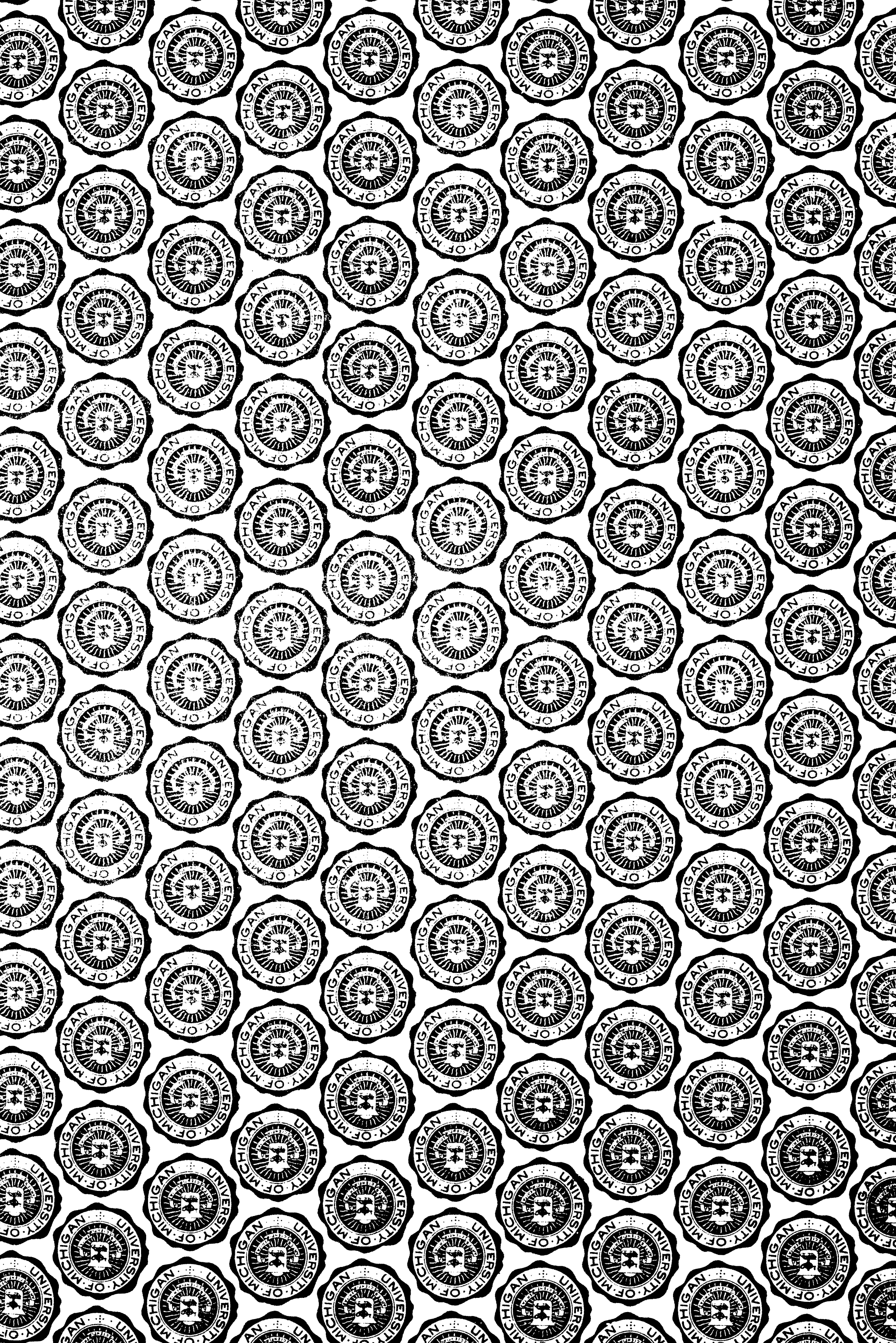
PHILIPPINE
JOURNAL
OF
SCIENCE

36
MAY-AUG
1928


UNIVERSITY OF MICHIGAN

THE PHILIPPINE JOURNAL OF SCIENCE

VOLUME 36

MAY TO AUGUST, 1928

WITH 57 PLATES AND 15 TEXT FIGURES

MANILA
BUREAU OF PRINTING
1928

General
Water

CONTENTS

No. 1, May, 1928

[Issued July 2, 1928.]

No. 2, June, 1928

[Issued July 3, 1928.]

No. 3, July, 1928

[Issued August 3, 1928.]

No. 4, August, 1928

[Issued September 20, 1928.]

THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 36 MAY, 1928 No. 1

RINDERPEST, WITH SPECIAL REFERENCE TO ITS CONTROL BY A NEW METHOD OF PROPHYLACTIC TREATMENT

By WILLIAM HUTCHINS BOYNTON

Of the Division of Veterinary Science, College of Agriculture, University of California, Berkeley

THREE PLATES

GENERAL DISCUSSION

The new prophylactic, or vaccine, treatment for rinderpest, which is to be described in this paper, is the culmination of experiments and observations on that disease in the Philippine Islands from 1910 to 1924, during which time the writer was continuously employed as the veterinary pathologist of the Bureau of Agriculture.

Previous to 1921, the simultaneous method of immunization, the "serum-alone" treatment, and the "quarantine-alone" method had been employed in the Philippine Islands in combating rinderpest. Since that time the vaccine treatment has practically supplanted the first two and it is now used to supplement the quarantine-alone method.

A letter from Dr. Stanton Youngberg, present director of the Bureau of Agriculture, Philippine Islands, written in October, 1926, stated that, by January 1, 1927, over three hundred thousand head of cattle and carabaos will have received the vaccine treatment. By the use of this vaccine several provinces which had been considered enzoötic to rinderpest, in as much as the disease had resisted all other methods, had already been declared free.

The success we achieved in developing the vaccine treatment for rinderpest was not a one-man problem. In working out the minute details in the control of such a disease, we needed loyalty, coöperation and, above all, honesty. The late Dr. Ildefonso Patdu exemplified these qualities and, through his untiring efforts and enthusiasm, we made great progress in introducing the new treatment to his countrymen. Praise and credit are due to all the men who worked at the Veterinary Research Laboratory, as well as to the several veterinarians who used the vaccine in the field. Through their successes and also their failures, we worked out better methods of producing and administering the vaccine on a large scale. Due credit is given the late Director of Agriculture of the Philippine Islands, Mr. Adriano Hernandez, and to Dr. Stanton Youngberg, at that time chief veterinarian, for their aid in furnishing us with an abundance of experimental animals and additional equipment as the work advanced.

It has been observed that the best method of controlling rinderpest in infected areas is by the combination of quarantine and vaccination. A rigid quarantine is placed upon all animals, especially the exposed and sick. All susceptible animals are vaccinated and these, in the course of two or three weeks, become resistant to rinderpest. The infected ones either recover or die. When infected territory is declared free from the disease and the quarantine is raised, there is no chance of an immediate recurrence of infection as all the animals have become immune, either by passing through a natural attack of rinderpest or by the vaccine treatment.

In localities free from rinderpest the vaccine can be used with equal facility. Here no quarantine measures are necessary. Animals undergoing the vaccine treatment do not present any ill effects during the process of immunization. They do not develop a reaction by which they would transmit the disease to a susceptible animal. Draft animals can be worked every day without detriment to themselves or to the type of immunity developed. Dairy cattle show little or no subsidence in milk production during the vaccine treatment. The nervous type of dairy cow may show a slight depression for one or two days following vaccination, but the normal production is resumed promptly and without any further interference. Calves are immunized by the vaccine treatment as readily as are mature animals.

At this point, a review of the work that led to the development of the rinderpest vaccine will be given.

TREATMENT OF RINDERPEST WITH DRUGS

On May 30, 1911, experiments were started on the treatment of rinderpest with different drugs. (1) These experiments were carried out at various times during a period of approximately six and a half years. Twenty-seven preparations were used, and were administered in varying ways as to combinations, quantities, time of administration, etc. Over fifty animals were used, and but two of those treated recovered from the disease, which was positive proof that the drugs, as we administered them, had no curative power for an animal suffering from rinderpest.

Dr. Stanton Youngberg, the then chief veterinarian, and several veterinarians in charge of immunization stations in the provinces, used strychnine, nitroglycerine, and echinocoid on animals that had a severe reaction while passing through the simultaneous immunization. These workers found that all three of the drugs prolonged the life of animals by their stimulating effect and, in many instances, seemed to sustain life long enough for the development of sufficient antibodies to combat the disease, in this way enabling them to make a recovery. However, these drugs are practically useless for animals that contract rinderpest in the usual way without having previously received a protecting dose of serum.

From the results obtained it was quite obvious that either the virus of rinderpest was very resistant to the action of the drugs used or that the virus was so located in the body tissues that the drugs could not act upon it, the virus in the blood stream being merely a surplus thrown off from these body tissues.

LONGEVITY OF THE VIRUS OF RINDERPEST IN LEECHES

On July 13, 1912, experiments were started on the duration of the infectiveness of virulent rinderpest blood in the water leech, *Hirudo boyntoni* Wharton. (2) It was proved that the large water leech could retain the virus of rinderpest alive in its body for at least twenty-five days and in a virulent condition. A similar amount of virulent rinderpest blood kept in a cotton-plugged test tube under similar temperature conditions would lose its virulence in from seven to ten days.

From the results obtained in the experiments with leeches, it would appear that the virus of rinderpest needed partial or complete anaërobic conditions for its longevity and development. There was also a possibility that the virus was protozoan in nature, as several workers have performed similar experiments on protozoan diseases. Bass and Johns(3) cite the statements of Sakharov, Rosenbach, Blumer, Hamburger, and Mitchel, that they kept malaria plasmodia alive for several days in leeches that had been allowed to draw the blood of malarial patients. Laveran and Mesnil(4) state: "Various trypanosomes which were found by Brumpt in fresh-water fishes can be divided into several groups according to their mode of evolution in the bodies of leeches (Hemiclipsis)." Elsewhere they state, in discussing a trypanosome disease of horses in Annam, that Vassal(5) found that "The blood of leeches which had fed on infected animals was infective on injection into rats immediately after the meal of blood, but not four hours later. The trypanosomes are killed off very readily in the stomach of the leech." Daniels and Alcock(6) state: "Many parasites maintain their virulence for a considerable period in the stomach of leeches, but leeches are not known to act as carriers of disease." Nencki, Sieber, and Wijnikewitch(7) allowed leeches to feed upon animals infected with rinderpest. Later, they examined the blood in these leeches for the presence of the organism regarded by them as the causative agent of rinderpest, but without success.

With the results of the work in the Philippines with leeches in mind and noting the work on the cultivation of malaria by Bass and Johns,(3) also that of Nencki, Sieber, and Wijnikewitch,(8) experiments were started on the cultivation of the virus of rinderpest in vitro.(9) These results showed that it is possible that the virus of rinderpest requires either partial or complete anaërobic conditions for its existence.

EXPERIMENTS ON THE CULTIVATION OF THE VIRUS OF RINDERPEST

The virus of rinderpest was carried in virulent form in two separate series up to the sixth transfer in glucose-blood culture medium, covering periods of nineteen and twenty-one days, respectively. In one series, the original tube was nonvirulent at the end of twelve days, while the fourth transfer from this same tube of culture medium, after the same period of time, was virulent.

EXPERIMENTS IN ATTEMPTING TO LOCATE THE VIRUS IN THE SEPARATE BLOOD ELEMENTS

In the cultivation experiments, we also tried to locate, if possible, the blood element which harbored the virus. For assistance in this work, I was greatly indebted to Dr. M. A. Barber, of the Bureau of Science, who used his pipette method for the isolation of single microörganisms in picking out the separate and different blood elements.

Animals were injected with red blood cells alone, leucocytes alone, and blood platelets alone, which had been obtained from the blood of an animal sick with rinderpest. None of these separate elements affected the animals injected, though they were later proved susceptible. Whole blood taken from the same sick animal and injected in a 5 cubic centimeter dose into a susceptible animal, however, caused rinderpest.

ESTIMATION OF THE MINIMUM LETHAL DOSE OF VIRULENT RINDERPEST BLOOD NECESSARY TO TRANSMIT THE DISEASE

The question then arose as to whether the virus impregnated the blood of an infected animal to the extent that had been previously supposed. Experiments were carried out along this line and it was found that 1/2970 of a cubic centimeter of virulent blood transmitted the disease to a susceptible animal, but that 1/9060 of a cubic centimeter and 0.0001 of a cubic centimeter of virulent blood failed to transmit the disease. In summing up these experiments, it would appear that the virus of rinderpest is not intracorpuscularly located.

Braddon(10) described various bodies he observed in the erythrocytes from animals suffering with rinderpest, and considered these as the possible causative agent of the disease.

OBSERVATIONS ON THE NATURE OF THE VIRUS OF RINDERPEST

Tartacovsky(11) gave a thorough review of the results obtained by numerous workers up to 1896. Koch,(12) in 1897, in the second report of his investigations in South Africa on the etiology of rinderpest, states that all his efforts to isolate and cultivate the virus of rinderpest were fruitless.

Several experiments, which have heretofore not been reported by me, also gave some idea as to the nature of the virus of rinderpest. It was observed that by drawing blood from an animal sick with rinderpest direct into large test tubes and allowing it to clot, the virus would retain its virulence for a considerably longer time in the blood clot than in a similar quantity of virulent blood which had been either defibrinated or citrated to prevent its clotting. Hens' eggs were injected with virulent blood and incubated at 40° C. A small portion of shell, approximately 4 millimeters square, was removed. Care was taken to see that the underlying membrane was left as nearly intact as possible. A finely drawn out pipette containing the virulent blood was then inserted through the egg membrane, rather deep into the egg, and the virulent blood expelled. The small square of shell previously removed was replaced and the area covered with high melting point paraffine. It was found that the virus remained in a virulent form for sixteen days in fertile eggs, but lost its virulence much sooner in nonfertile eggs. The same quantity of virulent blood, approximately 0.2 of a cubic centimeter, when placed in a test tube and kept under similar temperature, would lose its virulence in about three days. There results exemplified the necessity of at least partial anaërobic conditions for the virus to maintain its virulent properties for any length of time.

BLOOD CHANGES IN AN ANIMAL SICK WITH RINDERPEST

While studying the blood changes in animals infected with rinderpest it was observed that, in many cases, there was a slight increase in the number of leucocytes in the circulating blood just prior to the initial rise in temperature. With this rise, there was constantly a marked decrease in the number of leucocytes, which continued until the crisis of the disease. In the case of death, there was a marked increase. This condition was especially prominent when the temperature of the animal dropped to subnormal. If recovery was made, the leucocytes would rapidly increase to their normal number. Another constant blood change was in the platelets. These elements would become enlarged and granular, as if undergoing hydropic degeneration. Réfik-Bey(49) cites quite similar observations on the blood changes in cattle suffering from rinderpest in Egypt.

TRANSMISSION EXPERIMENTS ON RINDERPEST

A series of experiments bearing on the subject of the transmission of rinderpest, designed to simulate natural conditions as nearly as possible, was performed by Ward, Wood, and Boynton.(13) In combating rinderpest, information concerning the length of time the virus remains active outside of the body under various natural conditions is of great importance in suggesting the measures to be employed in the field. Information concerning the period during the course of the disease when the virus is disseminated by the sick animals is of equal usefulness.

The literature on the disease consulted by us contains scanty and contradictory reference to these significant topics. Hutyra and Marek(14) give an extensive symposium on the views of various writers.

Réfik-Bey and Réfik-Bey(15) state the following: "Infected areas do not remain dangerous for long if we may believe our own observations. We regard rinderpest virus as essentially fragile and incapable of development in external media."

Edington(16) states: "Similarly the nasal mucus from a spontaneous case of rinderpest was found to lose its virulence very quickly if exposed to the air and kept for any period beyond 24 hours."

