book (A) states that the kea lives "up in the mighty mountains where the snow never melts and men seldom go. Sometimes it is driven from its stronghold and is compelled to seek food at lower elevations."

The late Mr. T. H. Potts (A, N) describes the bird as living "far above the dwarfed vegetation . . . in a region often shrouded with dense mist or driving sleet," &c.

It is quite true that the keas do sometimes live in these desolate regions, for they are common at Mount Cook near the large glaciers, where they may be seen soaring from peak to peak. Sir Julius von Haast (I, *a*) saw two of them flying over the Godley Glacier; but, though he saw keas several times while exploring the mountains of Canterbury, only once did he see them in the perpetual-snow-clad regions and among the glaciers. Again, nearly all the accounts of these birds attacking sheep have come from districts which are situated many miles from the regions described by many writers as the kea's home.

At the present day, however, the bird does not seem to be a dweller of the glacier regions only, and, although it does often frequent these heights, it is most commonly found about the forest-limit.

Dr. L. Cockayne describes, in a communication to me, its habitat as follows: "I have observed the kea in various parts of the Southern Alps, from the Humboldt Mountains in the south to Kelly's Hill in Westland. Although frequently met with on the open alpine and subalpine hillside, I consider the bird essentially one of the forest-limit, where it may be seen in numbers at the junction of the forest and subalpine meadows, and in the *Nothofagus* forests at lower levels where such are pierced by river-beds."

Mr. Taylor White (V) does not consider the bird one of the forest, for he says, "I remember being astonished on reading of the kea living in the forest, for I never, even during the severest winter, saw it perched on trees." However, in spite of this, as early as 1862, Haast (I, *b*) saw one in a tree near Lake Wanaka, and since then they have been often seen perching in the forest.

I have on several occasions seen the kea both on the Birdwood Range and Mount Torlesse, and each time the bird has been about the forest-limit. Though I have often seen them at an altitude of 5,000 ft., I have never seen them above that height. Twice I have seen them perching in the *Fagus* forest—once in July, 1903, in a bush behind the Glenthorne Homestead, and while camping for several days near the source of the Avoca River we continually saw them flying in and out of the forest, about 500 ft. above us.

Seeing these birds so low down in summer rather upsets the statements of many writers who say that the keas only come from higher altitudes in severe weather, for both times when I saw the birds at low altitudes it was in midsummer, and the weather was warm and fine. They come much lower than some people suppose. Potts (N) says that they have been seen at Hororata, near the Malvern Hills, and Mr. G. Rutherford states that nearly every year keas have been shot in the Thirteen-mile Bush, which is situated near the foot of Porter's Pass.

At first I thought that perhaps the keas had learnt to live at lower altitudes so as to be near the sheep, but the fact that before the kea had learnt to kill sheep—namely, between 1861 and 1867—Sir Julius von Haast (I) saw more keas below the snow-line than above is against this suggestion.

I consider that in the future their habitat should be described as follows, in the words of Dr. Cockayne: "Although frequently met with on the open alpine and subalpine hillside, the kea is essentially a bird of the forest-limit, where they may be seen in numbers at the junction of the forest and subalpine meadows, and in the *Nothofagus* forest at lower levels where such are pierced by river-beds."

Distribution.

The kea was first found in the Murihiku district, where it was discovered by Mr. W. Mantell in 1856. I had a great difficulty in finding out where that district is, but on inquiring, Mr. D. Barron, Chief Surveyor of the Dunedin Lands and Survey Department, informed me that the Murihiku district embraces from the Mataura River south and westward, including practically all Southland.

At first the kea's area of distribution was thought to be very limited, but as soon as men travelled back into the mountainous country of the South Island it was found that the area was much wider than at first supposed. A few years after its discovery it was found in the mountains of Otago, Southland, and in Canterbury as far north as the Rangitata Gorge. In 1859 Dr. Haast (I, *b*) found it in the Mount Cook region, and a year later—1860—Sir W. Buller (J, *b*) saw it in the Rangitata Gorge. In 1861–62 Sir James Hector noticed it in most of the snow mountains of Otago, during his survey, and in the same year Dr. Haast (I, *a*) saw it on the Godley Glacier. As early as 1865 he found it a long way above its supposed northern limit—namely, at Browning Pass, at the source of the Wilberforce River; and two years later he saw it still further north, near Arthur's Pass, on the West Coast Road. In 1868 they were common around the lakes which lie around the borderline of Otago and Canterbury, and ten years later Sir W. Buller speaks of them as being plentiful in Southland.

Dr. Cockayne, in a communication to me, states that his brother-in-law, Mr. A. Blakely, shot a kea in Arthur's Pass in June, 1881; and in 1882 Potts (N) reports that keas were known at Grassmere, West Coast Road; Lochinvar Station, North Canterbury; and at the head-waters of the Esk and Hurunui Rivers—that is, at the northern boundary of Canterbury.

In 1883 Sir W. Buller (J, R), quoting a letter from Mr. Shrimpton, says that the kea's area of distribution did not extend north of the Rakaia River. However, as both Dr. Haast (I, *d*) and Mr. Potts (N) had already published records of their being north of this limit, the former at Arthur's Pass and the latter at Grassmere, Lochinvar, and Hurunui, it shows that this statement was too limited.

In 1888 Mr. W. W. Smith (U) says, "When Sir W. Buller published his last paper on the kea five years ago he gave the ranges on the upper reaches of the Rakaia River as its extreme northern limit. During the last three winters it has visited the ranges above the Otira Gorge, thus showing its range to be extending north." Mr. Smith, like Sir W. Buller, had evidently not seen the reports of Haast (I, *d*), who saw it on Arthur's Pass twenty-three years before; and I think that the record of Mr. A. Blakely, who shot one there in 1881, as well as the report of Mr. Potts that it was known at Hurunui as early as 1882, shows that the kea's northern limit was very much beyond the line stated by Mr. Smith.

Mr George Rutherford states that in 1885 it was known at Benmore Run, near Porter's Pass, West Coast Road, and Mr. Bond (Q) reports that it was seen on the Mount Algidas Station about that time.

For some years the stations around Hanmer seemed to be its northern limit, but in 1903 Mr. Edward Kidson, Christchurch, in company with Messrs. F. G. Gibbs and H. M. Bryant, Brightwater, Nelson, saw one at close quarters on Mount Robert, near Lake Rotoiti, about forty miles south of the City of Nelson. Mr. H. M. Bryant, who has done a fair amount of mountaineering in the Nelson Province, says that he had never seen one before, and the late owner of the station at Mount Robert told him that it was the first time that a kea had been seen on his station.

Through the kindness of Mr. R. Kidson I am able to record two other instances in the Nelson Province. In 1904 a kea was caught by Mr. A. G. Hammond at Appleby, thirteen miles south-west of the City of Nelson; and in the same year Mr. S. T. Rowling caught one at Riwaka, a few miles north of Motueka. This is at present the most northern limit where a kea has been found, and the distance between its southern and northern limit is only about four hundred miles.

Through the kindness of Mr. T. E. Currie, Christchurch, I have been able to obtain some reports of its presence in the Marlborough Province, where it has been almost unknown. In May, 1906, on the Tarndale Station, at a place half-way up the Saxton River, some miles north of the homestead, one afternoon about 4 o'clock, Mr. Currie, with eleven other men, saw a kea flying across. As it passed over it gave the well-known kea cry. Though these birds are fairly common around the homestead, they had rarely been seen so far north. Again, in January, 1906, at the head of the Waihopai River, at a place known as the Glazebrook Whare, near the Blue Mountains, Hellersden Station, farther north still, he saw a kea again. It was about 8 o'clock in the evening, and therefore almost impossible to see it, but as the bird gave its peculiar cry there seems little doubt that it was a kea. One had been seen near that spot in 1905, but never before. The only other report of its appearance in Marlborough is from Mr. F. R. O'Brian, who states that he has seen one only thirty miles from Blenheim.

They appear to extend westward almost, if not quite, to the coast-line. They have been seen at Koiterangi, near Hokitika; at Mahitahi, near Bruce Bay; and Captain Bollons informed me that in June, 1906, he saw one flying along the beach at Bruce Bay itself. It has also been found in several other parts of Westland, for in his report on the survey of Westland Dr. Bell (W) states that it was common on the mountains, and especially around Browning Pass. They may almost be around the sounds of western Otago and Southland, but at present I can find no records of their presence there.

The area of the kea's distribution is therefore confined to the mountainous country of the South Island of New Zealand, from Southland in the south to Tasman Bay in the north, from the coast-line in the west to the limit of the high country in the east. It is about four hundred miles in length, and about one hundred miles in breadth at its widest part.

The Northward Migration.

It has often been stated by early and present-day writers that since its discovery in Southland the kea has gradually migrated northward, through Otago, Canterbury, and Nelson. This idea has been freely quoted as if it were a scientifically proved fact, but from what I can see there is very little evidence at present on record to support it. The records seem to indicate very forcibly that whenever and wherever men have explored the mountainous country from Southland to North Canterbury we have at once records of the kea being found in the parts explored. It is only because the mountainous country in Otago was explored first, and then the northern portions of the Island later, that people have been led to think that the keas are spreading northward. Very likely if Dr. Haast (I) had explored Arthur's Pass or Browning's Pass before 1856, people would have thought that the kea had spread from Canterbury southward.

Even if we take the records of the kea's discovery, they do not support the northern-migration theory. In 1856 Dr.

Mantell found it in Southland—the exact place is not known; three years later Dr. Haast found it about two hundred miles further north, at Mount Cook. It was not till three years later that Sir James Hector (J), during January, found it on the snow mountains of Otago: yet these mountains are closer to Southland than Mount Cook.

In the same year Dr. Haast (I, *a*) found it on the Godley Glacier, and three years later, in 1865, he saw it on Browning's Pass (I, *c*), about eighty miles north of Mount Cook. In 1867 Mr. D. Macfarlane, Peel Forest, says that it was known on the Lochinvar Station, about sixty miles north of Browning's Pass; yet at Arthur's Pass, which is situated between Browning's Pass and Lochinvar Station, though no doubt the kea was there all the time, it was not reported to be there until Dr. Haast explored that country in 1867.

With the exception of the instance stated in Mr. Macfarlane's letter, we have no record of the kea being found further north until 1882. This is very likely because no one explored that part of the country—or, if they did, they left no records of what they saw. However, in 1882, Potts (N) reported them as far north as the head-waters of the Esk and Hurunui Rivers. From what I can see from the recorded evidence, at the time of its discovery in 1856 the kea's area of distribution extended from Southland to the Hurunui River in North Canterbury, and very likely north of this limit. No doubt the reason why the keas are common now on some stations where they were unknown is that since their discovery they have greatly increased in numbers, and have therefore had to widen their area of distribution both east and west, for they have been seen on the coast-line of Westland, and have extended to the eastern limit of the mountainous country in Canterbury.

There is, however, some evidence of a migration at the present time into the north of the Nelson and in the Marlborough Province, but whether they have been there for some time and have not been seen, or that they are really spreading into these provinces, is uncertain. However, even if they were present in the northern part of Nelson and in Marlborough they were not common, and within the last three years they have been recorded from places where before they were unknown. Now that they are spreading into Marlborough, one wonders if the Cook Strait will prove a sufficient barrier to prevent them from flying over to the North Island. The two islands are only about fifteen miles apart at their nearest points, and on a clear day the opposite coast can easily be seen.

If the kea had migrated north from Southland, as many suppose, one would expect the bird to be rare in the south where it was first found, but in 1905, from records received, they were still plentiful there.

There is also a certain amount of evidence which seems to indicate that the sheep-killing habit has spread and is still spreading since it was first started about 1868. The first record was from Lake Wanaka, and from there it seems to have spread south to Lake Wakatipu and north to the Amuri district. About 1880 the birds' depredations were recorded from the lakes in the south of Canterbury, and by 1886, after passing north through Peel Forest and the Ashburton Gorge, it was recorded from Lake Coleridge and the stations around Mount Torlesse.

Since writing the above I have received a letter from Mr. D. Macfarlane, who says, "In 1866–67 I was in charge of the Lochinvar Station, at the head-waters of the Waimakariri, and during shearing I noticed many sheep with deep wounds in the loins, and the shepherds told me it was done by keas, and that many sheep were killed by the birds." If this report is true, then the killing of sheep began in Canterbury about the same time that it did in Otago, and therefore there would be two centres from which the habit would spread. Since then the habit has extended to the stations in the Amuri district, and in 1906 a meeting of runholders was held to try and abate the nuisance.

So far I have no records of sheep-killing in Marlborough and North Nelson, though the keas are to be found there.

In Westland the habit has spread west, for in 1906 Mr. Condon, Bruce Bay, South Westland, had some sheep killed at Mahitahi for the first time.

The Kea's Extinction.

As early as 1888, Sir W. Buller says that he is certain that these interesting birds would soon be extinct, but in spite of the thousands that have been killed they are still common in the mountainous country of the South Island. No doubt the almost inaccessible position of their nests, as well as the rough nature of the country in which they live, are responsible for their non-extinction. However, closer settlement of the land and the systematic slaughter that is now going on must in time exterminate the mountain-parrot, and, like many other interesting forms of our avifauna, it will disappear for ever before the march of civilisation.

I would suggest that in order to prevent these interesting birds from becoming quite extinct a number of them should be placed on one of the outlying islands, where they could live and flourish without doing injury to any one. The most suitable islands, as far as I can ascertain, are the Aucklands, which lie ninety miles south-by-west from the most southerly point of Stewart Island. There would be very little chance of the birds returning to the mainland; and though the hills only rise to a height of about 2,000 ft., there seems to be enough forest and high country to make a very satisfactory reserve for these interesting parrots.

In concluding I should like to take this opportunity of thanking all those who have so willingly helped me in my investigations. I am specially indebted to Dr. L. Cockayne, who has helped me with many valuable suggestions, and also to those who have given me their actual experiences with keas, for I know that without their co-operation this paper could never have been written.

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EXPLANATION OF PLATE XV.

MAP OF THE SOUTH ISLAND OF NEW ZEALAND, SHOWING THE KEA'S DISTRIBUTION.

No. 1. Places where keas have been seen to attack sheep and authentic accounts have been sent in.
No. 2. Places where keas have been reported to have attacked sheep but no accounts have been sent in.
No. 3. Place where keas have been reported to have been seen.
No. 4. Capital towns of the provinces.

ART. XXIX.—*On Isogonal Transformations: Part I.*

By EVELYN G. HOGG, M.A., Christ's College, Christchurch.

[*Read before the Philosophical Institute of Canterbury, 5th December, 1906.*]

1. "Two points P, P′, which are such that lines drawn from them to the summits of the triangle of reference are equally inclined to the bisectors of its angles are called isogonal conjugates with respect to the triangle."—*Casey.*

If the trilinear co-ordinates of P be $(\alpha\,\beta\,\gamma)$, those of P′ will be $\left(\frac{\kappa^2}{\alpha}\,\frac{\kappa^2}{\beta}\,\frac{\kappa^2}{\gamma}\right)$; but as in what follows trilinear ratios will be for the most part used, the co-ordinates of P′ will be $\left(\frac{1}{\alpha}\,\frac{1}{\beta}\,\frac{1}{\gamma}\right)$. If the co-ordinates of P′ be written $(\alpha'\beta'\gamma')$ we have $\alpha\alpha' = \beta\beta' = \gamma\gamma' =$ a constant: hence an isogonal transformation is a species of inversion, and in the following paper isogonal transformations will be described in the language of inversion.

The incentre and three excentres $(1 \pm 1 \pm 1)$ of the triangle of reference ABC are the only points which invert into themselves. The four points $(\alpha \pm \beta \pm \gamma)$ forming the vertices of a harmonic quadrangle invert into four points $\left(\frac{1}{\alpha} \pm \frac{1}{\beta} \pm \frac{1}{\gamma}\right)$ forming the summits of another harmonic quadrangle.

It may also be noticed that according as P is within or without the triangle ABC so is its inverse point P′ within or without that triangle.

2. The line whose equation is

$$l\alpha+m\beta+n\gamma = o$$

will invert into the conic having for equation

$$l\beta\gamma+m\gamma\alpha+n\alpha\beta = o$$

Also, any conic circumscribed to the triangle ABC will invert into a line: in particular the circumcircle of the triangle ABC will invert into the line at infinity.

If a point P $(\alpha_1\beta_1\gamma_1)$ be determined by the intersection of the circle ABC with the conic $l\beta\gamma+m\gamma\alpha+n\alpha\beta = o$, it may be at once shown that the lines

$$\beta\beta_1-\gamma\gamma_1 = o,\quad \gamma\gamma_1-\alpha\alpha_1 = o,\quad \alpha\alpha_1-\beta\beta_1 = o$$

which determine the position of the inverse of P, are all parallel to the line $l\alpha+m\beta+n\gamma=o$.

A line passing through a vertex of the triangle ABC inverts into a line passing through the same vertex.

3. The conic $l\beta\gamma+m\gamma\alpha+n\alpha\beta = o$ will be a hyperbola, parabola, or ellipse according as

$$\sqrt{la}+\sqrt{mb}+\sqrt{nc} > = \text{ or } < o$$

but this is the condition that the line $l\alpha+m\beta+n\gamma = o$ shall intersect, touch, or not intersect the circle ABC: hence the theorem that a line inverts into a hyperbola, parabola, or ellipse according as it cuts, touches, or does not cut the circumcircle of the triangle of reference.

4. The asymptotes of the conic $l\beta\gamma+m\gamma\alpha+n\alpha\beta = o$ are given by

$$lmn\,(a\alpha+b\beta+c\gamma)^2+\Delta\,(l\beta\gamma+m\gamma\alpha+n\alpha\beta) = o$$

where

$$\Delta = a^2l^2+b^2m^2+c^2n^2-2bcmn-2canl-2ablm$$

It is easily shown that the angle (ϕ) between the asymptotes is given by

$$\tan\phi = \frac{\sqrt{\Delta}}{2\text{R}\,(l\cos\text{A}+m\cos\text{B}+n\cos\text{C})}$$

R being the radius of the circle ABC. Hence

$$\cos\phi = \frac{l\cos\text{A}+m\cos\text{B}+n\cos\text{C}}{\Omega}$$

where $\Omega^2 = l^2+m^2+n^2-2mn\cos\text{A}-2nl\cos\text{B}-2lm\cos\text{C}$.

If p be the length of the perpendicular from the centre of the circle ABC on $l\alpha+m\beta+n\gamma=o$, then

$$p=\frac{R\,(l\cos A+m\cos B+n\cos C)}{\Omega}$$

therefore $\cos\phi=\frac{p}{R}$: but $\frac{p}{R}$ is the cosine of the angle between the chord $l\alpha+m\beta+n\gamma=o$ of the circle ABC and the tangent to the circle at the extremity of the chord, hence the angle between the asymptotes of the conic $l\beta\gamma+m\gamma\alpha+n\alpha\beta=o$ is equal to the angle at which the line $l\alpha+m\beta+n\gamma=o$ cuts the circle ABC.

Moreover, since the excentricity (ϵ) of the conic is connected with ϕ by the relation $\epsilon=\sec\frac{\phi}{2}$ and $p=R\cos\phi$, it follows at once that tangents to circles concentric with the circle ABC invert into similar conics.

5. Suppose that a curve S inverts into a curve S′: then to any two points P and Q on S will be two corresponding inverse points P′ and Q′ on S′. If now the point Q move up to P and become infinitely close to it, the point Q′ will become infinitely close to P′. Hence if the tangent to S at the point P be inverted, it will become a circumconic touching S′ at the point P′.

If the line $l\alpha+m\beta+n\gamma=o$ be inverted, then any tangent to the conic $l\beta\gamma+m\gamma\alpha+n\alpha\beta=o$ will invert into a conic touching $l\alpha+m\beta+n\gamma=o$, and a pair of tangents to the conic $l\beta\gamma+m\gamma\alpha+n\alpha\beta=o$ will invert into a pair of circumconics intersecting in the point which is the inverse of that from which the tangents were drawn and having the line $l\alpha+m\beta+n\gamma=o$ as a common tangent.

6. Let two lines $L_1=l_1\alpha+m_1\beta+n_1\gamma=o$ and $L_2=l_2\alpha+m_2\beta+n_2\gamma=o$ be taken: these will invert into the conics

$$S_1=l_1\beta\gamma+m_1\gamma\alpha+n_1\alpha\beta=o$$
$$S_2=l_2\beta\gamma+m_2\gamma\alpha+n_2\alpha\beta=o$$

Let $L=\lambda\alpha+\mu\beta+\nu\gamma=o$ be a common tangent of S_1 and S_2: then L will invert into the conic

$$S=\lambda\beta\gamma+\mu\gamma\alpha+\nu\alpha\beta=o$$

which will have double contact with the line pair $L_1\,L_2$: its equation therefore will be of the form

$$L_1L_2-(p\alpha+q\beta+r)^2=o$$

Comparing this with the form of S given above we have

$$p^2 = l_1 l_2,\ q^2 = m_1 m_2,\ r^2 = n_1 n_2$$

hence the equations of the four chords of contact with L_1 and L_2 of the conics which are the inverses of the common tangents of S_1 and S_2 are

$$\sqrt{l_1 l_2}\,\alpha \pm \sqrt{m_1 m_2}\,\beta + \sqrt{n_1 n_2}\,\gamma = o$$

The inverses of the points in which these four lines meet L_1 and L_2 are the points of contact of the common tangents of S_1 and S_2.

$$\begin{aligned} \text{Let } c_1 &= \sqrt{l_1 l_2}\,\alpha + \sqrt{m_1 m_2}\,\beta + \sqrt{n_1 n_2}\,\gamma = o \\ c_2 &= \sqrt{l_1 l_2}\,\alpha - \sqrt{m_1 m_2}\,\beta - \sqrt{n_1 n_2}\,\gamma = o \\ c_3 &= -\sqrt{l_1 l_2}\,\alpha + \sqrt{m_1 m_2}\,\beta - \sqrt{n_1 n_2}\,\gamma = o \\ c_4 &= -\sqrt{l_1 l_2}\,\alpha - \sqrt{m_1 m_2}\,\beta + \sqrt{n_1 n_2}\,\gamma = o \end{aligned}$$

and form the conic

$$T_1 = L_1 L_2 - c_1^2 = o$$

which is the inverse of a common tangent t_1.

Now write

$$\begin{aligned} P_1 &= \sqrt{m_1 n_2} - \sqrt{m_2 n_1} \qquad & P_2 &= \sqrt{m_1 n_2} + \sqrt{m_2 n_1} \\ Q_1 &= \sqrt{n_1 l_2} - \sqrt{n_2 l_1} \qquad & Q_2 &= \sqrt{n_1 l_2} + \sqrt{n_2 l_1} \\ R_1 &= \sqrt{l_1 m_2} - \sqrt{l_2 m_1} \qquad & R_2 &= \sqrt{l_1 m_2} + \sqrt{l_2 m_1} \end{aligned}$$

Then the conic T_1 reduces to

$$P_1^2\beta\gamma + Q_1^2\gamma\alpha + R_1^2\alpha\beta = o$$

On inversion we obtain the four common tangents of S_1 and S_2

$$\begin{aligned} t_1 &= P_1^2\alpha + Q_1^2\beta + R_1^2\gamma = o \\ t_2 &= P_1^2\alpha + Q_2^2\beta + R_2^2\gamma = o \\ t_3 &= P_2^2\alpha + Q_1^2\beta + R_2^2\gamma = o \\ t_4 &= P_2^2\alpha + Q_2^2\beta + R_1^2\gamma = o \end{aligned}$$

To find the co-ordinates of the points of contact of t_1 with S_1 and S_2, solve for $\alpha\,\beta\,\gamma$ between c_1 and L_1 and c_1 and L_2 and invert.

We thus find that t_1 will touch S_1 and S_2 respectively in the points

$$\left(\frac{\sqrt{l_1}}{P_1}\ \frac{\sqrt{m_1}}{Q_1}\ \frac{\sqrt{n_1}}{R_1}\right) \qquad \left(\frac{\sqrt{l_2}}{P_1}\ \frac{\sqrt{m_2}}{Q_1}\ \frac{\sqrt{n_2}}{R_1}\right)$$

with similar expressions for the points of contact of t_2, t_3, and t_4 with these conics.

7. Any triangle circumscribing the conic

$$S = \lambda\beta\gamma + \mu\gamma\alpha + \nu\alpha\beta = o$$

will invert into three circumconics having the line

$$L = \lambda\alpha + \mu\beta + \nu\gamma = o$$

as a common tangent.

A family of n parabolas circumscribing the triangle of reference will invert into an n-sided polygon in which the circle ABC is inscribed.

The pencil of lines represented by the equation

$$l_1\alpha + m_1\beta + n_1\gamma + \kappa\,(l_2\alpha + m_2\beta + n_2\gamma) = o$$

where κ varies, will invert into a family of conics passing through the four points of intersection of the conics

$$l_1\beta\gamma + m_1\gamma\alpha + n_1\alpha\beta = o$$
$$l_2\beta\gamma + m_2\gamma\alpha + n_2\alpha\beta = o$$

In particular a system of parallel lines will invert into a family of conics passing through four concyclic points.

Hence, as there will always be two lines, whether of the pencil or of the parallel system, which are equidistant from the centre of the circle ABC (excluding those lines of either system which are diameters of this circle), we see that all conics passing through four given points may be arranged in pairs of similar conics.

8. Two tangents drawn from a point P to the circle ABC will invert into two parabolas passing through ABC and P′— the inverse of P with respect to the triangle ABC.

Hence if four points, ABCD, be given, and if A′ B′ C′ D′ be respectively the inverses of those points with respect to the triangle formed by joining the remaining three points, we see that the two parabolas which may be drawn through four given points can be regarded as originating by inversion of the pair of tangents from the four points A′ B′ C′ D′ to the circles BCD, CDA, DAB, ABC respectively.

Now, if one of the points, say D′, fall within the circle ABC, the tangents from it to that circle are imaginary, and consequently the two parabolas through ABCD are imaginary: therefore the remaining points A′ B′ C′ must lie within the respective circles BCD, CDA, DAB.

We may state this result as follows: If any four points be taken on a parabola, the inverse of any one of the points with respect to the triangle formed by joining the remaining three points lies without the circumcircle of that triangle.

9. We may determine the equation of the two parabolas which can be drawn through ABC and $P(\alpha_1\beta_1\gamma_1)$ as follows:—

The curve whose equation is

$$\sqrt{\frac{a}{\alpha}}+\sqrt{\frac{b}{\beta}}+\sqrt{\frac{c}{\gamma}}=o$$

is the locus of points whose axes of homology touch the circle ABC, while the conic

$$\frac{1}{\alpha_1\alpha}+\frac{1}{\beta_1\beta}+\frac{1}{\gamma_1\gamma}=o$$

is the locus of points whose axes of homology pass through

$$\left(\frac{1}{\alpha_1}\ \frac{1}{\beta_1}\ \frac{1}{\gamma_1}\right)$$

Let these two curves cut in the point $\alpha'\beta'\gamma'$: then

$$\frac{\alpha}{\alpha'}+\frac{\beta}{\beta'}+\frac{\gamma}{\gamma'}=o$$

will be a tangent to the circle through $\frac{1}{\alpha_1}\ \frac{1}{\beta_1}\ \frac{1}{\gamma_1}$

We have also

$$\frac{1}{\alpha\alpha'}+\frac{1}{\beta\beta'}+\frac{1}{\gamma\gamma'}=o$$

$$\sqrt{\frac{a}{\alpha'}}+\sqrt{\frac{b}{\beta'}}+\sqrt{\frac{c}{\gamma'}}=o$$

whence, eliminating $\alpha'\beta'\gamma'$, we have the equation of the two tangents in the form

$$\sqrt{a\alpha_1(\beta_1\beta-\gamma_1\gamma)}+\sqrt{b\beta_1(\gamma_1\gamma-\alpha_1\alpha)}+\sqrt{c\gamma_1(\alpha_1\alpha-\beta_1\beta)}=o$$

and the equation of the pair of parabolas is

$$\sqrt{a\alpha\left(\frac{\beta}{\beta_1}-\frac{\gamma}{\gamma_1}\right)}+\sqrt{b\beta\left(\frac{\gamma}{\gamma_1}-\frac{\alpha}{\alpha_1}\right)}+\sqrt{c\gamma\left(\frac{\alpha}{\alpha_1}-\frac{\beta}{\beta_1}\right)}=o$$

10. Let there be four concyclic points A, B, C, D, and let the position of the point D be determined by the intersection of the circle ABC and the conic

$$l\beta\gamma+m\gamma\alpha+n\alpha\beta=o$$

Then the two parabolas through the four points will be the inverses of the two tangents to the circle ABC which are parallel to the line $l\alpha+m\beta+n\gamma=o$.

Consider the conic whose equation is

$$\frac{mc-nb}{\alpha}+\frac{na-lc}{\beta}+\frac{lb-ma}{\gamma}=$$

It is the locus of points whose axes of homology are parallel to $l\alpha+m\beta+n\gamma = o$.

Let this conic cut in the point $(\alpha'\beta'\gamma')$ the curve

$$\sqrt{\frac{a}{\alpha}}+\sqrt{\frac{b}{\beta}}+\sqrt{\frac{c}{\gamma}} = o$$

Then the axis of homology of $(\alpha'\beta'\gamma')$ will be a tangent to the circle ABC and parallel to the line $l\alpha+m\beta+n\gamma = o$. Eliminating $\alpha'\beta'\gamma'$ between the equations

$$\frac{\alpha}{\alpha'}+\frac{\beta}{\beta'}+\frac{\gamma}{\gamma'} = o$$

$$\frac{mc-nb}{\alpha'}+\frac{na-lc}{\beta'}+\frac{lb-ma}{\gamma'} = o$$

$$\sqrt{\frac{a}{\alpha'}}+\sqrt{\frac{b}{\beta'}}+\sqrt{\frac{c}{\gamma'}} = o$$

we have for the equation of the pair of tangents

$$a\sqrt{\frac{l}{a}(b\beta+c\gamma)-(m\beta+n\gamma)}+b\sqrt{\frac{m}{b}(c\gamma+a\alpha)-(n\gamma+l\alpha)}$$

$$+c\sqrt{\frac{n}{c}(a\alpha+b\beta)-(l\alpha+m\beta)} = o$$

The equation of the two parabolas may be written down from the above by substituting in it $\frac{1}{\alpha}\frac{1}{\beta}\frac{1}{\gamma}$ for $\alpha\ \beta\ \gamma$ respectively.

11. Any line parallel to $\alpha = o$ will invert into a conic of the form

$$\kappa\beta\gamma+a\beta\gamma+b\gamma\alpha+c\alpha\beta = o$$

All conics of this family touch each other and the circle ABC at the vertex A of the triangle of reference.

The two tangents to the circle ABC parallel to $\alpha = o$ invert into the pair of parabolas

$$(b\pm c)^2\beta\gamma+a\alpha(b\gamma+c\beta) = o$$

The two tangents to the same circle drawn parallel to the diameter of the circle through A invert into the pair of parabolas

$$a\beta\gamma+b\gamma\alpha+c\alpha\beta\pm 4\,\mathrm{R}\sin\mathrm{B}\sin\mathrm{C}\,\alpha\,(\beta\cos\mathrm{B}-\gamma\cos\mathrm{C}) = o$$

where R is the radius of the circle ABC.

12. Any diameter of the circle ABC will invert into a rectangular hyperbola.

Let the diameter be taken which is perpendicular to the line $\alpha = o$; the equation of its inverse is

$$\frac{\sin(B-C)}{\alpha} + \frac{\sin B}{\beta} - \frac{\sin C}{\gamma} = o$$

This conic cuts the circle ABC at the extremity H of the diameter which passes through the vertex A of the triangle of reference; it also passes through the points $\left(-\frac{1}{a}\frac{1}{b}\frac{1}{c}\right)$ and the orthocentre of the triangle ABC: its centre is at the middle point of the line BC: the tangent to the conic at A passes through the symmedian point (abc) of the $\triangle$ ABC, while the tangent at H passes through the point ($-abc$).

Art. XXX.—*Some Observations on the Coastal Vegetation of the South Island of New Zealand.—Part I: General Remarks on the Coastal Plant Covering.*

By L. Cockayne, Ph.D.

[*Read before the Philosophical Institute of Canterbury, 8th August,* 1906.]

Contents.

1. Introduction.

In this series of papers no attempt will be made to give a detailed description of the whole coastal vegetation of the South Island. This introductory paper is purposely quite general, and intended chiefly to pave the way for future work, and to save repetition when dealing with the formations themselves. As for these latter, only those will be described which I have had some special opportunity of examining during the last few years. Each account will treat of some special part of the coast, and be complete in itself, therefore no classification of the formations will be attempted, nor any such presentation of them in a connected sequence as would be necessary were the coastal vegetation of the South Island as a whole the theme. The treatment of the formations, too, will be far from exhaustive. Such can only be expected from local botanists. Some attempt, however, will be made to give a word-picture of each formation, and details will be furnished regarding the conditions under which such exists, while something will be said as to the life-forms of the most important constituents. As in my former phytogeographical papers, the term "formation" is adhered to on the score of priority,* while that of "association" is restricted to those smaller combinations or groups of plants which are frequently clearly defined within a formation.†

At the conclusion of this paper are included, in the Bibliography, the names of the more important papers referring to my subject. It must, however, be pointed out that these usually contain but little matter of ecological interest, and that for the most part they are lists of plants. In fact, so little has, up to the present time, been published regarding the coastal vegetation of the South Island that I do not consider it necessary to give a summary of our knowledge on the subject.

Properly speaking, the South Island of New Zealand does not form a distinct phytogeographical province. Strange as it may seem, Cook Strait forms no line of demarcation between the North Island and the South Island floras—so far, at any rate, as the lowland region is concerned. It is not until latitude 42°‡ south is reached that the South Island vegetation

* See, on this head, Olsson-Seffer, P., "The Principles of Phytogeographic Nomenclature," Bot. Gaz., vol. xxxix, p. 183 (1905).

† Such are now clearly recognised by many ecologists—*e.g.*, Ganong, W. F., Bot. Gaz., vol. xxxvi, pp. 301, 302 (1903); Harshberger, J. H., *ibid.*, p. 372; Smith, W. G., Scot. Geol. Mag., vols. xx, xxi, p. 620, p. 20. This latter botanist also uses the term "sub-association."

‡ Latitude 38° south forms a much more natural floral boundary, to the north of which lies the "northern province" of New Zealand, as it may be called, while from 38° south to 42° south is the "central province,"

properly commences; but it must be pointed out that this limit is at best but a very artificial one. Notwithstanding the above, it is a convenient and quite legitimate plan to discuss the vegetation of either Island as a whole, and the method of treatment here adopted can, with the above explanation, lead to no misconception.

Regarding the term "coastal vegetation," it is not generally feasible to set any hard-and-fast limit as to its boundaries. Generally speaking, it is confined to quite a narrow zone following the coast-line, and determined, amongst other things, by the salt in the soil, the average distance sea-spray may blow inland, and the configuration of the land. In some places there are distinct traces of ancient shores, and such may contain in large part maritime plants, but unless these are in fairly close proximity to the sea they will not be specially dealt with.

As some of the notes, &c., made use of in the preparation of this paper were taken during several voyages in the Government steamer "Hinemoa," I thank most sincerely the Hon. W. Hall-Jones, M.H.R. (at that time Minister of Marine), for the opportunities thus afforded of visiting some little-known places on the coast and many of the adjacent small islands. To Captain J. Bollons, who assisted me in every way possible to carry on my work, my most hearty thanks are due. I must also express my gratitude to Messrs. F. G. Gibbs, M.A., D. Petrie, M.A., H. J. Matthews, J. Crosby-Smith, and T. F. Cheeseman, F.L.S., who have furnished me with much valuable information, and in other ways materially assisted this work.

2. Physiography and Climate.

The extensive coast-line of the South Island, facing the actual ocean for some 4,845 km., and extending in many places far inland, affords, as may well be supposed, a very considerable diversity of stations for plant-life, with the consequence that a by no means uniform plant covering clothes the shore and its environs. This absence of uniformity, far greater than might have been expected from differences of latitude, is in large part due to the fact that, thanks to the position of the Southern Alps, a quite different climate occurs, generally speaking, in the east than in the west, south, and many parts of the north. In fact, to mention two extremes, the west has an average rainfall of more than 253 cm., the extreme south-west corner having, in-

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and from this latter parallel to the southern extremity of Stewart Island is the "southern province." Lat. 42° is, however, only a boundary so far as the vegetation near the coast is concerned; inland the southern province reaches much further north.

deed, twice that amount, while certain parts of the east coast hardly get 50 cm.* The number of rainy days, too, is much greater in the west than in the east. The climate of the west is also comparatively uniform, whereas in that part of the east where dry conditions prevail the summers are hotter and the winters colder than elsewhere on the coast—in fact, — 8° C. is not uncommon close to the shore of the Canterbury Plain. Much of the east, too, is subject to violent hot and dry north-west winds, known nowhere else in New Zealand, and which have been sufficiently described by me elsewhere (11; p. 110).

The form of the coast-line is varied. In some places high mountains descend steeply—at times, indeed, almost perpendicularly—to the water; in others there are steep cliffs against which the sea dashes; while in many places the land is comparatively flat, being frequently raised but a few feet above the sea-level, or in some parts so low as to be subject to inundation.

The exposure of the coast with regard to the ocean is very various. Large stretches of land abutting directly upon it are subject to the full fury of wind and wave; and this, of course, is much augmented if they face the prevailing wind, or lessened if there is some sheltering headland. In other parts of the coast, on the contrary, are deep fiords, extending for many miles inland, and there, of course, very much calmer conditions prevail, to which the vegetation bears ample testimony. Shallow estuaries shut off from the sea by banks of gravel and sand are not uncommon, and here another condition of affairs exists for plant-life. Similar conditions are also afforded by tidal rivers, along whose banks coastal formations extend inland.

The geological structure of the coast is of considerable phytogeographical importance. Here it need only be pointed out that rocks of diverse kinds occur—volcanic, granitic, calcareous, sandstone, shale, &c. How far plant-distribution is correlated with the composition or age of the geological formations has not been worked out at any detail as yet for any part of New Zealand; at most a few very general facts are available.

As for the actual sea-shore, it may be sandy, rocky, shingly, gravelly, or muddy. Shells in many places also are abundant. Sandy shores merge into dunes, generally of no great height. Gravelly and rocky shores are succeeded by cliffs, stony terraces, gravelly dunes, steep banks, &c., while muddy shores are frequently the forerunners of salt meadows. Boggy and swampy places also occur near the sea, fed by fresh-water

* See the highly instructive rainfall map of the South Island (36; p. 238).

brooks and springs. Streams, too, sometimes flow over the shore. In both these cases special conditions occur for plant-life, but such, it may be pointed out, are not coastal unless salt be present in excess.

3. Ecological Factors.

The special factors with regard to coastal vegetation are superabundance of salt in the soil, and high or frequent and prolonged winds. Together with these comes a more equable climate than further inland, so far as extremes of temperature are concerned, but at the same time there is often strong insolation and bright illumination. The biotic factor, apart from introduced animals and those concerned in fertilisation, is of little moment, with the exception of the part played by the small land-crabs in the salt meadows, whose innumerable holes must assist materially in aerating the soil, and to some measure, also, in draining the ground.

As for the salt in the soil, this comes either through the flooding of the ground more or less frequently, or through sea-spray blowing inland. The effect of the former is strongly marked, and on it the most typical halophytic formations depend—*e.g.*, salt meadows, salt marshes, and brackish-water vegetation. As for the effect of sea-spray, it has probably been very much overestimated. Quite recently T. H. Kearney (27) has shown this to be the case for certain parts of the east coast of North America, and he comes to the conclusion that dune plants, and even those of the strand, for the most part do not owe their adaptations against transpiration to excess of salt in the soil, but to other conditions, and that they are rather ordinary xerophytes than halophytes.

The above explanation seems to meet New Zealand conditions. Thus, the large shrubby nettle, *Urtica ferox*, is a common maritime plant, growing in some instances on the upper strand not far from high-water mark. But, as is well known, that genus is one which is distinctly averse to salt in the substratum (Warming, 44; p. 304). *Macropiper excelsum*, another frequent coastal plant, belongs also to the same category. *Mesembrianthemum australe*, an extremely succulent plant, usually grows on the face of cliffs, where salt could not penetrate to any extent. The "coastal scrub" at the base of the Bluff Hill would most certainly be non-existent were there excess of salt in the soil, and yet some of its members overhang rocks covered with seaweeds. In short, the effect of spray seems to be largely dependent upon the position of a formation with regard to the prevailing wind, and upon the frequency and force of this latter. And this brings me to the point that, in New Zealand at any rate, the wind factor cannot be overestimated. Its mechanical effect is everywhere apparent along the coast. The palm in north-west Nelson, the forests clothing the great mountains rising out of the sea in the south-west, the shrubs hugging the ground on the shore of Foveaux Strait, all exhibit an extreme wind-shorn appearance. But the wind not only exerts an influence on plant-form, but it markedly affects the distribution of the formations themselves. This is admirably illustrated by the vegetation on the Bluff Hill, to quote a specific example. On the sheltered side is mixed forest (taxads, *Weinmannia*, and *Metrosideros*), with the belt of shrubs mentioned above between it and the sea, but as the wind-swept side of the hill is approached the forest dwindles and finally gives way to xerophytic shrubs (*Cassinia vauvilliersii*, *Leptospermum scoparium*); finally the coastal scrub vanishes, and a scanty meadow of very low-growing herbs alone remains.

The soil factor, of course, also plays a prominent part both in the form of the plants and the distribution of the formations. Dunes, salt meadows, gravelly and sandy shores, and clayey hills occupied by low tussock-grass are well enough known to require no special mention here. In the south, however, are wet, peaty flats or slight slopes, frequently more or less mixed with sand, and which are, in fact, coastal moors. On these is a very distinct vegetation, containing, it is true, many characteristic salt-meadow plants, which, however, do not give the stamp to the formation. On the contrary, special species are dominant, such as *Euphrasia repens*, *Gentiana saxosa*, *Plantago hamiltonii*, *Montia fontana*, *Epilobium nummularifolium minimum*, *Crassula moschata*, and *Rumex neglectus*, while the rock-ferns *Asplenium obtusatum* and *Lomaria dura* are frequently conspicuous.

The rainfall, and, more important still, the number of rainy days, is a factor not peculiar to the coast, but nevertheless of vital importance to the distribution of the formations. As pointed out in the introduction, there is a vast difference between much of the eastern coast and the whole of the western, with the consequence that one is dominated by arborescent formations and the other by meadows. The north in large measure, and the south and south-west, for the same cause are rain-forest districts. On the east, too, are local climates where forest comes, or originally came, to the shore-line, as at the base of the Seaward Kaikouras and thence southwards to the Waiau River, Banks Peninsula, and the neighbourhood of Dunedin. Even in Eastern Canterbury are many evidences of former forests to be seen in swamps near the coast, and Riccarton Bush is the surviving remnant of such forests, whose presence most likely depended rather on edaphic than climatic conditions—*i.e.*, on subsoil water rather than number of rainy days.

The above rain-forests are not, strictly speaking, "coastal," but are merely the ordinary lowland forests of the particular locality. But their seaward margin is frequently distinctly modified by coastal conditions. Thus, there may be a dense growth of shrubs or low trees, as originally pointed out by Hector (21), forming a definite plant-association or maybe formation, which at times exhibits a zonal arrangement of its members, defined by their wind- or spray-resisting powers, the trees or shrubs being gradually more xerophytic from within outwards. In other places *Phormium tenax* may form a natural wind-break between the forest and the actual shore, reaching so close to the water that seaweed and pieces of driftwood may be stranded at its base.

Certain edaphic formations are not affected by the rainfall. Thus the dunes at Martin's Bay, in the very centre of the wet region, maintain clearly their desert character, while at the head of the western sounds far inland in the heart of vast forests are muddy flats covered with the usual halophytes. With rock formations, on the other hand, it is quite the contrary. These vary much in their plant covering according to the rainfall. On the dry east coast, masses of the succulent *Mesembrianthemum australe* depend from rock-crevices and alone hide in a few places the bareness of the surface. But in the west great walls of rock are covered with arborescent plants, the constant wet being most favourable for peat-production, which, lodging on ledges and in hollows, forms a thin soil, which the plants can use, thanks to the far lateral spread of their roots. Between such fertile cliffs and those of the east there are many transitions in harmony with the water conditions of the station.

4. Dunes, Salt Marshes, and Salt Meadows.

The absence of uniformity in the coastal formations, as mentioned previously, is not without some striking exceptions. Such are found in the case of those before-mentioned formations which depend on some special edaphic rather than climatic influence. Of these, the most common are dune, salt-marsh, and salt-meadow formations. Not only are dunes, salt meadows, and salt marshes remarkably uniform throughout the South Island, but through nearly the whole of the New Zealand biological region—a sandhill in the north of Auckland, for instance, not differing much from one of the extreme south of the South Island, Stewart Island, or even of Chatham Island (12; p. 259 *et seq.*). To find a dune floristically and even ecologically distinct one must visit the Auckland Islands, whose sandhills contain none of the characteristic New Zealand psammaphytes (13; p. 237). But there are a number of differences in New Zealand dunes, and these are sufficiently marked to enable a botanist conversant with the coast to tell within certain limits to what part of New Zealand a particular sandhill would belong. One example will suffice here, and, as it is an interesting case of representative species, it is worth emphasizing. The genus *Cassinia* is represented in New Zealand by six species, one of which—*C. albida*, Cockayne—would be considered by many as a variety only, and another, *C. amœna*, is confined to the North Cape. As for the remaining four, all are common at sea-level, while two of them ascend into the subalpine region. As for their life-forms, they are very similar, being of the ericoid, sclerophyllous type with tomentose leaves. Commencing at the subantarctic islands, *C. vauvilliersii* occurs near the coast to the south of the South Island, where it is succeeded by *C. fulvida*, this in its turn giving place to *C. leptophylla* in the central province, and this to *C. retorta* in the northern province. Everywhere *Scirpus frondosus* is the leading sand-binding plant, but in the central and northern provinces this is reinforced by *Spinifex hirsutus*. But no more need be said here as to the above edaphic formations, as they will receive detailed treatment in the special part of this series.

5. Physiognomy of Coastal Vegetation.

Formerly the physiognomy of vegetation was merely a geographical concern pure and simple, but this is no longer the case, since it is recognised that the life-form of a plant is a physiological matter depending on the relationship of form to outer factors and to inner causes. This being so, the general appearance of the landscape as determined by the presence of certain dominant species becomes an affair of high biological interest. Now, the scenery may be affected in two ways: either some particular plants or life-forms may be especially striking, or it may be a group or even the character of a whole formation that may specially catch the eye. Thus, taking New Zealand as a whole, the scenery is distinctly affected by the abundance of *Cordyline australis* and *Phormium tenax*, while that life-form the "tussock" is perhaps the most striking characteristic of large areas. On the other hand, where forests dominate the landscape their individual members exert little influence, it being their evergreen character and close growth which stamps their physiognomy.

Coming now to the subject of this section, *Cordyline australis*, *Phormium tenax*, *P. cookianum*, and tussock-grasses play frequently quite a prominent part in the physiognomy of the coastal vegetation, the first-named dotting stable dunes or grassy hillsides, the second forming long belts just above high-water mark, or in the case of *P. cookianum* especially beautifying barren cliffs, and the tussocks occurring in many situations and under various conditions. But the above are not specially coastal plants, and it is the coastal formations proper which supply the peculiar features. Walking along a sandy shore the only plant which may be seen for miles is *Scirpus frondosus*, with its tufted, stiff leaves especially conspicuous through their yellow colour. Further from the shore, however, as the dunes become more stable, are here and there the curious low-growing bushes of *Coprosma acerosa arenaria*, with their interlacing extremely wiry stems of a distinct reddish-yellow colour, and associated with them the more upright-growing but also yellow *Cassinia fulvida*. Further from the sea still may be a dark-coloured heath of *Leptospermum scoparium*, relieved, however, by huge tussocks of green *Arundo conspicua*, with its straw-coloured plumes in summer.

Tidal rivers, shores of estuaries, and salt meadows are distinguished by lines, groups, or thickets of the roundish, black-coloured bushes of *Plagianthus divaricatus*, while the floor of the meadow owes its green turf to a number of close-growing herbaceous plants furnished with far-creeping stems.

Generally speaking the appearance of the coast is desolate enough, but in the wettest regions this is not the case, for here it is not coastal plants adapted for peculiar and severe conditions which dominate, but the luxuriant rain-forest. This, although black in the distance, becomes much more pleasing at a closer view, when its varied greens are evident, and glimpses of tree-ferns appear through the foliage. Here, however, as pointed out before, is frequently a protecting hedge of closely packed tall shrubs, and of these *Olearia operina*, with its toothed lanceolate leaves white with dense tomentum on their undersurface, *Senecio rotundifolius* with its large, round, leathery leaves, and the tender-green *Veronica elliptica*, give a distinct character to this exterior vegetation. This is sometimes varied by the presence of large quantities of *Freycinetia banksii*, and with this liane creeping right out on to the shore in stiff tangled masses the scene becomes distinctly tropical in aspect. Nor is this tropical character much changed when the long line of *Phormium* fringes the shore; where, too, in north-west Nelson, the beautiful palm *Rhopalostylis sapida* raises its huge feathery leaves above the other and frequently wind-shorn foliage; or where, in north and east Marlborough, the great glossy leaves of *Griselinia lucida* crown some rocky point.

Quite different from the above is the steppe character, where-slopes in the east are covered with brown tussocks of *Poa cæspitosa*, from amongst which rise up dark-coloured semi-pyramidal masses of the liane *Muehlenbeckia complexa*, which has assumed a shrubby habit, and stiff, erect, dull-green bushes, quite leafless, of a species of *Carmichælia*.

Many other physiognomic peculiarities could be cited, but it would lead to a general account of formations, here obviously out of place. Other characters which affect the landscape depend upon the blooming of various plants, and this is dealt with to some extent in another section.

6. The Small Coastal Islands; Endemism.

Not the least interesting portions of the coast, if they may be so included, are the islands situated at no great distance from the mainland with which they have been connected at some earlier period. Of such islands some have been inhabited for a considerable time, while a few are still in their virgin state (14). In the former case the effect of man and herbivorous mammals on a primeval vegetation is fairly easy to estimate, since their area is small enough for close observation. Dog Island and Centre Island, which are to be treated of, are of this class, while the Open Bay Islands and the yet unexplored Solanders belong to the other category. The limited size of these small coastal islands, too, permits detailed observations to be taken as to the distribution of formations, the effect of introduced plants, the change of edaphic conditions on the vegetation, and the like. Finally, it is in such spots that relics either of former vegetation not existing elsewhere or of incipient species might be expected.* As for the latter, a variety of *Brachycome thomsoni* named *minima* is reported by Kirk for Dog Island (34; p. 260), and I mentioned a form of *Veronica elliptica* as peculiar to the Open Bay Islands (14a; p. 371). On East Cape Island, in February, 1905, I collected a very robust and fleshy plantain, which is either a new species† or Colenso's *P. picta*. Other examples are afforded by the more distant islands—*e.g.*, *Veronica gigantea* of Chatham Island, closely related to the common *V. salicifolia*, and *Acæna sanguisorbæ* var. *antarctica* of the Southern Islands.

But it is as a haven of refuge that islands figure more conspi-

* See also, regarding this question, Laing and Blackwell (35; p. 302 *et seq.*).

† This plant I have raised from seed in a soil containing no excess of salt, and in a greenhouse. The early leaves of the seedlings are, however, extremely fleshy. Of course, such fleshiness may not be shown in future generations, but that it is present at all is suggestive and interesting.

cuously, and as this is an important phytogeographical matter having a bearing on general plant geography, I am going into the facts at some length. That some species have been more widely spread on the mainland than at present is known in some cases. Thus *Lepidium oleraceum* was so common at the time of Captain Cook's visit that he fed his crew on it, calling it "scurvy-grass." This plant is now virtually extinct on the mainland, but abounds on certain of the small outlying islands. *Sicyos australis** has become quite rare on the mainland, but on the Little Barrier Island and other islands in the north it is abundant, climbing high up *Metrosideros tomentosa* or straggling over *Macropiper excelsum.* The magnificent *Meryta sinclairii* is no longer to be encountered on the mainland, and is only known from the Three Kings, where it is plentiful (8A), and the Hen and Chickens.† If a plant, abundant on a far-distant island, occurs very rarely or over an extremely limited area on the mainland, it seems reasonable to conclude that it was once much more widely spread, especially when geological evidence proves that the island is the younger land. Thus *Suttonia chathamica*, a common tree of the Chatham Island forests (12; p. 277), was found by G. M. Thomson in one station in the south-east of Stewart Island. *Hymenanthera chathamica*, an equally common Chatham Island tree, has been observed at one spot in the Wellington Province, North Island, by Sir James Hector (34; p. 46). Other similar cases are: *Pratia arenaria*, which is confined to the Southern Islands and Chatham Island, where it is abundant in various formations; *Urtica australis*, common in both the last-mentioned groups and almost reaching the South Island, since it occurs on both Dog and Centre Islands, in Foveaux Strait; *Archeria racemosa*, found on the mountains of both Great and Little Barrier Islands and on the Coromandel Ranges of the North Island; *Stilbocarpa lyallii*, common in Stewart Island, Ruapuke and others of the Stewart Island group, but only recorded in the South Island from near Preservation Inlet. *Lepyrodia traversii*, the most characteristic bog plant of the Chathams (12; p. 287), and for a time thought to be endemic, is now known, thanks to the researches of Cheeseman (7), to be abundant in some of the Waikato swamps. The endemic genus *Myosotidium* of the Chatham Islands was also probably much more widely

* Kirk states (34; p. 183) that the plant on the outlying islands differs in leaf-form from that of the mainland. If this is always the case, and the two forms come true from seed, here is another example of an incipient species.

† During my recent visit to the Poor Knights Islands I saw no trace of this tree (15).

spread,* and it is hard to believe that the Australian *Styphelia richei* did not reach the above group by way of New Zealand originally.

7. Southern and Northern Limits of Coastal Plants.

The coastal formations consist, as is shown further on, of two classes of plants—viz., the coastal plants proper, and those which are common inland. Now, although the strictly coastal plants are usually of wide distribution, not only in the South Island, but through much of the New Zealand biological region, some are confined to a small area, and others again only reach a certain distance to the north or the south, as the case may be. Considering first this latter category, the question is at once opened up as to the reason why certain plants have a definite northern and southern limit. This inquiry is much easier to propound than to answer in the present state of knowledge. At first sight the matter under consideration might seem merely to be a question of climate—that when, say, a northern plant of a frostless climate reached a point where frost occurred, it could advance no farther; or such a plant, again, might require for its well-being a certain average maximum of heat. But an examination of the facts shows that there is something much more far-reaching in the matter than the above; but this can be best understood by citing some specific examples. Take, first of all, the case of the kauri (*Agathis australis*), which, although not a coastal tree, may fairly be used as an example, since the matter under consideration concerns the whole New Zealand flora, while the kauri, moreover, is one amongst a number of plants which are confined to the north, roughly speaking, of the 38th parallel of latitude. Now, south of this line for a considerable distance, especially on the west of the North Island, there are no climatic conditions which should inhibit the growth of this tree in many places. Moreover, at Wellington, more than 3 degrees to the south of the kauri limit, this tree grows famously in cultivation, producing cones regularly. Even at Christchurch, in the South Island, in the Domain, where −9° C. has been frequently recorded, the kauri grows well and has recently fruited. Also, a young plant has withstood the cold of this winter in the garden of the biological laboratory, Canterbury College, in a position where it could get no sun, and where a plant of *Veronica elliptica* collected by me in Campbell

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* G. M. Thomson is also of opinion that this plant must have formerly existed in New Zealand, and he suggests that it may have died out or been "eaten out by some more recent form of animal life, perhaps by moas, which were formerly enormously abundant, and were vegetable-feeders" (43; p. 315).

Island was killed outright. Finally, so far south as Dunedin, the kauri is by no means difficult to cultivate.* *Metrosideros tomentosa*, the pohutukawa, is the characteristic tree of certain coastal rock formations of the northern part of New Zealand, and has much the same distribution as the kauri (33; p. 238), yet, without any apparent reason, it also does not extend beyond a certain latitude, although it is perfectly hardy near the shores of Cook Strait, being a frequent plant of gardens in Wellington and elsewhere. *Corynocarpus lævigata*, the karaka, a plant probably more susceptible to frost than either of the above, occurs spontaneously as far south as Banks Peninsula, about lat. 44°, but further does not go, although quite hardy on the Otago Peninsula, and doubtless easily able to grow on any part of the west coast. *Pittosporum crassifolium*, another coastal tree of the kauri region, is perfectly hardy in the Christchurch Domain, and yearly produces abundance of fertile seeds, which germinate on the soil beneath the tree; indeed, there is no reason to doubt that this plant could hold its own, so far as climate is concerned, in any part of the whole New Zealand forest region. Many other examples could be cited, but these will suffice.

Now, in all the above and similar cases it may be argued that an abnormally severe frost, such as occurs at times, would damage these trees to so great an extent that they would not be able to cope with the more hardy indigenous vegetation. Doubtless this is in part true Such frosts do occur. Leaving out of the question the doubtful record of $-25{\cdot}5°$ C.† in Central Otago in the winter of 1903, there is no question that the cold then was exceptionally severe. T. W. Adams reports (1; p. 288) how "the exceptionally severe winter of 1899" killed at Greendale, on the Canterbury Plain, the introduced *Eucalyptus globulus*, 70 ft. high and nearly 3 ft. in diameter, and how *Leptospermum scoparium* and *Cordyline australis* were also killed. But at the same time it must be pointed out that many groves of *Cordyline* on the Malvern Hills and on the foothills of the Southern Alps, and much *Leptospermum* in the same localities at a much higher elevation than Greendale, and probably exposed to a lower temperature, were not damaged at all. Further, it is a well-known fact, to which others and myself have drawn attention, that certain New Zealand plants exist at the very limit of their frost-enduring capacity (see Rutland, 39; and Cockayne, 10). But another class of facts opens up a different

* T. W. Adams calls attention to this matter of the kauri (see 1; p. 286).

† Report of Department of Lands and Survey, New Zealand, 1904.

aspect of the case. I refer to those southern plants which only reach a certain distance northwards. *Senecio rotundifolius* is an example. This, as will be seen further on, is an important constituent of a somewhat local plant formation found in the south-west of the South Island. It is also abundant in Stewart Island, but is not found on the east of the South Island at all, although many stations are most suitable, nor is it found on the west coast beyond latitude 44°, or on the south coast beyond the eastern boundary of Bluff Harbour (14B). Yet on the east, this plant, cultivated at Dunedin, forms magnificent hedges, while it is grown with success even as far north as Auckland City. Here there is, then, no question of frost, or even of any damage from a hotter summer climate ; if there is any inhibitory climatic factor in this case it would be rather a question of want of moisture. A still more interesting example is *Veronica elliptica.* This plant, which is also a native of Tierra del Fuego, is a most common feature of coastal rocks and cliffs in the southern part of the South Island, and it extends even to the far-off Auckland and Campbell Islands. But in the northern part and north-east of the South Island it is quite wanting, nor does it occur at all in the North Island or the Chatham Islands, in both of which, however, there are rock-loving veronicas. Now, although this is a strictly southern plant, being identical possibly with the Fuegian species of the same name, it cannot, as shown above, tolerate much frost.* This species, then, seems more suited to the warmer north, and yet, as stated above, it is quite wanting in the North Island. The distribution of *Crassula moschata*, too, is interesting. This low-growing succulent herb, a native also of the Fuegian region, occurs in abundance on the Southern Islands. In the South Island it is common in the south and south-west, but further north it is quite local, wide reaches of coast being destitute of this species, although so far as station and climate go they are quite suitable. It occurs sparingly on Banks Peninsula, and then, so far as I know, is not found again until the shores of Cook Strait are reached, which it crosses, and is finally found in the neighbourhood of Island Bay, Wellington, and its vicinity, but does not occur further north.

From the above cases it seems evident that extremes of climate is only one of the factors with regard to the distribution of coastal plants in New Zealand. Rather, perhaps, than heat or cold alone is the matter one of the ecological optimum†

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* A plant of *Veronica elliptica*, originally from the Bluff, grown in my former garden near New Brighton on an ancient sand-dune since 1897, has never thriven, being yearly cut back by frost.

† For explanation of this term see Schimper (41 ; p. 44).

of any special plant. Many plants would extend farther to the north or the south, but they encounter competitors better equipped for the struggle—*i.e.*, more in harmony with the surroundings than themselves. A plant which is slightly more suited than another for a particular station must evidently become the victor in the struggle for existence, although both outwardly may appear equally matched in every particular. The distribution of *Sophora chathamica* is an interesting case in point. Judging from the behaviour of the closely allied *S. microphylla* on the volcanic hills of Banks Peninsula, where this plant is abundant, one would conclude that similar hills on Chatham Island would be the habitat of *S. chathamica.* On the contrary, it is quite absent in such stations, being evidently not able to cope with the lowland forest plants, and it is confined to a narrow strip of limestone country near the margin of the great lagoon. In this place the difference of soil evidently equalises the struggle, and it and the other lowland forest trees there exist side by side (12; p. 271).

Further, in considering the above question, the diverse origin of the New Zealand flora must not be lost sight of. Roughly speaking, there is a northern element, consisting of Malayan, Australian, and Polynesian genera or species, which may be called a "subtropical element"; then there is a southern element, consisting of South American and so-called antarctic genera and species, to which must be added some endemic species also, and this element may be called, with Schenck and Skottsberg, "subantarctic" (41, 42). The species composing these two classes have come to New Zealand probably at very different times and by slow degrees during great extensions of the land surface. Some of the subantarctic species may be actually New Zealand, if this country has originally formed a part of a palæoceanic continent. Between these alien plants, the subtropical and the subantarctic, a fierce struggle must have taken place—just such a conflict, indeed, as is now in progress between the indigenous and introduced plants in New Zealand, these latter mostly plants of temperate Europe. From the former struggle have resulted our present plant formations, in some of which the subtropical element is dominant, while in others the subantarctic flourishes.*

The present distribution of certain plants is of interest with regard to this struggle. Thus, as pointed out before, north of the 38th parallel is a powerful subtropical element. South of

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* This view I have already published in a series of "popular" articles which appeared recently in various New Zealand daily papers, entitled "New Zealand Plants and their Story."

this line many of the northern species and genera are wanting, but a large proportion extend south, some just crossing Cook Strait, others finding their southern limit at Banks Peninsula, or at other definite points east and west, while others, again, extend right to Stewart Island and even to the Southern Islands. In the same way the subantarctic element, including in this some of the endemic genera — *e.g.*, *Celmisia*, *Olearia*, *Aciphylla* — has pushed northwards, leaving here and there outposts or settlements cut off from the main body, such as the *Crassula moschata* at Island Bay, Wellington, before mentioned, but especially the patches of *Nothofagus* in northern Auckland. Generally speaking, in this struggle the subtropical element is the conqueror, the subantarctic plants being driven into the more unfavourable stations, such as lowland bogs, the subalpine region where pure *Nothofagus* forests flourish, or alpine heights.

As to how finally the various combinations of plants have come about which make the formations and associations, it seems in the present state of knowledge vain to inquire. The action of minor climatic changes is but little known. Our ignorance is great regarding the mutual reactions of plants on one another when brought into contact, reactions which must have much to do in determining what plants shall finally occupy a station. In this matter experiment is imperative, and a fruitful field is open in New Zealand, where, with the introduction of so many exotic plants and animals, unpremeditated experiments are even now in progress everywhere.

Finally, to sum up the matter, all that can be said about the distribution of the New Zealand coastal plants is that it is the resultant of a large number of causes. The historical factor and evolution determine the species, climate and soil sort them out into groups, and the struggle for existence, which is governed by the life-forms and constitutions of the competitors, finally fixes the formation—that is, so far as a formation may be termed a fixed entity.

8. Local and Limited Distribution.

Coming now to those plants mentioned above as being confined to a small area, the following citations must suffice, but these include some of the most striking amongst New Zealand plants: *Helichrysum purdici* occurs, so far as is known, only in one or two stations on the north shore of the Otago Harbour, and there are only a few plants in each locality. I found by cultivation that this plant would not endure much frost. *Olearia insignis*, so far as its coastal distribution is concerned, is limited to cliffs on the Marlborough coast,* and it is sometimes accom-

* Inland it is frequent on rock-faces, and it ascends to the alpine region in the Kaikoura Mountains.

panied by the beautiful *Veronica hulkeana*. *Celmisia lindsayi* occurs only on rocky faces and stony *débris* in the neighbourhood of the Nuggets and Catlin's River, south-east Otago.* This is a remarkably easy species to cultivate. The thickets of *Olearia operina* are found only at the West Coast Sounds, and the closely allied *O. angustifolia*, so far as its South Island distribution is concerned, has been recorded from only one locality, the base of the Bluff Hill, Foveaux Strait, although it is an abundant plant on some parts of the coast of Stewart Island and the neighbouring small islets. *Capsella procumbens*, one of Petrie's numerous discoveries, has been recorded only from Oamaru. *Lepidium banksii* occurs only on the southern shores of Cook Strait. *Stilbocarpa lyallii*, a common plant of Stewart Island and of some of the islands adjacent, is found, according to Kirk, only in the South Island in the vicinity of Preservation Inlet.

9. Primitive and Modified Formations.

The coastal plant formations of settled districts are usually in a much more primitive condition than are those of the adjacent lowlands. The nature of the soil, and its possession in some instances of more salt than is beneficial for the majority of plants, has had the effect of keeping away the rank and file of the invading host of foreign plants which now form such a marked feature in many districts in New Zealand. Certain parts of the coast, especially in the west, are far removed from the inroads of domestic animals, and there the plant covering is truly primeval. On the other hand, certain formations, which at first sight appear primitive, on a closer examination prove to have been modified considerably by fires, drainage, grazing animals, and introduced plants. For instance, the majority of dunes at the present time are certainly much more unstable than they were originally, their great protector, *Scirpus frondosus*, being eaten by rabbits and other animals.† Also, these dunes, inhospitable as they appear, are not seldom thickly occupied by introduced plants, which have quite overcome the original plant inhabitants. A very striking case is that of *Lupinus arboreus*, introduced in the first instance as a sand-binding plant, but which now forms dense thickets in all parts of many dunes except the most unstable. Also, *Ulex europæus* and *Sarothamnus scoparius*, planted originally as hedge plants, occupy wide areas and frequently struggle with each other and with the tree-lupin for the supremacy. In some places the forest which came to near high-water mark has been cut

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* Regarding the occurrence of this plant inland see Cockayne (14c).
† See, for instance, F. Truby King (28).

down, and a second growth, easily mistaken for a primitive one, now occupies the ground. An actual sea-beach may be occupied exclusively, or almost so, by introduced plants. Thus the steep, unstable gravel beach at Kaikoura abounds with *Sherardia arvensis* and *Scandix pecten-veneris*, the only indigenous plant present being *Rumex obtusifolius*.* The effect of drainage may be well observed where such operation has been carried on in a salt meadow, the native plants decreasing as the ground gets drier, and finally introduced grasses being dominant. Even slightly brackish water is not free from the foreign element, the customary dense red mat of *Azolla* having to give place to *Glyceria fluitans*, or to the watercress, *Nasturtium officinale*.

10. Mountain Plants on the Coast.

There is at times a close ecological resemblance between some coastal plant formations and those of higher altitudes. This is probably owing to the fact that somewhat similar climatic and edaphic conditions are provided. Alpine plants must in many instances have been driven into the mountains by a more vigorous lowland vegetation, such as lowland mixed forest or tussock meadow, and where these formations cannot exist—*e.g.*, owing to sea-breezes, halophytic conditions, or a too scanty supply of soil, such as rocky places or a gravel beach provide—then subalpine or alpine plants, or those ecologically related to such, may find a haven of refuge. The *Olearia insignis* formation alluded to above is an excellent example, since it not only occurs on cliffs facing the ocean and lapped by the waves, but, with few members added or changed, it ascends high into the mountains. *Claytonia australasica*, a plant of stony, subalpine river-beds, shallow running water, and alpine shingle-slips, descends to sea-level on sandhills near Dunedin (37; p. 544), and also on the shores of Foveaux Strait. *Helichrysum selago*, a shrub of subalpine and alpine rock-faces, occurs on ancient sea-cliffs near Cape Saunders, Otago Peninsula. In the West Coast Sounds, *Cordyline indivisa*, a plant of subalpine or montane forests, is not infrequent on cliffs quite near the water's edge. Coastal scrubs, as I have pointed out elsewhere, are frequently closely related to subalpine scrub, both ecologically and floristically. Finally, to quote an easily observed North Island example, certain shady cliffs near Island Bay, Cook Strait, have a fairly rich vegetation of *Phormium cookianum*, *Aciphylla squarrosa* var., *Senecio lagopus*, and a broad-leaved

* See also Kirk's remarks on this subject (34a; p. 18).

form of *Craspedia fimbriata*, while on the stony beach are large, circular, silvery patches of *Raoulia australis*.*

Many more examples of mountain plants growing naturally at abnormally low altitudes could be given, but the subject is of too much importance for a brief treatment such as could be afforded here.

11. Occurrence of Coastal Plants Inland.

So long ago as 1871, Mr. T. Kirk (29) pointed out how certain coastal plants occurred far from the reach of tidal waters in the Waikato district. Among these species were such well-known coastal plants as *Selliera radicans*, *Ruppia maritima*, *Scirpus maritimus*, and *Leptocarpus simplex*. To explain this distribution Kirk called in Hochstetter's conception of an ancient shallow arm of the sea in the middle Waikato basin. Since that time many more facts as to occurrence inland of coastal plants have been recorded. Thus several occur on the shores of the central North Island lakes, of which perhaps the most interesting is the beautiful tree *Metrosideros tomentosa*, which occupies similar positions on the cliffs of Lake Taupo, Lake Rotoiti, &c., to what it does on the coast of the northern floristic province. Near hot springs at Ohinemutu and elsewhere grow *Leptocarpus simplex* and *Triglochin striatum filiforme*.

The South Island also supplies some interesting examples. On the Maniototo Plain or its neighbourhood Petrie recorded *Chenopodium triandrum*, *C. glaucum ambiguum*, *Atriplex buchanani*, *Senecio lautus*, and *Ranunculus acaulis*. From near Lake Wanaka he collected *Selliera radicans* (37). *Linum monogynum* occurs on the upper Canterbury Plain and reaches to the base of the Southern Alps, and to similar altitudes in south Nelson. *Angelica geniculata*, which Kirk did not believe to extend inland, was noted by me at a slight elevation on the Rock and Pillar Range, Otago, and also at the Lower Waimakariri Gorge, where it is accompanied by other coastal plants.

How far all the above cases denote a former shrinkage of the land and extension of the coast-line inland is not for a botanist to settle, but certainly, so far as geological evidence goes at present, they are suggestive, to say the least.

A more interesting case, perhaps, is that of the limestone rocks at Castle Hill, Canterbury, the Weka Pass, and else-

* This subalpine "patch plant" is also common on stony river-beds of the lowland region, reaching high-water mark near the mouth of the Rakaia, which it has probably reached in the first instance through water-carriage.

where. Here the well-known coastal fern, *Asplenium obtusatum*, and the shore groundsel, *Senecio lautus*, grow abundantly. If such a distribution is correlated with the marine origin of the rocks, then it is evident that species can exist under special conditions for enormous periods of time. It may be pointed out in favour of the fern being a relic that it grows normally on any kind of rock, and even on wet peat, and the limestone can have no special advantage as a spot where the spores could germinate and thrive over any other open rock station.

12. Flowers of the Coastal Plants.

The flowers of the coastal plants are usually not very striking, but this is, indeed, the case with the majority of New Zealand lowland plants. Some, however, are distinctly showy. *Samolus repens procumbens* in due season spreads white sheets of bloom over the salt meadows, contrasting with yellow masses of *Cotula coronopifolia*. In the neighbouring marshes and shallow, sluggish streams the flowers of *Mimulus repens*, of a bright lilac, marked with yellow on the lower lip and throat, are distinctly pretty. *Olearia operina*, *O. insignis*, and *Senecio monroi* would attract attention in any flora, not merely from their handsome flowers, but from the form of their leaves and the contrast of the green with the tomentose surfaces. All the veronicas have a profusion of pretty flowers, and, in addition, those of *V. elliptica* are very sweetly scented. The white-flowered *Gentiana saxosa* is very beautiful, trailing over rocks or banks near the sea on some small island in Foveaux Strait, or on the south coast. Where *Metrosideros lucida* hangs, in the south, over the shore of some land-locked harbour, its myrtle-like leaves dipping almost into the water, the masses of bright-crimson flowers in due season are a glory. The coastal scrub at times is here and there adorned with the drapery of purest white of *Clematis indivisa*. On bare cliffs of the Marlborough coast hang the long, soft, lilac racemes of *Veronica hulkeana*, emerging from the foliage of shining green. In the north, according to Mr. H. J. Matthews, the shores of D'Urville Island and Pelorus Sound are decorated in late January with multitudes of the truly lovely flowers of *Euphrasia cuneata* —white, with a yellow eye, and striped with purple.

Finally, even stations so desolate as the dunes are enlivened by the large delicate flowers of *Calystegia soldanella* (white striped with lilac), by the silvery bushes of *Pimelea arenaria*, the snowy masses of *Leptospermum*, and the tall, waving, shining plumes of *Arundo conspicua*.

13. Coastal Distribution as an Aid in defining the Floral Districts.

Up to the present time no attempt has been made to divide the South Island into various floristic small divisions.* Such are, in fact, very difficult to delimit. This arises from the fact that the species of wide areas are not known, and can be only guessed at, and also that these smaller divisions must overlap and be likewise in some measure artificial. It seems interesting to inquire whether the distribution of the coastal plants can shed any light on this matter. Such minor divisions may be termed "districts," just as the three larger have been named "provinces," the whole of the New Zealand area forming a "region."

On the south side of Cook Strait the dunes with *Spinifex hirsutus*, and the cliffs with *Coprosma baueri*, give a distinctive character to that area. Here, too, are *Entelea arborescens*, *Corynocarpus lævigata*, *Veronica speciosa*, *Euphrasia cuneata*, *Griselinia lucida*, and some other plants which are peculiar to the district or only reach south for a short distance.

Cliffs with a formation of *Olearia insignis*, *Phormium cookianum*, and *Veronica hulkeana* are distinctive of east Marlborough, and that distinction is heightened in comparison with Canterbury by the groves of *Corynocarpus lævigata*, *Myoporum lætum*, and *Dodonæa viscosa*, while on the summits of rocks is *Griselinia lucida*. The nikau palm (*Rhapalostylis sapida*), according to Mr. H. J. Matthews, is a feature of the shores of west Nelson. Here, too, is *Veronica gracillima*. On the volcanic rocks of Banks Peninsula is the fine *Senecio lagopus*,† and, at a greater altitude, the beautiful *Veronica lavaudiana*—this, however, not really a coastal plant. South-west Otago, as mentioned before, is characterized by the coastal thickets of *Olearia operina* and *Senecio rotundifolius*, and by the fine *Aciphylla intermedia*. The shores of Foveaux Strait have the coastal moors before described, with *Gentiana saxosa* and *Euphrasia repens*.

From the above, then, it seems clear that the coastal plants and formations are distinctly an aid towards defining the floristic districts of the South Island.

14. Floristic Details.

The pteridophytes and spermaphytes composing the coastal vegetation consist in part of species confined to the coast or

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* For this purpose the geographical divisions have been used hitherto, and these are quite unsuitable and unnatural from both the biological and floristic standpoint.