Stockman,(17) writing about the serum-alone method, observed: "The virulent material does not remain active for more than a day or two outside the animal body."

Yersin(18) states that two days of desiccation are sufficient to destroy the virulence of the blood.

Ruediger(19) states that pastures which have been occupied by sick animals may remain infected for months or even years.

In concluding our work, rinderpest virus was not shown to have survived beyond twenty-four hours in corrals bare of vegetation but containing water. The tests were made at all seasons of the year, with accompanying variation in sunlight, rain, and conditions of the soil; the amount of shade varied widely. Animals became infected in such corrals within half an hour, twelve hours, and seventeen and a half hours, respectively, after removal of the sick.

Animals infected with rinderpest, and also their blood, were shown to be capable of transmitting the disease by close contact only during the febrile period; however, during the convalescent stage, when the temperature was nearly normal, such transmission did not take place.

The virus in urine, diluted with water and sprinkled on grass, was in some instances demonstrated to survive for thirty-six hours, but not always. Fæces, mixed with water and sprinkled on grass, infected an animal twenty-four hours later. Fæces and urine, diluted with water and kept in a vessel in the shade, remained infective for thirty-six hours, but not longer.

No evidence was secured to show that recovered cases transmit the disease.

The foregoing facts indicate that the virus of rinderpest perishes soon after discharge by an infected animal.

ATYPICAL CASES OF RINDERPEST

Further information concerning the action of rinderpest virus was obtained accidentally in choosing for experiment a carabao in which the disease ran an atypical course.(20) The purpose of the experiment was to determine if the blood of an animal which had been inoculated with virulent rinderpest blood was infective before the donor presented the first symptom of disease; namely, a rise in temperature. An incubation period of five days was regularly observed in the animals inoculated with the virus used at the laboratory at this time. Blood was obtained from this animal at forty-eight, seventy-two, ninety-six, and one hundred twenty hours after it was injected. Each bleeding was injected into a susceptible animal. Since the donor did not develop a fever on the sixth day after injection, the daily bleeding was discontinued, as it was feared the carabao was immune. On the ninth day after injection, this carabao developed diarrhœa and presented congested eyes, and the animals that received the forty-eight and seventy-two-hour blood also began to manifest symptoms of rinderpest. On the eleventh day after injection, this carabao refused food. It was again bled and the blood injected into another animal. Susceptible animals were exposed in a small corral to the sick carabao on the eleventh, twelfth, and thirteenth days, although it had died on the night of the twelfth day.

Rinderpest was developed in all of the animals that received blood from this carabao, but not in those that were merely exposed.

It was concluded that an animal may experience a fatal attack of rinderpest without the occurrence of a rise in temperature.

The blood of this animal was shown to be infected within forty-eight hours after it was originally injected with virulent blood. It was also shown that the blood was virulent on the eleventh day when injected into a susceptible animal, yet exposure to this animal did not transmit rinderpest to a susceptible animal.

Regarding the three animals which failed to contract rinderpest by exposure, the question is raised as to whether this disease spreads by contact readily in the later stages or whether it must necessarily be accompanied by a rise of temperature before it can be so spread. Littlewood,(21) in Egypt, has observed that cattle imported from Asia Minor may not show clinical symptoms and yet at autopsy reveal lesions of rinderpest. Rickmann,(22) writing of rinderpest in German South Africa, refers to the fact that cattle and other animals may be infected to an imperceptible degree. Eggebrecht(23) observed in China that some animals infected with rinderpest show no visible sign of the disease beyond a rise of temperature to 40° C., or higher, for two days. Baldrey,(24) describing conditions in India, states that by long residence of an organism of contagious animal disease in one place, the disease becomes weakened in virulence to the animals of that locality. Thus, animals infected with rinderpest may act as carriers without showing symptoms.

CULTURE EXPERIMENTS FOLLOWING BALDREY'S TECHNIC

Important facts were observed concerning the virus of rinderpest in experiments which were carried out in an attempt to verify its cultivation(25) as described by Baldrey, who stated(26) that antirinderpest serum can be prepared by the inoculation of virulent blood diluted with broth. Also, it appears possible that an active toxin is produced and excreted into the broth by the rinderpest organisms contained in the virulent blood, and that by this means the results recorded are obtained.

This material, or probable toxin, is rapidly excreted and is so active that it appears quickly to inhibit any further growth of the rinderpest organism, destroying its virulence and finally killing it. The substance so obtained is very much more active than that obtained in virulent blood, so much so that it cannot be given subcutaneously with safety on account of the extreme inflamatory condition it sets up.

In our experiments, following Baldrey's technic, we found that rinderpest virus does die in Martin's broth culture after incubation for seventy-two hours, but there was no evidence that a toxin is formed. The experiments further revealed that the virus will survive in neutral or alkaline Martin's broth at 37° C. for at least forty-eight hours, but not for seventy-two hours. Two cases were tested at twenty-four, two at forty-eight, and three at seventy-two hours. Virus kept in acid Martin's broth or in 5 per cent potassium citrate solution did not survive after forty-eight hours at 37° C.

The principal phase which facilitated the development of the rinderpest vaccine was the fact that the virus survived longer in neutral or slightly alkaline medium than it did in an acid medium.

HISTORY OF RINDERPEST IN THE PHILIPPINES AND ITS CONTROL BY MEANS OF IMMUNIZATION, QUARANTINE, AND SLAUGHTER

At this point a partial review of the history and methods of handling rinderpest in the Philippine Islands will be given.

According to Youngberg(27) it is generally believed that rinderpest was introduced into the Philippine Islands in 1886 or 1887. It appears that the introduction was by means of carabaos imported from French Indo-China that were intended for breeding purposes. The disease spread to most parts of the Philippine Islands and caused enormous losses of cattle and carabaos. In many places, these losses were as high as 90 per cent. During 1901 and 1902, it is reported that 629,176 cattle and carabaos died of the disease.

In the Philippines, the severe epizoötics come in cycles of from eight to ten years. The first big wave was in 1887. The next, according to the most reliable information, was in 1897, and the third was well started in 1907. In 1916, the increasing death rate in provinces where the disease had been running a fairly mild course for several years gave indications that another big wave was forming.

During 1901 and 1902 the glycerine-bile method of producing immunity was tried to a limited extent. A serum laboratory was opened by the Board of Health and the production of antirinderpest serum was begun in August, 1902.

The problem in all rinderpest-infected countries was to find a method by which the cost of production of antirinderpest serum could be reduced.

Ruediger(28) found that he could increase the production of virulent material by giving peritoneal injections of normal salt solution, allowing it to remain for two hours before bleeding the virus animal to death, and then aspirating the saline solution from the peritoneal cavity.

Thomson,(29) to increase the production of virulent material, used normal salt solution peritoneal injections a short time before bleeding the animal to death, and then aspirated the saline solution from the peritoneal cavity.

Ward and Wood(30) found that the severity of the immunizing reaction could be controlled by the amount of serum employed, and that, while the serum from reactors is somewhat more potent than that from nonreactors, by increasing the dose of the nonreactor serum, the same results may be obtained. They further found that an animal may be immunized by simultaneous inoculation without showing either fever or symptoms. In later experiments and observations,(31) they show that it is not necessary to use hyperimmune serum at the immunization stations, and that potent serum can be obtained from animals which have just recently recovered from the disease. This method of obtaining serum for simultaneous immunizing purposes was used in the field for several years up to the time that the rinderpest vaccine began to be used.

Braddon(32) states that in South Africa the injection of uninfected animals with defibrinated blood from recently recovered pest cases was abandoned in favor of Turner's method of using serum from animals that had received successive and increasing doses of virus.

Turner(33) states that in the Transvaal and Natal an immune animal was injected with 100 cubic centimeters of virulent blood and was bled after all reactions had ceased. This blood, when defibrinated, was injected into a susceptible animal which was smeared on the muzzle with virulent material and placed with others suffering with rinderpest. This method of simultaneous inoculation, using blood prepared at the time, seems to have been abandoned in favor of a serum requiring more elaborate preparation.

Gibson(34) is the first writer who has questioned the necessity of hyperimmunizing serum-producing animals.

Shealy(35) makes a similar observation to the effect that the results obtained with the serum prepared from animals after recovery from an attack were found to be just as good as when the animal was not bled until it had been hyperimmunized.

Holmes(36) gives additional information regarding the overestimation of the value of serum from hyperimmunized animals. He concludes that the serum obtained after natural recovery or after an immunizing reaction is little inferior in potency to that taken after the process of hyperimmunization.

Topacio(37) gives a thorough description of the process of producing hyperimmune serum in the Philippines. He estimates that, as produced by the Bureau of Agriculture, it costs, delivered in the field, 24 pesos [1] (12 dollars) per liter. In the Transvaal, the cost was 25 pesos (12.50 dollars) per liter. The Bureau of Agriculture purchased serum from the Pasteur Institute at Nha-Trang, French Indo-China, at the rate of 47.89 pesos (approximately 23.95 dollars) per liter, and from the Experiment Station for Animal Diseases, Tokyo, Japan, for 34.40 pesos (17.20 dollars) per liter. With these prices, the least an animal could be immunized for was in the neighborhood of 8 pesos (4 dollars), and if it presented a severe reaction, the cost would amount to practically the price of a liter. In many instances, a liter of serum is required to save an animal. By using serum drawn from recently recovered animals, the cost is reduced to approximately 1.50 pesos (75 cents) per animal.

Kern(38) gives a thorough description of the precautions necessary to take in using antirinderpest serum in the field. He states that the animals that recover from attack of the disease produce a serum of varied degrees of potency, according to the reactions through which they pass during the disease. Those that present severe symptoms and high temperatures usually produce a serum of a very high potency, while that from those that pass through a mild form and run a low or no temperature is of less potency. He observed that carabaos produce a serum of higher potency than do cattle, probably due to the severe reaction suffered. It is found to be of highest potency about the ninth day after the animal recovers and gradually becomes less potent as the number of days increases until it is bled.

Nicolle and Adil-Bey(39) were the first to develop a method by which the virulent material could be increased. When an infected animal presented symptoms of diarrhœa, they introduced into the peritoneal cavity a mixture composed of three volumes of normal saline solution and one of a slightly alkaline solution of Martin's peptone. Six liters of this material were introduced into yearling cattle (the quantity varying according to the size of the animal). After three hours, the animals were bled to death, the peritoneal cavities were opened, and the fluid was aspirated. This was allowed to coagulate and the

[1] One peso Philippine currency is equivalent to 50 cents Unites States currency.

clear liquid was then drained off and used. The fluid that was thus obtained gave an increase in virulent material; this was used with success in hyperimmunization.

Ruediger (40) obtained similar results using a 5 per cent sodium citrate solution.

Holmes (41) diluted the virulent blood with an equal volume of potassium citrate solution and claims the diluted blood gave better results than undiluted defibrinated blood.

Martoglio (42) developed a method by which he claims to wash out the blood vessels and lymphatic system and to obtain a potent virus, increasing the virulent material about 70 per cent. His technic is as follows:

When the infected bovine presents the buccal lesions, usually at the end of the fourth or fifth day of the fever, less commonly at the end of the third, sixth, or seventh, it is immobilized in the stocks and intubed in the jugular and carotid on the same side. The jugular is put in communication with a capacious glass receptacle, placed on a level with the head of the animal and containing saline solution, sterilized, and held at a temperature of 38 to 39° C., leaving the outlet tube of rubber closed by compression of pincers. The carotid is put in communication with the receptacle that is to receive the pest blood, and the bleeding begins. When the convulsions preceding the death struggle begin, the bleeding should stop. The assistant shuts the tube for drawing the blood with a clamp and opens the tube admitting the sodium chloride solution; immediately the serious symptom-complex changes, the muscular contractions begin to cease, the respiration and pulse that were accelerated become regular, and the animal, when it has received about as much solution as it has lost blood, enters a period of calm.

We usually inject enough solution to make two and one-half times the volume of blood taken, without ill results. The operation over, the animal returns to its shed without assistance. After a lapse of about five or six hours, the animal is bled from the same carotid, this time until it dies.

Youngberg and Shaffer (43) used a simple method of slightly increasing the production of virulent blood as follows:

Two to 4 liters of blood are taken from the virus animal, depending upon its size, on the second day of fever. The animal is then allowed to stand overnight, during which time the body has an opportunity to replace the volume of blood lost. On the following day it is bled to death. In the final bleeding, practically as much blood in bulk is obtained as would be procured in a single bleeding, which gives an increase in virulent material corresponding to the amount obtained at the initial bleeding.

Boynton,(43) in his work on organ extracts from rinderpest-sick animals, has obtained a filtrate of extracts prepared from the organs of a Batanes bull (virus animal) after bleeding it to death for virus. The total virulent material obtained from this animal was 9 liters of blood and 11 liters of filtrate. He states further that, by combining this method with that of Martoglio,(42) the total output of virus from this one animal would reach 26,300 cubic centimeters, or three times the quantity an animal of this type would produce had it only been bled to death.

Immunization of cattle and carabaos against rinderpest in the Philippine Islands with the simultaneous method has produced good results in districts where the disease is purely enzoötic. Its use is dangerous in rinderpest-free areas or in localities where the infection has recently been introduced, because the immunization stations are a constant focus of infection.

The serum-alone treatment as a general field measure against rinderpest is expensive and inefficient, as the protection it affords is of short duration (from ten days to three weeks), after which period the animals are as susceptible to reinfection as they were prior to the serum treatment.

At stations where animals were being immunized, many instances have been noted of the introduction of other diseases, such as surra, Texas fever, and anaplasmosis,(44) through the use of virulent blood taken from an animal which was a carrier of one or more of these diseases.

The quarantine and slaughter method of eradicating rinderpest was used in a few instances. Thomson(45) states that the success in eradicating rinderpest from Davao was attributed to adequate laws and ordinances of the province, which, coupled with the influence of the officials, enabled them to maintain the necessary rigid quarantine and to accomplish the slaughter of infected and exposed animals.

Similar methods were used in some of the provinces in northern Luzon,(27) but without success, as the farmers, rather than have their sick and exposed animals slaughtered, would not report the disease, would hide the sick ones, and would slip those that had been exposed through the quarantine lines at night. As the Philippines, generally speaking, is an unfenced country, this was fairly easy to accomplish.

Quarantine, without slaughtering the sick and exposed animals, was extensively used in the Philippines with some good results. However, as soon as the quarantine was lifted, all the animals that had not passed through the disease were as susceptible to it as before and, in many instances, reinfection would occur and the quarantine would again be established. Such conditions were not satisfactory, either to the cattle owners or to the veterinarians in charge.

A STUDY OF THE VIRULENCE OF CERTAIN BODY ORGANS IN RINDERPEST

During January, 1917, experiments were started on the study of the virulence of body organs in rinderpest.(46) This work gave the first evidence of the possibility of developing a vaccine against that disease.

Since the virus of rinderpest could not be satisfactorily cultivated under artificial conditions, it was decided to try to extract it from the tissues of animals suffering from the disease. From the symptoms, lesions, and microscopical findings, it was evident that the virus attacked primarily the involuntary muscles, the endothelial lining of the capillary vascular system, and the parenchymatous tissue.

On reviewing the work accomplished up to this time, it was quite evident that the virus of rinderpest does not have its fountain head of development in the blood stream. The real place where it multiplies appears to be inside the tissue cells, where the disinfectants and drugs cannot penetrate, the virus in the blood stream being merely a surplus that is thrown off from these tissue cells. In following this line of reasoning it was decided to consider certain tissues, where lesions were more or less pronounced, as cultures, and extracts were made from them.

The tissues used were liver, spleen, lymph glands, heart, intestines, thymus, skeletal muscle, larynx, pharynx, and the base of the tongue. These tissues were taken from aniamls that were either bled to death for virulent blood or that had died after a regular course of the disease; they were taken as soon after death as possible. The amount of tissue desired was weighed and put through a meat grinder that had been previously sterilized to keep external contamination down to a minimum.

The material thus prepared was placed in a sterilized flask and twice as much phenol solution (the strength of which varied for different experiments) was added. Both crude phenol and the pure crystal form were used in these experiments with similar results. After preparation, the material was kept in the refrigerator, which averaged between 15 and 16° C., and it was thoroughly agitated two or three times daily. In some experiments, the material was placed in a shaking machine and agitated continuously for forty-eight hours at room temperature, which averaged 26° C. in the morning and 28° C. in the afternoon, some days rising to 30° C. It was then placed in the refrigerator for twenty-four hours, after which it was filtered through gauze to separate the coarse particles, and the filtrate was replaced in the refrigerator until used.

When the intestines were to be extracted, they were first thoroughly washed free from fæcal matter, then placed in a 5 per cent phenol solution for ten minutes, after which they were placed in a large container of boiled water which was cooled to at least 37° C. The tissue was allowed to soak in this water for a few minutes to dilute the phenol that remained intact. By this method a greater percentage of the bacteria on the surface of the intestinal mucosa was destroyed. Following this treatment, the tissue was weighed, passed through the meat grinder, and treated in a manner similar to the other tissue.

From the results obtained in these experiments, it was observed:

1. That water extracts of liver, spleen, and lymph glands, three days old, are highly infectious to susceptible animals.

2. That a 0.5 per cent phenol extract of liver, spleen, and lymph glands, five days old, is highly infectious to susceptible animals.

3. That a 0.5 per cent phenol extract of heart muscle, five days old, is highly infectious to susceptible animals.

4. That the skeletal muscle apparently is not suitable tissue for making extracts in the case of rinderpest.

5. That a 0.5 per cent phenol extract of liver, spleen, and lymph glands can hold the virus of rinderpest in virulent form for periods of time varying from eight to fifty-five days.

6. That a 0.5 per cent phenol extract of cæcum and colon, five days old, is highly infectious to susceptible animals.

7. That the larynx, pharynx, and base of the tongue are not suitable tissue for making extracts in the case of rinderpest.

8. That the pancreas is not a suitable tissue for making extracts in the case of rinderpest.

9. That a 1 per cent phenol extract of lymph glands, six, seventeen, and twenty days old, is highly infectious to susceptible animals.

10. That a 1 per cent phenol extract of liver, spleen, cæcum, and lymph glands, seventeen days old, is highly infectious to susceptible animals.

11. That a 1 per cent phenol extract of liver, twenty-one days old, is highly infectious to susceptible animals.

12. That a 1 per cent phenol extract of spleen, twenty-one days old, is virulent to susceptible animals.

13. That a 2 per cent phenol extract of spleen, five days old, is infectious to susceptible animals.

14. That when glycerine is added to a 2 per cent phenol extract that has been agitated for forty-eight hours, the virus of rinderpest is readily destroyed.

15. That in a 2 per cent phenol extract of lymph glands, eight days old, the virus of rinderpest is destroyed.

16. That the tissues best adapted for this work are the liver, spleen, lymph glands, heart, fourth stomach, cæcum, and colon.

17. That the virus in virulent rinderpest blood is readily destroyed when it is handled in a manner similar to the tissues.

In performing these experiments, we obtained some very gratifying results with old extracts. On these occasions, the animals presented no reaction to the injection. After a period of two weeks they were exposed to rinderpest by contact with sick animals, by inoculation with virulent blood, and by inoculation with extracts. No ill effects resulted from the exposures to which they were subjected, showing that they had been immunized by the primary injection of extract.

The fact was established that animals highly susceptible to rinderpest could be immunized against the disease without developing any of the severe reactions that frequently accompany the simultaneous method of immunization; also, that a solid immunity was produced as the experimental animals underwent the most severe exposure to the disease.

PROGRESS IN DEVELOPING THE RINDERPEST VACCINE

Our problem was to develop a method by which this material could be produced with regularity. From our observations, we decided to use the liver, spleen, and lymph glands as the most suitable tissues. These were ground, extracted in a 0.75 per cent phenol solution, and kept in the refrigerator for thirty days. In some instances, we obtained good results; in others, the material was either inert or still virulent. We finally used 0.85 per cent sodium chloride solution instead of distilled water in preparing the phenol solution. After numerous experiments, it was also decided to titrate the carbolized salt solution to a point where it was slightly alkaline to litmus. Our next step was to obtain as much of the parenchymatous tissue as possible in the extract. To this end the tissue, after being passed through the meat grinder, was placed with sterilized sand in a mortar and thoroughly ground. Two parts of phenolized salt solution to one part of tissue were added, thoroughly mixed to bring the tissue into suspension, and allowed to stand for a few minutes to permit as much of the sand as possible to settle, after which the supernatant material was strained through gauze. The fluid, intermixed with the dismembered parenchymatous tissue, was passed through the gauze, while the connective tissue was held back. The filtrate was kept to be used in immunization experiments.

As the work developed, it was found that the best results were obtained from tissues taken from animals in the early stages of the disease, about the third day of fever, at the onset of diarrhœa. It was also observed that, by using salt solution instead of distilled water, the virus retained its virulence for a longer period. We had to hold the material for from sixty to seventy days before it was safe to use it.

The next problem was to shorten the time of preparing this prophylactic material, which was accomplished by using a simple type of shaking machine in which the material, placed in bottles, was agitated for forty-eight hours at room temperature. During the hot months of the year, it was found necessary to abandon the preparation of the material at ordinary room temperature, and a satisfactory place was found in the hallway of the ice and cold-storage plant of the Philippine Government, where a fairly even, cool temperature was maintained. From our observations on the influence of temperature, it was decided to heat the material to 44° C. in a water bath for three hours before agitating it in the shaking machine. During these experiments, it was also noticed that much better results were obtained when the material was kept in amber-glass bottles.

Up to this point we had made wonderful strides although the work had consumed the better part of two years. The material taken from an animal during the early stages of the disease, finely ground, suspended in either 0.5 or 0.75 per cent carbolized physiological salt solution which was faintly alkaline to litmus, strained through gauze to get rid of the connective tissue, placed in amber-glass bottles, heated to 44° C. for three hours in a water bath, and agitated for forty-eight hours in a cool room or at room temperature during the cool months of the year, could be used as soon as the process was completed. This product gave excellent and quite uniform results, but retained its immunizing properties for a short time only.

Since glycerine is used in preserving smallpox vaccine virus, we decided to add it to this material and found, after several trials, that it titrated to a point where it was slightly alkaline to litmus and, added in proportion of one part glycerine to three parts carbolized 0.85 per cent sodium chloride solution, enhanced the keeping quality of the material to a marked degree. It is of great importance to use only the best grade of glycerine as the inferior grades soon undergo changes and cause rapid deterioration of the material to which it is added. By the addition of glycerine, we were able to preserve this material in potent form for from five to six months when stored in the refrigerator in tightly stoppered bottles.

One of the problems that confronted us was to devise a method by which the tissue could be ground to a fine consistency without the use of the mortar and sand, as it was practically impossible to obtain a filtrate free from sand after passing it through this process and, in many instances, unsatisfactory results had been experience on this account.

In 1919, while the writer was in the United States, various supply houses were visited in search of some type of mill which would grind the tissues to the proper consistency. We explained our needs to Mr. Robertson Matthews, who was at that time assistant professor of mechanical engineering at Sibley College, Cornell University, and he immediately designed and made a tissue mill that produced the desired results. This mill both cuts and macerates, thereby breaking the tissue into minute elements. By this method we obtained a larger amount of vaccine material and a purer product, since it was free from sand and other contaminating material encountered in the mortar process.

TESTING FOR THE PRESENCE OF AGGRESSINS

The question then arose as to whether we were dealing with an aggressin or a vaccine. We had observed on numerous occasions that, if an animal in the incubation period of rinderpest or in the early stages of the disease was injected with this material, the disease was greatly aggravated and ran a rapid and fatal course.

Through the courtesy of Director E. D. Merrill and the assistance of Dr. Otto Schöbl and Mr. A. H. Wells, of the Bureau of Science in Manila, some of the material was run through a Sharpless centrifuge, by which method the liquid and the solid components were separated. On testing these separate products, it was found that the liquid constituent had no immunizing power, while the solid component, made up of the parenchymatous tissue, was potent and gave excellent results. It was, therefore, quite definitely settled that we were dealing with a vaccine or modified virus in the tissues and not with an aggressin. We also observed that the vaccine held its potency somewhat longer when separated from the liquid and that the protecting dose was considerably smaller. With the former material, the immunizing dose was 50, 100, or 150 cubic centimeters, depending upon the size and age of the animal. With the separated tissue, however, we found that 2 grams suspended in 35 cubic centimeters of a glycerinated diluting fluid, administered in two weekly doses, gave excellent results.

We then performed an experiment in which we followed Bail's technic(50) for using exudates from an animal to produce serous aggressins. It was noticed on numerous occasions that, if a large amount of virulent tissue extract (1 liter or more) was injected subcutaneously into an animal, in one or two days an œdematous swelling would develop on the pendant portion of the chest and belly, such swelling being filled with a clear, straw-colored, serous exudate. A susceptible animal was inoculated with virus and, at the first symptom of rinderpest (a rise in temperature), it was injected subcutaneously on both sides of the body with 2 liters of freshly prepared virulent tissue extract. In two days, confluent œdematous swellings were observed along the pendant portion of the body; this was at the most virulent stage of the disease, the third day after the initial rise in temperature. The animal was then killed, the œdematous tissue procured, and the liquid expressed by the aid of a meat press. To this fluid was added enough phenol, drop by drop, to make a 0.5 per cent dilution of the entire solution. In order to prevent precipitation, the solution was agitated continually and then heated to 44° C. for three hours in a water bath. This solution was used in 5- and 10-cubic-centimeter doses on a few animals. Upon exposure to infection they showed a slight reaction followed by prompt recovery, indicating that the protection afforded by this material was not as complete as the immunity produced by the vaccine. Whether we were dealing with an aggressin in this instance or with a modified virus is an unsettled question. Since such a small amount of this material could be obtained from an animal and since it was not as effective for immunization purposes as were the tissue extracts, this line of experimentation was discontinued.

In searching for a simpler method of preparing a more-potent vaccine with better keeping qualities, it was decided to use the blood from the virus animals with the tissue and to use less sodium chloride solution. By this procedure the amount of virus was increased, and the vaccine was preserved in its normal medium. With this advance the Sharpless centrifuge was no longer necessary.

PREPARATION OF THE RINDERPEST VACCINE

The final procedure in preparing the rinderpest vaccine was as follows:

A highly susceptible animal was infected with the disease by injecting it with virulent blood, and was kept under close observation. As soon as symptoms of diarrhœa developed, which was usually on the third or, in some cases, the fourth day after the initial rise in temperature, it was bled to death and the blood retained in a sterile container. The animal was skinned and washed with a good disinfectant solution to keep external contamination down to a minimum. It was then eviscerated and all the lymph glands, spleen, liver, heart, kidneys, and testicles were placed in sterile containers and transferred to the laboratory. The fat, heavy connective tissue, and fascia were removed from these organs, which were washed in sterile water and, in order to destroy any contaminating organisms that might have been deposited during handling, were placed for ten minutes in a 5 per cent solution of phenol, after which they were again washed with sterile water to remove any excess solution. They were then cut into small pieces, passed through a meat grinder, and this finely ground material was further ground in the Matthews's tissue mill. To obtain the maximum results, it should be ground in this mill two or three times. The grinding process was facilitated by the addition of blood from the animal, and a small amount of sterile glycerinated salt solution (glycerine, 1 part, and 0.85 per cent sodium chloride, 2 parts, titrated to p_H 7.6–7.8) may also be added for this purpose; care should be taken to use no more than is necessary, however. The macerated material was next strained through a 1/12-inch-mesh wire screen (a finer mesh may be used; a coarser one, however, is not advisable) which retained the connective tissue and coarser elements and allowed only the parenchymatous tissue to pass, and this was saved for vaccine.

Pure phenol to make a 0.5 per cent suspension in the mixture was added to an amount of sterile glycerine, p_H 7.8, equivalent to one-third the weight of the tissue. This phenol-glycerine and the tissue material were then thoroughly mixed to insure uniform consistency; for example, to 900 grams of tissue, 300 cubic centimeters of glycerine and 6 cubic centimeters of phenol would be added. The resulting material was then poured into slender-bodied, amber-glass bottles to about five-sixth of their capacity, and the cotton plugs replaced. The type of bottle used at the Veterinary Research Laboratory at Pandacan, Manila, was of 500-cubic-centimeter capacity, although the 450-cubic-centimeter amber-glass lysol bottle is also suitable for this work. The greatest care must be exercised to prevent any of this highly virulent material from coming in contact with the inside surface of the neck of the bottles or from splashing above the point to which the bottles are filled.

The filled bottles were placed in an electrically heated water bath. It is best to have the bottles immersed to their necks, as the water must reach well over the level of the tissue mixture. When all the bottles were in the bath, the electricity was turned on and the temperature of the water brought to 42 to 42.5° C. When the 42° mark was reached, the time was noted and the water bath held at the temperature as above stated (42 to 42.5° C.) for three hours, when the bottles were taken from the bath and the contents of each emptied into a large sterile container. The material was again thoroughly mixed by agitating it for two or three minutes to insure as nearly as possible the same degree of potency in each cubic centimeter. Fresh sterile bottles were filled with the vaccine and stoppered with tightly fitting corks. This concentrated rinderpest vaccine must be stored in a refrigerator or good ice box until it is used.

Although the liver, heart, kidneys, and blood contain an abundance of virus, they are not suitable tissues when used separately or collectively; but, when added to the lymphatic tissues and spleen, they form a vehicle which increases the yield of vaccine to a marked degree. By the addition of these organs, the average virus animal furnished approximately 6,000 cubic centimeters of vaccine.

VARIATIONS IN THE STRENGTH OF THE VACCINE

Variations in the strength of the vaccine can be produced as follows:

1. By heating the material to 41.5° C. for three hours; however, the effect of this upon an animal is likely to be a more or less severe reaction. If such material is stored in a refrigerator for three or four months, age will gradually attenuate it, rendering it safe for use.

2. By heating the material from 43.5 to 44° C. for three hours. Vaccine prepared in this manner can be used soon after its preparation, but it loses its potency more rapidly and larger doses are required.

3. By holding the temperature between 44 and 45° C. for three hours. This is likely to destroy the potency of the vaccine.

METHOD OF TESTING AND ADMINISTERING THE VACCINE

Each lot of vaccine must be tested on highly susceptible animals before it is used in the field.

With a potent vaccine, 2 cubic centimeters of the concentrated material are sufficient for fully developed cattle and carabaos. Each dose is diluted to 20 cubic centimeters in a sterile diluting fluid, composed of two parts 0.85 per cent sodium chloride solution and one part glycerine, and titrated to p_H 7.8. The area is disinfected and the injection of 20 cubic centimeters is made on either side of the animal, preferably over the ribs. This amount is used as, with massage, it insures a good spread of the diluted vaccine under the animal's skin and thereby facilitates rapid absorption. The needle puncture is painted with either dilute pine tar or tincture of oidine.

Seven days after the first vaccination, a second injection is given on the opposite side of the body. The dose of concentrated vaccine may be increased to 3 or 4 cubic centimeters. A week following the second treatment, the animal may be exposed to rinderpest by placing it in direct contact with others sick with the disease and by giving it a subcutaneous injection of from 5 to 10 cubic centimeters of virulent blood. When the test animal passes through these exposures without developing any signs of infection, the vaccine is considered effective and may be used in the field; the dosage is 2.5 to 3 cubic centimeters of the concentrated material.