† *Senecio saxifragoides* of Hooker's Handbook and Cheeseman's Manual, with which determination, in the face of Raoul's plate and the habitat of his *S. lagopus*, I cannot agree. Laing and Blackwell also hold the same opinion (35 ; p. 438).

occurring inland only under special conditions, and in part of ordinary lowland or even mountain plants.

Of the plants peculiar to the coast there are ninety-four species, including certain well-marked varieties, belonging to sixty-five genera and thirty-five natural orders. Of the natural orders *Chenopodiaceæ* have ten species, *Scrophulariaceæ* nine, *Compositæ* eight, *Cyperaceæ* and *Gramineæ* each seven, *Umbelliferæ* six, *Cruciferæ* and *Potamogetonaceæ* each five, *Filices* and *Aizoaceæ* each three, and the remainder one or two each.

Of the sixty-five genera the following are well-known maritime genera elsewhere, or possess characteristic halophytic species: *Lepidium, Tissa, Tetragonia, Eryngium, Apium, Samolus, Chenopodium, Suæda, Atriplex, Salicornia, Triglochin, Ruppia, Bromus, Carex.*

Turning now to the species, fifty, or 53·1 per cent., are endemic; twenty-seven, or 26·5 per cent., occur in eastern Australia or Tasmania, where they are not necessarily coastal plants; thirteen, or 13·7 per cent., are subantarctic; and nine, or 9·5 per cent., are cosmopolitan, these latter being excluded from the Australian and subantarctic estimates.

With regard to local distribution in New Zealand, sixty-four, or 68 per cent., of the ninety-four species occur also in the North Island of New Zealand; thirty, or 31·9 per cent., are found only in the South Island or Stewart Island, and of these it is interesting to note that a large part—namely, sixteen—are confined (or nearly so) to the south, south-east, or southwest; finally, nine occur only in the north of the Island ("Northern Province"), but eight of these are more or less common North Island plants, where they occur in analogous formations, and the exception *Lepidium banksii* is probably not really a species.

If we further consider the foreign element of the coastal flora we find that of the nine cosmopolitan plants three live submerged in brackish water, and four are salt-marsh or salt-meadow plants—*i.e.*, there are seven which would tolerate the immersion of their seeds in salt water.

Of the twenty-seven members of the Australian element, eight are grasses, rushes, or cyperaceous plants, eighteen halophytes common in salt meadows or marshes, or which live on rocks exposed to the sea-spray, and one a submerged brackish-water plant.

The subantarctic element also, with the exception of *Veronica elliptica* and *Carex trifida*, consists of plants of more or less salt-saturated ground. As for the *Veronica* and the *Carex*, nothing is known as to the salt-resisting capacity of their seeds.

Leaving the halophytes out of the question, the *Coprosma* of Norfolk Island has succulent drupes, and *Sicyos* has barbed fruits.

The endemic element is not nearly so evidently coastal as the foreign. Many of the species are ecologically just as much alpine as maritime plants, and look, indeed, quite out of place on the sea-shore to one acquainted with our alpine vegetation. The endemic *Scirpus frondosus* is interesting as belonging to an endemic section of the genus, while ecologically it is highly specialised as a sand-binding plant, which characteristic was developed in the absence of grazing animals; and so, notwithstanding its coriaceous texture, it is frequently damaged by those which have been introduced by settlement.

The distribution of the South American element is of some interest, since it shows that so far as the coastal plants are concerned those of subantarctic origin are not confined by themselves to any part of the coast. Of the thirteen species, ten occur abundantly from the north of the North Island to the south of the South Island. *Crassula moschata*, most abundant and luxuriant in the south, reaches, however, the north shore of Cook Strait. There remain, then, as more or less specially southern or south-western forms, only *Carex trifida* and *Veronica elliptica*, and these occur on the east also, at least as far north as Dunedin.

However, this special distribution by no means disproves what has already been stated as to the struggle between the "subtropical" and "subantarctic" elements, because, in the first place, the coast is an unfavourable region for plant-life, and, in the second, all the species except three are also Australian, some having a wide range as well. And the above three species, which are essentially southern in their distribution, are purely subantarctic.

15. Life Forms and Adaptations of the True Coastal Plants.

Special details regarding the life forms of the coastal plants proper are briefly given in the table towards the end of this paper. Here a few general remarks are alone necessary.

A considerable number of the plants are halophytes, and these exhibit more or less the typical succulence of that class. Many have the rush-like habit, and of these *Leptocarpus simplex* has extremely stiff stems. Sand-binding plants—*i.e.*, those which rapidly grow at the extremities of their shoots as they are being buried, rooting at the same time—are present on the dunes, and exhibit the habit in various degress of intensity. On the salt meadows are turf-forming plants with crowded small leaves and far-creeping stems by which they increase rapidly. Indeed, vegetative reproduction of this kind is frequent amongst coastal plants, and is manifestly of advantage to the denizens of wind-swept, barren stations. Certain shrubs have the ericoid habit; others have leaves clothed below with dense tomentum. *Pimelea arenaria* has small leaves closely covered with white silky hairs.

The twiggy, divaricating habit of growth so characteristic of New Zealand, and which bears every mark of having been evolved in a region of frequent winds of long duration, is shown in *Coprosma acerosa arenaria* of the dunes, *Plagianthus divaricatus* of the salt marsh, and *Hymenanthera crassifolia* of rocks. This latter has much thicker and stiffer branches than is usual in this class of plants.

None of the shrubs lose their leaves in winter except *Plag. divaricatus*, which is practically deciduous, though in some localities a few leaves remain in the interior of the bush. Some of the salt-meadow and salt-marsh herbaceous plants have their leaves in part or altogether destroyed during the winter, and so late as early September a salt meadow in Canterbury looks as if burnt up by drought.

The three ferns are evergreen, and have coriaceous leaves, though those of *Lomaria banksii* are not strongly so. *Lomaria dura* and *Asplenium obtusatum* frequently develop short trunks.

The grasses are of the "steppe" character, excepting *Calamagrostis billardieri* and *Bromus arenarius*, both of which have thin, flat leaves. *Atropis stricta* has a ring of dead leaf-sheaths at the base of its leaves, as in many New Zealand inland grasses and those of deserts. *Senecio rotundifolius* and *Olearia operina* and its close relative *O. angustifolia* have extremely coriaceous leaves, and are in habit like shrubs of the subalpine region. So, too, are *Aciphylla latifolia* and *A. lyallii* ecologically equivalent to subalpine meadow plants.

The roots of the psammaphytes and rock plants are long, those of the salt marsh and salt meadow of medium size or even short. *Plagianthus divaricatus* has long horizontal roots, thus recalling those of the mangrove *Avicennia officinalis*, and growing in a somewhat similar station at times. When it grows in firm ground it still has roots of the same kind. The subantarctic "trunk-forming" habit such as we see in *Carex secta* is occasionally to be found in *Leptocarpus simplex*. Such "trunks" are not living structures, but are made up of dead roots and rhizomes, and are an excellent contrivance for raising a plant out of excess of water.

Stilbocarpa lyallii belongs to a class to itself, since one plant can extend over many square metres of ground by means of long arching runners which root at the nodes, there producing a thickish rootstock, from which many huge leaves raised high on long hollow stalks arise, each mass of leaves looking like an independent plant, as indeed it really is. Such a plant is an example of those large-leaved subantarctic plants which seem altogether too luxuriant for their surroundings. (See Cockayne, 13; p. 259.)

Lianes are not common amongst the true coastal plants, there being only *Tetragonia trigyna*, *Angelica geniculata* (if this be included among the "coastal"), and occasionally *Calystegia soldanella*. Parasites are altogether wanting. *Griselinia lucida* is frequently epiphytic in North Island forests, but in the South Island, where it seems strictly a coastal plant, it is confined to rocks.

Heterophylly, where absolutely different leaves appear on the same plant, or where there is a juvenile stage distinct from the adult, or a prolonged juvenile form, is wanting among the real coastal plants, though it is so common a phenomenon in New Zealand, and shown even by some inland-coastal plants. *Hymenanthera crassifolia* and *Plagianthus divaricatus* may, however, be considered to exhibit it to some small extent.

On the other hand, many of the plants are "plastic" enough. *Coprosma baueri* is a tree on dry clayey hillsides and a prostrate shrub on rocks. In both cases it has thick, rolled leaves. But when it is grown in the shade and in a wind-still atmosphere it has thinner, much larger, and quite flat leaves (Cockayne, 15A). Shade, too, has a most marked effect on the leaves of *Selliera radicans*. In other cases the nature of the soil and its water content makes the difference. Thus *Rumex neglectus* grows most luxuriantly amongst the coarse shingle of an upper shore, whereas in the wet soil of a coastal moor it is so stunted as to be hardly recognisable. *Cotula dioica*, however, may be much more luxuriant in the mud of a river-flat exposed to brackish water than when growing in a dry salt meadow. But this plant varies much in form and character in the same meadow, and doubtless some of the forms are rather constitutional and perhaps hereditary than merely the result of a special stimulus. *Myoporum lætum* is usually a low tree, but on the Moko Hinou Islands and Cuvier Island it is quite prostrate, with slender, flexible branches. *Dodonæa viscosa*, too, is either a tree, a shrub, or a prostrate plant according to its position. At Kaikoura in a salt meadow I collected a form of *Salicornia australis* with abnormally slender shoots, but which on cultivation in ordinary garden soil soon acquired a more typical form. This latter case is of interest, since the Kaikoura station was limestone, and the chemical nature of the ground seems to have been the determining factor in change of form. The colour of the shoots of *Leptocarpus simplex* seems to vary with the environment, it being dull-green in the salt marsh but more or less red in the drier ground. *Calystegia soldanella*, as already noted, is prostrate usually, but where a support is available it assumes the climbing habit. *Veronica elliptica* is usually a tall shrub, but Mr. H. J. Matthews informs me it is a low-growing prostrate plant at West Wanganui Inlet, its most northern habitat. The form of this plant, also, as I have shown (14A; p. 371) is different on the Open Bay Islands from elsewhere on the coast. *Senecio lautus* is a luxuriant plant with pinnatifid leaves when growing on gravel shores or clay banks, but when on dry rocks its leaves become small and frequently entire. Finally, *Cotula coronopifolia* has both a land and a water form.

16. Details as to the Inland-coastal Plants.

With regard to those plants which belong also to inland formations, the most important will be dealt with in the special part of this series of papers. But here it must be pointed out that where climatic conditions permit the lowland forest to reach the shore, the coastal plants are much increased in number by many forest plants which are not truly maritime. These not only spread on to the beach, but may occupy rocks which were formerly a part of the mainland. In this latter case the plants are remnants of a former forest, and it is remarkable how some of them, which have no special adaptations, can exist in positions fully exposed to wind and sea-spray. One striking example may be cited. At Jackson's Bay, South Westland, stands on the beach a rock which is an island at high water, but can be approached at low tide. On its summit is a dense growth of *Coriaria ruscifolia*, *Nothopanax arboreum*, *Coprosma fœtidissima*, *Veronica salicifolia*, *Phormium tenax*, &c.; while on a covering of peaty soil on the face of the rock, below the above, is a dense mat of the charming liliaceous *Enargea marginata*, a plant of the forest-floor in certain parts of the North and South Islands and Stewart Island. Leaving out of consideration the above class of plants, there are also true coastal forests—or, more properly speaking, belts of trees and groves, some of whose members are much more frequent on the coast than elsewhere, and many of which perhaps ought to be included amongst the coastal plants proper—at any rate, such are true coastal formations: *Myoporum lætum* (*Myoporaceæ*), *Urtica ferox* (*Urticaceæ*), *Dodonæa viscosa* (*Sapindaceæ*), *Corynocarpus lævigata* (*Cornyocarpaceæ*), *Griselinia lucida* (*Cornaceæ*), *Macropiper excelsum* (*Piperaceæ*), and in the extreme north *Dysoxylum spectabile* (*Meliaceæ*), *Paratrophis banksii* (*Moraceæ*). The palm *Rhopalostylis sapida* may also be included here.

But there is also a large element of the coastal vegetation the members of which are common inland plants, some even ascending high into the mountains. The following are more or less common examples, and they occur for the most part on the stable dunes.

A. Shrubs or low trees: *Liliaceæ — Cordyline australis; Leguminosæ — Carmichælia cunninghamii* (?), *Sophora microphylla; Violaceæ—Melicytus ramiflorus; Rhamnaceæ—Discaria toumatou; Epacridaceæ—Styphelia frazeri; Myrtaceæ—Leptospermum scoparium, Metrosideros lucida; Rubiaceæ—Coprosma propinqua; Thymelæaceæ—Pimelea lævigata repens; Compositæ—Cassinia fulvida, C. leptophylla, Olearia solandri.*

B. Lianes: *Polygonaceæ — Muehlenbeckia adpressa, M. complexa; Pandanaceæ—Freycinetia banksii.*

C. Parasites: *Loranthaceæ—Loranthus micranthus.*

D. Herbaceous plants (excluding grasses, sedges, rushes, &c.): *Iridaceæ — Libertia ixioides; Liliaceæ — Phormium tenax, P. cookianum; Orchidaceæ — Microtis porrifolia, Thelymitra longifolia; Caryophyllaceæ — Scleranthus biflorus; Rosaceæ — Acæna novæ-zelandiæ; Onagraceæ—Epilobium nerterioides; Umbelliferæ — Crantzia lineata; Scrophulariaceæ — Mazus pumilio; Plantaginaceæ—Plantago raoulii; Compositæ—Celmisia longifolia, Microseris forsteri, Raoulia australis.*

E. Grasses, sedges, &c.: *Typhaceæ — Typha angustifolia; Gramineæ—Hierochloe redolens, Zoysia pungens, Poa cæspitosa, Arundo conspicua; Cyperaceæ—Scirpus nodosus, Schœnus concinnus, Mariscus ustulatus, Cladium vauthiera, Carex lucida, C. appressa, C. ternaria.*

Had the coastal plants of the whole New Zealand biological area been under consideration the list of plants of all denominations would have been greater, since many important North Island coastal plants are absent, and the outlying islands possess some remarkable ones peculiar to themselves.

Before leaving the inland-coastal plants it is interesting to note the stations that several occupy, both inland and on the coast, as it shows the apparently wide range of conditions that many can tolerate. This is more apparent than real, since it can be seen without any special explanation that such seemingly diverse stations frequently agree in this, that they are physiologically dry, and so their plant inhabitants can find quite a congenial home on the stable dunes, for example. The following will serve as examples:—

Name of Plant.	Stations.
Cordyline australis ..	Swamps, clayey hillsides, stony river-beds, open forests, dunes.
Discaria toumatou ..	River-fans, stony plains, river beds and terraces, dry hillsides, rocks, dunes.
Styphelia frazeri ..	High alpine meadows, stony plains, river beds and terraces, clayey hills, dunes.
Leptospermum scoparium	Open forest, stony plains, dry montane slopes, old river-beds, swamps in constant water, bogs in *Sphagnum*, near solfataras and hot springs, dunes, brackish swamps.
Pimelea lævigata var. *repens.*	Subalpine tussock meadows, stony river-beds, stony plains, dunes, rocks surrounded at high water.
Cassinia fulvida ..	Montane and subalpine tussock meadows, stony plains, river-beds, dunes hardly stable, stable dunes.
Muehlenbeckia complexa ..	Taxad forests, river-terraces, montane meadows on stony ground, tussock slopes near sea forming semi-pyramidal dense bushes.
Phormium tenax ..	Lowland swamps, dry hillsides, moist hillsides, banks of streams, wet ground in river-beds, rocks, dunes, upper strand.
Phormium cookianum ..	Subalpine meadows, banks of subalpine streams, subalpine scrub, coastal cliffs.
Scleranthus biflorus ..	Montane and subalpine meadows, stony river beds and terraces, stony plains, dunes, coastal cliffs, shingly shores.
Acæna novæ-zelandiæ ..	Hillsides, dunes.
Crantzia lineata ..	Muddy shores of subalpine lakes, banks of tidal rivers to low-water mark, muddy shore, rocks, coastal moors.
Celmisia longifolia ..	Subalpine and hilly meadows, stony plains, subalpine and montane bogs, rocks, stable dunes.
Microseris forsteri ..	Montane and subalpine meadows, coastal rocks and cliffs.
Raoulia australis ..	River-beds to subalpine region, stony plains, dunes, shingly beaches.
Aciphylla squarrosa ..	Hilly meadows, dunes, shingly beaches.
Arundo conspicua ..	Swamps, wet ground in river-beds, rocks, margins of streams, dry hillsides, stable dunes.
Carex ternaria ..	Swamps, subalpine bogs, forests, dunes.

17. INTRODUCED PLANTS.

As the coastal formations become modified by the action of man through drainage, burning, and so on, and by the trampling of cattle, horses, and other introduced animals, their grazing and manuring, a large number of introduced plants make their appearance even in a formation so antagonistic as a wet salt meadow, and by slow but sure means the indigenous plants are ousted and a new formation comes into being. Such gradual changes are a distinct study in themselves, and must be reserved for the special part of this series. Likewise, the burning or uprooting of an artificial formation, such as that of *Ulex europeus*, or *Lupinus arboreus* on the dunes, is a special case of the same kind, and plants could there gain a footing which would have no chance on an unmodified dune. And this leads the way to the repetition of that great truth which I have stated before, that in a formation where man and introduced animals have never penetrated there are few or no introduced plants. Therefore it is very hard indeed at the present time to estimate what introduced plants have come naturally from the inland modified formations into the coastal region. On the virgin Open Bay Islands, for example, I only noted *Poa annua* (15). But, however they may have come, there are now a considerable number of introduced plants on many parts of the coast, where the formations are to all intents and purposes primitive. Some of these have been planted to stop the drifting sand—*e.g.*, *Ammophila arenaria*, *Elymus arenarius*, *Lupinus arboreus*, and *Mesembrianthemum edule*. *Ulex europeus* and *Sarothamnus scoparius* of the same formation have escaped in the first instance from hedges.

The following are common everywhere, and some extend to high-water mark on shingly beaches: *Hypochœris radicata*, *Holcus lanatus*, *Bromus sterilis*, *Rumex obtusifolius*, *R. acetosella*, *Œnothera odorata*, *Trifolium repens*, *T. arvense*, *Silene quinquivulnera*, *Ranunculus sceleratus*, *Nasturtium officinale*, *Sagina apetala*, *Chenopodium album*, *Senebiera coronopus*, *Stellaria media*, *Medicago denticulata*, and *Glyceria fluitans*. But the introduced plants vary much in different parts of the coast, some being confined to limited areas and special conditions, and their names and distribution are quite beyond the scope of an introductory article.

18. Origin of the Coastal Vegetation.

There is no space to inquire at any length into the origin of the coastal vegetation. The fact that nearly all the species can be cultivated easily in ground devoid of salt and far from the seashore* shows that such plants are little dependent on their special and peculiar environment for their well-being. On the other hand, many garden plants can be grown successfully close to

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* I have cultivated or seen cultivated under non-coastal conditions the following coastal plants: *Veronica elliptica*, *V. lewisii*, *V. macroura*, *V. macroura cookiana*, *V. speciosa*, *V. dieffenbachii*, *V. chathamica*, *Plantago*, sp., of the Auckland Islands, *Plantago*, sp., East Cape Island, *Crassula moschata*, *Salicornia australis*, *Myosotidium nobile*, *Myosotis capitata albiflora*, *M. antarctica traillii*, *Aciphylla intermedia*, *Samolus repens*, *Lepidium tenuicaule*, various coastal forms of *Cotula dioica*, *Stilbocarpa lyallii*, *Plagianthus divaricatus*.

the sea, even in the most wind-swept localities,* if they are afforded shelter—*i.e.*, if the wind factor be eliminated. The seeds of many maritime plants are easily capable of spreading inland by various means, and yet there is the comparatively large number (94) of species which are confined exclusively to the coast. All the above points distinctly to the supposition that *the coastal plants as a whole occupy their peculiar station not from choice, but from necessity, and that they are ordinary inland plants* which have been driven out of the more hospitable ground by better-equipped competitors. Of course, having finally settled down in a halophytic or psammaphytic station, it goes without saying that such plants would in some instances, in course of time, develop those special adaptations which distinguish coastal plants.

Certain inland xerophytes (see list in Section 16) which commonly grow under coastal conditions owe their position to their xerophytic structure and the abundance of room offered in the open coastal formations for plant-colonists. It is easily conceivable that if certain causes changed the condition of existence for such inland xerophytes, the plants of the coast might be the sole survivors. In this way, too, without any special competition with other plants, coastal species may have originated. Such, in one instance, I have shown to be the case in Chatham Island, where *Phormium tenax*, formerly a most common plant, is day by day becoming restricted to a few special stations owing to the attacks of domestic animals and drainage (12).

19. Some Differences between North Island and South Island Coastal Vegetation.

Before concluding, a few words seem desirable on certain general differences which exist between the coastal vegetation of the North and South Islands. As already pointed out, the coastal vegetation proper of the South Island does not commence until parallel 42° S. is crossed, this being, however, a by no means rigid line of demarcation. To the north of this limit the formations are closely related to those of the southern part of the North Island. It is therefore between the vegetation of the northern and southern floristic provinces that a comparison may be drawn, rather than between the two Islands as a whole. These two provinces, even on the coast, are more or less different in many ways, but these differences have a twofold origin, the

* At New Brighton, Canterbury, a garden sheltered by a paling fence has been for some years on the actual shore, and many kinds of ordinary garden plants thrive excellently. The gardens of the lighthouse-keepers, where excellent vegetables are raised, are admirable examples of the same kind. So, too, are the many inland European plants which now grow naturalised close to high-water mark so frequently.

one floristic, the other ecological. These two classes are, however, somewhat closely associated.

The floristic difference is one of genera and species. As for the latter, twenty-seven are peculiar to the North Island coast, of which some sixteen are confined to the northern province, and it is some of these plants which strongly affect the physiognomy of the vegetation. On the other hand, the peculiar southern plants play a similar *rôle.*

But the ecological difference is still more marked. This is shown chiefly in the fact that some of the northern formations have a tropical or subtropical stamp, a feature dependent partly on historical and partly on climatic factors, especially rainfall; while the southern bear a subantarctic impress, the result of the very frequent cold south-west gales.

The viviperous mangroves fringing tidal rivers and estuaries, their pneumatophores emerging from the mud; the trunks of *Metrosideros tomentosa* projecting from the coastal cliffs, densely covered with huge masses of the epiphytic *Astelia banksii*, looking like a tropical bromeliad; the succulent *Peperomia* clothing dry banks or rocks; and *Entelea arborescens*, with its great, thin leaves, are tropical enough, to quote some examples.

On the other hand, the prevailing tone of the southern province, so far as the coast is concerned, and leaving out of the question those edaphic formations common to the two Islands, is distinctly subantarctic. Here stout tussocks, coastal moors, and shrubby growths resembling those of the high mountains form a distinct feature. But even here, on the west more especially, the tropical appearance is not wanting, and, indeed, is striking enough. *Freycinetia banksii* comes right on to the upper strand, forming the fringe of a truly subtropical forest, ecologically speaking, out of which peep the feathery fronds of tall tree-ferns, and within the dim light of which filmy ferns and luxuriant liverworts abound.

20. List of Coastal Plants Proper, their Distribution and Life-forms.

In the following list the various elements of the coastal flora are thus indicated: A = endemic, B = Australian, C = subantarctic, Cos. = cosmopolitan, whether entirely or confined specially to warm regions. Other elements are indicated by an abbreviated name of the special region, as Nor. I. = Norfolk Island, Polyn. = Polynesian Islands, N. Cal. = New Caledonia, &c. For the New Zealand distribution, 1 = North Island, 2 = South Island, 3 = Stewart Island, 4 = New Zealand sub-antarctic (Southern) Islands, 5 = Chatham Islands, 6 = Kermadec Islands. The terms used for distribution on the South Island coast speak for themselves.

Name of Plant and Natural Order.	Distribution.			Station.	Life-form of Plant.
	General.	New Zealand.	South Island.		
FILICES.					
Asplenium obtusatum, Forst. ..	C, B	1, 2, 3, 4, 5, 6	All	Rocks, cliffs, peaty ground	Moderate-sized fern with very stout rhizome and thick coriaceous leaves.
Lomaria dura, Moore ..	A	2, 3, 4, 5	S.E., S., S.W.	Rocks, cliffs, peaty ground	Moderate-sized fern with thick, coriaceous, dark-green, rather narrow leaves, stout rhizome or sometimes a short arborescent stem.
Lomaria banksii, Hook. f. ..	A	1, 2, 3	E., W., S.	Rocks, cliffs, stony ground	Rather small fern with narrow, dark-green, somewhat coriaceous leaves and stout woody rhizome.
SPERMAPHYTA.					
POTAMOGETONACEÆ.					
Ruppia maritima, L. ..	Cos.	1, 2, 5	All	Lagoons, tidal streams	Slender, much-branched, aquatic herb with long filiform submerged stems, filiform leaves, and minute hermaphrodite flowers.
Zostera nana, Roth ..	Cos.	1, 2, 3	All	Muddy estuaries, between tide-limits	Grass-like aquatic herb with slender, far-creeping, matted rhizomes, narrow, thin, green, ribbon-like leaves, minute monœcious flowers, and rather short roots from the nodes.
Zostera tasmanica, Martens ..	B	1, 2	All (?)	As for *Z. nana*, but frequently in deeper water	As for *Z. nana*, but rhizomes farther-creeping and leaves longer.
Zanichellia palustris, L. ..	Cos.	1, 2	E.	Shallow estuaries, tidal streams	Slender, submerged, aquatic herb with much-branched filiform stems and filiform leaves forming close masses and minute monœcious flowers.
Althenia bilocularis (T. Kirk), Ascherson	A	2	E.	Shallow estuaries, tidal streams	Very slender, submerged, aquatic herb with branched filiform stems, very narrow leaves, and minute diœcious flowers.

Name of Plant and Natural Order.	Distribution.			Station.	Life-form of Plant.
	General	New Zealand.	South Island.		
SCHENZERIACEÆ.					
Triglochin striata, Ruiz and Pav., var. *filifolia*, Buchanan	B, C	1, 2, 3, 5	All	Salt marsh, salt meadow	Small perennial herb with stoloniferous rhizome giving off tufts of erect, slender, filiform, flaccid leaves and short fibrous roots. Flowers numerous, minute, greenish.
GRAMINEÆ.					
Spinifex hirsutus, Labill. ..	B, N. Cal.	1, 2	N., N.E.	Sandy shore, dune	Very stout, bamboo-like, sand-binding grass with extremely long, woody, creeping stems, rooting deeply, and long, silvery, coriaceous, involute leaves densely clothed with silky hairs. Flowers diœcious. Infrutescence with long spines specially adapted for spreading by wind.
Calamagrostis billardieri (R. Br.), Stend.	B	1, 2, 5	All	Dunes	Medium-sized, erect, tufted, perennial grass with thin, rather broad, flat, striated leaves and rather long roots.
Poa astoni, Petrie	A	2, 3	S., S.E.	Rocks, cliffs ..	Densely tufted perennial grass with narrow, tapering, slender, involute leaves, persistent leaf-sheaths, and long roots.
Atropis stricta (Hook. f.), Hack.	B	1, 2	All	Salt meadow ..	Rather small grass with tufted leafy culms clothed at base with dead leaf-sheaths. Leaves annual, sheathing almost the whole culm, pale-green, soft, involute. Roots short, slender, white, matted.
Atropis novæ-zealandiæ (Petrie), Hack.	A	2	S.	Salt meadow ..	Rather small very pale green grass with densely tufted leafy culms, 3–4-noded, of stouter habit than *A. stricta*. Leaves conduplicate, soft, thin.

Festuca littoralis	B	1, 2, 3, 5	All	Dunes	Densely growing perennial tussock-grass with ereet, pale-yellow (green when young), rigid, elosely involute, smooth, pungent leaves.
Bromus arenarius, Labill. ..	B	1, 2	N.	Dunes	Rather small annual grass, covered everywhere with soft hairs. Leaves linear, thin, flaccid, soon withering.
CYPERACEÆ.					
Elæocharis neo-zealandica, C. B. Clarke	A	1, 2	N.	Dunes	Very small sedge with short, slender, assimilating stems and slender creeping rhizome.
Scirpus frondosus, Banks and Sol.	A	1, 2, 3, 5	All	Unstable dunes ..	Very stout sand-binding sedge with extremely thick, woody, much-branching, far-creeping rhizome many metres in length, and giving off numerous tufts of extremely rigid, thick, coriaceous, curved and channelled, yellowish leaves, expanded below into broad, resin-exuding membranous sheaths, and tapering at apex into long points. Roots long.
Scirpus americanus, Pers. ..	B, C, S. Eur., N. Am.	1, 2, 5	All	Salt marsh, salt meadow	Moderate-sized rather rush-like plant with perennial, moderately stout, long, black, woody rhizome, triquetrous, green, erect, slender, annual stems, and short, narrow, sheathing leaves.
Scirpus robustus, Pursh. ..	B, N. Am.	1, 2	All	Salt marsh, brackish streams	Tall rush-like plant with stout, perennial, creeping stem and three-angled leafy culm furnished with a few broad, flat, grassy leaves.
Carex litorosa, Bailey ..	A.	1, 2, 3	All	Salt marsh, muddy shore	Moderately tall sedge forming close pale-green tussocks. Leaves narrow, rather thick, eoncave in front, convex behind. Roots moderate, rather matted.
Carex trifida, Cav.	C	2, 3, 4	N.(?) W., S.E., S.	Wet peaty ground where water lies	Extremely tall robust sedge forming dense and large tussocks. Leaves long, broad, tapering to fine point, bright-green, subcoriaceous but flexible, channelled on upper surface, eovered with wax between numerous ribs of under surface. Roots long.

Name of Plant and Natural Order.	Distribution.			Station.	Life-form of Plant.
	General.	New Zealand.	South Island.		
Carex pumila, Thunb. ..	C, D, E. Asia	1, 2, 3	All	Dunes and dune hollows, sandy shores, sandy beds of estuaries in shallow water at high tide	Rather small sedge with far-spreading, deeply buried, flexible rhizome producing from nodes scanty tufts of short, stout, leafy culms with flexible, thick, glaucous-green, incurved leaves, arching and tapering to a point. Roots fibrous with many short lateral rootlets.
RESTIONACEÆ.					
Leptocarpus simplex, A. Rich.	A	1, 2, 3, 5	All	Salt marsh, dunes	Tall rush-like plant forming close dense masses of crowded, hard, stiff, terete, wiry, smooth, green or reddish, assimilating, slender stems coming from a far-creeping, stout, woody rhizome. Roots wiry, frequently more or less horizontal. Flowers diœcious.
JUNCACEÆ.					
Juncus maritimus, Lam., var. *australiensis*, Buchen.	B	1, 2	N., N.E., N.W.	Salt marsh, salt meadow	Stout rush forming close masses or large tufts of densely growing, rigid, wiry, brownish stems.
LILIACEÆ.					
Arthropodium cirrhatum (Forst. f.), R. Br.	A	1, 2	N., N.W.	Cliffs	Rather large herbaceous plant with broad, pale-green, soft, rather thick and fleshy leaves and stout rootstock with many long fleshy roots. Flowers white, rather large and showy.
POLYGONACEÆ.					
Rumex neglectus, T. Kirk. ..	A	1, 2, 3, 4	S., S.W., S.E.	Shingly shore, coastal moor	Perennial creeping herb with spreading rhizome and leaves varying much in size according to situation, green, rather thin, horizontal. Roots stout, long. Flowers inconspicuous.
CHENOPODIACEÆ.					
Rhagodia nutans, R. Br. ..	B	1, 2, 6	N., N.E.	Cliffs	Prostrate suffruticose plant with more or less mealy tomentum on leaves and young stem.

					Leaves small, flat, thin. Flowers minute, semi-diœcious. Root long. Fruit fleshy.
Chenopodium triandrum, Forst. f.	A	1, 2	N.E., S.W.	Cliffs	Suffruticose trailing plant with small, thin, green, more or less mealy, membranous leaves. Flowers very minute.
Chenopodium glaucum, L., var. *ambiguum*, Hook. f.	B	1, 2, 3	All	Salt meadow, gravelly shore	Annual, much-branched, prostrate, succulent herb with fleshy green leaves, white with meal beneath. Flowers small. Root medium.
Atriplex cinerea, Poir. ..	B	1, 2	N.	Salt meadow ..	Small branching shrub covered with appressed scurfy tomentum. Leaves medium, thin. Flowers diœcious, small.
Atriplex patula, L. (including var. *hastata*)	Cos.	1, 2	All	Salt meadow ..	Annual herb varying in habit from erect to prostrate. Leaves moderate-sized, flat, rather thin. Flowers small, monœcious.
Atriplex buchanani, T. Kirk. ..	A	1, 2	N.E., S.	Cliffs	Much-branched. prostrate, semi-suffruticose plant forming small greyish-white patches. Leaves small, rather thin, densely clothed with scurfy tomentum. Flowers monœcious, minute. Root long.
Atriplex billardieri, Hook. f. ..	B	1, 2, 3, 5	S.	Sandy or gravelly shore	Succulent prostrate herb with much-spreading radiating shoots covered everywhere with watery papillæ. Leaves small, thick, succulent and fleshy. Flowers monœcious, small. Root long.
Salicornia australis, Sol. ..	B	1, 2, 5	All	Salt meadow, rock	Semi-suffruticose plant with numerous spreading, semi-prostrate, succulent, almost leafless, assimilating stems, the upper parts of which die in winter together with much of the cortex. Flowers minute. Roots stout, woody, frequently spreading horizontally.
Suæda maritima, Dum. ..	Cos.	1, 2	All	Open salt marshes	Much-branched semi-suffruticose plant varying in height, with short, thick, succulent, semiterete or cylindrical leaves and small greenish flowers.

Name of Plant and Natural Order.	Distribution.			Station.	Life-form of Plant.
	General.	New Zealand.	South Island.		
Salsola kali, L.	Cos.	1, 2	N.E.	Sandy shore ..	Rigid, semi-procumbent, loosely and much branched herb with rather short, thick, dull-green, succulent, semi-terete, prickle-pointed leaves. Flowers small. Root long.
AIZOACEÆ.					
Mesembrianthemum australe, Sol.	B, Nor. I. Howe	1, 2, 5, 6	All	Cliffs, rocks, stony shore	Suffruticose trailing or creeping plant with very long, rooting at nodes, rather thin stems and largish, thick, succulent, triquetrous leaves. Flowers large, whitish or pink. Roots long, rather slender.
Tetragonia expansa, Murr. ..	B, C, Nor. I., Howe, Jap.	1, 2, 3, 6	All	Sandy shores, gravelly shores	Semi-erect, spreading, or decumbent herb with succulent rather thick leaves. Flowers small, yellow, fairly conspicuous. Root long. Fruit horned.
Tetragonia trigyna, Banks and Sol.	B	1, 2, 3, 5, 6	All	Sandy shore, coastal shrubs beyond shore	Trailing or climbing semi-suffruticose plant with long stems and leaves, &c., much as in *T. expansa*. Fruit succulent.
CARYOPHYLLACEÆ.					
Colobanthus muelleri (*typica*), T. Kirk.	A	1, 2, 3, 5	All	Cliffs, rocks, stony shores	Tiny perennial herb with very small, channelled, rigid leaves in small rosettes. Flowers small. Root long, stout above.
Tissa media (L.), Dumort. ..	Cos.	1, 2, 3	All	Salt meadow, rocks	Prostrate or semi-erect herb with linear, viscid-pubescent, succulent, tufted leaves. Flowers pinkish, moderately conspicuous. Roots very stout, long.
RANUNCULACEÆ.					
Ranunculus recens, T. Kirk ..	A	1, 2	E.	Dunes	Small, low-growing, perennial herb with small, thick, coriaceous leaves in a rosette from a stout rootstock. Flowers small, yellow. Roots long, stringy.

Ranunculus acaulis, Banks and Sol.	C	1, 2, 3, 4, 5	All	Sandy, muddy, and stony shore	Prostrate perennial herb with pale, slender, creeping, underground stem and small, succulent, 3-lobed or 3-foliate pale-green leaves close to the ground forming patches of small rosettes. Flower yellow, small, usually buried in sand up to the calyx. Ripe flower-stem arching into or towards ground frequently. Roots long, fleshy.
CRUCIFERÆ.					
Capsella procumbens, Fries. ..	Cos.	2	E.	Cliffs	Slender low-growing herb with small leaves and numerous stems, decumbent below, ascending above. Flowers minute, white.
Lepidium oleraceum, Forst. f., var. *acutidentatum*, T. Kirk	A	1, 2, 3, 4, 5	All	Rocks, rocky shores	Tall semi-suffruticose plant with thick stem and fair-sized, rather thick, glabrous leaves. Flowers white, moderately conspicuous. Root stout, long.
Lepidium banksii, T. Kirk (perhaps, as Cheeseman suggests, identical with the preceding)	A	2	N.	Station (?) ..	As for preceding.
Lepidium flexicaule, T. Kirk ..	A	1, 2	N.W.	Station (?) ..	Procumbent, fleshy, glabrous herb with numerous branched stems and medium-sized pinnatifid leaves. Flowers white, small.
Lepidium tenuicaule, T. Kirk..	A	2, 3	E., S.E., S.	Gravelly shore ..	Low-growing herb with numerous short, procumbent, slender branches and much-cut slightly fleshy leaves close to the ground. Root extremely thick, taproot. Flowers white, small.
CRASSULACEÆ.					
Crassula moschata, Forst. ..	C	1, 2, 3, 4, 5	All	Rocks, wet cliffs, shallow-water pools, coastal moor	Succulent herb with tufted stems, prostrate below ascending above, very small thick leaves, and inconspicuous white flowers. Root moderate.
Crassula helmsii (T. Kirk), Cockayne	A	2	N.W.	Station (?) ..	Herb with numerous slender stems forming large patches and distant, small, linear leaves. Flowers minute.

Name of Plant and Natural Order.	Distribution.			Station.	Life-form of Plant.
	General.	New Zealand.	South Island.		
LINACEÆ.					
Linum monogynum, Forst. f. ..	A	1, 2, 3, 5	..	Rocks, cliffs, dunes, clayey hills and banks	Somewhat tall, rather slender, bushy, suffruticose plant with numerous small, rather narrow, more or less patent, soft, slightly fleshy, palish-green leaves and deeply descending, long, stout, and woody taproot. Flowers rather large, white, showy.
EUPHORBIACEÆ.					
Euphorbia glauca, Forst. f. ..	Nor. I.	1, 2, 5	All	Dune, gravelly shore	Tall stout herb with far-reaching deeply buried rhizome and stout, erect, fleshy stems with rather large, crowded, fleshy, glabrous leaves. Flowers small. Root long.
TILIACEÆ.					
Entelea arborescens, R. Br. ..	A	1, 2	N.	Station (?) ..	Low tree with moderate trunk and round crown. Leaves very large, thin. Flowers abundant, white, large. Fruit covered with large rigid bristles.
MALVACEÆ.					
Plagianthus divaricatus, Forst.	A	1, 2, 5	All	Salt marsh, salt meadow	Ball- or cushion-shaped, much divaricatingly-branched, almost deciduous shrub with stiff slender twigs and numerous small leaves. Flowers almost unisexual, numerous, very small, yellowish-white, sweet-scented. Roots stout, frequently spreading horizontally.
VIOLACEÆ.					
Hymenanthera crassifolia, Hook. f.	A	1, 2	N., E., N.W. (?)	Cliffs, rocks ..	Dense-growing, low, evergreen shrub with very rigid, thick, tortuous, interlacing branches frequently forming a dense stiff mat flattened against the substratum. Leaves numerous, small, thick. Flowers inconspicuous, on underside of branches. Fruits succulent, white with dark blotches.

THYMELIACEÆ.					
Pimelea arenaria, A. Cunn. ..	A	1, 2, 5	All	Dunes	Much-spreading shrub forming low cushion-like bushes of slender flexible branches clothed above with dense silvery tomentum. Leaves small, closely silvery-tomentose beneath. Flowers white, in close heads, conspicuous, polygamo-diœcious. Fruit fleshy. Roots cord-like, long.
HALORRHAGIDACEÆ.					
Gunnera hamiltoni, T. Kirk ..	A	2, 3	S	Station (?) ..	Creeping, much-branched, perennial plant with stout rhizome and numerous coriaceous small brownish-green leaves with stout, reddish, channelled petioles, in broad flat rosettes forming patches. Monœcious. Flowers small. Fruit fleshy.
Gunnera arenaria, Cheesem. ..	A	1, 2	N.E., S.	Moist hollows, amongst dunes, or flat sandy ground at back of dunes	Creeping perennial herb forming large round patches close to the ground of stout runners, fleshy and juicy, rooting at nodes, where they bear small rosettes of rather long-petioled, thick, subcoriaceous, small leaves. Flowers inconspicuous, monœcious, dimorphic. Fruit fleshy. Roots fleshy, moderate.
ARALIACEÆ.					
Stilbocarpa lyallii, Armstg. ..	A	2, 3	S.W.	Rocky shore, in dry peaty ground, among coastal shrubs	Very large herbaceous evergreen plant with long arched runners swollen into rootstocks at nodes, which root below and give off above bright shining-green, long-petioled leaves with large, thin, orbicular-reniform blades. Flowers small, reddish-purple. Plants cover large areas and increase enormously vegetatively. Roots thick, long, rather woody.
UMBELLIFERÆ.					
Hydrocotyle tripartita, R. Br., var. *hydrophila* (Petrie), Cheesem.	A	2, 3	E., S.	Shallow brackish water	Small creeping herb with short filiform stems and minute, shining, tripartite leaves. Flowers inconspicuous.
Eryngium vesiculosum, Lab. ..	B	1, 2	N., N.W., E.	Salt meadow ..	Low-growing herb with prostrate rooting stems and crowded, stiff, rosulate, moderate-sized, spiny thin leaves. Flowers in dense heads, pale-blue.

Name of Plant and Natural Order.	Distribution.			Station.	Life-form of Plant.
	General.	New Zealand.	South Island.		
Apium prostratum, Lab. ..	B, C	1, 2, 3, 4, 6	All	Salt meadow, dune, stony beach, rock	Prostrate or suberect perennial herb with thick stems and rather thick, usually large leaves, but varying much in size and texture. Flowers white, small. Root very stout and long.
Apium filiforme (A. Rich), Hook. f.	Isle of Pines	1, 2	All	Salt meadow, coastal moor, stony beach	As for preceding, but stems slender and prostrate, and much smaller in all its parts.
Aciphylla intermedia (Hook. f.), Benth. and Hook.	A	2, 3	S.E., S., S.W.	Sandy and gravelly shore, cliff	Tall perennial herb with stout erect stems full of milky juice and broad much-divided leaves with stout long petiole. Flowers white, conspicuous through their number, rather unpleasantly scented. Root thick, long.
Aciphylla lyallii (Hook. f.), Benth. and Hook.	A	2	S.W.	Sandy and gravelly shores	As for preceding, but leaf-segments much narrower.
PRIMULACEÆ.					
Samolus repens (Forst.), Pers., var. *procumbens*, R. Knuth.	B, C	1, 2, 3, 4, 6	All	Salt meadows, salt marsh, rock	Creeping herb with wiry underground stems and short, erect, leafy branches. Leaves small, rather fleshy. Flowers white, numerous, and conspicuous though small. Root medium, wiry.
GENTIANACEÆ.					
Gentiana saxosa, Forst.	A	2, 3	S.W., W., S.	Sandy peaty ground, coastal moor	Tufted herb with rather stout stems, prostrate below but ascending near apices. Leaves closely crowded, fleshy, shining, often arching downwards. Flowers large, white, conspicuous, only slightly raised above foliage. Root rather stout, long.

CONVOLVULACEÆ.					
Calystegia soldanella (L.), R. Br.	Cos.	1, 2, 3, 5, 6	All	Dune, sandy and stony beach	Creeping but occasionally climbing perennial herb with thick and partly subterranean fleshy stems and long-stalked, moderately large, fleshy, reniform leaves. Flowers showy, white with lilac stripes. Roots long.
BORAGINACEÆ.					
Myosotis capitata, Hook. f., var. *albiflora*, Armstg.	A	2, 3, 4	S., S.E.	Shady damp rocks in peat	Stout perennial herb with pale-green, medium-sized, densely-hairy, thick, soft leaves in semi-horizontal rosettes, below which are the persistent leaves of the previous year. Flowers raised considerably above leaves, white, rather small. Roots medium.
Myosotis antarctica, Hook. f., var. *traillii*, T. Kirk	A	2, 3	S., S.W.	Gravelly beach, dune	Low-growing, tufted, perennial herb with slender, spreading, leafy branches, small hispid leaves, and minute white flowers.
SCROPHULARIACEÆ.					
Mimulus repens, R. Br. ..	B	1, 2, 3	N., E., S., N.W.	Shallow streams in salt meadow, salt marsh	Perennial herb with rather thick, creeping, succulent stems, rooting at nodes, prostrate or erect branches, and small succulent leaves. Flowers showy, bright-lilac with protuberances on lower lip yellow dotted with orange. Root medium.
Glossostigma submersum, Petrie	A	2	E.	Tidal shore of lagoon	Minute, slender, branched herb forming small close mats on the ground, stems rooting at nodes, and leaves minute. Flowers extremely small and inconspicuous.
Veronica speciosa, R. Cunn. ..	A	1, 2	N.	Station (?) ..	Rather tall stout shrub with spreading branches and large, thick, coriaceous, dark-green, glossy leaves. Flowers showy, in dense racemes, crimson.
Veronica divergens, Cheesem.	A	2	W.	Coastal scrub (?)	Small laxly-branched shrub with slender twiggy branchlets and small leaves. Flowers rather small, white, in slender racemes.

Name of Plant and Natural Order.	Distribution.			Station.	Life-form of Plant.
	General.	New Zealand.	South Island.		
Veronica amabilis, Cheesem. ..	A	2	S.	Coastal scrub ..	Tall shrub with not very dense, erect, rather slender stems furnished near their extremities with rather large, slightly thick, willow-shaped leaves. Flowers showy, in long racemes of white flowers.
Veronica amabilis, Cheesem., var. *blanda*	A	2, 3	E., S.W.	Coastal scrub ..	Much as preceding, but with denser habit and perhaps thinner leaves. Flowers white, showy.
Veronica lewisii, Armstg. ..	A	2	E.	Station (?) ..	Moderately tall close-branched shrub with stout branches, medium-sized pale-green leaves, and medium racemes of large pale-lilac flowers.
Veronica elliptica, Forst. f. ..	C	2, **3**, **4**, 5 (?)	S.E., S., W.	Rocks, cliffs, coastal scrub	Tall, much-branched, evergreen shrub of dense habit with numerous rather small, pale-green, thick, close-set leaves and short racemes of large, sweet-scented, pale-lilac flowers, finally becoming white.
Euphrasia repens. Hook. f. ..	A	2, 3 (?)	S.	Coastal moor ..	Small perennial herb with (for size of plant) stout creeping stem, rooting at nodes and giving off numerous prostrate or semi-erect short branches, forming extremely dense roundish patches or semi-cushions. Leaves three-lobed, minute. Flowers small, but conspicuous owing to extreme abundance, white with purple line down centre of limb, and white-and-orange tube.
PLANTAGINACEÆ.					
Plantago hamiltonii, T. Kirk (This, if not a good species, is certainly a distinct form of *P. triandra*, Bergg.)	A	2	S.	Coastal moor, peaty bank	Small, perennial, evergreen herb having rather broad, small, rather thick, coriaceous, shining-green but with purplish-brown base, almost glabrous leaves, overlapping and forming close flat rosettes which grow crowded together and

					form a dense covering to the ground. Rootstock short and fleshy. Flowers very small. Root long and fibrous.
RUBIACEÆ.					
Coprosma baueri, Endl. ..	Nor. I.	1, 2, 6	N., N.W.	Cliffs, hillsides, rock	A small tree with gnarled branches, or a more or less prostrate shrub. Leaves shining-green, rolled more or less, fleshy. Flowers diœcious, not showy. Fruit fleshy.
Coprosma acerosa, A. Cunn., var. *arenaria*, Cheesem.	A	1, 2, 3, 5	All	Dune	Evergreen shrub with much interlaced, very wiry, yellow-coloured, twiggy branches and small narrow leaves forming a dense, low, flat bush. Flowers diœcious, inconspicuous. Roots long.
CUCURBITACEÆ.					
Sicyos australis, Endl. ..	B, Nor. I., Howe	1, 2	N.	Station (?) (Queen Charlotte Sound, collected first voyage of Captain Cook, but now probably extinct in this habitat)	Tendril-climbing liane with stout succulent stem and long-petioled, thin, large, membranous leaves. Flowers monœcious, small, greenish. Fruits small, densely covered with barbed spines. Roots long.
CAMPANULACEÆ.					
Wahlenbergia saxicola (R. Br.), A. DC., var. *congesta*, Cheesem.	A	2	N.W.	Sand	Creeping perennial herb with much-branched and interlacing stems forming dense matted patches and small leaves. Flowers medium, pale-blue.
GOODENIACEÆ.					
Selliera radicans, Cav. ..	B, C	1, 2, 3, 5	All	Salt meadow ..	Procumbent perennial herb with stout, chestnut-brown, wiry, creeping, underground stem and thick, fleshy, vertical leaves forming a dense turf. Flowers white, fairly conspicuous. Roots medium, slender.
COMPOSITÆ.					
Brachycome thomsoni, T. Kirk (excluding var. *membranifolia* and var. *polita*)	A	2, 3	E., S.	Peaty ground ..	Medium-sized perennial herb with stout creeping rhizome and stems and glaucous fleshy leaves glandular-pubescent. Heads medium, with white ray-florets. Roots fibrous, moderately long.

Name of Plant and Natural Order.	Distribution.			Station.	Life-form of Plant.
	General.	New Zealand.	South Island.		
Olearia operina (Forst. f.), Hook. f.	A	2	S.W.	Coastal scrub ..	Stout, tall, evergreen shrub with thickish, rigid, tomentose branches having rather large, lanceolate, coriaceous leaves densely tomentose on under surface, showy heads of flowers with disc yellow and ray-florets white, and long roots.
Olearia angustifolia, Hook. f...	A	2, 3	S.	Rocky ground ..	As for preceding, which it almost exactly resembles in every respect except the disc-florets are purple.
Helichrysum purdiei, Petrie ..	A	2	E.	Stony bank ..	Evergreen, suffruticose, spreading, wiry, more or less prostrate plant with many slender branches tomentose at their tips and small membranous leaves tomentose beneath. Flower-heads inconspicuous. Roots long.
Cotula coronopifolia, L. ..	B, C	1, 2, 3, 5	All	Salt meadow, salt marsh, shallow water	Evergreen herb with soft, succulent, creeping or floating stem and medium-sized, narrow, rather fleshy leaves. Flower-heads yellow, rather showy. Roots medium.
Cotula dioica, Hook. (including all its forms excepting those specially inland)	A	1, 2, 3, 4	All	Salt meadow, coastal moor	Small, evergreen, perennial herb with far-creeping stem rooting at nodes, and close-growing, aromatic, rather fleshy, green or brownish leaves. Flowers rather pale, not showy.
Senecio lautus, Forst. f. (excluding var. *montanus* and var *discoidens*)	B	1, 2, 3, 5, 6	All	Rocks, cliffs, stony shores, clayey banks	More or less erect biennial (?) herb with succulent leaves varying much in size and form according to station. Flower-heads small, yellow. Roots medium, stout.
Sonchus asper, Hill, var. *littoralis*, T. Kirk (I think this is a good species, and in a paper now in the press am dealing with it as such.)	A	1, 2, 3	..	Cliffs	Stout perennial herb with thick stems bearing rosettes of rather large, pale-green, rather thick leaves, which have a very fleshy midrib. Young leaves densely tomentose. Flower-heads moderately large, florets white. Root long, thick, and full of latex.

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ART. XXXI.—*Supplementary Note on the Defoliation of* Gaya *in New Zealand.*

By L. COCKAYNE, Ph.D.

[*Read before the Philosophical Institute of Canterbury, 14th November,* 1906.]

IN the "Transactions of the New Zealand Institute" for 1904 I published a note to the effect that *Gaya lyallii* var. *ribifolia*, growing at an altitude of less than 3,000 ft., was in its natural habitat a deciduous tree, notwithstanding the general opinion to the contrary. I also suggested that, in all probability, *Gaya lyallii* (the western plant) was also deciduous at all altitudes. Previously to this, it had been looked upon as a fact that the New Zealand forms of *Gaya* were evergreen at below 3,000 ft. and deciduous at above that altitude—a very remarkable biological fact indeed, if true. Even in the recently published "Manua of the New Zealand Flora," Mr. T. F. Cheeseman, referring to *Gaya lyallii* (the type), writes (page 80), "It is partly deciduous at high elevations, but is certainly evergreen in the river-valleys of Westland and Nelson, where it is abundant." In the appendix, however, Cheeseman quotes my contrary assertion, without, however, expressing any opinion as to its truth or the contrary. The following letter, which I received some time ago from my friend Mr. H. J. Matthews, Chief Government Forester, throws some fresh light upon the subject:—

"Dunedin, 2nd September, 1905.

"Dear Dr. Cockayne,—

"*Defoliation of* Gaya lyallii *var.* ribifolia (*Trans., vol. xxxvii*).

"In reference to your paper on this subject, I have pleasure in confirming your statement as far as I have observed adult trees in the neighbourhood of Mount Torlesse and Mount Cook. Regarding the south-western species, *Gaya lyallii*, I have recently (April and May last) observed adult specimens at Tapanui, Pomahaka Gorge, Routeburn Valley, Matukituki Valley, and Hunter River, and *in every instance* they were either leafless or nearly so; in the latter case, only a few yellow-tinged leaves remained on the extremity of the branches, and these would certainly fall with the first severe frost. At Dunedin there are hundreds of cultivated specimens which are always entirely bare of foliage during the winter. Seedling and young plants, however, without exception, retain their juvenile foliage during the winter. This refers both to wild and cultivated seedlings. Cuttings struck from the 'old wood' in all cases lose their foliage annually. The lowest and most easterly habitat of *Gaya lyallii* known to me is Tapanui, lower valleys of the Blue Mountains and the banks of the Pomahaka River, both about 500 ft. altitude. From an experience of this tree during the last quarter of a century, I believe it is entirely leafless in the adult stage at any situation or elevation.—I am, &c.,

"H. J. Matthews."

Now, from Matthews's observations and my own, there appears no doubt but that *Gaya ribifolia* is truly deciduous, especially as it still maintains that character on the Seaward Kaikouras, not being in leaf in the middle of October.*

On the other hand, so far as *Gaya lyalli* is concerned, there must remain a faint doubt as to its universal deciduousness until careful observations are recorded from Nelson and the west of the South Island.

* Cockayne, L.: "Notes on the Subalpine Scrub of Mount Fyffe (Seaward Kaikouras)": Trans. N.Z. Inst., vol. xxxviii, 1906, p. 365.

Art. XXXII. — *Note on the Cook Strait Habitat of* Veronica macroura, *Hook. f.*

By L. Cockayne, Ph.D.

[*Read before the Philosophical Institute of Canterbury, 14th November,* 1906.]

According to T. Kirk (Trans. N.Z. Inst., vol. xxviii, p. 531) and T. F. Cheeseman ("Manual of the New Zealand Flora," p. 501), *Veronica macroura* has not been observed on the shores of Cook Strait of late years, notwithstanding that this was one of the habitats where Colenso discovered a *Veronica* which, with the one common in the East Cape district, was made into the "systematic species" bearing the above name. This note is merely to point out the fact that a few plants of this species, however, do still occur on the shores of Cook Strait, growing on the face of solid rock facing the ocean between Island Bay and Happy Valley. I am quite well acquainted with *Veronica macroura* as it grows on the shores of the East Cape district, and the Cook Strait plant is, in my opinion, a form of the same species. Mr. H. J. Matthews, who with me visited the Island Bay habitat in January, 1906, agrees with my determination, but at the same time considers that the form in question should be distinguished by, at any rate, a varietal name. With this opinion I am quite in accord. I have deposited specimens in the herbarium of the Canterbury Museum, and placed a living plant in the botanical experimental garden of Canterbury College, where it is still keeping its semi-prostrate habit, thus showing clearly that this latter feature is not merely a non-hereditary adaptation to the wind-swept, dry, rocky station.

Art. XXXIII.—*Some Hitherto-unrecorded Plant-habitats* (II).

By L. Cockayne, Ph.D.

[*Read before the Philosophical Institute of Canterbury, 14th November,* 1906.]

The following list contains not only the names of plants collected or observed by myself, but also by others who have kindly supplied me with specimens or information, notably Messrs. H. J. Matthews, Henry P. Young of Orepuki, R. M. Laing, M.A., B.Sc., F. G. Gibbs, M.A., of Nelson, J. Crosby-Smith of Invercargill, and F. W. Huffam of Motueka.

So far as the Longwood Range is concerned, all the plants observed above the forest-line by Crosby-Smith, H. P. Young, and myself are noted, with the exception of those formerly collected by Mr. T. Kirk mentioned in Cheeseman's "Manual of the New Zealand Flora." This range, 20 km. in length and 868 m. in altitude, runs almost due north from Kawakapatu Bay, Foveaux Strait, and is of special phytogeographical interest, since it is the nearest high land of the South Island to Stewart Island. Although the height of the Longwoods is not great, the open land on the summit contains a rather rich subalpine vegetation. Mr. Crosby-Smith and myself were unfortunate during a visit last November to the range, since it rained heavily all day, and the mist on the summit was so thick as to make it inadvisable to proceed far from the track. Consequently, it was impossible to take more than the briefest notes, or to make a collection of any importance. Fortunately, Mr. Young has since then commenced to collect the plants of his neighbourhood, and he is also supplying most excellent details as to the stations, so that with his assistance I hope to publish before long a detailed account of the plant formations of this interesting district.

In all cases where I have seen an authentic specimen, even if collected by myself, a mark of exclamation is used; when there is no such mark I have not seen a specimen. In one or two instances habitats are given, which are noted in Cheeseman's Manual, but from which he had personally seen no specimens. I have also given in a few instances MS. names rather than leave a plant unrecorded. Where any doubt as to an identification exists a mark of interrogation is appended.

Filices.

Lomaria banksii, Hook. f.

Banks Peninsula, near Akaroa Lighthouse. L. C. !

Lycopodiaceæ.

Lycopodium ramulosum, T. Kirk.

Abundant on moist floor of stunted forest on Mount Remarkable, Stewart Island. L. C. !

Taxaceæ.

Libocedrus doniana, Endl.

Between Collingwood and West Wanganui Inlet. H. J. Matthews.

Dacrydium biforme (Hook.), Pilger.

Longwood Range. Crosby-Smith and L. C. !

Podocarpus acutifolius, T. Kirk. L. C. !

Taxad forest near Lake Brunner, Westland. L. C. !

(This habitat has already appeared in Pilger's "Taxaceæ: Das Pflanzenreich," heft 18, but it is not given by Cheeseman, and so may be overlooked by New Zealand students.)

Pandanaceæ.

Freycinetia banksii, A. Cunn.

Base of Seaward Kaikouras, a little to north of River Hapuka. H. J. Matthews !

Gramineæ.

Ehrharta colensoi, Hook. f.

Candlestick Mountains, Waimakariri district, Canterbury, on rock, 1,200 m. altitude. L. C. !

Microlæna polynoda, Hook. f.

Remnant of old forest, Port Hills, Banks Peninsula. L. C. !

Microlæna avenacea (Raoul), Hook. f.

Forest, Mount Egmont.* L. C. !

Hierochloe fraseri, Hook. f.

Subalpine meadow, Mount Egmont. L. C. !

Agrostis dyeri, Petrie.

Subalpine scrub and subalpine meadow, Mount Egmont. L. C. !

Trisetum antarcticum (Forst. f.), Trin.

Subalpine scrub, Mount Egmont. L. C. !

Danthonia pungens, Cheesem.

Summit of Mount Remarkable, in stony ground, Stewart Island. Robert Gibb !

Danthonia semiannularis, R. Br.

Subalpine meadow, Mount Egmont. L. C. !

Poa anceps, Forst. f.

Subalpine forest and scrub, Mount Egmont. L. C. !

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* Buchanan only noted two grasses in the Mount Egmont region (Trans. Linn. Soc., vol. x, p. 62, 1869). Since that time Cheeseman, Petrie, and myself have increased the number to thirteen.

Cyperaceæ.

Mariscus ustulatus (A. Rich), C. B. Clarke.

Near shore, Piraki, Banks Peninsula. L. C. !

Carpha alpina, R. Br.

Bogs, Longwood Range. Crosby-Smith and L. C. !

Cladium sinclairii, Hook. f.

(1.) On face of cliffs, Patea; L. C. ! (2.) On face of shale cliff near Taihape; L. C. !

Oreobolus pectinatus, Hook. f. (O. *pumilio*, R. Br., var. *pectinatus*, C. B. Clarke.)

Bogs, Longwood Range. Crosby-Smith and L. C. !

Uncinia riparia, R. Br. ?

Subalpine scrub, Mount Egmont. L. C. !

***Uncinia pedicillata**, Küken, sp. nov.

Forest, Ruapuke Island, Foveaux Strait. L. C. !

Restionaceæ.

Hypolæna lateriflora, Benth., var. **minor**, Hook. f.

Bogs, Longwood Range. Crosby-Smith and L. C. !

Juncaceæ.

Luzula pumila, Hook. f.

Scoria slope, Mount Egmont; altitude, 1,850 m. L. C. !

Liliaceæ.

Cordyline indivisa (Forst. f.), Steud.

(1.) Mount Egmont; L. C. ! (2.) Mount Herbert, Banks Peninsula; R. Nairn.

(The Banks Peninsula habitat was recorded in 1880 by J. B. Armstrong, the plant being thus indicated: "*Cordyline hookeri*, Kirk (*C. indivisa ?*)." I refer to this habitat here as the eastern distribution in the South Island is not given in Cheeseman's Flora.)

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* "Proxime *U. purpurata*, Petrie, differt 1, foliis rubris; 2, spicula valde elongata; 3, utriculis squamas minus excedentibus nonnisi obsolete nervosis longe pedicellatis."—*Extract from letter from Kükenthal to L. C.*

Astelia linearis, Hook. f.

Bogs, Longwood Range. Crosby-Smith and L. C.!

Astelia petriei, Cockayne ?

Wet ground, Longwood Range. Crosby-Smith and L. C.!

Arthropodium cirrhatum (Forst. f.), R. Br.

Cliffs, Stephen Island, Cook Strait. L. C.!

Arthropodium candidum, Raoul.

On loamy soil overlying limestone *débris* in partial shade of tussock and rock, Castle Hill, Waimakariri region, 800 m. altitude. F. C.!

Herpolirion novæ-zelandiæ, Hook. f.

(1.) Bogs at Waipahi, Southland; L. C.! (2.) Waimarino Plateau, west of Ruapehu, in wet ground; L. C.!

CHLORANTHACEÆ.

Ascarina lucida, Hook. f.

Forest near Kumara, Westland. L. C.!

FAGACEÆ.

Nothofagus fusca (Hook. f.), Oerst.

(1.) Patch of forest on Mount Grey, Canterbury; L. C.! (2.) Forest on Limestone Creek, south-east Marlborough; H. J. Matthews and L. C.!

URTICACEÆ.

Urtica incisa, Poir., var. **linearifolia**, Hook. f.

Subalpine scrub, Humboldt Mountains, Otago. L. C.!

POLYGONACEÆ.

Rumex neglectus, T. Kirk.

Shingly beach and peaty turf, Dog Island and Centre Island, Foveaux Strait. L. C.!

Muehlenbeckia ephedrioides, Hook. f.

(1.) Stony terrace of Ninety-mile Beach, near mouth of Rakaia River, Canterbury; L. C.! (2.) Floor of Manuka Heath, Culverden Plain, south Nelson; L. C.!

Muehlenbeckia axillaris, Walp.

(1.) Stony shore north of Greymouth, west Nelson; L. C.! (2.) Hagley Park, Christchurch, Canterbury; C. Chilton!

Chenopodiaceæ.

Atriplex billardieri, Hook. f.

Sandy shore of Mayor Island, Bay of Plenty. L. C. !

Portulacaceæ.

Claytonia australasica, Hook. f.

(1.) Wettish open ground, base of Bluff Hill, near Foveaux Strait, Southland. Crosby-Smith and L. C. !

(2.) Stony ground in subalpine meadow of Mount Holdsworth, Tararua Mountains. L. C !

Montia fontana, L.

Horseshoe Lake, near Christchurch, Canterbury. R. M. Laing and L. C. !

Hectorella cæspitosa, Hook. f.

On rock, summit of Greenhill, alpine region, Waimakariri district, Canterbury. A. H. Cockayne and L. C. !

Caryophyllaceæ.

Colobanthus muelleri, T. Kirk.

(1.) Ninety-mile Beach, Canterbury; L. C. ! (2.) Sea-shore, Orepuki, Foveaux Strait, Southland; L. C. !

Stellaria parviflora, Banks and Sol.

Mount Egmont. L. C. !

Ranunculaceæ.

Clematis afoliata, Buch.

(1.) Near high-water mark, "the Rocks," near mouth of Waipara River; H. J. Matthews ! (2.) Sea-shore, Cheviot; H. J. Matthews and L. C. ! (3.) Base of cliffs, Quail Island, Lyttelton Harbour; C. Chilton and L. C. ! (4.) Mount Grey Downs, Canterbury; L. C. !

Ranunculus tenuicaulis, Cheesem.

Subalpine meadow, Mount Holdsworth, Tararua Mountains. L. C. !

Ranunculus acaulis, Banks and Sol.

(1.) Ninety-mile Beach, on shingle, near mouth of Rakaia River; L. C. ! (2.) Salt meadow, base of Kaikoura Peninsula; L. C. ! (3.) Dog and Centre Islands, Foveaux Strait; L. C. !

Cruciferæ.

Pachycladon novæ-zealandiæ, Hook. f.

Stony ground, Mount Bonpland; altitude, 1800 m. L. C.!

Lepidium tenuicaule, T. Kirk.

Shingly beach, Waipapa Point, Southland. L. C.!

Crassulaceæ.

Crassula moschata, Forst.

Near the Akaroa lighthouse, Banks Peninsula. L. C.!

Saxifragaceæ.

Donatia novæ-zelandiæ, Hook. f.

Boggy ground on summit of Longwood Range. Crosby-Smith; H. P. Young; L. C.!

Rosaceæ.

Acæna depressa, T. Kirk.

Dunes near Riverton, Southland. L. C.!

This form of *Acæna*, which I am referring as above, has been in cultivation in H. J. Matthews's garden for a number of years, and keeps its character perfectly. It seems to me very different indeed from any subalpine or alpine form of *Acæna* with which I am acquainted. I have in cultivation specimens of this Riverton plant.

Leguminosæ.

Carmichælia monroi, Hook. f.

Stony bed of Waimakariri River, Lower Canterbury Plain. L. C.!

So far as I know, this plant does not occur on the plain itself, and the specimen here noted has evidently been brought by the river from the Southern Alps.

Carmichælia australis, R. Br. (Form with very broad cladodes.)

Waitakerei Ranges, Auckland. Petrie and L. C.!

Carmichælia, sp. (*flagelliformis*, Col. ?)

Subalpine scrub, Mount Egmont; L. C.!

Sophora prostrata, Buch.

(1.) Stony ground, Port Hills, Banks Peninsula; L. C.! (2.) Stony ground near terrace of Waimakariri River, at the

Lower Gorge, Canterbury Plain, in company with *S. microphylla*; L. C.!

Swainsonia novæ-zelandiæ, Hook. f.

Mount Ida, Central Otago. H. J. Matthews.

Geraniaceæ.

Geranium microphyllum, Hook. f.

Subalpine region, Mount Egmont. L. C.!

Rutaceæ.

Melicope ternata, Forst.

(1.) Plentiful near coast of north Nelson; F. W. Huffam. (2.) Forest, Seaward Kaikouras; L. C.!

Meliaceæ.

Dysoxylum spectabile (Forst. f.), Hook. f.

(1.) Abundant throughout the Marlborough Sounds; H. J. Matthews! (2.) Forms large part of forest of Stephen Island; L. C.!

Corynocarpaceæ.

Corynocarpus lævigata, Forst.

(1.) Near shore, Port Robinson, Cheviot; H. J. Matthews and L. C.! (2.) Along coast, south of Kaikoura Peninsula to Goose Bay; H. J. Matthews and L. C.!

Stackhousiaceæ.

Stackhousia minima, Hook. f.

(1.) Waimarino Plateau, west of Mount Ruapehu; L. C.! (2.) Culverden Plain, south Nelson; L. C.!

Elæocarpaceæ.

Aristotelia colensoi, Hook. f.

(1.) In remains of forest near Waihopai River, Invercargill. Crosby-Smith and L. C.!

(2.) Near creek, base of Mount Holdsworth, Tararua Mountains.

Aristotelia fruticosa, Hook. f.

Subalpine scrub, Mount Egmont. L. C.!

Tiliaceæ.

Entelea arborescens, R. Br.

(1.) Goat Island, off Cook's Cove. Marlborough; H. J. Matthews. (2.) Fisherman's Island, near Motueka, north Nelson, and other islands near the coast; F. W. Huffam.

Violaceæ.

Melicytus lanceolatus, Hook. f.

(1.) Mount Egmont; L. C.! (2.) Otira Gorge, Westland; L. C.!

Viola lyallii, Hook. f.

Longwood Range. H. P. Young!

Passifloraceæ

Tetrapathæa australis, Raoul.

Riccarton Bush, Canterbury Plain. Mrs. J. Deans; L. C.!

Thymeliaceæ.

Drapetes dieffenbachii, Hook.

Hills near Clinton. L. C.!

Pimelea lævigata, Gaertn., var. *repens*, Cheesem.

Dunes, Colac Bay, Southland. L. C.!

Myrtaceæ.

Metrosideros hypericifolia, A. Cunn.

Riccarton Bush, Canterbury Plain. L. C.!

Onagraceæ.

Epilobium pictum, Petrie.

(1.) Slopes of Mount Isabel, Hanmer Plains district; L. C.! (2.) Riccarton Bush, Canterbury Plain; L. C.!

Epilobium chloræfolium, Hausskn.

Mount Egmont, subalpine region. L. C.!

Epilobium linnæoides, Hook. f.

Mount Egmont. L. C.!

Epilobium sp. (aff. *E. krulleanum*, Haussku.).

Rocks on track to Bowen Falls, Milford Sound. L. C.!

(This is to call attention to this plant, so that any one interested in plants visiting the locality might perhaps collect a living plant and dried specimens for the writer.)

Epilobium rubro-marginatum, sp. nov. ined.

(1.) On consolidated stony *débris* under cliffs of Otira Glacier; L. C.! (2.) Similar station to above, and very common, near source of Rolleston Creek, Westland; A. H. Cockayne! (3.) Mount Arthur Plateau; F. G. Gibbs! I am not absolutely certain as to identity of this.

Epilobium tenuipes, Hook. f.

Stony river-flat at base of Mount Holdsworth, Tararua Mountains. L. C.!

Halorrhagidaceæ.

Gunnera prorepens, Hook. f.

Sphagnum bog, Ruapuke Island, Foveaux Strait. L. C.!

Gunnera dentata, T. Kirk.

(1.) Lochinvar Plain, Waimakariri Region; L. C.! (2.) River Kowhai, near base of Mount Torlesse Range; L. C.!

Araliaceæ.

Nothopanax edgerleyi (Hook. f.), Harms.

Common in "beech-pine forest" on the flanks of the Longwood Range, near Otautau. L. C.!

Nothopanax sinclairii (Hook. f.), Seem.

Mount Tauhara, near Lake Taupo. H. J. Matthews!

Nothopanax colensoi (Hook. f.), Seem.

Subalpine scrub, Mount Egmont. L. C.!

Pseudopanax ferox, T. Kirk.

Forest, Raincliffe Reserve, Canterbury; H. J. Matthews! Waitakere Range, Auckland (I have seen seedlings and specimens of adult plants said to have come from this habitat in garden of Messrs. Nairn and Son, Christchurch).

Umbelliferæ.

Eryngium vesiculosum, Lab.

Happy Valley, near Island Bay, Wellington; not common. L. C.!

Oreomyrrhis andicola, Endl., var. **colensoi**, Kirk.

Mount Egmont. L. C. !

Ligusticum aromaticum, Hook. f.

Summit of Longwood Range. H. P. Young !

Aciphylla squarrosa, Forst.

(1.) Stony shore of Lyall Bay, Wellington; L. C. ! (2.) Marlborough Sounds, near sea-level; H. J. Matthews.

Angelica geniculata, Hook. f.

Near base of Rock and Pillar Range, Otago. L. C. !

ERICACEÆ.

Gaultheria perplexa, T. Kirk.

On old dunes near Awarua bog, Southland. L. C. !

Gaultheria antipoda, Forst. f., var.

"Growing in peaty soil on western slope, sheltered from westerlies by a rock," Longwood Range. H. P. Young !

Gaultheria rupestris (Forst. f.), R. Br.

"Among rocks in well-drained loam, sheltered from westerly winds," Longwood Range. H. P. Young !

Pernettya nana, Col.

(1.) On open slope of Mount Earnslaw, near its base; L. C. ! (2.) Mount Ida, 1,200 m.; H. J. Matthews.

EPACRIDACEÆ.

Pentachondra pumila (Forst. f.), R. Br.

(1.) "Matted, growing in bog or semi-bog of peaty loam exposed to westerly winds," crest of Longwood Range; H. P. Young ! (2.) Abundant on old dunes near Awarua Bog, Southland, at sea-level; L. C. !

Cyathodes acerosa, R. Br.

"In shelter of forest on western slope," Longwood Range. H. P. Young !

Cyathodes empetrifolia, Hook. f.

Abundant in semi-bog in open, summit of Longwood Range. Crosby-Smith and L. C. !

Dracophyllum pearsoni, T. Kirk.*

Boggy ground on Mount Remarkable, Stewart Island. L. C. !

Dracophyllum kirkii, Berggren.

Rocky places on Mount Alexander, Westland, subalpine region. L. C. !

Dracophyllum uniflorum, Hook. f., var. **acicularifolium**, Cheesem.

As member of terrace scrub, with *Veronica traversii*, *Gaya ribifolia*, *Aristotelia fruticosa*, *Discaria toumatou*, and *Corokia cotoneaster*, River Kowai, Upper Canterbury Plain. L. C. !

Myrsinaceæ.

Suttonia montana, Hook. f.

Forest near Taihape. L. C. !

Suttonia nummularia, Hook. f.

(1.) Semi-bog, summit of Longwood Range. Crosby-Smith and L. C. !

(2.) Subalpine meadow, Mount Holdsworth, Tararua Mountains. L. C. !

Suttonia divaricata (A. Cunn.), Hook. f.

Subalpine scrub, Mount Egmont. L. C. !

Boraginaceæ.

Myosotis forsteri, Lehm.

Waimarino Forest. L. C. !

Labiatæ.

Mentha cunninghamii, Benth.

Grassy terrace of Otira River, Westland. L. C. !

Scrophulariaceæ.

Calceolaria repens, Hook. f.

Banks of creeks at base of Mount Holdsworth, Tararua Mountains. L. C. !

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* There is perhaps some mistake here. Since visiting Stewart Island a second time I find that *D. pearsoni* is a plant of the subalpine scrub and not of the bog.

Mimulus repens, R. Br.

In semi-brackish water near beach, Kaikoura. L. C. !

Mazus radicans (Hook. f.), Cheesem.

Summit of river-terrace, in open, Otira Valley, Westland. L. C. !

Mazus pumilio, R. Br.

Flat ground of dune region near Waimakariri Estuary. L. C. !

Veronica divergens, Cheesem.