If the test animal gives a slight reaction to the above-mentioned exposures, the field dose should be raised to 5 or 7 cubic centimeters of the concentrated vaccine. No set rule can be given as to the exact size of the dose; however, the person preparing such material soon develops ability, from experience and observation, to estimate the amount which should be used of the different lots of vaccine as they are tested out. Moreover, rinderpest vaccine loses its potency with age. If a lot, potent in 2-cubic-centimeter doses at two months of age, is held for four or five months, it may be necessary to raise the dose to 5 or 7 cubic centimeters to obtain the same protection. The vaccine has no curative effect on an animal sick with rinderpest or in the incubation period of that disease. It is a purely prophylactic treatment.

LENGTH OF IMMUNITY DEVELOPED BY THE VACCINE

The length of immunity developed by the vaccine is not definitely known. From field observations, it has been noticed that, with animals receiving three treatments of potent vaccine, the protection has lasted for three years and even longer. Several of our test animals were immune to rinderpest after four and a half years. With our present knowledge, however, it would be advisable to revaccinate full-grown animals every two years. Calves should be revaccinated the following year and every two years after that time. Our experience in the Philippines has taught us that young animals, no matter by what method they are immunized, have a tendency to outgrow their immunity.

METHOD OF USING VACCINE IN INFECTED AREAS

When the vaccine is used in infected areas, we have found that it is helpful to apply general quarantine measures. The owners of animals will submit them for treatment more readily in order to hasten the lifting of the quarantine. It is also easier to keep track of the animals and to know that they return for their second vaccination, or third if the necessity arises.

We have had splendid success in smothering the disease on numerous occasions by the combined use of vaccine and quarantine. Areas have been declared free from rinderpest in which it had been considered enzoötic and all other methods of combating the disease had been resisted.

Care should be exercised not to vaccinate any animal that is sick or in the incubation period. The vaccine will only aggravate the disease in such instances and will be considered responsible for the death of the animal. We found it a wise procedure, when working in such localities, to take the temperature of all animals before they were vaccinated. Any animal with a high temperature should be rejected, for undoubtedly such a one under these conditions is developing the first symptom of rinderpest.

RESULTS OF THE USE OF VACCINE ON VARIOUS BREEDS OF CATTLE

The vaccine was used with success not only on Philippine cattle and carabaos but also on cattle imported from the United States and Australia for dairy and breeding purposes. We have vaccinated Herefords, Ayreshires, Jerseys, Guernseys, Holsteins, and mixed breeds. Many of these animals came from areas free from Texas fever. It would have been impossible to immunize them by the simultaneous method, as practically all the animals used for virus are carriers of that disease and it would be transmitted in the virulent blood. There is, however, a possibility that carabaos do not contract or transmit Texas fever. This is a problem that should be investigated. Carabaos are evidently resistant also to anaplasmosis,(44) a disease quite similar to Texas fever.

Rinderpest vaccine was used with equally good results on animals at the Canton Christian College in Canton, China, and at the Hongkong Dairy Farm, Hongkong, China.

COST OF IMMUNIZATION BY THE VACCINE METHOD AS COMPARED WITH OTHER METHODS

In figuring the cost of immunizing animals by this vaccine method, estimates were made of the purchase price and maintenance of the animals used to furnish material for the vaccine, the chemicals, and the labor of producing and administering the vaccine and its transportation. When a large number of animals were treated at one locality, the cost amounted to approximately six centavos, or three cents gold, per animal. This is an enormous saving as compared with the prices cited above for either reactor or hyperimmune serum used in the simultaneous method of immunization.

Not only is the low cost of immunization by the vaccine treatment to be considered, but also the economy of time and animal labor to the owner. Animals immunized by the simultaneous method must be taken to an immunizing station where they are kept under observation throughout the process, which lasts three weeks or longer, depending upon the severity of the reaction. During this period, the owners are responsible for their maintenance, which is quite a problem in many instances. With the vaccine treatment, the animals remain at home and may be worked every day or used for any purpose the owner may desire, without detriment to the animal or the type of immunity developed.

When animals to be vaccinated were not too far from the laboratory, the vaccine was diluted ready for use and placed in thermos bottles. By this means the vaccine was kept cool and would not deteriorate for at least thirty-six hours. When, however, the animals were at a considerable distance from the laboratory, or on other islands of the Philippine group, it was found best to ship the concentrated vaccine, well packed in ice, to a central point in that locality where ice could be obtained. A temporary laboratory was installed, where the vaccine was diluted ready for use, placed in thermos bottles, and shipped out. By this means we were always sure of using a freshly prepared vaccine.

RINDERPEST VACCINE DEVELOPED BY OTHER INVESTIGATORS

Kakizaki, Nakanishi, and Oizumi,(47) investigating rinderpest in Korea, have developed a vaccine for which they claim good results. Their technic in some respects differs from the method described in this paper, although the principles involved are practically the same. Many of their observations are quite similar to ours. They found the tonsils to be the most satisfactory tissue for vaccine material; that made from the lymph glands seemed to be somewhat inferior. Apparently the only tissues they used were the tonsils, lymphatic glands, and possibly the spleen, which made their output from each animal small. They claimed a period of preservation for their vaccine of from two and a half to three and a half years, which is longer than we were able to preserve a potent vaccine made from a mixture of the various organs mentioned in our technic.

In the April number of the Journal of the American Veterinary Medical Association for 1927, it is reported that Maj. R. A. Kelser,(48) who is now stationed in the Philippines, is making further developments in perfecting rinderpest vaccine. No details of his method are given; therefore, no comment can be made. It is gratifying, however, to learn that our years of labor and observation have contributed to further success along this line.

A full report of the technic of preparing and administering the rinderpest vaccine as described in this paper was delivered to the Director of the Bureau of Agriculture, Philippine Islands, on March 10, 1924, to be filed as a ready reference for the continuation and further development of the vaccine method of immunizing animals against rinderpest.

Kakizaki, Nakanishi, and Nakamura,(54) in their later report, find that by combining such organs as the spleen, lymphatic glands, thymus, and tonsils, a more economical and potent rinderpest vaccine can be produced. They also added lung tissue to some of their preparations, but found it less efficacious than those lacking it. They state further: "It will be worthy of note that, by employing the combination method, the preparation of vaccine was highly improved, and the quantity of vaccine which can be prepared from one calf was amounted up to twice as much as before. For this reason we should like to designate the vaccine prepared by the combination method as 'the economical rinderpest vaccine'."

MISCELLANEOUS

The observations on the plurality of the virus of foot-and-mouth disease made by Valleé and Carré,(51, 52) and confirmed by Olitsky, Schoening, and Traum(53) in their reports on the study of foot-and-mouth disease and vesicular stomatitis in Europe, are of great importance. Their citations bring to mind some difficulties we had in making a potent rinderpest vaccine from the tissues of animals imported from Indo-China. Shipments of cattle and carabaos were landed at the quarantine station at Pandacan, Manila, that frequently were infected with rinderpest upon arrival, many of the animals being in such condition that they had to be slaughtered. On several occasions tissues were procured from these animals and vaccine prepared from them. In none of the trials, however, were we able to produce a vaccine that would protect animals against the virus we were using at the laboratory, and we concluded that the imported animals were too far advanced in the disease to produce vaccine, as we had learned from previous experience that the best vaccine is obtained from tissues taken from animals in the early stages of rinderpest. Since the results obtained by Olitsky, Schoening, and Traum, however, we must consider the possibility that these animals were infected with a strain of rinderpest virus which would not immunize them against the strain of virus with which we were working in the Philippine Islands. Further work along these lines is necessary before definite conclusions can be formed.

Before leaving the Philippine Islands, we prepared some virulent rinderpest material, composed of liver, spleen, lymph glands, heart, and blood, obtained from an animal in the early stages of the disease. This material was put through the Matthews's tissue mill, and one-third per weight of glycerine p_H 7.8 and enough phenol to bring the entire bulk to 0.5 per cent were added. This material was bottled, tightly corked, and placed in the refrigerator, where it was kept for virulence tests. A letter from Doctor Patdu stated that he had tested this material at various intervals and had killed five test animals with it. He found it still virulent at the end of 271 days. Just how long it remained virulent, however, is not known, as the experiment was interrupted by the untimely death of Doctor Patdu.

CONCLUSIONS

1. From years of observation and the large number of animals that have been protected, it is evident that a potent vaccine against rinderpest can be made from certain body organs of animals suffering from this disease.

2. The lymphatic tissues are of primary importance as components of this vaccine.

3. Although the liver, heart, kidneys, and blood contain an abundance of virus, they are not suitable, either separately or collectively, for the production of vaccine; but, when these tissues are added to the lymphatic tissues, a potent vaccine can be produced from the entire mass.

4. The virus of rinderpest is thermolabile, and a temperature of over 44° C. is detrimental to the vaccine if such temperature is held for any length of time.

5. Animals immunized by the vaccine treatment do not undergo any noticeable systemic reaction. They can be worked

every day and cohabit with susceptible animals without detriment to themselves or to the animals with which they come in contact.

6. In the neighborhood of 6,000 cubic centimeters of vaccine can be obtained from one virus animal. This amount is sufficient to protect one thousand or more animals, depending on the titration of the vaccine. Thus, by the vaccine treatment, we have developed a safe and inexpensive method of protecting animals against rinderpest.

7. In using the vaccine in rinderpest-infected areas, it is essential to combine the vaccine treatment with quarantine measures.

8. When vaccine is applied to animals in rinderpest-free areas, there is no need of the enforcement of quarantine.

9. It is advisable to have all animals revaccinated every two years.

10. By the use of the vaccine, rinderpest has been eradicated from certain localities in the Philippine Islands, where the disease had resisted all other measures of control.

REFERENCES

1. BOYNTON, WILLIAM HUTCHINS.
1917. Experiments on the treatment of rinderpest with various drugs. Philip. Agr. Rev. **10**: 272; also Philip. Journ. Sci. § B **13** (1918) 95–121.

a. LAMBERT.
1916. The comparative resistance of bacteria and human tissue cells to certain common antiseptics. Journ. Exp. Med. **24**: 683.

b. RUSSELL.
1914. The effect of gentian violet on Protozoa and on tissues growing in vitro, with special reference to the nucleus. Journ. Exp. Med. **20**: 545.

c. WALKER.
1912. The treatment of rinderpest and haemorrhagic septicaemia with permanganate of potash. Journ. Comp. Path. and Therap. **25**: 185–202.

2. BOYNTON, WILLIAM HUTCHINS.
1913. Duration of the infectiveness of virulent rinderpest blood in the water leech, Hirudo boyntoni Wharton. Philip. Journ. Sci. § B **8**: 509–521; also Bull. Philip. Bur. Agr. **29**.

3. BASS and JOHNS.
1912. The cultivation of malarial plasmodia (Plasmodium vivax and Plasmodium falcifarum) in vitro. Journ. Exp. Med. **16**: 567.

4. LAVERAN and MESNIL.
   1907. Trypanosomes and trypanosomiases. Translated by Navarro. Bailliere, Tindall and Cox, London 495.

5. VASSAL, J. J.
   1906. Ann. d. l' Inst. Pasteur **20**: 256–295.

6. DANIELS and ALCOCK.
   1910. Tropical medicine and hygiene, Pt. **2**: 180.

7. NENCKI, M., N. SIEBER, and W. WIJNIKEWITCH.
   1898. Recherches sur la peste bovine. Arch. Sci. Biol. St. Petersburg **6**: 379.

8. NENCKI, M., N. SIEBER, and W. WIJNIKEWITCH.
   1896. Arch. Sci. Biol., St. Petersburg **4**: 374–396.

9. BOYNTON, WILLIAM HUTCHINS.
   1914. A preliminary report of experiments on the cultivation of the virus of rinderpest in vitro. Philip. Journ. Sci. § B **9**: 39–44.

10. BRADDON, W. LEONARD.
    1913. Some peculiar and probably specific bodies in the erythrocytes in rinderpest and another allied disease. Parasitology **6** No. 3; 265–275.

11. TARTACOVSKY, M. M.
    1896. Contribution à l'étiologie de la peste bovine. Arch. Sci. Biol., St. Petersburg **4**: 295–327.

12. KOCH, R.
    1897. Berichte des Herrn Prof. Dr. Koch über seine in Kimberley gemachten Versuche bezüglich Bekämpfung der Rinderpest. Vet. Journ. **45**: 204.

13. WARD, ARCHIBALD, R., FREDERICK WILLIAM WOOD, and WILLIAM HUTCHINS BOYNTON.
    1914. Experiments upon the transmission of rinderpest. Philip. Journ. Sci. § B **9**: 49–79; also Bull. Philip. Bur. Agr. **30**.

14. HUTYRA and MAREK.
    1910. Spezielle Pathologie und Therapie der Haustiere. G. Fischer, Jena.

15. RÉFIK-BEY and RÉFIK-BEY.
    1899. La peste bovine en Tueque. Ann. d. l' Inst. Pasteur **13**: 596.

16. EDINGTON, A.
    1899. A retrospect of the rinderpest campaign in South Africa. Lancet **1**: 357.

17. STOCKMAN, S.
    1903–04. Report on work of Veterinary Department since May, 1903. Ann. Rpt. Transvaal Dept. Agr. 67.

18. YERSIN, A.
1904. Étude sur quelques epizootics. Bull. Économ. n. s. **6**: 241.

19. RUEDIGER, E. H.
1909. Observations on cattle plague in the Philippines and the methods employed in combating it. Philip. Journ. Sci. § B **4**: 381.

20. BOYNTON, WILLIAM HUTCHINS.
1914. An atypical case of rinderpest in a carabao. Philip. Journ. Sci. § B **9**: 45–47.

21. LITTLEWOOD, W.
1905. Cattle plague in Egypt in 1903–04–05. Journ. Comp. Path. and Therap. **18**: 312.

22. RICKMANN, W.
1908. Tierzucht und Tierkrankheiten in Deutsch Südwest Africa 156.

23. EGGEBRECHT, M.
1910. Untersuchung über die Rinderpest in Ostasien. Zeitschir. f. Infektionskrankh. Haustiere **7**: 54.

24. BALDREY.
1912. Climatic influence upon the incidence of disease. Agr. Journ. India **7** pt. III: 294.

25. BOYNTON, WILLIAM HUTCHINS.
1914. Experiments on the cultivation of rinderpest virus as described by Baldrey. Philip. Journ. Sci. § B **9**: 259–268.

26. BALDREY.
1911. Journ. Trop. Vet. Sci. **6**: 251.

27. YOUNGBERG, STANTON.
1922. A brief history of rinderpest in the Philippine Islands. Philip. Agr. Rev. **15** No. 3: 205.

28. RUEDIGER, E. H.
1908. Filtration experiments with the virus of cattle plague. Philip. Journ. Sci. § B **3**: 165.

29. THOMSON, C. G.
1909. Anti-rinderpest serum, its production and use. Philip. Agr. Rev. **2**: 672–673.

30. WARD, A. R., and F. W. WOOD.
1912. Experiments on the efficiency of anti-rinderpest serum. Bull. Philip. Bur. Agr. **19**.

31. WARD, A. R., and F. W. WOOD.
1914. Simultaneous method of inoculating cattle and carabaos with serum from animals that have been recently immunized. Philip. Journ. Sci. § B **9**: 125–133.

32. BRADDON, W. LEONARD.
1902. Report to the government of Negri Sembilan on an experimental investigation into the methods of protection of buffaloes and cattle against rinderpest. Kuala Lumpur.

33. TURNER, G.
1906. Rinderpest in South Africa. Journ. Trop. Vet. Sci. **1**: 269.

34. GIBSON, ADAM.
1910. A method of dealing with rinderpest in the field. Journ. Trop. Vet. Sci. **5**: 23.

35. SHEALY, A. S.
1910. Some facts and ideas about rinderpest and their relation to the Philippines. Proc. Am. Vet. Med. Assoc. 397.