"Growing in company with *V. elliptica*," sea-coast near Brighton, south Nelson. H. J. Matthews !

(This is the Manual habitat, but it is again recorded here on account of details as to its companion plant.)

Veronica buxifolia, Benth. (A quite prostrate form.)

Wet ground, summit of Longwood Range. Crosby-Smith and L. C.

I have this plant in cultivation, and also the following form.

Veronica buxifolia, Benth. (A very distinct erect form, differing altogether in appearance from either the type or the var. *odora*.)

Summit of Longwood Range. Crosby-Smith and L. C. !

Ourisia cockayniana, Petrie.

Near foot of large waterfall by Lake Minchin, Snowcup Range, Canterbury. L. C. !

Ourisia colensoi, Hook. f.

On floor of subalpine scrub, Longwood Range. Crosby-Smith and L. C. !

Ourisia macrocarpa, Hook. f.

Mount Bonpland and Lake Harris Saddle. H. J. Matthews.

Euphrasia repens, Hook. f.

Moist, sandy peat in various places near the shore of Foveaux Strait—*e.g.*, Ocean Beach, Riverton Flats, Waipapa Point. Crosby-Smith and L. C. !

Gesneriaceæ.

Rhabdothammus solandri, A. Cunn.

Waimarino Forest. L. C. !

Rubiaceæ.

Coprosma grandifolia, Hook. f.
Forest on Seaward Kaikouras. L. C. !

Coprosma lucida, Forst. f.
Subalpine scrub, Mount Egmont. L. C. !

Coprosma baueri, Endl.
Abundant on cliffs of Stephen Island, Cook Strait. L. C. !

Coprosma cunninghamii, Hook. f.
Mount Egmont. L. C. !

Coprosma tenuifolia, Cheesem.
Waimarino Forest. L. C. !

Coprosma areolata, Cheesem.
Riccarton Bush, Canterbury Plain. L. C. !

Coprosma ramulosa, Petrie.
Mount Torlesse. L. C. !

Coprosma crassifolia, Col.
Riccarton Bush, Canterbury Plain. L. C. !

Coprosma colensoi, Hook. f.
Very abundant in forest of Longwood Range. L. C. !

Coprosma banksii, Petrie.
As for *Cop. colensoi.*

Coprosma repens, Hook. f.
Summit of Longwood Range. Crosby-Smith and L. C. !

Campanulaceæ.

Pratia angulata (Forst. f.), Hook. f.
Longwood Range. H. P. Young !

Candolleaceæ.

Phyllachne subulata (Hook. f.), F. Muell.
(1.) Bog near Waipahi, south Otago; L. C. ! (2.) Waimarino Plateau; L. C. !

Forstera sedifolia, L. f.
Summit of Longwood Range. H. P. Young !

Compositæ.

Olearia illicifolia, Hook. f., var. **mollis,** T. Kirk.

(1.) Subalpine scrub, head of Otira Gorge, Westland; L. C.! (2.) Clinton Saddle, west Otago; R. M. Laing!

(I have for many years been of the opinion that this is a species distinct from *O. illicifolia*, just as much so, at any rate, as is *O. macrodonta*.)

Olearia haastii, Hook. f.

Dart Valley, Otago; 540 m. altitude. H. J. Matthews.

Olearia oleifolia, T. Kirk.

As for *O. haastii*.

Olearia coriacea, T. Kirk.

Mount Blairich. H. J. Matthews!

This form has not the peculiar saddle-shaped leaves of the Mount Fyffe plant.

(Plants of *O. coriacea* are now in cultivation in the Canterbury College garden, and in that of H. J. Matthews.)

Olearia fragrantissima, Petrie.

Saddle Hill, near Dunedin. H. J. Matthews.

Olearia hectori, Hook. f.

Tapanui. H. J. Matthews.

Olearia solandri, Hook. f.

Awatere Valley, Marlborough. H. J. Matthews.

Celmisia walkeri, T. Kirk.

Clinton Saddle. R. M. Laing!

Celmisia ramulosa, Hook. f.

Mountains near Lake Harris, Otago; abundant. H. J. Matthews.

Celmisia sp. aff. *C. hieracifolia*, **Hook. f.**

Subalpine meadow, Mount Holdsworth, Tararua Mountains. L. C.!

Celmisia holosericea, Hook. f.

Rock Burn and Sylvan Lake, Otago. H. J. Matthews.

Celmisia prorepens, Petrie.

(1.) Kingston, Mount Ida, Rock and Pillar Range; H. J. Matthews. (2.) Flagstaff Hill, near Dunedin; H. J. Matthews.

Celmisia spectabilis, Hook. f.

(1.) Mount Blowhard, one of foothills between Canterbury Plain and Upper Ashley Plain, 900 m. altitude; L. C.! (2.) Waimate Gorge and Raincliffe, South Canterbury; H. J. Matthews.

This latter is a form with long, upright leaves, and is most distinct from the common "rosette" habit of this species. Both forms are in cultivation side by side in the Christchurch Botanical Gardens, and the striking difference in habit is thus clearly manifest.

Celmisia verbascifolia, Hook. f.

Growing on side of railway-line south of Oamaru, where it has evidently reappeared since the enclosing of the line from stock, &c. L. C.!

Whether this plant is really the *C. verbascifolia* of Hook. f. is another matter. The original specimens were collected in the extreme west of Otago, and this eastern plant has not been seen there so far. It is possible that the western plant known as *C. brownii*, Chapman, is the true *C. verbascifoli* (s e remarks in Cheeseman's Manual, p. 309).

H. J. Matthews sends the following note as to distribution of this eastern plant: "From Shag Point on railway-line just above high water to 3,500 ft. on Kakanui Mountains towards Naseby, also railway-line near Hampden and mountains behind."

Celmisia brownii, F. R. Chapman.

Cheeseman refers (Manual, p. 310) to a plant gathered by me on the Humboldt Mountains which seems to be intermediate between *C. brownii* and *C. verbascifolia* (the eastern plant). The form in question I first collected in 1888, and grew it for a number of years in my garden. It is very abundant in the alpine meadows of Mount Bonpland. Its resemblance to the eastern plant is more marked when dried than when living—indeed, the two plants can be distinguished at a glance; but whether it is identical with Chapman's plant is another matter.

Celmisia mackaui, Raoul.

This is said to be still growing wild in a gully near the Akaroa lighthouse. It is probably extinct on Mount Herbert and most other parts of Banks Peninsula.

Celmisia coriacea, Hook. f.

(1.) Mount Grey, Canterbury; H. J. Matthews, L. C.! (2.) Reported from the Tararua Mountains by Buchanan, but this needs confirming. I did not note it on my recent visit to those mountains.

Celmisia,* sp. undetermined, but probably related to *C. armstrongii.*

" Restricted, so far as I was able to examine, to a hollow having a westerly aspect," Longwood Range. H. P. Young! (I have the plant in question in cultivation.)

Celmisia longifolia, Cass., var.

Wet ground, summit of Longwood Range. H. P. Young!

Celmisia laricifolia, Hook. f.

" In semi-bog, loam, eastern slope, in full sunshine," Longwood Range. H. P. Young!

Celmisia glandulosa, Hook. f.

(1.) Semi-bog, Longwood Range; H. P. Young! (2.) Waimarino Plateau; L. C.!

Celmisia parva, T. Kirk.

(1.) Mount Cobb; F. G. Gibbs! (2.) Mount Rochfort; H. J. Matthews.

Celmisia argentea, T. Kirk.

Summit of Mount Remarkable, Stewart Island. R. Gibb!

Raoulia glabra, Hook. f.

Mount Egmont. L. C.!

Raoulia australis, Hook. f.

(1.) Sea-shore, Lyall Bay, near Wellington; L. C.! (2.) Shingly shore of Ninety-mile Beach, Canterbury; L. C.! (3.) Dunes near Colac, Southland; L. C.!

Cassinia albida, Cockayne.

Mount Blairich. H. J. Matthews!

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* Since writing the above I have procured, through the kindness of Mr. Reichel, of Orepuki, a number of specimens of this plant, and propose shortly to publish a description of it under the name of *Celmisia lanceolata*. Its systematic position is between the common Otago form of *C. coriacea* and *C. armstrongii.*

Cassinia fulvida, Hook. f.

Bed of Waimakariri River, Lower Canterbury Plain. L. C. !

Senecio hectori, Buchanan.

"Between Greymouth and Point Elizabeth, 50 ft. altitude." H. J. Matthews.

Senecio cassinioides, Hook. f.

Summit of Blowhard, 900 m. altitude. L. C. !

Senecio rotundifolius, Hook. f.

(1.) West Wanganui Inlet, north-west Nelson; H. J. Matthews. (2.) Cliffs, Centre Island, Foveaux Strait; L. C. !

Art. XXXIV. — *Note on the Behaviour in Cultivation of a Chatham Island Form of* Coprosma propinqua, *A. Cunn.*

By L. Cockayne, Ph.D.

[*Read before the Philosophical Institute of Canterbury, 14th November, 1906.*]

That certain plants normally of upright habit, when exposed to constant violent winds, especially when growing in physically or physiologically dry stations, assume a prostrate habit is well known; but such habit depends entirely upon their environment, as culture experiments readily prove. Other plants, again, growing naturally in similar positions, such as *Veronica chathamica* and *Hymenanthera crassifolia*, are always prostrate, and do not materially change in cultivation. *Coprosma propinqua* is a plant of the former category. This shrub, in its usual stations, such as lowland or subalpine scrubs and fresh-water swamps, is erect with numerous more or less divaricating branches. But when it grows on the coast—as, for instance, on the shores of Foveaux Strait, at the base of the Bluff Hill—it is usually much "wind-shorn" and frequently quite prostrate, being flattened against the rocks which emerge from the peaty ground, and clinging closely to their surface. But all transitions may be seen, from the wind-swept plant to the normal, and there is no reason to expect that the former form is in any way hereditary.

Growing on the rocky face of the most easterly of the cones of the volcanic hill known as the Horns, which forms a feature in the landscape of the south-west corner of Chatham Island, I observed in 1901 a prostrate *Coprosma* which, at first glance, I thought to be a new species. On further examination it seemed more probable that it was merely a rock form of *Coprosma propinqua*, a common plant of the lowland swamps of the island. Also, similar plants, although not quite so prostrate, were observed by me growing on the wet peaty surface of the upland bogs. A living specimen of these latter I brought back with me to Christchurch.* This was cultivated for some time in a pot, and finally, about two years ago, I planted it in a sheltered part of the Canterbury College botanical experimental garden, in ordinary garden soil, and where, during dry weather, it is kept well watered.

Now, notwithstanding that this plant has every opportunity to assume an erect habit, it remains almost prostrate, with its branches spreading out laterally; indeed, it resembles, so far as my recollection goes, the Chatham Island plant of the xerophytic bog.

It may, of course, be argued that my identification is incorrect, and that the plant is not a form of *Coprosma propinqua* at all, but a new species. Even in that case its behaviour in cultivation is of interest, for all such cases should be tested by experiment as to the permanency of their adaptation-characters.

This particular class of plants in wind-swept localities, which hug the rocks on which they grow, and which in one set of species are merely non-hereditary variations caused by the mechanical action of the wind plus a dry station, and in the other are hereditary, seem to me to point strongly to the heredity of acquired characters under that particular class of circumstances. Of course, I know that the natural-selectionist pure and simple will point out how natural selection could have brought the special prostrate form into existence, and the mutationist would show how a mutation would do it still more effectively. But, with all deference to the opinion of both, and especially to the latter, it does seem that, had neither natural selection nor mutation ever been heard of, in such a case as this I have recorded, the inheritance of acquired characters would have been considered a sufficient and ample proof.

* I also brought plants from the Horns, but these unfortunately died.

Art. XXXV.—*On the Vegetation of the Westport District.*

By W. Townson.

[*Read before the Auckland Institute, 3rd October,* 1906.]

Plates XIV and XIVa.

In presenting this catalogue of the plants of Westport and its surrounding district I feel sorry that I could not stay long enough there to make it more complete, as I had expected to spend at least another year, working up the distribution and altitudinal range of my various specimens, and in verifying the notes taken during my botanical wanderings. However, I found that to be impossible, and consequently the descriptive portion of the catalogue is deficient in some respects.

A few years before the late Thomas Kirk's death I collected many specimens for him in a desultory sort of way, and he frequently asked me to take the matter up more earnestly and to prepare a list of the plants of the district. However, as I was engaged in a business which demanded close attention and in which I had little leisure, I could not see my way to accede to his request, but subsequently I was advised to reconsider the matter by Mr. Cheeseman, and I yielded, and for the last few years have devoted most of my spare time and my vacations to the work which it entailed.

All my specimens were sent up to Auckland for Mr. Cheeseman's inspection, and were carefully studied and identified by him, and proved of service in the preparation of the "Manual of the New Zealand Flora." I only claim to have collected the plants, all the technical work being done by Mr. Cheeseman, who was ever ready with kindly encouragement, and gave me much useful advice as to the prosecution of my work.

I have never regretted consenting to prepare this list, although I had no conception that it would prove to be such a big undertaking, for thousands of miles had to be walked, over hill country and plain, in fair weather and foul, and numerous difficulties had to be surmounted. But in looking back upon these years of wandering, when all my senses were on the alert, and my thews and sinews were strung to stand the strain of the longest day's tramp—when the book of nature was no more a sealed book for me, and the trees, plants, and birds became my familiar friends—they were undoubtedly the happiest years of my life.

I do not for a moment imagine that I have collected all the plants which are to be obtained in the area covered, for some of the localities were remote and not very accessible, and only admitted of a flying visit at one season of the year. The mountains forming part of the watershed of the Buller River—viz., Mounts Owen, Murchison, and Mantell—I only had the opportunity of exploring once; and, considering their many spurs and massive proportions, they would require at least a dozen such visits to anything like exhaust their store of floral novelties. Then, again, justice cannot possibly be done to a locality by a summer visit only, as the spring-time has much tribute to offer, and the autumn amongst the subalpine meadows is the season *par excellence* for a profusion of flowers. From Westport the most accessible mountain is Mount Rochfort, and consequently I have climbed it nearly a score of times at various seasons of the year, and on every occasion, with one exception, have come home with some new acquisition, met with for the first time through a change of route, or perhaps overlooked or missed on a previous search. The whole surface must be covered before one can say with any certainty that a particular plant does not grow in the district. For example, I chanced on a narrow shingle-slide on the eastern side of the peak of Mount Buckland, and there discovered *Ranunculus lyallii* blooming; and, so far as I know, that is the only locality in the Westport district where it can be found. On Caroline Terrace I came upon a small patch of *Pelargonium australe*, and never met with it subsequently. On a rocky spur of Mount Lyell I gathered a peculiar variety of *Aciphylla lyallii*, and on no other part of the mountain could I afterwards meet with it. Again, in a small patch of pakihi forest I discovered *Corysanthes cheesemanii* growing amongst the *Fagus* roots, and on the margin of the same forest *Pterostylis puberula* flourished under shelter of the fern; and, search as I would, I never found them elsewhere. Many plants are so local in their distribution, and others so easily missed, that I consider it safer to say that I have not found them than that they do not grow in the district.

In a botanical sense the Westport district was almost a *terra incognita*, as no systematic botanical work had ever been undertaken in it. Mr. T. F. Cheeseman, when working up his "Flora of the Nelson District," explored the Upper Buller Valley and Lake Rotoiti, but approached the coast no closer than Longford, near Murchison. The Rev. F. H. Spencer climbed Mount Rochfort and discovered a new species of gentian, named by Mr. Kirk *Gentiana spenceri*, and he also collected some plants at Mokihinui. Dr. Gaze some years ago made a small collection of plants in the district around Westport, but made no additions to the West Coast flora. Thus it will be seen that I had a large area of virgin country to explore, with every opportunity for making discoveries of interest, both in regard to finding novelties and of determining the range of known species. How far my efforts were crowned with success the subjoined catalogue will show, but I feel sure that a diligent search would yield many more interesting discoveries to an intelligent and persevering collector.

In a mountainous district there is so much more surface to travel over than where the country is flat, and to do anything approaching justice to the botany of the district I found it necessary to examine the slopes and summits of sixteen mountains. Of those forming the chains overlooking the sea-coast I only managed to botanize the sea-face and the tops, as on the inland side some of them are clothed from base to crown with dense forest through which no tracks exist, as several of the highest peaks have not yet been surveyed. This part of the work was always to me the most interesting, as in the subalpine regions not only was there the constant expectation of making some fresh discovery, but there is a fascination, a bracing-up and exhilaration in the higher altitudes unknown to the flats. When exploring the Lyell Mountains I was accompanied by my friend Mr. Boswell, of the Westport State School, who is an enthusiastic naturalist and an accomplished artist, and we set up our camp at an elevation of 3,000 ft., under the brow of Boundary Peak, and from that base we worked our way for many miles along the Brunner Range. At the end of ten days we broke camp, and with the aid of a pack-horse transported our belongings by way of Lyell Creek to a deserted roadman's tent under the lee of Mount Lyell, which, although at a lower elevation than our former camp, gave us ready access to the mountain.

So much time is generally lost in travelling to and from the foot of the mountains in these remote regions that that fact accounts to a large extent for our small knowledge of the upper slopes and peaks, and it was at once evident to me that if I was to do work of any value I must establish myself in the back country, and this was accordingly done. I also spent a couple of weeks in the neighbourhood of Murchison, and made an ascent of Mount Owen from the Buller side, Mount Murchison also from the Buller Valley, and Mount Mantell from the Matakitaki, returning from each one of these expeditions laden with spoils.

The Paparoas, which extend in a serried chain from the south bank of the Buller River down almost to Greymouth, stand guard over the coast-line in a series of rugged peaks, and their outline, seen from the Brunner Range, reminded me of the unevenly cut teeth of a Yankee cross-cut saw. Five of these mountains I have scaled, two of them on several occasions, and on their spurs some rarities have been gathered. The highest peak in the range, which was formerly included amongst the Buckland Peaks, I had permission from the Surveyor-General to give a distinctive name to, and I named it Mount Kelvin;

for, as its neighbour on the one hand was named Mount Buckland, and on the other Mount Faraday, a uniformity was maintained by naming this peak after the distinguished scientist, Lord Kelvin. Mount Bovis in this chain was the point farthest south of Westport which I reached, whilst a mountain at Karamea, locally known as Mount Stormy, was the limit north; and I will endeavour to describe as well as I can some of the physical features of the country lying between these two points.

An outline of the general geological formation of the explored area may prove of interest, and I cannot do better than quote from Mr. A. McKay's "Report on the Geology of the South-west Part of Nelson and the Northern Part of Westland." As many of the mountains which I shall describe form a part of the Buller's watershed, my best plan will be to briefly trace that river's course from its rise in the back ranges, through the gorge, so famous for its scenery, to where it reaches the sea at Westport. In a beautiful lake lying to the east of Mount Murchison, and named Lake Rotoiti, at an elevation of 1,800 ft. above sea-level, the Buller River takes its rise. After receiving the waters of the Hope River it is joined by the River Gowan, which drains another lake called Lake Rotoroa, lying at an elevation of 1,600 ft., and becomes quite an imposing stream. Its next tributary is the River Owen, which drains the granite and limestone spurs of Mount Owen. Below Murchison its volume is greatly increased by its union with the Matakitaki, and again at Fern Flat, where the Maruia joins it, both of which streams take their rise in the Spenser Mountains. Between these two rivers, some miles from where they junction with the Buller, rises the great bulk of Mount Mantell, which belongs to the Cretaceo-tertiary formation. At Lyell the creek of that name joins the main stream, taking its rise amongst the granite and auriferous slate ranges amongst which the dominant peak is Mount Lyell. Boundary Peak and the Lyell end of the Brunner Range also contribute streams, these mountains stretching along the west side of the Maruia Valley to the Buller Gorge, above the Lyell Township. "They consist mostly of gneissic schist and granitic rocks, crossed by bands of mica-schist, which in places is largely developed; and on the western slope, from Rainy Creek to the Buller, quartz-drifts are developed." Most of the important streams taking their rise in this range flow into the Inangahua River, which joins the Buller at the Inangahua Junction, some twenty-two miles from Westport. Roughly, the river from its rise in Lake Rotoiti to its estuary runs a course of about a hundred miles. Below the junction, at a point known as White Cliffs, the river has cut its way through the Cretaceous limestone, leaving high cliffs on both sides of the stream.

The shingle of the river-bed and terraced banks is mainly composed of granitic detritus brought down from the ranges by tributary streams, or due to falls of granite rock from the precipitous mountain-faces overlooking the gorge. "There are alluvial flats in many parts of the river's course which, though generally above high-flood mark, must nevertheless be regarded as having been deposited by the river during the modern period, and were formed when the river was running at a higher level than it does at the present time." From this point to the mouth of the gorge, six miles away from Westport, the river bends and turns in a succession of noisy rapids and still pools, at the head of the falls gliding with an unrippled and glassy sweep over the gently inclined shingle-bed, until, reaching the constricted channel where the unyielding granite rocks contract its bed, it frets and froths in a turmoil of broken water. Lovely vistas through overarching tree-tops; sunny reaches of blue water rippling over glittering shingle-beds; frowning precipices and crags, moss and fern clad from base to summit, captivate the eye at every turn of the road.

"Below the junction with the Ohika River the gorge is cut through granite mountains which dip down to the water's edge. At Hawk's Crag the breccias are met with, which extend for some miles up the Blackwater and constitute between that stream and the Little Ohika the most rugged and inaccessible country of the whole Paparoa district. The same rocks form very rugged country east of the Mount William Ridge to Hawk's Crag. The Buller then breaks through the Paparoa–Papahua chain of mountains, where the outer slopes of the ranges are granite, until passing Mount Rochfort the steep slope west from the plateau shows coal-measures tilted to high angles, and resting on the granite. Along the foot of the range high-level terraces extend from the mouth of the gorge to Fairdown, and below these, gradually sloping to the coast-line, are the pakihis—swampy plains which are partly due to the action of the river, but principally littoral marine formation." From the gorge-mouth to where the river enters the sea it runs over a winding bed of shingle, and there is always a strong current. "The Maitai slates appear in the gorge of the Waimangaroa River, and east of the granite belt are developed throughout the watershed as the fundamental rock on which rest the Cretaceo-tertiary or Cretaceous coal-measures." Mount William and Mount Frederic also belong to the Cretaceo-tertiary coal-bearing formation. Further north slates again appear in the Mokihinui River bed, and as far as I recollect granites and slate formed the chief rocks on Mount Glasgow.

"South of the Buller, in the Paparoa Range, the rocks in the higher regions, extending from the gorge to Bullock Creek, are gneissic schists, passing sometimes into granites, and at others into mica-schists." High terraces flank the mountain, varying in height from 300 ft. to 600 ft. near the Four-mile, and in parts they are two miles wide. "From Cape Foulwind the bulk of the rock is porphyritic granitoid gneiss, and often a simple gneiss," and together with limestone these rocks have been quarried for the construction of the Westport Breakwater. "Near the cape, towards the mouth of the Nile River, the coast is bold, being formed of gneissic granite followed inland by coal-bearing rocks, and at Charleston the rocks are composed of gneiss and mica-schist." From the coast-line to the base of the granite mountains is a distance of seven miles, and the intervening area is composed of pakihis and a succession of terraces. "Blue fossiliferous sands and marl clays underlie the black-sand beds and gravel deposits which form these terraces, and at Cape Foulwind they show in section, and exhibit strata in some places abounding in fossils. A range of limestone hills commences near the mouth of the Totara River, and sweeps inland in a semicircle from this point to Brighton." Fox's River has cut part of its course through this limestone range, forming one of the most beautiful gorges imaginable, for it is but a stone's throw from cliff to cliff, yet they tower up mantled with ferns and creepers for hundreds of feet. At the mouth of this river stands a remarkable pyramidal rock composed of breccia conglomerate, which is tunnelled through with lofty caves, in the floor of which I found a deposit a couple of feet deep of shells and refuse from Maori middens. "Away from the vicinity of the mouths of the larger rivers, and from a precipitous coast-line, the shingle passes into sands on the low-sloping beaches." North of the Buller River, beyond Fairdown, the shingly type of beach again makes its appearance, and continues past Mokihinui to the Little Wanganui River. From the mouth of that river to Karamea there is a sandy beach, and where the sea has cut into the bank numerous Maori ovens and shell-heaps are exposed.

"The pakihis, which take up such a large area of the flat lands of that part of the coast, are open swampy plains formed mostly by the action of the sea, and having an impervious substratum of cemented gravel where the rain-water accumulates and is held as in a sponge, encouraging the growth of semiaquatic plants." In places where the ironsand has oxidized a hard cement is formed, which is crushed in batteries for the sake of the fine gold which much of it contains. Where the surface is comparatively dry, low undulating sandy ridges and mounds appear. These lands are quite unfitted for settlement, and, to show their extent, there are 1,000 acres north of Westport and about 4,000 acres to the south, on which a few cattle wade about picking up a precarious living. Patches of forest are scattered over their surface, and a fringe of forest of varying depth forms a line of demarcation between the pakihis and the sea-beach. Rivers and creeks intersect their surface, and water-races form quite a network between the numerous dams.

I made no meteorological observations in Westport, but, situated as it is within the influence of the westerly rainfalls, it has a large proportion of wet days. The highest temperature which I remember was 81° in the shade, and in winter-time there is seldom more than two or three degrees of frost. The prevailing winds are south-west and north-west, and during the summer months a cool south-westerly breeze generally springs up before noon, pleasantly tempering the midday heat.

Starting from Westport, and taking a northerly direction, there is good travelling for six miles on a firm sandy beach, except at high water, when the sands are impracticable. This beach extends to Fairdown, but beyond that point it is shingled up, and makes very bad walking. The pakihis commence at Serjeant's Hill, extending past Fairdown, almost reaching to Waimangaroa, six miles away, and in parts they have a width of several miles. On these wet plains walking is difficult, except in very dry weather, as there are considerable areas of swampy ground where *Typha* flourishes, associated with *Carex paniculata*, *C. virgata*, *C. gaudichaudiana*, and *Leptocarpus simplex*. The creeks and rivers traversing the pakihis have their banks fringed with bushes, conspicuous amongst which are *Coprosma lucida*, *C. grandiflora*, and *C. parviflora*, with *Veronica salicifolia*, *V. gracillima*, and *Ascarina lucida*. On the drier portions where slight elevations exist, *Leptospermum scoparium* and *L. ericoides* flourish, whilst *Pteris aquilina* and *Gleichenia circinata* are the prevailing representatives of the Filices. The railway crosses these pakihis, and train can be taken from Westport to Mokihinui Mine, a distance of thirty-one miles. On the banks of the railway I have found many curious plants, which have become naturalised there through vessels from Australian ports arriving at Westport, the ballast from which has been utilised for making up the railway embankment. Amongst these are *Portulaca oleracea*, *Amarantus blitum*, *Chenopodium murale*, *Emex australis*, *Asphodelus fistulosus*, *Cynodon dactylon*, *Eleusine indica*, and others which have not been identified, and which probably came from Africa.

The pakihis extend to the foot of Mount Rochfort and some distance up its slopes, and in all the Papahua Mountains considerable tracts of these swampy lands are found at an elevation of from 1,000 ft. to 2,000 ft.

Many gullies seam the face of Mount Rochfort, and in one of them runs Giles's Creek, which supplies the Town of Westport with excellent water. This joins with other creeks running in adjoining gullies to form the Orowaiti River, which enters the sea a couple of miles from the town. In Giles's Creek I found *Gnaphalium subrigidum* and *Raoulia tenuicaulis* growing on the shingly bed of the stream, whilst *Lindsaya viridis* and *Trichomanes elongatum*, though rare, may be found draping the face of the papa cliffs in dark and sheltered situations. *Lomaria frazeri* grows luxuriantly in all these gullies, and *Dicksonia squarrosa* is abundant. *Fagus* forms the greatest proportion of the timber in that locality, and I have seen trees fairly ablaze with the scarlet flowers of *Elytranthe tetrapetala* in the early summer.

On climbing out of the gully on to the high-level terrace, where in days gone by good gold was found, numerous bare patches are seen on the mountain-face where fires have burned off the scrub, leaving little else to clothe the surface than *Hypolœna lateralis*, *Gleichenia dicarpa*, and *G. circinata*, with a few gentians and orchids.

Mount Rochfort was one of my favourite hunting-grounds, and many interesting plants were found on its spurs. In the forest at an elevation of from 1,000 ft. to 2,500 ft. grows the rarest of our ratas—viz., *Metrosideros parkinsonii.* It forms a very conspicuous object with its brilliant crimson flowers, which grow in clusters on the branches, which are often bare of leaves. At times it is a straggling shrub, and at others a small tree; and I have noticed that nearly every specimen is affected with a blight which blackens and pits the leaves. I have also found it growing about 200 ft. above sea-level at Caroline Terrace, and it is thinly distributed through the forests clothing the Paparoa Mountains. On the mountain pakihis numerous orchids are to be found, the most noticeable being *Thelymitra pachyphylla*, with its flowers variously coloured from a beautiful dark-blue to purple, and again shading from delicate pink to a pale creamy-white; the curious *Calochilus paludosus; Pterostylis banksii;* and here and there under shelter of the mountain-flax the rare *Pterostylis venosa*; whilst in the higher regions *Prasophyllum colensoi*, *Lyperanthus antarcticus*, *Caladenia minor*, and *C. bifolia* are plentiful. *Gastrodia cunninghamii* and *Microtis porrifolia* are also fairly abundant. In these open situations *Actinotus novæ-zealandiæ*, another very interesting plant, grows freely amongst the rocks on the drier part of the pakihi, and is seldom found at a lower elevation than 1,500 ft. In the subalpine bogs the delicate purple flowers of *Utricularia monanthos* are not uncommon, often associated with the white star-like flowers of *Liparophyllum gunnii*, which are at times submerged, the plant growing deeply bedded in the peaty soil. Both of these plants I have also found on the pakihis, almost at sea-level, growing in the peaty bogs and on the spongy banks of the watercourses, and they are both quite common in these situations. The gentians at the lower levels are *Gentiana spenceri* and *G. townsoni*, Cheesem., a new species which Mr. Cheeseman has honoured me by giving my name to, and which is one of our most beautiful West Coast flowers. It grows in the open and most exposed situations, and many plants may often be seen clustered together; and as several stems generally arise from one root, each crowned with its umbel of large white flowers, a patch of these gentians forms a veritable beauty-spot upon the uniformly dreary surface of these boglands. *Gentiana spenceri* affects the scrub, and where it grows on the open ground I imagine that the bushes which formerly sheltered it have been burnt off. Up at the trig. station *Gentiana montana* whitens the surface and blooms in magnificent profusion amongst the tussocks of *Danthonia raoulii.*

A peculiar form of *Celmisia* is found on these upland bogs which has the unusual habit of not only growing on the open ground, but also deep in the shelter of the scrub. Mr. Cheeseman has decided that it is a new species, and has named it *Celmisia dubia.* In the low forest under the shade of *Fagus cliffortioides, Dacrydium biforme, Elæocarpus hookerianus,* and *Panax lineare* grows another rarity—viz., *Drimys traversii.* On the Westport mountains it seldom exceeds a height of 16 in., and it straggles over the moss-covered rocks just where the low forest is thinning out at the higher levels. It is a shy bloomer, and for flowering specimens I have always had to make a close search, as its small green flowers are very inconspicuous; and only on one occasion did I find the dark-purple berry, so I conclude that the ripe berries, with those of *Astelia lineare*, which are also hard to find, form a part of the diet of the wekas which abound in those regions. From 1,500 ft. to 2,500 ft. is its altitudinal range, and Mount Rochfort and Mount Frederic are the only mountains on which I have found it growing, never having met with it on the Paparoas across the Buller River. I had the good fortune to discover in the same situation a little orchis which forms a new genus, and which Mr. Cheeseman has honoured me by naming *Townsonia.*

I must take this opportunity of thanking him for the compliment which he has paid me in thus associating my name with the science of botany in New Zealand, and giving me such liberal rewards for my work, which has always proved to be to me a labour of love. This delicate little plant *Townsonia de-*

flexa is only found at about the same elevation as the *Drimys* just described, growing in the shelter of the manuka and *Olearia colensoi*, on the bosses of moss and prostrate tree-trunks. It blooms in November and December, but is easily overlooked, as it is very slender, averages from 4 in. to 5 in. in height, and its colour much the same as the cushions of moss on which it grows. When fully matured the flowers show a purplish tint. I have also found it growing on Mount Frederic, and across the Buller on Mount Buckland, at the same elevation.

On the open stony places near the summit *Celmisia lateralis* and a small form of *Celmisia longifolia* abound, and on the edges of the dense patches of *Olearia* which border the bare ground grow *Forstera sedifolia*, *Euphrasia revoluta*, and *Anagosperma dispermum*. *Ourisia macrocarpa* blooms amongst the conglomerate cliffs on the eastern face, and *Ourisia macrophylla* is plentiful around the waterfalls in the numerous gullies. *Coprosma colensoi* and *C. retusa* are found in the fissures and crevices of the crags below the trig. station, and in the same sheltered niches the rare little grass *Ehrarta thomsoni*. *Pimelea gnidia* and *P. longifolia*, *Epacris alpina*, *Archeria traversii*, *Leucopogon fasciculatus*, and *Cyathodes acerosa* are also abundant. *Ligusticum haastii* and *L. aromaticum*, *Senecio bellidioides*, and *Drapetes dieffenbachii* are plentiful, but you look in vain for *Veronicas* with the exception of *V. buxifolia*, *Aciphyllas*, or any varieties of *Myosotis*. No *Raoulias* excepting *R. grandiflora*, and few varieties of *Epilobium*, occur.

The Westport Coal Company's workings at Denniston and Coalbrookdale are situated on Mount Rochfort, and back from them and more to the eastward Mount William rises to an elevation of 3,300 ft. I only climbed this mountain once, and made no discoveries of any importance, only bringing back with me *Dracophyllum rosmarinifolium* and *Oreobolus pumilio*. In Cascade Creek, running at its base, I found *Calceolaria repens* flowering amongst the drip from the rocks, and at Cedar Creek, a neighbouring stream, I gathered *Carex cockayniana*. Near the Iron Bridge workings, and also below in the gorge of the Waimangaroa River, I found a new species of *Dracophyllum* named *Dracophyllum pubescens*, Cheeseman. It grows on the steep face of the rock, being often out of reach, and is a stout much-branched plant with a procumbent habit, its leaves acuminate and finely pubescent on both surfaces, and the flowers in 3–5-flowered spikes. It is very local, for I have not met with it in any other locality.

The Waimangaroa River divides Mount Rochfort from its neighbour, Mount Frederic, a slightly higher mountain, but which has not proved so good a field for botanical research. The track takes up from the river, and is the old incline down which coal was formerly lowered from the Koranui workings, and very rough walking it makes, as the surface-water has made a channel of the incline, guttering it out and cutting it up badly. Bordering the track *Gaultheria rupestris*, with its beautiful white racemes, and *Cordyline indivisa* flourish, the latter being found on parts of the mountain growing in quite extensive groves, where I have found it flowering, although a very shy bloomer, and occasionally have found two flower-heads on one stem. *Gahnia hectori* also grows alongside the track. *Fagus*, *Panax simplex* and *P. edgerleyi*, *Pseudopanax crassifolium*, *Weinmannia racemosa*, *Quintinia acutifolia*, *Coprosma fœtidissima*, and *Myrsine salicina* form the greatest proportion of the forest at the low levels. Amongst the yellow-pines, at an elevation of 2,000 ft. or more, the beautiful purple-veined flowers of *Gentiana montana* var. *stolonifera* are met with, and when searching for specimens of this plant I came across numbers of the shells of *Paryphanta hochstetteri*, but seldom found one perfect, as the wekas destroy them. Close to the summit *Celmisia dallii* makes its appearance, and *Cassinia vauvilliersii* is fairly plentiful, and where the surface is bare the peculiar green humps of *Raoulia mammillaris* are not uncommon. Amongst the loose stones a stunted form of *Gentiana patula* forms beautiful rosette-like clusters, but *Gentiana montana* is absent. *Drimys traversii*, *Metrosideros parkinsoni*, *Townsonia deflexa*, and *Pterostylis venosa* are amongst the rarest of the plants which grow on Mount Frederic, and *Drosera arcturi* is quite common in the moss-covered bogs.

Passing in a northerly direction along the range you reach Millerton, at an elevation of nearly 2,000 ft., where the Westport Coal Company has workings, and from the township a track leads down to Granity Creek, where the coal-bins are situated. *Pterostylis banksii* is abundant on the sides of the track, and *Olearia cunninghami* here reaches its southern limit. At Granity Creek there is an abrupt coast-line, the spurs of the mountains coming down to within a few chains of the beach, and at Christmas time their slopes are scarlet with the flowers of *Metrosideros robusta*, which, together with the feathery fronds of the tree-ferns and the graceful crowns of the nikau palms, make a very charming picture, which is completed by the sea breaking in foamy lines upon the shingle-banks at their foot. From Granity Creek to Mokihinui the travelling, either by way of the beach or on the railway-bank, is bad, and until the road through is completed one or other of these routes must be followed.

I camped for a week at Mokihinui, and made two ascents of Mount Glasgow from there. It is an exceedingly treacherous mountain, as rarely a day passes without its peak being shrouded in fog, and on both occasions I had the misfortune to be enveloped in it. An old survey track had to be reblazed and opened up with a bill-hook, and much precious time was lost in track-cutting. The mountain rises to a height of 4,800 ft., its ridge extending apparently for some miles and describing three parts of a circle, where, in the hollow thus enclosed, and 500 ft. below the ridge, lies a beautiful lake, deep, dark, and placid, and it looks to be at least half a mile in diameter. A grand precipice rises sheer from its eastern bank, making a most imposing picture, whilst a number of lakelets in adjoining hollows greatly enhance its beauty. Here I found *Olearia lacunosa* on the forest-margin; *Helichrysum grandiceps* and *H. bellidioides* amongst the rocks on the ridge; and *Veronica carnosula*, *Poa novæ-zealandiæ*, and *Agrostis dyeri* amongst the rough boulders which surround the lake. So far as I could see, *Ranunculus*, *Aciphylla*, and *Myosotis* were unrepresented.

From Mokihinui I walked to Karamea by the inland track, the road zigzagging up the steep bank of the Rough-and-Tumble until, after crossing the saddle, it descends again into the valley of the Little Wanganui. If I remember rightly, *Arthropodium candidum* was the only addition made to my collection on the side of this track, and my trip to Karamea was remarkably barren in results. For one reason, it is difficult country to travel about in, as most of the roads at that time consisted of disconnected sections, whilst lagoons and back-waters proved very embarrassing. I gathered *Carmichælia flagelliformis* on the banks of the salt-water lagoons, and I noticed some fine clumps of *Corynocarpus lævigata*, evidently about the sites of ancient Maori camping-places. There was evidence of a large number of Maoris having once lived near the estuary of the Karamea River, and I have had numerous stone axes sent to me from that locality.

I returned to Mokihinui along the beach track, parts of which can only be negotiated at low water. After being ferried across the Little Wanganui River your route lays for miles over a rough boulder-strewn beach, and you can only progress by jumping from one to another, and it makes progression slow and difficult, especially in rough weather when the spaces between the boulders are filled in with spume from the breakers. At a point known as Big Hill the track takes to the bush, through which you climb up several hundred feet on the cliff-face; and I noticed that in places where the water ran across the track it left a deposit on all that it touched, coating over grass, moss-leaves, and ferns with a crust of lime, with which the water is highly impregnated. *Corysanthes macrantha* is very abundant on this bluff, and I found *Veronica macrocarpa* var. *crassifolia* growing there, which Mr. Cheeseman describes as "differing markedly from the type in having much narrower, smaller, more coriaceous, and rigid leaves, and in the acute calyx segments, and may prove to be a separate species." Pellucid glands form a dotted margin to each leaf, and I noticed that in a plant which I now have under cultivation this appearance is less marked. Beyond the Big Hill, where the track again reaches the beach, some fine limestone cliffs rise to a height of several hundred feet, forming a conspicuous object from Cape Foulwind, nearly fifty miles away. Here and there along this rugged coast-line are patches of karaka growing to a great size, and groves of nikau palms beautify the cliffs' base, whilst *Poa cæspitosa* var. *australis* and *Deyeuxia billardieri* drape the rocks with their green tassels. Under the shelter of the *Coprosmas*, *Piper excelsum*, and *Fuchsia* bushes, *Pteris macilenta* grows in great luxuriance, and *Lomaria banksii* and *Polypodium tenellum* are also plentiful. Between the bluffs and the mouth of the Mokihinui River there is a stretch of open beach, where I found *Hydrocotyle dissecta* and *Carex colensoi* growing amongst the driftwood, and I also collected *Lepidium flexicaule*, *Tetragonia expansa*, *T. trigyna*, and *Chenopodium glaucum* on the sandy beaches about Mokihinui. Cape gooseberries cover a considerable area as you approach the banks of the river, and must yield a handsome harvest to the settlers living on the spit. On the banks of the river *Carmichœlia angustata* is common, and a few miles up-stream a curious variety of *Aristotelia racemosa* grows, which bears large red berries, and forms a beautiful object when loaded with fruit. Between Mokihinui and Westport the beach furnishes nothing of particular interest.

My best course will be now to briefly describe the botanical features of the portion of the Buller Valley which I visited, and give what information I can as to the plant-distribution. At the mouth of the Buller River there are tidal lagoons which cover quite an extensive area, and which at low water become converted into mud-flats, covered mostly with *Samolus repens*, *Selliera radicans*, *Eleocharis acuta*, *Leptocarpus simplex*, *Scirpus lacustris*, and *Juncus*. There are several islands amongst the lagoons bearing grass and pasturing a few head of stock, and the banks of the islands are fringed with low bushes, conspicuous amongst which are *Veronica salicifolia* and *V. parviflora; Coprosma fœtidissima*, *C. parviflora*, *C. propinqua*, and *C. lucida; Carmichœlia angustata* and *C. subulata; Myrsine salicina*, *M. durvillei*, and *M. divaricata*, with a few bushes of the rare *Myrsine montana; Cordyline australis*, *Pittosporum tenuifolium*, and *Dodonœa viscosa*. Some little way above the railway-bridge which spans the Buller the bush approaches the banks of the river, and this condition exists almost continuously through the gorge, only a few cultivations and grass clearings existing between the mouth of the gorge and the Inangahua Junction. Close to the bridge, on the rocks which are only exposed at low water, the little *Myriophyllum pedunculatum* forms compact green patches, and near by in a wet paddock *Gratiola nana* is plentiful, a plant by no means common around Westport. About two miles up-stream, in some low bush composed of *Aristotelia racemosa, Hedycarya arborea,* and *Melicytus ramiflorus,* is one of the best ferning-grounds which I know of. In that restricted area I have collected *Pteris tremula* and *P. macilenta, Pellæa falcata* and *P. rotundifolia, Asplenium umbrosum, Lomaria membranacea* and *L. frazeri,* and *Aspidium richardi,* amongst others. Doubtless the spores of some of these ferns are carried down from the back country when the river is in flood, and, finding a congenial soil, have now become permanently established. *Coprosma rugosa,* a new species, closely allied to *C. acerosa,* grows on the banks near the first falls, and attains a height of 12 ft. or more. Just above the falls there is an island of some extent, covered for the most part with low bush, and under its shelter I found my first specimens of *Australina pusilla,* growing amongst the moss, and here and there a bush swathed with *Clematis fœtida,* a plant very uncommon about Westport. An introduced plant, *Lysimachia nummularia,* or money-wort, covers some swampy ground bordering the bush, and Mr. Cheeseman considers it to be its first appearance in New Zealand. *Carex ternaria* and *Carex comans* are common on the sandy beaches, and *Poa colensoi* var. *intermedia* and the graceful *Poa anceps* droop gracefully from the overhanging rocks. On the more marshy ground, and sometimes in the slowly running water, *Isotoma fluviatilis* is seen, and is quite common in similar situations around Westport.

At the Blackwater I found the delicate *Adiantum æthiopicum* growing amongst the rocks in the river-bed, and on the sandy banks *Claytonia australasica* seemed quite robust almost at sea-level, although the last time that I had seen it was at an altitude of 4,000 ft. on Mount Mantell. *Senecio hectori,* with its corymbs of beautiful white flowers and showy foliage, *Carpodetus serratus, Pennantia corymbosa,* with *Schefflera digitata* and *Hoheria populnea,* give variety to the river-banks, whilst the scarlet blooms of *Metrosideros florida* and *Elytranthe tetrapetala* provided the requisite touch of colour. Under the limestone cliffs near the Junction I found quantities of both *Pellæa rotundifolia* and *P. falcata,* and amongst the rocks in the river-bed *Adiantum æthiopicum* was growing in nearly every crevice. I was sorry to see that the country around the Junction was overrun with blackberry, and I noticed that it had taken complete possession of several paddocks near the bridge. Ragwort is also in evidence in several parts of the Buller Valley, and is especially noticeable at Fern Flat.

It is about eleven miles from the Junction to the Lyell, and on the road I discovered *Gratiola peruviana* growing in the boggy ground on the roadside, and *Lythrum hyssopifolium* was plentiful there. I secured no novelties about the Lyell Township, so went on to Murchison, where I stayed for a week. On the Buller River bed, close to its junction with the Matakitaki, *Corokia cotoneaster* was in full berry, *Discaria toumatou* was plentiful, and I made my first acquaintance with *Epilobium microphyllum*, which I found in abundance on the shingle amongst the driftwood.

From Murchison I made my first excursion up the Matakitaki for the purpose of climbing Mount Mantell, and on my way found *Helichrysum depressum*, which grows on the shingle-banks in the river-bed. The mountain presents no difficulties to the climber, and there is an ample reward for the labours of the ascent in the extended view which is obtained from the summit, including as it does nearly the whole of the watershed of the Buller. I observed that clover grew luxuriantly around the trig. station, and it is accounted for by the fact that when sheep were run on the mountain the open ground was sown with English grasses and clover. My Mount Mantell collection included *Helichrysum microphyllum*, *Gnaphalium traversii* var. *mackayi*, *Veronica traversii* and *V. armstrongii*, *Claytonia australasica*, *Ligusticum piliferum*, and *Brachycome sinclairii*. I was greatly charmed with the wealth of blossom in the gullies, where *Senecio lyallii*, in tints varying from bright-yellow to pure white, blooms so freely.

My next excursion was to Mount Murchison, and I was kindly entertained by Mr. Rait, who has a sheep-run at the base of the mountain. He accompanied me in making the ascent on the following morning, and as I was approaching ground which had never been botanized my expectation of securing some rare specimens was correspondingly great. My high hopes were not realised, however, for on reaching the open country the fog descended upon us, and it became so cold and wet that we were compelled to beat a hasty retreat. I gathered, amongst other plants, *Celmisia spectabilis* and *C. hieracifolia*, *Craspedia fimbriata* var. *lanata*—found for the first and last time—*Epilobium novæ-zealandiæ* and *E. chloræfolium*, *Euphrasia monroi*, *Geum leiospermum*, *Pimelea lyallii*, *Myosotis australis*, *Pozoa roughii*, *Celmisia monroi*, and *Veronica cockayniana*.

I was sorry not to have the opportunity of spending another day on Mount Murchison, but my time was very limited, and I had arranged for a fresh expedition next day, so I once more forded the Buller on horseback, and with a son of Mr. Win's left the Owen Junction for the deserted township situated close to the foot of Mount Owen. We loaded our outfit on to a pack-horse and walked the eight miles over a very indifferent road which traverses Baigent's run, and crosses and recrosses the Owen River. On the marshy lands through which we passed I saw great quantities of *Bulbinella hookeri*, but I could not find time to examine the flat. . We took up our quarters at the old Enterprise Hotel, which contained the furniture and fittings, which had never been interfered with since the house had been abandoned many years ago when the Owen reefs duffered out. It afforded us an ideal camping-place, and we had a paddock also for the horse. We got on our way by starlight in the morning, passing the ruined huts and batteries, and by sunrise were well up the lower spurs of the mountain. My attention was first arrested by the curious little orchis, *Adenochilus gracilis*, which grows amongst the cushions of moss between the *Fagus* roots, at an elevation of about 1,000 ft. In the scrub belt *Olearia lacunosa* was conspicuous, but I could not spend much time at that level for fear of fog invading the higher regions. On leaving the subalpine forest the climbing for some distance was mostly done on hands and knees, owing to the steepness of the spur and the slippery nature of the surface. Here *Epilobium vernicosum* was in bloom, and formed the most striking feature of the flora, in conjunction with *Myosotis concinna*. *Veronica linifola* formed bright-purple patches amongst the rocks, and a peculiar form of *Aciphylla* with flaccid unarmed leaves proved of great service in affording good hold for our hands on the steep spurs. *Erechtites glabrescens* and *Cotula pyrethrifolia* grew on the middle slopes, and at an altitude of from 3,000 ft. to 5,000 ft. I gathered *Angelica decipiens*, *Cardamine latisiliqua*, and *Ranunculus geraniifolius*, whilst amongst the fissures of the rock *Ranunculus insignis* and *Colobanthus canaliculatus* were not uncommon. These, together with *Coprosma cuneata* and *C. repens*, *Euphrasia cheesemanii*, *Gnaphalium microphyllum*, *Notothlaspi australe*, *Veronica armstrongii*, and *Poranthera alpina*, made up a very interesting collection. At an elevation of 4,500 ft. *Cystopteris fragilis* was growing under the shelter of the cliffs, and from that point on to the summit, 6,100 ft., was the most difficult travelling which I had encountered. The formation was crystalline limestone, which was fissured and channelled and riddled with caves, in which the snow still lay at midsummer, and the surface was cut about in such a way as to compel us to travel with great caution.

It may not be out of place to quote from a magazine article which I wrote some years ago, in which I gave a description of the view from the peak of Mount Owen. "In the middle distance to the north Mount Arthur and the mountains at the head of the Karamea River were the most conspicuous objects, whilst more to the eastward Tasman Bay was seen gleaming blue as amethyst. To the south-west the Lyell Ranges formed a rugged line, and further south the Paparoas stood guard over the coast-line down as far as the Grey Valley. The River Maruia could be followed south in its long-winding course towards the Cannibal Gorge, near where it takes its rise, and the Matakitaki could be traced as a silver line from its rise in the Spenser Ranges to the gorge where Mount Mantell overshadows it. The Buller was seen from its source in Lake Rotoiti, threading its way past Kerr's Lake Station, and increasing in volume as it coursed past the Owen and Murchison."

My next camp was set up on Boundary Peak at an elevation of 3,000 ft., with the view of botanizing the Lyell end of the Brunner Range. A prospecting-track has been cut along the range for some twenty odd miles, and when completed will reach the Victoria Range near Reefton. This track proved of great service to us, for where the country is clear the line has been marked out by finger-posts, which saved us from taking many a roundabout course when returning tired to our camp. The summit of Boundary Peak reaches an altitude of 4,500 ft., whilst some of the mountains in the chain approach 5,000 ft. and are extremely rugged. There I found a variety of gentian with large flabby leaves, and the pretty little *Euphrasia zealandica*, but the flowers do not quite answer to the description given in the Flora, as they have a bright-pink centre instead of being white as in the type. *Aciphylla lyallii*, *A. colensoi*, *A. hookeri*, and *A. townsoni* were plentiful on the farther spurs, associated with *Celmisia coriacea* and *C. armstrongii*. Mr. Cheeseman has on several occasions remarked the paucity of varieties of *Aciphylla* on the eastern ranges as compared with the western, where there are so many. Amongst the stony ridges *Azorella haastii* and *A. pallida* were constantly met with, and both *Ligusticum deltoideum* and *L. imbricatum* were not uncommon. *Drapetes villosa* var. *multiflora*, *Celmisia petiolata* var. *membranacea*, *Notothlaspi australe* var. *stellatum*, and *Ranunculus tenuicaulis* were some of the rarities obtained, and amongst the rough crags at an elevation of 4,000 ft. I discovered a new variety of *Myosotis*. It is white-flowered, and Mr. Cheeseman remarks that "it is apparently allied to *M. saxosa* and *M. lyallii*, but differs from both in the flowers being chiefly axillary," and he has named it *Myosotis townsoni*. It is apparently a rare plant on the Brunner Mountains, as I only secured a few specimens after making an exhaustive search. *Myosotis antarctica*, *Ranunculus monroi* and *R. geranifolius* (the large-leaved variety), *Coprosma depressa*, *Brachycome thomsoni* var. *membranifolia*, *Microseris forsteri* (gathered for the first time), *Archeria traversii*, *Dracophyllum urvilleanum* var. *montana*, *Gentiana bellidifolia*, *Veronica cockayniana* and *V. coarctata*, *Euphrasia cheesemanii*, *Juncus antarcticus*, *Scirpus aucklandicus* var. *subcucullata*, *Uncinia purpurata*, and *Carex acicularis* were the chief additions made to my collection in that camp; and amongst the grasses *Poa dipsacea*, *P. imbecilla*, and *P. kirkii* var. *mackayi* were the most interesting. We had rather a novel experience when on leaving that camp we came down to the river with the intention of crossing in the chair and putting up at the hotel which was on the opposite bank. The chair was suspended over the middle of the stream, and as we pulled it up to the landing the hauling-line parted, leaving us without any means of crossing. It was too late in the evening to effect repairs, and we had to go to bed supperless, lying on the grass under the canopy of heaven and badly tormented by mosquitoes.

After setting up our camp at the Lyell Creek, I made several ascents of Mount Lyell, and added a few more novelties to my collection. On one of the rocky spurs I found a plant described by Mr. Cheeseman as a remarkable variety of *Aciphylla lyallii*, having larger and more rigid leaves, the lower pinnæ of which are trifid or again pinnate. *Celmisia monroi* was also found on this mountain. On the road leading down from our camp to the Lyell I collected *Uncinia riparia*, and more specimens of the flabby-leaved gentian met with before on Boundary Peak; also *Rubus parvus* was in fruit on the roadside; and I noticed in many of the wet mossy spots which were exposed to the drip from the rocks above there were mats of *Calceolaria repens* in full bloom, and charming the eye with their delicate beauty.

Returning again to Westport, the next point of interest is Cape Foulwind, and the seven miles can be most pleasantly walked at low water on a hard sandy beach. Amongst the granite rocks which strew the beach just beyond the cape *Lepidium flexicaule* is fairly plentiful, and a peculiar form of *Wahlenbergia*, named *W. saxicola* var. *congesta*, grows amongst the gravel, and further down the coast is quite common amongst the sandhills. Mr. Cheeseman says of it, "Mr. Townson's plant from Cape Foulwind, which forms broadly matted patches in sandy soil, has a very distinct appearance, and almost deserves specific rank." *Desmoschœnus spiralis*, *Mariscus ustulatus*, *Euphorbia glauca*, and *Veronica elliptica* are the most conspicuous plants, not forgetting *Senecio rotundifolius*, which attains its northern limit just beyond Westport. *Tillæa moschata*, *Colobanthus muelleri*, and *Plantago triandra* grow in situations exposed to the salt spray, whilst *Lomaria banksii*, *Pteris macilenta*, and *Polypodium tenellum* are fairly plentiful. There is a considerable patch of *Corynocarpus lævigatus*, probably planted there in former times by the hand of the Maori. In the low bush around the lighthouse I gathered *Acianthus sinclairii;* and at Tauranga Bay, a mile or two further down the coast, *Corysanthes triloba* is abundant under the shelter of the nikaus and tree-ferns. In that bay, on a sandy knoll, there is a clump of *Weinmannia racemosa*, showing a most unusual mode of growth, for from the horizontal branches descend stout limbs, which are rooted in the ground, giving the trees the appearance of mangroves as I have seen them pictured. *Pimelea arenaria*, *Coprosma acerosa*, and *Spinifex hirsutus* are the commonest plants on the sandhills, whilst *Arundo conspicua* and *Festuca littoralis* are also abundant. I met with a few patches of *Gaultheria perplexa* and *Discaria toumatou* straggling over the sand, and *Mazus radicans* is not uncommon on the sandy banks.

Following the coast-line to Charleston, a most unusual condition of things is found on a spray-swept promontory called "Usher's Rock," for there, just at sea-level or a little above it, grow *Gentiana saxosa*, *Celmisia coriacea*, *Senecio bellidioides*, and *Pimelea longifolia*, many of them plants which in other parts of the district are mostly found at high elevations. I do not recollect gathering any of these plants on the Cape Foulwind bluffs, nor on the White Horse bluffs, near Brighton, some miles south of Charleston.

Between Westport and Charleston most of the country lying between the high-level terraces which flank the Paparoas and the sea is composed of pakihis interspersed with patches of forest. The bulk of the low-growing forms of plant life on these wet plains is made up of *Gahnia rigida*, *G. ebenocarpa*, and *G. setifolia ; Cladium teretefolium*, *C. glomeratum*, and *C. capillaceum ; Dianella intermedia ; Epilobium pubens*, *E. nummularifolium*, and *E. rotundifolium ; Gunnera monoica*, *Haloragis micrantha*, various forms of *Hydrocotyle*, *Celmisia longifolia*, and *Epacris pauciflora ;* together with *Arundo conspicua*, *microlæna stipoides*, and *Danthonia semiannularis*. *Gentiana townsoni* is scattered over the whole area, and *Thelymitra pachyphylla* helps to vary the monotony of the brown surface ; whilst here and there *Orthoceras solandri*, *Pterostylis graminea*, *P. banksii*, and *Prasophyllum colensoi* may be found. In some of the more boggy spots the pale-blue flowers of *Herpolirion novæ-zealandiæ* are conspicuous, the delicate flowers of *Anagospermum dispermum* forming broad patches of colour, and *Liparophyllum* *gunnii* starring over some of the bare patches of brown peat. *Drosera binata* is ubiquitous, and *Acæna sanguisorbæ* is plentiful on the drier parts of the surface. The most abundant ferns are *Pteris aquilina*, *P. incisa*, *P. scaberula*, and *Gleichenia dicarpa;* whilst on the margins of the forest *Lomaria frazeri* flourishes.

On the main road to Charleston, where it crosses the pakihis, patches of *Gnaphalium collinum* and *Helichrysum filicaule* are seen on the roadside, and growing amongst them I found a *Gnaphalium* new to Mr. Cheeseman, and which he thinks must be introduced. In the same locality, growing on the banks at the side of the road, and also on dry elevations amongst the pakihis, I collected *Prasophyllum rufum*, in reference to which Mr. Cheeseman remarks, "I suspect that the New Zealand plant will prove to be a different species to the Australian, and it is probable that the North Island plant described in the Handbook under the name of *P. nudum* is distinct from McMahon's and Townson's South Island specimens. Mr. Townson's have a broad obtuse lip, but in Fitzgerald's 'Australian Orchids' (vol. ii, part iv) the lip of *P. rufum* is represented as lanceolate and acute."

In many places these marshy plains extend from the top of the high-level terraces to the foot of the mountain-spurs, and are favourite sites for gold-miners' dams.

The nearest peak of the Paparoa Mountains to Westport is Mount Buckland, which overlooks the Buller Gorge. Round about Caroline Terrace, which flanks this mountain, and on the foothills, I met with a new species of *Dracophyllum*, named *D. townsoni*, Cheesem., the peculiarity of which is its bearing curved and drooping panicles of fœtid-smelling flowers, situated beneath the leaves. It grows to a height of from 10 ft. to 20 ft., and the branches are ringed with the scars of the fallen leaves, and so far as I know it grows only in that locality. On that terrace I found *Elytranthe flavida* parasitic upon *Fagus solandri;* also, by the dam, a patch of *Pelargonium australe;* and I never found either plant again in any other locality. The mountain forest is chiefly *Fagus*, and where it runs out, *Dracophyllum urvilleanum* var. *montanum*, *Dacrydium biforme*, *Archeria traversii*, and *Olearia colensoi* replace it. On reaching the open country *Aciphylla hookeri* appears; and on a swampy tableland *Ranunculus gracilipes* is in abundance amongst the grass; and where it is more stony, *Celmisia dallii*, *C. sessiliflora*, and *C. lateralis* are fairly common. In the mossy bogs *Caltha novæ-zealandiæ* and *Plantago brownii* are plentiful, whilst *Ourisia glandulosa* and *Geum uniflorum* decorate the rock-ledges. Near the peak *Veronica gilliesiana* and *Ourisia sessiliflora* grow in some abundance, and on a shingle-slide on the eastern face I was pleased to find *Ranunculus lyallii* in bloom. In my many excursions amongst the other peaks in this chain I never found this plant growing again, but it may occur on the Greymouth end of the range. *Euphrasia cockayniana* and *E. revoluta* are not uncommon, and there are many patches of *Donatia novæ-zealandiæ* on the higher slopes. My last experience on this mountain was not a very pleasant one, as my companion and myself became enveloped in dense fog, and the narrow saddle by which we could gain the clear country was not to be picked up, and consequently we had to spend the night on the rocky peak, fireless and half-perished, and were obliged to tramp up and down a shelf of rock all through the night, as there was no shelter of any sort. We walked for thirty-one consecutive hours on that expedition, but experienced no bad results from the exposure.

The next mountain in the chain is Mount Kelvin, which over-tops its neighbours by nearly 1,000 ft. Here *Aciphylla hookeri* and *A. townsoni* grow in profusion, *A. colensoi* being plentiful in the valleys between the spurs, whilst the two former affect the dry slopes. *Celmisia armstrongii* and *C. coriacea* star the meadows over, and amongst the rocks *Senecio lyallii* in places whitens the surface. One noticeable feature regarding these flowers is the colouring, for on the Paparoa Range, where they grow so freely, I have never found a specimen of *Senecio lyallii* or its variety *scorzoneroides* other than pure white. *Gnaphalium grandiceps* mats over some of the dry rocks, and *Coprosma serrulata* and *Carex forsteri* are found on the banks of the rills and in spots that are sheltered. I have gathered *Geranium microphyllum* at an elevation of 4,000 ft. *Ehrharta colensoi*, *Danthonia raoulii*, and *D. australis* grow in abundance, the last-named being popularly called "carpet-grass," and rendering the surface of the steep spurs very slippery indeed. On one occasion after scaling this peak a party of us got belated, and as the country was too rough to attempt travelling in the dark we were obliged to camp in the bed of the Totara River, and make the best of it until daylight appeared, when we resumed our march.

Mount Faraday is the next important peak in the Paparoas, and I approached it by way of the Four-mile River, as a good track follows the river to within a short distance of the foot of the mountain. On the side of the track I gathered *Mazus radicans*, and, where it crossed a small swamp, *Centrolepis viridis*. I camped for the night in company with Mr. Boswell in a bush-feller's tent, and from there on the following day we made a successful ascent of the mountain. In the subalpine scrub on parts of this range *Podocarpus nivalis* is found, and is most difficult to make one's way through; sometimes, when too thick to crawl under, the only course is to climb over the top of it. The only curiosities which I obtained on Mount Faraday were *Hydrocotyle novæ-zealandiæ* var. *montana*, *Drapetes dieffenbachii* var. *multiflora*, a form of *Ligusticum* resembling *L. haastii* but smaller and more slender and bearing pink flowers, and a curiously matted form of *Polypodium serpens* which grows amongst the rocks around the peak.

From the Four-mile we returned to Brighton, where we were staying, and on our way home I gathered *Dichelachne sciurea* where the road crosses the saddle. At the mouth of Fox's River, at Brighton, amongst the rocks on the sea-face, grows a new species of *Veronica*, named *V. divergens* by Mr. Cheeseman, whose remarks regarding it I cannot do better than quote: "Although unwilling to create new species in a genus like *Veronica*, I feel compelled to assign specific rank to this, which appears to be well characterized by the small oblong or elliptic-oblong flat spreading leaves, dense racemes, very short and broad corolla-tube, and broadly oblong subacute capsule. In some respects it approaches *V. macroura* var. *dubia*, but its nearest ally is probably *V. salicifolia* var. *kirkii*." Not far from the mouth of the river is an island called Seal Island, which can only be approached at low water on spring tides, and there I found *Juncus cæspiticius* and *Agnopyrum scabrum* growing, and on many of the rocks in the vicinity *Tillæa sieberiana* may be found. Following Fox's River through one of the most picturesque gorges which I have ever seen, we approached the foothills of the main range, the peaks of Mount Faraday, the Razorback, and Mount Bovis serrating the sky-line. On a subsequent visit I made one of the first ascents of the Razorback, but made no fresh botanical discoveries. On the banks of the river *Poa anceps* hangs in long tresses from the cliff-face side by side with *Schœnus pauciflorus*; on the shingly banks here and there *Senecio hectori* was in full flower. *Olearia ilicifolia* var. *molle* was one mass of white bloom, and *Elytranthe colensoi* showed in scarlet masses pendent from the limbs of *Fagus fusca*. *Corysanthes micrantha* was plentiful in shaded situations, and where a stream strongly impregnated with lime flowed across the roadway *Veronica macrocarpa* var. *crassifolia* was again met with, and on the more open banks *Urtica ferox* and *Arctium lappa* were not uncommon.

Mount Bovis was the last mountain in the Paparoa Chain which I was able to visit, and to reach it we travelled overnight to Bullock Creek, from which point it is most easily approached. To reach our destination we were obliged to ford Fox's River some twenty-two times, but as the stream was low the fords presented no difficulties, and at the end of our journey we were hospitably entertained by a settler who runs cattle on the river-flats. Sometimes on O'Brien's land, where the surface is undermined by subterranean streams, huge rata-trees disappear bodily, and where they stood will be pools of water from which a few of the topmost twigs of the trees protrude. On Mount Bovis I collected *Celmisia bellidioides*, *Ourisia cæspitosa*, *Veronica vernicosa*, *Abrotanella cæspitosa*, and *Epilobium gracilipes*.

There is a noticeable absence in these ranges of the mountain forms of *Ranunculus*, and no varieties of *Myosotis* were found on the Paparoas. There are no *Carmichælias*, whilst the only *Raoulias* are *R. grandiflora* and *R. eximia*, and the whipcord *Veronicas* are almost unrepresented. No mountain varieties of *Clematis* were ever observed by me, and I only collected three species of this genus in the whole district. The Paparoas are bush-clad to an elevation of from 2,000 ft. to 3,000 ft., and much of the lands on the flat are clothed with forest, and beyond Bullock Creek there are grand belts of *Podocarpus spicata* growing on limestone country which will doubtless prove valuable grazing lands when cleared. *Rhopalostylis sapida* is found in magnificent groves dotted about on the coastal bluffs as far south as I reached, but they do not extend inland very far.

The excessive rainfall, which reached 72 in. in 1904 and 1905, may account for the absence of many plants which are found further inland, and in the mountains especially many plants that one would naturally expect to find at a given elevation are conspicuous by their absence. They may still be discovered on the sheltered eastern face of the ranges when they are examined.

Some southern plants seem to make the Westport district their northern limit—for instance, *Gentiana montana* and *G. saxosa*, *Liparophyllum gunnii*, *Ranunculus lyallii*, *Actinotus novæ-zealandiæ*, *Epilobium gracilipes*, *Euphrasia cockayniana*, *Coprosma retusa*, *Senecio rotundifolius*, *Veronica elliptica*, and *Ehrharta thomsoni*. On the other hand, many northern species find their southern limit in the vicinity of the Buller, amongst which are *Lepidium flexicaule*, *Notothlaspi australe* var. *stellatum*, *Myriophyllum robustum*, *Nertera cunninghamii*, *Olearia cunninghamii*, *Celmisia dallii*, *Astelia banksii*, *Orthoceras solandri*, *Calochilus paludosus*, *Pterostylis venosa* and *P. puberula*, *Corysanthes cheesemanii*, and *Poa anceps;* and amongst the Filices, *Adiantum æthiopicum*, *Pteris macilenta* and *P. tremula*, and *Asplenium umbrosum*. Mr. Cheeseman has several times remarked whilst looking over my specimens that Westport and its immediate neighbourhood seems to be the meeting-place of many northern and southern species. Another interesting feature of this part of the West Coast is the low elevation at which alpine and sub-alpine plants occur, some of them, such as *Celmisia coriacea*, *Anagospermum dispermum*, *Liparophyllum gunnii*, and *Claytonia australasica*, being found at sea-level.

If I had had the opportunity of making a closer and more exhaustive search over the area included in the appended sketch-map no doubt many more species and varieties than the 755 comprising my catalogue would have been obtained, and this number with the thirty-four contained in the supplementary list makes a total of 789. Seventy-four natural orders are represented, Filices heading the list with ninety-two species, Compositæ coming next with seventy-six, followed by Cyperaceæ with fifty-six, Gramineæ with thirty-nine, Scrophularineæ with thirty-four, and Orchideæ with thirty-two. *Carex* takes the lead amongst the genera with twenty-five species, *Coprosma* follows with twenty, and *Celmisia* accounts for seventeen. Some plants, such as *Drimys traversii* and *Metrosideros parkinsonii*, are very rare outside the district. Some few make their appearance for the first time in the South Island—viz., *Lepidium flexicaule*, *Gnaphalium subrigidum*, *Pterostylis venosa* and *P. puberula*, and *Corysanthes cheesemanii;* and it yet remains to be proved by future observers whether the new species, such as *Aciphylla townsoni*, *Celmisia dubia*, *Wahlenbergia saxicola* var. *congesta*, *Dracophyllum townsoni* and *D. pubescens*, *Myosotis townsoni*, *Veronica macrocarpa* var. *crassifolia* and *V. divergens*, *Townsonia deflexa*, and *Prasophyllum rufum*, are confined to the district or have a more extended range.

I feel that my thanks are due not only to Mr. Cheeseman, who suggested the work and helped it through its various stages, but to Mr. A. McKay, from whose geological report I obtained all my information on geology, and from which I largely quoted, and also to the companions who accompanied me on many expeditions, and often had to put up with hardships and exposure to which they had not been inured—who were often leg-weary and yet never complained, and in that way helped forward my botanical work, of which this catalogue is the outcome. I must not omit recording my thanks also to the County Engineer, who kindly lent me an outfit when going on a camping-out expedition into the Lyell Ranges.

In describing the new species I have not given any minute details, as that has been done so well by Mr. Cheeseman in his very excellent "Manual of the New Zealand Flora."

Catalogue of the Flowering-plants and Ferns gathered in the Districts around Westport.

Ranunculaceæ.

Clematis indivisa, Willd. Common throughout the district.

,, *indivisa*, var. *lobulata*, Kirk. Common throughout the district.

,, *fœtida*, Raoul. Island in Buller River, near Westport.

Ranunculus lyallii, Hook. f. Mount Buckland, on peak; altitude, 4,000 ft.

,, *insignis*, Hook. f. Mount Owen; between 4,000 ft. and 5,000 ft.

,, *monroi*, Hook. f. Mount Murchison and Boundary Peak; altitude, from 3,000–4,000 ft.

,, *geranifolius*, Hook. f. Mount Murchison, Brunner Range; ascending to 4,500 ft.

,, *tenuicaulis*, Cheesem. Boundary Peak; altitude, 3,500 ft.

,, *gracilipes*, Hook. f. Mount Buckland; altitude, 3,000 ft.

,, *hirtus*, Banks and Sol. Throughout the district.

,, *lappaceus*, Sm. Plentiful throughout the district.

,, *rivularis*, Banks and Sol. Plentiful throughout the district in wet ground.

,, *acaulis*, Banks and Sol. On sandhills between Cape Foulwind and Charleston.

Caltha novæ-zealandiæ, Hook. f. On the Brunner Range and Paparoas, in bogs in subalpine regions, at an altitude of from 3,000–4,000 ft.

Magnoliaceæ.

Drimys axillaris, Forst. In the Cape Foulwind and Mokihinui woods.

,, *colorata*, Raoul. Not uncommon in woods in damp situations.

,, *traversii*, T. Kirk. Mount Rochfort and Mount Frederic, at an elevation of from 2,000–3,000 ft.; fairly abundant on the mossy surface under the shade of the low *Fagus* forest.

Cruciferæ.

Nasturtium palustre, DC. Common in damp situations.

Cardamine hirsuta, L. Common; ascending to 4,000 ft. on Paparoas.

,, *latesiliqua*, Cheesem. Mount Owen; altitude, from 3,000–5,000 ft.

Lepidium flexicaule, T. Kirk. On the beach at Cape Foulwind, and also between Mokihinui and Karamea on the stony beach.

Notothlaspi rosulatum, Hook. f. Mount Owen; altitude, from 4,000–5,000 ft.

,, *australe*, var. *stellatum*, Kirk. On a shingle-slip on Boundary Peak; altitude, 4,000 ft.

Violarieæ.

Viola filicaulis, Hook f. Common.

,, *lyallii*, Hook. f. Common; ascending to 4,000 ft. on the Paparoas.

,, *cunninghamii*, Hook. f. Common.

Melicytus ramiflorus, Forst. Abundant in all woods at low elevations.

,, *lanceolatus*, Hook. f. Buller Valley.

Pittosporeæ.

Pittosporum tenuifolium, Banks and Sol. Abundant throughout the district.

,, *colensoi*, Hook. f. Not uncommon.

,, *rigidum*, Hook. f. Not uncommon from sea-level to 2,000 ft.

,, *eugenioides*, A. Cunn. At Tauranga Bay, near Cape Foulwind.

Caryophylleæ.

Stellaria parviflora, Banks and Sol. Common. A matted form found on Mount Lyell, at an altitude of 3,000 ft.

Colobanthus quitensis, Bartl. Mount Mantell; altitude, from 4,000–6,000 ft.

, *billardieri*, Fenzl. Buller Valley; not uncommon.

,, *muelleri*, T. Kirk. Abundant on the rocks along the coast.

,, *canaliculatus*, T. Kirk. On limestone rock on Mount Owen; altitude, 4,000 ft.

Portulaceæ.

Claytonia australasica, Hook. f. Buller River bed at the Blackwater; Mount Mantell; altitude, 5,000 ft.

Montia fontana, Linn. Not uncommon in slow-running watercourses.

Elatineæ.

Elatine americana, Arn. On muddy margin of Lake Rochfort; altitude, about 1,500 ft.

Hypericineæ.

Hypericum japonicum, Thunb. Abundant in marshy meadows.

Malvaceæ.

Plagianthus divaricatus, Forst. Abundant on the salt marshes.
,, *betulinus*, A. Cunn. Throughout the district.
Hoheria populnea, A. Cunn., var. *angustifolia*. Throughout the district.

Tiliaceæ.

Aristotelia racemosa, Hook. f. Abundant throughout.
,, *fruticosa*, Hook. f. Boundary Peak, at an altitude of 3,000 ft. I never gathered specimens on the coastal ranges.
Elæocarpus dentatus, Vahl. Fairly abundant.
,, *hookerianus*, Raoul. Common in subalpine forests.

Lineæ.

Linum monogynum, Forst. Abundant on the coastal cliffs and in places on the Buller River bed.

Geraniaceæ.

Geranium dissectum, L. Common.
,, *dissectum*, var. *patulum*, Hook. f. Buller Valley.
,, *microphyllum*, Hook. f. Common on dry banks.
,, *sessiliflorum*, Cav. Sandhills between Cape Foulwind and Charleston.
,, *molle*, L. Throughout the district.
Pelargonium australe, Jacq. Caroline Terrace, at an elevation of about 500 ft.
Oxalis corniculata, L. Common.
,, *magellanica*, Forst. Abundant up to an elevation of 3,000 ft.

Rutaceæ.

Melicope simplex, A. Cunn. Mount Rochfort and Paparoas; altitude, from 1,000–2,000 ft.

Olacineæ.

Pennantia corymbosa, Forst. Abundant on the margins of forest lands and amongst the low bushes on river-banks.

Rhamneæ.

Discaria toumatou, Raoul. Sandhills at Cape Foulwind, and Buller Valley.

Sapindaceæ.

Dodonæa viscosa, Jacq. Along the coast-line is abundant.

Anacardiaceæ.