36. HOLMES, J. D. E.
1913. Rinderpest. Further investigations on questions connected with the economical production of antiserum. Memo. Dept. Agr. India Vet. Series **2**: 2.

37. TOPACIO, TEODULO.
1922. The manufactory of anti-rinderpest serum in the Philippine Islands. Philip. Agr. Rev. **15** No. 3: 229–236.

38. KERN, H. F.
1922. The use of anti-rinderpest serum in the field. Philip. Agr. Rev. **15** No. 3: 241–245.

39. NICOLLE and ADIL-BEY.
1901. Études sur la peste bovine. Ann. d, l'Inst. Pasteur 715.

40. RUEDIGER, E. H.
1908. A reduction in the cost of anti-cattle plague serum. Philip. Journ. Sci. § B **3**: 407.

41. HOLMES, J. D. E.
Experiments carried out to test the susceptibility of cattle from several districts in India and on improved methods of rinderpest serum production. Indian Civ. Vet. Dept. No. 3: 98–205.

42. MARTOGLIO, F.
1915. On the technique for the production of serum against rinderpest. Utilization of the liquid of (blood) vessel lavage as antigen. Memoir of the Eritrea Sero-Vaccine Inst. Asmara, No. 1.

43. BOYNTON, WILLIAM HUTCHINS.
1918. Note on the use of organ extracts in place of virulent blood in immunization and hyperimmunization against rinderpest. Philip. Journ. Sci. § B **13**: 152.

44. BOYNTON, WILLIAM HUTCHINS.
1922. Further notes on anaplasmosis in cattle in the Philippine Islands. Philip. Agr. Rev. **15** No. 3: 218–228.

45. THOMSON, C. G.

1911. Report on the recent outbreak of rinderpest in the District of Davao, Mindanao. Philip. Agr. Rev. 4 No. 5: 243–247.

46. BOYNTON, WILLIAM HUTCHINS.

1917. Preliminary report on the virulence of certain body organs in rinderpest. Philip. Agr. Rev. 10: 410; also Philip. Journ. Sci. § B 13 (1918) 127–150.

47. KAKIZAKI, CHIHARU, SCHUNZO NAKANISHI, AND TAKASHI OIZUMI.

1926. Experimental studies on prophylactic inoculation against rinderpest. Report III. Journ. Jap. Soc. Vet. Med. 5 No. 4: 221–276.

48. KELSER, R. A.

1927. Rinderpest vaccine developed. Journ. Am. Vet. Med. Assoc., n. s. 24 No. 1: 97.

49. RÉFIK-BEY.

1902. Modifications leucocytaires dans la peste bovine. Ann. d. l'Inst. Pasteur 16: 163.

50. BAIL.

1914. Immunity, methods of diagnosis and therapy and their practical application- by Julius Citron, translated by A. L. Garbat. Aggressive Immunization, second edition 36.

51, 52. VALLÉE, H., and H. CARRÉ.

1922. Sur la pluralité des virus aptheux. Comptes Rendus de l'Academie de Sciences 174, 3: 207, also 1498.

53. OLITSKY, P. K., HARRY W. SCHOENING, and JACOB TRAUM.

1927. Summary of the observations of the Commission to study foot and mouth disease. North Am. Vet. 8 No. 2: 42–47.

54. KAKIZAKI, C., S. NAKANISHI, and J. NAKAMURA.

1927. Experimental studies on the economical rinderpest vaccine. Journ. Jap. Soc. Vet. Med. 6 No. 2: 107–120.

233980——3

ILLUSTRATIONS

PLATE 1

FIG. 1. Passing the ground up tissue through the Matthews's tissue mill. All the bottles, the implements, and the tissue mill are throughly sterilized before being used.

2. Passing the ground up and mascerated tissue through the wire strainer. The strainers fit inside the large funnels. The material to be saved for vaccine passes into the large bottles. All implements are throughly sterilized before being used.

PLATE 2

FIG. 1. Filling the amber-glass bottles with the virulent tissue mixture. Care must be taken that none of this virulent material splashes onto the inside of the neck or the unfilled portion of the bottles.

2. Heating the vaccine in the electric water bath. The level of the water should stand halfway on the necks of the bottles to make sure that the vaccine gets the full benefit of the heat.

PLATE 3

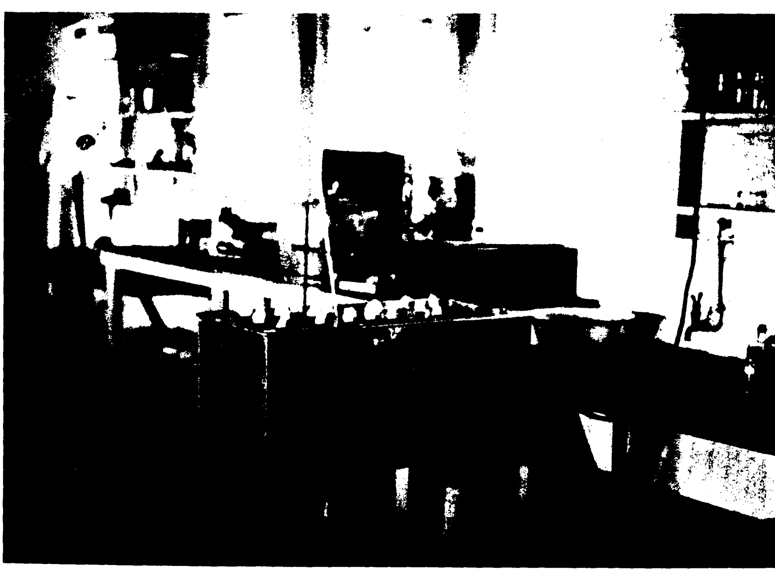
The method of administering the rinderpest vaccine.

1

2

PLATE 1.

1



2

PLATE 2.

PLATE 3.

LARVAL TREMATODES FROM PHILIPPINE SNAILS

By MARCOS A. TUBANGUI

Of the College of Veterinary Science, University of the Philippines Los Baños

FIVE PLATES

The larval trematode fauna of the Philippine Islands has not been investigated previously; yet, there are in this country several species of adult trematodes long known to be parasitic in man and in some of the domesticated animals. Among the most important of such trematodes may be mentioned *Schistosoma japonicum, Paragonimus westermanii,* and *Fasciola hepatica.* Although the modes of development of these parasites are already known in other countries, where they also occur, in the Philippines their molluscan intermediate hosts remain to be determined. There are, therefore, two reasons which led to the inquiry reported in this paper: first, to fill up partially the gap existing in the recorded fauna of the Islands; and, second, to make use of the results of the inquiry as a basis for future attempts to find out the life histories of some of the Philippine flukes.

The following, widely distributed, fresh-water snails were examined: *Melania* sp., *Melania asperata philippinensis* Sowerby, *Vivipara angularis* Miller, and *Ampullaria lagunaensis* Bartsch. From *Vivipara angularis* not a single cercaria has thus far been found, but from the three other species of snails nine different forms of larval flukes have been recognized and these are described below.

CERCARIA PARVOMELANIAE sp. nov. Plate 1, figs. 1 and 2.

Host, *Melania* sp.
Location, liver.
Locality, Los Baños, P. I. (Molawin Creek.)
Percentage of infestation, 4 to 6, June to September, 1927.

This cercaria is allied to the members of the Pleurolophocerca group of monostome cercariæ created by Sewell (1922) and is most similar to that author's Indian form designated by him as *Cercariae Indicae* VII. In open water this larva is a very active swimmer, moving from place to place with lightning velocity. It does so by curling its body ventrally, which is then propelled forward by means of the strong lashing movements of the powerful tail. Periods of active swimming generally alternate with periods of apparent rest, during which time the larva lies flat on the substratum with both body and tail performing a peculiar lateral shivering motion. When prevented from swimming, as under a cover glass, it moves vigorously by means of the active contraction and extension of the body muscles aided by the oral sucker.

The body, being capable of a considerable amount of contraction and extension, varies in shape accordingly. It is often flask-shaped when extended and pyriform when moderately contracted. During the latter state it measures from 0.09 millimeter by 0.06 millimeter to 0.13 by 0.10. It is transparent and of a greenish hue, which is imparted by the numerous coarsely granular cystogenous glands that are widely scattered in the parenchyma. It is covered anteriorly up to the level of the pharynx with small backward-pointing spines and bears on the dorsal surface of the anterior third of its length two conspicuous dark eyespots. The tail, which is attached on the ventral aspect of the posterior end of the body, varies greatly in length. When completely relaxed, it is from two to three times as long as the body. It is provided with a pair of lateral cuticular fins, which occupy the anterior third of its length; a dorsal fin, which starts from a level behind the termination of the lateral fins; and a ventral fin, which is about half as long as the dorsal fin. The dorsal and ventral fins extend and unite beyond the tip of the tail. When this organ is contracted, the lateral fins become folded and give the false impression of being supported by raylike structures.

The oral sucker, or penetrating organ, as Sewell prefers to call it, is nearly spherical in shape and measures 0.025 millimeter in transverse diameter. As in *Cercariae Indicae* VII, it is protrusible and invertible and is provided dorsally behind its extreme tip with a transverse row of spines. The mouth is subterminal in position. In some specimens a small, poorly developed pharynx is seen immediately behind the oral sucker.

There are eight pairs of finely granular salivary glands[1] arranged as in *Cercariae Indicae* VII, between the eyespots and the excretory bladder. The ducts of these glands pass anteriorly on both sides of the pharynx and open at the anterior dorsal region of the oral sucker.

The parts of the excretory system which I was able to detect are the following: The excretory bladder which is either transversely oval or bicornuate, depending upon the general shape of the body, and which discharges its contents outside through a small excretory pore situated on the dorsal surface at the junction of the body and tail; two main lateral collecting tubes arising from the anterolateral sides of the excretory bladder; a caudal collecting tube going into the tail from the posterior diverticulum of the excretory bladder; and two pairs of flame cells located as shown in Plate 1, fig. 1. There are undoubtedly other flame cells, but which I was unable to detect owing to the presence of the cystogenous glands which obscure the internal structure of the body and to the fact that the larva dies soon after it begins to quite down.

The reproductive system is represented by a mass of small roundish cells found in the space bounded by the salivary glands and the excretory bladder.

Development takes place in simple elongated radiæ, the mature ones of which contain from 8 to 10 cercariæ in various stages of development. The mature rediæ measure from 0.41 to 0.73 millimeter in length by 0.09 in width, while the immature ones average about 0.23 by 0.04 in size. A conspicuous pharynx is present followed, in young rediæ, by a long capacious rhadocœle gut. In mature rediæ the intestine is short and sometimes apparently absent, being crowded and hidden by the inclosed cercariæ.

CERCARIA REDICYSTICA sp. nov. Plate 1, figs. 3, 4, and 5.

Host, *Ampularia lagunaensis*.

Location, reproductive glands.

Locality, Los Baños, P. I. (Irrigation canal at the Experiment Station, College of Agriculture, University of the Philippines.)

[1] I have followed Sewell's designation, salivary glands, for the large unicellular structures, usually found in the middle and posterior parts of the bodies of larval trematodes. The term penetration glands, used by Miller (1926) with reference to the furcocercous cercariæ, may not be applicable in the case of other larvæ which do not penetrate into the bodies of their final hosts.

Percentage of infestation, 2, August, 1927.

This larva is a moderately active swimmer. Under a cover glass it is actively motile, quieting down only when near the point of complete dryness and death. It is related to Sewell's *Cercariae Indicae* XLI and, therefore, belongs to that author's "Agilis" group of distome cercariæ.

The unarmed, pyriform body is attenuated anteriorly, its maximum diameter being immediately in front of, or opposite, the acetabulum. It is packed with numerous, roundish cystogenous glands which are filled with rodlike bodies, arranged parallel to one another. The tail is massive and is attached on the ventral aspect of the posterior end of the body.

The two suckers are well developed, the ventral sucker located between the third and last fourths of the body length. In favorable specimens I was able to observe small, delicate, triangular spines arranged in circular fashion on both the oral and the ventral suckers, as shown in Plate 1, fig. 3. They are difficult to detect because the suckers are contracted most of the time and are, therefore, hidden from view. The cavity of the oral sucker leads into a prominent prepharynx, which is followed in succession by an oval pharynx and a very short œsophagus which divides into two short cæca. The measurements of these organs as well as of the moderately extended body and tail under different conditions are as follows: In living specimens, body 0.331 by 0.196 millimeter, tail 0.312 by 0.065 (at base), oral sucker 0.054 (transverse diameter), acetabulum 0.061 by 0.070, prepharynx 0.025 (length), pharynx 0.022 by 0.018, œsophagus 0.007 (length); in stained mounted specimens, body 0.225 by 0.097, tail 0.190 by 0.024, oral sucker 0.040, acetabulum 0.045 by 0.047.

The mouth is surrounded by a pattern of small, papillalike structures that are closely set together. On the dorsal lip of this opening there were observed, at least ten small, round spots, which are probably the terminations of the salivary glands, but the connections of which I was unable to follow. Neither did I succeed in determining the exact number of the salivary glands, of which I saw several pairs on each side of the pharynx and behind the intestinal cæca, due to the densely crowded cystogenous glands.

The excretory bladder, which opens outside through a median dorsal pore, is oval in outline, but at times it is constricted so that it becomes divided into anterior and posterior chambers.

Anterolaterally it gives off two main lateral collecting tubes which reach anteriorly as far as the level of the pharynx, from where they loop back and at a level anterior to the acetabulum they divide into anterior and posterior collecting tubules. These main lateral tubes are filled with rounded, fatlike masses, which probably represent excretory products. The caudal collecting tube, as usual, arises from a posterior diverticulum of the excretory bladder. Seven pairs of flame cells in the position shown in Plate 1, fig. 3, were seen, but it is possible that other cells escaped detection owing to the presence of the cystogenous glands. The general structure of the excretory system is, however, similar to that of the echinostomes, and because of this and together with the presence of spines on the suckers it is possible, as enunciated by Sewell, that this and related larvæ occupy a position among the echinostomes.

The reproductive system is represented by a group of cells lying ventral to the acetabulum.

This cercaria develops in rediæ which possess a posterior pair of locomotor appendages. The young rediæ, 0.47 by 0.087 millimeter in size, are actively motile, while the mature ones, 2.12 by 0.41 in size, are less so. One characteristic feature in connection with this cercaria is its ability to encyst while still inclosed within the redia. I have seen as many as five cysts thus formed within a redia. They are slightly oval in shape, with thick walls, and measure from 0.151 by 0.129 millimeter to 0.160 by 0.136.

CERCARIA PHILIPPINDICA nom. nov. Plate 2, figs. 1, 2, 3, 4, and 5.

Host, *Melania* sp.

Location, liver.

Locality, Los Baños, P. I. (Molawin Creek.)

Percentage of infestation, only one snail among thousands examined during July, August, and September, 1927.

This large cercaria is plainly visible to the unaided eye. In its behavior and general morphology it resembles the members of the Megalurous group or heavy-tailed cercariæ proposed by Cort (1915), and I am convinced that it is identical with Sewell's Indian form, *Cercariae Indicae* IV. For this reason the new name, *Cercaria philippindica,* is offered, in as much as Sewell's terminology does not constitute a name according to zoölogical nomenclature.

The body is long and narrow, its greatest diameter in front of the acetabulum. It usually presents a slight constriction in the region opposite the acetabulum or at a level immediately posterior to that organ. It is covered with small spines and is darkly pigmented due to the presence of numerous cystogenous glands which are widely distributed in the parenchyma (Plate 2, fig. 1). The tail, which is attached to the posterior end of the body, appears, as in the other members of the Megalurous group, vacuolated and is invaginated at the distal end to form a so-called "adhesive organ." The oral and ventral suckers are more or less circular in outline and of about the same size, the ventral sucker being located in the middle, or a trifle behind the middle, of the body length.