Corynocarpus lævigata, Forst. From Cape Foulwind along the coast to Karamea in isolated patches, and a few solitary trees on the banks of the Buller River.

Coriarieæ.

Coriaria ruscifolia, L. Abundant throughout the district.
,, *thymifolia*, Humb. Buller Valley and Fox's River.

Leguminosæ.

Carmichælia subulata, T. Kirk. Buller Valley, salt-water lagoons, and littoral swamps.
,, *angustata*, T. Kirk. Common in Buller Valley, and on the banks of the Karamea, Mokihinui, and Fox's Rivers.
,, *flagelliformis*, Col. Banks of salt-water lagoons, Karamea.

Sophora tetraptera, J. Mull. In the vicinity of lagoons and on river-flats, common.

Rosaceæ.

Rubus australis, Forst. Common.
,, *cissoides*, A. Cunn. Common.
,, *parvus*, Buch. Lyell Creek Road.

Geum parviflorum, Sm. Mount Mantell; altitude, from 3,000–5,000 ft.
,, *uniflorum*, Buch. Paparoas, Mount Mantell; altitude, from 3,000–5,000 ft.
,, *leiospermum*, Petrie. Mount Murchison; altitude, from 3,000–4,500 ft.

Acæna sanguisorbæ, Vahl. Abundant from sea-level to 3,000 ft.
,, *sanguisorbæ* var. *pilosa*. T. Kirk. Brunner Range, from 3,000–5,000 ft.
,, *microphylla*, var. *inermis*. T. Kirk. Buller Valley and Mokihinui.

Saxifrageæ.

Donatia novæ-zealandiæ, Hook. f. Abundant on the Papahua–Paparoa Mountains; altitude, from 2,000–3,000 ft.

Quintinia acutifolia, T. Kirk. Abundant throughout the district from sea-level to 2,000 ft.

Carpodetus serratus, Forst. Abundant on the margins of forests.
Weinmannia racemosa, L. Abundant throughout the district from sea-level to 2,000 ft.

Crassulaceæ.

Tillæa moschata, DC. Common on the rocks along the coast.
,, *helmsii*, T. Kirk. On marshy lands about the estuaries of the rivers.
,, *sieberiana*, Schultz. On the sea-cliffs and rocks at St. Kilda and Brighton.

Droseraceæ.

Drosera stenopetala, Hook. f. Abundant on the mountains at an altitude of from 2,000–4,000 ft.
,, *arcturi*, Hook. Common at an elevation of from 2,000–4,000 ft.
,, *spathulata*, Labill. Not uncommon from sea-level to 4,000 ft.
,, *binata*, Labill. An abundant plant on all the pakihis.

Halorageæ.

Haloragis alata, Jacq. Abundant on the river-banks and flats.
,, *depressa*, Walp. On sandhills between Cape Foulwind and Charleston.
,, *micrantha*, R. Br. Common all over the pakihis.
Myriophyllum elatinoides, Gaud. I only found this plant on one occasion in the Buller Valley.
,, *intermedium*, DC. Not uncommon in still pools and on marsh lands.
,, *robustum*, Hook. f. Common in swamps about the Orowaiti and Cape Foulwind.
,, *pedunculatum*, Hook. f. Not uncommon in the Buller River bed.
Gunnera monoica, Raoul. Abundant throughout the district.
,, *monoica*, var. *albocarpa*, Kirk. Common on the sea-cliffs.
,, *dentata*, T. Kirk. Buller and Matakitaki river-beds.
Callitriche verna, L. Abundant.
,, *muelleri*, Sond. Abundant.

Myrtaceæ.

Leptospermum scoparium, Forst. Common. On coastal ranges ascends to an altitude of 2,000 ft.
,, *ericoides*, A. Rich. Common, many parts of district.

Metrosideros florida, Sm. Abundant from sea-level to 2,000 ft.
,, *lucida*, A. Rich. Abundant from sea-level to 2,000 ft.
,, *parkinsonii*, Buch. On Mount Rochfort and Mount Frederic, also the Westport end of the Paparoas; altitude, from 1,000–2,500 ft.
,, *hypericifolia*, A. Cunn. Abundant.
,, *robusta*, A. Cunn. Abundant in the coastal forests, ascending to an altitude of 2,000 ft.
,, *scandens*, Sol. Common.
Myrtus obcordata, Hook. f. Abundant on river-flats and on the borders of forests.
,, *pedunculata*, Hook. f. Not uncommon; ascending to altitude of 1,500 ft.

Onagrarieæ.

Epilobium pallidiflorum, Sol. Abundant in swampy ground.
,, *chionanthum*, Haussk. In Orowaiti swamps.
,, *junceum*, Sol. Common.
,, *junceum*, var. *macrophyllum*, Haussk. Lyell Creek.
,, *pubens*, A. Rich. Common.
,, *chloræfolium*, Haussk. Mount Murchison; from 3,000–4,000 ft.
,, *insulare*, Haussk. Not uncommon in swamps.
,, *rotundifolium*, Forst. Abundant throughout the district.
,, *linnæoides*, Hook. f. Mount Rochfort, at elevation of 3,000 ft.
,, *nummularifolium*, R. Cunn. Common.
,, ,, var. *pedunculare*, Hook. f. Common.
,, *gracilipes*, Kirk. Mount Bovis; from 2,000–3,500 ft.
,, *vernicosum*, Cheesem. Mount Owen, Boundary Peak; at elevation of from 3,000–5,000 ft.
,, *microphyllum*, A. Rich. Buller Valley, at Murchison.
,, *glabellum*, Forst. Common in mountainous districts.
,, *novæ-zealandiæ*, Haussk. Mount Murchison; altitude, 3,000 ft.
Fuchsia excorticata, L. Common.
,, *colensoi*, Hook. f. Common.

Ficoideæ.

Mesembryanthemum australe, Sol. Abundant on the coast.
Tetragonia expansa, Murr. Mokihinui Beach.
,, *trigyna*, Banks and Sol. Abundant about headlands on the coast.

Umbelliferæ.

Hydrocotyle elongata, A. Cunn. Common in river-valleys.
,, *dissecta*, Hook. f. Beach at Mokihinui.
,, *novæ-zealandiæ*, DC. Abundant through district.
,, *novæ-zealandiæ*, var. *montana*, Kirk. Paparoas; altitude, 4,000 ft.
,, *moschata*, Forst. Abundant throughout.
,, *microphylla*, A. Cunn. Buller Valley.
,, *asiatica*, L. Common on the sea-beach.

Azorella haastii, Benth. and Hook. f. Brunner Range; from 3,000–4,000 ft.
,, *pallida*, T. Kirk. Brunner Range; from 3,000–4,000 ft.
,, *trifoliata*, Benth. and Hook. f. Buller Valley.

Actinotus novæ-zealandiæ, Petrie. Coastal mountains; from an elevation of 1,500–3,000 ft.

Apium prostratum, var. *filiforme*. Common near the coast.

Oreomyrrhus andicola, Endl. Brunner Range; from 3,000–4,000 ft.
,, *andicola*, var. *colensoi*, Kirk. Paparoas, Mount Owen, and Mount Mantell.

Crantzia lineata, Nutt. Buller River bed.

Aciphylla colensoi, var. *conspicua*, Kirk. Mount Kelvin; altitude, 4,500 ft.
,, *colensoi*, var. *maxima*, Kirk. Mount Murchison and Brunner Range; altitude, from 3,000–4,000 ft.
,, *hookeri*, T. Kirk. Paparoas and Brunner Range, at an altitude of from 2,500–4,500 ft.
,, *lyallii*, Hook. f. Lyell Mountains; altitude, from 3,000–4,000 ft.
,, *monroi*, Hook. f. Mount Murchison; from 3,000–5,000 ft.
,, *townsoni*, n. s., Cheesem. Mount Faraday, Mount Kelvin, Mount Buckland, and Lyell Mountains; altitude, from 3,000–4,500 ft.

Ligusticum haastii, F. Muell. Common on all the coastal mountains, ascending to 4,000 ft.
,, *deltoideum*, Cheesem. Lyell Mountains; from 3,000–4,000 ft.
,, *piliferum*, Hook. f. Mount Mantell, from 4,000–5,000 ft.; Brunner Range, from 3,000–4,000 ft.
,, *aromaticum*, Hook. f. Common on coastal mountains at an altitude of from 2,000–4,000 ft.
,, *imbricatum*, Hook. f. Brunner Range; altitude, 5,000 ft.

Angelica gingidium, Hook. f. Buller Valley, Fox's River, and Mount Faraday.
,, *decipiens*, Hook. f. Mount Owen, Buller Valley.

Araliaceæ.

Panax lineare, Hook. f. Common on the mountains at an elevation of from 1,500–3,500 ft.

,, *simplex*, Forst. Not uncommon from sea-level to an elevation of 3,000 ft.

,, *edgerleyi*, Hook. f. Not uncommon from sea-level to an elevation of 2,000 ft.

,, *colensoi*, Hook. f. Abundant in mountains, ascending to 4,000 ft.

,, *arboreum*, Forst. Common throughout the district.

Schefflera digitata, Forst. Abundant in woods, ascending to 1,000 ft. or more.

Pseudopanax crassifolium, C. Koch. Abundant from sea-level to 2,000 ft.

Cornaceæ.

Corokia cotoneaster, Raoul. Buller River bed at Murchison.

Griselinia lucida, Forst. Abundant throughout the district.

,, *littoralis*, Raoul. Abundant from sea-level to 2,000 ft.

Rubiaceæ.

Coprosma grandiflora, Hook. f. Abundant throughout the district.

,, *lucida*, Forst. Abundant throughout.

,, *serrulata*, Hook. f. Plentiful on western slopes of coastal ranges; from 3,000–4,000 ft.

,, *baueri*, Endl. Common on the whole line of the sea-coast.

,, *robusta*, Raoul. Common throughout the district.

,, *cunninghamii*, Hook. f. Common in river-valleys.

,, *rotundifolia*, A. Cunn. Abundant throughout.

,, *areolata*, Cheesem. Buller Valley; not common.

,, *rhamnoides*, A. Cunn. Abundant in low-lying situations.

,, *parviflora*, Hook. f. Common, ascending to 4,000 ft.

,, *acerosa*, A. Cunn. Common on beaches and beds of rivers.

,, *rugosa*, n. sp., Cheesem. Buller Valley, on the sand-banks by the river.

,, *propinqua*, A. Cunn. Abundant, especially in the salt marshes.

,, *linarifolia*, Hook. f. Not uncommon at an elevation of from 2,000–3,000 ft.

,, *fœtidissima*, Forst. Common from sea-level to 3,000 ft.

,, *colensoi*, Hook. f. On coastal ranges; from 2,000–3,000 ft.

Coprosma retusa, Petrie. Mount Rochfort; 3,000 ft.
,, *cuneata*, Hook. f. Mount Owen, Mount Murchison, and Mount Mantell; altitude, from 3,000–4,000 ft.
,, *depressa*, Col. ex Hook. f. Boundary Peak; altitude, 4,000 ft.
,, *repens*, Hook. f. Mount Murchison, Brunner Range, Mount Faraday; altitude, 3,000–4,000 ft.
Nertera depressa, Banks and Sol. Not uncommon in Buller Valley.
,, *cunninghamii*, Hook. f. Throughout the Westport district.
,, *dichondræfolia*, Hook. f. Abundant under shelter of low woods.
Galium tenuicaule, A. Cunn. Common in low damp situations.
,, *umbrosum*, Sol. ex Forst. Plentiful.
Asperula perpusilla, Hook. f. Mount Mantell; altitude, 5,000 ft.

Compositæ.

Lagenophora forsteri, DC. Common throughout the district; a large-leaved variety grows on the track to Denniston.
Brachycome sinclairii, Hook. f. Mount Mantell, Mount Murchison; from 3,000–5,000 ft.
,, *thomsoni*, var. *membranifolia*, Kirk. Brunner Range; from 3,000–4,000 ft.
Olearia colensoi, Hook. f. Abundant in mountains, from 2,000–3,500 ft.
,, *nitida*, Hook. f. Abundant from sea-level to 3,000 ft.
,, *ilicifolia*, var. *mollis*, Kirk. Fox's River and Bullock Creek.
,, *cunninghamii*, Hook. f. Mount Frederic; from 200–500 ft.
,, *lacunosa*, Hook. f. Mount Owen, Mount Murchison, Mount Glasgow; from 3,000–4,500 ft.
,, *avicenniæfolia*, Hook. f. Not uncommon in Buller Valley.
Celmisia lateralis, Buch. Mount Rochfort, Mount Frederic; altitude, 3,000 ft.
,, *lateralis*, var. *villosa*, Cheesem. Mount Murchison; from 3,000–4,500 ft.
,, *dallii*, Buch. Mount Rochfort, Mount Frederic, and Paparoas; from 2,500–4,000 ft.
,, *hieracifolia*, Hook. f. Mount Murchison; from 3,000–4,000 ft.
,, *discolor*, Hook. f. Abundant in mountains; most plentiful at about 3,000 ft.
,, *incana*, Hook. f. Paparoas and Mount Mantell.

Celmisia incana, var. *petiolata*, Kirk. Paparoas; from 3,000–4,000 ft.

,, *petiolata*, var. *membranacea*, Kirk. Brunner Range. Only found in one valley, at an altitude of 4,000 ft.

,, *spectabilis*, Hook. f. Mount Mantell; altitude, 4,000 ft.

,, *dubia*, n. sp., Cheesem. Coastal mountains; altitude, from 2,000–3,000 ft.

,, *coriacea*, Hook. f. On all mountains, attaining an elevation of from 3,000–5,000 ft., and descending to sea-level at Charleston.

,, *armstrongii*, Petrie. Common on Paparoas and Brunner Range; altitude, from 2,500–4,500 ft.

,, *monroi*, Hook. f. Mount Lyell; from 3,000–3,500 ft.

,, *longifolia*, Cass. Common from sea-level, where it grows on the pakihis, up to an elevation of 4,000 ft. on Lyell Mountains.

,, *laricifolia*, Hook. f. Westport Mountains; from 3,000–4,000 ft.

,, *sessiliflora*, Hook. f. Paparoas, Mount Glasgow, Lyell Mountains; altitude, from 3,000–4,000 ft.

,, *bellidioides*, Hook. f. Mount Bovis; 4,000 ft.; rare.

Vittadinia australis, A. Rich. On shingle-beds in Buller Valley.

Gnaphalium lyallii, Hook. f. Common on banks of rivers and creeks.

,, *trinerve*, Forst. Common on sea-cliffs.

,, *keriense*, A. Cunn. Common on all river-banks.

,, *subrigidum*, Col. Giles's Creek.

,, *traversii*, var. *mackayi*, Kirk. Mount Glasgow, Mount Lyell, Mount Mantell; from 4,000–5,000 ft.

,, *paludosum*, Petrie. Orowaiti, in swamp, at sea-level.

,, *luteo-album*, L. Abundant throughout.

,, *japonicum*, Thunb. Abundant in dry stony situations.

,, *collinum*, Lab. Not uncommon.

Raoulia australis, Hook. f. Abundant on beaches and river-beds.

,, *tenuicaulis*, Hook. f. Giles's Creek.

,, *grandiflora*, Hook. f. In the mountains; from 2,500–5,000 ft.

,, *mammillaris*, Hook. f. Mount Frederic, 3,000 ft.; Mount Kelvin, from 4,000–5,000 ft.

,, *bryoides*, Hook. f. Mount Mantell; from 4,000–6,000 ft.

Helichrysum bellidioides, Willd. Abundant in mountains, from sea-level to 5,000 ft.

Helichrysum filicaule, Hook. f. Not uncommon in dry stony situations.

,, *grandiceps*, Hook. f. Paparoas, Lyell Ranges; from 3,000–4,500 ft.

,, *depressum*, Benth. and Hook. Matakitaki River bed, near the gorge.

,, *microphyllum*, Benth. and Hook. Mount Owen, Mount Mantell; from 4,000–5,000 ft.

Cassinia vauvilliersii, Hook. f. Coastal ranges; altitude, from 3,000–3,500 ft.

Craspedia uniflora, Forst. Abundant on sea-cliffs and river-banks.

,, *uniflora*, var. *lanata*, Hook. f. Mount Mantell, at an altitude of 5,000 ft.

Cotula coronopifolia, L. Abundant in wet situations.

,, *australis*, Hook. f. Abundant from sea-level to 1,000 ft.

,, *pyrethrifolia*, Hook. f. Mount Owen, at an altitude of from 3,000–5,000 ft.

,, *squalida*, Hook. f. Abundant.

,, *dioica*, Hook. f. Especially abundant on the coast.

Centipeda orbicularis, Lour. Not uncommon throughout district.

Abrotanella linearis, Bergg. Plentiful on coastal range at an altitude of from 2,000–4,000 ft.

,, *cæspitosa*, Petrie. Mount Bovis; altitude, from 3,000–4,000 ft.

Erechtites prenanthoides, DC. Common.

,, *arguta*, DC. Not uncommon.

,, *glabrescens*, T. Kirk. Mount Owen and Mount Mantell; from 3,000–4,000 ft.

Brachyglottis repanda, Forst. Common from sea-level to 1,500 ft.

Senecio bellidioides, Hook. f. Common in mountains, from 2,000–4,000 ft.; down to sea-level at Charleston.

,, *lyallii*, Hook. f. Mount Kelvin, Brunner Range, Mount Owen, and Mount Murchison; from 3,000–5,000 ft.

,, *lyallii*, var. *scorzonerioides*, Kirk. In same situations as preceding.

,, *lautus*, Forst. Not uncommon on the sea-cliffs; ascending to 3,000 ft. elevation.

,, *latifolius*, Banks and Sol. Abundant on the banks of rivers, but almost confined to sea-level.

,, *hectori*, Buch. Buller Valley and Fox's River.

,, *elæagnifolius*, Hook. f. Common in mountainous districts; altitude, from 2,000–4,000 ft.

,, *rotundifolius*, Hook. f. Abundant on the sea-cliffs south of Westport.

Senecio bidwillii, Hook. f. Abundant on Mount Mantell, at an altitude of from 3,000–4,000 ft.

,, *bidwillii*, var. *viridis*. Lyell Ranges; altitude, from 3,000–4,000 ft.

Microseris forsteri, Hook. f. Boundary Peak; altitude, from 4,000–5,000 ft.

Sonchus oleraceus, L. Common throughout.

Stylidieæ.

Oreostylidium subulatum, Bergg. In places on the mountains at an elevation of from 1,000–2,000 ft.

Forstera sedifolia, Linn. f. Mount Rochfort, Mount Frederic, at an altitude of from 2,000–3,000 ft.

,, *tenella*, Hook. f. Common on the mountains forming Buller Watershed; altitude, from 2,000–4,000 ft.

Goodenovieæ.

Selliera radicans, Cav. Abundant on tidal mud-flats.

Campanulaceæ.

Pratia angulata, Hook. f. Abundant throughout district, ascending to 3,000 ft.

,, *macrodon*, Hook. f. Mount Murchison, Mount Stormy, Karamea.

Lobelia anceps, Linn. f. Abundant.

Isotoma fluviatilis, F. Muell. Abundant in marshy situations near Westport.

Wahlenbergia gracilis, A. DC. Abundant throughout the district.

,, *saxicola*, A. DC. Abundant throughout the district; sea-level to 5,000 ft.

,, *saxicola*, var. *congesta*. On sandhills between Cape Foulwind and Charleston.

Ericaceæ.

Gaultheria antipoda, Forst. Abundant; growing to an altitude of 3,000 ft.

,, *perplexa*, T. Kirk. On sandhills between Westport and Charleston.

,, *rupestris*, R. Br. Buller Valley, and on stony elevations to an altitude of 3,000 ft.

Epacrideæ.

Pentachondra pumila, R. Br. Abundant at elevation of from 2,000–4,000 ft.

Cyathodes acerosa, R. Br. Abundant at elevation of from 1,500–3,000 ft.

,, *empetrifolia*, Hook. f. Mount Rochfort; altitude, 1,500 ft.

Leucopogon fasciculatus, A. Rich. Abundant; sea-level to 2,000 ft.

,, *fraseri*, A. Cunn. Abundant on sandhills.

Epacris pauciflora, A. Rich. Common on lowland and upland pakihis.

,, *alpina*, Hook. f. Mount Rochfort; altitude, from 1,000–2,000 ft. Mount Owen.

Archeria traversii, Hook. f. Coastal mountains and Brunner Ranges, abundant from 2,000–3,000 ft.

Dracophyllum latifolium, A. Cunn. Common at an elevation of from 1,500–3,000 ft.

,, *traversii*, Hook. f. Paparoas, Mount Glasgow, Brunner Range; from 2,000–4,000 ft.

,, *townsoni*, n. sp., Cheesem. Spurs of Mount Buckland; from 500–2,500 ft. elevation.

,, *longifolium*, R. Br. Between Westport and Charleston, growing to the proportions of a tree in patches of pakihi forest.

,, *urvilleanum*, A. Rich. Common from 500–3,000 ft. elevation.

,, *urvilleanum*, var. *montanum*. Lyell Mountains; altitude, from 3,000–4,000 ft.

,, *pubescens*, Cheesem., n. sp. Waimangaroa Gorge; from 1,500–2,500 ft.

,, *uniflorum*, Hook. f. Common on coastal mountains from 2,000–3,000 ft.

,, *rosmarinifolium*, R. Br. Mount William, Mount Frederic; altitude, 3,000 ft.

Primulaceæ.

Samolus repens, Pers. Abundant along the coast.

Myrsineæ.

Myrsine salicina, Heward. Common throughout from sea-level to 2,000 ft.

,, *urvillei*, A. DC. Abundant from sea-level to 2,000 ft.

,, *montana*, Hook. f. Banks of tidal lagoons; rare.

,, *divaricata*, A. Cunn. Common on salt marshes and on banks of tidal lagoons.

Apocynaceæ.

Parsonsia heterophylla, A. Cunn. Common, sea-level to 1,500 ft.
,, *capsularis*, R. Br. Thinly distributed over the district.

Gentianeæ.

Gentiana townsoni, Cheesem., n. sp. Abundant on pakihis, and reaching an elevation of 2,500 ft.
,, *montana*, Forst. Mount Rochfort, 3,000 ft.; Mount Lyell, from 3,000–4,000 ft.
,, *montana*, var. *stolonifera*. Mount Frederic, Mount Rochfort, and Paparoas; from 2,000–4,000 ft.
,, *patula*, Cheesem., n. sp. Mount Kelvin, Mount Mantell, Mount Owen; altitude, from 2,000–4,000 ft.
,, *bellidifolia*, Hook. f. Brunner Range; from 3,000–5,000 ft.
,, *spenceri*, T. Kirk. Mount Frederic, Mount Rochfort, Paparoas; from 1,500–3,500 ft.
,, *saxosa*, Forst. Only found on rocks at Charleston, slightly above sea-level.
Liparophyllum gunnii, Hook. f. Not uncommon on the peaty bogs on the pakihis, ascending to 3,000 ft. on the mountains.

Boraginaceæ.

Myosotis antarctica, Hook. f. Boundary Peak; from 4,000–5,000 ft.
,, *australis*, R. Br. Mount Mantell; from 4,000–5,000 ft.
,, *forsteri*, Lehm. Not uncommon.
,, *townsoni*, Cheesem., n. sp. Brunner Range; far from abundant; 3,000–4,500 ft.
,, *concinna*, Cheesem. Plentiful on Buller face of Mount Owen; altitude, from 3,000–4,500 ft.

Convolvulaceæ.

Calystegia sepium, R. Br. Abundant throughout the district.
,, *soldanella*, R. Br. Abundant on sandhills and shingle-banks along the coast.
Dichondra repens, Forst. Abundant.
,, *brevifolia*, Buch. On shingle beach at Granity Creek.

Solanaceæ.

Solanum nigrum, L. Common.
,, *aviculare*, Forst. Abundant on margins of forests.

Scrophularineæ.

Calceolaria repens, Hook. f. Giles's Creek, Cedar Creek, and Lyell Creek.

Mimulus repens, R. Br. Orowaiti, on mud-flats.

Mazus radicans, Cheesem. Sandhills along the coast; Four-mile River, and at Fairdown.

Gratiola peruviana, L. Buller Valley and Charleston.

,, *nana*, Benth. Several wet situations near Westport.

Glossostigma elatinoides, Benth. In marshy situations; not uncommon.

Veronica divergens, Cheesem., n. sp. On sea-cliffs south of Brighton.

,, *salicifolia*, Forst. Common throughout.

,, *macrocarpa*, var. *crassifolia*, Cheesem. Big Hill on the road over the rocks from Mokihinui to Karamea, and on the side of the track up Fox's River.

,, *parviflora*, Vahl. Abundant in the river-valleys.

,, *gracillima*, Cheesem., n. sp. Buller Valley, and especially abundant in swamps between Fairdown and Waimangaroa.

,, *elliptica*, Forst. Abundant along the coast, growing into a tree over 20 ft. high near Cape Foulwind.

,, *traversii*, Hook. f. Mount Mantell; altitude not observed.

,, *vernicosa*, Hook. f. Waimangaroa Gorge, altitude 2,000 ft.; Mount Bovis, altitude 3,000 ft.

,, *cockayniana*, Cheesem., n. sp. Mount Lyell, Mount Murchison; from 2,000–4,000 ft.

,, *buxifolia*, Benth. Abundant on mountains at an elevation of from 2,000–4,000 ft.

,, *carnosula*, Hook. f. Mount Glasgow; altitude, 4,000 ft.

,, *gilliesiana*, T. Kirk. Mount Buckland, altitude 4,000 ft.; Mount Mantell.

,, *coarctata*, Cheesem., n. sp. Mount Owen and Brunner Range; altitude, from 3,500–5,000 ft.

,, *armstrongii*, T. Kirk. Mount Mantell, Mount Owen; from 4,000–5,000 ft.

,, *linifolia*, Hook. f. Mount Owen; abundant between 3,000 ft. and 4,000 ft.

,, *lyallii*, Hook. f. Abundant on river-banks; ascending to 3,000 ft.

Ourisia macrocarpa, Hook. f. Mount Rochfort, Paparoas; from 3,000–4,000 ft.

,, *macrophylla*, Hook. Abundant on coastal ranges and on banks of mountain-streams; altitude, from 1,000–4,000 ft.

Ourisia sessilifolia, Hook. f. Mount Buckland; altitude, 4,000 ft.
,, *cæspitosa*, Hook. f. Paparoas; altitude, 4,000 ft.
,, *glandulosa*, Hook. f. Paparoas; altitude, from 3,000–5,000 ft.

Euphrasia monroi, Hook. f. Mount Murchison and Brunner Range; altitude, from 3,000–4,000 ft.
,, *revoluta*, Hook. f. Coastal ranges; common at an altitude of from 2,000–4,000 ft.
,, *cockayniana*, Petrie. Paparoa Range; altitude, from 3,000–4,000 ft.
,, *zealandica*, Wettst. Boundary Peak; from 4,000–5,000 ft.
,, *cheesemanii*, Wettst. Mount Mantell, Brunner Range; from 3,500–5,000 ft.

Anagosperma dispermum, Wettst. On pakihis; altitude, 500 ft.; quite abundant. Coastal mountains; from 2,000–3,500 ft.

Lentibularieæ.

Utricularia monanthos, Hook. f. On pakihis nearly at sea-level to 3,000 ft.

Myoporineæ.

Myoporum lætum, Forst. Abundant on the coast.

Labiatæ.

Mentha cunninghamii, Benth. Plentiful, especially on sandhills near the sea.

Plantagineæ.

Plantago raoulli, Decne. Abundant along the coast, on sandhills.
,, *brownii*, Rapin. Paparoa Range, altitude from 3,000–4,000 ft., in subalpine bogs.
,, *triandra*, Berggr. Common along the coast, and also on the banks of Buller River.

Chenopodiaceæ.

Rhagodia nutans, R. Br. On sea-cliffs below Cape Foulwind.
Chenopodium glaucum, L. On shingle beaches on coast.
Salicornia australis, Soland. ex Forst. Orowaiti Beach; not common.

Polygonaceæ.

Polygonum aviculare, L. Abundant.
,, *serrulatum*, Lag., gen. et sp. Abundant.
Rumex flexuosus, Sol. ex Forst. Abundant.

Muehlenbeckia australis, Meissn. Common up to 1,500 ft.
,, *complexa*, Meissn. Most abundant on the coast.
,, *axillaris*, Walp. Common on stony ground bordering the beach.

Piperaceæ.

Piper excelsum, Forst. A common littoral plant.
Peperomia endlicheri, Miq. Cape Foulwind, on cliffs.

Chloranthaceæ.

Ascarina lucida, Hook. f. Common in the Westport district, especially in the neighbourhood of Cape Foulwind.

Monimiaceæ.

Hedycarya arborea, Forst. Abundant throughout district.

Thymelæaceæ.

Pimelea longifolia, Banks and Sol. Abundant in the mountains, from 1,500–2,500 ft.; sea-level at Charleston.
,, *gnidia*, Willd. Mount Rochfort; from 1,500–2,500 ft.
,, *arenaria*, A. Cunn. Abundant on sandhills between Cape Foulwind and Charleston.
,, *lævigata*, Gaertn. Common on all waste lands along the coast.
,, *lyallii*, Hook. f. Sea-level on Seal Island; 4,000 ft. on Mount Murchison.
Drapetes dieffenbachii, Hook. Mount Rochfort, from 2,000–3,000 ft.; Mount Murchison, from 2,000–4,000 ft.
,, *villosa*, Cheesem. Mount Faraday; altitude, from 3,000–4,000 ft.
,, *villosa*, var. *multiflora*. Brunner Range; altitude, 4,000 ft.

Loranthaceæ.

Loranthus micranthus, Hook. f. Abundant throughout.
Elytranthe colensoi, Engl. Common as a parasite on *Fagus*.
,, *tetrapetala*, Engl. Abundant from sea-level to 2,000 ft.
,, *flavida*, Engl. Caroline Terrace, 500 ft. above sea-level; parasitic on *Fagus solandri*.

Santalaceæ.

Exocarpus bidwillii, Hook. f. Westport Mountains; altitude, from 2,000–3,000 ft.

Euphorbiaceæ.

Euphorbia glauca, Forst. Common along the sea-beach.
Poranthera alpina, Cheesem. Mount Murchison; from 3,000–5,000 ft.

Urticaceæ.

Paratrophis heterophylla, Bl. A common constituent of lowland forests.
Urtica ferox, Forst. Not uncommon in Buller Valley and banks of Fox's River.
,, *incisa*, Poir. Not uncommon throughout district.
Australina pusilla, Gaud. On island, Buller River.

Cupuliferæ.

Fagus menziesii, Hook. f. Plentiful; sea-level to 3,000 ft.
,, *fusca*, Hook. f. Plentiful; sea-level to 3,500 ft.
,, *solandri*, Hook. f. Plentiful; sea-level to 3,000 ft.
,, *cliffortioides*, Hook. f. Plentiful from altitude of 2,000–4,000 ft.

Coniferæ.

Libocedrus bidwillii, Hook. f. Not uncommon up to an altitude of 2,000 ft.
Podocarpus totara, D. Don. Not uncommon throughout.
,, *hallii*. T. Kirk. Not uncommon throughout.
,, *nivalis*, Hook. Paparoas; 3,000 ft.
,, *ferrugineus*, D. Don. Abundant.
,, *spicatus*, R. Br. Local in its distribution; abundant below Brighton.
,, *dacrydioides*, A. Rich. Abundant on low-lying ground.
Dacrydium biforme, Pilger. Abundant from 2,000–4,000 ft.
,, *cupressinum*, Soland. ex Forst. Abundant throughout.
,, *intermedium*, T. Kirk. Abundant from sea-level to 4,000 ft. Yellow-pine. Wood is durable, and used largely for railway-sleepers.
,, *colensoi*, Hook. Not uncommon from sea-level to 3,000 ft. Silver-pine. Wood durable, and used largely for railway-sleepers.
Phyllocladus alpinus, Hook. f. Not uncommon from sea-level to 3,000 ft.

Orchideæ.

Dendrobium cunninghamii, Lindl. Common; sea-level to 2,000 ft.
Bulbophyllum pygmæum, Lindl. Not uncommon throughout.
Earina mucronata, Lindl. Abundant.

Earina suaveolens, Lindl. Abundant.

Sarcochilus adversus, Hook. f. Rather a rare plant, growing mostly on *Aristotelia racemosa* in Buller Valley.

Thelymitra longifolia, Forst. Abundant from sea-level to 3,000 ft.

,, *pachyphylla*, Cheesem., n. sp. An abundant species on both lowland and mountain pakihis; sea-level to between 2,000 ft. and 3,000 ft.

,, *uniflora*, Hook. f. Abundant from sea-level to 3,000 ft.

Orthoceras strictum, R. Br. On stony elevations on the pakihis, at sea-level; not common.

Microtis porrifolia, R. Br. Common from sea-level to 2,000 ft.

Prasophyllum colensoi, Hook. f. Abundant from sea-level to 4,000 ft.

,, *rufum*, R. Br. Not uncommon on sides of roads, and on dry elevations on the pakihis.

Pterostylis banksii, R. Br. Abundant; ascending to an elevation of 2,000 ft.

,, *graminea*, Hook. f. Less abundant than the preceding. Grows on pakihis under shelter of low bushes, and on margins of the patches of *Fagus* forest.

,, *venosa*, Col. Mount Rochfort and Mount Frederic, amongst mountain-flax, at an elevation of from 2,000–3,500 ft.

,, *puberula*, Hook. f. On margin of pakihi forest, and amongst *Pteris aquilina* on elevated ground on "Waite's pakihi"; not common.

Acianthus sinclairii, Hook. f. In forest around Cape Foulwind, but not common.

Calochilus paludosus, R. Br. Not uncommon on the pakihis from sea-level to 2,000 ft.

Lyperanthus antarcticus, Hook. f. On coastal mountains from an elevation of 2,000–4,000 ft. or more; fairly abundant.

Caladenia minor, Hook. f. Not uncommon from sea-level to 2,000 ft.

,, *bifolia*, Hook. f. Mount Rochfort, Mount Frederic; from 2,000–3,000 ft.

Chiloglottis cornuta, Hook. f. Not uncommon from sea-level to 2,000 ft.

Adenochilus gracilis, Hook. f. Mount Owen, in *Fagus* forest; altitude, 1,000 ft.

Townsonia deflexa, Cheesem. Mount Rochfort, Mount Frederic, and the Paparoas, at an elevation of from 1,500–2,500 ft., growing in low forests on mossy surface of logs and rocks; not uncommon.

Corysanthes cheesemanii, Hook. f. Amongst *Fagus roots* in pakihi forest on "Waite's pakihi"; far from common.
,, *oblonga*, Hook. f. Abundant in shady woods.
,, *rivularis*, Hook. f. In damp forests; not uncommon.
,, *rotundifolia*, Hook. f. Not uncommon on the rock-faces where the tributaries of the Buller run through narrow gorges.
,, *triloba*, Hook. f. On the sea-slopes near to Cape Foulwind, under shelter of tree-ferns and nikau palms.
,, *macrantha*, Hook. f. Abundant between Mokihinui and Karamea on the road by the beach and in Fox's River.
Gastrodia cunninghamii, Hook. f. Not uncommon from sea-level to 1,000 ft.

Irideæ.

Libertia ixioides, Spreng. Abundant.
,, *pulchella*, Spreng. Abundant from sea-level to 3,000 ft.

Liliaceæ.

Rhipogonum scandens, Forst. Abundant in lowland forests.
Enargea marginata, Banks and Sol. Common in mountain forests.
Cordyline banksii, Hook. f. Abundant on all river-flats.
,, *australis*, Hook. f. Ascending to 2,000 ft.
,, *indivisa*, Steud. On all the coastal mountains; forming beautiful groves on the slopes of Mount Frederic at an elevation of from 2,000–3,000 ft.
Astelia linearis, Hook. f. On the mountains between 2,000 ft. and 4,000 ft.; fairly plentiful.
,, *cunninghamii*, Hook. f. Not uncommon; mostly terrestrial.
,, *banksii*, A. Cunn. Lower Buller Valley.
,, *trinervia*, T. Kirk. Near to Westport.
,, *solandri*, A. Cunn. Common throughout.
,, *nervosa*, Banks and Sol. Common from sea-level to an altitude of 4,000 ft.
,, *nervosa*, var. *montana*, Kirk. On coastal ranges from 2,000–4,000 ft.
Dianella intermedia, Endl. A common plant on the pakihis; ascending to 2,500 ft.
Phormium tenax, Forst. Abundant; sea-level to 4,000 ft.
,, *cookianum*, Le Jolis. Abundant.
Bulbinella hookeri, Benth. and Hook. Not uncommon in upland logs.

Arthropodium candidum, Raoul. Rough-and-Tumble Saddle, on Mokihinui track to Karamea.
Herpolirion novæ-zealandiæ, Hook. f. Common on banks amongst the pakihis.

Juncaceæ.

Juncus pallidus, R. Br. Buller Valley.
,, *vaginatus*, R. Br. Common in vicinity of coast.
,, *effusus*, L. Abundant from sea-level to 2,000 ft.
,, *maritimus*, Lam. Not uncommon throughout the coastal regions.
,, *bufonius*, L. Common throughout.
,, *tenuis*, Willd. Orowaiti and other localities on coast.
,, *planifolius*, R. Br. Buller Valley.
,, *cæspiticius*, E. Mey. Seal Island and Charleston.
,, *antarcticus*, Hook. f. Boundary Peak; altitude, from 3,000–4,000 ft.
,, *prismatocarpus*, R. Br. Not uncommon in Buller Valley.
,, *lamprocarpus*, Ehr. Muddy shores of Lake Rochfort, 1,500 ft.; Buller Valley.
,, *novæ-zealandiæ*, Hook. f. A common plant, ascending to 3,000 ft. in the mountains.
Luzula colensoi, Hook. f. Brunner Range; altitude, from 4,000–5,000 ft.
,, *campestris*, DC. Abundant from sea-level to 4,000 ft.

Palmeæ.

Rhopalostylis sapida, Wendl. and Drude. Abundantly distributed in groves from Karamea to Brighton, and generally near the coast at a low elevation.

Pandaneæ.

Freycinetia banksii, A. Cunn. Common in all the forests to an altitude of 2,000 ft.

Typhaceæ.

Typha angustifolia, L. Abundant in bog lands.
Sparganium antipodum, Graebner. In sluggish watercourses; not common.

Naidaceæ.

Triglochin striatum, Ruiz and Pav. In salt marshes on the coast.
Potamogeton polygonifolius, Pourr. Not uncommon.
,, *cheesemanii*, A. Bennett. Common throughout from sea-level to 2,000 ft.
Ruppia maritima, L. Common along the coast in both still water and watercourses.
Zostera nana, Roth. On beach at Mokihinui.

Centrolepideæ.

Centrolepis viridis, T. Kirk. On Four-mile Track, Charleston, a little above sea-level.

Restiaceæ.

Leptocarpus simplex, A. Rich. Abundant on mud-flats and wet lands along the coast.

Hypolæna lateriflora, Benth. Abundant on the pakihis, and ascending to 3,000 ft. altitude.

Cyperaceæ.

Mariscus ustulatus, C. B. Clarke. Common on all the sandhills on the coast.

Eleocharis acuta, R. Br. Common in tidal lagoons and on river-banks.

,, *cunninghamii*, Boeck. Not uncommon from sea-level to 2,000 ft.

Scirpus aucklandicus, var. *subcucullata*, C. B. Clarke. Brunner Range; altitude, 4,000 ft.

,, *cernuus*, Vahl. Abundant; sea-level to 2,000 ft.

,, *inundatus*, Poir. Abundant in damp lowland situations.

,, *sulcatus*, Thouars. Watercourses at Waimangaroa.

,, *prolifer*, Rottb. Buller Valley.

,, *frondosus*, Banks and Sol. On all coastal sandhills.

,, *lacustris*, L. On tidal lagoons.

Carpha alpina, R. Br. On pakihis, in places growing to a height of 2 ft.; abundant; altitude, from 2,000–4,000 ft.

Schœnus tendo, Banks and Sol. Mount Rochfort; altitude, from 1,000–2,000 ft.

,, *pauciflorus*, Hook. f. Not uncommon in subalpine situations.

,, *axillaris*, Poir. Westport mountains, up to 2,000 ft.

Cladium glomeratum, R. Br. Not uncommon from sea-level to 2,000 ft.

,, *teretifolium*, R. Br. Abundant on pakihis, ascending to an altitude of 2,000 ft.

,, *gunnii*, Hook. f. Common on pakihis.

,, *vauthiera*, C. B. Clarke. Abundant near the coast.

,, *capillaceum*, C. B. Clarke. On high-level pakihis; abundant.

Gahnia setifolia, Hook. f. Abundant.

,, *rigida*, T. Kirk. Common on swamp lands along the coast.

,, *xanthocarpa*, Hook. f. Not uncommon on pakihis and river-flats.

Gahnia procera, Forst. On coastal ranges from sea-level to 2,000 ft.
,, *pauciflora*, T. Kirk. Mount Frederic; altitude, from 500–1,500 ft.
Oreobolus pumilio, R. Br. Mount Rochfort and Mount William; 3,000 ft.
Uncinia purpurata, Petrie. Boundary Peak; altitude, 4,500 ft.
,, *cæspitosa*, Boott. Not uncommon.
,, *australis*, Pers. Common.
,, *riparia*, R. Br. Lyell Creek; from 500–1,500 ft.
Carex acicularis, Boott. Boundary Peak; altitude, 4,000 ft.
,, *trachycarpa*, Cheesem. Mount Mantell, from 3,000–4,500 ft.; Mount Faraday.
,, *virgata*, Sol. ex Hook. Common in swamps.
,, *secta*, Boott. Common in swamps.
,, *inversa*, R. Br. Not uncommon.
,, *colensoi*, Boott. On beach at Mokihinui.
,, *leporina*, L. Wet land about Orowaiti River.
,, *gaudichaudiana*, Kunth. Common on more swampy portions of pakihis north of Westport.
,, *ternaria*, Forst. Abundant from sea-level to between 3,000 ft. and 4,000 ft.
,, *ternaria*, var. *pallida*, Cheesem. Buller Valley.
,, *sinclairii*, Boott. Boundary Peak; from 4,000–4,500 ft.
,, *dipsacea*, Berggr. Not uncommon.
,, *testacea*, Sol. ex Boott. Abundant on sandhills.
,, *lucida*, Boott. Abundant.
,, *comans*, Berggr. Abundant in Buller Valley.
,, *dissita*, Sol. ex Hook. Abundant on the sandhills.
,, *solandri*, Boott. Mokihinui, on sea-cliffs.
,, *pumila*, Thunb. Not uncommon on the coast.
,, *flava*, L. Charleston.
,, *cockayniana*, Kukenthal. Mount Kelvin, 4,000 ft.; Cedar Creek.
,, *forsteri*, Wahl. Mount Kelvin; 3,500 ft.
,, *pseudo-cyperus*, L. Abundant in swampy ground.

Gramineæ.

Zoysia pungens, Willd. Plentiful in dry ground near the sea.
Spinifex hirsutus, Labill. Common on sandhills between Westport and Charleston.
Ehrharta colensoi, Hook. f. Mount Rochfort, Paparoas; from 3,000–5,000 ft.
,, *thomsoni*, Petrie. On all coastal mountains, from 2,000–4,000 ft.
Microlæna stipoides, R. Br. A common grass on the pakihis.

Microlæna avenacea, Hook. f. Abundant in forests, ascending to 2,500 ft.

Hierochloe redolens, R. Br. Not uncommon on the pakihis.

,, *fraseri*, Hook. f. Common in subalpine regions.

Echinopogon ovatus, Beauv. Not uncommon.

Sporobolus indicus, R. Br. Patches often met with on pakihis.

Agrostis muelleri, Benth. Abundant in mountains from 2,000–4,000 ft.

,, *dyeri*, Petrie. Mount Glasgow; altitude, 4,000 ft.

,, *parviflora*, R. Br. Near summit of Mount Rochfort, 3,000 ft.

Deyeuxia forsteri, var. *lyalli*. Cape Foulwind; abundant.

,, *billardieri*, Kunth. Mokihinui Beach, Tauranga Bay.

,, *setifolia*, Hook. Mount Rochfort; altitude, from 2,000–3,000 ft.

,, *quadriseta*, Benth. Not uncommon.

Dichelachne crinita, Hook. f. Abundant on sandhills near coast.

,, *sciurea*, Hook. f. Four-mile Saddle, on road to Brighton.

Deschampsia cæspitosa, Beauv. Common around the Orowaiti district.

Trisetum antarcticum, Trin. Boundary Peak; from 3,000–4,000 ft.

Danthonia cunninghamii, Hook. f. Buller Valley, Mokihinui; but not common in the vicinity of Westport or in the lower Buller.

,, *raoulii*, Steud. Abundant in the mountains at elevation of from 3,000–5,000 ft. There is a good deal of variation in the breadth of leaf in various localities.

,, *australis*, Buch. A common grass on the Paparoas; altitude, from 3,000–5,000 ft.

,, *semiannularis*, R. Br. Abundant throughout, especially on pakihis.

Arundo conspicua, Forst. Common throughout, on sandhills, river-banks, and swamps.

Poa novæ-zealandiæ, Hack. Mount Lyell, Mount Glasgow, at an elevation of 4,000 ft.; abundant.

,, *anceps*, Forst. Buller Valley and Fox's River.

,, *dipsacea*, Petrie. Boundary Peak; from 3,000–4,000 ft.

,, *cheesemanii*, Hack. Only gathered on two occasions, on pakihi south of Westport.

,, *cæspitosa*, var. *australis*, Benth. Not uncommon on the sea-cliffs.

,, *colensoi*, Hook. f. Paparoa Range; altitude, from 4,000–5,000 ft.

,, *colensoi*, var. *intermedia*, Cheesem. Buller Valley.

Poa kirkii, var. *mackayi*, Hack. Mount Lyell and Boundary Peak, at an elevation of from 3,000–4,000 ft.
,, *imbecilla*, Forst. Brunner Range; from 4,000–5,000 ft.
Festuca littoralis, Labill. Common on sandhills near sea.
,, *ovina*, L. Denniston plateau.
Agropyrum scabrum, Beauv. Seal Island, near Brighton.

Filices.

Hymenophyllum rarum, R. Br. Not uncommon in mountainous districts; altitude, from 1,000–2,000 ft.
,, *polyanthos*, Swartz. Abundant.
,, *australe*, Willd. Abundant in lowland forests.
,, *pulcherrimum*, Col. Not uncommon up to 2,000 ft.
,, *dilatatum*, Swartz. In shady woods throughout.
,, *demissum*, Swartz. Common from sea-level to 3,000 ft.
,, *scabrum*, A. Rich. Abundant.
,, *flabellatum*, Lab. Abundant, ascending to 2,000 ft.
,, *rufescens*, T. Kirk. Abundant in mountainous districts, ascending to 3,000 ft.
,, *subtilissimum*, Kunze. An abundant fern in woods at sea-level, ascending to 2,000 ft. or more.
,, *malingii*, Metten. Mount Rochfort; 2,000 ft.
,, *tunbridgense*, Smith. Abundant; sea-level to 2,000 ft.
,, *multifidum*, Swartz. Buller Valley; not uncommon.
,, *bivalve*, Swartz. Abundant throughout district.
Trichomanes reniforme, Forst. Abundant up to an altitude of 3,000 ft.
,, *lyallii*, Hook. and Bak. Plentiful from sea-level to 2,000 ft.
,, *humile*, Forst. Not uncommon.
,, *venosum*, R. Br. Abundant.
,, *colensoi*, Hook. f. Mount Rochfort; altitude, from 1,000–2,000 ft.
,, *strictum*, Menz. ex Hook. and Grev. Not uncommon from sea-level to 2,000 ft.
,, *elongatum*, A. Cunn. Giles's Creek, not common; Buller Valley.
Cyathea dealbata, Swartz. Granity Creek, but rare in Westport district.

Cyathea medullaris, Swartz. Abundant in river-valleys; ascending to 2,000 ft.
Hemitelia smithii, Hook. ex Hook. and Baker. Abundant.
Dicksonia squarrosa, Swartz. Common up to 2,000 ft.
,, *lanata*, Col. Mount Rochfort and Mount Frederic; sea-level to 2,000 ft.
Davallia novæ-zealandiæ, Col. Abundant in Buller Valley.
Cystopteris fragilis, Bernh. Mount Owen, 5,000 ft.
Lindsaya trichomanoides, Dryand. Abundant.
,, *viridis*, Col. Giles's Creek, Millerton, Costello's Hill on Charleston Road.
Adiantum æthiopicum, L. Buller Valley, at Blackwater and Inangahua.
,, *affine*, Willd. Common throughout.
Hypolepis tenuifolia, Bernh. Serjeant's Hill.
,, *distans*, Hook. Not uncommon throughout.
Pellæa falcata, Fée, gen. Buller Valley; not uncommon.
,, *rotundifolia*, Hook. Buller Valley; not uncommon.
Pteris aquilina, L. Common; sea-level to 3,000 ft.
,, *scaberula*, A. Rich. Common up to 2,000 ft.
,, *tremula*, R. Br. Bank of Buller, near Westport.
,, *macilenta*, A. Rich. Abundant in low forest fringing the coast-line.
,, *incisa*, Thunb. Abundant at low elevations.
Lomaria patersoni, Spreng. In most damp gullies and gorges throughout the district.
,, *discolor*, Willd. Abundant.
,, *vulcanica*, Blume. Abundant on river-banks throughout the district.
,, *lanceolata*, Spreng. Common.
,, *banksii*, Hook. f. Comparatively common on the cliffs along the coast.
,, *alpina*, Spreng. Abundant on banks of Buller River.
,, *nigra*, Col. Not uncommon in damp shady situations; ascending to 2,000 ft.
,, *fluviatilis*, Spreng. Common.
,, *membranacea*, Col. Not uncommon in lower Buller Valley.
,, *frazeri*, A. Cunn. Abundant in many gullies on the sea face of the mountains and in the forest fringing the lowland pakihis.
Asplenium flabellifolium, Cav. Upper Buller Valley.
,, *falcatum*, Lam. Not uncommon.
,, *obtusatum*, Forst. Plentiful along the coast.
,, *hookerianum*, Col. Not uncommon on wooded banks of Buller River.

Asplenium bulbiferum, Forst. Abundant throughout.
,, *flaccidum*, Forst. Abundant throughout.
,, *umbrosum*, J. Sm. Not uncommon on wooded banks of Buller River.
Aspidium aculeatum, Swartz. Abundant throughout, ascending to an altitude of 4,000 ft.
,, *richardi*, Hook. In several situations in lower Buller Valley.
,, *capense*, Willd. Not uncommon throughout.
Nephrodium decompositum, R. Br. Forests on Mount Rochfort, &c.
,, *glabellum*, A. Cunn. Plentiful in Buller Valley, &c.
,, *hispidum*, Hook. Abundant in forests.
Polypodium punctatum, Thunb. Not uncommon in river-valleys.
,, *pennigerum*, Forst. Abundant from sea-level to 2,000 ft.
,, *australe*, Mett. Not uncommon.
,, *grammitidis*, R. Br. Not uncommon from sea-level to 2,000 ft.
,, *tenellum*, Forst. Cape Foulwind, on rocks; Mokihinui, on trunks of trees, on beach track to Karamea.
,, *serpens*, Forst. Abundant throughout; a curiously matted form on Mount Faraday, at 4,000 ft.
,, *cunninghamii*, Hook. Not uncommon in Buller Valley.
,, *pustulatum*, Forst. Abundant.
,, *billardieri*, R. Br. Abundant from sea-level to 3,000 ft.
Gleichenia circinata, Swartz. Plentiful, ascending to 2,000 ft.
,, *dicarpa*, R. Br. Common on pakihis, ascending to 2,000 ft.
,, *cunninghamii*, Heward ex Hook. Not uncommon throughout.
Schizea fistulosa, Labill. Not uncommon on lowland and upland pakihis.
Todea hymenophylloides, A. Rich. Not uncommon below 2,000 ft.
,, *superba*, Col. Mokihinui, Karamea, Buller Valley; abundant in shady situations; sea-level to 3,000 ft.
Ophioglossum vulgatum, L. In many localities.

Lycopodiaceæ.

Lycopodium billardieri, Spring. Not uncommon in Westport district.
,, *ramulosum*, T. Kirk. Abundant on some of the upland pakihis.

Lycopodium fastigiatum, R. Br. Mount Frederic and other mountains, from 2,000–3,000 ft.
,, *scariosum*, Forst. Abundant; sea-level to 3,000 ft.
,, *volubile*, Forst. Abundant from sea-level to 3,000 ft.
Tmesipteris tannensis, Bernh. Abundant in low forests, pendent from limbs of trees.

Naturalised Plants.

Ranunculus acris.
Nasturtium officinale.
Barbara vulgaris.
Capsella bursa-pastoris.
Senebiera didyma.
,, coronopus.
Silene gallica.
Cerastium glomeratum.
,, vulgatum.
Stellaria media.
,, graminea.
,, uliginosa.
Sagina apetala.
Spergula arvensis.
Spergularia rubra.
Polycarpon tetraphyllum, *L.*
Portulaca oleracea, *L.*
Hypericum humifusum.
Erodium cicutarium.
Lupinus arboreus.
Cytisus scoparius.
Ulex europæus.
Medicago denticulata.
Trifolium arvense.
,, pratense.
,, repens.
,, hybridum.
Lotus major.
Vicia sativa.
,, tetrasperma.
Rubus fruticosus.
Rosa rubiginosa.
Lythrum hyssopifolium.
Mesembryanthemum angulatum.
Fœniculum vulgare.
Arctium lappa.
Lapsana communis.
Crepis virens.
Hypochæris radicata.
Anagallis arvensis.
Myosotis lingulata.
Cuscuta epithymum.
Physalis peruviana.
Verbascum blattaria.
Digitalis purpurea.
Veronica serpyllifolia.
Lysimachia nummularia.
Bartsia viscosa.
Mentha pulegium.
Plantago lanceolata.
,, major.
,, coronopus.
Prunella vulgaris.
Amarantus blitum.
Chenopodium album.
,, murale.
Polygonum convolvulus.
Rumex obtusifolius.
,, viridis.
,, acetosella.
Emex australis.
Euphorbia peplus.
Asphodelus fistulosus.
Panicum crus-galli.
Phalaris arundinacea.
Anthoxanthum odoratum.
Phleum pratense.
Agrostis alba.
Ammophila arundinacea.
Holcus lanatus.
Aira caryophyllea.

Sherardia arvensis.
Bellis perennis.
Erigeron canadensis.
Achillea millefolium.
Chrysanthemum leucanthemum.
Helichrysum cymosum.
Senecio vulgaris.
,, sylvaticus.
,, jacobæa.
,, aquaticus.
,, mikanioides.
Cynodon dactylon.
Brisa minor.
Dactylis glomerata.
Eleusine indica.
Cynosurus cristatus.
Poa annua.
Glyceria fluitans.
Festuca myurus.
Bromus mollis.
,, unioloides.
Lolium perenne.

List of Flowering-plants and Ferns gathered by Others, and principally by Mr. Cheeseman in the Upper Buller Valley, Parts of which I never reached.

Clematis colensoi, Hook. f. Buller Valley; T. F. Cheeseman.
Stellaria minuta, Kirk. Westport Beach; Dr. Gaze.
Melicytus micranthus, Hook. f. Buller Valley; T. F. Cheeseman.
Gaya lyallii, J. E. Baker. Buller Valley; T. F. Cheeseman.
Carmichælia nana, Col. ex Hook. Buller Valley; T. F. Cheeseman.
,, *grandiflora*, Hook. f. Buller Valley; T. F. Cheeseman.
Geum urbanum, L. Buller Valley; T. F. Cheeseman.
Tillæa sinclairii, Hook. f. Buller Valley; T. F. Cheeseman.
Epilobium macropus, Hook. Buller Valley; T. F. Cheeseman.
,, *billardierianum*, Ser. Upper Buller Valley; Cheeseman.
,, *melanocaulon*, Hook. Buller Valley; T. F. Cheeseman.
Pseudopanax ferox, T. Kirk. Buller Valley; T. Kirk.
Raoulia subsericea, Hook. f. Buller Valley; T. F. Cheeseman.
Cotula minor, Hook. f. Buller Valley; T. F. Cheeseman.
Forstera bidwillii, Hook. f. Buller Valley; T. F. Cheeseman.
Senecio geminatus, T. Kirk. Buller Valley; T. F. Cheeseman.
Limosella tenuifolia, Nutt. Buller Valley; T. F. Cheeseman.
Drapetes lyallii, Hook. f. Buller Valley; T. F. Cheeseman.
Dacrydium laxifolium, Hook. f. Buller Valley; T. F. Cheeseman.
Cyrtostylis oblonga, Hook. f. Buller Valley; T. F. Cheeseman.
Potamogeton natans, L. Buller Valley; T. F. Cheeseman.
Scirpus nodosus, Rottb. Buller Valley; T. F. Cheeseman.
Uncinia filiformis, Boot. Buller Valley; T. F. Cheeseman.

Carex pyrenaica, Wahl. Buller Valley; T. F. Cheeseman.
„ *echinata*, Murr. Buller Valley; T. F. Cheeseman.
„ *breviculmis*, R. Br. Buller Valley; T. F. Cheeseman.
Agrostis muscosa, T. Kirk. Buller Valley; T. F. Cheeseman.
Hymenophyllum villosum, Col. Buller Valley; T. F. Cheeseman.
„ *cheesemanii*, Bak. ex Hook. and Bank. Waimangaroa; Dr. Gaze.
Alsophila colensoi, Hook. f. Serjeant's Hill; Mr. Green.
Lomaria dura, Moore. Waimangaroa Gorge; Mr. Wright.
Hypolepis millefolium, Hook. Buller Valley; T. F. Cheeseman.
Lycopodium selago, L. Buller Valley; T. F. Cheeseman.

Art. XXXVI.—*Notice of the Occurrence of* Hydatella, *a Genus new to the New Zealand Flora.*

By T. F. Cheeseman, F.L.S.

[*Read before the Auckland Institute, 3rd October*, 1906.]

In the "Manual of the New Zealand Flora" (p. 756) I have provisionally described, under the name of "*Trithuria inconspicua*," a curious little plant collected by Messrs. H. Carse and R. H. Matthews at Lake Ngatu, near Ahipara. As mentioned in the Manual, the plant differs in several respects from *Trithuria*, but my specimens were not sufficiently complete to justify me in treating the species as the type of a new genus.

A few months ago, through the kindness of Dr. Diels, I received a copy of the "Fragmenta Phytographiæ Australiæ Occidentalis," an important publication devoted to an account of the plants collected or observed by Drs. Diels and Pritzel in West Australia in the years 1900 and 1901. On turning to the *Centrolepidaceæ* I was much interested in finding the description of a genus, for which the name *Hydatella* was proposed, which evidently included the Lake Ngatu plant. Dr. Diels remarks that the genus is allied to *Juncella*, F. Muell. (*Trithuria*, Hook. f.), but differs in the inflorescence being monœcious, in the stipitate flowers, in the longer and more numerous styles, and in the bracts being usually two only; to which may be added that the ovaries are neither angled nor compressed. Two species are described, *H. australis* and *H. leptogyne*, the first of which is excellently figured.

Shortly after the sheets containing the *Centrolepidaceæ* of the Manual had passed through the Press further specimens of the

Lake Ngatu plant were kindly forwarded by Mr. R. H. Matthews, and an additional parcel has just been received from the same gentleman. Unfortunately, Mr. Matthews has so far failed to find the male flowers; but his specimens show all stages of the female flowers, from the young bud to the fully ripened fruit, and they leave no doubt in my mind that the plant must be transferred to the genus *Hydatella*. I therefore subjoin a description of the genus and an amended specific character.

Hydatella, Diels.

Minute tufted and stemless annual herbs. Leaves numerous, all radical, filiform. Scapes usually numerous, radical, shorter than the leaves, each bearing a terminal head of minute flowers enclosed within 2–5 bracts; heads unisexual. Bracts usually 2 in the Australian species, 3–5 in the New Zealand. Male flowers: Stamens with a filiform filament and a 2-celled oblong anther. Female flowers: Ovaries densely crowded within the bracts, numerous, oblong or ovoid, not angled nor compressed, 1-celled and 1-ovuled; styles numerous, filiform, elongated, unequal in length. Fruit oblong or elliptic-ovoid, apparently indehiscent.

A genus of three species, two found in West Australia, the third endemic in New Zealand.

1. **H. inconspicua,** Cheesem.

A very minute slender perfectly glabrous annual herb, forming dense moss-like tufts $\frac{1}{2}$–1 in. high. Leaves numerous, all radical, filiform, strict, erect, terete, gradually tapering to an acute point. Scapes very short in the flowering stage, lengthening to one-half or three-quarters the length of the leaves when in fruit. Bracts 3–5, erect or erecto-patent, linear-lanceolate to ovate-lanceolate, acute, thin and membranous, $\frac{1}{12}$–$\frac{1}{8}$ in. long. Heads unisexual; males not seen. Ovaries densely crowded within the bracts, usually from 10 to 20, shortly stipitate, ovoid or oblong-ovoid, smooth, pale yellow-brown or reddish. Styles numerous, very delicate, forming a spreading brush at the tip of the ovary, and often much longer than it. Ripe fruit elliptic-ovoid, pale yellow-brown with a dark spot at each end.

So far this has only been found on the sandy shores of Lake Ngatu, a small lake situated behind the coastal sand-dunes about six or eight miles north of Ahipara, but doubtless it will be found on the shores of some of the numerous similar lakes existing in the North Cape peninsula. It principally differs from the Australian species in the more numerous bracts, and (judging from Dr. Diel's plate) in the stricter and more densely tufted habit.

ART. XXXVII.—*Notes on* Pittosporum obcordatum.

By T. F. CHEESEMAN, F.L.S.

[*Read before the Auckland Institute, 3rd October*, 1906.]

IN examining the flora of any country, considerable interest always attaches to those species found living at distant and far-separated points. It is true that the area of distribution of most plants is more or less discontinuous, and that in nearly all cases the localities where a particular species is plentiful are separated by spaces more or less extensive where it is altogether absent. But such instances are far removed from those where the habitats are not only distinct and totally unconnected, but are separated by expanses of hundreds of miles in extent. New Zealand possesses several instances of this nature, all of which deserve special study and inquiry. I do not propose to give a catalogue of these plants here, but it may be useful to mention some striking examples.

Melicytus macrophyllus is a common tree in hilly forests to the north of the Waikato River, but I have never seen or heard of it in the central or southern portions of the North Island, nor in the South Island, save in the one locality of Waikari Creek, near Dunedin, where it was discovered by Mr. G. M. Thomson many years ago. In this case there is an apparent gap of nearly six hundred and fifty miles between the northern and southern localities.

Drosera pygmæa was originally collected by Colenso near Cape Maria van Diemen, in the North Cape district, and has since been found by myself at Parengarenga, and by Matthews and Carse at Ahipara, in the same district. In 1877 Mr. T. Kirk found the same plant on the Bluff Hill, in the extreme south of the South Island, a station separated from those previously cited by almost the whole length of the colony.

Urtica australis, first discovered in the Auckland Islands by Sir J. D. Hooker, has since been gathered on Stewart Island and the Chatham Islands, and is said to have been collected by Bidwill on the north side of Cook Strait, near Wellington.

Danthonia bromoides, a species founded on specimens collected by Mr. Stephenson on cliffs in Cook Strait, appears again on the sea-coast to the north of Whangarei and the Bay of Islands, but in no intermediate locality. And, in addition, it is considered by Hooker to be identical with a grass common in the Auckland and Campbell Islands, quite at the other end of the colony.

Lastly, there is *Pittosporum obcordatum*, the subject of the present memoir, which was discovered by Raoul at Akaroa about 1840, and which, after being lost sight of for more than sixty years, has been lately refound by Mr. R. H. Matthews at Kaitaia, a station six hundred miles to the north of the original locality.

Now, it is quite possible that careful investigation may prove that in some of the instances quoted above we are not dealing with a single species, but with two distinct though closely allied species having a different geographical range. In the case of *Danthonia bromoides* it seems very doubtful whether the Auckland Island plant is conspecific with the northern one. More probably we have here two species—one endemic in the Auckland Islands, the other, to which the name "*bromoides*" should be restricted, found only on the rocky coast-line of the North Island. Similarly it may be questioned if Bidwill's specimens of *Urtica australis*, said to have been collected near Wellington, are really identical with the typical form from the Auckland Islands. They may be referable to another and much more common species, a supposition which would at once explain the fact that all recent attempts to find the true *U. australis* on the shores of Cook Strait have failed. As the existence of any species in widely separated localities is in itself a remarkable circumstance, it is not only natural, but highly desirable, that the evidence upon which such statements rest should be carefully examined and scrutinised from all points of view.

The recent discovery of *Pittosporum obcordatum* at Kaitaia has undoubtedly added another remarkable instance of discontinuous distribution to those already on record, and it is not at all surprising that attempts have been made to offer an explanation. As Raoul botanised at the Bay of Islands as well as at Akaroa, it has been suggested that his specimens may have been obtained in the first-mentioned locality, which is only fifty miles distant from Kaitaia. This view has been adopted in Laing and Blackwell's "Plants of New Zealand," and in some newspaper writings of Dr. Cockayne. But it is by no means difficult to prove that the facts will not admit of this interpretation.

Pittosporum obcordatum was first described by Raoul in the "Annales des Sciences Naturelles" for 1844; but a fuller account, accompanied by a beautiful plate, was given in his "Choix de Plantes de la Nouvelle Zélande," issued in 1846. In it Raoul gives the habitat as "Akaroa, in umbrosis humidisque nemoribus," and he adds at the close of the description the remark (to which I invite special attention) "Florebat Decembre." Since Raoul's time Akaroa has been repeatedly visited by botanists or botanical collectors, such as Sir Julius Haast, Mr. Buchanan, Mr. T. Kirk, and many others. During these visits *Pittosporum obcordatum* was specially searched for, but always without success. Similarly, all attempts to find it in other localities in Canterbury or elsewhere in New Zealand met with uniform failure, until, in 1901, it was unexpectedly discovered at Kaitaia by Mr. R. H. Matthews. The assumption mentioned above that Raoul's specimens were probably gathered at the Bay of Islands and not at Akaroa no doubt explains a very puzzling case of discontinuous distribution, but the suggestion should scarcely have been made without some evidence in support of it. Raoul is well known to have been most accurate in any statements based upon his own personal observations. During the preparation of my "Flora of New Zealand" I have had occasion to check all the habitats assigned by him to New Zealand plants, and I cannot call to mind a single instance where he has given an erroneous locality or confused the habitats of any plant collected by himself. As a simple matter of justice to one of the pioneers in New Zealand botany, it appears desirable to examine all the known facts that bear upon the question.

Raoul arrived at the Bay of Islands on his first visit on the 11th July, 1840. He botanised at Kororareka (Russell), Paihia, and Waitangi, and left again on the 31st July, his stay being limited to twenty days. He observes that owing to the season of the year, and the abundant rains, he could only collect some well-known species. He arrived on a second visit on the 2nd December, 1841, remaining until the 13th of the same month, or eleven days. Lastly, in January, 1843, on his way back to Europe, he made a third call of a few days only. Altogether, he did not spend more than thirty-five or thirty-six days in the district. His visits to Akaroa were of much longer duration. On the first occasion he arrived on the 15th August, 1840, and remained until the 21st November, 1841, or over fifteen months, comprising, as he says, a complete series of the seasons. His second visit extended from the 26th January, 1842, until the 11th January, 1843, or very nearly twelve months. Altogether he resided for twenty-seven months at Akaroa. It is consequently not at all remarkable that the greater number of the plants mentioned in the "Choix" as being collected by himself have the habitat of Akaroa assigned to them.

The specimens figured by Raoul are in flower, and, as mentioned above, a note is appended to the description to the effect that the flowering month is December. If the specimens were collected at the Bay of Islands it must have been in December, 1841; if at Akaroa it may have been either December, 1840, or December, 1842. Now, it is well known that in the case of species which range through the whole length of the colony there is a considerable difference between the times at which they flower in the North Island and South Island respectively, the same species blooming quite six weeks later in Canterbury than at the Bay of Islands. It appears to me that this difference in the flowering period supplies us with a simple means of deciding in which of the two localities Raoul's specimens were obtained. If they were gathered in December at the Bay of Islands, then the plant will also flower in that month at Kaitaia; if, on the other hand, we accept Raoul's statement that they were collected at Akaroa, it is obvious that the flowering season at Kaitaia will be about six weeks sooner, or about the end of October. I therefore applied to Mr. R. H. Matthews for information as to the time of flowering at Kaitaia. He has gone into the matter with considerable care, and informs me that the first fully expanded flowers were noticed on the 19th October. On the 27th October the plant was in full flower, continuing in that state through the early part of November, but entirely passing out of bloom before the end of the month. I think that it will be admitted that these observations of Mr. Matthews prove—(1) that Raoul could not have collected flowering specimens at the Bay of Islands, for the simple reason that the plant was not in flower at the time of his visits; and (2) that the flowering period at Akaroa would probably be in the month of December, thus harmonizing with Raoul's own statement. This evidence is, of course, of an indirect nature, but it appears to be quite sufficient to warrant us in accepting as correct Raoul's original habitat as published by him.

In the present state of our knowledge it is premature to speculate as to the reasons why *Pittosporum obcordatum* should apparently be confined to two localities so far apart as Kaitaia and Akaroa. The facts have yet to be collected which will explain such remarkable instances of discontinuous distribution. But it may be observed that systematic inquiry into the causes which have operated in such cases is of greater importance than would appear at first sight. If we could fully explain the discontinuous distribution of the plants mentioned at the beginning of this paper, we should know much of the past history of the flora and its gradual development, and we should be more fully acquainted with the vicissitudes of climate and the changes which have taken place in the physical conditions of the country.

One important consideration remains for discussion. Sir Joseph Hooker, in the "Flora Novæ-Zealandiæ" (vol. 1, p. 22), remarks with respect to *Pittosporum obcordatum*, "It presents some peculiarities of form and habit shared by several New Zealand plants of very different genera, which are not easily distinguished from it and from one another by the leaf alone at first sight. These are *Melicytus micranthus*, *Panax anomalum*, and a state of *Alseuosmia banksii*." To these might well be added *Myrsine divaricata*, *Melicope simplex*, certain *Coprosmæ*, and some of the juvenile states of *Pennantia corymbosa* and *Elæocarpus hookerianus*. The resemblance of *Myrsine divaricata* to the *Pittosporum* is particularly close, and some years ago flowerless specimens of the former were actually distributed by a Christchurch collector as *Pittosporum obcordatum*. It is quite possible, and personally I consider it highly probable, that the *Pittosporum* has been mistaken in a flowerless state (and its flowers are by no means conspicuous) for some of the plants mentioned above, the close general similarity of which has been noticed by all authors when describing the physiognomy of New Zealand vegetation. Under such circumstances it may well have a more general distribution than is commonly supposed. I would recommend a search for *Pittosporum obcordatum* to those New Zealand botanists who reside near the course of our larger rivers, the banks of which are often fringed for miles with a vegetation largely composed of the species mentioned above.

ART. XXXVIII.—*Contributions to a Fuller Knowledge of the Flora of New Zealand*: No. 1.

By T. F. CHEESEMAN, F.L.S., Curator of the Auckland Museum.

[*Read before the Auckland Institute, 3rd October*, 1906.]

Plate XI.

UNDER the above title, I propose from time to time to place upon record any additional information respecting the New Zealand flora that appears to be of sufficient importance, either as regards the characters, relationships, properties, &c., of the various species composing the flora, or with respect to their geographical range within the colony. For the present instalment I am largely indebted to the kindness of various correspondents, who have gone to considerable trouble in obtaining specimens and other information, and who have succeeded, in several instances, in bringing to light new facts of interest. My warmest thanks are due to all.

With respect to the local distribution of New Zealand plants, it will not be out of place to take this opportunity of stating that much remains to be done before the colony can be said to be fairly well explored, and before really accurate general conclusions can be arrived at respecting the latitudinal and altitudinal range of the species. Taking the North Island first, the portion between the North Cape and the Upper Waikato has probably been more closely examined for plants than any other part of the colony, and tolerably complete catalogues of the species found in various subdivisions have been prepared. But, even within that area, several districts are imperfectly known—as, for instance, the rugged forest-clad country between Ahipara and Hokianga, and that between Hokianga and the Northern Wairoa, the latter district including the highest peaks north of Auckland. South of the Waikato, the elevated central plateau of the North Island, upon which stand the snow-clad mountain Ruapehu and its neighbours Ngauruhoe and Tongariro, has never been systematically explored, although several botanists have collected in a cursory manner thereon. Considering its position, and its peculiarities of soil and climate, which have left a marked impress on the flora, it is probable that a reliable catalogue of its plants would be more useful to the New Zealand botanist than any other. It is still more remarkable that no complete account of the vegetation of Mount Egmont has yet been prepared, for that issued many years ago by Mr. Buchanan can only be looked upon as a preliminary sketch. The mountain is now so accessible to the traveller, and so easily ascended, that it is to be hoped that some Taranaki botanist will undertake its investigation. The Tararua Range, which probably has the most varied alpine vegetation of any mountain-chain in the North Island, has barely been examined at all. Finally, it can hardly be considered satisfactory that Mr. Buchanan's sketch of the flora of Wellington, prepared more than thirty years ago, and admittedly incomplete at that time, should still be the only list of the plants of the southern portion of the North Island, including the vicinity of the capital of the colony.

In the South Island the eastern side is fairly well explored, although much remains to be done in certain districts, such as the neighbourhood of Mount Stokes, the Kaikoura Mountains, and the extreme south-east of Otago; but the central chain of the Southern Alps is still imperfectly explored, and on the western side of the Island large portions have not been examined at all—in fact, it can be roundly stated that the whole district from Cape Farewell to Preservation Inlet requires a careful scrutiny. The western slopes of the chain of mountains stretching from Collingwood to Mount Arthur and Mount Owen offer a promising field for exploration. Nearer to Westport, the recent researches of Mr. Townson have shown what can be done by a diligent local observer. To the south of Greymouth little systematic work has been accomplished, especially on the mountains; while as regards the West Coast Sounds and the mountains immediately behind them our knowledge of the vegetation is practically in the same state as it was left by Lyall, more than fifty years ago. It is in this portion of the colony that we may look forward to numerous additions to the alpine flora, and for many fresh observations on the nature and composition of the flora generally.

A descriptive account of the vegetation of Stewart Island, accompanied by a list of species, would be a boon of the first order to the New Zealand botanist, for up to the present time a partial examination only has been made by Messrs. Thomson, Petrie, and Kirk.

It would be easy to mention other localities which are still wanting exploration, or are imperfectly known, but enough has been said to show that, although the leading facts of plant-distribution in New Zealand are known, much of the detail has yet to be filled up. It is to country residents, and to local observers generally, that we must look for much of the information required.

I. RANUNCULACEÆ.

Ranunculus insignis, var. **lobulatus.**

Dr. Cockayne proposes to treat this as a separate species under the name of *R. lobulatus* (Trans. N.Z. Inst., xxxviii, 1906, 373). I am only acquainted with it through a single flowerless specimen in Mr. Kirk's herbarium; but this, as I have stated in the Manual (p. 11), has a very distinct appearance, and I suspect that Dr. Cockayne is quite right in the course he has taken.

III. CRUCIFERÆ.

Lepidium banksii.

I am indebted to Mr. J. H. Macmahon for specimens of this, collected in Queen Charlotte Sound.

V. PITTOSPOREÆ.

Pittosporum cornifolium.

Mr. H. J. Matthews informs me that this is not uncommon at West Wanganui Inlet, to the south of Cape Farewell. This is the first recorded locality on the west coast of the South Island.

X. MALVACEÆ.

Plagianthus cymosus.

According to Mr. H. J. Matthews, this is abundant on the banks of the Pelorus River (Marlborough), between Brownlee's Mill and Canvastown, where it grows intermixed with *P. betulinus* and *P. divaricatus*.

Gaya lyallii, var. ribifolia.

Dr. Cockayne has given this the rank of a species, under the name of *G. ribifolia* (Trans. N.Z. Inst., xxxviii, 373). He appears to rely principally on the more incised and less pointed leaves, with a more copious stellate pubescence on the under-surface. No doubt it is a well-marked variety, but I cannot accept the differences as being sufficient to separate it as a species.

XI. Tiliaceæ.

Entelea arborescens.

Mr. J. H. Macmahon informs me that a few plants of this are still to be found in Resolution Bay, Queen Charlotte Sound, but that it is fast verging towards extinction in that locality.

Elæocarpus dentatus, var. obovatus, Cheesem., n. var.

Leaves broadly obovate; blade 2–2½ in. long by 1¼–2 in. broad, rounded at the apex, at the base rather suddenly narrowed into a long slender petiole. Flowers not seen.

Riwaka (north-west Nelson); *H. J. Matthews!*

A very distinct variety, respecting which fuller information is much desired. Although *E. dentatus* is a variable plant, I have never seen specimens with the leaves so broad and obtuse.

XXII. Leguminosæ.

Clianthus puniceus.

At the present time this is so rare in the wild state that most New Zealand botanists are only acquainted with it as a cultivated plant. Its rarity has induced some writers to question its nativity in New Zealand—as, for instance, the Rev. R. Taylor, who suggested that it originated in the Bay of Islands from a box of seeds taken by the Maoris from a French ship which they had plundered! It is perhaps hardly necessary to observe that this ingenious hypothesis does not explain how, in that case, the plant could have been previously gathered by Banks and Solander in both the Bay of Islands and East Cape districts. Mr. Taylor also neglects the pertinent fact that *C. puniceus* has never been found in any other country but New Zealand. However, the present distribution of the plant is so restricted that it is in every way probable that within a few years it will have disappeared in a wild state. Under these circumstances it appears desirable to particularise those localities where there is reason to believe it is truly native, or has been within the memory of those living.

I. Bay of Islands and Whangarei.—Motuarohia Island, *Banks and Solander*, according to Solander's MS. (1769). Taranaki Island (at the mouth of the Kerikeri River); *Colenso* (Trans. N.Z. Inst., xviii, 292), *Rev. R. Taylor*, *Bishop Williams*, and others. Mr. Colenso also states (Trans. N.Z. Inst., *l.c.*) that it was also found "on two or three of the smaller islets of that bay." Limestone Island (Whangarei River); *R. Mair*, who informs me that in 1843 there were numerous fine bushes of it in this locality, and that it lingered as late as 1880. McLeod's Bay (Whangarei Heads); *R. Mair*, who observed a few plants in 1850. In this locality it disappeared shortly after the establishment of European settlers and their cattle.

II. Other Northern Localities.—Great Barrier Island; *Kirk* (Trans. N.Z. Inst., i, 150). Thames; *Kirk*, "Students' Flora" (now extinct in a wild state). Flat Island, near Howick; *T. F. C.;* not uncommon in 1878, but has been extinct for many years. Mercury Bay; *A. Cunningham*, in his "Precursor," gives this as a locality where it had been collected by the missionaries in 1833. I have been unable to find any evidence that it still exists in the district.

III. East Cape District.—Anaura Bay (Tigadu) and Tolago Bay; *Banks and Solander!* 1769. Still exists on Motu-o-roi Island, off Anaura Bay; *Bishop Williams.* Banks of the Hikuwai River, flowing into Tolago Bay; not uncommon as far back as 1844; *Bishop Williams.* Is still found at a gorge twelve miles inland from Tolago Bay, and on cliffs at Tokomaru Bay; *H. Hill.* East Cape Island; *Bishop Williams:* still fairly plentiful; *Mr. Arnold.* Mangatokerau Gorge, beyond Waiapu; Tiniroto; road to Morere; still found in all three localities; *H. Hill.* Back of Maraetaha (Poverty Bay); fairly plentiful in 1841 and succeeding years, but now extinct; *Bishop Williams.* Taikawaka (near Whareongaonga, Te Kooti's landing-place); fairly plentiful; *H. Hill.* Cliffs on Lake Waikaremoana, and gorge near the Reinga Falls; not uncommon; *H. Hill.*

From the above list it is evident that the plant had a fairly wide distribution, chiefly on or at the base of cliffs in littoral districts. Its disappearance is doubtless due to cattle, which greedily eat it, and soon exterminate it in any locality to which they have access.

Mr. Hill informs me that in the East Cape localities the flowers vary considerably in colour, size, and in the shape and relative proportions of the petals. At Waikaremoana the flowers are comparatively small and reddish-purple. At Tolago and Tokomaru the flowers are large, and the standard very broad, with a whitish stripe on each side near the base. A white-flowered variety is stated by the Maoris to grow on the Tiniroto cliffs —possibly it may be identical with the white-flowered form sometimes cultivated in gardens.

XXIII. Rosaceæ.

Rubus parvus.

Cobb Valley; *F. G. Gibbs!* Wangapeka Valley; *R. I. Kingsley.*

Geum uniflorum.

Mount Luna, Upper Wangapeka Valley; *R. I. Kingsley.*

XXVIII. Myrtaceæ.

Metrosideros tomentosa.

It appears desirable to specify the inland localities in which the pohutukawa occurs, so far as they are known, with a little more detail than is given in the Manual.

Lake Rotorua.—Mokoia Island, and cliffs on the northern shore of the lake from Kawaha Point and Hamurama to the Ohau Channel; *H. J. Matthews, C. B. Turner, T. F. C.*

Lake Rotoiti.—Cliffs on the northern shore of the lake, plentiful and of large size, less generally distributed on the southern shore; *H. J. Matthews, C. B. Turner, T. F. C.*

Lake Tarawera.—Before the eruption of Tarawera Mountain in June, 1886, the cliffs along the greater part of the northern shore were clothed with pohutukawa, which attained a luxuriance only inferior to that which it exhibits on the coast-line of the northern portion of the Auckland Provincial District; *Kirk! Captain G. Mair.* At the present time it is still fairly plentiful, mainly from the new growth of the old trees broken down by the eruption. According to Mr. H. J. Matthews two solitary trees occur in the Waikaripo Bush, some distance from the southern shore of the lake, and about three miles west of Lake Rotomahana.

Tarawera River.—Abundant along the banks of the river almost as far as Matata; *Colenso, Captain G. Mair, T. Kirk, H. J. Matthews.*

Lake Okareka. — Cliffs on the eastern shore, scarce; *H. J. Matthews, T. F. C.*

Lakes Okataina, Rotoehu, and *Rotoma.*—Fairly plentiful along the shores; *H. J. Matthews.*

Lake Rotokawau.—A few small trees on the cliffs; *H. J. Matthews.*

Lake Taupo.—Plentiful on Motutaiko Island, but of small size; *T. Kirk, H. Hill, T. F. C.* Also on Whakaipo Bluff, where it attains a fair size; and on several of the headlands between Whakaipo and Taupo Township.

Lake Waikaremoana. — In several localities on the cliffs fringing the lake; *Colenso* (1841), *H. Hill*, *C. B. Turner*.

XXXIII. Umbelliferæ.

Eryngium vesiculosum.

West Wanganui Inlet; *R. I. Kingsley*. The only station yet recorded for the west coast of the South Island.

Angelica geniculata.

I am indebted to *Mr. J. H. Macmahon* for specimens of this, collected on Motuaro Island, Queen Charlotte Sound. This is doubtless the locality where it was originally discovered by Forster, although he does not specifically mention where he collected his specimens.

XXXV. Cornaceæ.

Griselinia littoralis.

Summit of Mount London, between the Southern Wairoa and the Firth of the Thames; *E. Phillips Turner*.

XXXVIII. Compositæ.

Brachycome odorata.

Mr. Guthrie Smith has sent me a specimen of this collected on the Tutira Run, near the head-waters of the Mohaka River, Hawke's Bay.

Olearia haastii.

Head of the Dart River, Otago; *H. J. Matthews*.

Olearia coriacea.

I have received a specimen of this collected on Mount Fyffe by *Mr. H. J. Matthews*. It has rather thinner leaves than Kirk's type, but does not otherwise differ. Mr. Matthews states that plants of *O. forsteri* and *O. cymbifolia* were growing in the same locality, and suggests that it may be a hybrid between these two species. When flowering specimens are obtained it will be interesting to note whether these show any tendency towards the reduction in the number of florets which is such a singular characteristic of *O. forsteri*.

Olearia cymbifolia.

In the Manual I have followed Sir J. D. Hooker in treating this as a variety of *O. nummularifolia*. Further study, however, has convinced me that it is a distinct species, which should bear the name of *O. cymbifolia*.

Cassinia vauvilliersii, var. albida.

This has been separated as a distinct species by Dr. Cockayne, under the name of *C. albida* (Trans. N.Z. Inst., xxxviii, 1906, 374). As he remarks, it is distinguished from the typical state by the tomentum on the under-surface of the leaf, which is white or pale-yellowish-white and not fulvous. This character gives the plant a more distinct appearance than might be supposed, so that it is more readily separated from *C. vauvilliersii* by a cursory inspection than some states of *C. leptophylla* from *C. retorta*, or *C. fulvida* from *C. leptophylla*. All the New Zealand species of *Cassinia* are very closely allied and difficult of discrimination. With it, as with several other New Zealand genera—*e.g.*, *Veronica*, *Gentiana*, *Epilobium*, *&c.*—there seems to be no middle course between largely reducing the number of species—which is opposed to the present tendency of systematic botany—or accepting as distinct a considerable number of closely related forms. The course to be followed in the present instance will depend largely on the point of view and personal judgment of the observer, coupled, of course, with a full consideration of the evidence available. The variety or species—whichever it may be called—appears to be abundant along the seaward face of the Kaikoura Mountains, extending in a westerly direction as far as the Clarence River and the middle portion of the Wairau Valley, where I gathered a form referable to it many years ago.

Senecio rotundifolius.

West Wanganui Inlet, to the south of Cape Farewell; *H. J. Matthews*. This shows a considerable northwards extension of the range of this fine plant. Mr. Matthews informs me that it has been advantageously employed for garden-hedges in the south of the South Island.

LIV. Scrophularineæ.

Euphrasia cuneata.

Abundant on D'Urville Island; *H. J. Matthews*.

LXXVI. Urticaceæ.

Paratrophis banksii.

Mr. J. H. Macmahon informs me that this occurs on Motuaro Island, Queen Charlotte Sound, but I have seen no specimens. It has been recorded from Stephen Island.

LXXVIII. CONIFERÆ.

Phyllocladus alpinus.

A memoir on some points in the morphology of this species, by Agnes Robertson, D.Sc., is printed in the "Annals of Botany" for July, 1906 (p. 260).

LXXIX. ORCHIDEÆ.

Thelymitra ixioides.

Mrs. H. J. Matthews forwards undoubted specimens of this species collected at Rotorua.

Thelymitra intermedia.

To this I refer, with some doubt, a pink-flowered species collected by *Mrs. H. J. Matthews* in the vicinity of Rotorua. In most respects it agrees with Berggren's plate and description, with the exception that the lateral lobes of the column-wing are not so slender as represented by Berggren.

Thelymitra decora.

This species also has been gathered at Rotorua by *Mrs. H. J. Matthews*. Her specimens are larger and stouter than those collected by myself to the south of Lake Taupo, and have more numerous and rather larger flowers, but the structure of the flowers is precisely the same.

Pterostylis barbata.

Among *Leptospermum* scrub near Cowes, Waiheke Island; *J. H. Harvey!*

Corysanthes oblonga.

Mr. R. H. Matthews, of Kaitaia, sends a curious variety with the flowers entirely green, showing no sign of red whatever.

LXXXII. LILIACEÆ.

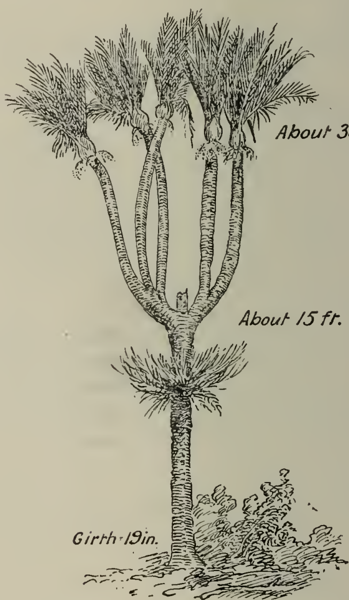
Cordyline indivisa.

Summit of Mount London (Kohukohunui), between the Southern Wairoa and the Firth of the Thames, altitude 2,000 ft., *E. Phillipps Turner.* The most northerly locality recorded.

LXXXIV. PALMÆ.

Rhopalostylis sapida.

In the Manual I have alluded to the fact that branched specimens of the nikau palm are occasionally seen. One figured and described by Mr. Percy Smith (Trans. N.Z. Inst., x, 357, t. 15) is well known to New Zealand botanists; and a photograph of a curious 6-branched specimen is given in Laing and Blackwell's "Plants of New Zealand" (p. 89). I have now to record two additional instances. The first was found about eighteen years ago at Kaiwaka, North Auckland, by Mr. D. A. Mackenzie, of Waipu. From the accompanying sketch for-



warded to me by Mr. Percy Smith, to whom it was given by Mr. Mackenzie, it will be seen that the main stem has been injured, causing the death of the terminal bud. The injury has evidently led to the production of a lateral branch on each side, one of which has, by successive forking, produced three branches, the other two. This specimen is interesting on account of the proof which it affords that the branching was due to some injury to the terminal bud. For my knowledge of the second instance, which is the most remarkable yet recorded, I am indebted to Mr. H. J. Matthews, the head of the Forestry Department. It was recently found in the State forest reserve at Puhipuhi, between Whangarei and the Bay of Islands. Its height is about 30 ft., and it possesses no fewer than seventeen branches. The health and vigour of the tree is undiminished, and there is no sign of any previous injuiy. The excellent photograph given to me by Mr. Matthews, which I reproduce herewith (Plate XI), will give a better idea of the mode of branching than any description of mine.

XC. Restiaceæ.

Lepyrodia traversii.

Peaty swamps near the outlet of Lake Tongonge, near Kaitaia; *R. H. Matthews!* This is an interesting and most unexpected discovery, the only other locality known on the mainland being the large peaty swamps between Hamilton and Ohaupo, in the Middle Waikato district.

XCI. Cyperaceæ.

Carex dipsacea.

Fairburn (Mongonui County); *H. Carse!* A marked northern extension of the range of this species.

XCII. Gramineæ.

Trisetum cheesemanii.

Summit of Mount Blairich, Marlborough, altitude 5,000 ft.; *J. H. Macmahon!*

XCIII. Filices.

Trichomanes elongatum.

Westport district, at Giles's Creek, and in the lower portion of the Buller Valley; *W. Townson!*

Lindsaya viridis.

In several localities in the Westport district, as Giles's Creek, Millerton, and road to Charleston; *W. Townson!*

Adiantum æthiopicum.

This also occurs in several localities in the Buller Valley, near Westport; *W. Townson!* Mr. A. Frood informs me that he has a crested variety in cultivation, found near some small lakes along the sea-coast opposite to Te Kopuru, Northern Wairoa.

Asplenium umbrosum.

Banks of the Buller River, near Westport; *W. Townson!* The most southern locality known to me.

Todea barbara.

A form with the tips of the fronds regularly crested is now in cultivation in Mr. G. E. Smith's fernery at Aratapu, Northern Wairoa.

XCVI. Lycopodiaceæ.

Tmesipteris tannensis.

According to Mr. Percy Smith, the Maori name for this plant is "raupiu."

Naturalised Plants.

Ranunculus aquatilis.

I hear from Mr. G. M. Thomson that this is rapidly spreading in several streams in eastern Otago. It first appeared in the Waikouaiti River, then in the upper part of the Waipahi, and quite recently in the Pomahaka. No doubt it will ultimately find its way into the Clutha and other large streams.

Ranunculus flammula.

Waiharakeke Stream, Piako; *J. H. Allen!* I believe that this is the first recorded instance of the occurrence of this species in New Zealand.

Trifolium subterraneum.

This is increasing rapidly in the Auckland district.

Ornithopus perpusillus.

Mr. H. E. Potter, of Brookby, Auckland, has forwarded specimens of this species, which he states has appeared in some quantity in newly sown grass paddocks in his district. So far as I am aware, this is the first record of its occurrence in New Zealand.

Bidens tripartita.

Near Ohaupo, in the Middle Waikato district; *A. V. Macdonald!* Apparently the first appearance in New Zealand of a very undesirable immigrant.

Alisma plantago.

Vicinity of Marton, Wellington Province; *W. Townson!* The first specimens I have seen on the western side of the Island.

Art. XXXIX.—*Notes on certain Maori Carved Burial-chests in the Auckland Museum.*

By T. F. Cheeseman, F.L.S., F.Z.S., Curator of the Auckland Museum.

[*Read before the Auckland Institute, 3rd October,* 1906.]

Plates XII and XIII.

Very little appears to be known respecting the occasional former use by the Maoris of carved burial-chests or coffins in which the bones of deceased chiefs were placed after the ceremony of *hahunga*, and then deposited in the burial-cave of the tribe. In none of the earlier accounts of Maori burial customs can I find any description of such articles. The usual statements made as to the disposition of the bones after the *hahunga* are well summarised by Mr. Colenso in his "Essay on the Maori Races of New Zealand," where he says (page 20): "After being exhibited, seen, wept, and wailed over, they [the bones] were carried by a single man and near relative to their last resting-place, the exact spot of deposit, for wise political reasons, being only known to a select few. Sometimes the bones were thrown into some old volcanic rent or chasm; sometimes thrown into very deep water-holes; and sometimes neatly and regularly placed in a deep, dark cave; always, if possible, wherever those of his ancestors happened to be."

The only reference of old date respecting the use of coffins that I have been able to find—and that a mere passing mention—is in Mr. Colenso's account of his discovery of the tree manoao (*Dacrydium colensoi*), printed in the "London Journal of Botany" (vol. i, p. 298), where he says, speaking of the rarity of the tree and the durability of its wood, that the Maoris "wherever they could find a tree reserved it for a coffin to hold the remains of a chief." Nor do I find in any Maori dictionary a word that could be applied to a coffin or burial-chest; and Bishop Williams, to whom I applied for information on the subject, has informed me that he is unacquainted with a Maori term for such articles. The word "*atamira*," which of late years has been applied to them, he considers to be more correctly used for the stage or platform upon which a dead body is laid out.

Mr. Elsdon Best's valuable paper on Maori eschatology, printed in the last volume of Transactions (vol. xxxviii, pp. 148–239), which is a storehouse of information respecting the customs, &c., relating to death and burial among the Maori people, contains some references to the placing of dead bodies in boxes or coffins, which were sometimes placed in trees, sometimes on the top of tall posts. But it appears to me that these receptacles are of quite a different nature, being plainly temporary, and only intended to hold the decomposing body until the time of the *hahunga.* The only mention made by Mr. Best respecting coffins to hold the bones after the *hahunga* refers to the specimens I am now about to describe.

The first examples of carved wooden coffins that came under my notice were two obtained by an Auckland dealer some years ago. These were of precisely the same pattern as those now in the Museum, and had been originally carved all over the surface, but owing to their great age, and the consequent decay of the wood, the details of the carving were to a considerable extent obliterated. The better one of the two is now in the Melbourne Museum; the other one was purchased by Mr. A. Hamilton, and now forms part of his collection deposited in the Colonial Museum. A photograph of this is reproduced in Mr. Hamilton's "Maori Art" (page 158).

In the autumn of 1902 two Europeans were pig-hunting in a rough and rugged part of the Waimamaku Valley, a few miles to the south of Hokianga. While so doing they accidentally discovered two small caves situated on the face of a precipitous cliff. Entering these, they found that they were literally packed with human skeletons, and that they also contained no less than eight carved burial-chests, most of them full of bones. The caves being on Government land, the finders reported the discovery to the Commissioner of Crown Lands at Auckland, with the result that Mr. Menzies, Government Road Inspector, was instructed to proceed to the caves and take charge of the chests, impressing on the Natives the desirability of presenting them to the Auckland Museum.

One of the discoverers, Mr. Louis Morrell, has kindly furnished me with information as to the position in which the burial-chests were found. He states that all the chests, except one carved on the back to resemble a lizard, were found in the largest cave, which is really a shelf of conglomerate rock about 20 ft. long by 10 ft. wide, situated on the face of a cliff, the cliff overhanging and keeping the floor dry. The cave faces the north, and the sun shines into it for most of the day. The chests were standing up with their backs against the wall, and most of them were full of bones. Those that were not were evidently empty because the lashings which had fastened the lids to the back of the chests had given way, the bones falling out. The small carved box with square ends and perforated sides, and painted with *kokowai,* also had bones in it, and was resting on its lid at the western side of the cave at the point marked 7 in the sketch. The

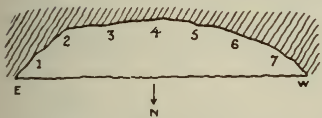


figure 3 represents where the tallest chest was placed, and 1 and 5 the positions of those next in size; 2, 4, and 6 those of the others.

Round the corner of the cliff, at the west end of this cave, and about 12 ft. higher up the cliff, was a second cave, barely more than 6 ft. in total length, and with a very small entrance. Right in the entrance, and almost blocking it, was a single burial-chest carved on the surface to represent a lizard. It was placed with its flat or hollow side downwards on the floor of the cave, the head of the lizard pointing to the south. The chest itself was empty, but numbers of skeletons (from twenty to twenty-four, according to Mr. Morrell) were packed around it—so closely, in fact, that the chest could not be removed until the bones were displaced.

The only other articles found in the caves—but in which of them Mr. Morrell does not state—were a short *tao*, or spear; a *ko*, or spade; a wooden comb; and some fragments of Maori flax cloaks.

The discovery of the burial-chests naturally caused great excitement among the Maoris residing near Waimamaku, and at first they strongly objected to the proposed removal of the chests to the Auckland Museum. They were unable to understand why these sacred articles should be taken from them, especially as they were actually the receptacles of the bones of their ancestors. They regarded the matter as an attempt to trample on their most sacred rites and traditions; and it was not until there had been several heated discussions between the Maoris and the Resident Magistrate, Mr. Blomfield, that an arrangement could be arrived at. Mr. Blomfield at length succeeded in convincing them that as the chests, if left at Waimamaku, would soon perish by the ravages of time, it would be wise on their part to deposit them in a secure place where they would be preserved for ages to come, and would form a permanent memorial of their ancestors who made them, and whose memory they themselves wished to keep alive. Ultimately it was agreed that the articles should be handed over by the Natives to the Hon. the Native Minister as their trustee, and that he should place them in the Auckland Museum to remain there for ever. The chiefs concerned in the gift were Ngakura Pana and Iehu Moetara, of Waimamaku, and Hoterene Wi Pou and Heremaia Kauere, of Otaua.

A considerable amount of evidence was taken by Mr. Blomfield when holding his inquiry, and this I have been kindly allowed to peruse. I have extracted the following dealing with the history of the chests. Heremaia Kauere said,—

I belong to Ngaitu Hapu, and to Ngatene Hapu, also to Ngatiteka and Nga-te-po. These are the hapus that made these things. Ngaitu made all these things. Kohuru was the man that made them; he was a chief, and was skilled in carving, and an instructor to the tribe. He lived at Otaua, say twenty miles away, but used to go all over the place. There are five *tikis* in the cave. One he made for Kahu Makaka, who had been dead for a long time, to put his bones in. It was the custom to put the body in trees, and then get the bones after. Kohuru died at Waimamaku. He belonged to Ngaitu and Ngatene. The *tiki* was put in a cave called Kohekohe, the cave which the Europeans have now disturbed. Kohuru himself conveyed the bones to the cave in the *tiki*; he took them from a stone close to the cave. He was a priest. The right was limited to the priests. I do not know whose bones were in the other *tikis*. They were all taken by Kohuru to the cave. The *waka* was made for the bones of Tangataiki. Taiki was his father. When he died, his body was placed in a hollow tree, a totara. Some years after, when they went to get the bones they found the skin dried over the head, which was preserved, showing the elaborate tattooing. The skin was also preserved over the other parts of the body; the legs were the only parts that had gone. The body was taken down and placed in the cave at the time of the fight of Motukauri. Whitinga was the man who took the body and placed it in the cave; he died four years ago. He put it in the cave and placed the *waka* over it. Kohuru did not make the *waka*—it was his descendants, about five generations after. A *tiki* was placed at each side of the entrance to the cave. The *waka*, with the lizard on it, stretched across the mouth inside. The bones of each ancestor were grouped along each side of the cave. There were three hapus—Ngaitu, Ngatene, and Nga-te-po—on the right-hand side, and Ngatiteka on the left. There were great numbers of bones there. My grandfather, Kahu Makaka, a namesake of the former Kahu Makaka, when he came with the bones of Hui, one of his relations, walked over the top of the lizard and placed the bones at the end of the cave. He must have been confused; he did not go round the *waka* as was the custom. He stepped back again over the lizard, and was bitten by the spirit of the lizard. He felt sick when he got out; went home, and died. They took his body to the cave, and afterwards conveyed the bones to Otaua. My father died at Otaua. After the death of Kahu Makaka my father lived at Waimamaku, and went to Otaua before the Treaty of Waitangi. The lizard was endowed by the incantations of our forefathers with powers of evil. It was placed as a guard over the bones of the dead, to prevent interference. The *tao*, being the weapon of one of the ancestors, was taken with the remains to the cave. The *korowai* coverings were those of Tangataiki. It is over sixty years since our people lived at Waimamaku before the Treaty of Waitangi; they lived in the valley, say two miles or less from the cave. Pene te Pana was one of the owners of the land that was sold to the Crown containing the cave. Hapakuku Moetara (dead), Tiopira (dead) were also owners; their ancestors are in the cave. Hapakuku is a direct descendant of Kahu Makaka. The name of the *wahitapu* where the cave is is Piwakawaka. There are three sets of caves there. The things referred to were all taken from Kohekohe.

It will be noticed that Heremaia Kauere distinguishes between the five (it should be six) *tikis* made by Kohuru and the much later *waka*, carved to represent a lizard, which was taken to the cave by Whitinga. This is borne out by the condition of the carvings, the *waka* being evidently of much more recent date than the others. Heremaia does not mention the small square-ended box-like chest with perforated sides. With respect to the names applied to the chests by Heremaia, it may be said that the word "*tiki*" would naturally be used by the present-day Maoris to designate a carving imitating the human figure; and that "*waka*" is regularly employed to represent anything shaped like a canoe—for instance, *waka-huia*, a box for holding huia-feathers.

As already mentioned, the chests are eight in number. Of these, six are much older than the rest, and are carved representations of the human figure, with a hollow body, and a flat lid at the back. The largest is 5 ft. 9 in. in height, the next is 5 ft., and two others are 4 ft. 6 in. The remaining two were evidently smaller than the above at first, but are both injured, one having lost its head, and both of them portions of the legs. The carving is very distinctive, and quite unlike anything else in the Museum. The photographs reproduced in illustration of this article (Plates XII and XIII) will give a better idea than any description of mine, but I may draw attention to the singular leaflike pattern, very well marked in the two largest figures, and which is set at an acute angle to a central line passing down the middle of the body. The peculiar way in which the eyes are represented, the remarkable tongue of the largest figure, and the very curious manner in which the hands are carved, are all points worthy of close study. It should also be mentioned that the carving on the body of the third largest figure differs from all the others in being unlike on the opposite sides of the central line—one side showing the leaflike pattern of the rest, the other a succession of parallel longitudinal lines with numerous dots between, the effect being very similar to the old style of tattooing with straight lines and dots, represented in one of the plates in "Cook's Voyages." The two remaining chests, already stated to be of more recent date, are more or less canoe-shaped with square ends. The one with the representation of a lizard on the back is very finely and regularly carved with a modification of the same leaflike pattern, the carving being much more deeply cut than in the other figures. Both of these chests were coloured red with *kokowai* when found, whereas the others showed no trace of ever having been coloured.

It is permissible to speculate as to the age of the chests. According to Heremaia Kauere, the death of his grandfather, Kahu Makaka—who was bitten by the lizard—took place some years before the Treaty of Waitangi in 1840, and the lizard must have been in the cave some years before Kahu's visit. We cannot assign a lesser age than seventy-five years to this, the youngest of the chests. And the *tikis*, which were carved by Kohuru five generations earlier, must therefore be about two hundred years old. Their condition and general appearance quite bear out this assumption, to say nothing of the archaic style of carving, as already described.

Quite recently another discovery of burial-chests has been made, this time to the south of Auckland, on the sandhills near Raglan. I understand that they have been purchased by a gentleman at Wellington for his private collection.

Art. XL.—*Notes on the* Callianassidæ *of New Zealand.*

By Charles Chilton, M.A., D.Sc., F.L.S., Professor of Biology, Canterbury College, N.Z.

[*Read before the Philosophical Institute of Canterbury, 5th December,* 1906.]

Plate XVI.

Though the *Callianassidæ* of New Zealand are few in numbers they have been only imperfectly described, and there has been some confusion as to the number of species found in New Zealand. This has been mainly due to the fact that, owing to their habit of burrowing in sand and mud, specimens are obtained only by some fortunate accident. Through the kindness of various friends I have now specimens of three species, and in this paper I give descriptions of these and endeavour to clear up the synonymy as much as possible. I am taking the family *Callianassidæ* as used by the Rev. T. R. R. Stebbing* to include, among others, the two genera *Upogebia* and *Callianassa*, to which our New Zealand species have been assigned, and I make no attempt to discuss the characters of the genera. Some discussion of these two genera is given in Mr. Stebbing's "South African Crustacea," part i, pp. 38–46, where those who are interested in the matter will find numerous references to other papers. *Upogebia* and *Gebia* are two names used by Leach for the same genus, the former being the earlier and therefore the one to be retained.†

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* "History of Crustacea," London, 1893, p. 183; and "South African Crustacea," part i, 1900, p. 38.

† See Stebbing, "History of Crustacea," p. 185.

Upogebia hirtifrons (White).

Gebia hirtifrons, White, P.Z.S., 1847, p. 122; Ann. Mag. Nat. Hist., ser. 2, i, p. 225; List Crust. Brit. Mus. (1847), p. 71; Miers, Ann. Mag. Nat. Hist., ser. 4, xvii, p. 223; Cat. N.Z. Crust., p. 71, and Zool. "Erebus" and "Terror," Crust., p. 4, pl. iii, fig. 5; Kirk, Trans. N.Z. Inst., xi, p. 401; Ortmann, "Decapoden und Schizopoden der Plankton Expedition," p. 49; Index Faunæ N.Z., p. 253 (part); (not of Dana, U.S. Expl. Exp., xiii, Crust., part i, p. 511, nor of Haswell, Cat. Aust. Crust., p. 164).

This species was briefly described by White in 1847 from a specimen obtained during the Antarctic expedition of the "Erebus" and "Terror," but without any definite indication of habitat. Later on Dana referred specimens obtained at Bay of Islands, New Zealand, by the United States Exploring Expedition, to White's species. In 1876 Miers pointed out that this identification was incorrect, and that Dana's specimens belong to a different species, which he named *Gebia danai* (see below). In 1879 Mr. T. W. Kirk recorded the existence of a specimen of a *Gebia* in the private collection of Mr. H. B. Kirk. This specimen is no longer available, but from Mr. Kirk's description it is evident that it belongs to White's species as more fully defined by Miers in the "Catalogue of the New Zealand Crustacea," p. 71, though, curiously enough, Mr. Kirk refers it by name to Dana's species, and hence "*Gebia hirtifrons*, Kirk," was put down in the "Index Faunæ Novæ-Zealandiæ," p. 253, as a synonym of *Upogebia danai*, Miers, instead of under the present species.

The confusion was afterwards increased by Professor Haswell, who referred a *Gebia* found in the interior of sponges in Port Jackson to White's species (Cat. Aust. Mus., p. 164). It appears, however, that his specimens belong neither to *Gebia hirtifrons*, White, nor to *G. danai*, Miers, but to a third species, probably *Upogebia* (*Gebiopsis*) *bowerbankii*, Miers.

The result has been that it has long remained uncertain whether *Gebia hirtifrons*, White, occurred in New Zealand or not, though, of course, the question would have been settled in 1879 by Mr. Kirk's specimen if it had not been wrongly named. I have, moreover, recently obtained undoubted specimens of White's species from Mr. H. Suter, and also from Mr. J. Macmahon, so that there is now no doubt that *Gebia hirtifrons*, White, and *G. danai*, Miers, are both found in New Zealand.

Specific Diagnosis.—Cephalothorax about one-half the length of the abdomen, the front hardly at all trilobed, its anterior end and lateral margins with stout teeth, smaller teeth and tufts of setæ arranged partially in longitudinal rows on its dorsal surface, the scabrous surface thus formed reaching nearly to the cervical groove; a single small lateral tooth behind the eyes.

Abdomen with the 6th segment a little longer than the others, which are subequal; 1st segment narrow, its lateral margins nearly free from setæ; 2nd with a few setæ on lateral margin; 3rd, 4th, and 5th with dense woolly setæ along lateral margins, similar setæ extending across the dorsal surface at posterior margins of 3rd and 4th segments, and to a less extent at that of the 2nd. Dorsal surface of abdomen without carinæ or other ridges.

Chelipeds subequal; merus about as long as propod, its lower inner margin with well-marked fringe of long hairs but without teeth; a small tooth on upper margin near distal end; carpus about half as long as propod, a well-marked tooth on upper inner margin and a smaller one (or sometimes two) on inner surface, the one on lower margin nearly or quite obsolete; propod slender, narrowing slightly towards distal end, surface marked with slight longitudinal ridges and furrows, upper margin roughened, lower margin not denticulate, numerous hairs on the lower outer surface, some along upper margin, and a well-marked row on inner surface near upper margin. Fixed finger short, stout, curved, reaching only slightly beyond the end of propod. Dactyl much longer than fixed finger, about half as long as propod, very hairy. 2nd pereiopod large, broad, somewhat compressed, and very hairy towards distal end.

Telson rectangular, distinctly broader than long, its posterior border straight with angles slightly rounded, fringed with long hairs; outer branch of uropods a little longer than telson; the inner branch slightly shorter than telson; inner branch with a median ridge, outer with two ridges near middle.

Length, about 70 mm. (cephalothorax, 22 mm.; abdomen, 48 mm.).

Hab.—Auckland and Manukau Harbours (*H. Suter*); Kenepuru (*J. Macmahon*).

Remarks.—Miers (Zoological Collections of H.M.S. "Alert," p. 281) says, "*Gebia carinicauda* is nearly allied to, and may prove to be identical with, *G. hirtifrons*, White, which Mr. Haswell mentions as commonly occurring in sponges at Port Jackson"; but he proceeds to point out that "in the latter species the spine of the lower margin of the hand (which exists in adult examples of *G. carinicauda*) is absent." I have not access to Stimpson's description of *G. carinicauda*, but if we are to consider his specific name *carinicauda* as descriptive, the two species differ in this respect also, for there is no carina either on the abdomen or telson of *G. hirtifrons*, White; indeed, the telson may be marked by a narrow depressed median line.

In making the comparisons quoted above Miers appears to have been relying on the type specimen of *G. hirtifrons*, White, in the British Museum; Mr. Haswell's specimens from sponges at Port Jackson, as already stated, do not belong to White's species. I am indebted to the trustees of the Australian Museum for several specimens from Port Jackson, and they are certainly quite distinct from White's species, being easily distinguished, in addition to other points of difference, by the fingers of the chelipeds being subequal and the chelipeds therefore perfectly chelate, so that the species comes under the genus or subgenus *Gebiopsis* as defined by A. Milne-Edwards; the authorities of the Australian Museum consider the specimens as probably belonging to *Gebiopsis bowerbankii*, Miers.

Mr. Stebbing has directed attention to the character of the 1st pleopods in the genus *Upogebia* as previously described by De Haan and Boas—viz., that in the male these appendages are absent, while in the female they are present but quite different from the four following pairs (see "South African Crustacea," part i, p. 45). This is also true of my specimens, the Kenepuru specimen being a male with the 1st pleopods absent, the other two being females with small uniramous 1st pleopods. The one from Auckland Harbour bears eggs: these are attached to the small 1st pleopod, to the inner branch of the 2nd, and to both branches of the 3rd and 4th pleopods.

Mr. J. Macmahon, to whom I have been indebted for various specimens of *Crustacea* at different times, thus describes the capture of the Kenepuru specimen. It was, he says, "taken alive at the entrance of a hole about half an inch wide in sand near low-tide mark; this hole was well formed, and went some depth into the sand, over which fresh water ran on its way to the sea, much of it percolating down the hole."

Upogebia danai (Miers).

Gebia danai, Miers, Ann. Mag. Nat. Hist., ser. 4, xvii, p. 223; Cat. N.Z. Crust., p. 70; Index Faunæ N.Z., p. 253. *Gebia hirtifrons*, Dana, U.S. Expl. Exped., xiii, Crust., part i, p. 511, pl. xxxii, fig. 2; Filhol, "Mission de l'Ile Campbell," p. 428 (not of White, P.Z.S., 1847, p. 122, nor of Kirk, Trans. N.Z. Inst., xi, p. 401).

Specific Diagnosis.—Cephalothorax about two-thirds the length of the abdomen; the front distinctly trilobed, lobes triangular, acute, middle one the largest; the scabrous portion of the front not reaching half-way to the cervical groove, except the lines of minute spines extending backwards from the outer margin of lateral lobes, which reach nearly to the cervical groove. No lateral tooth behind the eyes. Abdomen with 1st segment narrow, the 6th segment the longest, the 1st the shortest, the others subequal. Lateral margins of the segments mostly free from setæ but with some on the 3rd, 4th, and 5th segments. Dorsal surface smooth.

Inner antennæ with the flagella shorter than the last joint of the peduncle. Outer antennæ about as long as the abdomen, the peduncle a little longer than the peduncle of inner antennæ.

Chelipeds subequal, merus about as long as the propod, its lower margin bearing 5 or 6 small teeth on the proximal portion; carpus about half as long as merus, triangular, lower surface produced distally into a sharp tooth; propod fairly broad, with outer surface smooth, lower margin with a row of small teeth, the fixed finger somewhat stout and incurved, arising at some little distance from the distal end of the propod and scarcely projecting beyond it, some long hairs on the upper margin of propod, on the upper part of the inner surface and along the lower margin; dactyl slender, more than half as long as the propod, and covered with dense rows of long hairs.

Telson broader than long, its posterior margin rounded and fringed with setæ. Both branches of uropods longer than the telson, the outer longer and broader than the inner, which is subtriangular in outline; the posterior margins of both fringed with setæ; both branches with a median ridge, a small tooth on the base of this ridge on the outer branch, and another small tooth on the basal joint just over the proximal end of the ridge of the inner joint.

Length of specimens examined, about 25 mm. Dana gives the length of his specimen as "nearly 2 in."

Hab.—Bay of Islands (*Dana*); Auckland Harbour (*Suter*); Plimmerton (*H. B. Kirk*); Stewart Island (coll., Canterbury Museum).

Remarks.—The history of this species has already been given along with that of the preceding species. Judging from the specimens I have seen, it is much smaller than that species, and may be readily distinguished from it by the trilobed front and by the characters of the chelipeds.

In my specimens (sex uncertain) there are no pleopods on the 1st segment of abdomen; the 2nd, 3rd, 4th, and 5th segments bear pleopods of the usual type.

In his description, as quoted by Miers, Dana says, "Caudal segment not broader than long"; but in the two specimens that I have been able to examine closely it is appreciably though not greatly broader.

Callianassa filholi, A. Milne-Edwards. Plate XVI, figs. 1 to 5.

Callianassa filholi, A. Milne-Edwards, Bull. Soc. Philomathique Paris, 7[me] ser., tome iii, p. 112; "Mission de l'Ile Campbell," p. 429 and p. 491; Index Faunæ N.Z., p. 253.

This species was originally briefly described by A. Milne-Edwards from specimens gathered by Filhol at Stewart Island. I have seen several specimens, including one from the type locality, that evidently belong to it, and I am therefore able to give a somewhat fuller description than has hitherto been done. In the "Mission de l'Ile Campbell" Filhol gives only an abstract of Milne-Edwards's original description, but adds figures of the antennæ and the chelipeds. The "*Callianassa*, sp. ind.," mentioned by Mr. T. W. Kirk in the "Transactions of the New Zealand Institute," vol. xi, page 401, but not described, probably belongs to this same species, which is the only one of the genus at present known from New Zealand.

Callianassa ceramica, recently described by Messrs. Fulton and Grant from Port Phillip and Western Port, Victoria,* is evidently very closely related to the New Zealand species, and may indeed ultimately prove to be identical with it. For the sake of comparison I have therefore based the following description on theirs.

Specific Diagnosis.—The cephalothorax is about one-fifth the total length of the body, and is somewhat laterally compressed. Rostral point short but acute; the lateral angles between the ocular peduncles and external antennæ only faintly indicated. A groove on the dorsal surface runs parallel with the front, extends laterally as far as the base of the external antennæ, then joins the line on each side defining the branchial region. This line extends to the posterior margin, and is joined about midway by the cervical groove, the dorsal portion of which is about one-fourth of the length of the cephalothorax from its posterior margin. Cephalothorax otherwise smooth.

Abdomen flattened dorso-ventrally towards posterior end, 1st segment narrow, the 2nd segment slightly longer than the 5th and 6th, which are about equal in length, and longer than the others; 1st segment with lateral margin free from setæ, 2nd with a very few setæ towards posterior end, 3rd, 4th, and 5th with posterior portion of margin fringed with setæ, and with a tuft on the side nearer the anterior end of the margin; 6th segment with a few very short setæ on the margin. Dorsal surface of all segments free from carinæ or spines.

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* Proc. Roy. Soc. Victoria, 19 (n.s.), p. 12, plate v.

The whole integument of body imperfectly calcified, the cephalothorax and anterior portion of abdomen being more or less membranous, posterior part of abdomen more calcified, but the great chelipeds the only parts thoroughly calcified.

Eye peduncles flattened, triangular with outer margin convex, inner margins contiguous and produced anteriorly into a short spine projecting upwards and forwards. Eyes round and generally well pigmented.

The 1st antennæ about as long as the cephalothorax; peduncle longer than flagellum, its 1st joint short, a little longer than the eye-lobes, 2nd longer, 3rd as long as 1st and 2nd together, the two flagella equal in length. 2nd antennæ slender, fully twice as long as cephalothorax; peduncle a little shorter than that of the inner; flagellum very slender.

Third maxillipeds with the ischium and merus much swollen and rounded, line of junction wide and straight, the two joints together being subglobose; on their inner face a longitudinal row of small spines runs along the middle of the ischium in the direction leading to the insertion of the carpus; on the merus it is represented only by a line of long setæ. Inner margins and part of the outer surface fringed with long setæ. Three terminal joints slender.

Chelipeds unequal, either the right or the left may be the larger. The larger cheliped much expanded and flattened, outer surface slightly convex, integument much calcified, the whole appendage probably serving as an operculum to close the opening of the burrow in which the animal lives. General shape and proportions of the joints much as *C. ceramica*, but the upper and lower margins of the carpus and propod more produced into thin flat crests, the upper margin of carpus being produced proximally into a small rounded lobe, and the lower margin produced downwards into a large rounded lobe towards the distal end.

The smaller cheliped with a small spine on lower margin of merus. Remaining pereiopods of usual shape.

Telson a little longer than the branches of uropods, somewhat narrowed posteriorly, posterior margin rounded, fringed with long setæ, dorsal surface smooth; branches of uropods with posterior margins rounded and fringed with long setæ, dorsal surface of outer branch with slight median ridge.

Length—Cephalothorax, 13 mm.; abdomen, 42 mm.: total length of body, 65 mm.

Colour (in spirit), dull white.

Hab.—Stewart Island (*Filhol* and *H. B. Kirk*); Oamaru (*T. Forrester*); Timaru (specimens in Canterbury Museum, collected by *A. Haylock*).

Remarks.—From the description given above it will be seen that this species comes very close to *C. ceramica* of Victoria, Australia. It appears to differ in the possession of a small spine on the ocular peduncles, in the greater development of the crest-like expansions of the greater chelipeds, and perhaps also in the proportions of the abdomen and of the telson and branches of the uropods, and in other minor details. None of these differences are of very much importance, and some of them may be due to differences in age and sex. Mr. Stebbing has described two species, *C. kraussi* and *C. rotundicaudata*, from South Africa, but both of them appear to differ considerably from the Australian and New Zealand species. A. Milne-Edwards describes the chelipeds of *C. filholi* as being almost equal in the specimens he examined, but in all the specimens I have seen one is much larger and broader than the other. The figures of the chelipeds given by Filhol do not appear to be particularly accurate.

In the few works at my disposal I have been unable to find much information about the pleopods, more particularly as regards the 1st and 2nd and their modification in the two sexes. Mr. Stebbing briefly described these appendages in *C. kraussi*, but does not figure them nor mention which sex he is describing ; in *C. rotundicaudata* there is, he says, no trace of pleopods on the first two segments of the pleon.

In most of the specimens of *C. filholi* that I have seen there is no appendage on the 2nd segment of the pleon, and only a small one on the 1st : this is only 4 mm. long, and consists of a slender basal joint followed by a second joint of about the same length, but stouter, and bearing two or three simple setæ. (See Plate XVI, fig. 3.) In one specimen both 1st and 2nd pleopoda are present, and they are much better developed. In the 1st (fig. 4) the basal joint is long and bent into a curved or boomerang shape ; it bears a dense tuft of long setæ, most of which are plumose, at the bend of the joint, and tufts of similar setæ at the distal end. Some of these setæ are irregular towards the end and appear covered with some mucilaginous substance ; the basal joint bears only a single branch, of which the 1st joint is a little longer than the 2nd ; both bear numerous long setæ, most of which are plumose. The 2nd pleopods (fig. 5) are large and biramous, the basal joint is stouter than in the 1st pleopod but similarly bent and supplied with setæ ; the outer branch is composed of two joints, the 1st of which is about half as long again as the 2nd ; the inner branch is rather longer than the outer and consists of two subequal slender joints. Dense tufts of plumose setæ are found at the bend and distal end of the basal joint, and at the distal end of the 1st joint of the outer branch ; the other parts bear numerous long simple setæ as shown in the figure.

I presume, on the analogy of *Gebia*, that the specimen bearing the well-developed 1st and 2nd pleopods is a female, and that the others are males, but I am unable to find any well-marked external sexual characters to confirm this supposition. The large chelipeds are found in both.

EXPLANATION OF PLATE XVI.

Fig. 1. *Callianassa filholi:* large cheliped (from left side of specimen); × $2\frac{1}{2}$.
Fig. 2. *Callianassa filholi:* small cheliped (from right side of same specimen); × $2\frac{1}{2}$.
Fig. 3. *Callianassa filholi:* 1st pleopod (? of male); × about 7.
Fig. 4. ,, 1st pleopod (? of female); × about 7.
Fig. 5. ,, 2nd pleopod (? of female); × about 7.

Art. XLI.—*The Comparison of the Oceanic Languages.*

By the Rev. C. E. Fox.

[*Read before the Auckland Institute, 3rd October,* 1906.]

The present paper is written with the object of drawing attention to the present state of our knowledge and the large field for inquiry which lies open to us, not in order to offer anything original. Many difficulties present themselves to any one who tries to compare two Oceanic languages—for example, Maori and Mota (Banks Islands). If he has been told that they both belong to a common Oceanic stock he is surprised to find on comparing their vocabularies how many words differ, and not by any means only rare words, but in many cases the names of common objects and actions. This difficulty may be met in one of two ways. The shortest, and at first sight the simplest, explanation is that there is really no common stock at all, but that one language has borrowed a certain number of words from the other—he would suppose either that Maori had borrowed from Mota, or possibly Mota from Maori. But as his knowledge of the two languages grew wider and deeper he would soon begin to doubt whether the borrowing theory would not raise more serious difficulties than before, and some knowledge of Oceanic languages in general would confirm his suspicions. Convinced that the best explanation after all was the origin from a common stock, he would have to explain in some way the diversity in the two vocabularies. Some suggestions by way of explanation are here brought together.

The simplest division of the Oceanic languages is that proposed by Mr. S. H. Ray,* who distinguishes four main branches from the common stem :—

(1.) Indonesian, comprising the languages of Madagascar, Malacca, Sumatra, Java, the South-eastern Sunda Islands, Borneo, Celebes, the Philippines, and Formosa.

(2.) Micronesian, comprising the languages of Palau, Caroline, Marshall, and Gilbert Groups.

(3.) Melanesian, comprising the languages of the Bismarck Archipelago, portions of south-eastern and north-eastern New Guinea, the Solomon, Fiji, Banks, and New Hebrides Groups, the Loyalty Islands, and New Caledonia.

(4.) Polynesian, comprising the languages of the Eastern Pacific from Hawai, Marquesas, and Easter Islands to Samoa, Tonga, and New Zealand.

The term "Papuan" is now restricted to non-Oceanic languages which are found in parts of New Guinea, especially on the west coast. Traces of a non-Oceanic language are also found, it is thought, in the Moluccas, the northern Solomons, Santa Cruz, and Paumotu.

Mr. Ray has shown that, excluding the exceptional areas above mentioned — (1) The vocabulary shows evidence of a common origin ; (2) apparent differences in grammar are modifications of the same methods rather than actual differences of structure ; (3) the principal constructive particles are the same ; and (4) the languages are in various stages, of which the Polynesian is the latest.

The present paper deals only with the first point, and with that only in a negative way. The positive evidence in favour of origin from a common stock is very strong. It is gathered partly from the number of common words, and partly from the varying form of these words precluding the possibility of one group having borrowed from another. Mr. Ray mentions such words as the Maori forms *rau, rimu, taturi*, which are found in one dress or another all over the Oceanic region ; and the list of such common words is a large one. But there is also real diversity even in every-day words, and this is no less interesting than the agreement.

It is worth while to remark at the outset that it is impossible in a general way to speak of one group as having borrowed from a neighbouring group the words common to both. There is a tendency, for instance, to speak of "the Polynesian element in Fijian" or "the Malay element in Maori." Borrowing there undoubtedly has been, but with our present knowledge of the

* S. H. Ray, "The Common Origin of the Oceanic Languages.'

history of these languages such phrases are only misleading. For example, there is an Oceanic language spoken on the shores of Bartle Bay, on the north-east coast of British New Guinea, in three villages, Wedau, Wamira, and Divari; of this language a short dictionary has been published.* Any one examining its vocabulary, after having learnt the language of Mota, in the Banks Group, would recognise about 20 per cent. of words common to the two—such as *ia*, fish; *ama*, father; *qari*, owl; *ivo*, tooth; *ire*, pandanus; *lagi*, wind; *digo*, staff; *baba*, talk; *mata*, eye; *nogi*, nest; *numa*, house; *ruva*, measure; *bara*, bent; *uma*, drink; *uwa*, bear fruit; *tano*, earth; *natu*, child. The same number, perhaps, would be recognised by a person who knew Maori—words such as *baba*, slab; *koti*, cut; *kumara*, sweet potato; *manu*, bird (only in compounds); *mutu*, cape (?); *nima*, hand; *tutu*, nail; *tae*, excrement; *taniga*, ear (?); *tarai*, cut down; *toi*, drop or trickle; *waga*, boat; *tuna*, eel; *bebe*, butterfly; *muriai*, afterwards. A person conversant with the language of Florida would probably notice quite as many words whose forms were alike—*e.g.*, *gigi*, toe or finger; *tete*, ridge or path; *ai*, tree or wood; *kokorereko*, fowl; *buruburu*, long grass. Some of the above words are common to all three—Mota, Maori, and Florida. Are we, then, to speak of a Mota, or a Maori, or a Florida element in Wedau? Evidently this is impossible: the words are from a common Oceanic stock. There are, of course, some cases where we know that a word has been introduced from one group into another, but otherwise it is only misleading to speak of a Melanesian, or Malay, or Polynesian element in some other kindred group—as misleading as it would be to say that Wedau contained so-many words borrowed from Maori, so-many from Mota, so-many from Florida, so-many from other islands, with perhaps a real native element of 5 or 6 per cent. of true Wedau words.

Again, there is no doubt that a Melanesian differs very much from a Polynesian or from a Malay in physical features. Whether the Polynesians of the Eastern Pacific are a race resulting from the mixture of a dark Melanesian people with traders from the mainland—a race who spoke the language of their Melanesian mothers rather than that of their foreign fathers†—or whether the two races are distinct and one has imposed its language on the other (if this be credible), is really not a question for the student of languages. How it happens that people so different in physical features speak languages which are branches from a common stock he cannot tell.

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* By the Rev. Copland King, M.A., of the Anglican New Guinea Mission.

† Suggested by Dr. Codrington, "Melanesian Languages," page 33.

The settlement of the peoples of the Melanesian group must have taken place long before that of the Polynesian peoples, because the languages of the former group differ much more among themselves than those of the latter group do. A student of Polynesian languages finds a marked agreement between the languages of two Polynesian islands, such as Tonga and New Zealand, once a regular change of letters, such as *h* and *s*, *f* and *wh*, *l* and *r*, has been made. In fact, a Native of the one can make himself understood by a Native of the other. This is not at all the case in Melanesia. A Native of the Banks Islands would be quite unintelligible to a Native of the New Hebrides, or southern or northern Solomons, or Fiji. Students of Polynesian languages do not perhaps realise this. They suppose that the Melanesian languages agree among themselves as much as the Polynesian languages do; but the diversity of their vocabularies is really remarkable. In fact, the vocabulary of the northern Solomons shows more agreement with that of the northern New Hebrides than with that of the Banks Group, which lies midway between the two. All this points to ancient settlement and long isolation. The settlement of the Eastern Pacific must have been much more recent, and the constant state of warfare in which the Melanesians lived, their isolation and lack of trade enterprise in most cases, all tended to add to that divergence in their languages which long settlement would naturally produce.

Some words have been introduced into certain Melanesian languages from other kindred groups or from foreign sources. The Mota word for cloth is *siopa*. The Mota people themselves say that they obtained this word from a party of Polynesian foreigners ("Tongans") who settled at Qakea, a little island off Mota, more than sixty years ago and remained there for a short time: thus *siopa*, from the Polynesian *siapo*, by metathesis. Here we have a distinct Polynesian element in Mota, a Melanesian language. *Kumara* is said to be the word now used for "sweet potato" in Fiji, the name being formerly *a-kawai-ni-vavalagi*. Here is a distinct Polynesian element in Fijian. It would be most interesting to know more of these real cases of borrowing among the different groups. Of course, English words in Native dress are now common. *Sem* in Mota means "to scold," and owes its origin to the character of a trader who lived at Mota, Mr. *Sam* Fletcher. The shell used as a chisel at Mota is called *tive*; it was not known at Raga, where they call a chisel *bisope*, because these tools were first obtained from Bishop Patterson. In languages so capable of coining new words local passing terms may become permanent, and even displace older forms.

Some words, again, will drop out of a language because they become *tapu,* or at least will lie somewhere at the back of the language, like a person's name when we say we have it at the tip of our tongue; or old forms may only be preserved in the language spoken by chiefs. At Mota a man may not use words which form part or the whole of the names of his relations by marriage. If a man has a relation named *Pantutun* he must not use either of the common words *panei*, hand, or *tutun*, hot. He uses other words only kept for such occasions, but perhaps survivals of older forms. All such restrictions must be taken into account in explaining the divergence of vocabularies.

Some words, too, are pretty sure to be merely local terms which have taken the place of the more widely spread form. The Mota *qatia*, an arrow, is probably one of these. *Qatia* means "tree-fern," then the arrowhead made of tree-fern wood, then the arrow itself. In the New Hebrides, though *qasia* means a "tree-fern," the word for "arrow" is quite different—a form of *lipa*, a widespread oceanic word. In Raga this is found as *lia*, and it may occur in Mota in the words *liamule* and *liawora*.

Melanesian languages are very rich in their power of forming adjectives—*e.g.*, by prefixing *ma* or suffixing *ga*. For this reason adjectives should not generally be compared. *Malumlum*, the common Mota word for "soft," is perhaps formed from *lum*, a root, which means moss or seaweed. But another group will be quite as likely to take some other substance as the characteristically soft thing. The Mota word *gesagesaga* means "bright-blue," and is formed from *gegesa*, the name of a *Tradescantia* with bright-blue flowers, or from *gesa*, the name of a bright-blue volcanic stone found in the neighbouring island of Vanua Lava, with the adjectival suffix *ga*. But there is no reason for supposing that the people of the next island will take the tree *gegesa* or the bluestone *gesa* to describe all bright-blue objects. A tree in Mota called *resa*, with flowers striped pink and white, may be the origin of the Mota adjective *resa*, striped. The Florida word for "red," *sisi*, is the name of the red *Hibiscus*.* The Duke of York word for "red" is *dara*, which is obviously the common Oceanic word for "blood."* The word *ngira* is the name of a hard-wooded bush in Mota; in New Georgia the same word means anything hard.*

In such a poetic race as the Oceanic peoples the general tendency of all languages to use metaphor and then forget that the word was metaphorical will have full play, and some objects, such as a rainbow, a river, or a hurricane, will be expressed by varying metaphors. Thus, a bridge in the language of Wedau,

* Dr. Codrington, "Melanesian Languages."

in New Guinea, is *ai tete*, which means "a wooden path"; in Mota it is *pe lagolago*, which means "the water-crosser"; in Maori, *ara whata*, perhaps "the raised path."

In many Oceanic languages *tae*, excrement, has the secondary meaning of "rust"; but in Mota, *wal*, which means "to rise in lumps," like fat in cooking or gum on trees, is the word used for "rust," although *tae* has its usual meaning.

The Wedau word for "nail" is *tutu* (Maori *titi*), the same word meaning "elbow," "knee," or "pins in the outrigger of a native canoe"—*i.e.*, something which sticks out. The same word in the New Hebrides means "spikey." The New Hebrides word, however, for "nail" is *turi*, which means "that which goes through an opening," and is also used for "needle," and (as a verb) for a ship going through the narrow entrance into a harbour. But in Mota the word used for "nail" is *pismarawa*, the finger of Marawa, a fairy, fairy-finger.

"Black lava" in Maori is *rangitoto*, a word which means literally "sky of blood," no doubt so named from the appearance of some active volcano. In Mota they more justly call it *vat maeto*, the black or dirty stone. "River" in Tongan is *vaitafe*, the flowing water; in Mota is it *peilava*, the large water; in Florida *beti tina*, the mother water. "Hurricane" is *langvus* in Mota, which possibly means "the wind that strikes." In the New Hebrides it is *siritano*, that which passes over the ground like a razor. "Rainbow" in Mota is *gasiosio*, *siosio* meaning "bent like a bow"; in Maori, *kahukura*, the red surface or covering (of the sky); in Florida, *langigabu*, the rain of blood, or the sky of blood.

In compaiing vocabularies this fondness for metaphor must be especially allowed for in Oceanic languages.* But the real reason why the words so seldom seem to correspond is that they occur at what Dr. Codrington calls "different levels of language." For instance, the name of a common object may be quite different in Maori and Mota, but the Maori word appears after all in Mota, only at a different level—*e.g.*, in the name of a village—and the Mota word at another level in Maori. For real comparison a vocabulary of two or three thousand common words is not sufficient—a thorough knowledge is needed of obscure and little-used words, and also as wide a knowledge as possible of Oceanic languages in general. And in this respect a gieat deal might be done in Melanesia, where most of the languages are little known.

The following are some interesting examples of the appearance of words at different levels in two or more languages. Many

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* In Mota, safety-matches are called *masis matamotmot*, "stingy matches," because they will only strike on their own box.

of the examples are taken from Dr. Codrington's "Melanesian Languages." The Motu (New Guinea) word for "water" is *rano;* in Fiji "water" is *wai*, quite a different word; but *rano* occurs in Fiji in the form *drano*, which means "a swamp, or pool of water." *Maso* means "the sun" in Espiritu Santo; elsewhere in the New Hebrides it means "a star"; in Mota only "the morning star," *maso maran*. In Madagascar *maso* occurs with the meaning "eye," and is also found meaning "the sun"—*maso andro*. Thus a comparison of the Mota and Espiritu Santo words for "sun" would show no agreement; yet the Espiritu Santo word is present in Mota, only at a different level.

If the Maori and Mota words for "blood" be compared they are found to be very different—Maori, *toto;* Mota, *nara*. In both these languages the word for "sap" differs from that for "blood," but in the New Hebrides the same word is used for both—*daga*, blood; *dagavi*, sap: and also in Fiji, where *dra* means "blood" or "sap." This is the Mota *nara*. But *toto* also occurs in Mota at a different level in the word *toto*, a poisoned arrow, from the *totoai*, sap, with which the arrowhead was smeared. In San Cristoval, southern Solomon Islands, *toto* means "congealed blood"; and in Florida, where the ordinary word for "blood" is *gabu*, *mimi toto* is the name of a blood-disease. A mere comparison of the Maori, Mota, and Florida words for "blood" would show no agreement.

The Maori word for "sky" is *rangi*. Compare this with the Mota *tuka* and no agreement is seen. But *rangi* occurs in Mota in the form *langi*, which means "wind"; in San Cristoval this means "rain," while in Florida *langi gabu* is "the rainbow."

The Maori words for "shore" and "inland country" are *tatahi* and *uta;* the Mota words are *lau* and *uta:* the second in both cases is the same word, the first differs. But *tatahi* is only another form of the Polynesian *tahi*, the sea or salt water, and *tahi* (which occurs in Melanesia either as *tahi* or *tasi*) is found in Mota in *Tasmate*, the name of a village on the lee side where the the sea is *mate*, dead; in *tasig*, to season by pouring salt water over a Native oven; and most likely in *tas*, a retiring-place, which was probably in the sea. The Mota *lau* is the Malay *laut*, a second Oceanic word for "sea." But any one comparing the Mota and Maori words for "sea" or "shore" or "salt water" would find no agreement.

So, there are two Oceanic words for "bird," *manu* and *kiu* (unless the second is a relic of a non-Oceanic language, as it perhaps may be); Maori has *manu;* Santa Cruz, *kio;* while Wedau, in British New Guinea, has both—*kiu* the generic name, and *manu* the specific, only used in compounds: *manubada*, the fish-hawk; *manuqari*, the owl; *manutoa*, the seagull.

The Mota word for "dirt" is *lepa ;* in Florida the word used is *meto. Meto,* however, is found in Mota as the name for a small black mole on the skin; in the form *maeto,* black basalt; and in the New Hebrides *meto* is "black," the "deep sea" being *tahi meto ;* perhaps the Maori *meto,* putrid, may be the same word. The Mota *lepa,* on the other hand, is found in the Solomon Islands in the Bugotu word *dhepa,* meaning "ground," and in Polynesia as the Tahitian *repo,* earth, mould, dust, and Hawaiian *lepo,* ground, soil, dust, or dirt.

Panei is the Mota word for "hand," Maori *ringa ;* but *ringa* in the form *lima* finds a place in Mota as part of *tavelima,* five, and in the phrase *van vivsag lima,* walk with hands clasped; and as a substitute for *panei* if the speaker has a relation by marriage in whose name the word *panei* occurs.

In Wedau *vigo* means "to whistle"; in Mota this is *was ;* but the Mota word for native panpipes is *vigo.*

The Merelava (Banks Islands) word for "sit" is *sag,* the Mota word *pute,* though Mota is only forty miles from Merelava. However, *sag* occurs in Mota as *sage,* to sink (used of a stone sinking to the bottom of a pool).

The Wedau word *bara,* bent (*barabara,* a bend or angle) shows no resemblance to the Mota *sigerai,* an angle. But it occurs in Mota as *parapara,* an axe (the blade set sideways, unlike the adze); *sus para,* to crouch aside; *mule parapara,* to go slanting off; and *Ureparapara,* the name of an island in the Banks Group with steep slopes—"the place of slopes." A Malay word *parai* means "to go zigzag" (as a ship tacking); and a Maori word *parahi,* a steep slope or acclivity, which Mr. Tregear derives from *pa,* to block or obstruct, and *rahi,* great, is much more likely to be connected with the New Guinea *bara* and Mota *para.* Thus, though the New Guinea *barabara,* angle, shows no agreement with the Mota *sigerai,* the Malay *juru,* or the Maori *hau,* it nevertheless occurs in Mota, Malay, and Maori, but at a different level of language.

The Maori *tiro* and the Mota *ilo,* to see, may possibly be forms of the same word, but *tiro* itself occurs in Mota in the phrase *tiro o tamate,* become initiated into the secret society called the *tamate,* see clearly into its mysteries (any one not yet initiated being said to be *matawonwono,* blind); and probably in *tironin,** the pool of clear water into which a man gazed to see his own image (the New Hebrides *titiro* means "to gaze into the sea looking for fish" or "to gaze at one's image in water"); and in *tiro,* clear or transparent.

Mr. Tregear gives a number of interesting meanings which

* The word now used for glass.

the Maori *koko* takes—*i.e.*, different levels at which it appears in different languages. In Maori, he says, it means "a spoon," "a shovel," "a shrimp-net," or the act of taking up with these, or baling out a canoe; in the Solomon Islands "a basket." In Java *gogoh* means "to catch fish in shallow water by inserting the hand under them." This word *koko* in Mota means "to lift up water in the hands"; *kokos*, to enclose, as fish in a net, or people in a church; *kokota*, narrow. In the New Hebrides *kokoti* is a net for catching fish. It is safe to say that hundreds of such instances of words occurring at different levels might be given.

Mr. Tregear, speaking of Malay and Maori, writes: "Many important Malay words, such as those for sky, fire, root, hill, eye, &c., resemble Polynesian, and are almost certainly related, but other vital words, such as sun, moon, mother, son, true, smoke, &c., have no apparent likeness." Although they have no apparent likeness, most of those mentioned certainly strengthen our belief in the common origin of Malay and Maori.

The Maori for "sun" is *ra;* the Malay *mata ari*, eye of day, *mata* meaning "disk," in some languages "eye," in others "face," with which meaning it appears in Maori. The Maori for "moon" is *marama;* Malay, *bulan*. It is quite possible, since *vula* in both Mota and Fijian means either "moon" or "white," that the Malay word, if not occurring in Maori, yet does occur in allied Polynesian tongues—in Paumotu as *pura*, phosphorescent (Florida, *pura*, white); Tahiti, *pura*, flashing; Samoan, *pula*, to shine.

The Maori *rakau*, tree, is seen in the Fijian *kau* and the Malay *kayu*, wood, timber, tree. The Maori *au*, smoke (in Tongan, *ahu;* Mota, *asu*), is the Malay *asap*, probably a compound of *asu*, smoke, and *api*, fire.* The Maori for "child" is *tamaiti*, and the Malay *anak;* but the Malay word (at a different level) may perhaps be found in the Maori possessive noun *na* (as in *naku*, mine), the Mota *anai*, which means primarily "an appendage or belonging."*

Thus vocabularies which at first sight appear to differ are found to show real agreement. The discovery of a fair number of common words might be explained by trade intercourse, but it is difficult to see how the same word occurring at different levels of language in different islands can mean anything but origin from a common stock.

To give an example of the apparent diversity of vocabulary, only bringing out into brighter light a deep though hidden

* Dr. Codrington, "Melanesian Languages."

agreement, ten words are given from Mota in the Banks Group and Raga or Pentecost Island in the New Hebrides—the words for bamboo, sap, cave, finger, sea or salt water, picture or image, black, shoot, bend, go.

	Mota.	Raga
Bamboo ..	.. Au	Bua.
Sap ..	.. Totoai	Dagavi.
Finger ..	.. Pisui	Qararuga.
Cave ..	.. Lia	Malanga.
Sea ..	.. Nawo	Tahi.
Image ..	.. Totogale	Nunu.
Black ..	.. Silsiliga	Meto.
Shoot ..	.. Tiqa	Bubus.
Bend ..	.. Taqa	Siolo.
Go ..	.. Mule	Lago.

There is no agreement between these lists. However, the Raga *bua*, bamboo, occurs in Mota in the word *pue*, a bamboo water-carrier (*cf.* New Britain *pu*, a bamboo; Oba *bue*, a knife —a native knife being made from the bamboo).

The Raga *dagavi*, sap, is a form of *daga*, blood, which is found in Mota as *nara*, blood.

The Mota *pisui*, finger, is found in the Raga form *pihu*, which means "the last joint of the finger" or "the finger-nail."

The Raga *malanga*, cave, is very likely the Mota word *malanga*, which means "a lifting of the clouds after rain," or "a spot in the forest where the undergrowth has been cleared away."

The Raga *tahi* is found, as already mentioned, in the Mota *Tasmate*, the name of a village; and the words *tasig* and *tas*.

The Raga *nunu*, an image, is the Mota *nunuai*, a shadow with well-defined figure (not shade).

The Raga *meto*,* black, is found in the Mota *meto*, a small black mole on the skin, and *maeto*, basalt.

The Raga *bubus*, shoot, occurs in Mota in the form *pupus*, to puff out (as a whale spouting, or the wind through a narrow opening). The surf also is said to *pupusag* in narrow clefts. It is no doubt the Maori word *puhi*, to blow; and perhaps the Mota *vus*, in *langvus*, a hurricane, is the same. In that case the original stem has in Mota two shoots, *vus* and *pupus*—as *burung*, bird, and *bulu*, feather, in Malay are said to be shoots of one stem; and *vava*, speak, and *wawanga*, open the mouth, in Mota. In Mota *tamate tiqa* is the word used for "gun"—*i.e.*, ghost-shooter; in Raga it is *bubusi*, the puffer.

* It is interesting to note that in Raga *meto* is "black" and *bili* is "dirty," while in Florida *bili* is "black" and *meto* is "dirty."

The Raga *siolo*, bend, is found in the Mota word *siolo*, which means "to crawl like a snake": the prominent idea is no doubt the folds into which a snake throws its body, as in the Mota *gasiosio*, a rainbow.

The Raga *lago*, go, is found in several Mota words: *taplagolago*, now used of a cart from the fact of its going on wheels, formerly "a wheel" (children made a hoop of sago fronds and set it rolling, crying "*Tap* lagolago*," "It runs of its own accord"); *pelagolago*, a bridge; *lago*, a rare word meaning "to take long strides"; *lagota*, a giant. On the other hand, the Mota *mule*, to go, occurs in Raga with the sense of the Mota *kel*, to go and return back again; and in Mota this meaning of *mule* is still found: *mule*, to be refreshed;† *muleag*, the trees budding again in spring; *lul mule*, the wind blowing softly after a storm; and perhaps in *lia mule*, to shoot a member of one's own party in a fight. Probably it is a form of the Maori word *muremure*, to return to a thing frequently.

To all such sources of real or apparent diversity must be added phonetic changes, which disguise words more or less. The change between Maori and Tongan of *l* and *r* is quite regular. A dialect of Oba, New Hebrides, is said to be exactly like a neighbouring dialect except that *h* always takes the place of *s*.

We must remember, too, that the letters in these languages do not represent exactly English sounds. The Melanesian *g*, for example, is not the English *g*, and has been compared with the Hebrew *ain*. When the language was first written, it was sometimes written as *k*, sometimes as *r*, sometimes altogether omitted; thus *takai* was written for *tagai*, *raru* for *garu*, *ate* for *gate*. This fact explains how the Raga *daga*, blood, can be the equivalent of the Mota *nara* (*d* and *n* being a common interchange); the Mota *gaso*, a rafter, of the Maori *kaho*; and the Mota *magarosa*, pitiful, of the Maori *aroha*—the *ma* of *magarosa* being the conditional prefix. The Malagasy *o* is sounded *u* (*oo*), so that the Malagasy word *toto*, to pound, is clearly the same with the Mota *tut*, to thump with the fist. Mr. Tregear says of the Malagasy word *vorodolo* that it is an example of how letter-changes may cloak a real affinity — the Malagasy *voro*, bird, being the Maori *huru*, and *dolo* the Maori *ruru*. The Mota word *langvus*, hurricane, is probably the Maori *rangi*, sky, and *puhi*, blow. The Malagasy word *havitra*, hook, is found in the Loyalty Islands in the much-altered form *ge*.‡

The conclusion one would draw from these various facts is

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* As in *tapsoga*, a board falling out of its own accord.

† *Mate mule*, to faint—*i.e.*, to die and come to.

‡ S. H. Ray, "The Common Origin of the Oceanic Languages."

that these languages, in Melanesia especially, are those of peoples long settled. That there are foreign elements to be taken into consideration is certain. The Malays have borrowed from Asia, especially India. The Polynesians may also have borrowed words either before their migration or to some extent from the people they dispossessed. In Santa Cruz, Savo, Vella Lavella, and some bush dialects, Mr. Ray (and modern German philologists) believe there are traces of a pre-Melanesian tongue. In New Guinea, Papuan words have been borrowed, in some cases plentifully. This borrowing from foreign sources is a very different thing from an Oceanic language, such as Fijian, borrowing from another Oceanic language, such as Tongan.

Where the diversity of vocabulary arises from mere borrowing from a kindred tongue, from certain words becoming *tapu* and dying out while other (less common) forms are substituted, from merely local use or local metaphor, from the appearance of words at different levels of language, or from phonetic change, a fuller and wider knowledge will show it to be more apparent than real.

The most interesting field for the student of Oceanic languages lies at present in New Guinea and Melanesia, both because these languages are in an earlier and more primitive stage of growth, and because, with some few exceptions, they are very little known. The derivation of words must at present be very uncertain.

This paper will have done its work if it helps to point out to New Zealand students of language the wide and interesting field which lies close to them, at present but little explored.

ART. XLII.—*Notes on a Coal (?) from Boby's Creek, Waipara.*

By L. H. HARRISON, B.A.

Communicated by Professor Evans.

[*Read before the Philosophical Institute of Canterbury, 3rd October,* 1906.]

THE coal or shale herein described is of especial interest inasmuch as it carried on its surface *both free sulphur and calcium-sulphate*, and so appeared to illustrate a definite stage in the development of such shales. The calcium-sulphate crystals appeared in the form of large and well-developed rosettes, while the sulphur was scattered in small particles throughout the fissures in the coal, but only in small quantity.

Results of Analysis.

A. *Proximate Analysis.*

	Per Cent.
Water	8·01
Volatile matter other than water ..	12·45
Fixed carbon	11·45
Ash	68·13
	100·04

B. *Detailed Analyses of Coal and Ash.*

(1.) *Coal.*	Per Cent.
Carbon	16·87
Hydrogen	2·42
Nitrogen	1·03
Sulphur (in coal substance ?)	3·21
Water	8·01
Ash (including 2 per cent. sulphur) ..	68·13
	99·67

(2.) *Ash.*	Per Cent.
Silica	72·44
Iron and alumina	19·14
Lime	2·81
Soda	3·60
Potash	0·44
Sulphuric acid	2·01
	100·44

(3.) *Sulphur.*

The total sulphur as given by Eschka and Carius methods was 5·21 per cent. By boiling the powdered coal with much water 2 per cent. of sulphur was extracted, and the ash of the extracted coal contained only traces of sulphur.

Art. XLIII.—*Observations on New Zealand Fishes, &c., made at the Portobello Marine Fish-hatchery.*

By T. Anderton, Curator.

Communicated by George M. Thomson, F.L.S.

[*Read before the Otago Institute, 13th November,* 1906.]

Plates XVII, XVIII, XIX, XX.