The digestive tract is well developed. The mouth, which is subterminal in position, leads through a narrow passage in the oral sucker into a prepharynx, the latter being followed in succession by a pharynx, an œsophagus, and two blind cæca which reach almost to the extreme posterior end of the body.

The measurements of the different organs noted above under various conditions are as follows, based on well-extended specimens: Living specimens, body 0.605 by 0.147 millimeter in size, tail 0.450 by 0.030, oral sucker 0.071 (transverse diameter), acetabulum 0.080 (transverse diameter), prepharynx 0.032 (length), pharynx 0.027 (transverse diameter), œsophagus 0.093 (length); in stained, mounted specimens, body 0.500 by 0.113, tail 0.400 by 0.034, oral sucker 0.052 by 0.046, acetabulum 0.053 by 0.057, prepharynx 0.036, pharynx 0.024, œsophagus 0.090.

The excretory bladder, which opens through a median dorsal pore, is pyriform in shape and gives off the following vessels: Anteriorly, two main lateral collecting tubes which reach to the posterior level of the pharynx, from where they turn back and at the level of the acetabulum each divides into anterior and posterior collecting tubules; posteriorly, a caudal collecting tube which goes into the tail.

I was not able to study the flame-cell formula due to the fact that I encountered this larva at a time of day when it was not possible for me to keep it under prolonged observation. I left the specimens overnight in a dish of water, hoping to study them again; but when morning came they had all perished. Instead, I found a large number of characteristic flask-shaped figures which I immediately took for cysts due to their resemblance to those described by Looss (1900). In fact, they were cysts, for inside some of them I was able to observe the inclosed cercariæ still moving. In Plate 2, fig. 5, is shown the outline of one of these cysts, which measure 0.34 by 0.20 millimeter in size.

The reproductive system is represented by small cells arranged in the form of a streak which extends from behind the point where the œsophagus divides to immediately in front of the excretory bladder.

Development takes place in rediæ which are provided posteriorly with a pair of locomotor appendages. Measurements taken of living rediæ were: Mature ones packed full with cercariæ 2.07 millimeters by 0.36 millimeter in size; young ones containing no cercariæ 0.50 by 0.08. In young rediæ the pharynx is prominent and the rhabdocœle gut may extend posteriorly almost to the level of the locomotor appendages. I was able to detect four flame cells in such young forms, as shown in Plate 2, fig. 3.

CERCARIA MELANIASPERATA sp. nov. Plate 3, figs. 1, 2, and 3.

Hosts, *Melania* sp. and *M. aspereta philippinensis.*

Location, liver.

Locality, Los Baños, P. I. (Molawin Creek.)

Percentage of infestation, *Melania* sp., 18; *M. asperata philippinensis,* 16, July, 1927.

This small cercaria is referred to Sewell's "Pusilla" group of Xiphidiocercariæ, being similar in many respects to *Cercariae Indicae* XVIII and *C. Indicae* XIX. It is an active swimmer in open water; on a substratum it makes attempts to move by means of its suckers and the general contraction and relaxation of the body, but makes very little progress or none at all.

The body is generally oval in shape, but is capable of considerable elongation and contraction; it measures, when extended, from 0.086 millimeter long by 0.060 millimeter in maximum width to 0.100 by 0.050. In the moderately contracted state it measures on the average 0.078 by 0.056. The tail, which is attached on the ventral aspect of the posterior end of the body, when extended, is 0.108 to 0.130 millimeter long by 0.012 to 0.014 millimeter wide at or near the base. It can, however, be contracted so that it may be shorter than the body. The body surface is covered with minute, posteriorly directed spines, but the tail is unarmed.

The oral sucker is moderately developed, from 0.024 by 0.026 millimeter to 0.030 by 0.030 in size. Its anterior dorsal wall carries a stylet of the shape shown in Plate 3, fig. 2, measuring 0.020 to 0.024 millimeter in length by 0.002 in maximum width. The acetabulum, averaging about 0.015 millimeter in transverse diameter, is situated immediately behind the middle of the body length. The mouth is subterminal in position and leads through a cavity of the oral sucker into a small pharynx, about 0.005 millimeter in transverse diameter and found immediately behind the oral sucker. Three pairs of conspicuous salivary glands are found lateral to the acetabulum, the first pair being a little anterior, the second pair opposite, and the last pair posterior, of the middle level of that organ. The glands are finely granular, the first two pairs appearing lighter and the third pair greenish in color. Their ducts pass dorsally to the oral sucker to open at both sides of the stylet.

The excretory bladder, which opens outside through a median dorsal pore, is reniform in shape. From each horn of the bladder a main lateral collecting tube arises, which at about the level of the acetabulum divides into an anterior and a posterior collecting tubule. The anterior collecting tubule, after giving off a short branch near its point of origin, courses anteriorly toward the lateral aspect of the oral sucker where it divides into two branches. The ramifications of the posterior collecting tubule are the counterparts of those of the anterior collecting tubule; that is, after sending off a branch from near its point of origin, it goes posteriorly toward the lateral aspect of the excretory bladder, where it divides into two branches. Each of the branches of the collecting tubules ends in a flame cell so that the total number of these excretory cells on one side of the body is six. The excretory formula is, therefore, $2 \times 6 \times 1 =$ 12 flame cells in all. A caudal excretory tube going into the tail is given off from the posterior diverticulum of the excretory bladder.

The reproductive system is represented by an elongated mass of small round cells, occupying a median longitudinal position in the middle third of the body length.

The development of this cercaria occurs in simple elongated sporocysts, which vary in size from 0.34 by 0.06 millimeter to 0.70 by 0.16. The number of cercariæ noted in each sporocyst was from 4 to 34.

CERCARIA MAQUILINGI sp. nov. Plate 3, figs. 4 and 5.

Hosts, *Melania* sp. and *M. asperata philippinensis.*

Location, liver.

Locality, Los Baños, P. I. (Molawin Creek.)

Percentages of infestation, *Melania* sp., 12; *M. asperata philippinensis,* 8, July, 1927.

This cercaria, which belongs to the "Virgula" group of the Xiphidiocercariæ, has practically the same behavior as *Cercaria melaniasperata.* It is however larger, the body when moderately extended measuring about 0.120 millimeter in length by 0.080 in maximum width. Under the same condition the tail, which is attached on the ventral aspect of the posterior end of the body, is about as long as the latter, but it may be so contracted as to appear as a mere stump. The body is covered with small, backward-pointing spines. The entire surface of the tail is similarly armed, although in some specimens only its posterior region appears to carry spines.

The oral sucker, which contains a characteristic structure, the "virgula organ" of Sewell (1922), is slightly oval or circular in outline, having an average diameter of 0.04 millimeter. The stylet is 0.018 to 0.020 millimeter in length by 0.004 to 0.005 in maximum width and is located anterior to the virgula organ. The circular acetabulum, 0.02 millimeter in diameter, is found behind the middle of the body length. The mouth, which is subterminal in position, leads into a small pharynx, 0.008 millimeter in transverse diameter, located immediately behind the oral sucker. Three pairs of salivary glands are present; the first two pairs are anterior to the middle of, and the last pair at the same level as, the acetabulum. The first and third pairs of salivary glands are coarsely granular and of greenish hue, while the second pair is finely granular and of lighter color. The corresponding ducts of these glands open, as in other cercariæ, at the anterior end, dorsal to the mouth opening.

The structure of the excretory system is quite similar to that of *C. melaniasperata.* The excretory bladder is triradiate, from the posterior horn of which a caudal collecting tube going to the tail is given off. From the anterior horns of the bladder arise the two main lateral collecting tubes, each of which divides at the level of the acetabulum into an anterior and a posterior collecting tubule. Each collecting tubule in turn divides into three capillary branches, each of which connects with a flame cell. The excretory formula is, therefore, $2 \times 6 \times 1 = 12$ flame cells in all.

The genital mass of small round cells is curved in outline and is situated immediately dorsal to the acetabulum.

Development occurs in small, simple, roundish to oval sporocysts, 0.27 by 0.21 millimeter, containing from 5 to 15 cercariæ in varying stages of development.

CERCARIA LAGUNAENSIS sp. nov. Plate 4, figs. 1 and 2.

Host, *Ampullaria lagunaensis.*

Location, liver.

Locality, Los Baños, P. I. (Laguna de Bay and Maitim Creek.)

Percentage of infestation, 5 to 8, August, 1927.

This cercaria is an active swimmer. The clear transparent body is ovoid in shape and is covered with minute spines. It measures from 0.13 to 0.17 millimeter in length by 0.08 to 0.09 millimeter in maximum width. The tail, which is unarmed and attached on the ventral aspect of the posterior end of the body, is from 0.23 to 0.28 millimeter long by 0.03 millimeter in width near the base.

The oral sucker, 0.04 by 0.03 millimeter to 0.06 by 0.05 in size, is provided with a stylet, 0.048 to 0.060 long, which appears to be inclosed within a membranous capsule. The acetabulum, 0.03 millimeter in diameter, is weak and poorly developed, and is located in the anterior region of the second third of the body length. The mouth is subterminal in position. Immediately behind the oral sucker is a pharynx, 0.008 millimeter in transverse diameter, followed by a blind œsophagus. There are three pairs of pyriform salivary glands, lying on each side of the acetabulum. The first two pairs of these glands are finely granular and darkish in appearance, while the third pair, which is also finely granular, has a hyaline appearance. The ducts of these glands open at the dorsal lip of the mouth.

The excretory system is composed of a reniform excretory bladder, which opens outside through a median dorsal pore; two main lateral collecting tubes, which divide in the middle of the body length into anterior and posterior collecting tubules; a median, caudal collecting tube which goes to the tail; and 18 pairs of flame cells, as shown in Plate 4, fig. 1. The excretory formula is, therefore, $2 \times 18 \times 1 = 36$ flame cells in all.

The reproductive system is represented by a rounded mass of cells anterior to the acetabulum.

Cercaria lagunaensis develops in simple, round to oval sporocysts, containing from 2 to 10 cercariæ in different stages of development.

CERCARIA RARISSIMA sp. nov. Plate 4, figs. 3 and 4.

Host, *Ampullaria lagunaensis.*

Location, liver.

Locality, Los Baños, P. I. (Irrigation canal at the experiment station of the College of Agriculture, University of the Philippines.)

Percentage of infestation, 1.

This cercaria is very similar in appearance and behavior to *Cercaria lagunaensis,* but I have decided to consider it as a distinct species because of certain differences between the two forms in the appearance and structure of the stylets and salivary glands, both of which organs, according to Sewell (1922), are of specific diagnostic value.

The body of *Cercaria rarissima,* 0.12 to 0.15 millimeter long by 0.08 in maximum width, is covered with minute, backward-pointing spines. The tail, unarmed, is from one and a half to three times as long as the body, on the ventral aspect of the posterior end of which it is attached.

The oral sucker, 0.044 to 0.051 millimeter in transverse diameter, is nearly spherical. The stylet, 0.041 millimeter long, differs from that of *C. lagunaensis* in having thicker walls and a more conspicuous shoulder at the anterior third of its length and it does not appear to be inclosed inside of a membranous capsule. The mouth is subterminal in position; immediately behind the oral sucker is a pharynx, 0.009 millimeter in transverse diameter. The acetabulum, 0.025 to 0.030 millimeter in transverse diameter, is in the anterior portion of the last third of the body length. On each side of the acetabulum are the three pairs of salivary glands, the first two pairs of which are small, pyriform, and finely granular, while the glands of the third pair are larger, irregular in outline, and coarsely granular. The ducts of these glands are very conspicuous, opening on both sides of the dorsal lip of the mouth.

The excretory bladder and principal excretory vessels are arranged as in *C. lagunaensis.* I was able to detect 8 pairs of flame cells, distributed as shown in Plate 4, fig. 3, but it is possible that some cells escaped my detection.

The genital mass is located on a level immediately in front of the acetabulum.

Development takes place in simple, oval sporocysts, containing from 5 to 12 cercariæ in different stages.

CERCARIA MAITIMENSIS sp. nov. Plate 5, figs. 1 and 2.

Host, *Ampullaria lagunaensis.*

Location, liver.

Locality, Los Baños, P. I. (Maitim Creek and Laguna de Bay.)

Percentage of infestation, 10 to 12, August, 1927.

This large cercaria is a clumsy swimmer. It prefers to crawl on the substratum, after the fashion of a measuring worm. In performing the latter movement it uses its two strong suckers, aided by the posterior lateral angles of the body which are sharply defined and the musculature of which appears to be quite well developed.

The body is elongated and covered with prominent spines. It appears pigmented in the region around the acetabulum due to the presence of small dark glands. The tail, unarmed, is attached at the posterior end of the body, between the constricted posterolateral angles of the latter. The oral sucker is well developed and carries a stylet of the shape shown in Plate 5, fig. 2. The acetabulum, like the oral sucker, is circular in outline and well developed, and is situated near the middle of the body length. Behind the oral sucker is a short prepharynx, followed in succession by a small pharynx and a short œsophagus which divides into two cæcal diverticula.

Sizes under various conditions: Maximum extension of living specimens, body 0.37 by 0.14 millimeter, tail 0.38 by 0.033 (near base), prepharynx 0.013 long, pharynx 0.013 in transverse diameter, œsophagus 0.020 long, oral sucker 0.060 in transverse diameter, acetabulum 0.060 in transverse diameter, stylet 0.035 by 0.006 (at base); well-extended, mounted, stained specimens, body 0.340 by 0.080, tail 0.210 by 0.022, oral sucker 0.04, acetabulum 0.04, prepharynx 0.008, pharynx 0.012, œsophagus 0.008.

There are three pairs of brownish, very finely granular, pyriform salivary glands at the posterior end of the body, on each side of the excretory bladder. They are individually distinct when the body is well extended, but when the body is contracted their nuclei become hidden and they seem to coalesce, forming a hat-shaped figure which totally obscures the outline of the excretory bladder. The ducts of these glands are very prominent and open on both sides of the dorsal lip of the mouth.

The excretory system is composed of the following: A flower-vase-shaped excretory bladder which opens outside through a median dorsal pore; two main lateral collecting tubes which arise from the anterolateral angles of the bladder and which divide at a level midway between the bladder and the acetabulum into anterior and posterior collecting tubules; a caudal collecting tube arising from the posterior diverticulum of the bladder and going into the tail; and the fine excretory capillaries which permeate the body substance and which end in 18 pairs of flame cells. The excretory formula is, therefore, 2 x 18 x 1 = 36 flame cells in all.

The genital mass is a C-shaped structure found dorsal to the acetabulum.

This larva develops in simple, sausage-shaped sporocysts, 0.27 to 0.41 millimeter by 0.08 to 0.10 in size, containing from 3 to 12 cercariæ in different stages of development.

CERCARIA DORSOCAUDA sp. nov. Plate 5, figs. 3 and 4.

Host, *Ampullaria lagunaensis.*

Location, reproductive glands.

Locality, Los Baños, P. I. (Maitim Creek and irrigation dam between Los Baños and Bay, Laguna, Luzon.)

Percentage of infestation, 10, August, 1927.

This larva belongs to Sewell's "Vivax" group of furcocercous distome cercariæ. Miller (1926), on the other hand, refers the group to the Monostomata and includes its members among his pharyngeal longifurcate monostome cercariæ.

Cercaria dorsocauda is a very active swimmer, moving through the water with the tail invariably foremost. Periods of active swimming generally alternate with periods of rest, during which time it remains suspended under the surface of the water with the tail uppermost.