Although the culture of trout, carp, perch, and many other species of fresh-water fishes has been in vogue for centuries, it is only within very recent years that serious attention has been paid to the culture of marine food fishes. To such a fine art has the former pursuit been reduced that there exist at the present time, in England and elsewhere, fish-farms, some of which are privately owned, while some are formed into limited-liability companies. These farms are run, so to speak, on the same lines as a poultry-farm—the eyed eggs, fry, yearlings, &c., being purchased by farmers and others desirous of stocking any ponds, lakes, or streams on their property with fish.

In 1864 Professor G. O. Sars, the distinguished Norwegian naturalist, was commissioned to make an investigation of the cod-fisheries around the Lofoden Isles. During this work he discovered in his tow-net collections large quantities of minute transparent globules, which were afterwards identified as the floating eggs of the cod. The following year he succeeded in artificially fertilising and hatching these eggs. In 1868 Professor Malm found that the eggs of the flounder were buoyant, though he does not say they were actually floating on the surface. In 1882, in an account published in the United States by Professor Alexander Agassiz, he states that the eggs of many of the American fishes, including flat fishes, were of the buoyant type. In 1884 Professor McIntosh and Dr. Cunningham were engaged in the study of floating spawn in Scottish waters, when the eggs of the cod, haddock, gurnard, whiting, turbot, plaice, and many other fishes were added to the list of pelagic or floating eggs. Even so recently as 1885, during the sitting of the Royal Commission on beam trawling in Scotland, it was most confidently asserted by many "expert" witnesses that the beam trawl caused the destruction of millions of fish-eggs upon the sea-floor.

Of late years a great deal more attention has been given to this subject in Europe, but the most notable success has been achieved by the United States Fish Commission, which was established in 1871. As showing the extent to which fish-culture has been carried on by the Commission, it may be stated that the total output of fry for 1904 was 1,267,343,025, including both indigenous and introduced fresh- and salt-water fishes.

Many of the declining fishing industries, such as the salmon, lobster, and shad, have been revived, and new industries created by means of artificial propagation.

Such is a brief outline of the history of the work in other countries, from which it will be seen that it is only a little over forty years since the floating nature of the majority of the eggs of marine fishes was first discovered.

An account of the marine fish-hatchery and biological station established in 1904 at Portobello is published in the New Zealand Institute Transactions, vol. xxxviii. In this paper Mr. G. M. Thomson has given a history of the movement to establish a station, together with a statement of its objects and details of construction, and a report of the work undertaken during 1904. The following notes practically constitute a continuation of Mr. Thomson's paper.

The Gurnard (*Trigla kumu*).

Although fairly abundant around various parts of the coast, this fish is seldom caught by the local trawlers, and then generally only singly or in pairs.

On the 5th March about two thousand eggs were taken from a female on board the s.s. "Napier," off Otago Heads. We were fortunate in securing a male fish in the next haul, and the eggs were impregnated and brought to the station. The egg (Plate XVII, figs. *a*, *b*, *c*, *d*, *e*, *f*, *g*) is the largest marine fish-egg secured up to the present time, and is 1·7 mm. in diameter. It is of the buoyant or pelagic type, spherical and transparent, with (chiefly) a single large oil-globule, but in some cases three or four, which soon appear to merge into one. This oil-globule is at first of a bright-orange colour, and gives the eggs a bright and conspicuous appearance when floating in a mass on the surface of the water. The colour gradually fades, and by the time the embryo is ready for hatching the colour has entirely disappeared. The eggs hatch on the seventh day, at an average temperature of 9° C.

The gurnard is probably a summer spawner, as the eggs were collected when the water had reached its highest temperature. The larva (Plate XVIII, figs. *b* *c*, *d*, *e*) is about 4 mm. in length; the pigmentation is black and yellow, and the yolk-sac large and interspersed with the same black-and-yellow markings. By the second day the yolk-sac has appreciably diminished in size, and the larvæ become more active. The pectoral fins appear to be chiefly used as a means of locomotion, assisted by a sharp wriggling motion of the body. Little change takes place until about the sixth day, by which time the eyes and mouth are open, the yolk-sac absorbed, and the little fish may be seen actively pursuing the minute organisms on which they feed. A few were reared until the twelfth day in a small aquarium jar, by which time they had begun to assume many of the characteristics of the adult fish. The pectoral fins are very prominent, and the three lower rays, although showing prominently, are still connected with the upper portion of the fin. It is interesting to note that the gradual disappearance of the colour in the oil-globule has been observed in Great Britain in the eggs of *Trigla gurnardus* and *T. cuculus*.

THE BRILL (*Caulopsetta scapha*).

This fine fish appears to be only an occasional visitor; it is seldom taken on the trawling-grounds off Otago Heads, and only in small quantities. It is a very handsome fish, and is greatly esteemed as a table delicacy. Nothing is at present known of its habits and movements, but it is a fish deserving every possible attention. Single ripe females have occasionally been taken, but, in the absence of males, the eggs were not fertilised. But on the 8th August of this year a small number were fertilised, as an experiment, with the milt of the sole (*Peltorhamphus novæ-zealandiæ*). These were taken to the station, and all were found to be fertilised. Development proceeded favourably until the 11th, when these, along with many other eggs in the boxes, were killed during a frosty night, and the interesting experiment of hybridizing these fish could not be followed up, but may be attempted on a future occasion.

On the 17th August a few thousand of the eggs were successfully fertilised by Mr. Baird, engineer of the trawler "Express," and were sent to the station. The egg (Plate XIX, fig. *c*) is the largest of any of the local *Pleuronectidæ*, being 1·7 mm. in diameter. It is of the usual spherical form, transparent, and buoyant, and contains a large number of oil-globules evenly dispersed over the entire egg. It hatches at a mean temperature of 5·5° C. in five days.

The newly hatched larva (Plate XIX, fig. *e*) is at first very inactive, generally floating helplessly on the surface of the water. The oil-globules remain in the yolk-sac after hatching, and the yellow pigmentation is very conspicuous. Owing to pressure of other work these larvæ were only kept for a few days, and no further drawings were made. The larvæ are easily identified by their large size, their colour, and by the peculiar extension over the head of the rudimentary dorsal fin.

The Flounder.

Owing to the uncertainty as to the identity of the two species of flounders which were taken in the harbour, it was considered inadvisable in last year's report to publish an account of the eggs and larvæ until the species had been definitely ascertained. This has now been done by Professor Benham, and we are able to give a few particulars of each species.

Rhombosolea plebeius, commonly known as the sand-flounder: This species was taken in large numbers by the steam trawlers and seine fishermen in June last, in Blueskin Bay. They were, almost without exception, very large fish, and the females greatly predominated. As many as twenty dozen were taken in a night's fishing with one seine net, from Purakanui Beach. It was decided to attempt to convey some of these fine fish to the spawning-ponds, in hopes that better results would be obtained from them than from the smaller fish taken in the bay the previous year. The fish taken in the trawl were all too much bruised for this purpose, and an arrangement was made with Messrs. King, of Purakanui, to retain the largest females in a coff until the following day, when they were towed off to the trawler "Express" and placed in tubs into which a constant stream of water was pumped, until arrival at Port Chalmers, where they were again transferred to the coff, towed to the station, and placed in the ponds. As seining is always carried on at night and on an open surf beach, these fish were subjected to a considerable amount of rough handling, on one occasion remaining in the coff overnight in Port Chalmers, through bad weather. This resulted in their being in very indifferent condition when they were placed in the ponds. Five dozen large females were obtained in this manner; the males and a few other females were afterwards caught in the harbour. From facts which have since been ascertained, it is very evident that these ocean-caught flounders should have spawned about the middle of August, as by the end of that month all the flat fishes that were examined on board the trawlers were spent, but nearly ripe females were still being taken within the harbour as late as the 30th September (both *R. plebeius* and *R. tapirina*). This fact would almost lead one to conclude that the flounders frequenting the harbour remain within or almost within the colder waters of the bay, and that the ripening of the ova is thus retarded. It is a noteworthy coincidence that the first eggs were collected from the pond on the 9th October, the exact date on which the first collection was made in 1905.

During the spawning season of 1905 the total collection of flounder-ova was 650,000, from which 562,000, or 87 per cent. of larvæ, were hatched. Up to date of writing (30th November)

250,000 ova have been collected this year, and 217,000, or 86·8 per cent. of larvæ, hatched.

Some two dozen of the stock fish in the pond have succumbed at various times, and there is every reason to believe that the cause of death may be attributed to their removal to shallower and colder water, and that the long retardation and non-extrusion of the eggs has caused these fish to sicken and die. Many of the females still retain their eggs, and it is expected that large numbers will be collected before long. The results from fish confined in the ponds up to the present have been very poor, a very heavy handicap being the small range of tides in these waters, and the consequent shallow ponds with extremes of temperature. The best results were obtained from the (evidently) late-spawning harbour flounders, and it will probably be found expedient to secure a stock of small immature fish and allow them to become acclimatised to the extremes of temperature experienced in the ponds. There are at present a few such fish, from 4 in. to 5 in. long, which are probably about three years old.

On the 8th August 283,000 ripe eggs were taken from a single flounder (*R. plebeius*) on board the trawler, and all were successfully fertilised. The egg (Plate XVIII, figs. *f* and *g*) is buoyant, and is very minute, being only 0·65 mm. in diameter, with from eight to thirteen small oil-globules. The larvæ (figs. *c* and *d*) hatch in five days at an average temperature of 9° C. The newly hatched larvæ are fairly active, and are almost transparent, with bright-yellow and black pigment markings. They are perfectly symmetrical, but are at first unable to see or feed, though they appear quite conscious of the presence of a dipping-tube or other instrument when placed near them. They are provided with a comparatively large yolk-sac containing the albumen on which they subsist until able to forage for themselves. The oil-globules remain in the yolk-sac after hatching. By the fifth day (Plate XIX, fig. *b*) the yolk-sac is almost absorbed, the eyes and mouth are open, and the larvæ are able to seek out their own particular sustenance.

R. tapirina: The ova of this species is considerably larger than that of *R. plebeia*, being 0·8 mm. in diameter, and it contains a single large oil-globule of a light-orange colour. The larvæ hatch in five days, as with the other species, but they are much larger and more active. No drawings were made of either eggs or larvæ, as no fish were kept in the ponds this year.

The Sole (*Peltorhamphus novæ-zealandiæ*).

From the irregular nature of the observations made on this fish, which is commonly known as the English sole, it is not possible to give much information as to its annual movements. Vast numbers were taken by the trawlers in the shallower waters (5 to 6 fathoms) of Blueskin Bay during the months of June and July. Their presence there was generally stated by the local fishermen to be for spawning purposes. This belief was no doubt strengthened by the very large roes contained by the females. None of them were, however, found to be ripe, and no sole-eggs were taken in the tow-nets in the water of the bar. An examination of the contents of the stomachs disclosed in every instance large numbers of cumaceans (*Diastylis novæ-zealandiæ*), and it is very probable that the fish were attracted to this locality by the presence of myriads of these *Crustacea*, upon which they were feeding voraciously. Large masses of seaweed were dredged up at each haul, and were found to be full of these *Crustacea*. By the end of July the soles appear to have migrated into deeper water, and considerable hauls of them were being made by the trawlers in 13 to 18 fathoms of water to the north-east of Otago Heads. Almost all the females were found to be ripe early in August, and on the 8th the first ova were collected on board the trawler "Express." Two collections were made, on the 8th and 10th August, when 1,422,000 eggs were successfully fertilised, and placed in the hatching-boxes. For some reason, which is attributed to the low temperature (2° C.) of the water in the boxes, all of these eggs died on the third night. After considerable experimenting with available material, it was found possible to maintain a steady temperature of 5° C., corresponding to the temperature of the water on the spawning-grounds. This was effected by placing four large Miller lamps under the supply-pipe, with a hot-air chamber of zinc above the pipe. By raising the lights a little in the evening and lowering them early in the morning a very even temperature of 5° C. could be maintained. Collections of the ova were again made between the 15th and 22nd August, a total of 3,175,000 being collected and fertilised, from which 2,747,000, or 86 per cent., of larvæ were hatched. These were liberated in the harbour on the first of the ebb tide, from two to seven days after hatching

The egg (Plate XIX, fig. *d*) is 0·5 mm. in diameter. It is spherical and buoyant, and contains from two to six small oil-globules. The larvæ hatch out in five days, at a temperature of 5° C. As is the case with all the *Pleuronectidæ*, the larvæ are perfectly symmetrical, and do not bear the slightest resemblance to the unsymmetrical contorted-looking adult. The spawning season appears to be very brief, as by 22nd August almost all the females were spent, although a small quantity of ova could still be expressed from a few of the smaller fish until the end of the month. The newly hatched larvæ are the smallest and most helpless of any that have yet been handled; they are quite transparent and colourless, and lay for a long time motionless on the surface of the water. A drawing was made of a larva on the third day after hatching (Plate XIX, fig. *f*).

The Crayfish (*Palinurus edwardsii*).

The crayfish is very valuable to us, inasmuch as it is the only large edible crustacean at present inhabiting our coastal waters. It is generally supposed to be of sedentary habits, and to live for a great part of its life within a very restricted area. Large hauls of them are occasionally taken in the trawl some distance from shore, and on a sandy bottom. The fishermen say they are then on the move, and it would appear that at certain periods a great migratory movement takes place from one part of the coast to another. I do not know at what part of the year this occurs, or if at regular intervals every year, but no doubt more light will be thrown on the subject before long.

Two large berried females were brought alive to the station on the 27th April by Mr. J. Noble, of the ketch "Carrie." These two have been continually under observation—for some time in a glass tank and some time in the tidal pond—for a period of eight months, and the eggs were found to be "eye-ing" at the end of November, and by the 7th December they were commencing to hatch out.

On the 8th November sixteen other berried females were brought to the station by Mr. Noble. All the attached eggs were eyed. The adults were placed in a 5 ft. by 5 ft. glass tank, where they soon made themselves at home, and fed well. During the daytime they generally huddled together in a heap in a corner of the tank, but moved about freely at dusk. They could often be seen "sitting up," as it were, on their tail, and rapidly moving their swimmerets and attached eggs to and fro, as if in the act of swimming, using their last pair of legs, which in the females are chelate, to clean off any particles of sediment that had adhered to them.

The eggs of two were combed off into a McDonald hatching-jar on the 8th, and these commenced to hatch on the 18th November. The first embryos were seen in the large tank on the 24th November, and from that date until the 10th December vast numbers swarmed in the tank, swimming freely near the surface, and generally congregating where the light was strongest. It is estimated that seven million embryos were hatched, most of which were retained in the hatching-boxes from three to nine days, and then were liberated in the harbour on the first of the ebb tide. A technical account of these embryos is appended to this note by Mr. G. M. Thomson.

All the adults had finished spawning by the 10th December, but they will be retained, if possible, in one of the tidal ponds, in order to ascertain if moulting will take place, and whether spawning is annual or biennial. As showing the fecundity of the crayfish, 394,100 eggs were gathered from a specimen measuring only 9 in. The egg is 0·8 mm. in diameter, and is attached to the swimmerets by means of fine filaments during the period of incubation, which probably extends for about nine months of the year. Considerable numbers are still retained in a large glass tank, and it is hoped that a few may be reared through the various brephalops and megalops stages.

Note on the Development of Palinurus edwardsii, *by George M. Thomson, F.L.S.*

The embryo, on emerging from the egg, has the characteristic *Phyllosoma* appearance (Plate XX, fig. *a*). The length of the body, from the middle of the front margin to the extremity of the pleon, is 2 mm. The carapace is fully 1 mm. in length, and is nearly circular in form, with large well-developed eyes on stout pedicels. At the centre of the front margin, between the bases of the eye-stalks, there is a well-defined ocellus. The antennæ are 1-jointed, and are nearly as long as the carapace. The antennules are considerably longer, and bear a number of plumose setæ, by the lashing and waving of which the minute animal progresses through the water. At this stage the other limbs are more or less curled around and folded under the body, and appear to be functionless, there being no trace of the plumose filaments on the pereiopoda, by which later they swim.

How long this first stage lasts was not clearly made out. Probably it is only a few hours, for no moult was detected by Mr. Anderton, yet after a time the plumose filaments of the antennules had quite disappeared, while those of the three posterior pereiopoda were seen to be developed. In this second stage (Plate XX, fig. *b*) the length of the body from between the eyes to the end of the pleon is 2·5 mm., and the spread of the limbs is rather more than 6 mm. The carapace tapers more to the front than in the preceding stage, and the eye-stalks are relatively longer and more prominent. The divisions of the pereion were not clearly made out behind the broad base of the carapace, but it bears 5 pairs of pereiopoda. The antennæ are 1-branched and apparently 1-jointed; they are slightly longer than the eye-peduncles, and bear a single setæ on their outer margin and two or three at their extremity. The antennules are slightly longer than the first pair and are 2-branched; each branch ends in 3 spinose setæ, of which the middle one is the longest. The only mouth organs detected were a pair of mandibles, working between the rounded upper and lower lips. The divisions of the pereion were not clearly made out behind the broad base of the carapace, but it bears five pairs of pereiopoda, each of them 6- (? 7-) jointed. The first pair are very short —little more than one-third as long as the carapace; and at the base of each, and in front of it, is a small rudimentary 2-jointed appendage (? branchia). The second pair are 1-branched and slender, and reach considerably beyond the front of the carapace. The third and fourth pairs are longer and stouter, and are 2-branched. The second branch springs from the end of the third joint, and is multi-articulate, bearing long plumose setæ towards its extremity. It is by the vigorous lashing of this plumose appendage of the third and fourth pereiopoda that the animal now swims. The fifth pair are long, slender, and 1-branched. In all the pereiopoda there is a tendency to red coloration towards the extremity of the joints, especially of the propodos. The pleon is short, tapering, and ends in a bifurcate apex.

Among the larvæ of a few days old there appears to be a third stage in which the carapace is broadly pear-shaped and the eye-stalks are longer and more slender. In this form the lobes of the liver were very clearly made out, and the movements of the simple heart were very easily seen. The colourless blood, marked by its corpuscular particles, is seen to pass into a wide open sinus at the posterior extremity of the vessel, and to be driven forward by the pulsation, to escape again at two apertures close to the anterior end of the tube, near the front of the carapace.

Munida sub-rugosa.

We are not yet able to establish the identity of this species with the free-swimming form known as "whale-feed" (*Grimothea gregaria*). The first *Grimothea* were noticed in the harbour early in November, but on the 8th and 14th I received a number of specimens of *Munida sub-rugosa* from Mr. S. Bradley, which had been picked up by his seine net. Two of these were females with the eggs attached to the swimmerets, but unfortunately both specimens were dead. The eggs (unmeasured) are very minute and of a greenish hue, and it is difficult to conceive that the large form at present so abundant in the bay is the product of this season's spawning. Several of the fishermen are at present on the look-out for the berried adults, and it may be possible this season yet to hatch out these eggs and to finally settle the question. During the season that the "whale-feed" are found in the ocean and the bay, the stomachs of almost all fish, excluding flat fish, have then been found to contain large numbers of them, and it is certain that they constitute one of the most important fish-foods, and no doubt play a considerable part in the migrations of many fishes.

Introduction of Lobsters.

The desirability of introducing this valuable crustacean into these seas, a description of the pond for their reception, and other notes on the subject, are to be found in vol. xxx of the "Transactions of the New Zealand Institute."

Thirteen "berried" females and twelve males were procured by Dr. E. H. Allen, Director of the Marine Biological Station at Plymouth, and were forwarded to London by rail, for shipment by the Shaw, Savill, and Albion Company's steamship "Karamea." The claws of each lobster were tied, and each fish wrapped in scrim; they were then placed in two fish-baskets and sent on by rail at 10 p.m. on the 8th May, 1906. They arrived safely on board the "Karamea" at noon of the next day, fourteen hours out of water, when they were at once placed in the tanks prepared for their reception. As it was not deemed advisable to use the foul and brackish water of the Thames, the tanks were filled with water from a ballast-tank which had been filled previous to entering the river. In this water they remained two days, during which the water was only renewed twice, and it was not until the third day that a regular flow was maintained by means of a pipe leading from the salt-water circulatory system. The temperature of the water in the English Channel was 51° Fahr., gradually rising until the maximum of 84° was reached on the 22nd May. A constant supply of water was maintained by means of a $\frac{3}{4}$ in. rubber hose at first, but was replaced on the 17th by a $2\frac{1}{2}$ in. hose, as the lobsters were looking very seedy, and the engineer considered that a larger flow was necessary. The supply-pipe was formed into a treble coil enclosed in a forty-gallon cask, which was filled with ice, renewed daily; but owing to the large volume of water and the rapidity with which it passed through the chamber, this apparatus proved altogether inadequate for the purpose of reducing the temperature of the water sufficiently, and only effected a reduction of 2° Fahr.

From the first the lobsters appear to have been very sluggish in their movements. This was no doubt due to their lengthy stay out of water, and their two days' confinement in stagnant ballast-tank water. Their vitality appears to have been so much impaired by this that they were unable to withstand the high temperatures which were soon encountered.

Date.	Temperature. °Fahr.	Deaths.
May 13	58	1
„ 16	62	1
„ 21	82	2
„ 22	84	3
„ 23	84	5
„ 24	84	5
„ 25	78	5
„ 26	76	1

The above table gives the dates on which the deaths took place and the temperature of the water on that date. It will be seen from this that the mortality was greatly increased with the increase of the temperature, and the greatest mortality occurred during the hottest period of the voyage. By the 26th May all but two were dead; but, as the water from this date gradually became cooler, these two survived, and arrived in Port Chalmers on the 29th June, when they were at once taken over to the station and placed in a large glass tank. Both are females, and had, unfortunately, shed their eggs only a few days previous to their arrival. A small number were still attached to the swimmerets of one, but on examination under the microscope were found to be dead, but with a well-developed embryo. Since their arrival, six months ago, these two lobsters have been kept in a glass tank measuring 5 ft. by 2 ft. 6 in. by 2 ft. deep. A steady supply of water is maintained, and their surroundings made as natural as possible by means of gravel, weeds, and rock shelters. Each lobster sticks religiously to its own shelter, to which it always returns after a forage for food. Whenever the tank is cleaned out, each one, on being replaced, goes at once into its own den head first, but immediately turns round so as to face the entrance, leaving only the large chelæ projecting. They are fed somewhat irregularly on fish, but appear to be very small eaters; if a piece of fish is thrust into their hiding-place when they are not hungry they at once seize it and carry it out, dropping it some distance away.

In order to ascertain the possibilities of lobsters and crayfish living peaceably together, one of each, both accustomed to confinement, were placed in an observation-tank. But there can be no question as to the lobster being "boss," as it chased the crayfish about the tank, snapping at it with its powerful claws, the crayfish having to ascend to the surface to get out of its way, so that they had to be at once separated.

It is interesting to note that the lobsters have not moulted since their arrival.

It is due to Mr. Purves, the chief engineer of the s.s. "Karamea," to state that, although the shipment was intrusted to his care, the fitting of the tanks and the cooling-apparatus was not superintended by him. But he is quite sanguine that a number will be brought out on the next voyage of the "Karamea," when a more effective cooling-apparatus will be fitted. The "Karamea" will probably arrive in the colony about February or March, and, if so, the eggs should not be so far advanced, and will not be so liable to hatch during the voyage. Therefore the arrival of a larger consignment with the attached eggs in a healthy condition may be confidently expected at an early date.

Temperatures (in ° C.) of Air in Shade, Ocean Surface Waters, Bay, and Ponds for 1906.

Date.	Air.	Ocean.	Bay.	Ponds.	Date.	Air.	Ocean.	Bay.	Ponds.
Jan.					Feb.				
1	12·8	..	11·6	..	4	10·8	..	11·4	..
2	12·4	..	10·6	..	5	7·4	..	10·2	..
3	10·2	..	11	..	6	8·4	..	10·6	..
4	12	..	10	..	7	11·2	..	10·6	..
5	10·6	..	9·2	..	8	11	..	11·4	..
6	11·6	..	10·4	..	9	12·4	..	12	..
7	9·2	..	10·4	..	10	12·2	..	12·4	..
8	11·8	..	10·6	..	11	11·4	..	12	..
9	12·8	..	11·4	..	12	11·2	..	11·8	..
10	12·6	..	12	..	13	12	..	12	..
11	12·8	..	11·8	..	14	9	..	11·4	..
12	14	..	13	..	15	8	..	10	..
13	14·2	..	13·2	..	16	7·4	..	10	..
14	11·6	..	12·4	..	17	10·4	..	10	..
15	14	..	12	..	18	10·6	9·2	10	..
16	13·8	..	11·8	..	19	9·4	8·8	9·2	..
17	12·6	..	12	..	20	6·2	..	8·6	..
18	17·2	..	12·8	..	21	7·8	9·2	8·2	..
19	14·6	..	13·2	..	22	12	9·2	9·2	..
20	14·4	..	13	..	23	14	..	9·8	..
21	11	..	12·4	..	24	9·8	..	8·8	..
22	10·4	..	12·8	..	25	9·4	9·2	8·6	..
23	9·2	..	12	..	26	7·8	..	8·4	..
24	11·2	..	12	..	27	8·2	9·2	8·4	..
25	15·6	..	11·8	..	28	8	8·8	8·6	..
26	11·6	..	12	..	Mar.				
27	9	..	11·4	..	1	7·6	9·2	9	..
28	9·4	..	11·4	..	2	10	..	9·2	..
29	7	..	11	..	3	15	..	10·4	..
30	10·4	..	10·4	..	4	12·8	9·8	10·8	..
31	10·4	..	10·8	..	5	10·4	10·2	10·8	..
Feb.					6	10·6	9·4	11·8	..
1	11·4	..	11	..	7	7·8	8·8	11	..
2	10	..	11·2	..	8	7·8	..	9·4	..
3	10·2	..	11·2	..	9	7·4	..	8	..

TEMPERATURES (IN ° C.)—*continued.*

Date.	Air.	Ocean.	Bay.	Ponds.	Date.	Air.	Ocean.	Bay.	Ponds.
Mar.					April				
10	11	10	8·4	..	29	6	..	6·4	..
11	12·6	..	9·8	..	30	5·6	..	6	..
12	7	8·8	9·2	..	May				
13	9·8	9	9·4	..	1	6·2	7·2	5	..
14	13	9·2	10·2	..	2	7·8	7·6	5·8	..
15	9	8·8	10·4	..	3	4·2	..	6	..
16	9	9·2	10	..	4	3·4	7	4·8	..
17	9	9·2	9·8	..	5	3·4	7	4	..
18	10·4	..	10	..	6	4·2	7	4	..
19	12	9·2	10·4	..	7	5	..	4·4	..
20	11·4	9·4	10·4	..	8	5·6	7	5·2	..
21	10·8	9·2	10·6	..	9	3·8	..	4·8	..
22	12	..	11·4	..	10	5·4	..	5	..
23	8·8	9·2	10·8	..	11	7·8	..	5·4	..
24	8·2	..	10	..	12	6·6	..	6	..
25	9	9	9·8	..	13	4·2	6·6	5·8	..
26	6	..	8·2	..	14	5·4	7	5·6	..
27	5·4	..	7·6	..	15	5·4	7	5·8	..
28	7·2	..	7	..	16	5·8	6·6	5·8	..
29	5·6	..	6·4	..	17	4·2	6·6	5·4	..
30	8·2	..	7	..	18	6	..	5·2	..
31	8	..	7	..	19	6·4	..	5·4	..
April					20	6·6	..	5·4	..
1	6·4	8·2	6·2	..	21	3	6·2	4·6	..
2	8	7·8	6·6	..	22	1	..	3·2	..
3	7·2	..	6·6	..	23	5	..	3·6	..
4	10	..	7·2	..	24	4·8	..	3·6	..
5	6·6	8	7	..	25	4·2	..	3·4	..
6	7	7·6	7	..	26	3·8	6·6	3·6	..
7	4·6	..	6·6	..	27	4	6·2	3·8	..
8	7·2	7·6	6·6	..	28	6·4	6	4·4	..
9	6	7·6	6·4	..	29	8·8	5·6	4·8	4·8
10	4·4	..	6	..	30	4·6	5·6	4·6	4·4
11	6	7·6	5·6	..	31	2·2	6	4·4	4
12	4·2	..	5·2	..	June				
13	5	..	5·6	..	1	1·6	..	4·2	4·2
14	7·6	..	6	..	2	3·6	..	4	4
15	7·2	..	6	..	3	5	5·6	4·2	4·2
16	8·6	7·6	7·4	..	4	4·4	5·4	4·2	4·2
17	8·8	7·6	7·2	..	5	2	5·6	3·8	3·4
18	9	7·2	7·4	..	6	1·2	5·4	3·4	3
19	7·6	8	7·6	..	7	2	5·2	3·6	3·4
20	15	8	8·4	..	8	2·6	5·4	3·6	3·2
21	5·8	..	7·8	..	9	1·8	..	3·4	3
22	7·4	7·6	7·8	..	10	1·6	..	2·6	2·2
23	5	..	6·2	..	11	0·8	5·4	1·8	1·8
24	7·6	7·6	6·4	..	12	2	5·4	2	2·2
25	8·8	..	6·6	..	13	3	..	2·2	2·2
26	8	7·2	6·2	..	14	9·2	5·2	4	4
27	7·8	..	6·4	..	15	2	..	3·2	2·2
28	5·2	..	6·4	..	16	2·8	..	3	2·2

TEMPERATURES (IN ° C.)—*continued.*

Date.	Air.	Ocean.	Bay.	Ponds.	Date.	Air.	Ocean.	Bay.	Ponds.
June					Aug.				
17	5·6	..	2·4	2·2	5	5	5	2·6	1·8
18	6·8	..	3	3·2	6	1·4	5·2	2	1
19	5·6	..	3·4	3·4	7	1·2	5	1·6	0·8
20	8	..	4·2	4·4	8	1	5	1·6	1
21	9	..	4·2	4·6	9	2·8	5	2·2	3·5
22	4·2	..	3·8	3·8	10	2·8	5	2·8	2·2
23	7·6	..	4·2	4·2	11	3	..	3	2·2
24	6·6	5·4	4·4	4·6	12	3	5	3·4	3·2
25	0	5·2	3·2	2·8	13	4·8	..	4	3·8
26	2	5	2·2	1·6	14	4	..	3·2	3·4
27	5	5·4	2·6	2·6	15	2	5	2·8	2·4
28	3·8	5·4	2·4	2·4	16	2·2	5	2·8	2·2
29	3·6	5·2	2·6	2·4	17	2·2	5	2·8	2·4
30	2	..	3	2·8	18	5	..	3·4	3·6
July					19	5	5	3·6	3·2
1	2·4	5·4	3	2·8	20	5	5·2	4·2	4
2	0	5·2	3·6	2	21	5	5·2	4·6	4·2
3	2	..	2·8	2·6	22	5·2	5·2	4·2	4
4	4·2	5	3	2·8	23	4	..	4·4	4
5	0·8	5·2	1·6	1·6	24	4·2	..	4·4	4·2
6	4	..	2·2	3	25	3·8	..	4·2	4
7	2·2	..	3·2	2·4	26	4	5·4	4·4	4·4
8	2	5·2	2·4	1·6	27	5·6	5·4	4·8	5
9	2·6	5·2	2·4	1·8	28	5	5·4	4·2	4·2
10	3	5	2·6	2·6	29	2	5·4	3·6	3·2
11	2·4	..	1·6	1·4	30	4·6	..	4	4
12	4·6	..	2·2	1·8	31	4·6	..	4·2	4·2
13	3·2	5	2·4	2	Sept.				
14	1·2	..	1·2	0·6	1	5·2	..	4·6	4·6
15	0·8	..	1·4	0·6	2	10	5·4	5·6	6
16	2	..	1·2	0·6	3	7	5·4	6	6·2
17	2·6	..	1	0·4	4	7	5·4	5·8	5·4
18	3·6	..	2	1·8	5	7·4	5·6	6	5·6
19	3·8	..	2·4	2	6	4·8	6	5·4	4·8
20	3·2	..	2·8	2·6	7	7·6	6	5·6	5·2
21	0·4	..	2·8	3·6	8	8·8	..	6·2	6·2
22	3·2	..	3	3·8	9	6·8	6	6·4	6·2
23	5·6	..	4	4·2	10	4·8	6	5·6	5·8
24	5·4	..	4·6	4·6	11	5·6	6	5·4	5·4
25	3·4	5·4	4·2	4	12	7·4	6·2	6	6
26	2·4	5·4	4·2	3·8	13	5·8	6	6	5·4
27	2·2	..	3·8	3·6	14	6·2	..	6	6
28	1	..	3·4	3·2	15	6	..	6	6
29	1·4	..	3	3	16	6·6	6	6	5·8
30	1·8	..	3	3	17	5·4	6	5·4	4·4
31	1·8	5	2·6	2·2	18	6·2	..	5·4	5·8
Aug.					19	6·2	6	5·8	5·4
1	2	..	3	2·6	20	5·8	6·2	5·8	5·2
2	0·2	..	2·6	2	21	5	6·2	5·6	5·4
3	2·2	..	2·8	1·2	22	5	..	5·4	5
4	2	..	2·6	2	23	6·2	..	5·8	5·4

TEMPERATURES (IN ° C.)—*continued.*

Date.	Air.	Ocean.	Bay.	Ponds.	Date.	Air.	Ocean.	Bay.	Ponds.
Sept.					Oct.				
24	6	6	5·6	5·6	28	8	7	8·2	7·6
25	6	6	6	5·4	29	7·6	7	8	7·2
26	5·6	6·2	6	5	30	7·2	7·2	7·8	7·2
27	6·2	6·2	6·2	5·8	31	8	7	8·2	6·8
28	6·2	6	6·4	6	Nov.				
29	8·4	..	6·6	6·8	1	7·4	6·6	7	6·4
30	8	6·2	6·4	6	2	8·2	6·8	7	7
Oct.					3	9·8	..	8	8·6
1	7·2	6·2	6·4	6·4	4	10	7	8·6	8·6
2	8·6	..	7·2	7·4	5	9·2	7·4	9	8·8
3	8·6	6·2	7·4	7·2	6	9	6·8	8·4	7·8
4	7·6	6·4	8·2	8	7	12	6·6	8·4	8·4
5	6·2	6·2	7·6	7·4	8	11	6·8	8·4	8·8
6	6·4	..	7·2	7	9	9	6·8	8·2	8·4
7	6·4	..	7·6	7·4	10	11	..	8·4	9
8	7·4	6	7·4	7	11	11·4	6·6	10·2	10·6
9	6·8	6	7·6	7·2	12	10·2	7·4	10	10
10	7·8	6·2	7·8	7·4	13	8·6	7·4	9·8	9·2
11	7	6·4	7·8	7·4	14	8·6	7·4	7·4	8·2
12	7·2	6·4	8	7·6	15	11	7	8	8
13	7·4	..	8	7·6	16	11·6	7·4	9·2	9
14	7	6·8	8	7·6	17	12	..	10	10·4
15	6	6·4	7·6	7·2	18	13·2	7·6	10	9·8
16	6·4	6·4	7	7	19	10	7·6	10·2	10
17	6·4	6·2	7·2	7·2	20	11	7·4	10·2	10
18	7·2	6·4	7·4	7·4	21	11	7·6	10·8	10·8
19	7·2	..	7·6	7·6	22	9·6	7·4	11·4	11·4
20	8	..	7·6	7·6	23	10·4	..	11	11
21	7·8	..	8	7·4	24	9·8	..	10·2	9·8
22	8	7	7·8	7·8	25	12	7·6	10·6	10·6
23	8·2	7	8	7·8	26	13	7·6	10·6	11
24	6	7	6·8	6·4	27	6	7·4	9·4	8·8
25	7·6	7	8	7·4	28	8·2	7·4	9·4	9
26	8	6·8	7·8	7·4	29	10	7·6	9·6	9·2
27	8	..	7·8	7·6	30	10	7·6	9·8	10

TEMPERATURES OF OCEAN AND BAY.

We are fortunate this year in being able to give an almost continuous series of records showing the comparative temperatures of the surface waters of the ocean and of the bay as recorded at 9 a.m. daily. The ocean-temperatures are mostly taken at a distance of from five to nine miles to the eastward of the entrance to Otago Harbour, and consequently in the current running towards the north. From a glance at the tables it will be seen that the highest recorded ocean-temperature is 10·2° C., which is not reached until March, three months after midsummer. The minimum is reached soon after midwinter, early in and during the month of August, when 5° C. is recorded. The range between the maximum and minimum is therefore only 5·2° C. The daily variation even of the surface waters is very slight. It will also be noticed that, so far as has been learned, the flat fishes all spawn during the period in which the water is the coldest.

The maximum temperature of the bay is reached in the middle of January, when 13·2° C. was recorded, and the minimum, 1° C., on the 17th July, the range between maximum and minimum being 12·2° C., being 7° C. or 12·6° Fahr. in excess of the range of the ocean waters. The range of the waters in the spawning-ponds is slightly in excess of this, but was not recorded this year during the warmest months, as the ponds were empty and remained open. This table is most valuable to us, as it enables us to compare the temperatures of the local waters with those of Great Britain, from which the lobsters, crabs, or any fishes may be brought for the purposes of acclimatisation. I cannot at present find a complete annual record taken at any of the stations in Great Britain, but from a report of trawling investigations off the east coast of Scotland in the twenty-second annual report of the Scottish Fishery Board, the minimum temperature recorded during 1903 was 5° C., and this was only recorded on one day. The usual midwinter temperature appears to be about 7° C., and the maximum 13·2° C. Although in considerably higher latitudes, the high temperature is no doubt attributable to the effects of the Gulf Stream. Many species of deep-sea fishes appear very susceptible to any change in temperature, but from our brief experience here it would appear as if even a slight reduction is fatal to the incubation of the eggs. I think, from the slight difference in the temperatures of the British and local waters, we may conclude that any European fishes, once introduced, would not be injuriously affected by the slight change in the ocean waters, but that the only difficulty would be in keeping the adult fish in our ponds without some means of raising the temperature through the winter months, during which the temperature has at times fallen below 0° C.

Almost all the knowledge that has been gained up to the present time, such as the collection of eggs, ocean tow-nettings, temperatures, examination of stomach-contents, &c., has only been made possible by the kindness and cordial co-operation of Mr. F. G. Sullivan, of Dunedin. Fish that have been required for the purposes of the station have been freely given, and

accommodation, meals, use of pumps, &c., provided free of any cost whatever. I would like to take this opportunity of thanking Mr. Sullivan, and the captains, engineers, and crews of the trawlers "Express" and "Napier," for their kind assistance at all times, and especially Mr. Baird, the engineer of the "Express," for the collection of many thousands of ova when it has been impossible for me to leave the station.

With the present limited means and facilities it is not for one moment pretended that any practical results may be expected from the infinitely small numbers of larvæ that are being from time to time liberated, the total for the two years being under five millions. The station must for some time to come remain a purely experimental one, involving only a small expenditure, the chief benefits to be derived from which are the accumulation of facts, which are now steadily being recorded, without a knowledge of which it is impossible to frame any beneficial legislation. This knowledge, if followed up carefully for a number of years, will form a substantial base for future and more extensive operations.

It is often remarked that it is not the small fish that, as at present, should be protected, but the large mature ones, at spawning-time: that is to say, there should be a close season, as is the case with the trout and salmon. This method of conserving the marine fishes, though quite practicable with a purely sporting fish like the trout, is obviously impossible with a staple article of diet, and would mean a suspension of all fishing during two or three months of the year. The injurious effects of overfishing have long ago been experienced in the older and more thickly populated countries, and these have in many instances been benefited by wise legislation, and latterly by artificial propagation. Notwithstanding this, it is still sometimes asserted that it is impossible for man by overfishing to upset the "balance of nature," and that even if an area were completely denuded of all life, nature, in her bounteous generosity, would at once assert her rights and establish her former balance of species. In support of this, it is pointed out that more fish are taken annually around the British coast than was the case a hundred years ago. But it must be remembered that whereas all the fishing was then done by lines and sailing-trawlers, within easy reach of the coast, there are now engaged hundreds of large well-equipped steam-trawlers, engaged in trawling at a distance of hundreds of miles from the coast, and as far north as Iceland.

It is generally admitted that to maintain the balance of a species it is only necessary for two from the hundreds of thousands, and in many cases millions, of eggs produced by a single fish to arrive at maturity. Whether this theory be accepted in its entirety or not, it is very evident, from the floating nature of the eggs of most marine fishes, and (locally) the close proximity of the spawning-area to the coast, that enormous numbers of these eggs must be washed on shore and lost, or otherwise destroyed. External fertilisation and consequent non-impregnation will probably account for the loss of a large percentage, and when we consider the vast hosts of enemies of the ova and fry swimming at or near the surface of the water, we cannot but conclude that it is during this helpless pelagic existence that the great bulk of the destruction is brought about. It is to compensate for this tremendous loss that nature has bestowed upon most marine fishes such wonderful provision for the maintenance of their kind. The vast heaps of "whale-feed" (*Grimothea*) cast up on the beaches at certain seasons of the year provide a visible and easily appreciated example of the enormous destruction that takes place in the early swimming stage of this important fish-food.

The waters around the New Zealand coast at the present time abound with a varied and valuable assortment of edible fishes. The fishing industry is as yet in its infancy, and it cannot be said that overfishing is being done, except in certain very limited areas, where, at any rate from local report, a marked decrease in the number and size of such fish as the flounder and blue-cod have been noted. It is chiefly amongst such purely littoral and estuarian fishes that a diminution of the supply may be expected as the result of human operations. Trawling on the east coast is at present confined to within about eight or nine miles from the land, and to about 24 fathoms of water. The absence of offshore banks and relatively quick shelving slopes around this part of the coast will probably tend towards keeping many species within a few miles of the land. The results of deep-sea trawlings will be awaited with interest, as it is intended to exploit the deeper waters and trawl to a depth of 100 fathoms. In the United States of America, large numbers of trained men, termed spawn-takers, are employed during the spawning season of the cod and other marine fishes. These men accompany the long-line fishermen at this season, and collect and fertilise the eggs of all the ripe fish that are caught. These eggs are forwarded (often by rail) to the nearest hatchery, where they are hatched, retained in the boxes as long as possible, and then liberated where it is considered that they are most likely to thrive.

The present method of liberating these tiny larvæ before the yolk-sac has been absorbed is not at all satisfactory, and there can be no question that a great improvement would be brought about if it were possible to rear and protect the fry for a longer period. But until our knowledge of their food and of the conditions suitable to their early stages is widened we must remain content with the present method. Only on few occasions have the larvæ of any of the flat fishes been reared until the adult bottom stage was reached, and then only in very small quantities, and with very constant attention. Experiments in planting the larval plaice in enclosed lagoons are now being conducted by the directors of the biological station at Port Erin, Isle of Man, and although no definite results have as yet been achieved, there appears to be every prospect of ultimate success.

Nothing has as yet been learned of the migrations, spawning habits and areas, &c., of most of the "round" fishes, such as the groper, ling, cod, moki, &c., but from our brief experience with the flat fishes it appears to be a matter of little difficulty to collect and hatch millions of the eggs (otherwise almost certainly lost) of many of these fishes. Even at the present time, when only two trawlers are engaged, it would be quite possible, by placing a spawn-taker on board of each trawler, to collect these eggs during spawning-time in numbers far beyond the capacity of the present equipment of the station.

It was hoped that more use would have been made of the station as a base for original research work, but it is to be regretted that again during the past year so little scientific aid has been enlisted to assist in the elucidation of the many problems with which we are faced, and which are only possible to the trained biologist.

EXPLANATION OF PLATES XVII–XX.

PLATE XVII.

Fig. *a*. Eggs of gurnard (*Trigla kumu*), twenty hours after fertilisation, at 9° C.

Fig. *b*. Eggs of gurnard (*Trigla kumu*), forty-three hours after fertilisation, at 9° C.

Fig. *c*. Eggs of gurnard (*Trigla kumu*), fifty-two hours after fertilisation, at 8·6° C.

Fig. *d*. Eggs of gurnard (*Trigla kumu*), sixty-eight hours after fertilisation, at 8·4° C.

Fig. *e*. Eggs of gurnard (*Trigla kumu*), ninety-one hours after fertilisation, at 8·4° C.

Fig. *f*. Eggs of gurnard (*Trigla kumu*), 115 hours after fertilisation, at 9° C.

Fig *g*. Eggs of gurnard (*Trigla kumu*), 139 hours after fertilisation, at 9·6° C.

PLATE XVIII.

Fig. *a*. Eggs of gurnard (*Trigla kumu*), 163 hours (just hatching), 9·8° C.
Fig. *b*. Newly hatched larva.
Fig. *c*. Larva, forty-eight hours after hatching.
Fig. *d*. Larva, four days after hatching.
Fig. *e*. Larva, six days after hatching.
Fig. *f*. Egg (unfertilised) of flounder (*Rhombosolea plebeius*).
Fig. *g*. Same, twenty-four hours after fertilisation.

PLATE XIX.

Fig. *a*. Newly hatched larva of flounder.
Fig. *b*. Same, fifth day after hatching.
Fig. *c*. Egg of brill (*Caulopsetta scapha*), just before hatching.
Fig. *d*. Egg of sole (*Peltorhamphus novæ-zealandiæ*), four hours after fertilisation; segmentation commencing.
Fig. *e*. Newly hatched brill.
Fig. *f*. Larval sole, three days after hatching.

PLATE XX.

DEVELOPMENT OF CRAYFISH (*Palinurus edwardsii*).

Fig. *a*. Larva on emerging from egg, showing the plumose antennæ.
Fig. *b*. Same after a few hours, showing plumose appendages on the 3rd and 4th pereiopoda.

ART. XLIV.—*Geological Notes on South-west of Otago.*

By Dr. P. MARSHALL, Otago University, Dunedin.

[*Read before the Otago Institute, 14th November,* 1905.]

Plates XXI–XXIII.

ALL geologists who have visited the fiord region of New Zealand have united in ascribing the peculiar physiographical features of the district to the effects of glacial erosion. The most recent writer on the subject, Mr. E. C. Andrews, of New South Wales, has given a fuller and more satisfactory description of the probable development of the land forms than any earlier author. His paper on the district, published in the "Transactions of the Australasian Association for the Advancement of Science," vol. x, contains references to previous literature on the subject. It is therefore not proposed to reconsider the origin of the fiords in this paper, though it must always be remembered that many eminent authorities regard ice as a preservative rather than a destructive agent of a land surface. By such geologists crustal movements, warping, and faults are most frequently invoked to account for the peculiarities of fiord depressions and the valley-lakes of alpine regions. The remarks and descriptions of Mr. Andrews have been found by the author to hold satisfactorily for the various sounds and inland valleys visited by him during the past few years. As stated in the "Geography of New Zealand," the peculiarities of the valleys of the Mount Cook region still occupied by glaciers reproduce in their main features the peculiar curves and mountain and valley forms found in such abundance in the fiord region. The beautiful illustrations in Mr. Andrews' paper depict satisfactorily the features of most importance in these Sounds, with the exception perhaps of those smoothed and rounded rock forms that are in all countries the most striking result of glacial erosion. Such rounded rock forms are present in abundance in some of the fiords, but nowhere more frequently than in Thompson's Sound, near Dea's Cove. Plate XXII gives an illustration of this, where the wall of the fiord rises to a height of 4,000 ft., while the water is 1,700 ft. deep.

We are extremely fortunate in New Zealand in having a well developed fiord region in which all the features characteristic of such areas are to be found typically developed, and at the same time a glacial region where the facts and principles of the erosion that ice performs can be studied in detail. Even at the present day the Fox Glacier has its terminal face only 600 ft. above sea-level.

It cannot be doubted that every one who compares the features of the two regions will come to the conclusion that glacial erosion is responsible for all the main characteristics of the fiords of the south-west of New Zealand.

ROCKS.

It has long been known that the Sounds region consists of crystalline rocks, but very few descriptions of the actual rocks have hitherto been given. Captain Hutton, in his "Geology of Otago and Southland," includes all the Sounds rocks in his Manapouri system of probable Archæan age. He mentions granite, gneiss, granulite, syenite, and various other types, but gives no descriptions of them. In another paper* he still includes these rocks in his Manapouri system, and states that their age is Archæan. His third paper on the general structure of New Zealand† makes no specific reference to these rocks, though he apparently regards them as intrusive masses of Maitai (Carboniferous) age.

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* Quart. Journ. Geo. Soc., 1885, p. 191.
† Trans. N.Z. Inst., 1899, p. 159.

Hector, in his "Outline of the Geology of New Zealand," in 1886, describes the rocks as crystalline schists, but he does not give a definite age to them, though he suggests a correlation with Humboldt's gneiss-granite series of South America. He says that the basement rocks are foliated and contorted gneisses associated with granite, syenite, and diorite, while round them wrap hornblende schist, clay slate, and other rocks, probably metamorphic representatives of Devonian age.

The only actual descriptions I can find are due to Hutton,* who mentions granitite from Port William, Stewart Island; syenite from Preservation Inlet and Wet Jacket Arm; biotite-pyroxenite from Dusky Sound; chloritic pyroxenite from Martin's Bay; and serpentine from Big Bay.

Seeing that so few accurate rock-descriptions have hitherto been published, it has been considered advisable to put on record the following notes on rocks collected at various points in the Sound region indicated in the map (Plate XXI). The results of the examination of the various specimens collected justifies the following general statements.

The prevailing rocks are gneisses containing but little quartz, much feldspar, some pyroxene hornblende, or biotite, and often garnet. At Half-moon Bay, Stewart Island, there is abundant hornblende. Irregular basic patches are numerous. The rock is here a diorite gneiss. At Golden Bay, a mile distant, granite outcrops, and there is a thick vein of graphic granite with microcline—microperthite. At Ruggedy Point there is a large intrusive mass of granophyre whose resistant nature causes it to form outstanding rugged pinnacles and cliffs. At Preservation Inlet there is a pink granite (syenite, Hutton) which apparently is intrusive in the spotted slates of that locality. At Dusky Sound there is a muscovite gneiss with little quartz, but with muscovite in plates often 2 in. across. At Duck Cove pyroxene gneiss with much garnet is the most frequent rock, but there are basic secretions of amphibolite and an altered crushed pale-green rock in which epidote and quartz form with a little feldspar the whole rock. At Breaksea Sound the pyroxene gneiss is the most abundant rock. In Doubtful Sound an amphibole schist occurs at Blanket Bay, and the same rock is found at Dea's Cove, Thompson's Sound, where a typical gneiss also constitutes a large rock-mass. At Milford Sound there is a peridotite intrusion† with gneissic rocks all round it. The enstatite of one of the hartzbergites is here in places entirely altered to a carbonate, and the rock appears a pure-white marble, though in section olivine is found to constitute a fourth of it.

* Trans. Roy. Soc. N.S.W., vol. xxiii, p. 112.
† Marshall, Trans. N.Z. Inst., 1904, p. 481.

In the gneisses of Milford Sound the feldspar is often pierced by epidote needles formed apparently by secondary action. The Darran Mountains appear to be composed in large part of a mica norite, while near the Mackinnon Pass a wehrlite was found.

In many of these rocks, but more especially in the pyroxene gneisses, rutile is a frequent constituent, but sphene is practically absent. As noticed by Hutton, there appears to be a general west to north-west dip; usually the amount of dip is considerable, often over 45°.

The rocks described from Anita Bay surround the intrusion of dunite and hartzbergite described in a previous paper,* but their relations to the magnesian rocks are not clearly seen.

Granites.

Golden Bay, Paterson's Inlet, Stewart Island (A 12): A white rock on the fractured surfaces, but golden-yellow on weathered surfaces. Section: Microcline microperthite, forming a coarse graphic intergrowth with quartz. The feldspar is somewhat decomposed.

Preservation Inlet (A 7): A coarse-grained pink granite, with little mica. Section: The feldspar is slightly decomposed; some of it is orthoclase, but the greater part is oligoclase. The quartz contains minute inclusions. The mica is biotite, and is somewhat weathered.

Granophyre.

Ruggedy Point, Stewart Island: A dull-pink rock showing no development of crystals. Section shows an intergrowth of feldspar and quartz of a granophyric nature. The feldspar is somewhat decomposed.

Mica Norite.

Cleddau River, Milford Sound (H 25): Hand-specimen a pale-grey rock showing several crystals with schiller surfaces imbedded in feldspars. Section: Feldspar abundant, sometimes with curved lamellæ, labradorite. Large plates of biotite. Some hypersthene and much diallage, both with schiller structure. Occasionally a little quartz intergrown in feldspar in granophyric fashion.

Wehrlite.

Mackinnon Pass (H 26): A dark heavy rock showing much hornblende in the hand-specimen. Section: Brownish-green hornblende showing strong pleochroism constitutes half the

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* Marshall, Trans. N.Z. Inst., 1904, p. 481.

section. Hypersthene with faint pleochroism rather frequent. Olivine less abundant, and some diallage. Iron-ore (magnetite) distributed as inclusions in most of the minerals.

Gneisses.

Resolution Island (G 13): Hand-specimen with marked schistose structure showing biotite and muscovite. Section: Structure cataclastic. Quartz highly irregular but plentiful. Muscovite and biotite in about equal quantity. The plates of the former often contain numerous highly refringent needles with straight extinction. They have negative elongation, evidently sillimanite.

Pigeon Island, Dusky Sound (G 5): Rock very similar to that from Resolution Island.

Pigeon Island, Dusky Sound (A 13): A perfectly white rock showing cleavage planes of feldspar on the fractured surface. Section: Oligoclase forms nine-tenths of the rock. There is a little interstitial quartz and a few small plates of muscovite.

Dea's Cove (A 9): A white rock with many feldspar cleavage surfaces and some small specks of mica. Section: Chiefly microcline, perfectly fresh, and finely twinned; some biotite, very dark-coloured, and a good deal of interstitial quartz.

Bowen Falls, Milford Sound (G 12, G 11): Hand-specimen shows large hornblende aggregates imbedded in a white feldspathic mass. Section shows abundant crystals of oligoclase, the lamellæ much bent and broken and often having undulose extinction. Throughout the oligoclase small needles and idiomorphic crystals of epidote, colourless in section, have formed in abundance (Plate XXIII, fig. 2), but otherwise the feldspar is perfectly clear and fresh. Hornblende abundant, often showing secondary corrosion in perfection. Except in the corroded cavities of the feldspar there is but little quartz in the section. Brown mica in large plates often associated with the hornblende. Some rutile, both brown and colourless. The epidote needles in the feldspar usually have their longer arcs parallel to the basal plane or to the brachypinacoid.

Road one mile from Beech Huts (G 22): A pale-grey rock with distinct gneissic structure. Section shows interlocking grains of triclinic feldspar (albite), some microcline and quartz. There is a small quantity of epidote in rounded grains and some rutile. Thin plates of muscovite are abundant.

Anita Bay, Milford Sound (G 4, G 18): Hand-specimen a dark rock showing much hornblende on the broken surface, large garnets, and a greyish-green epidote. Section: Hornblende bright-green with strong pleochroism to pale-brownish green, often intergrown with quartz, in which case the hornblende is optically continuous in large plates, and the thin arms of intergrown quartz are also continuous, so together they form a graphic structure. The boundaries of the hornblendes are highly irregular. Inclusions of brown rutile rather frequent. Quartz frequent, but in rounded and irregular grains, filling up spaces between the other minerals. Epidote almost colourless with no evident pleochroism, often 1·5 mm. by 0·5 mm. in size; apparently an older constituent than the hornblende. Garnet pale-pink, in large grains, highly irregular and discontinuous, with the interspaces filled with quartz, hornblende, or rutile. Very small amount of triclinic feldspar (Plate XXIII, fig. 3). In another section there is a quantity of colourless rutile sometimes surrounding the brown grains.

(G 27): A rock showing very distinct banded structure. The bands are coloured light-brown and white. In section the brown bands are seen to be composed of minute plates of biotite with some granular quartz. The white bands are compcsed entirely of quartz. The individual grains are small and angular. Occasionally larger rounded grains of quartz and round garnets colourless in section. The structure is completely cataclastic.

Anita Bay (G 31): A black rock evidently composed of hornblende. Section entirely hornblende, with intensely strong pleochroism—*c*, bluish-green; *b*, grass-green; *a*, very pale-yellow.

Island Beach Harbour, Breaksea Sound (G 15): Hand-specimen shows large granular groups of hornblende crystals imbedded in a white feldspathic mass. Section: Very little quartz; orthoclase and oligoclase plentiful. Larger irregular crystals of brown hornblende, slightly pleochroic, in many places changed into green fibrous hornblende. Some finely granular epidote interspersed with the fibrous hornblende. A good deal of granular brown rutile.

Beach Harbour (G 8): Very similar in hand-specimens and sections to the garnetiferous rock from Duck Cove. Oligoclase is much more frequent; quartz less frequent; and there is a little greenish-brown hornblende.

Duck Cove (G 24): Hand-specimen shows abundant garnets associated with a black ferro-magnesian mineral. These groups are imbedded in a white base. In section the garnet groups are granular, and the ferro-magnesian mineral is a pale-green faintly pleochroic pyroxene. The white minerals are quartz with highly irregular margins, and oligoclase. Much brown rutile associated with the garnet-pyroxene groups (Plate XXIII, fig. 4).

Duck Cove (G 19): A fine-grained pale-green rock. Sections completely cataclastic. Smashed grains of epidote and quartz constitute the whole mass of the rock.

Cutting north side Mackinnon Pass (G 17, G 10): A pale-green rock, with no distinct crystals showing. In thin slices, much crushed. Quartz frequent; oligoclase equal in quantity to quartz. Twin lamellæ curved and broken in many grains. Fine granular epidote frequent, and a few grains of rutile

Hornblende Schists.

Blanket Bay, Doubtful Sound (G 14): A dark greenish-grey rock, showing on the broken surface abundant cleavage planes of hornblende. In thin slices pale-green hornblende composes more than half the rock. Shows some secondary corrosion, as evidenced by the rounded inclusions of quartz. Around and between the hornblendes fine granular quartz and oligoclase angular grains completely interlocked. A few small plates of brown mica and some crystals of clear rutile. A few crystals of pale-pink garnet.

Dea's Cove, Thompson Sound (G 26): A finely foliated rock, with conspicuous hornblende, with cleavage planes parallel to the foliation planes. Section shows abundant pea-green hornblende, not highly pleochroic. It constitutes five-sixths of the rock. It contains some rounded quartz inclusions, but less noticeably than the rock from Anita Bay and Bowen Falls. The hornblende also contains inclusions of brown rutile. The colourless minerals are quartz showing undulose extinction and oligoclase with bent lamellæ. In some specimens (G 25) there are inclusions of rounded grains of colourless rutile in great abundance.

Anita Bay (G 20, G 23): Hornblende schist. A dark rock with conspicuous cleavage planes of hornblende. In thin slices the hornblende crystals are pale-green, not strongly pleochroic, sometimes with thin laths of brown mica round the margin. The rest of the rock is fine-grained, consisting of a mixture of hornblende and quartz, which often shows evidence of a flow movement round the larger crystals, producing an eye structure. There is a little magnetite in the fine-grained part. Other specimens from near the same locality have no large crystals of hornblende, but sphene is rather plentiful in them.

The rocks from Anita Bay described in a previous paper * were hartzbergite and dunite. The hartzbergite showed an apparent change from silicate to carbonate in some of the crystals, especially in those of enstatite. A further inspec-

* Marshall, Trans. N.Z. Inst., 1904, p. 481.

tion of specimens which before examination by microscope were thought to be marbles showed that these rocks were only a further and more completely changed hartzbergite, for they contained a large quantity of unchanged rounded grains of olivine (Plate XXIII, fig. 1). These white rock-specimens were found on the beach; none have yet been found *in situ*. The margins of crevices penetrating the hartzbergite showed, however, a far more complete carbonation than other parts of the rock.

EXPLANATION OF PLATES XXI–XXIII.

Plate XXI.

Map of fiord region of Otago, showing localities from which rocks were obtained.

Plate XXII.

Face of rock on east side of Thompson Sound, near Anita Bay, showing the effects of glacial erosion on the rocks.

Plate XXIII.

Fig. 1. Altered hartzbergite. Anita Bay. Rounded grains of olivine are surrounded by grains of magnesium-carbonate.

Fig. 2. Gneiss. Bowen Falls. A large plate of triclinic feldspar—andesine—showing albite twinning and undulose extinction is penetrated by needles of epidote, with their long axes parallel to the basal plane of the feldspar. To the left small grains of quartz and larger ones of hornblende.

Fig. 3. Gneiss. Anita Bay. On the right a large crystal of hornblende penetrated by epidote crystals, which extend to the left of the figure. Some of the crystals of epidote contain a central core of garnet.

Fig. 4. Pyroxene gneiss. Duck Cove, Dusky Sound. The pyroxene shown on the left of the figure is associated with much garnet, feldspar, and a little quartz.

Art. XLV. — *Dates on which Introduced Birds have been liberated, or have appeared, in different Districts of New Zealand.*

By J. Drummond, F.L.S.

[*Read before the Philosophical Institute of Canterbury, 1st December*, 1906.]

The following list has been prepared mainly from information supplied by means of a circular which I drafted two years ago, and which Mr. T. W. Kirk, F.L.S., Government Biologist, kindly issued for me through his Department. Copies of the circular were sent throughout the whole of this colony. The list of introduced birds, however, is not complete, as few records in regard to the introduction of small birds into New Zealand have been kept. In some of the items in the list the dates are only approximate. The list must not be accepted as a record of all the birds introduced into the colony. There are several birds whose introduction has not been recorded. Some of those liberated have not succeeded in establishing themselves. The list, therefore, must be taken as a contribution to the subject, rather than as a full and comprehensive table. I have adopted the plan of giving the popular and scientific name of the bird, the name of the districts in which it is found, and the year in which it was liberated, or made its first appearance. The names of the districts are arranged in alphabetical order:—

Sparrow (Passer domesticus).—Auckland, 1867; Bay of Islands, 1872; Christchurch, 1867; Carnarvon, 1880; Cape Egmont, 1875; Dunedin, 1868; Glorit, Kaipara Estuary, 1893; Hawke's Bay, about 1870; Havelock North, about 1890; Hokianga, 1869; Kaukapakapa, Auckland North, 1875; Kawau Island, 1873; Kimbolton, about 1885; Komako, Upper Pohangina, 1895; Marton, 1869; Mackenzie Country, South Canterbury, 1870; Makuri, about 1895; Mangatawhiri Valley, about 1880; Mangonui County, North Cape, 1875; Mercury Bay, 1872; Motu, Poverty Bay, about 1888; New Plymouth, 1872; Ngatimaru Survey District, 1895; Opotiki, 1877; Otepopo Survey District, about 1875; Parua Bay, Whangarei, before 1885; Patutahi, Poverty Bay, about 1885; Prebbleton, Canterbury, about 1875; Raglan, about 1865; Remuera, 1869; Rongomai, Eketahuna, 1890; Streamlands, Rodney, 1873; Thames, 1872; Tauranga, 1874; Upper Wangaetu, Wairarapa, 1895; Waikouaiti, Otago, about 1885; Wairere, Wairarapa North, about 1885; Wairio, about 1885; Waitara West Road District, about 1885; Waituna, 1892; Wanganui, 1866; Waverley, 1875; Weber County, Hawke's Bay, 1893; West Takaka, Nelson, 1875; Woodside, West Taieri, 1875; Wyndham, 1875.

Hedge-sparrow (Accentor modularis). — Auckland, 1867; Christchurch, 1867; Dunedin, 1868; Marton, 1875; Motu, Poverty Bay, 1890; Woodside, West Oxford, 1875.

Song-thrush (Turdus musicus).—Auckland, about 1865; Awakino, South Auckland, 1890; Bay of Islands, 1880; Cape Egmont, 1880; Carnarvon, about 1890; Castle Point, 1889; Christchurch, 1866; Dunedin, 1865 (two), 1867 (four), 1868 (forty-nine), 1889 (eighty-four); Havelock North, 1895; Hawke's Bay, 1870; Hokianga, 1885; Kaitaia, 1887; Kaukapakapa, 1880; Kimbolton, 1898; Komako, Upper Pohangina, before 1890; Mackenzie Country, 1875; Makuri, 1896; Mangahao, 1899; Mangonui, 1885; Mangatawhiri Valley, 1885; Marton, 1895; Motu, Poverty Bay, 1890; Ngatimaru Survey

District, 1898; Opotiki, 1899; Otepopo, 1875; Parua Bay, Whangarei, 1889; Pukekohu, Manakau, 1893; Patutahi, Poverty Bay, 1890; Rongomai, 1900; Streamlands, Rodney, 1880; South Hillend, 1895; Upper Wangaetu, 1903; Taranaki, 1868; Te Rangitumau, 1895; Waiapu, East Coast, 1900; Waikouaiti, Otago, 1885; Wairio, 1895; Waituna, 1890; Waverley, 1893; Weber County, Hawke's Bay, 1897; Whareama, Masterton, 1891; West Oxford, North Canterbury, 1892; West Takaka, Nelson, 1870; Woodside, West Taieri, about 1875.

Blackbird (Turdus merula).—Auckland, 1867; Bay of Islands, 1885; Cape Egmont, 1880; Castle Point, 1890; Christchurch, 1866; Dunedin, 1865 (two), 1867 (six), 1868 (thirty-nine), 1869 (twenty-one); Gisborne, Poverty Bay, 1878; Glorit, Kaipara Estuary, 1893; Hamilton, 1878; Hawke's Bay (Tutira), 1889; Hororata, Canterbury, about 1882; Havelock North, 1895; Hokianga, 1885; Kaitaia, 1887; Kaukapakapa, 1885; Komako, Upper Pohangina, before 1890; Kimbolton, 1898; Mackenzie Country, 1875; Makuri, 1896; Mangahao, Pahiatua, 1903; Mangonui, 1880; Mangatawhiri Valley, 1880; Marton, 1895; Motu, Poverty Bay, 1890; Ngatimaru Survey District, 1898; Opotiki, 1899; Otepopo, 1875; Parua Bay, Whangarei, 1901; Pukekohu, 1890; Rongomai, 1900; South Hillend, 1895; Streamlands, Rodney, 1880; Takapuna, 1872; Taranaki, 1868; Te Rangitumau, 1895; Upper Wangaetu, 1903; Waiapu, East Coast, 1900; Waikato, 1874; Waikouaiti, about 1885; Wairio, 1895; Waituna, 1891; Waverley, 1893; Weber County, Hawke's Bay, 1896; West Oxford, North Canterbury, 1880; West Takaka, Nelson, 1875; Whareama, 1891; Woodside, West Taieri, 1875.

Greenfinch (Ligurinus chloris).—Auckland, 1867; Cape Egmont, about 1887; Christchurch, 1866; Dunedin, 1868 (eight); Epsom, 1868; Havelock, about 1895; Kaitaia, about 1887; Kimbolton, about 1898; Marton, 1885; Mangatawhiri Valley, about 1885; Mackenzie Country, South Canterbury, about 1870; Opotiki, about 1883; Parua Bay, before 1885; Poverty Bay, 1876; Pukekohu, about 1895; Tauranga, 1876; Te Rangitumau, 1892; Waiapu, 1876; Waikato, 1876; Waikouaiti, Otago, about 1885; Waverley, 1885; West Oxford, North Canterbury, 1890; West Takaka, Nelson, about 1875; Whareama, 1893; Woodside, West Taieri, 1875.

Chaffinch (Fringilla cœlebs).—Auckland, 1867; Bay of Islands, 1876; Cape Egmont, 1888; Castle Point, 1900; Christchurch, 1867; Dunedin, 1868 (twenty-seven), and 1869 (six); Hawke's Bay (Tutira), 1902; Havelock North, 1895; Kaukapakapa, 1885; Kimbolton, 1878; Komako, 1899; Mackenzie Country, South Canterbury, 1870; Mongonui, 1868; Motu, 1890; Ngatimaru Survey District, 1897; Pukekohu, 1895; Tauranga, 1876; Waituna, 1895; Waverley, 1893; Weber County, Hawke's Bay, 1902; West Oxford, North Canterbury, 1890; West Takaka, Nelson, about 1875; Woodside, West Taieri, 1875.

Goldfinch (Carduelis elegans).—Auckland, 1867; Bay of Islands, 1895; Cape Egmont, about 1888; Carnarvon, about 1890; Castle Point, 1886; Christchurch, 1866; Dunedin, 1867 (three), 1868 (thirty), 1869 (fifty-four); Glorit, Kaipara Estuary, 1897; Hawke's Bay, 1875; Havelock North, 1895; Hokianga, 1892; Kaitaia, 1887; Kaukapakapa, 1885; Kawau Island, 1876; Kimbolton, 1898; Komako, 1895; Makuri, between 1895 and 1898; Mangatawhiri Valley, 1885; Mangonui, 1880; Marton, 1885; Mackenzie Country, South Canterbury, 1875; Motu, Poverty Bay, 1890; Ngatimaru Survey District, 1897; Otepopo Survey District, 1875; Parua Bay, 1889; Pukekohu, 1887; Rongomai, 1898; Thames, 1876; Tauranga, 1876; Te Rangitumau, 1885; Waikato, 1876; Waikouaiti, about 1885; Waituna, before 1892; Waverley, 1889; Weber County, 1894; West Oxford, North Canterbury, 1880; West Takaka, Nelson, 1875; Whareama, 1893; Woodside, West Taieri, 1875; Wyndham, 1875.

Redpoll (Linota rufescens).—Auckland, 1872; Christchurch, 1868; Dunedin, 1868 (ten); Hawke's Bay (Tutira), 1902; Mackenzie Country, South Canterbury, 1875; Waikato, 1873; West Oxford, North Canterbury, 1890; Whareama, 1893; Woodside, West Taieri, 1875.

Yellow-hammer (Emberiza citrinella).—Auckland, 1867; Bay of Islands, 1880; Cape Egmont, 1888; Castle Point, 1884; Carnarvon, 1890; Dunedin, 1868 (eight); Hawke's Bay, about 1875; Havelock North, 1895; Hokianga, 1890; Kaukapakapa, 1885; Kimbolton, 1898; Komako, 1895; Mangatawhiri Valley, 1885; Mangonui, 1885; Makuri, between 1895 and 1898; Marton, 1887; Matakohe, 1873; Mackenzie Country, South Canterbury, 1870; Motu, Poverty Bay, 1890; Ngatimaru Survey District, 1897; Opotiki, 1883; Parua Bay, before 1885; Rongomai, 1898; Upper Wangaetu, 1895; Waituna, 1892; Waverley, about 1883; Weber County, Hawke's Bay, 1890; West Oxford, North Canterbury, 1890; West Takaka, Nelson, about 1875; Whareama, 1893.

Cirl-bunting (Emberiza cirlus).—Dunedin, 1870 (seven); Mackenzie Country, South Canterbury, 1875.

Starling (Sternus vulgaris).—Auckland, 1867; Awakino, 1887; Bay of Islands, 1885; Cambridge, 1878; Carnarvon, 1897; Castle Point, 1898; Christchurch, 1867; Coromandel, 1869; Dunedin, 1867 (three), 1868 (eighty-one), 1869 (eighty-five); Epsom, 1868; Glorit, 1895; Hamilton, 1878; Hangaroa, 1902; Hawke's Bay, 1870; Havelock North, 1895; Hokianga, 1869; Hororata, Canterbury, 1885; Kaukapakapa, 1880; Kawau Island, 1874; Kimbolton, 1898; Komako, 1890; Makuri, between 1895 and 1898; Mangare, 1869; Mangonui, 1890; Mongonui, 1868; Mangatawhiri Valley, 1878; Marton, 1895; Mackenzie Country, South Canterbury, 1875; New Plymouth, 1872; Motu, Poverty Bay, 1890; Napier, Hawke's Bay, 1876; Ngatimaru Survey District, 1900; Opotiki, 1880; Otepopo Survey District, 1875; Parua Bay, 1895; Pahiatua, 1900; Piako, 1878; Poverty Bay, 1874; Pukekohu, 1882; Rongomai, 1898; Upper Wangaetu, 1901; Taranaki, 1876; Te Rangitumau, 1887; Tauranga, 1874; Thames, 1872; Waikato, 1874; Waikouaiti, about 1885; Waikato, 1876; Waituna, 1890; Waverley, 1883; Weber County, Hawke's Bay, 1894; West Oxford, North Canterbury, 1892; West Takaka, Nelson, 1875; Whareama, 1895; Woodside, West Taieri, 1875; Wyndham, 1875.

House-mynah (Acridotheres tristis).—Awakino, South Auckland, about 1893; Brightwater, Nelson, 1880; Cape Egmont, about 1882; Carnarvon, about 1893; Christchurch, 1879; Dunedin, 1875; Havelock North, about 1885; Hawke's Bay, 1877; Kimbolton, about 1902; Marton, 1895; Motu, Poverty Bay, about 1890; Ngatimaru Survey District, 1895; Patutahi, Poverty Bay, about 1890; Rongomai, 1900; Te Rangitumau, 1895; Upper Wangaetu, 1900; Waituna, 1899; Waiapu, 1889; Waikouaiti, about 1885; Waverley, about 1883; Weber County, Hawke's Bay, about 1896.

Rook (Corvus frugilegus).—Auckland, 1870; Christchurch, 1868.

Australian Magpie (Gymnorhina leuconota). — Auckland, 1867; Bay of Islands, about 1880; Carnarvon, about 1900; Christchurch, 1868; Dunedin, 1865 (three), 1866 (twenty), 1867 (thirty-two), 1868 (twenty), 1869 (six); Epsom, 1868; Glorit, Kaipara Estuary, about 1897; Havelock North, 1880; Kaukapakapa, Auckland North, 1885; Kimbolton, about 1902; Komako, 1902; Marton, 1887; Motu, Poverty Bay, about 1890; Upper Wangaetu, 1901.

Skylark (Alauda arvensis).—Aramoho, Waitotara, about 1885; Auckland, 1867; Awakino, 1880; Bay of Islands, 1880; Castle Point, 1879; Christchurch, 1867; Dunedin, 1867 (four), 1868 (thirty-five), 1869 (sixty-one); Epsom, 1868; Glorit, Kaipara Estuary, about 1897; Hawke's Bay, 1870; Hokianga, 1890; Hororata, Canterbury, 1872; Havelock North, 1890; Kaukapakapa, Auckland North, 1880; Kimbolton, 1885; Komako, 1895; Lower Rangitikei, 1875; Makuri, 1895; Mangatawhiri Valley, 1880; Mangonui, 1890; Marton, 1875; Mackenzie Country, South Canterbury, 1870; Motu, Poverty Bay, 1890; Ngatimaru Survey District, 1900; Opotiki, 1899; Otepopo Survey District, 1875; Parua Bay, Whangarei, 1882; Pukekohu, 1878; Rongomai, 1894; Tuapeka West, 1880; Upper Wangaetu, 1904; Waikouaiti, about 1880; Waitara West Road District, 1875; Waverley, 1885; Weber County, Hawke's Bay, 1894; Woodside, West Taieri, 1875.

The following are other birds, some of which have failed to become acclimatised :—

White Swan (Cygnus olor).—Auckland, 1867; Christchurch, 1866; Dunedin, 1868 (three), 1869 (one); Takapuna Lake, 1874.

Black Swan (Cygnus atratus).—Auckland, 1867; Christchurch, 1866; Kaitangata Lake (near Dunedin), 1860 to 1870; Poverty Bay, 1895.

Swamp Quail (Synœcus australis).—Auckland, 1867; Christchurch, 1866; Green Island, near Dunedin, 1868 and 1870.

Californian Quail (Callipepla californica).—Auckland, 1867; Bay of Islands, 1885; Christchurch, 1866; Dunedin, 1868 and 1871; Nelson, 1868; Ohinemuri, 1876; Poverty Bay, 1868; Waikato, 1868.

Common Pheasant (Phasianus colchicus).—Auckland, 1867; Bay of Islands, 1875; Christchurch, 1866; Dunedin, 1865 to 1874; Poverty Bay, 1875; Tauranga, 1868; Tolago Bay, 1869.