The body is generally pyriform, attenuated anteriorly and rounded posteriorly, its greatest diameter in the middle of its length. Its surface is covered with prominent spines. The tail, which is also armed with spines, is attached on the dorsal aspect of the posterior end of the body. Distally it becomes slightly constricted and divides into two long rami, which are provided with dorsal and ventral fins throughout their lengths. The two fins are continuous at the tip of each ramus, but they do not extend appreciably beyond it. Measurements taken of living specimens confined under a cover glass are: Body 0.52 by 0.21 millimeter to 0.64 by 0.40 in size, tail stem 0.56 by 0.07 to 0.65 by 0.04, furci 0.43 to 0.48 by 0.034.

The oral sucker, 0.066 by 0.100 millimeter to 0.093 by 0.107 in size, is a definite organ in this larva, while the acetabulum, 0.033 by 0.040, is rudimentary, and is represented by a roundish mass of parenchymatous cells in the middle of the body length or a little posterior of that level. Immediately behind the oral sucker is a small circular pharynx, 0.034 millimeter in transverse diameter, followed by an œsophagus, 0.08 millimeter in length, which divides into two wide cæca that reach to near the posterior end of the body.

The excretory system is typical of the group. The excretory bladder is more or less pentagonal in shape, opening through a median dorsal pore. From its anterolateral angles are given off the two main lateral collecting tubes, which course anteriorly lateral to the intestines up to the level of the œsophagus. From the anterior angles of the pentagon the median collecting tubes arise, the two uniting behind the acetabulum in a common canal which, behind the cæcal bifurcation, in turn divides into two branches, each branch crossing the corresponding intestine to join at the posterior level of the œsophagus the main lateral collecting tube on that side. Each common vessel thus formed immediately divides into two branches which are usually filled with fatlike globules of excretory material. From the posterior angle of the excretory bladder arises the caudal collecting tube going into the tail, at the distal extremity of the stem of which it divides into branches, each branch going into, and opening at the tip of, the corresponding ramus of the tail. The finer excretory capillaries are difficult to detect, but the flame cells are unusually large and conspicuous. There are 12 pairs of flame cells in the body and 3 pairs in the tail, so that the excretory formula is $2 \times 12 \ (+ 3) \times 1 = 30$ flame cells in all. All the flame cells on one side of the tail are connected to a common capillary tube which empties into the excretory bladder lateral to the point of origin of the caudal collecting tube.

The genital system is represented by a mass of rounded cells situated behind the acetabulum.

This larva develops in long, sausagelike sporocysts, 10 to 15 millimeters long by 0.24 wide.

LITERATURE CITED

CORT, W. W. Some North American larval trematodes. Illinois Biol. Mon. 1 (1915) 1–86.

LOOSS, A. Recherches sur la faune parasitaire de l'Egypte. Premiere Partie. Mem. L'Inst. Egyptiene 3 (1900) 1–252. Cited by Sewell (1922).

MILLER, H. M., Jr. Comparative studies on furcocercous cercariae. Illinois Biol. Mon. 10 (1926) 1–112.

SEWELL, R. B. S. Cercariae Indicae. Ind. Journ. Med. Res. Supp. 10 (1922) 1–173.

ILLUSTRATIONS

ABBREVIATIONS

ac, acetabulum.
at, anterior collecting tubule.
c, collar.
cg, cystogenous gland.
cs, adhesive organ.
ct, caudal collecting tube.
df, dorsal fin.
eb, excretory bladder.
encer, encysted cercaria.
ep, excretory pore.
es, eyespot.
fc, flame cell.
ft, locomotor appendage.
gm, genital mass.
ic, intestine.
lf, lateral fin.
mo, mouth.
mt, main lateral collecting tube.
oes, œsophagus.
os, oral sucker.
ph, pharynx.
pph, prepharynx.
pt, posterior collecting tubule.
rd, rhabdocœle gut.
sd, salivary duct.
sg, salivary gland.
st, stylet.
vf, ventral fin.
vo, virgula organ.

PLATE 1

FIG. 1. *Cercaria parvomelaniae* sp nov., dorsal view.
2. *Cercaria parvomelaniae* sp. nov., immature redia.
3. *Cercaria redicystica* sp. nov., ventral view.
4. *Cercaria redicystica* sp. nov., immature redia.
5. *Cercaria redicystica* sp. nov., mature redia.

PLATE 2

FIG. 1. *Cercaria philippindica* nom. nov., ventral view, showing cystogenous glands.
2. *Cercaria philippindica* nom. nov., ventral view, showing excretory system and digestive tract.
3. *Cercaria philippindica* nom. nov., immature redia.
4. *Cercaria philippindica* nom. nov., mature redia.
5. *Cercaria philippindica* nom. nov., outline of cyst.

PLATE 3

FIG. 1. *Cercaria melaniasperata* sp. nov., ventral view.
2. *Cercaria melaniasperata* sp. nov., stylet.
3. *Cercaria melaniasperata* sp. nov., sporocyst.
4. *Cercaria maquilingi* sp. nov., ventral view.
5. *Cercaria maquilingi* sp. nov., stylet.

PLATE 4

FIG. 1. *Cercaria lagunaensis* sp. nov., ventral view.
2. *Cercaria lagunaensis* sp. nov., stylet.
3. *Cercaria rarissima* sp. nov., ventral view.
4. *Cercaria rarissima* sp. nov., stylet.

PLATE 5

FIG. 1. *Cercaria maitimensis* sp. nov., ventral view.

2. *Cercaria maitimensis* sp. nov., stylet.
3. *Cercaria dorsocauda* sp. nov., ventral view, showing proportions of body, tail stem, and furci of tail.
4. *Cercaria dorsocauda* sp. nov., ventral view, showing the excretory system.

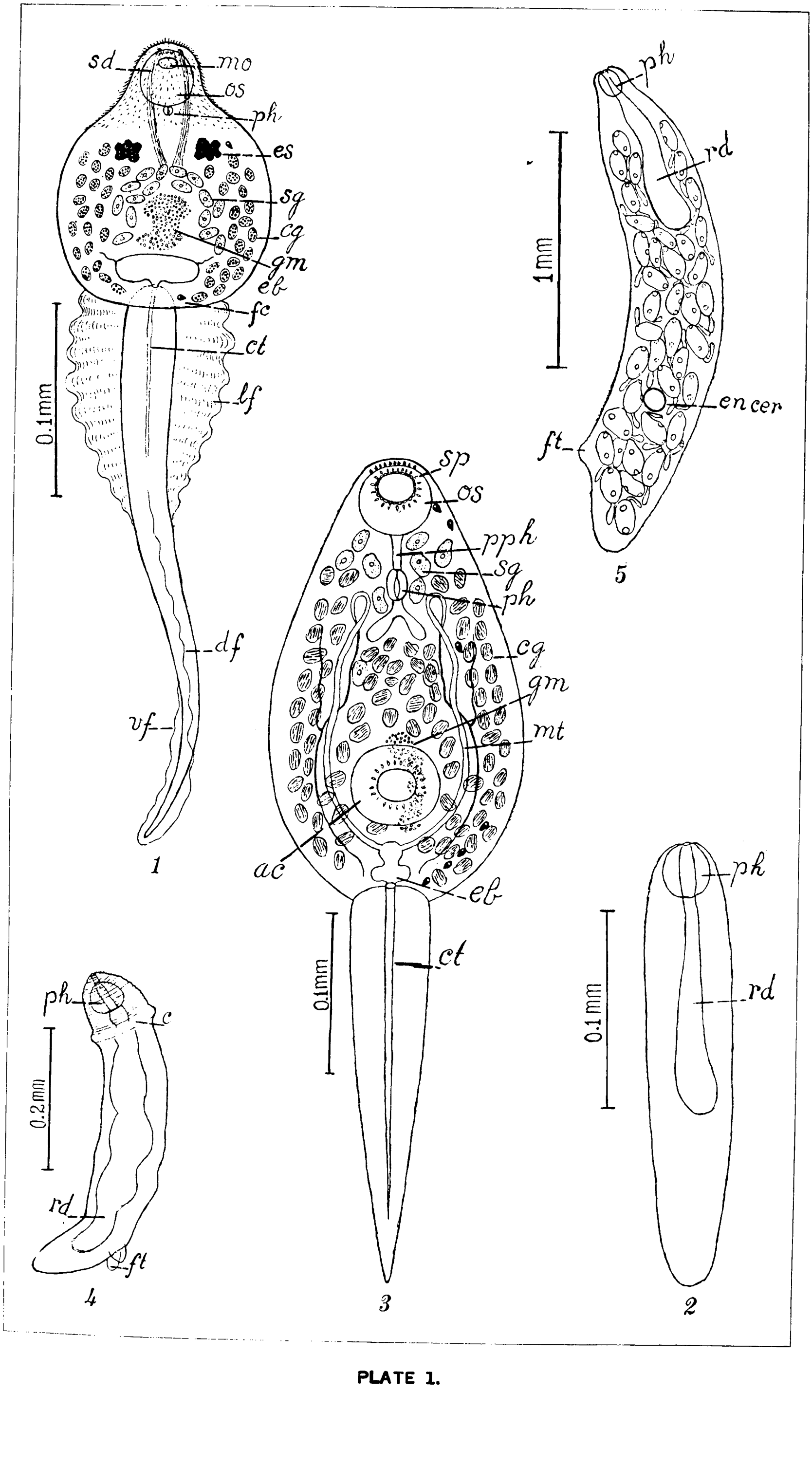

sd
mo
os
ph
es
sg
cg
gm
eb
fc
ct
lf
0.1mm
df
vf
1
ph
rd
1mm
en cer
ft
5
sp
os
pph
sg
ph
cg
gm
mt
ac
eb
ct
0.1mm
3
ph
c
0.2mm
rd
ft
4
ph
rd
0.1mm
2

PLATE 1.

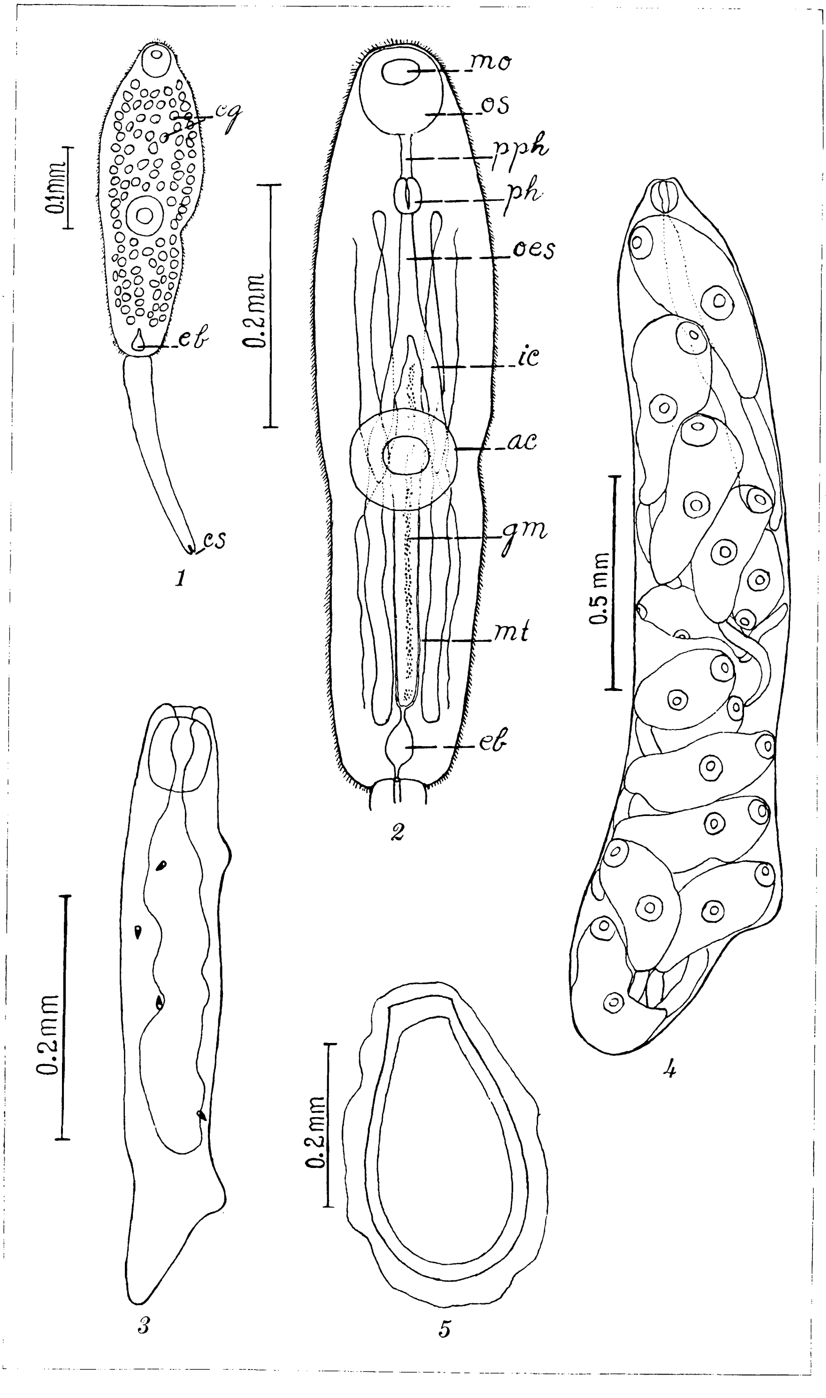

cg
0.1 mm
eb
cs
1
mo
os
pph
ph
oes
ic
ac
gm
mt
eb
0.2 mm
2
0.5 mm
4
0.2 mm
3
0.2 mm
5

PLATE 2.

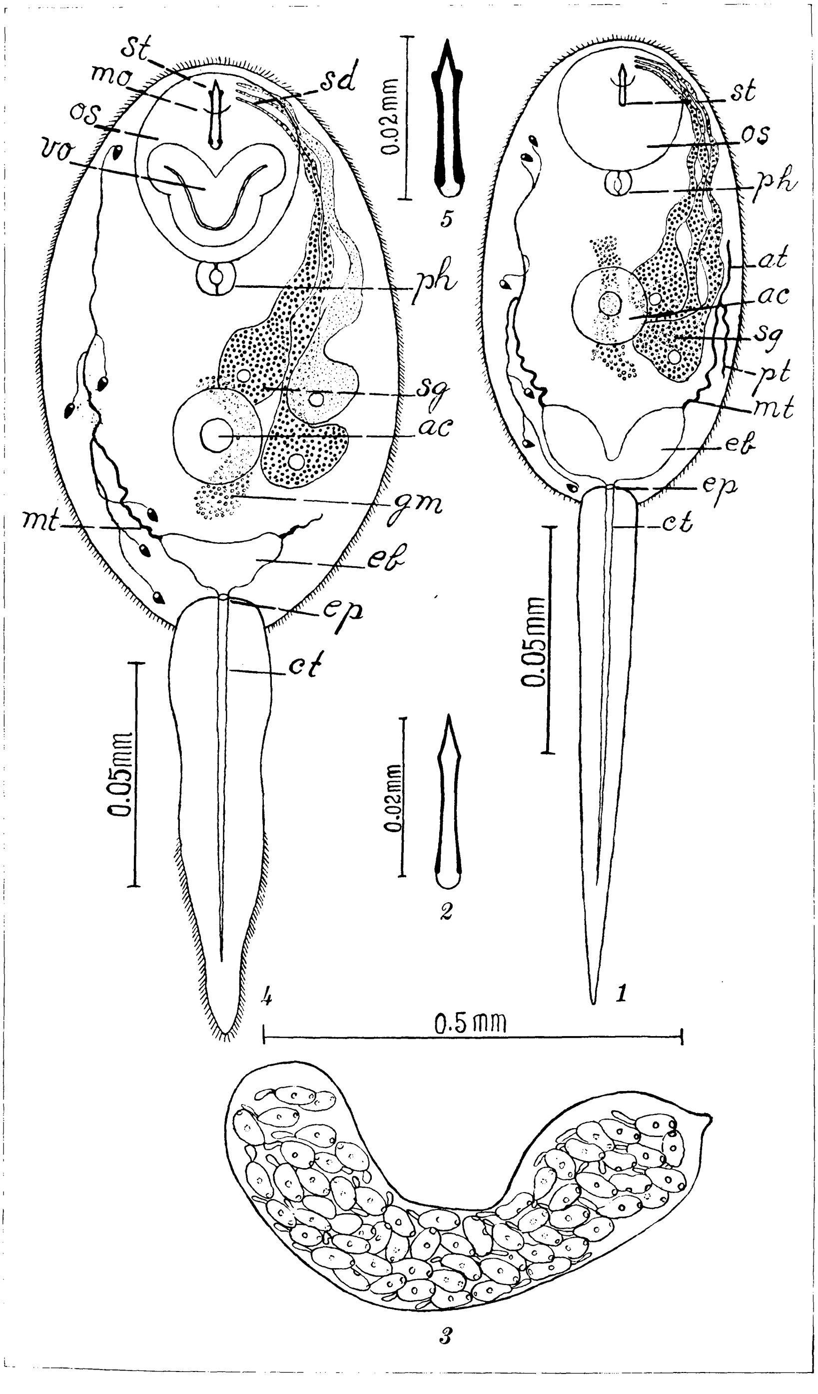

st
mo
os
vo
sd
ph
sg
ac
gm
mt
eb
ep
ct
0.05mm
0.02mm
5
2
4
st
os
ph
at
ac
sg
pt
mt
eb
ep
ct
0.05mm
1
0.5 mm
3

PLATE 3.