Lapwing (Vanellus cristatus).—Auckland, 1870; Westland, 1904.

Grey Linnet (Linota cannabina).—Auckland, 1867; Dunedin, 1867–68.

Pee-wee, Mud-lark, or Magpie-lark (Grallina picata).—Auckland, 1900; Hawke's Bay, 1900; Wellington, 1900; West Coast, North Island, 1897.

Robin Redbreast (Erithæcus rubecula).—Auckland, 1872 (three); Christchurch, 1879.

Nightingale (Danlius luscinia).—Christchurch, 1879.

Siskin (Carduelis spinus).—Christchurch, 1899.

Java Sparrow (Munia oryzivora).—Auckland, 1867; Christchurch, 1867

Art. XLVI.—*Oil-wells and Oil-prospects along the East Coast.*

By H. Hill, B.A., F.G.S., Napier.

[*Read before the Hawke's Bay Philosophical Institute, 11th September,* 1906.]

Plate XXIV.

The "striking of oil" at Moturoa, near the Town of New Plymouth, at a depth exceeding 2,000 ft., has again drawn attention to the oil-prospects along the east coast of this Island. For many years Poverty Bay has been regarded as the centre of an oil district of large extent, and in the years gone by, when travelling and means of conveyance were both difficult and expensive, quite a number of "enterprises" were undertaken in the hope of striking oil by those who knew something of American enterprises and had faith in a payable oil-field being discovered within the limits of Poverty Bay. And so long ago as eighteen years the news was spread over the colony that oil had been struck by the South Pacific Company. Speculation at the time ran high as to whether the news was a mere flash in the pan—a repetition of many similar reported successes—for a successful oil-well at that time meant much for the future prosperity of Poverty Bay and for the colony as a whole. Ten years previously a visit had been paid by me to the site where the first oil-bore had been attempted, on the top of a hill certainly 1,300 ft. above sea-level. At the time of my visit work had been stopped, but it was possible to collect in the well-holes scattered about a barrel of crude petroleum. This site was subsequently abandoned, and a new bore was tried on the bank of a small stream known as Wairongamea, some five miles or so below the place of the first sinking, and not far from the junction of the stream with the Waipaoa River that flows into Poverty Bay. This place is about thirty miles to the north-west of Gisborne, and is situated within an extensive district which geologically might be set down as Cretaceo-tertiary. Some distance further up the river, and near the junction of the Mangatu Stream with the Waipaoa, another well known as the Minerva was being put down by a company. This bore was about a mile or a little more from the Pacific Company's well. Having work to do within a few miles of the workings, and being interested in the alleged striking of oil, the opportunity was taken to visit the wells, and a paper in the Transactions for 1888 contains the results of my visit at that time.

The "striking of oil" had been followed by disaster, for an explosion had taken place, and the derrick had been burnt, and the tools lost in the well. There were, of course, rumours that things were not satisfactory—in fact, it was said that a dray-load of kerosene had been sent from Gisborne to the well a few weeks previous to the explosion, and the inference was that the oil in the well-tube was none other than the kerosene that had been taken from Gisborne. Be that as it may, I visited the well in company with the late R. T. Walker, of the *Hawke's Bay Herald*, and we drew oil from the well that was certainly not kerosene. Since then till now I have kept a bottle of the crude oil, and the sample shown here is taken from the bottle into which the oil was put so long since. It will be seen that when held against the light it possesses a fine rich colour, almost ruby-red, but otherwise it appears to possess a dull muddy-greenish tinge. The report that will be found in the context from an American manager of oil-wells will give information as to the quality of the oil. But when speculators grow suspicious, when "calls" are made upon investors in shares, and when times are bad, there is danger of a collapse unless directors can show something for the expenditure of large sums of money. And so it came to pass that the destruction of the derrick in the Pacific Company's well destroyed also public confidence, and soon afterwards the Minerva and Pacific bores were abandoned, and everything was sold that could be sold to meet liabilities.

Since then till now nothing has been done along the east coast in the way of further attempts at boring for oil, except that some years ago a gentleman from England, interested in oil, spent some time in Poverty Bay obtaining "options" in places where traces of oil or of gas-springs were known to exist. Those "options," I am informed, are not now of any value, so that there appears no hindrance in the way of any one that chooses to try for oil in the places formerly worked.

The discovery of oil at Moturoa at a depth exceeding 2,000 ft. has brought up this question for reconsideration. The sinkings in the east coast district were not as deep by nearly 1,000 ft. as is the Moturoa bore. Fortunately a sectional copy of the Pacific Company's well is available, showing the general character of the various beds passed through in the 1,321 ft. of the Pacific Company's well. This section appears in vol. xxi of the New Zealand Transactions, and a comparison between it and the Moturoa well sections (Plate XXIV) should prove both suggestive and of value in any future work that may be undertaken to test the oil-deposits along the east coast of this Island.

Many years ago Sir James Hector, the late Director of the Geological Survey, published in one of his reports an account of the east coast district extending, I believe, from Hicks Bay to Poverty Bay. Unfortunately the report is not available in the library of our Institute, and whatever is stated here must be the result of my own personal knowledge of the district under notice. The east coast district has been travelled by me for a period of twenty-eight years, and there are few places on the coast and inland for twenty-five miles that have not been visited during that time between Hicks Bay and the southern boundary of the old Hawke's Bay Provincial District—that is, for a distance of more than 320 miles. The facts referred to in this paper, however, will have reference to the district from the mouth of the Waiapu River in the north, nearly opposite East Cape Island, and Herbertville, locally known as Wainui.

The coast rocks that extend southwards from the Waiapu River belong to the Cretaceo-tertiary series. At Port Awanui they run into a remarkable variety of beds, from a coal-black and brown earthy type to a greenish and pale-blue clay rock as stiff and as sticky as the proverbial sticking-plaster. Sandstone grits are also met with, and the whole series is moving seawards, winter and summer alike, exactly like an enormous glacier. These rocks between Port Awanui and Reperoa, a distance of five miles, are seen to rest on an outcrop of the Maitai slates, which are exposed in a high bluff and extend for about half a mile along the coast. Between Reperoa and Tuparoa the country presents the same characteristics as along the coast already described. Gas-springs are met with here and there and inland, but striking to the south-west the same rock-characteristics continue. Between Tuparoa and Whareponga the lower beds are seen to be topped by the older Tertiaries, but these again disappear in the direction of Waipiro, so that at Aku Aku the Cretaceo-tertiaries again make their appearance, and continue along the coast to the southern end of Waipiro Bay, where they are topped by the Tawhiti sandstones, which have their connection with the cone-like hills that are to be seen inland between Tokomarua Bay and Waipiro Bay. The road between these two places now runs inland and passes some fine hot springs, where also are to be seen some remarkable gas-holes, where sufficient gas is given off to supply the requirements of many households. The rocks in the vicinity of the springs belong to the Cretaceous series, and they are evidently in close connection with the green-tinged sandstones which appear in several places within a couple of miles of the springs. The rocks between Tokomarua Bay and Tolago Bay belong to the sandstone series, of which Tawhiti Hill, 1,750 ft., is an offshoot. The Uawa River, that empties itself into Tolago Bay, runs through the valley, and on either hand the hills are made up of fairly soft sandstones of a light-brown colour. The rocks on the north side of Tolago Bay are similar to those at Cape Kidnappers and at the mouth of the Mohaka River, and a pumice band about 15 in. in thickness, with *Foraminifera* and other fossils, is met with. On the south side of Tolago Bay, as also in Cook's Cove adjoining, limestones appear, and are connected with the small islands that are seen on the north of the entrance to the bay. The hill that is crossed when going south from Tolago Bay towards Pakarae is made up of banded sandstone interbedded with a bluish sandy clay. It is fossiliferous, and belongs to the Miocene series. At Gable End Foreland the upper beds of the Cretaceo-tertiaries, with the characteristic greensands, again appear, and at Whangara, an island peninsula, the greensand tops blue clays interbedded with sandstone bands, but the black and brown shales are not exposed. They are seen, however, a little further along the coast, where there is the only other exposure of the Cretaceo-tertiaries until nearing Tua Motu Island, on the north side of Poverty Bay, where the sandstones again are met with and numerous gas-springs make their appearance. At Whareongaonga, south of Poverty Bay, celebrated as the landin-gplace of Te Kooti on his escape from the Chathams in the "Rifleman," the Cretaceo-tertiaries again appear, and there is a large development of sandstone between the Mahia and Nuhaka, where both hot springs and gas-springs abound, and limestones again are met with corresponding to the limestones at Tolago Bay. Inside Hawke's Bay the rocks are younger Tertiaries, and there is an absence of the older rocks; but proceeding along the coast to the south of the Kidnappers the rocks between Waimarama and Pourere are Cretaceo-tertiaries, and the green sandstone is very largely developed between Porangahau and Wainui, and gas-springs are fairly abundant there. All the exposures to which reference has been made show that the general strike of the beds is to the south-west, and the various roads inland from the coast pass across the strike of the beds; and the exposures show that the Cretaceo-tertiaries have a fairly wide distribution.

Similar characteristics are found in all the places named—that is, there are springs giving traces of oil or gas or salt. The well that has caused so much hope in Taranaki has reached a depth of 2,240 ft. This is nearly 1,000 ft. deeper than the deepest bore hitherto put down in the Poverty Bay district, as in the case of the Wairongamea well, and it may be worth while to continue the sinking further, as there are abundant traces of brackish water and gas and oil at the depth where work ceased.

The foregoing portion of my paper was written on Monday night, and on Wednesday last I received a letter from Akiteo dated the 1st September, as follows:—

"Dear Sir,—Hearing from Mr. Somerville, Postmaster, Herbertville, that you are fond of geology and follow it up, I am sending you a piece of stone which when taken from the reef is fairly saturated with kerosene. The reef smells strongly as you stand alongside. It was found by a metal-contractor who was getting metal for the road and put a shot in the reef, and when he found it the smell was very strong. The seams and the stone are quite damp and greasy, and smell very strong. What do you advise ? Is there any way of testing in any way ? What should we look for, &c. ?"

This illustrates the remark already made as to the east coast being in a large measure an oil-bearing area, and it is of the utmost importance that a more particular survey be made, so that specified areas may be tested to find out whether the oil-bearing beds lie below the 1,321 ft. which have already been tried, or whether the oil-bearing strata have been passed through without discovering the fact.

The height of the well above sea-level at Wairongamea is 450 ft., and oil-indications are met with much higher than this. At Port Awanui in the north, and at Herbertville in the south, the oil-shale beds are within 50 ft. of sea-level. To the north-west of Wairongamea, on the left bank of the Mangatu, similar shale-beds crop out 800 ft. or more above sea-level. At Waipawa, forty miles from Napier, the shales are exposed on the left bank of the river, near the brewery, 460 ft. above sea-level; and similar rocks occur in the hills overlooking Porangahau, 300 ft. above sea-level, and at Wimbledon and Weber, on the Wainui–Dannevirke Road. It will be seen from these remarks how widely distributed are the rocks that bear traces of containing oil.

In the early days of oil-explorations, and before "corners" had been heard of, the relationship between salt springs and petroleum was so intimate in American wells that in the case of oil-borers in certain districts "No salt, no oil" became a maxim among them. And in these days of discovery, when scores of districts are worked for "oil," gas-springs, salt springs, and sulphurous waters are looked upon by experts as important indications of petroleum.

The oil-fields of the world are now so numerous that it would be difficult to enumerate all the districts where petroleum is obtained; but no doubt there are many places where oil will be struck when geological surveys will have been carried on systematically and proper records obtained of the surface-characteristics of a country. The greatest oil-producing countries at the present time are Russia, North America, Roumania, further India, Japan, the Dutch Indies, Italy, and Algiers; but Russia, the United States, and Roumania are the only three countries from which oil is exported—in other words, countries where the supply is in excess of each country's requirements.

As to the depth of wells, it appears that in the various oil-bearing districts there is a great difference in the depths, and even in the same district a greater depth has to be tried after wells have been running for some time, as it is found the pressure is constantly diminishing. The Pennsylvania wells have an average depth from 1,600 ft. to 1,800 ft., but some wells reach about 3,000 ft.; and in West Virginia they are numerous between 2,000 ft. and 3,000 ft., whilst one actually reaches 5,000 ft. In the Baku district, bordering on the Caspian Sea, the pumping-wells exceed 1,000 ft. in depth, and there are fountains of flowing ones much deeper than this; and the tendency year by year as new wells are put down is to sink deeper.

These varying depths are given here to show that the depth of the Moturoa well is not excessive. Wells situated within continental areas may be supposed to contain larger oil-bearing basins than in the case of islands like New Zealand, and overlying beds may become saturated with oil by the chemical changes that may be assumed to have been in progress for long periods of time. In the case of the Baku field, for instance, it occupies an area where the rocks at a little distance below the surface were so saturated with oil that large quantities were obtained from wells less than 100 ft. in depth; but these supplies have ceased, and deeper wells have been put down, as in America and elsewhere.

Regarding the depth that ought to be tried along the east coast, it seems that the question is one of location. Hitherto the sinkings have been inland and at a comparatively high elevation, but the experience of American and other oil-explorers shows that it is not essential at all to put down a bore in the vicinity of a petroleum-spring. The oil usually finds a means to escape along the lines of rocks that are much fractured and broken, whilst the actual source of the oil may be miles away. In putting down a well all indications favourable to the work should be taken into account, such as gas-springs, salt springs, accessibility and probable cost of carriage of material. Thus it has been suggested again and again that trial bores might be put down within a few miles of Gisborne at very little expense, and with quite as good prospects of testing for oil as at Mangatu. The rocks are certainly similar, and gas, salt, and sulphurous springs are met with near Tua Motu, where the rocks indicate the close proximity of the black shales by the appearance of the overlying greensands. The troughing of the beds gives an advantage in favour of the last-named place as compared with Mangatu, and should oil ever be struck along the line indicated the flow should be better towards the coast than at any place further inland.

It has been pointed out that petroleum is widely distributed over the earth's surface, but, although the indications in the different countries are generally similar, it is curious how widely the rock-formations differ in which the petroleum is found. Thus, according to Professor Zuber, who is an authority on oil and its distribution, petroleum is found in every geological formation from the Silurian upwards. The oil-wells of Canada are supplied from Silurian rocks; those of the United States from Devonian; those in Argentine, Asia Minor, and Egypt from the Cretaceous system; and those in Italy, the Caucasus, Roumania, and Burma mainly from the Tertiaries—lower or upper.

Professor Engler, another high authority on oil-fields, says that "petroleum formations always consist of bituminous clay shales and other (chiefly variegated) clays, alternating with sandstones and conglomerates, while the limestones which are met with in these formations always contain tarry matters, though very rarely pure petroleum. Petroleum," continues the professor, "occurs solely in sandstone rocks, and the most reliable indications of the existence of petroleum are the occurrence of salt springs or salt beds and sulphuretted-hydrogen springs." This information is of value to the geologist in making observations favourable to the occurrence of a petroleum-basin. The characteristics here indicated are to be found irrespective of formation or geological age, and certainly, if there are indications of underlying beds of petroleum, there can hardly be reason to doubt that the petroleum-beds of the east coast are fairly extensive.

Another point of importance deserves to be noticed in connection with what is known as the "crude oil." It has been explained that petroleum is not limited to a particular system or rock-formation, and just as the formations differ so do the qualities and varieties of petroleum obtained. In the trade it has been laid down by Professor Mabery that four special kinds or types of petroleum are derived from the wells. These are paraffin petroleum, Russian or napthene petroleum, sulphur petroleum, and nitrogen petroleum. In the first, paraffins are found in the largest proportion; in the second, napthenes; whilst in the third and fourth there is either a trace of sulphur or of nitrogen.

The origin of petroleum is not known. There are various theories, some chemists holding it to be of vegetable origin, others of animal, whilst others, among whom may be named the famous Russian chemist, Professor Mendelieff, affirm that it is of chemical origin.

As showing the closeness of the compositions of coal and petroleum respectively the following percentages are interesting :—

	C.	H.	O.	N.	S.
Coal	84·31	5·09	7·24	1·49	0·13
Petroleum—					
Pennsylvanian	84·9	13·7	1·4	..	..
Baku ..	86·6	12·3	1·1	..	..

But although the percentages approximate each other in the case of carbon, the inference cannot be accepted that they have the same origin.

In the case of the rock sent to me from Akiteo, it is certainly saturated with oil that has the smell of petroleum. The rock is a greensand, and is always present with the black earthy-looking shales scattered along the east coast in the places indicated, and which contain traces of fish-scales, small hollow whitish tubes, and an abundance of gas. The greensands are more largely developed in certain localities to the south of the Kidnappers than further north, and they have their greatest development in the line of hills running parallel to the coast between Porangahau and Herbertville, Cook's Tooth being the culminating point. In the Poverty Bay district the greensands beginning at Whangara strike to the south-west, cross the upper portion of the Waimata Valley, and appear in the range of hills that contains the petroleum-springs where the first attempts were made to put down a well. They continue to the south-west, where the greensands meet, at Whakarau, the light sandstones similar to those between Waipiro Bay and Tokomarua Bay. They appear to run in the direction of Waikaremoana, and it may be that the range of sandhills in the Wharekopae district, owned by Murphy brothers, belong to the series, but I have not been sufficiently close to determine their age.

More than once remarks have been made as to the benefits that would accrue to the country were the Government to undertake trial bores for water, for oil, for coal, and even for gold. If there should be a failure the country as a whole sustains the loss, and if success is obtained the rights to sink or mine should be put up to public auction for a term of years, just as land is put up to lease for a term of years. The State equally with individuals would derive benefit by this plan. That there are numerous traces of oil throughout the whole of the district indicated is evident to the most superficial observer, and trial bores would have been made long ere this had the Government taken in hand the testing for minerals for the common benefit. The State is able to carry out detail work in geological matters better than a private individual. To go over a large extent of unbroken country at any time is by no means an easy task, but geology necessitates careful inspection, and inspection means expense. Unless, therefore, we can afford to spend generously both time and money, geological detail work cannot be carried out over any extensive area of country. We hear now and again a good deal about technical education, but one has yet to learn what has been and is being done to further scientific investigation by research methods. The country might easily benefit a thousandfold by the mere establishment of funds for the purpose of helping those capable of carrying out research work. The collecting of facts all bearing upon the question of petroleum need not be either a costly or a difficult undertaking were proper means taken, and there can be no doubt whatever as to the likely benefits that would accrue to the country. But, as in my own case, it is possible to traverse a whole district for several hundred miles from north to south and for fifty miles from east to west, and know all the characteristic rocks, but field geology requires more than this, for it needs patient observation and the keeping of all records as to the character of the rocks, the dip and strike of beds, the location of springs and places of suggestive importance.

These remarks are here made in the hope of directing attention to the duty of Parliament in relation to the practical application of scientific information. There is no need to encourage speculation for the discovery of a payable oil-field along the east coast, but there is need for the State to supply to the people that practical information, based upon inquiry and experiments, that will determine the course to be taken in searching for oil. And as showing the importance of the question, I venture to indicate a line of country to the south of the Kidnappers, and to the north of the Mahia Peninsula, that ought to be fully investigated. These places are between Pourere and Herbertville on the coast, and Waikopiro and Weber inland, in the south, and between Te Mahia and Morere, and Pakarae and Whakarau on the Motu Road, in the north. These districts contain all the characteristics that are to be found in the important oil-bearing districts in America, in Asia, and in Europe, but they require investigating in detail and tests made with a view to the discovery of payable petroleum. Having traversed the districts for more than a quarter of a century, and being acquainted with the general character and distribution of the oil-bearing rocks and the location of wells—oil, gaseous, and mineral—I am convinced that a proper geological survey would pay many times over for the work that must be done, and would readily be done but for the fact that a private and non-interested party cannot be expected to carry out work that properly belongs to a Government undertaking.

As to the quality of the petroleum found in New Zealand, the following copy of a letter that appeared in the *Poverty Bay Herald* of the 11th December, 1887, from Mr. P. G. McPherson, manager of the Pacific Coast Oil Company of San Francisco, will suffice. A sample of the oil from the Minerva well was sent to him by Mr. J. H. Stubbs, and he replied,—

"Yours of October 8th, 1885, was duly received, also sample of oil so kindly sent by you. I take pleasure in giving you the results of its distillation at our refinery. The oil proves to be exceedingly sweet, easily distilled and treated, furnishing an illuminating-oil of fine quality and high fire-test, and the largest percentage of same of any oil I have seen; in fact, I can say it is the best sample of crude petroleum that I have ever examined in an experience of twenty-five years. The same as received was 79 gravity, and yielded an illuminating-oil of 94·4 per cent.; paraffin, 2·95 per cent.; waste or loss, 2·55 per cent.: total, 100. Fire test was 190°. Should you obtain this oil in payable quantities its fine natural qualities would enable you to refine the same with works of exceedingly inexpensive construction."

I do not know whether any other analyses of the Poverty Bay oil were made, but the oil in my possession will be forwarded to Mr. Aston, the Government chemist in Wellington, and it will be discovered whether it is a natural oil or whether previously distilled oil was used in making it up.

Of the Moturoa petroleum as stated in the Taranaki company's prospectus, Professor Easterfield, of Wellington, reports:—

"I have examined the crude petroleum sent by you on the 6th instant, and certified as having been drawn in Mr. ———'s presence:—

"The crude oil: The sample was of a greenish colour, red in transmitted light, without offensive smell. It was semi-solid at the ordinary temperature but completely liquid at 80° Fahr. It contains sufficient volatile matters to flash at the ordinary temperature. The specific gravity was 0·84 at 65° Fahr. The sample was free from water and grit.

"Distillation test: When distilled the oil gave the following products:—

	Per Cent.
Benzine, distilling between 55° and 150° C.	20
Burning-oil, distilling between 150° and 300° C.	40
Heavy oil for lubricating, between 300° and 440° C. ..	37
Pitch	2
Loss	1
Total	100

It will be noticed that the qualities of the Poverty Bay and

Taranaki oils are widely different, the former being similar to the Pennsylvania oil in the very high percentage of kerosene that is in it, whilst the Taranaki oil belongs to the Caucasus or Baku series—the naphthene series—which produces a less percentage of kerosene but a larger percentage of oils suitable as a lubricant or even as fuel.

The oil from the first well attempted in Poverty Bay when drawn had a pale light-muddy-green tinge if held up to the light, but this appearance was not noticed in the oil collected on the surface of the water in the springs. The greenish tinge was similar in colour to the greensand rock when hammered and mixed with water, and which is characteristic in the Cretaceo-tertiary oil-beds along the east coast. The greensand is composed of rotten quartz, feldspar, and minute black specks scattered through the mass. It may be that the minute black particles, which are lustrous like pitch, are bitumen, but I do not think so; still, the matter is one for the chemist to decide. The greensandstone seems to be impregnated with oil, possibly from the underlying beds, and should the minute particles be bitumen they were probably formed by the evaporation, solidification, and consequent partial oxidation of the petroleum gases. But this is merely a suggestion.

The sketch-map accompanying this paper indicates the location of oil-springs, gas-springs, &c., personally known to me. Many others are no doubt known to shepherds and settlers in the more remote districts, but interest in the discovery of oil along the east coast had almost died away in Poverty Bay until the news was spread that oil had been struck near New Plymouth at a depth exceeding 2,000 ft. Already there is evidence of growing interest, and more than one inquiry has been made to me by outside parties anxious to know the most likely places for trial bores.

I have seen the oil from three widely separate localities in the east coast north of the Mahia Peninsula, and the rock from Akiteo furnishes another proof that the gas-springs, oil-shales, and other gas-bearing rocks are connected with petroleum districts in the southern portion of the Hawke's Bay District. For several years I have been aware of curious gas-bearing rocks between Waikopiro and Wallingford, and gas and salt springs certainly occur in the same locality. But careful geological investigation is wanted, and this it is the duty of the Government to undertake, just as they undertake the search for gold and coal and other minerals.

My purpose to-night is merely to direct attention to the great possibilities of the east coast should petroleum oil-beds be struck, as in the case of Taranaki. Trial bores can settle the question, and these, after a proper geological survey, the Government ought to undertake, to assure to the people as a whole benefits to which all are entitled.

Inland the rocks are more broken and shattered than towards the coast, and so the oil reaches the surface by means of the fractures, it being forced upward by the gases that are seeking an exit. But the practical tests must settle the question. As far as my own personal knowledge goes I have indicated the location of the greensands and oil-bearing shales, and it is for those who desire to obtain oil and who have faith in the facts to put theory to the test, or else call on the Government to carry out a proper geological survey, with a view to obtaining more reliable data than I have been able to give here.

Art. XLVII.—*Notes on Two Marine* Gymnomyxa.

By H. B. Kirk, M.A., Professor of Biology, Victoria College, Wellington.

[*Read before the Wellington Philosophical Society, 5th September*. 1906.]

Plates XXV and XXVI.

When tracing the development of a polychæte worm, in January of this year, I observed in the gelatinous matter in which the eggs of the worm were imbedded two *Gymnomyxa*—one a member of the *Lobosa*, the other nearer to the *Labyrinthulidea* than to any other class. I had these organisms under observation at the seaside during a fortnight; but I was not able in that time to fully trace the life-history of either. These notes must therefore be regarded as preliminary only.

Amœba agilis, n. sp. Plate XXV.

Endoplasm often not noticeably granular in appearance; pseudopodia varying, being sometimes blunt and rounded, at others tapering and flexible. Nucleus occasionally visible in unstained specimens; always easily seen in stained specimens. No contractile vacuole. Sometimes the animal is sluggish, but usually it moves quickly and, when well nourished, divides rapidly. When preparing for division the animal usually draws itself out into two masses, a more active mass drawing away, as it were, from a less active mass, the two remaining connected for a short time by an isthm s of non-granular matter, which finally gives way. In Plate XXV, figs. 1 to 27, are given outlines of an *Amœba* preparing for division. It will be noted that the animal frequently draws itself out into two or more masses before finally dividing. In this case the preparatory stages occupied thirteen minutes. The new *Amœba* to the left in fig. 27 divided again in five minutes; that to the right in fifteen minutes.

Streaming of the endoplasm is very marked and often very rapid, with sudden reversal. Streaming and change of shape cease at the same moment. At this moment the animal has become somewhat pear-shaped, the broad end leading. Then comes reversal of streaming and of movement, either immediately or after a very short rest. It is usual for the animal to move four or five times its own length before reversal.

The food of the animal consists, so far as it is visible, mainly of small diatoms and other unicellular plants. When the animal comes near a diatom the latter approaches it at a very rapid pace, appearing to rush to it. I could observe no mechanism to account for this. Food-vacuoles could not be detected. Fæces were egested slowly or quickly; if quickly, at the end of a pseudopodium.

The average diameter of the animal is about 0·1 mm.

Myxoplasma rete, n. gen. et sp. Plate XXVI.

Body flattened, apparently because the protoplasm is too fluid to resist gravitation. This flattened body may surround two or more large spaces and several smaller ones. Delicate pseudopodia are emitted, and these often anastomose. The protoplasm streams along these pseudopodia, gathering itself into larger or smaller masses here and there. At first the pseudopodia do not contain granular endoplasm, but this streams in and often becomes separated from the main granular mass. A notable feature of the pseudopodia is that they often exhibit waving movements like those of the tentacles of many hydroids. This movement is generally slow. At times a mass of granular matter detached from the main granular portion and surrounded by non-granular matter may be observed to move rapidly along the margin of the body, as though its non-granular isthmus actually rushed along. This indicates great contractility, and at the same time great fluidity of the non-granular matter. Nuclei were not observed. In general appearance the body resembles closely an active plasmodium of a Mycetozoan; but whether it originates as such a plasmodium does I am unable certainly to say.

A slide that had been under observation for eight days was left unobserved for three days during my absence. When I returned, the organism as I had observed it had disappeared. In its place were many active flagellulæ, each with a well-marked nucleus and a large vacuole, non-contractile (Plate XXVI, fig. 5). The body of a flagellula is pear-shaped, with a long flagellum at the posterior end. Nothing like an eye-spot is visible. These flagellulæ aggregated in places into small masses, losing their activity but not becoming fused. In connection with these quasi-plasmodia, or often not in connection with them, the flagellulæ formed into long strings and loose networks. In this stage the resemblance to the fibres and spindle cells of *Labyrinthula* is unmistakable. I did not, however, observe any spindle cells that moved along the threads.

I am not, of course, sure that the plasmodium-like body that I have called *Myxoplasma* broke up into flagellulæ. I am certain only that these appeared after *Myxoplasma* had disappeared, and that they united to form the *Labyrinthula*-like network. The network remained unaltered until I came to town, bringing it with me for permanent preparation.

The average long diameter of *Myxoplasma* is about 0·15 mm.

EXPLANATION OF PLATES XXV AND XXVI

Plate XXV. *Amœba agilis.*

Figs. 1–27. Actively dividing form, drawn at intervals of 30 seconds. At fig. 27 division is complete.
Figs. 28–46. Actively moving form with tapering pseudopodia. Drawn at intervals of 25 seconds.
Figs. 47–49. A diatom passing through the body. Total time, 49 seconds.

Plate XXVI *Myxoplasma rete.*

Figs. 1–3. A specimen drawn at 3.56 p.m., 4.3 p.m., and 4.10 p.m. At *a* is a diatom.
Fig. 4. Network of flagellulæ, possibly not connected with *Myxoplasma*.
Fig. 5. Active flagellulæ.

NEW ZEALAND INSTITUTE

NEW ZEALAND INSTITUTE.

THIRTY-EIGHTH ANNUAL REPORT.

The third annual meeting of the Board of Governors under the Act of 1903 was held in the Colonial Museum, Wellington, on the 25th January, 1906, and was attended by sixteen members.

The representatives of the Governor in Council and of the various incorporated societies during the year were as follows: By the Governor in Council—Messrs. A. Hamilton, J. Young, E. Tregear, and J. W. Joynt; Auckland Institute—Professor Thomas, Mr. J. Stewart; Wellington Philosophical Society—Professor Easterfield, Mr. M. Chapman; Philosophical Institute of Canterbury—Professor Chilton, Dr. Farr; Otago Institute—Professor Benham, Mr. G. M. Thomson; Hawke's Bay Philosophical Institute—Mr. Hill; Nelson Institute—Dr. Cockayne; Westland Institute—Mr. T. H. Gill; Manawatu Philosophical Society—Mr. W. Welch. Messrs. Joynt and Tregear retired in December and were reappointed by the Governor in Council, and Mr. W. J. O'Donnell was appointed in the place of Mr. W. Welch, who has left the colony.

At the annual meeting of the Institute the following officers were elected: President—Sir James Hector, M.D., F.R.S.; Treasurer—Mr. J. W. Joynt, M.A.; Editor of Transactions and Librarian—Mr. A. Hamilton; Secretary—Mr. T. H. Gill, M.A., LL.B.

The honorary members of the New Zealand Institute are twenty-five.

The members now on the roll of the various incorporated societies are as follows: Auckland Institute, 164; Wellington Philosophical Society, 106; Philosophical Institute of Canterbury, 146; Otago Institute, 111; Hawke's Bay Philosophical Institute, 56; Nelson Institute, 32; Westland Institute, 46; Manawatu Philosophical Institute, 46: total, 732.

Transactions.—The volumes of Transactions now on hand are—Vol. I (second edition), 317; Vol. V, 33; Vol. VI, 24; Vol. VII, 146; Vol. IX, 217; Vol. X, 139; Vol. XI, 394;

Vol. XII, 307; Vol. XIII, 144; Vol. XIV, 109; Vol. XV, 282; Vol. XVI, 272; Vol. XVII, 533; Vol. XVIII, 311; Vol. XIX, 558; Vol. XX, 455; Vol. XXI, 458; Vol. XXII, 564; Vol. XXIII, 573; Vol. XXIV, 674; Vol. XXV, 630; Vol. XXVI, 617; Vol. XXVII, 609; Vol. XXVIII, 693; Vol. XXIX, 596; Vol. XXX, 690; Vol. XXXI, 700; Vol. XXXII, 523; Vol. XXXIII, 616; Vol. XXXIV, 569; Vol. XXXV, 531; Vol. XXXVI, 692; Vol. XXXVII, 610.

The volume just published, Vol. XXXVIII, contains, in addition to a photograph and In Memoriam of the late Captain Hutton, 634 pages and 67 plates. The contents of Vols. XXXVII and XXXVIII are comprised below.

	1905. Pages.	1904. Pages.
Miscellaneous	130	215
Zoology	173	145
Botany	86	51
Geology	135	143
Chemistry and physics	50	27
Records of Milne seismographs	6	8
Proceedings	33	39
Appendix	21	32
	634	660

The whole of the work was done, as formerly, at the Government Printing Office.

The late Captain Hutton.—The following resolution was passed at the last meeting of the Board of Governors: "The Board of Governors of the New Zealand Institute desires to express its deep sense of the loss to natural science caused by the death of Captain F. W. Hutton, F.R.S., President of the Institute. Captain Hutton's connection with the New Zealand Institute dates from its inception in 1868, and his researches on the geology and zoology of New Zealand for a period of forty years have left an enduring mark on the science of the colony, and made his name widely known throughout the world. His single-hearted devotion to his work and his untiring enthusiasm inspired many others to continue the researches which he began. His assistance and advice were always at the service of his fellow-workers, and his influence will remain an effective factor in scientific work in the future."

In addition to passing this resolution the Board of Governors decided to commemorate Captain Hutton's scientific work in the colony by establishing a fund to be known as the "Hutton Memorial Research Fund," the money obtained to be devoted to the encouragement of original research in biological and geological science in New Zealand, and to be vested in and controlled by the Board of Governors of the New Zealand Institute. A committee consisting of Drs. Chilton and Cockayne and Messrs. Speight and Laing, of Christchurch, was set up to complete arrangements for the establishment of the fund, and to report with suggestions for dealing with the fund at the next annual meeting of the Institute.

Manual of Mollusca.—A letter was received at the last annual meeting from Mr. Henry Suter, of Auckland, *in re* preparing a work on the New Zealand *Mollusca.* A resolution was passed requesting the Government to consider favourably the desirability of issuing a new manual of New Zealand *Mollusca.* I am glad to state that the Government has decided to publish a work on this subject, and has appointed Mr. H. Suter editor.

Benjamin Franklin Celebrations.—The two-hundredth celebration of the birth of Benjamin Franklin was celebrated at Philadelphia in April, 1906. Professor E. Rutherford, an honorary member of the Institute, represented the New Zealand Institute on that occasion.

Library.—During the year a great deal of work has been done in the library. The books have been catalogued, and a number of serials has been bound at the Government Printing Office. The librarian will present a separate report.

Carter Bequest.—The amount standing to the credit of this fund on the 31st December, 1906, was £2,504 6s. 3d. In addition there is a quantity of scrip in the New Zealand Loan and Mercantile Company at face value. The money is invested by the Public Trustee, and is earning interest at the rate of 4 per centum per annum. This fund represents a bequest by the late C. R. Carter to the New Zealand Institute for the purpose of establishing an Astronomical Observatory. This has been accumulating, and on the 31st December last was as stated above.

Time-ball Observatory.—The Board of Governors deeply regret that it was found necessary to remove the Time-ball Observatory from the site it had occupied for forty years, the position of which had been laboriously determined and verified by various observers. The paper now being published in the Transactions by Dr. Otto Klotz of Canada bears witness to the value and accuracy of the old position from which the time was determined for colonial and maritime purposes.

Balance-sheet.—Herewith is presented the balance-sheet for the year just ended. From this it will be seen that the credit balance amounts to £344 14s. 8d.

James Hector, President.

Wellington, 31st January, 1907.

Balance-sheet of the New Zealand Institute for 1906.

Receipts.

	£	s.	d.
Balance from 1905	416	16	3
Sale of Transactions	1	0	0
Sale of "Maori Art"	4	3	6
Contribution from Wellington Philosophical Society	19	1	6
Statutory grant	500	0	0
	£941	2	3

Payments.

	£	s.	d.
Travelling-expenses (annual meeting)	22	14	4
Work in library	5	0	0
Work on catalogue	5	0	0
Services of messenger	3	0	6
Printing, stationery, postage, &c.	11	9	10
Publications	17	7	1
Card-index cabinet, &c.	16	14	7
Printing Transactions	439	6	9
Salaries, Editor and Secretary	75	0	0
Bank charge	0	10	0
Interest	0	4	6
Balance—			
Cash in hand	1	14	4
,, bank	343	0	4
	£941	2	3

Examined and found correct—J. K. Warburton, Controller and Auditor-General.

Carter Bequest.

	£	s.	d.
Amount of bequest with accrued interest ..	2,504	6	3
New Zealand Loan and Mercantile scrip, face value	17	0	0
	£2,521	6	3
Invested with the Public Trustee	2,504	6	3
Scrip held by Public Trustee	17	0	0
	£2,521	6	3

PROCEEDINGS

WELLINGTON PHILOSOPHICAL SOCIETY.

First Meeting: *2nd May*, 1906.

Mr. Martin Chapman, President, in the chair.

New Members.—Dr. Thomas A. Black and Dr. Charles Monro Hector.

Papers.—1. "Transpacific Longitudes," by Otto Klotz, LL.D., F.R.A.S., Chief Astronomer to the Government of Canada, Ottawa.

2. "The Great Californian Earthquake of 18th April, 1906," by G. Hogben, M.A.

Exhibits.—Mr. C. W. Adams exhibited two improved theodolites, viz:—

1. A 5 in. Cooke transit theodolite, reading by micrometers to 10″ and by estimation to 1″.

2. A 6 in. Kern transit theodolite, reading by scale microscopes to 1′ and by estimation to 6″.

Second Meeting: *6th June*, 1906.

Mr. Martin Chapman, President, in the chair.

Papers.—1. "Recent Observations respecting the Origin of the Vegetable Caterpillar," by G. V. Hudson, F.E.S.

Mr. A. Hamilton said that the specimen of vegetable caterpillar mentioned by Mr. Hudson as having been shown to him by the late Mr. N. J. Tone was duplicated in the Otago Museum. Mr. Hamilton exhibited a specimen of a fungus-infested caterpillar which had been found in the extreme north of New Zealand, probably a new species.

2. "Some Stray Notes on the Kea and the Seagull," by C. W. Adams.

3. "A Few Facts about the French Metric System," by C. W. Adams.

Exhibits.—1. The Rev. D. C. Bates exhibited a young guinea-pig—one of a number bred in the laboratory of the Health

Department at Wellington—showing grey markings, which he stated were very unusual in the guinea-pig.

He explained that several other guinea-pigs born in the same place were similarly coloured.

2. Professor H. B. Kirk showed some specimens of trap-door spiders' nests found near Wellington.

THIRD MEETING: *4th July*, 1906.

Mr. Martin Chapman, President, in the chair.

A popular lecture on "The Physiography of Westland" was delivered by Dr. J. M. Bell, Director of the New Zealand Geological Survey.

There was a large attendance of members and their friends.

The lecture was illustrated by a fine series of lantern-slides from photographs taken by Dr. Bell.

At the conclusion of the lecture a hearty vote of thanks was passed to Dr. Bell.

FOURTH MEETING: *1st August*, 1906.

Mr. Martin Chapman, President, in the chair.

New Members.—Dr. Alexander Paterson and Mr. J. D. Climie.

An advance copy of Volume XXXVIII (1905) of "The Transactions and Proceedings of the New Zealand Institute" was laid on the table.

The Chairman announced with much regret the death of Sir Walter Buller, K.C.M.G., who for many years was a member of the Council of the Society, and who had frequently filled the position of President.

The Chairman reminded members that Sir Walter was eminent in zoological science, particularly in the department of ornithology, in which he was regarded as one of the very highest authorities. He was always untiring in his work for the Society, and had contributed many valuable papers on subjects in which he was interested. Sir Walter was a recognised authority on Maori subjects, and possessed one of the finest collections in the world of Maori implements. His papers had commanded the attention of scientific men, not merely in New Zealand, but in Europe and America. Speaking as a personal friend of Sir Walter's, and as one who had been connected with the Society during the years of that gentleman's active membership, the Chairman said that he felt that we had suffered a great loss in his death, and concluded by moving: "That this Society has received with great regret the news of the death of Sir Walter L. Buller, K.C.M.G., and desires to place on record its high appreciation of his scientific work and of his services to the Society."

The motion was seconded by Mr. R. L. Mestayer, M.Inst.C.E., and carried unanimously.

The Chairman reported that the Council was co-operating with the councils of other societies in the colony in urging upon the Government the desirableness of causing a botanical survey of the colony to be made, and in recommending the appointment as Government Botanist of one of the most eminent botanists in the colony—Dr. Louis Cockayne, of Christchurch. It was to be hoped that the efforts of the societies would be successful.

Papers.—1. "Notes on the Entomology of the Routeburn Valley," by G. V. Hudson, F.E.S.

2. "The Reason why Three Fingers only are carved in Maori Images of Deities," by Dr. A. K. Newman.

Mr. R. C. Harding expressed the opinion that, although Dr. Newman might be right in thinking that Mr. W. T. L. Travers's suggested explanation of the carving of only three fingers in Maori images of deities was a mistaken one, yet the Natives who were Mr. Travers's informants might possibly have given their explanation in good faith. It might very well be that in the course of ages a knowledge of the real reason had been lost by the Maori race.

3. "Notes on Ferns," by H. C. Field.

4. "Notes on New Zealand Echinoderms, with Description of a New Species," by H. Farquhar; communicated by A. Hamilton.

5. "Note on the Bipolarity of Littoral Marine Faunas," by H. Farquhar; communicated by A. Hamilton.

FIFTH MEETING: *5th September*, 1906.

Mr. Martin Chapman, President, in the chair.

New Member.—Dr. J. S. Maclaurin.

Paper.—"On Two Marine *Gymnomyxa*," by Professor H. B. Kirk.

An address on "Petroleum" was given by Professor T. H. Easterfield.

Professor Easterfield illustrated his remarks by a number of experiments on New Zealand mineral oils.

The lecture was listened to by a very large audience, and at the close a vote of thanks to Professor Easterfield was carried by acclamation.

Exhibits.—1. Mr. G. Hogben exhibited and described seismograms of the great Chilian earthquake of August, 1906.

2. Miss Mestayer exhibited a crustacean (*Paridotea ungulata*) found by her recently at Island Bay, Wellington.

ANNUAL MEETING: *3rd October*, 1906.

Mr. Martin Chapman, President, in the chair.

The Council's annual report and annual statement of receipts and expenditure were read and adopted.

The report stated that, including an extra meeting held in November, 1905 (after the close of the session dealt with in the previous report), there had been six meetings of the Society.

Fourteen papers in all had been read, and at several of the meetings interesting exhibits had been shown. Popular lectures by Mr. E. F. Stead, Dr. J. M. Bell, and Professor T. H. Easterfield had been delivered to good audiences.

Seven new members had been elected, and two members had resigned. A number of names had been removed from the roll because of non-payment of subscriptions. There were now 104 members of the Society.

Regret was expressed at the death of Sir Walter L. Buller, K.C.M.G., F.R.S., who had frequently filled the position of President of the Society.

Mr. Martin Chapman and Professor T. H. Easterfield had been re-elected to represent the Society on the Board of Governors of the New Zealand Institute.

The Council had represented to the Government the advisableness of having a botanical survey of the colony made, and had recommended the appointment of Dr. Louis Cockayne as Government Botanist; but, unfortunately, the Government could not see its way to take the desired action.

The statement of receipts and expenditure showed that, inclusive of a balance of £36 4s. 1d. brought forward from the previous financial year, the receipts amounted to £150 13s. 1d., and the expenditure to £106 18s. 3d., leaving a credit balance of £43 14s. 10d. The Research Fund stood at £42 7s. 7d.; so that the total sum in hand was £86 2s. 5d.

ELECTION OF OFFICERS FOR 1907.—*President*—Professor H. B. Kirk; *Vice-Presidents*—Mr. G. V. Hudson, F.E.S., and Mr. A. Hamilton; *Council*—Mr. C. E. Adams, B.Sc., Mr. J. W. Poynton, Mr. T. W. Kirk, F.L.S., Dr. A. K. Newman, Dr. J. M. Bell, Professor T. H. Easterfield, and Mr. Martin Chapman; *Secretary and Treasurer*—Mr. Thomas King; *Auditor*—Mr. E. A. Dymock, A.I.A.N.Z.

Exhibits.—The secretary (Mr. Thomas King) exhibited and described a series of star stereograms by Mr. T. E. Heath, of Cardiff; also some photographic stereograms from the Yerkes Observatory, illustrative of a meteor-trail, of Borrelly's comet, and of the moon.

Papers.—1. "The New Zealand Plateau," by H. Farquhar; communicated by Thomas King.

2. "Preliminary Note on Matai-resin," by James Bee; communicated by Professor T. H. Easterfield.

3. "Notes on Ferns," by H. C. Field.

4. "New Zealand Flax," by H. C. Field.

5. "Notes and Descriptions of *Lepidoptera*," by E. Meyrell, B.A., F.R.S.; communicated by G. V. Hudson, F.E.S.

AUCKLAND INSTITUTE.

First Meeting: *4th June*, 1906.

Professor F. D. Brown, President, in the chair.

New Members.—H. G. Cousins, M.A., Miss J. Grant, M.A., W. A. Given, P. M. Hansen, H. A. E. Milnes, B.Sc., W. Rolfe, W. R. Wilson.

The President delivered the anniversary address, taking as his subject a consideration of the different views held respecting the chemical elements, from the time of the ancient Greeks to the present day.

Second Meeting: *2nd July*, 1906.

Professor F. D. Brown, President, in the chair.

New Members.—T. Buddle, J. Buttle, A. E. T. Devore, C. V. Haughton, H. Horton, Professor A. Jarman, Hon. E. Mitchelson, N. A. Nathan, Rev. P. R. Paris, W. W. Philson, F. E. Powell, W. A. Robertson, W. H. Smith, H. M. Smeeton, F. P. Worley, M.A.

Professor A. P. W. Thomas delivered a popular lecture, illustrated by lantern slides and diagrams, on "Earthquakes."

Third Meeting: *6th August*, 1906.

Professor F. D. Brown, President, in the chair.

Mr. E. V. Miller delivered a popular lecture, with numerous experimental illustrations, entitled "The Mystery of Matter."

Fourth Meeting: *3rd September*, 1906.

Professor F. D. Brown, President, in the chair.

New Members.—W. E. Bush, C.E., A. Clark, Rev. C. E. Fox, F. Renshaw.

Mr. J. A. Pond gave a popular lecture, with experimental illustrations, entitled "Our Drinking-waters, with Methods of Analysis and Estimation."

FIFTH MEETING: 1*st October*, 1906.

Professor F. D. Brown, President, in the chair.

Professor A. Jarman delivered a popular lecture, illustrated with lantern slides and diagrams, entitled "The Evolution of the Railway Locomotive."

SIXTH MEETING: 15*th October*, 1906.

Professor F. D. Brown, President, in the chair.

Papers.—1. "Notes on the Recent Discovery of Maori Burial-chests at Waimamaku," by T. F. Cheeseman.

2. "Maori Numeration," by Elsdon Best.

3. "Comparison of the Oceanic Languages," by the Rev. C. E. Fox.

4. "Notice of the Discovery of *Hydatella*," by T. F. Cheeseman.

5. "Notes on *Pittosporum obcordatum*," by T. F. Cheeseman.

6. "Contributions to a Fuller Knowledge of the New Zealand Flora: Part 1," by T. F. Cheeseman.

7. "On the Development of the Different Stages of Leaves in the New Zealand Conifers," by Miss E. M. Griffin, M.A.

SEVENTH MEETING: 29*th October*, 1906.

Professor F. D. Brown, President, in the chair.

New Members.—E. R. Benjamin, T. Coates, F. Heaton, J Hodgsony, G. Hutchinson.

Mr. H. A. E. Milnes, B.Sc., delivered a popular lecture on "School Humour."

ANNUAL GENERAL MEETING: 25*th February*, 1907.

Professor A. P. W. Thomas, Vice-President, in the chair.

ABSTRACT OF ANNUAL REPORT.

The report stated, *inter alia*, that during the twelve months thirty-one new members had been elected, but fourteen names had been withdrawn from the roll, the net gain being seventeen, and the total membership at present 170. Among the removals by death reference was made to the late Rev. Dr. Purchas, who was one of the founders of the Institute, as well as being associated with its affairs for many years. Other deaths were those of Messrs. James Adams, H. Campbell, and T. W. Kitt.

In regard to finance it was stated the total revenue of the Working Account had been £1,849 13s. 4d., but deducting such items as £655 1s. subscribed for the erection of the Maori house and the purchase of the late Mr. Fenton's *pataka*, £95 temporarily withdrawn from the Investment Account for the same purpose, and £137 18s. received on account of the Mackechnie bequest for the purchase of groups of mammals, the total ordinary revenue was £961 13s. 6d., as compared with £982 5s. 1d. last year. The receipts from the invested funds of the Costley bequest amounted to £356 5s., and the Museum endowment yielded in rents and interest £338 19s. 8d. The expenditure totalled £1,824 2s. 9d., inclusive of amounts expended over the erection of the Maori house and purchase of the *pataka*, and the disbursements in connection with the groups of mammals. Excluding these items the ordinary expenditure was £898 1s. 8d., leaving a credit balance of £84 4s. 3d. The total amount of the invested funds of the Institute was £16,373 11s. 8d.

The chief advance made in the Museum has been in connection with the Maori collection, consisting of the Maori house "Rangitihi" and the *pataka*, or food house, the latter being regarded as one of the most perfect examples of Maori art in existence. The Council recorded its grateful thanks to the citizens who gave such liberal and sympathetic assistance towards providing the means to make these permanent additions to the Museum. The cost of the house has amounted to £639 17s. 6d., and there remained a deficiency of £179 5s. 8d., which for the present has been borrowed from the Capital Account, and will be met by a Government subsidy of £1 for £1, not yet paid.

In the zoological department the principal addition is the third group of mounted animals provided for by the Mackechnie bequest, consisting of a polar bear and three musk oxen—male, female, and young; while a fourth group, which will comprise a zebra and several South African antelopes, is in preparation in London, and should arrive during the autumn. This will exhaust the funds of the bequest. The interest on the special bequest of £2,000 made by the late Mrs. Mackechnie in favour of the library has been regularly received and expended in the purchase of books, in all three consignments having been received from London. The growth of the library will soon make the question of additional accommodation a very pressing one.

In concluding the report the Council tendered its thanks to the numerous donors to the Museum and library, and referred to the generous action of the Shaw Savill Company in carrying free the large cases of mammals.

Election of Officers for 1907.—*President*—E. V. Miller; *Vice-Presidents*—Professor F. D. Brown and Professor A. P. W. Thomas; *Council*—J. L. Bagnall, H. Haines, H. D. M. Haszard, J. Kirker, T. Peacock, D. Petrie, J. A. Pond, J. Reid, Professor H. W. Segar, J. Stewart, J. H. Upton; *Secretary and Treasurer*—T. F. Cheeseman; *Auditor*—W. Gorrie.

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

First Meeting: *2nd May*, 1906.

Mr. R. Speight, President, in the chair.

Dr. Farr prefaced his ex-presidential address by expressing his regret that the committee of the New Zealand Institute appointed to organize the Hutton Memorial Fund had been confined to members of the Canterbury Institute. He also announced that the magnetic survey of New Zealand was almost completed.

Dr. Farr then delivered an address on "Electric Waves," which was illustrated by numerous experiments.

Second Meeting: *6th June*, 1906.

Mr. R. Speight, President, in the chair.

New Members.—Mrs. Hutton, Miss F. Sheard, Professor Macmillan Brown, Mr. Charles Lewis, M.H.R., the Rev. A. B. Chappell, Messrs. Coles, J. C. N. Grigg, J. Hartley Smith, Shrimpton, Chevassus, Waite, McCullough, Foster, Mulgan, Howell, Spiller, Newell, R. Herdman Smith, and C. H. A. T. Opie.

Address.—Mr. E. K. Mulgan, M.A., delivered an address on "The Home of the Kauri."

Paper.—"On the Occurrence of *Fredericella sultana* in New Zealand," by Professor Dendy; communicated by Dr. Chilton.

Third Meeting: *11th July*, 1906.

Mr. R. Speight, President, in the chair.

The President welcomed Mr. Heimbrod, of the Pacific Magnetic Survey, to the meeting.

New Members.—Miss Grant, Messrs. H. Allison and W. S. Wright.

Address.—Mr. P. H. Powell, M.Sc., gave an address entitled "The Experimental Study of Certain Magnetic Problems by the Aid of the Stream Lines in the Flow of a Perfect Fluid."

Paper.—"On the Occurrence in New Zealand of *Platalea regia*, Gould," by Mr. T. Iredale.

FOURTH MEETING: *8th August*, 1906.

Mr. R. Speight, President, in the chair.

Papers.—1. "Notes on the Natural History of the Kea, with Special Reference to its Reputed Sheep-killing Propensities," by Mr. G. R. Marriner.

2. "On the Occurrence of *Phyllitis fascia* in New Zealand," by Mr. R. M. Laing, M.A., B.Sc.

3. "Observations on the Coastal Vegetation of the South Island of New Zealand," by L. Cockayne, Ph.D.

The following resolution, moved by Sir John Hall and seconded by Dr. Chilton, was carried: "That this Institute desires to place on record its sense of the value of the work done by Sir Walter Buller in the interests of ornithology in New Zealand, and of the loss to science caused by his death."

FIFTH MEETING: *5th September*, 1906.

Mr. R. Speight, President, in the chair.

New Member.—Mr. T. W. Rowe.

Address.—Dr. L. Cockayne gave an address on "Modern Plant Geography."

SIXTH MEETING: *3rd October*, 1906.

Mr. R. Speight, President, in the chair.

New Member.—Mr. T. Keir.

Papers.—1. "On the Radio-activity of certain Soils," by Mr. J. H. Howell, B.Sc.

2. "A Diagram of the Periodic System of Elements, specially arranged for Teaching Purposes," by Dr. Evans.

3. "Notes on a Coal from Boby's Creek," by Mr. L. H. Harrison; communicated by Dr. Evans.

SEVENTH MEETING: *13th November*, 1906.

Mr. R. Speight, President, in the chair.

The President welcomed Mr. T. W. Kirk, Government Biologist, to the meeting.

New Member.—Mr. C. Godfray Whitaker.

Papers.—1. "The Increase of Nitrogen in certain Soils due to Nitro-culture," by Mr. A. M. Wright, F.C.S.

2. "On the Presence of another Australian Frog in New Zealand," by Mr. G. R. Marriner.

3. "Further Notes on the Defoliation of *Gaya lyallii*," by Dr. L. Cockayne.

4. "New Plant Habitats: Part II," by Dr. L. Cockayne.

5. "On the Effect of Change of Environment on a Chatham Island Form of *Coprosma propinqua*," by Dr. L. Cockayne.

6. "Note on the Cook Strait Habitat of *Veronica macroura*," by Dr. L. Cockayne.

7. "On the Harmonic Conic of Two Given Conics," by Mr. E. G. Hogg, M.A.

Eighth Meeting: 29*th November*, 1906.

Mr. R. Speight, President, in the chair.

Address.—Mr. C. O. G. Larcombe delivered an address on "The Mineral Resources of New South Wales."

Annual Meeting: 5*th December*, 1906.

Mr. R. Speight, President, in the chair.

New Members.—Mr. H. F. Skey and Mr. P. Revell.

Annual Report.

The Council has met eleven times since the last annual meeting of the Institute, and the average attendance of the members of the Council at such meetings has been seven. During the year Mr. H. G. Denham resigned his seat on the Council; the vacancy was filled by the appointment of Mr. Edgar R. Waite.

During the year the management of the Hutton Memorial Fund has been handed over to the New Zealand Institute. The sum of £330 has been raised by private subscription, and it is to be hoped that this will be materially increased. The sub-committee appointed by the New Zealand Institute to continue the work of raising subscriptions interviewed the Hon. the Premier, and he expressed himself in thorough sympathy with the objects of the fund. A sum of £300 has been placed on the supplementary estimates as a subsidy, and if this is available the fund will not only form a fitting memorial of our late distinguished member, but also be a valuable means of aiding scientific research in the colony.

The Council has been in communication during the past year with the Government and with the other branches of the New Zealand Institute with regard to the pressing need of a complete botanical survey of New Zealand at an early date on the modern ecological lines adopted in similar surveys now being conducted in Europe and North America; the Council strongly urged the appointment of a Government Botanist to carry on this important work. The Council regrets to report that the Government does not propose to take any steps in the matter at present.

The Council has also had under consideration the question of a general scientific survey of the outlying islands of New Zealand, for the purpose of increasing our knowledge of the magnetic distribution and of the botany, geology, and zoology of the islands. The Council is assured of the hearty support of the Otago, Wellington, and Auckland Institutes. The Council is of the opinion that it is not feasible to carry out the survey this year with the fullness demanded by a work so important, but strongly hopes that the survey may be undertaken at the close of next year. A deputation from the Council, which recently waited on the Hon. the Minister of Lands to confer with him on the matter, received a sympathetic hearing and a promise to bring the matter before the Cabinet in due course.

Much attention has been paid by the Council to the library during the year. Mr. Edgar R. Waite has been appointed Honorary Librarian. A considerable number of books and periodicals have been added and some new shelves have been erected in the library. Steps have also been taken to procure certain parts of journals and periodicals which are missing from the library. A new system of checking the books and periodicals borrowed by members has been introduced, and the Council trusts that it may receive the hearty co-operation of the members of the Institute in preserving the library and adding to its usefulness.

During the year twenty-seven new members have been elected, and the total membership of the Institute is now 146, including four life members. The average attendance at the meetings has been forty-five. Five addresses have been given, and nineteen papers have been read. The latter may be classified as follows: Botany, 7; chemistry, 3; mathematics, 2; physics, 1; zoology, 6.

The balance-sheet shows that after contributing £50 to the Hutton Memorial Fund, expending £47 13s. 1d. on the library, and renewing the sum of £50 on fixed deposit, there remains a credit balance of £36 8s. 11d.

The thanks of the Council are due to the Board of Governors of Canterbury College for the use of rooms, and to Mr. G. E. Way for his continued services as Honorary Auditor.

Papers.—1. "On the *Musci* of New Zealand: Genus *Tremotodon*," by Mr. R. Brown.

2. "Notes on the *Callianassidæ* of New Zealand," by Dr. Chilton.

3. "Dates on which Introduced Birds have been liberated, or have appeared, in Different Districts of New Zealand," by Mr. J. Drummond.

4. "On Isogonal Transformations: Part I," by Mr. E. G. Hogg, M.A.

5. "On the Sudden Appearance of a New Character in an Individual of *Leptospermum scoparium*," by Dr. L. Cockayne.

Election of Officers for 1907.—*President*—Dr. F. W. Hilgendorf; *Vice-Presidents*—Dr. L. Cockayne, Mr. R. Speight; *Honorary Secretary*—Mr. E. G. Hogg; *Honorary Treasurer*—Dr. Chilton; *Council*—Dr. Evans, Dr. Farr, Mr. J. H. Howell, Mr. R. M. Laing, Mr. J. B. Mayne, Mr. Edgar R. Waite; *Honorary Auditor*—Mr. G. E. Way.

OTAGO INSTITUTE.

First Meeting : *8th May*, 1906.

The President, Dr. P. Marshall, occupied the chair.

New Members.—Messrs. G. T. Goodman, G. Austin, G. A. Rawson, R. S. Rankin, and the Rev. Dr. Nisbet.

The President stated the steps that had been taken in regard to the Hutton Memorial Research Fund.

Some members of the Institute had subscribed to it, but he trusted others would feel sufficiently interested and sufficiently indebted to the late Captain Hutton for the work he had done to subscribe to the fund, which would be a memorial of his life's work.

The President delivered an address on "The History of Volcanic Action in New Zealand."

It was frequently remarked, he said, by visitors to the colony that, judging by the volcanoes in the North Island and the evidences of volcanic action elsewhere, this must be a young country. It was interesting to look around and see whether, from the evidence to be everywhere found of volcanic action, this was really so. There were plenty of evidences in the North Island—the cones around Auckland, the hot springs in the neighbourhood of Rotorua, and the steaming volcanoes further south. Anybody travelling over the country could easily gain an idea of the work that volcanoes had done in forming the country. The geologist, of course, made a deeper study than did the casual observer. He looked into the rocks, and from an examination of the minerals that occurred in them he was able to say whether a rock had solidified from fusion or whether it had been deposited by water. If the former, the conclusion was that it was a volcanic rock. Thus it was in the neighbourhood of Dunedin. Certainly, the hills around showed little evidence, so far as their external formation was concerned, of volcanic activity, and a certain amount of geological knowledge was required before the district could be recognised as a volcanic district. Very often, however, volcanoes were destroyed by the action of water and air, so that not only the cone was removed but also the old reservoir through which the minerals were thrown out. Generally speaking, the material for compiling a volcanic history of a district could be found in three ways—first, in the external configuration ; second, if the external configuration was destroyed, in the structure of the rocks ; and finally, in old reservoirs that were probably connected with volcanoes at one time. Even after a volcano had disappeared it was possible that in other districts pebbles or rock fragments would be found that would show that a volcano had once existed in the neighbourhood. The rocks of New Zealand had been more or less carefully studied from one end to the other. In the South Island there was in the south-western district a large area showing igneous rocks, which might indicate the age of New Zealand. They contained certain structures that showed they were as old as any rocks on the surface of the earth. In other words, they had a position with regard to old rocks that occurred on their flanks that indicated that they were of the highest antiquity. They were formed probably when conditions on the earth's surface were entirely different from what they are now—at a time, probably, when no life at all existed on the surface of the earth, and when all was void. Rocks that were once in a molten state at an extremely remote period were found in other parts of New Zealand. Some of these rocks were of exceptional interest, being very much heavier than the ordinary surface rock. Their density indicated that at one time they were resident probably two hundred miles beneath the surface, and their presence in abundance in certain quarters pointed to the fact that New Zealand at one time in its history was subject to tremendous disturbances. If volcanoes were connected with that extreme pressure they had now disappeared. Near the Bluff and elsewhere rocks were found that were once volcanic rocks, but where the volcanoes were that these rocks came from was not known. The Carboniferous beds formed an important part of the structure of New Zealand, and a study of them led one to conclude that there must have been an enormous amount of volcanic action in this country prior to the Carboniferous age. It was of interest to conjecture where this volcanic land was. The actual Carboniferous rocks must have been on the sea-shore at that time, and the whole of New Zealand seemed to have been a sea-shore, bounding some volcanic country. Those who had investigated the question most fully were doubtful whether the land extended to the east or to the west. Obviously the easiest way to come to a conclusion was to find out where the sediments were coarsest—on the east or on the west—but as far as that was concerned there did not seem to be very much difference in them. Sir James Hector favoured one view, and Sir Julius von Haast the other So far as his own limited observations had enabled him to come to a conclusion, he thought it was likely that the land extended a greater distance to the east than to the west. This, as he had said, was in the Carboniferous days, when New Zealand was nothing more than the coast-line to some huge continental area, from which rivers were constantly bearing down great volumes of water, and carrying to the coast-line immense quantities of sediment. This sediment had compacted, and now formed much of the country of New Zealand. For a long time after that there was no evidence of volcanic action, but about the beginning of the Tertiary period, when mammalian life was beginning to assert its dominance in the animal world, some disturbance took place on the east side of the Alps. The actual volcanoes had themselves disappeared, but the nature of the rocks clearly indicated that there was volcanic activity of some intensity over the surface of the land in those days. In all probability the rocks on Coromandel Peninsula were thrown up at the same time. Then there was little evidence of any other action until the Miocene period, when there was very widespread activity throughout the greater part of New Zealand. It was about this time that the Dunedin volcanic area was formed. This area, he pointed out, presented some peculiar features in its igneous rocks. One rock was heavy and another light, and there were also important differences in colour and in the crystallized structure. Red and black rocks, and sometimes white rocks, were found side by side. Did these rocks come from the same volcano or from the same reservoir? So far there was no satisfactory explanation of any cause that would produce differently coloured and differently natured rocks from the same volcano. In this district, again, there were evidences of considerable intervals between the periods of volcanic eruption. At Anderson's Bay, for instance, on the northern side of the bay, the lower portion of the cliff was soft, while the rock lying over it was hard. They were both volcanic rocks, and were hard at the time they were emitted, but an enormous time had elapsed between the emitting of the two—sufficient time to allow water to percolate through the first deposit. Then another molten mass flowed over the top of it. At Oamaru the volcanic development was very peculiar, because there was every evidence there of a submarine eruption occurring at a considerable depth below the ocean's surface. This was in the Miocene period. At the end of the Miocene and at the beginning of the Pliocene period volcanic action entirely ceased in New Zealand, and had not had any effect on the South Island since. Ruapehu, Egmont, Nga ruhoe, and other mountains were the result of activity that took place probably before the middle of the Pliocene period. Touching on theoretical matters, Dr. Marshall made some interesting remarks on the connection between volcanic action and earthquakes. The eruption of Tarawera was one of the most violent eruptions that had taken place in New Zealand or in historical times. The explosions of steam were very violent, and yet the earthquakes were not felt to such a great distance. Auckland was not greatly disturbed, and at Wanganui, Napier, and Gisborne they were hardly felt. Evidently there was no connection whatever between the violent earthquakes and volcanic action. At any rate, volcanic action did not generate earthquakes of great violence. If it were the case that volcanic eruptions were associated with great earthquakes, what parts of New Zealand would be subject to most disturbance? Surely, Auckland and Napier would be; and yet it was found that it was Wellington—the neighbourhood of Cook Strait—that was most liable to earthquake disturbance. Parts of the South Island that were of volcanic origin, such as Dunedin, were particularly free from earthquakes, and those places that were situated far from volcanic action were subject to disturbance. Referring to the possible continuance of volcanic action in New Zealand, the speaker said that all he could state on this matter was of a negative nature. The geologists were still infants in regard to their knowledge of the main causes of volcanic action. They did not know the exact conditions that determined the outbreak of volcanic activity in any area. It could not be said with safety that volcanic action had died out anywhere. It was supposed that the activity of Vesuvius had ceased at the beginning of the Christian era, but recent events had shown it had continued there till the present day.

On the motion of Dr. Hocken, the President was heartily thanked for his most interesting and instructive address.

Second Meeting: *12th June*, 1906.

The President, Dr. Marshall, in the chair.

New Members. — The Rev. Edgar Ward, Messrs. W. G. Grave, F. S. Oliver, H. B. Williams.

Exhibits.—Dr. Scott showed casts of carvings on bone, horn, &c., by prehistoric men, found in caves in the South of France.

The specimens showed that the men were fairly well advanced in civilisation. It was rather curious to know that in all the collections of prehistoric carving the vegetable kingdom was very slightly represented. The "artist" devoted his attention to the animals. There were horses, mammoths, wolves, reindeers, and some animals it was difficult to identify, but few representations of flowers or trees.

Mr. G. M. Thomson referred to the occurrence in enormous numbers of the interesting cumacean crustacean *Diastylis*.

He went on to mention some of the work done by the curator of the marine fish hatchery. Mr. Anderton had been going out for the last few months with the trawlers, collecting information regarding the habits of fish. Within the last few weeks fish had been coming into Blueskin Bay in large numbers, especially flounders and soles. They were evidently following food into the shallow water. He was sure that the observations of the curator would be found to be of great importance. Observers were now learning from the trawlers that there were enormous movements of small animals at the bottom of the sea, and the fish simply followed them.

Dr. Benham exhibited preparations recently added to the Museum illustrating the habits and life-history of three species of "wood-borer"—*Ophryops pallidus, Ambeodontus tristis* (natives), and *Anobium domesticum*, the "death-watch" (introduced into the colony).

Papers.—1. "Notes on Protective Resemblance in New Zealand Moths," by Mr. A. Philpott.

This was illustrated by Dr. Benham by means of a series of moths mounted on their natural surroundings, such as leaves, bark, &c.

2. "Notes on the Carnivorous Habit of the Kea," by Dr. Benham.

Third Meeting: 11*th July*, 1906.

Dr. J. Mackintosh Bell, Director of the Geological Survey, delivered an illustrated lecture on "Eighteen Months in the Far Canadian North," describing his exploring expedition to the Great Bear Lake and the Barren Lands.

Fourth Meeting: 14*th August*, 1906.

The President, Dr. Marshall, in the chair.

New Members.—Dr. Edward Alexander, Hon. T. Fergus, A. G. Lee, Frank H. Statham, A.O.S.M.

The President made reference to the death of Sir Walter Buller.

The deceased gentleman, the President said, was known and appreciated better than any other scientific man in New Zealand. His volume on the "Birds of New Zealand" was a most valuable ornithological work, and at the time of his death Sir Walter Buller was engaged in revising the volume. He had been honoured by being knighted by his Sovereign, and was also honoured by Cambridge University. The President paid a high tribute to Sir Walter's life and work, and expressed the regret of all members of the Institute that by his death a scientific man intimately associated with New Zealand had been removed.

Exhibits.—Dr. Benham exhibited a gigantic tadpole of the introduced frog, *Hyla aurea*, 6 in. or more in length, which had been obtained from Waitaki.

The abnormal specimen, it was explained, had probably attained its unusual proportions owing to its not being able to get upon land and develop in the ordinary way into a frog.

A series of fishes, artistically painted by the taxidermist of the Museum under Dr. Benham's directions, were also shown. These were intended for exhibition at the Christchurch Exhibition.

Mr. G. Howes exhibited a new kind of pocket-net for entomologists, in which a steel spring band takes the place of the old folding frame of cane.

Papers.—1. Mr. D. B. Waters read a paper on "The Present Status of Coal-power," illustrated by useful diagrams of various sorts of gas and oil engines.

2. "On a New Species of Pennatulid (*Sarcophyllum bollonsi*), by Dr. Benham.

3. "Some Ctenophores from the New Zealand Coastal Waters," by Dr. Benham.

FIFTH MEETING: 11*th September*, 1906.

The President, Dr. Marshall, in the chair.

The President referred to the destruction of penguins and elephant-seals at the Macquarie Islands, and stated that the attention of the Government of Tasmania would be drawn to the matter, with a request that measures would be taken to protect the king-penguin.

Exhibit.—The Curator of the Museum (Dr. Benham) exhibited a series of ethnological specimens from East Africa and Siam, which had been recently received in exchange.

Paper.—1. "On the Occurrence of *Geonemertes* in the North Island," by Robert Browne.

"During 1905 I found forty-one specimens of *Geonemertes novæ-zealandiæ* in the district of Tokonui, Southland; all agreed with Dr. Dendy's description, and had four dark stripes down the back. But in the Stratford district, Taranaki, during a period of eight months, I managed to collect twenty-eight specimens, of which twenty-seven differ from the South Island form in having only two stripes, corresponding to the broad stripes of the southern form, no sign of the two narrow stripes being present. They range from ½ in. to 1½ in. in length. At Feilding I found three other specimens of the same. These North Island forms may represent a distinct species. One of the Stratford specimens differs still more from the typical New Zealand species. It is of a uniform reddish-brown colour above, dirty-grey below, and has no sign of stripes. It is more robust, and attains a length of 2¼ in. Its colour resembles, when at rest on log, the small earthworms so plentifully found in decaying wood. I suggest the name *G. marshalli* for this very distinct species."

2. "The Reverend Samuel Marsden and the Early New Zealand Mission: Part III," by Dr. Hocken.

Sixth Meeting: *9th October*, 1906.

The President, Dr. Marshall, in the chair.

Exhibits.—1. Dr. Hocken exhibited nuts collected by him at Mangonui, North Auckland.

These nuts had been washed down from the creek that runs into Mangonui Bay. From time to time there had been floods and landslips in the locality, and one result was that the upper part of the bay into which the creek debouched was filled with these floating nuts. He explored the creek, and came across a bed of dense vegetable matter containing a few of the nuts, varying in size. It was plain that they belonged to the palm-tree order, which found its southern limit in New Zealand.

Dr. Marshall said these palm-nuts had been referred to in the literature of the colony as occurring at Mangonui, but he did not think any attempt had been made to come to any conclusion as to the kind of tree that produced them. There were many evidences in New Zealand, so far as the fossil vegetation was concerned, of a very considerable change of climate in comparatively recent times. There was good evidence that the kauri-tree in comparatively recent geologic times grew south of Dunedin.

2. Mr. G. M. Thomson exhibited the fossil fruit of a plant, probably allied to the *Hakea* of Australia—a genus not now found in New Zealand—that had been found by Mr. John Ewing, of St. Bathan's, in the alluvial drift.

Dr. Marshall pointed out that the *Hakea* had commenced to grow on some dry clay lands around Auckland in a manner which threatened the destruction of other vegetation. It was certainly strange that a plant which once flourished and became extinct should on its reintroduction make such headway.

3. Dr. Marshall showed a strip of material like chamois-leather, which he had obtained from Dr. Coughtrey, who had several square feet of it, all of uniform texture and thickness.

This peculiar substance was the dense mycelium of some fungus that had found its way down a split in a broadleaf tree.

Addresses.—1. "The Evolution of the Elephant," by Dr. Benham.

Dr. Benham described the characteristic features of the elephant, dwelling more especially upon the trunk, the teeth, and the square shape of the skull, contrasting the latter with the sloping skull of the ordinary land mammal. In comparing the skull of a bulldog with that of a greyhound, somewhat the same process was noted. There were only two species of elephant found to-day—one in India and one in Africa—but in past times elephants roamed all over the south of Europe. The mammoth, a hairy elephant, roamed all over the north of Europe and Siberia in enormous quantities, and its remains were still found in the frozen soil. For centuries the Chinese had collected and made use of mammoth tusks. The mammoth, which belonged to the Pliocene, could be traced back to the Miocene period. At this earlier period there was another elephant-like creature called the mastodon, which possessed a trunk and large tusks, though its face was distinctly more elongated than the face of the genus *Elephas*. Back beyond the mastodon had been found remains of the tetrobelodon, an animal of the elephant class, with a shorter trunk and relatively shorter tusks. This was the earliest kind of elephant that was known prior to Dr. Andrew's recent discoveries near Lake Moeris, in Egypt. These discoveries included the paleo-mastodon and the moeritherium, the latter having a pig-like skull with almost the full complement of teeth as found in the pig at the present day. This animal was much smaller than the elephant, being about the size of a moderate-sized deer. The moeritherium belonged to the Eocene period, and was the ancestor of the elephant, an animal whose grotesque features were rendered commonplace only by familiarity. There were older types still, hinted the professor, bringing us to the far-off animal who was the parent not only of the elephant, but, through another line, of man also.

2. " Exploration in the Sounds District," by Dr. Marshall.

He (Dr. Marshall) had accompanied Mr. Grave and others on an expedition through a valley lying between Clinton and Milford Sound offering an alternative route to the one now taken by tourists. There were good and sufficient reasons for the lack of enterprise in the way of exploration in this district at present. Supplies of food were difficult to obtain; the weather was very wet, the rainfall exceeding 250 in. in the course of a year; and the denseness of the vegetation. Dr. Marshall's further remarks on his tour, which was full of interest and not unattended with danger, were illustrated with lantern photographic views. The scenery was wild and rugged, but beautiful and imposing. There were many tarns and avalanches, precipices and abysses. Incidentally, the lecturer touched on the question of the formation of rock-basins, and expressed his preference for the glaciation theory.

On the motion of Dr. Fulton, the lecturers were accorded a hearty vote of thanks.

Seventh Meeting: 13*th November*, 1906.

The President, Dr. Marshall, in the chair.

New Member.—Mr. F. W. Sims, F.R.Met.Soc.

Exhibits.—1. Mr. G. A. Rawson exhibited photos of groups of the Natives of Port Darwin—some in corroboree costume.

These were excellently taken, but gave no confirmation to the reported discovery of the missing link mentioned by the German scientist Dr. Klaatsh. That report stated that one individual possessed feet like hands, or like a monkey's feet, with the big toe as far back on the foot as the thumb is on the hand.

Dr. Benham pointed out that it was not likely that such an ape character would be found—that some error in cabling must have occurred.

2. Mr. G. Howes exhibited a case of moths, collected recently by himself and two other members.

3. Dr. Benham exhibited a large duck's egg within which was a smaller spherical egg, consisting of a complete shell, containing, however, white only.

Papers.—1. " Some New Species of Amphipodous Crustacea," by G. M. Thomson, F.L.S.

2. "Notes on the New Zealand Food-fishes," by Mr. T. Anderton, Curator of the Marine Fish-hatchery; communicated by Mr. Thomson.

3. "Further Notes on *Lepidoptera*," by Mr. G. Howes.

4. "The Dunedin Phonolites," by Dr. Marshall.

5. "On Two New Species of Leeches," by Dr. Benham.

Annual Meeting.

The annual meeting was held. The following is a summary of the report:—

During the session our Treasurer (Mr. W. Fels) resigned office on leaving Dunedin for a holiday in Europe, and Mr. J. C. Thomson most kindly undertook to take on his work.

In accordance with a resolution of the members, passed at the meeting in November last, Messrs. G. M. Thomson and Benham were elected Governors of the New Zealand Institute, to serve for two years.

Your Council has, as hitherto, interested itself in several matters of scientific and colonial importance, and has memorialised the Government in connection therewith. First, as a result of communications that passed between Mr. G. M. Thomson and Professor Starr Jordan, of the Leland Stanford University, California, it was resolved, "That this Institute desires to bring under the notice of the Government the desirability of obtaining a fuller knowledge of the fish fauna of New Zealand, in view of the great economical importance of the fishes of the colony. It would therefore respectfully urge that the services of the eminent ichthyologists of the United States Fish Commission, who have already done so much work in connection with the fishes of the North Pacific, should be secured, if possible, for the preparation of an illustrated account of the New Zealand fishes." The scheme outlined by Professor Jordan would have enabled the monograph to have been prepared at a comparatively small cost. With your Council the Marine Fish-hatchery Board and the Philosophical Institute of Canterbury were associated. We received a certain amount of encouragement to hope that the scheme would be carried out, as the Minister of Marine wrote, in acknowledging the receipt of the resolution, that "the matter will be considered when the estimates are being dealt with." But the disaster at San Francisco did so much damage to the Leland Stanford University, of which Professor Jordan is principal, that it was no longer possible to hope for the services of its zoologist, and, moreover, no sum was placed on the estimates in connection with this scheme. Second: Your Council, with the support of the other scientific societies in New Zealand, approached the Premier in regard to the appointment of a Government botanist. A resolution was adopted, "That it is desirable that a botanical survey of the colony should be made on modern lines, and that a Government botanist, to be attached to the Colonial Museum, should be appointed to carry out such a survey." Members of the House of Representatives were prepared to back the proposal. The executive of the New Zealand Institute were requested to interview the Premier, but we were unsuccessful, as we were informed that "the Government does not propose to take any action in regard to the appointment for the present." The last three words lead us to hope that in the near future such an appointment may be made. Third: Steps have been taken to urge upon the Tasmanian Government to endeavour to put a stop to the slaughter of penguins, especially the king penguins, on the Macquarie Islands. The Australasian Association for the Advancement of Science has been requested to co-operate. Your Council has received the sympathetic reply from the Premier of Tasmania that "the matter will receive consideration, and that the lessee of the islands will be requested to take steps to protect the king-penguin." Fourth: This Institute learns with gratification that the Philosophic Institute of Canterbury proposes to organize a complete scientific survey of the southern islands in connection with an extension of the magnetic survey of New Zealand, and that the Hon. the Minister of Lands has given a sympathetic reception to the deputation that recently waited upon him in regard to the subject. Your Council will cordially support the efforts of the sister Institute to obtain a magnetic, zoological, botanical, and geological survey of these islands.

At the commencement of the year circulars were distributed to our members, as well as to those of other scientific societies, drawing attention to a fund which was started by the Canterbury Philosophical Institute to commemorate the work of Captain Hutton. We regret that the response of our members to the request for subscriptions was very meagre. The proposed memorial is to take the form of a medal for excellence in scientific research, and is one that deserved a much greater degree of support than it has received. Your Council contributed a sum of £50 to the fund, which has, we are glad to see, received a subsidy from the Government. Your Council also subscribed £25 to the fund for housing Dr. Hocken's valuable gift to the colony, and trusts that it may in a few years' time see that library installed in a wing to be added to the Museum.

The list of members of the Institute has received a considerable addition during the year, thirteen new members having been elected. Unfortunately, this is partly countered by the removal of members by death or resignation, so that the total now stands at 111.

As in recent years, a popular lecture was delivered by a non-member. Our efforts to persuade Sir James Hector to come to Dunedin and give us an account of his early experiences in the colony were ineffectual, but his successor in the post of Director of the Geological Survey (Dr. Bell) gave an interesting illustrated lecture on "The Far Canadian North," which was fairly satisfactorily attended.

Mr. J. C. Thomson (Hon. Treasurer) submitted a duly audited balance-sheet, from which it appeared that the receipts for the year, including a balance of £52 5s. 5d., amounted to £176 2s. 4d., and the expenditure to £159 14s. 3d., leaving a credit balance of £16 8s. 1d.

The Chairman pointed out that if they had not paid such large sums out of revenue as £50 to the Captain Hutton Memorial and £25 to the Dr. Hocken Library Fund, both of which were quite justifiable, the cash in hand would have been large.

The report and balance-sheet were adopted.

Election of Officers for 1907.—*President*—Dr. R. Fulton; *Vice-Presidents*—Drs. Marshall and Hocken; *Hon. Treasurer*—Mr. J. C. Thomson; *Hon. Secretary*—Professor Benham; *Auditor*—Mr. D. Brent; *Council*—Messrs. A. Bathgate, E. E. Collier, G. M. Thomson, D. B. Waters, Professor Malcolm, Professor Park, and Dr. F. Riley.

HAWKE'S BAY PHILOSOPHICAL INSTITUTE.

Annual Report.

In all there have been eight meetings of the Institute during the year—namely, annual general meeting, six ordinary meetings, and one extraordinary meeting. At these meetings two lectures were delivered and five papers read, a detailed list of which appears elsewhere. The Council held six meetings, at which a fair amount of general business was transacted.

During the session the Otago Institute raised the question of the desirability of a botanical survey of the colony being made, and of the appointment of a Government Botanist. Dr. Cockayne was named as the most suitable person for the post. After carefully considering the matter the Council decided to support the resolutions of the O.ago Institute and the claims of Dr. Cockayne to the position of Government Botanist.

A communication has been received from the Town Clerk, asking for the transfer of the Museum to the Borough Council, who are willing to take it over and maintain it. This question will have to be considered by members at this meeting.

As will be seen by the balance-sheet, this Institute contributed to the Hutton Memorial Fund inaugurated by the Canterbury Philosophical Society.

Seven new members were elected during the year, and eighteen new volumes were added to the library.

The Treasurer's balance-sheet shows a small balance in hand.

Papers read before the Hawke's Bay Philosophical Institute during the Session 1906.

1st May.—Inaugural Address by the President, W. Dinwiddie, "Some Modern Philosophical Movements."

5th June.—Lecture by Dr. Kennedy, "Radium," illustrated by lantern-slides and experiments.

3rd July.—Paper by C. J. Cooke, B.A., "Electricity, with Especial Reference to Submarine Cables."

Mr. Hill called attention to an important occurrence at the Kidnappers, where the rocky archway at the point had collapsed, and thus a second island had been formed.

7th August.—Paper by J. Guthrie-Smith, "Imported Animals noticed at Tutira since 1882," illustrated by maps thrown on the screen.

11th September.—Paper by H. Hill, B.A., F.G.S., "Oil-wells and Oil-prospects along the East Coast," illustrated by lantern-slides and by specimens of oil and shale.

28th September.—Lecture by Sir R. Stout, "A Pleasant Night in Wanganui," illustrated by numerous lantern-slides.

9th October.—Paper by W. Kerr, M.A., "Rock-cavities and their Contents," illustrated by lantern-slides and specimens.

Election of Officers for 1907.—*President*—E. A. W. Henley, M.B.; *Vice-President*—T. Tanner; *Council*—W. Dinwiddie, T. Hall, H. Hill, B.A., F.G.S., T. Hyde, J. P. Leahy, M.B., D.P.H., T. C. Moore, M.D.; *Honorary Secretary*—James Hislop, District School; *Honorary Treasurer*—J. W. Craig; *Honorary Auditor*—J. S. Large; *Lanternist*—C. F. Pointon.

APPENDIX

NEW ZEALAND INSTITUTE.

HONORARY MEMBERS.

1870.

Finsch, Otto, Ph.D., of Bremen, Leiden, Holland.

Hooker, Sir J. D., G.C.S.I., C.B., M.D., F.R.S., Royal Gardens, Kew.

1873.

Günther, A., M.D., M.A., Ph.D., F.R.S., Litchfield Road, Kew Gardens, Surrey.

1874.

Newton, Alfred, F.R.S., Magdalen College, Cambridge, England.

1875.

Sclater, Philip Lutley, M.A., Ph.D., F.R.S., Zoological Society, London.

1876.

Berggren, Dr. S., Lund, Sweden.

1877.

Sharp, Dr. D., University Museum, Cambridge.

1883.

Lord Kelvin, P.C., G.C.V.O., D.C.L., F.R.S., 13 Eaton Place, S.W.

Ellery, Robert L. J., F.R.S., Observatory, Melbourne.

1885.

Sharp, Richard Bowdler, M.A., F.L.S., British Museum (Natural History), London.

Wallace, A. R., F.L.S., Broadstone, Wimborne, England.

1890.

Nordstedt, Professor Otto, Ph.D., University of Lund, Sweden.

Liversidge, Professor A., M.A., F.R.S., Sydney.

1891.

Goodale, Professor G. L., M.D., LL.D., Harvard University, Massachusetts, U.S.A.

1894.

Dyer, Sir W. T. Thiselton, K.C.M.G., C.I.E., LL.D., M.A., F.R.S., Royal Gardens, Kew.

Codrington, Rev. R. H., D.D., Wadhurst Rectory, Sussex, England.

1896.

Lydekker, Richard, B.A., F.R.S., British Museum, South Kensington.

1900.

Avebury, Lord, P.C., F.R.S., High Elms, Farnborough, Kent.

Massee, George, F.L.S., F.R.M.S., Royal Botanic Gardens, Kew.

1901.

Eve, H. W., M.A., 37 Gordon Square, London.

Goebel, Dr. Carl, University of Munich.

1902.

Sars, Professor G. O., University of Christiania, Norway.

1903.

Klotz, Professor Otto J., 437 Albert Street, Ottawa, Canada.

1904.

Rutherford, Professor E., McGill University, Canada.

David, Professor T. Edgeworth, Sydney University, N.S.W.

1906.

Beddard, F. E., F.R.S., Zoological Society, London.

Milne, J., F.R.S., Isle of Wight, England.

Brady, G. S., F.R.S., University of Durham, England.

Dendy, Dr., F.R.S., University College, London.

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Bell, H. D.
Bell, Dr. J. M.
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Campbell, J. P.
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Christie, Mrs. Henry M.
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Cockayne, A. H.
Cowan, James
Denton, George
Downes, Thomas William, Wanganui
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FitzGerald, Gerald, A.M.Inst.C.E.

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Turnbull, Thomas
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Gray, G.
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Hallenstein, P. L.
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Hitchings, F.
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Lewis, C., M.H.R.
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McCallum, P.
McCullough, R.
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Moorhouse, Dr. B. M.
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Page, S., B.Sc.
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Seager, S. Hurst, A.R.I.B.A.
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Shrimpton, —.
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Smith, W.
Smith, W. W., F.E.S.
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Wright, W. S.

OTAGO INSTITUTE.

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Black, Professor J. G., M.A., D.Sc.
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Browne, Robert
Brown, William
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Chapman, Mr. Justice
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John Mackay, Government Printer, Wellington.—1907.

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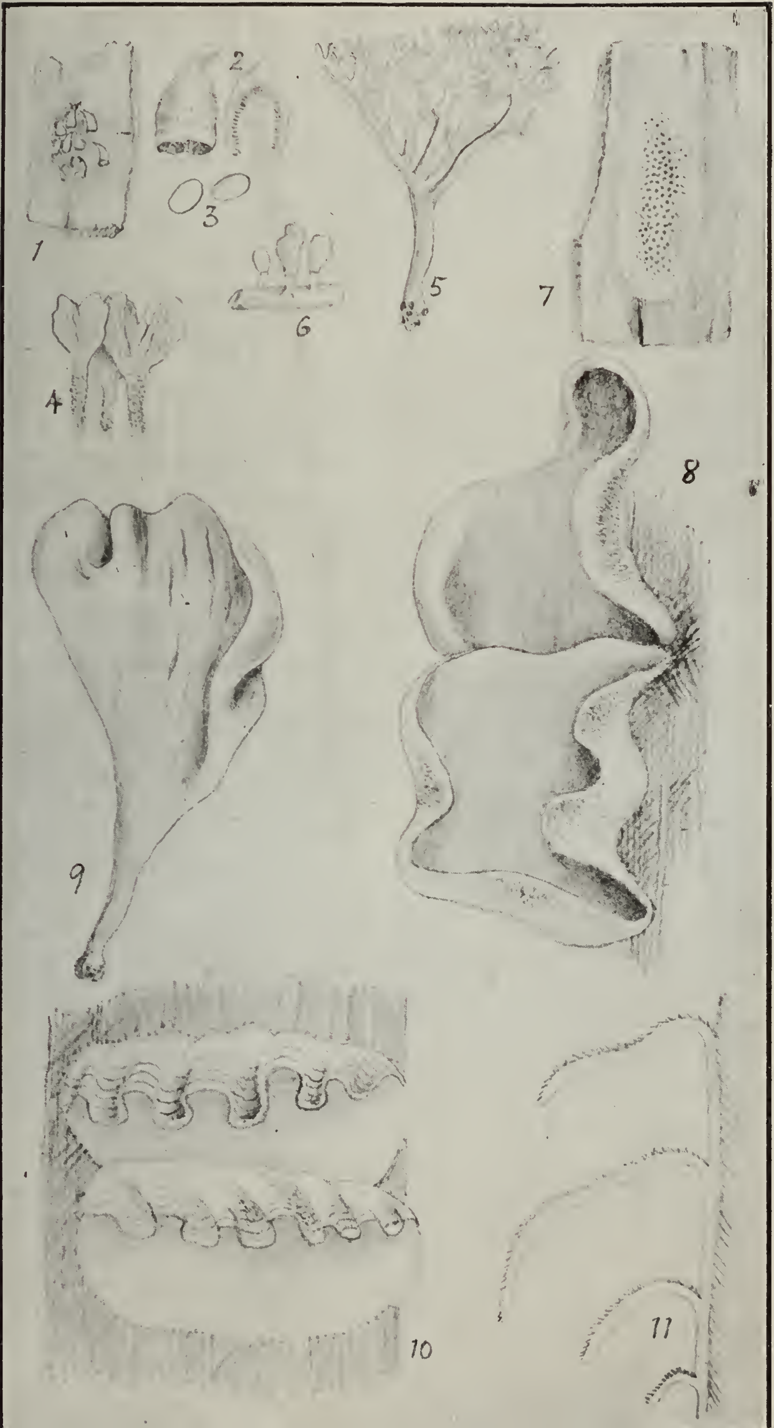
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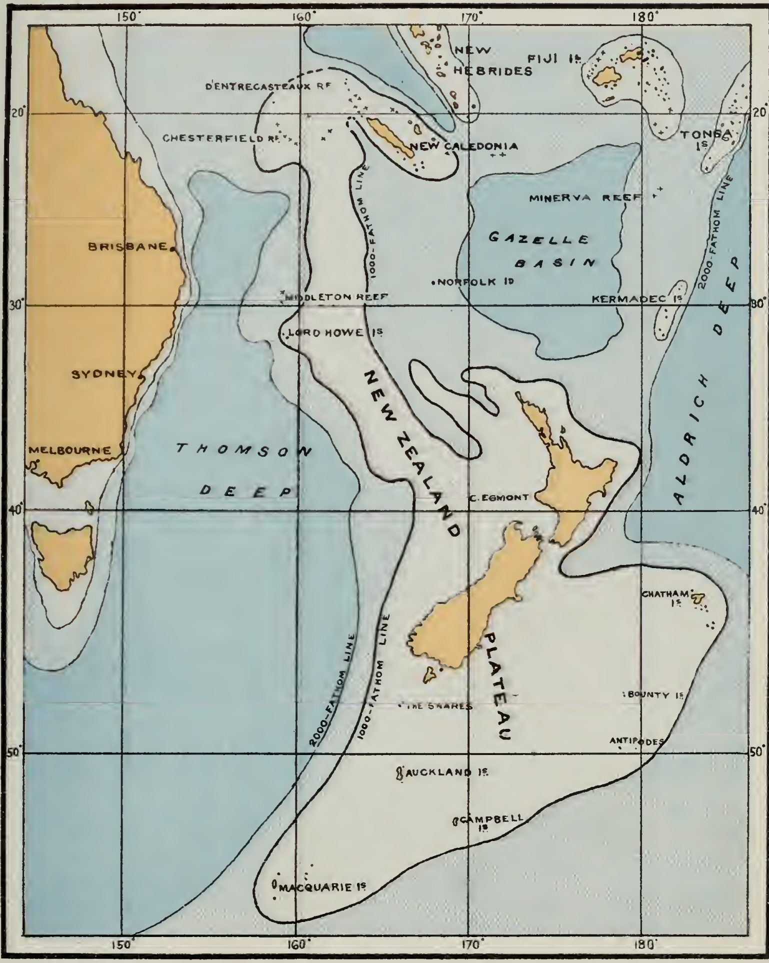
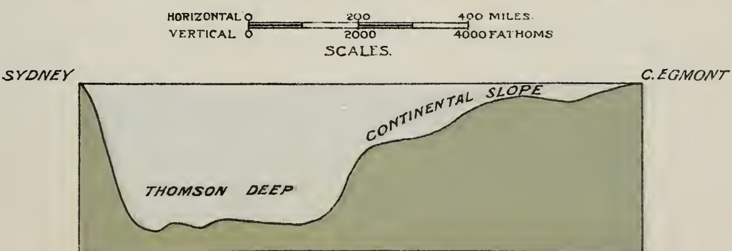
To accompany report of Dr. Klotz 1903–04.

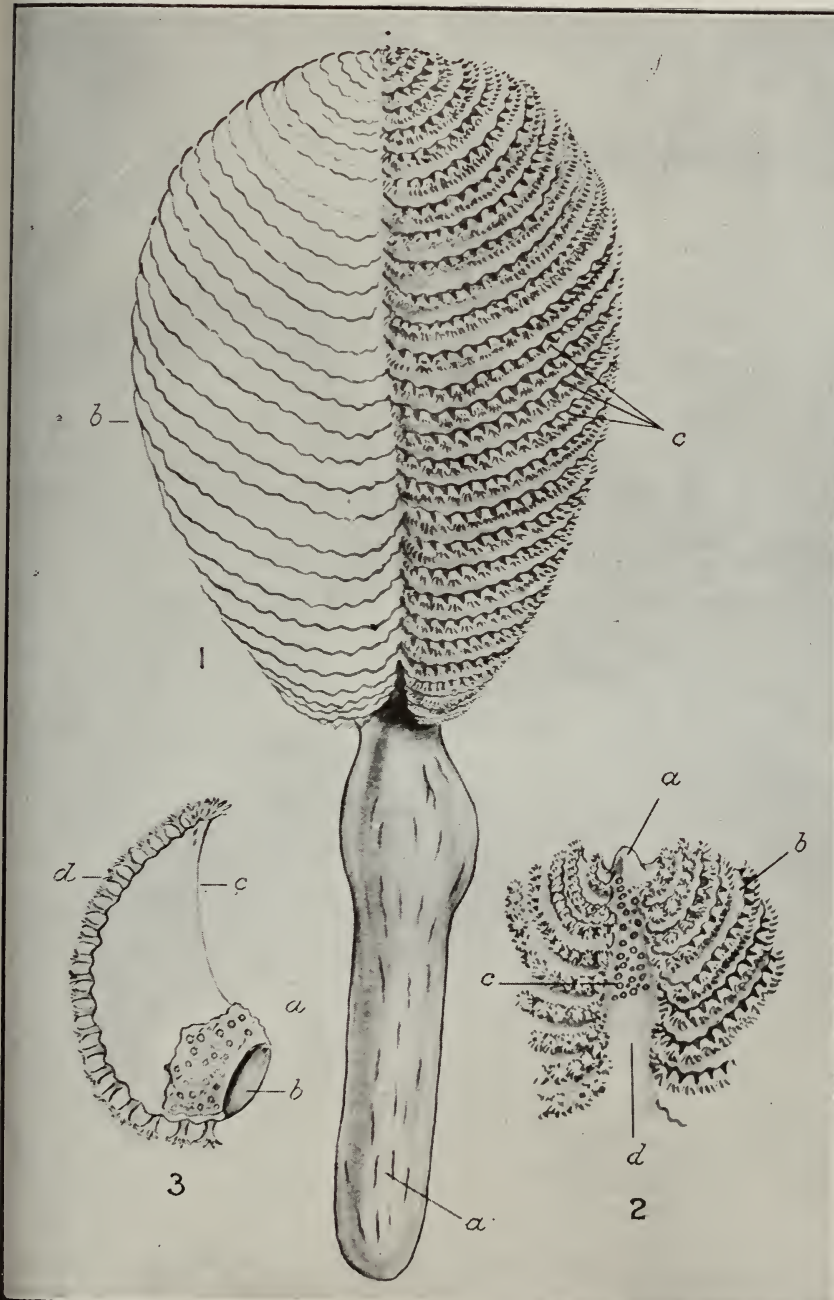
SHEEP-BONE OPENED BY KEA.—Benham.



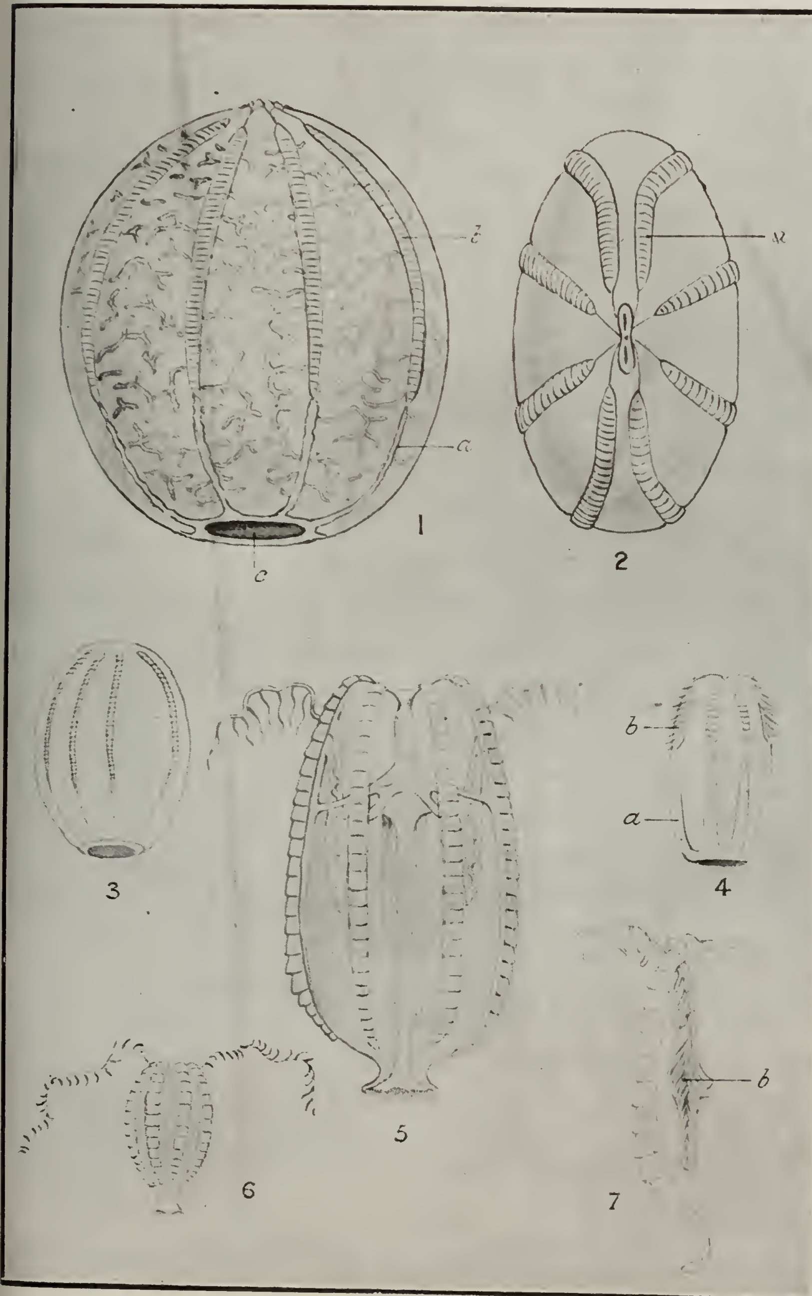


Section across the Tasman Sea from Sydney to Cape Egmont

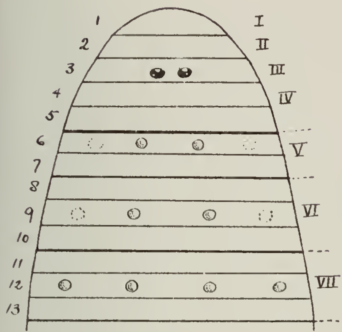
MAP OF N.Z. PLATEAU.—Farquhar.



SARCOPHYLLUM BOLLONSI.—Benham.



NEW ZEALAND CTENOPHORES.—Benham.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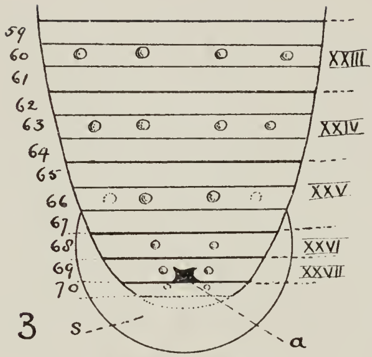
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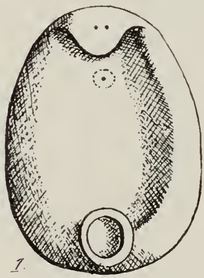

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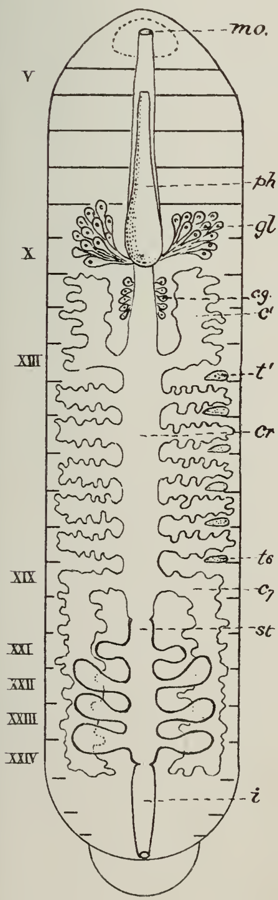
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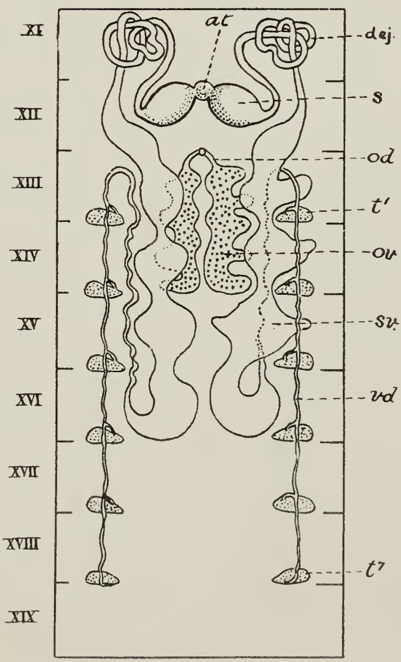
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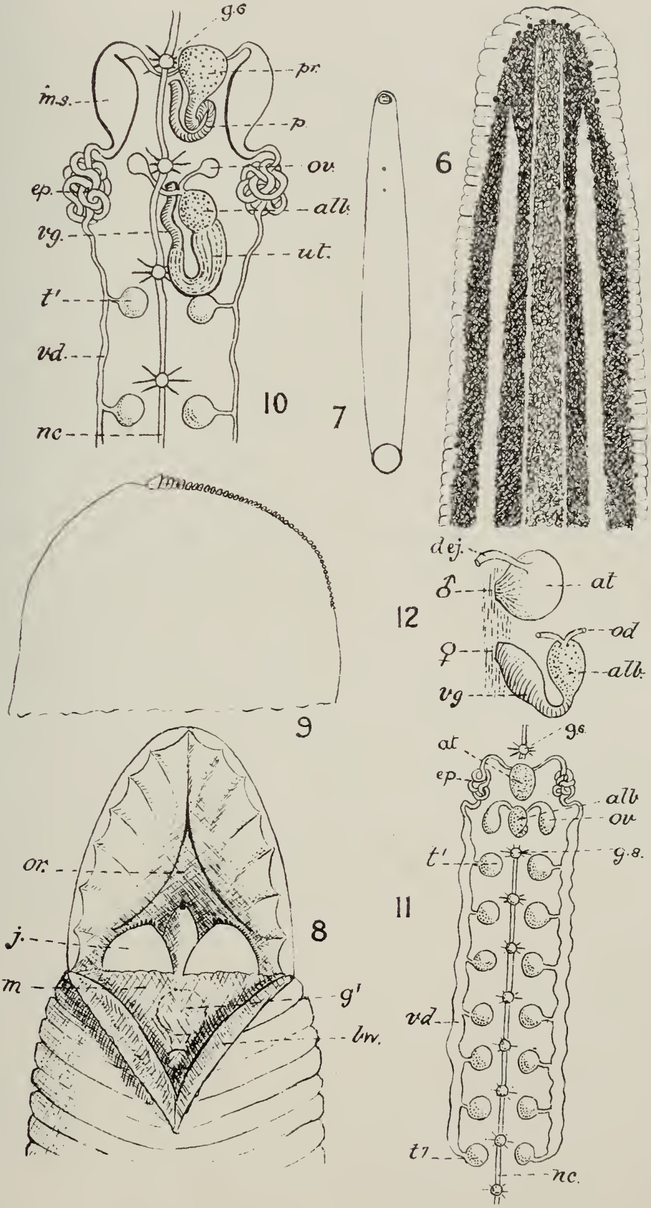
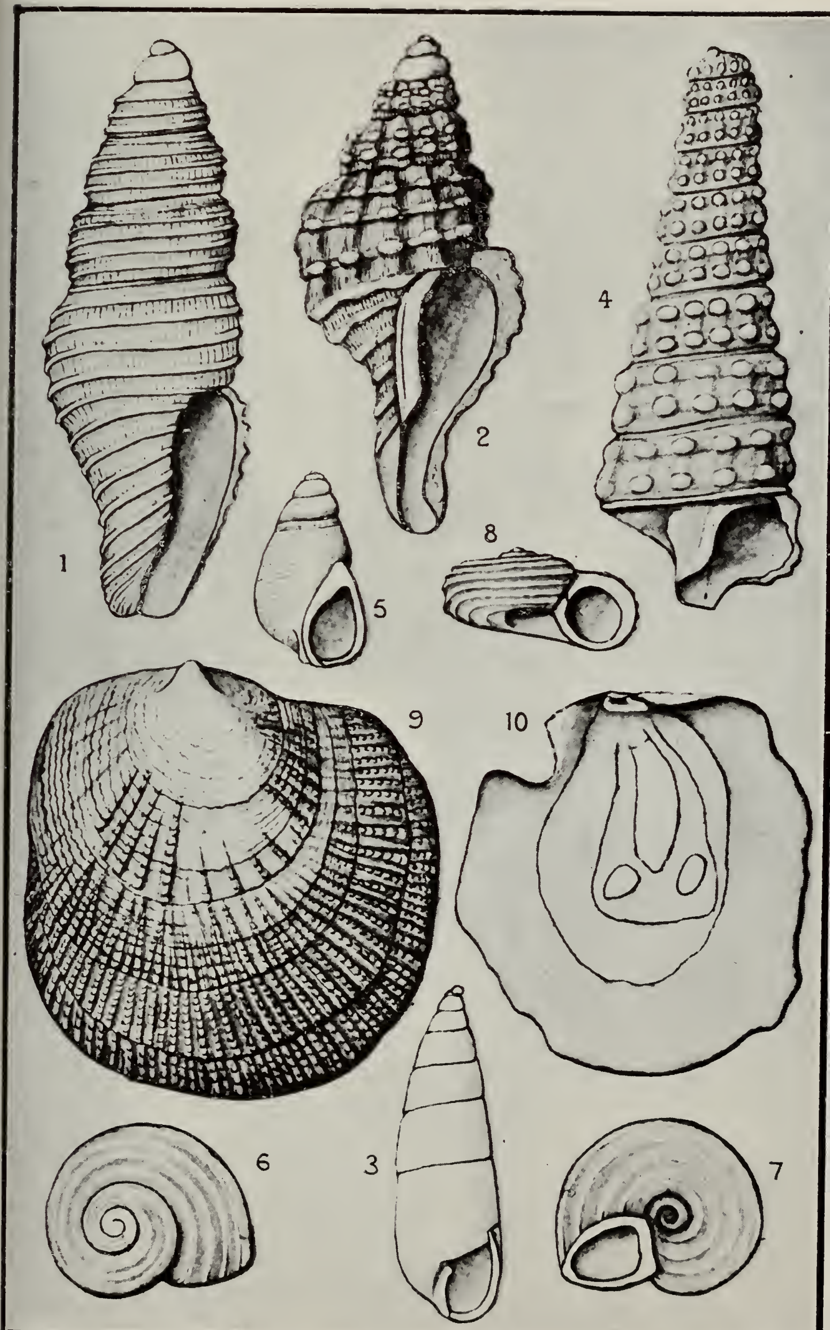
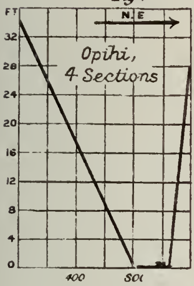


HIRUDO.—Benham.



NEW MARINE MOLLUSCA.—Suter.

Fig 1



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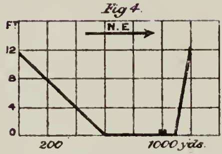

Ashburton & branches,
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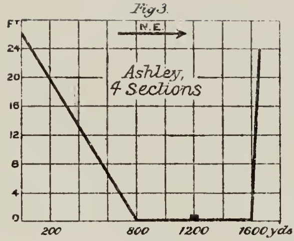
Fig 3.



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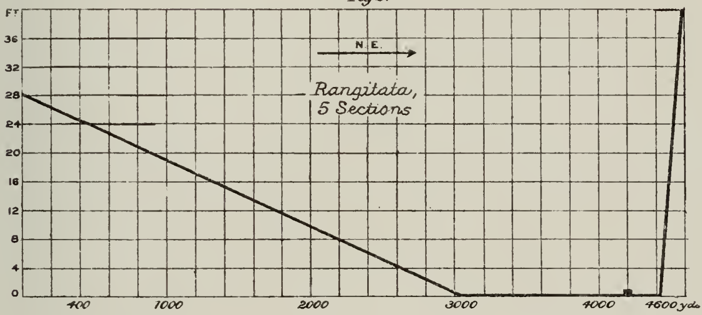

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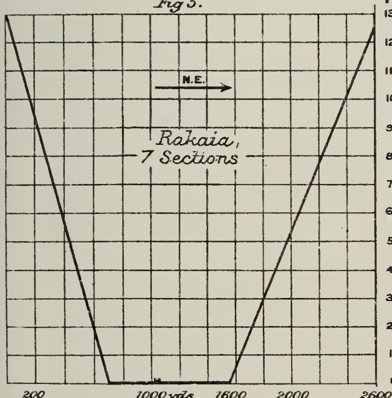

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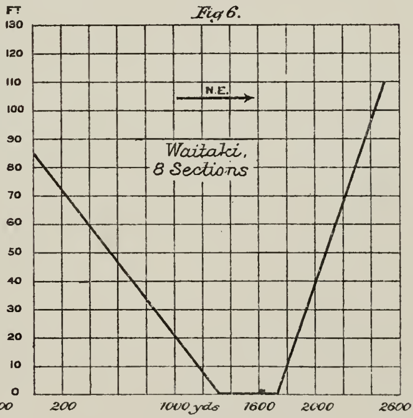

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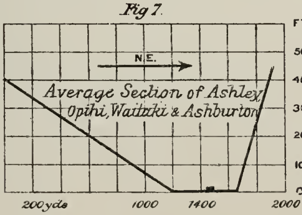

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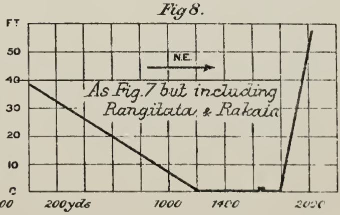
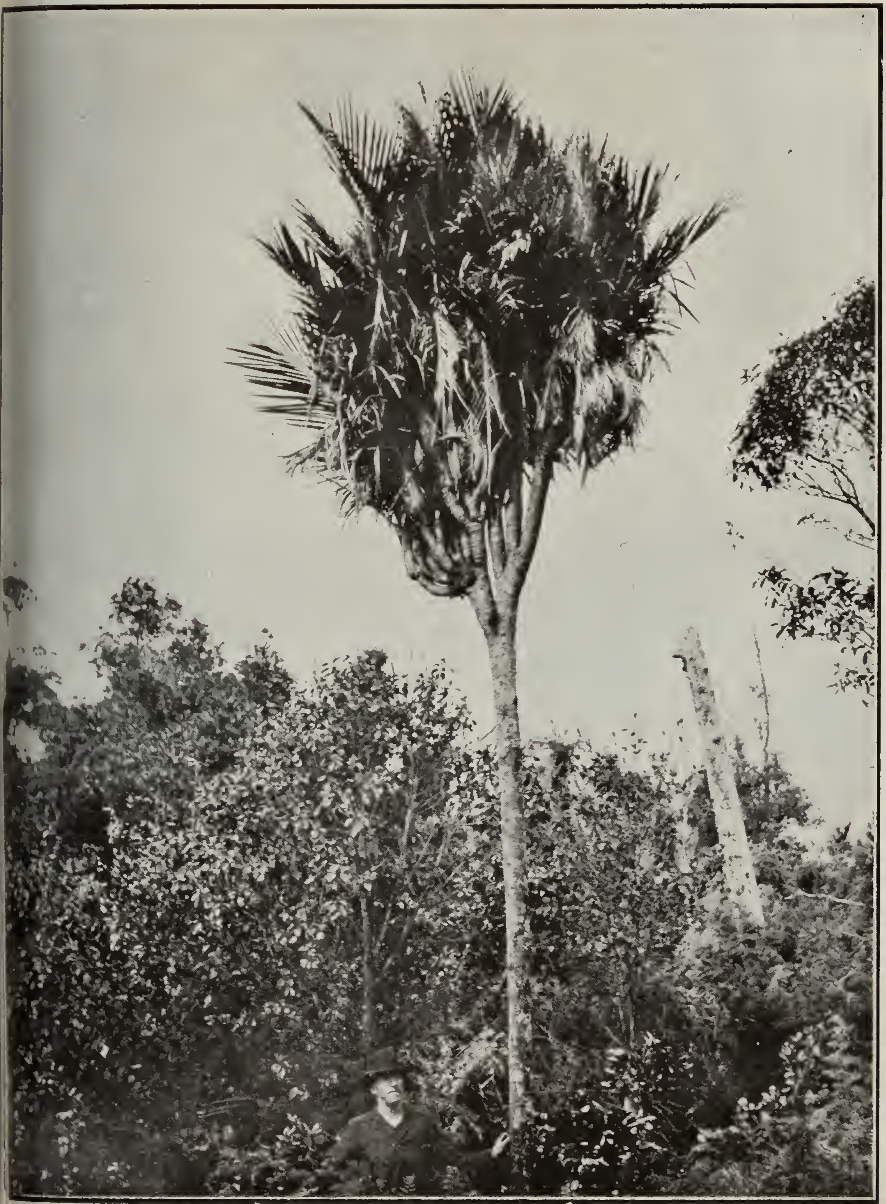


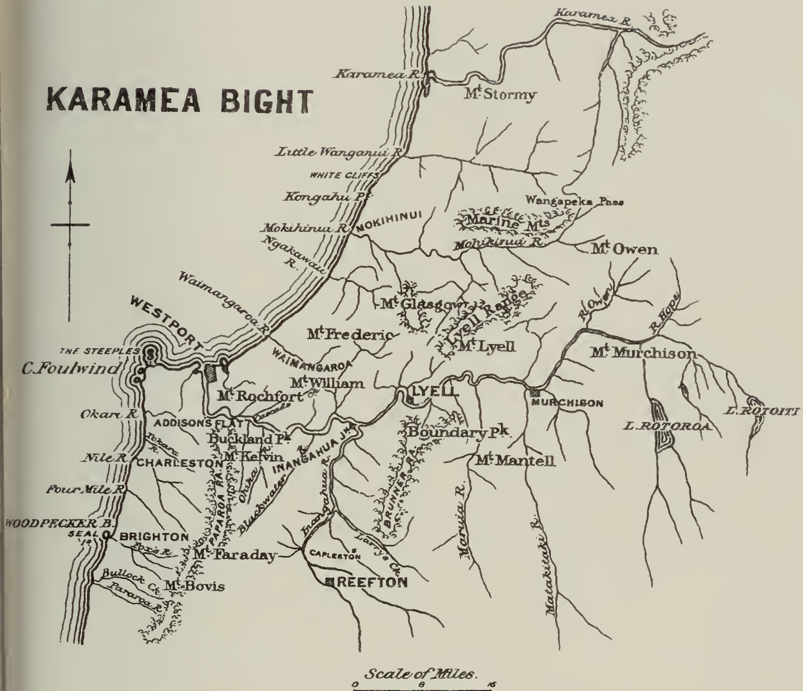


BRANCHED NIKAU.—Cheeseman.

CARVED BURIAL CHESTS.—Cheeseman.

CARVED BURIAL CHESTS.—Cheeseman.

WESTPORT VEGETATION, DRACOPHYLLUMS.—Townson.

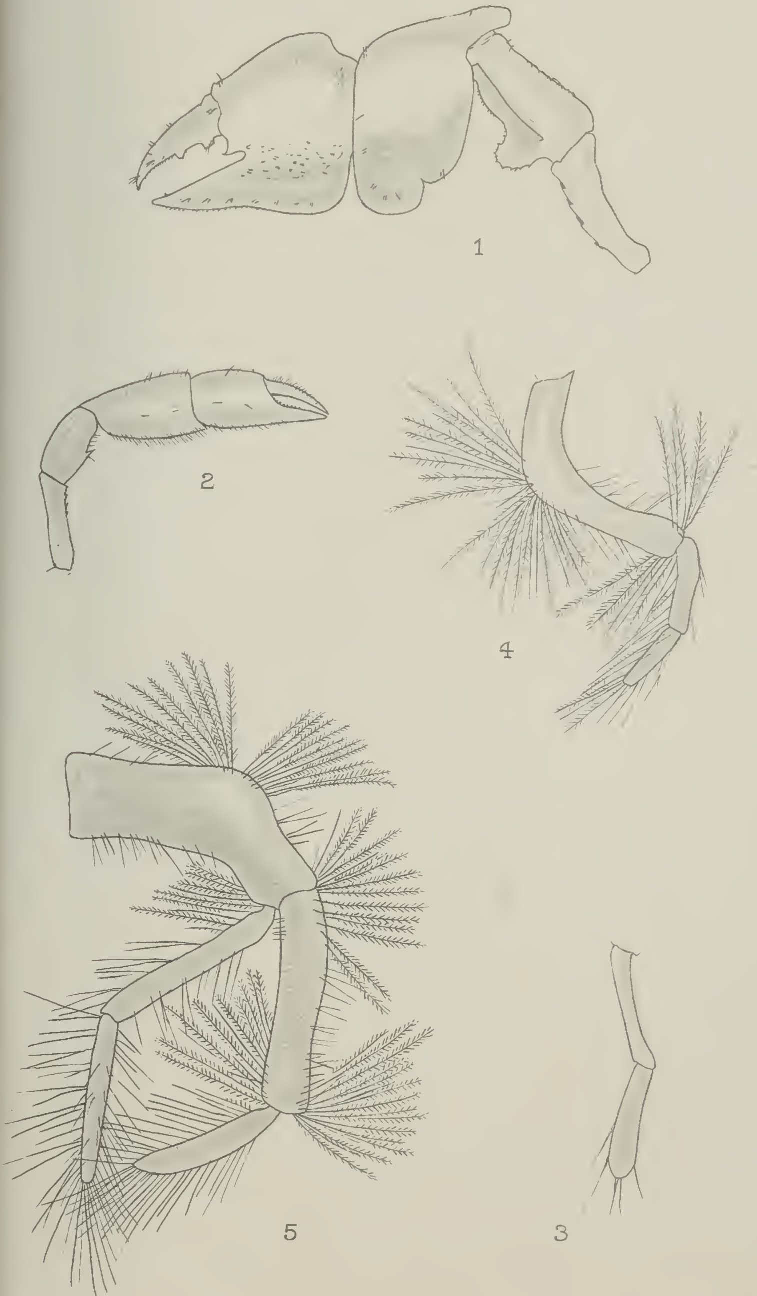


MOUNTAIN ALTITUDES.

Boundary Peak	4,800 ft.	Mount Kelvin (approximately)	5,000 ft.
Buckland Peak (approximately)	4,500 "	Mount Lyell	4,300 "
Mount Bovis	4,094 "	Mount Mantell	6,000 "
Mount Faraday (approximately)	4,500 "	Mount Murchison	4,813 "
Mount Frederic	3,596 "	Mount Owen	6,150 "
Mount Glasgow	4,800 "	Mount Rochfort	3,382 "
		Mount Stormy	3,547 "
		Mount William	3,482 "

MAP OF WESTPORT DISTRICT.—Townson.

MAP TO ILLUSTRATE ARTICLE ON KEA.—Marriner.



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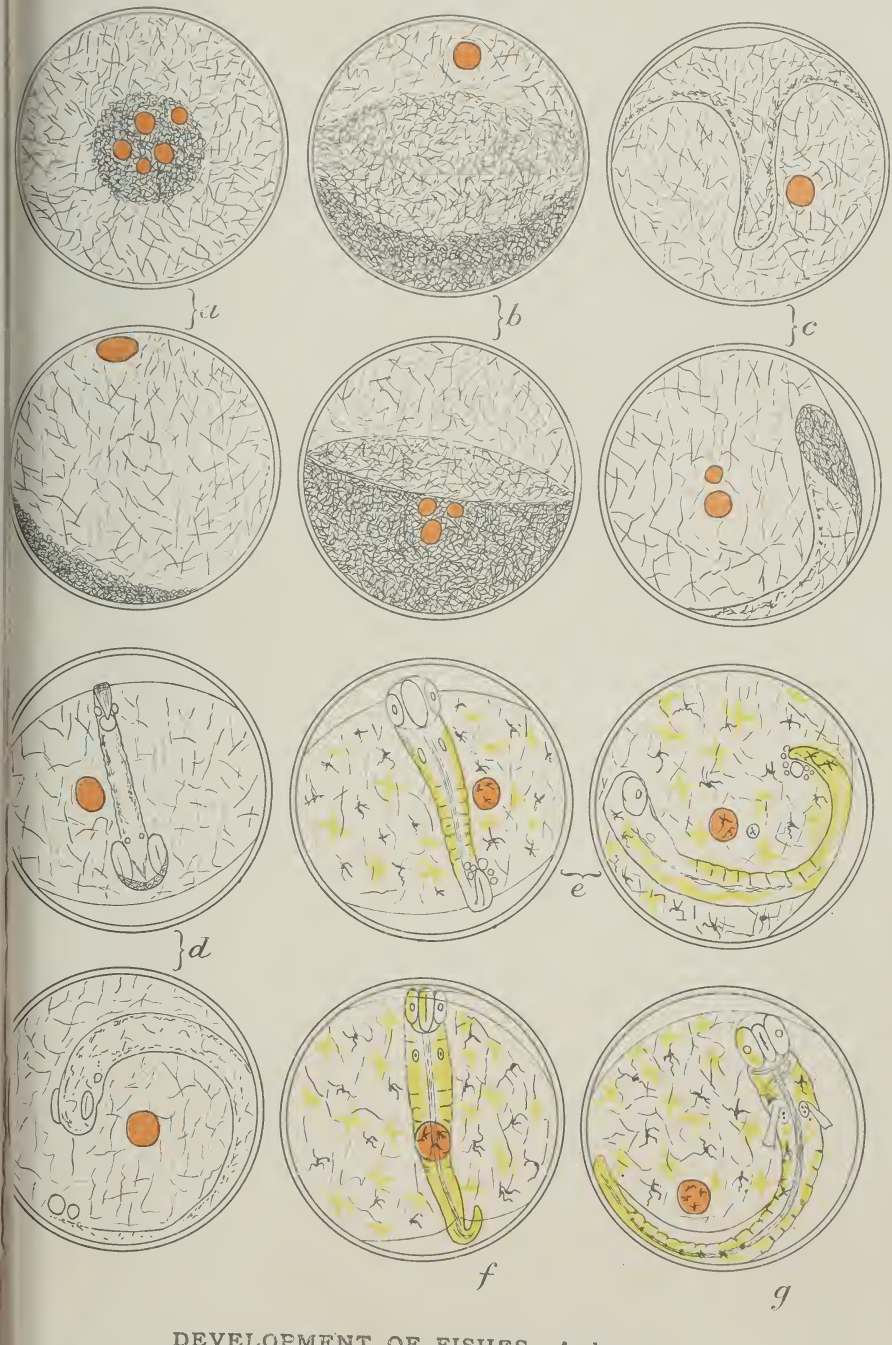
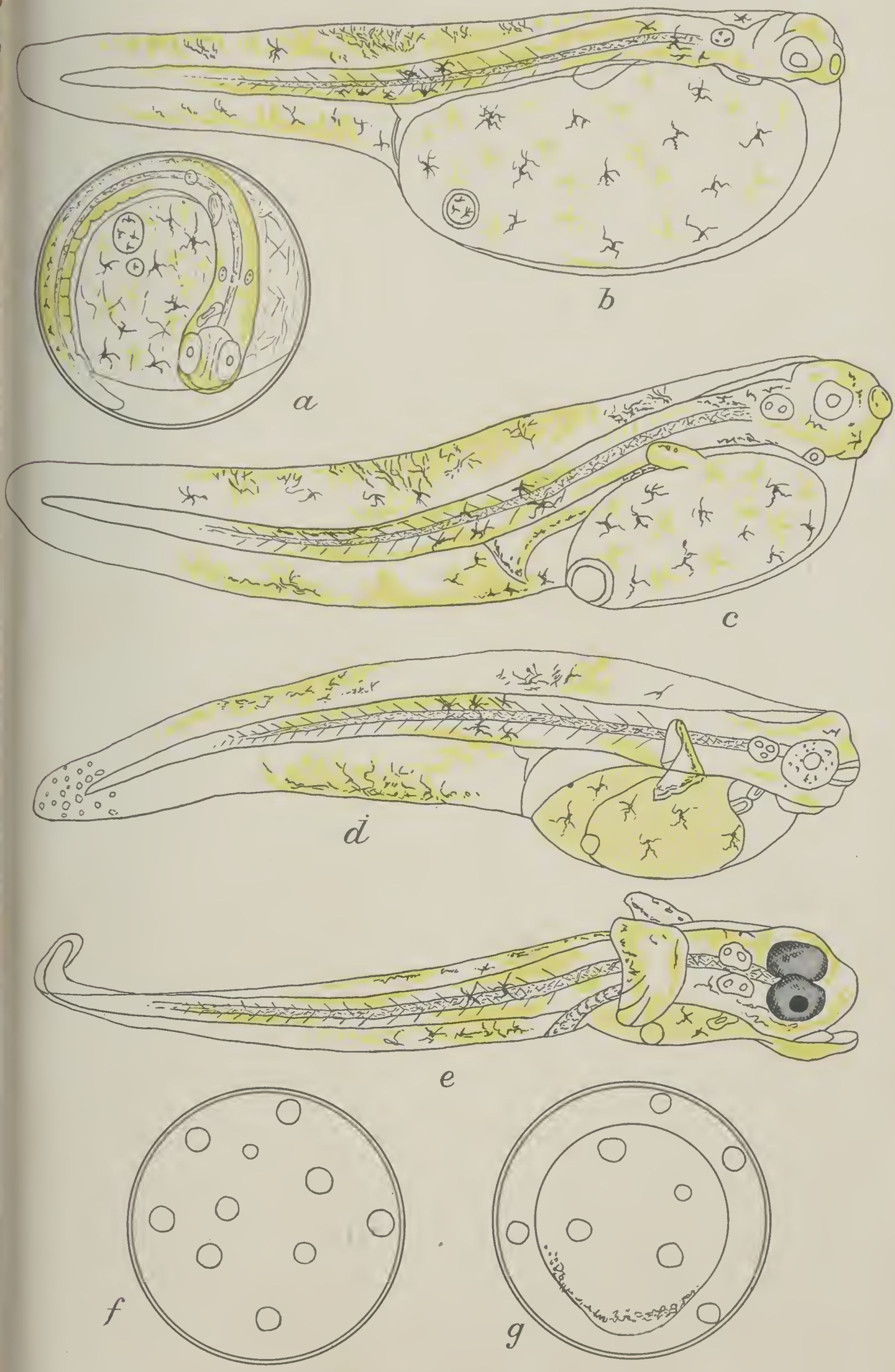


DEVELOPMENT OF FISHES.—Anderton.



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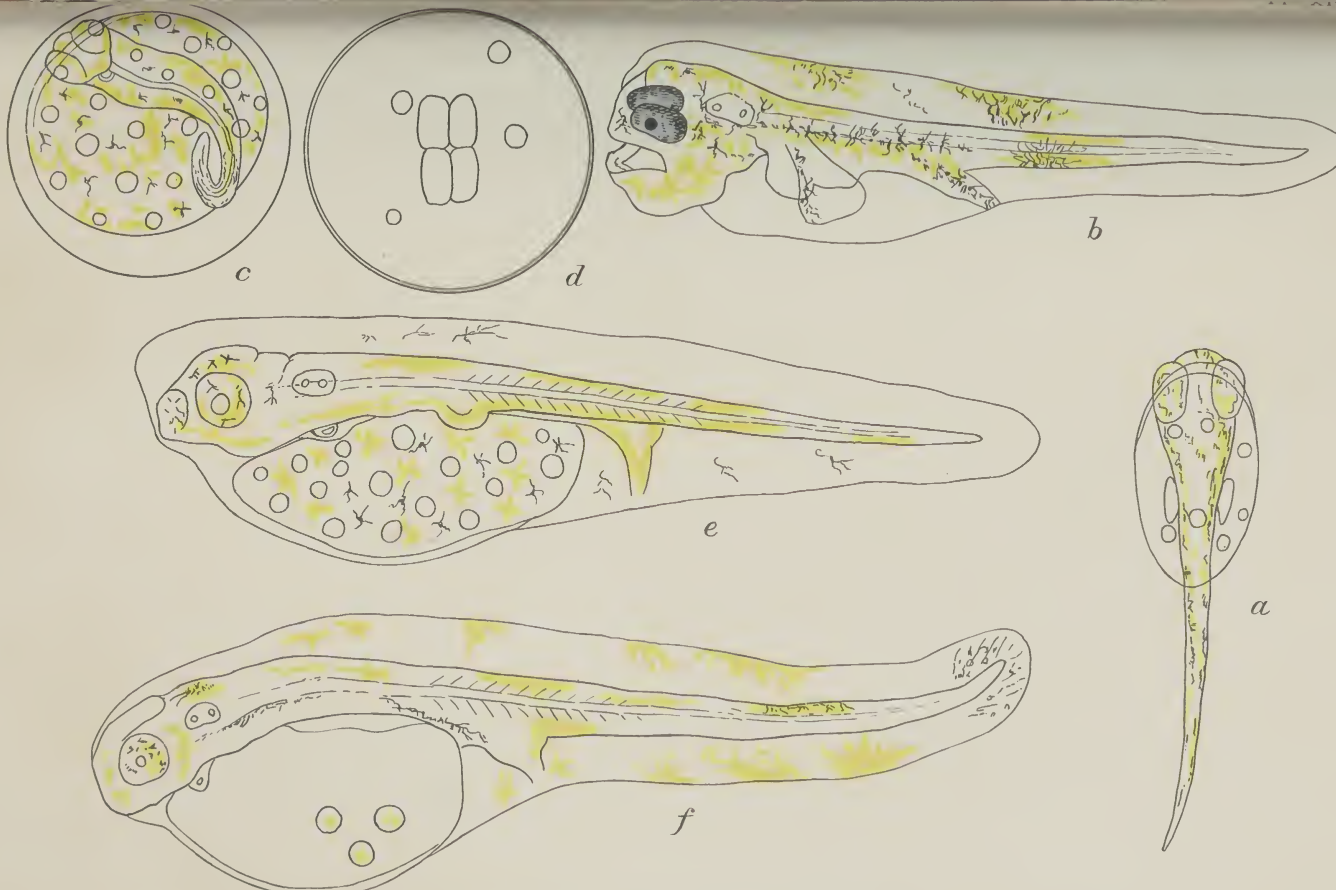
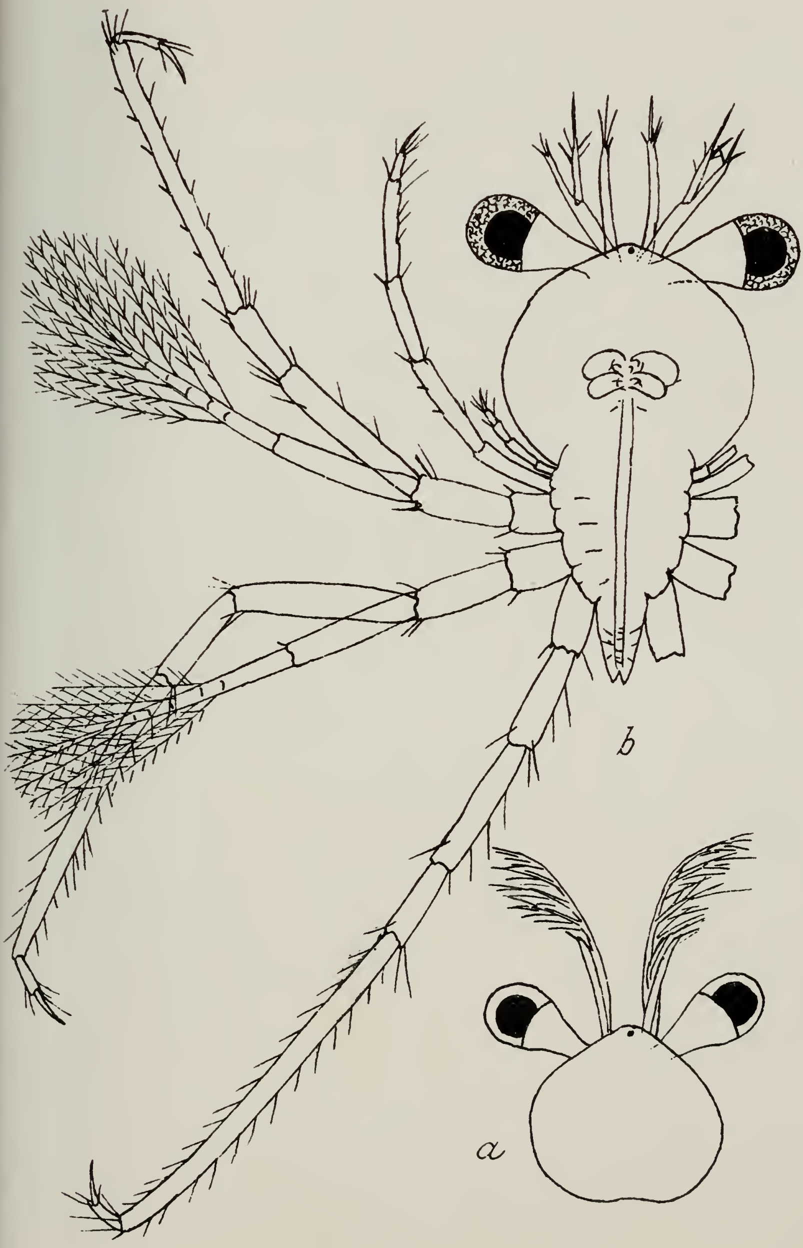
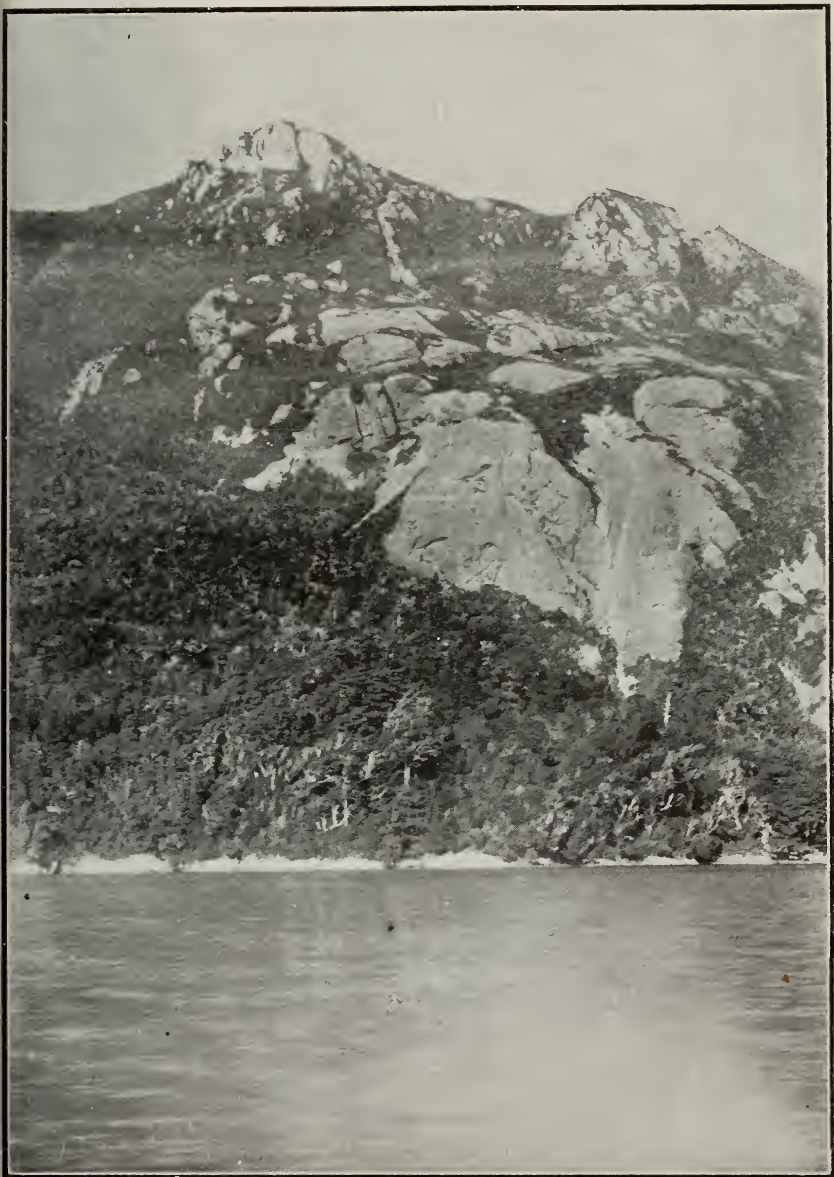


DEVELOPMENT OF FISHES.—Anderton.

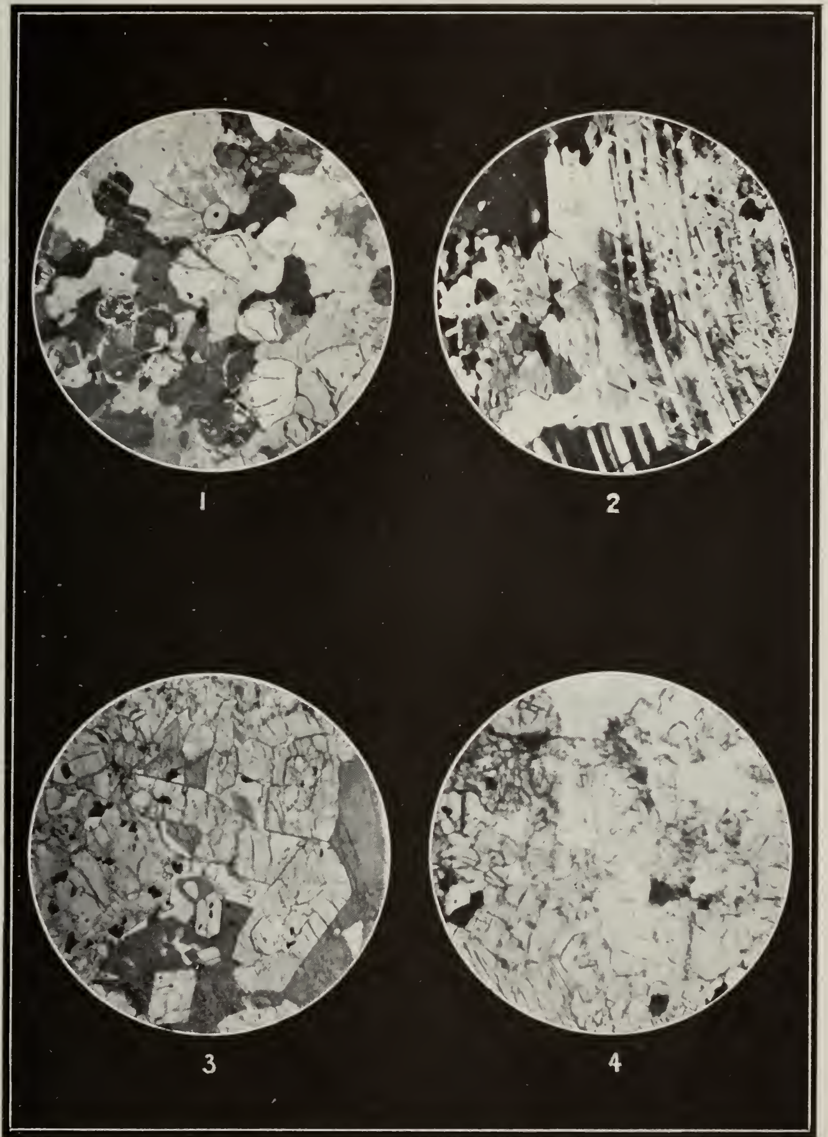


DEVELOPMENT OF PALINURUS EDWARDSII.—Anderton.

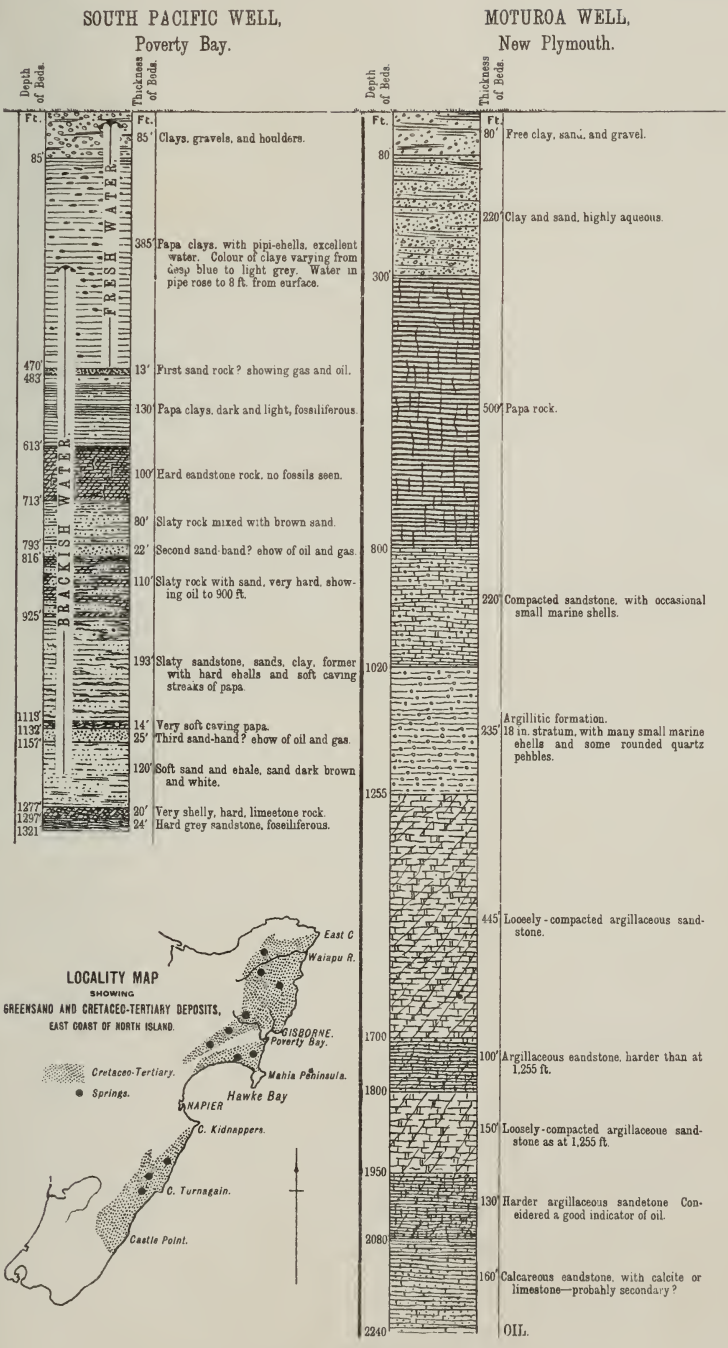
OTAGO FIORDS.—Marshall.



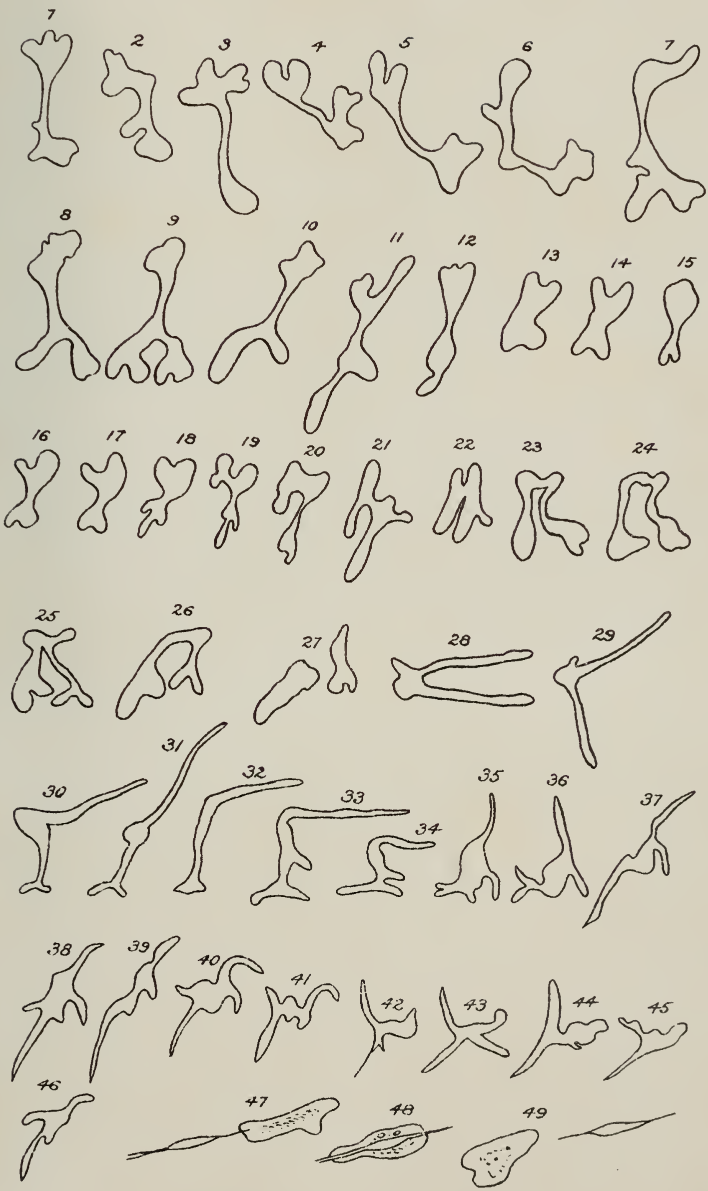
GLACIAL EROSION, THOMPSON SOUND.—Marshall.



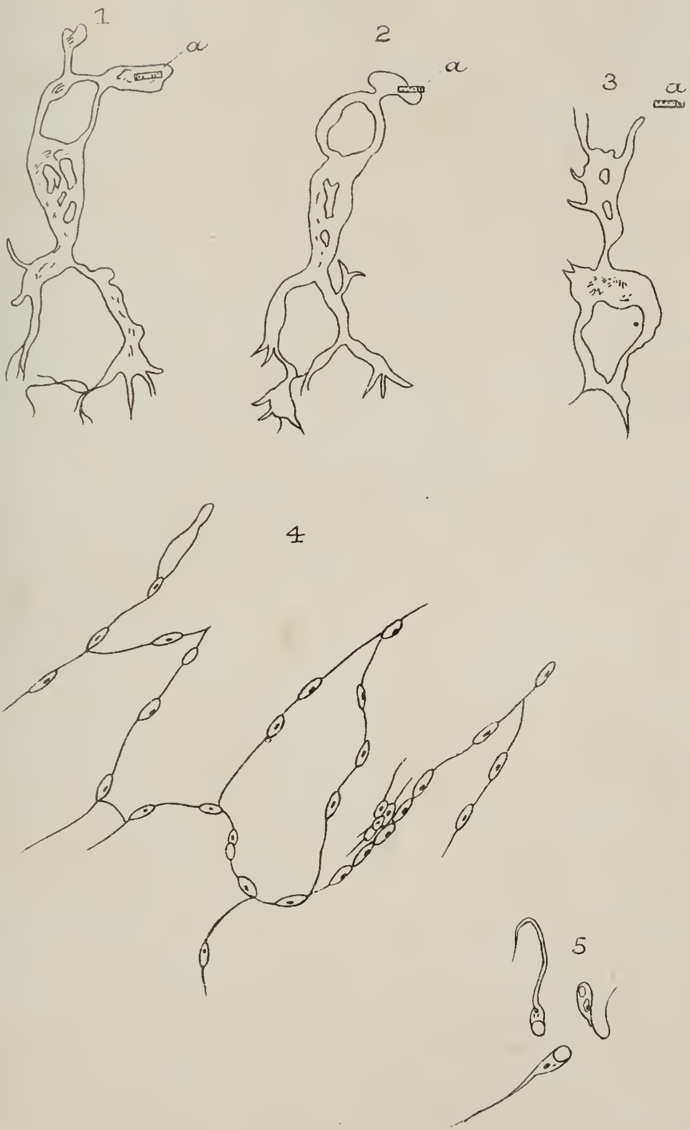
ROCK SECTIONS.—Marshall.



ARTESIAN SECTIONS.—Hill.



AMŒBA AGILIS.—Kirk.



MYXOPLASMA RETE.—Kirk.