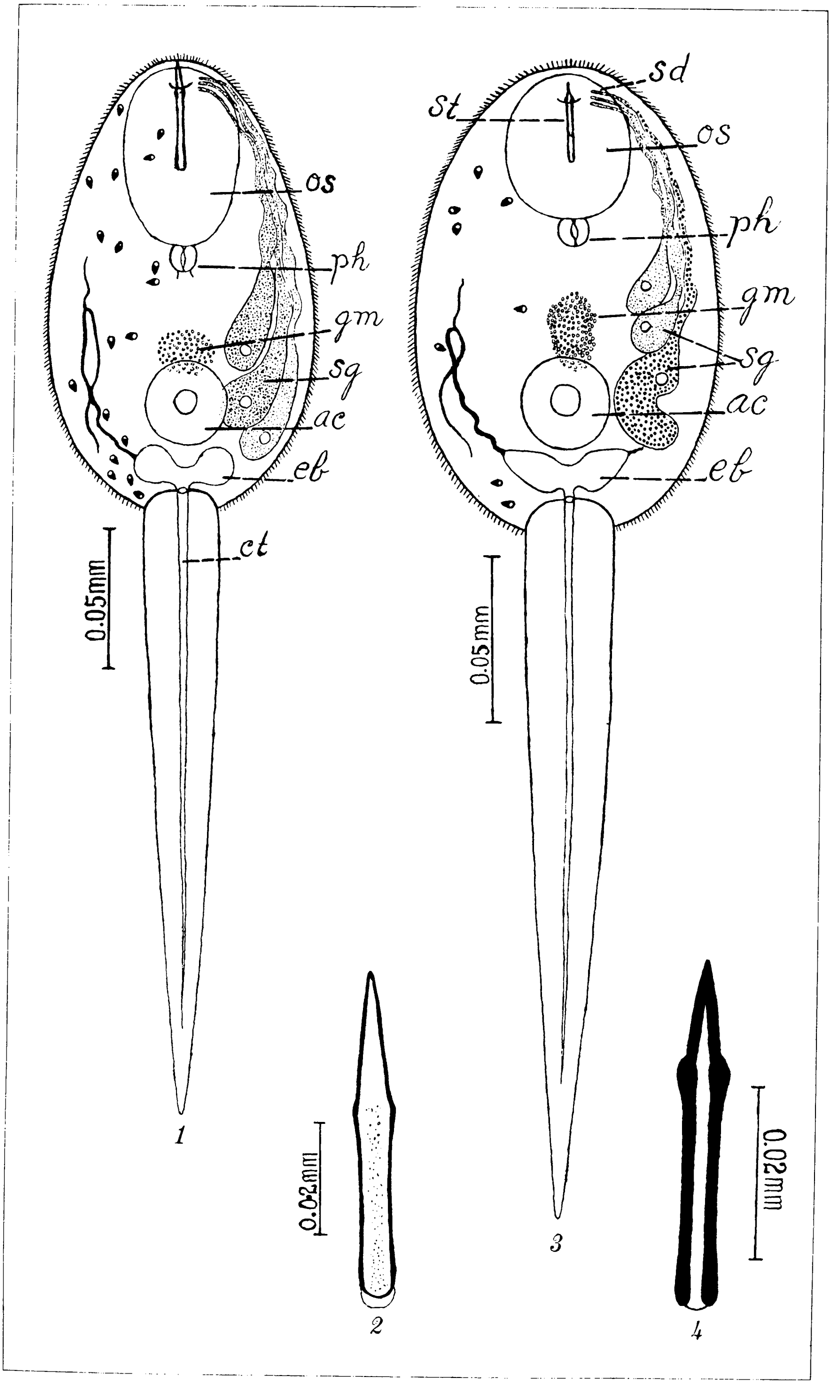

os
ph
gm
sg
ac
eb
ct
0.05mm
1
0.02mm
2
sd
st
os
ph
gm
sg
ac
eb
0.05mm
3
0.02mm
4

PLATE 4.

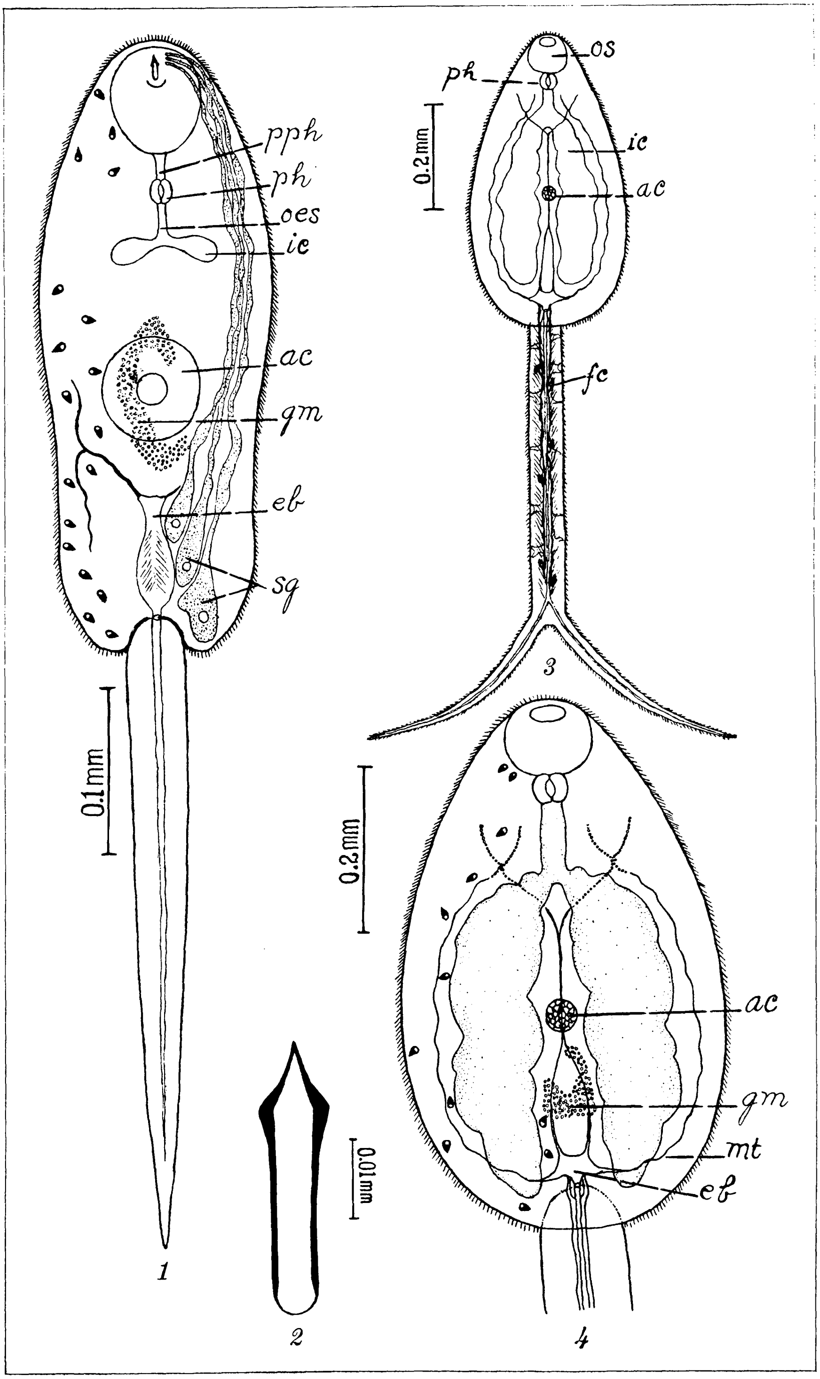

pph
ph
oes
ic
ac
gm
eb
sg
0.1mm
1
0.01mm
2
os
ph
0.2mm
ic
ac
fc
3
0.2mm
ac
gm
mt
eb
4

PLATE 5.

STRENGTH PROPERTIES IN RELATION TO SPECIFIC GRAVITY OF PHILIPPINE WOODS [1]

By José C. Espinosa

Of the Bureau of Science, Manila

FIVE TEXT FIGURES

The strength properties of wood have a certain definite relation with the actual amount of wood material in a given piece or, using the accepted terminology, with its density or specific gravity.

J. A. Newman and T. R. C. Wilson,[2] of the United States Forest Service, have established the relations for American timbers from an analysis of 200,000 tests conducted at the Forest Products Laboratory in Madison, Wisconsin.

L. G. den Berger,[3] writing on the mechanical properties of Dutch East Indian timbers, tabulated these relations, in the case of teak (*Tectona grandis* Linn. f.), not only with its specific gravity but also with the width of the annual rings.

From a study of data covering about 45,000 tests, these relations in the case of Philippine woods have been found and it is the object of this paper to express the above-mentioned relations in simple forms in order that, the specific gravity of a species being known, the corresponding strength values can be readily calculated. Consequently, it is possible to compare the different species as regards strength, and determine which species are especially adapted for certain purposes.

In the treatment of the material at hand, simplicity and clearness have been kept in mind, and the relationships are herewith presented both in graphical and in equation form.

SPECIFIC GRAVITY

As used in timber testing specific gravity is the ratio of the oven-dry weight of a piece of wood to the weight of a volume

[1] Submitted for publication August 20, 1927.

[2] Bull. U. S. Dept. Agr. Forest Service 676.

[3] Korte Mededeelingen van het Proefstation voor het Boschwezen No. 12, Departement van Landbouw, nijverheid en handel in Nederlandsch-Indie.

of water at 4° C. equal to the volume of the specimen at the time of test. Thus, this value is based on the weight of the specimen when oven dry and the volume at the time of test. Obviously, this is not the true specific gravity; but, for purposes of comparison, it has been adopted by standard laboratories on timber tests.

MOISTURE PERCENTAGE

The specimens included in this study are air dry. It has been found that variations in moisture percentage of green timbers have no effect on strength. On the other hand, in the case of air-dry specimens an increase in moisture percentage means a material decrease in strength.

For accurate comparisons between species, all of the strength values have been adjusted to 12 per cent moisture. This adjustment was made in the following manner: The logarithms of the strength values were plotted against the moisture percentage. It was found that the function approximates a straight line. Graphs were made for all the strength properties and, at 12 per cent moisture, the strength value was read directly. Text fig. 1 shows the method of obtaining the fiber stress at the elastic limit in bending for tangile, *Shorea polysperma* Merrill, Dipte-

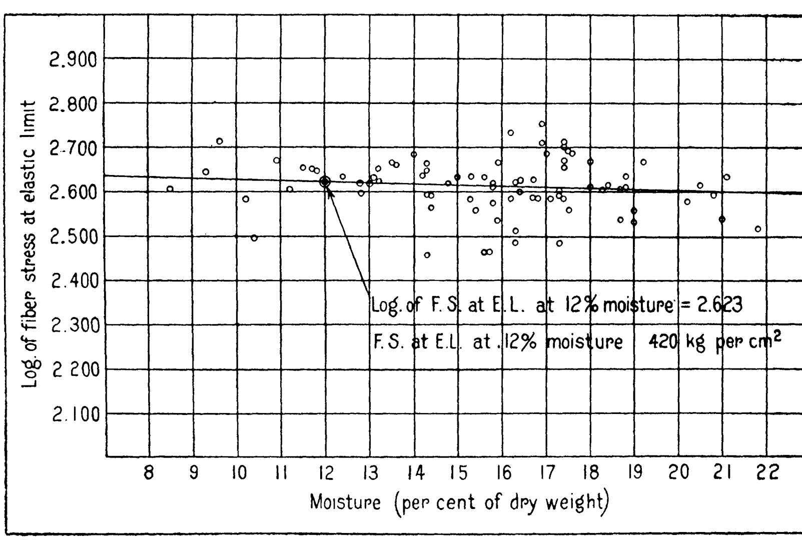


FIG. 1. Fiber stress at elastic limit in bending for tangile, *Shorea polysperma* Merrill, Dipterocarpaceæ. Relation of strength to percentage of moisture. Method of locating the strength at 12 per cent moisture.

rocarpaceæ, at 12 per cent moisture. The moisture content of the air-dry specimen varied from 8 to 22 per cent and, although 18 per cent is about the average in the Philippine Islands, 12 per cent has been chosen in conformity with the percentage given in other publications on timber testing, for purposes of comparison.

THE CURVES AND THEIR CORRESPONDING EQUATIONS

It has been observed, that, if the specific gravity is plotted against a strength property, the points follow either a smooth curve or a straight line which does not pass the origin. Newman and Wilson[4] have found the same behavior in the case of American woods. Following their method of treatment, it was assumed that the curve passes the origin, thereby approximating an equation of the following order:

$$S = kG^s$$

Where

S = the strength value.

k = a constant.

s = another constant.

G = the oven-dry specific gravity

Obviously,

$\log S = \log k + s \log G.$

This is the equation of a straight line and, if the logarithms of the strength values are plotted as ordinates, against the logarithms of the specific gravities as abscissas, and the straight line which best averages the points is drawn, the intercept on the Y axis gives k, while the slope of the line gives s.

Text fig. 2 illustrates the method of deriving the equation for longitudinal shear in bending. Each of the points is a species average corresponding to several hundred tests for some species. The straight line that best averages the points gives 59.6 for k and $\frac{5}{4}$ for s.

Thus, the equation for longitudinal shear in bending is:

$S^s = 59.6\ \sqrt[4]{G^5}$ in kilograms per square centimeter.

S^s is the longitudinal shear.

G is the oven-dry specific gravity.

This equation is then graphed, using the actual values of ten points from the best average line, mentioned above, and a smooth curve is drawn starting from the origin. This is curve No. 4,

[4] Bull. U. S. Dept. Agr. Forest Service 676.

fig. 3. It can be noticed that, at specific gravities 0.44 and 0.91, two short lines cut the curve. These give the limits of the extent in which this particular curve has been investigated. Dotted lines cover the rest of the curve where no data were available.

The curves in figs. 3, 4, and 5 were prepared in the same manner as outlined above, and give directly in graphical form

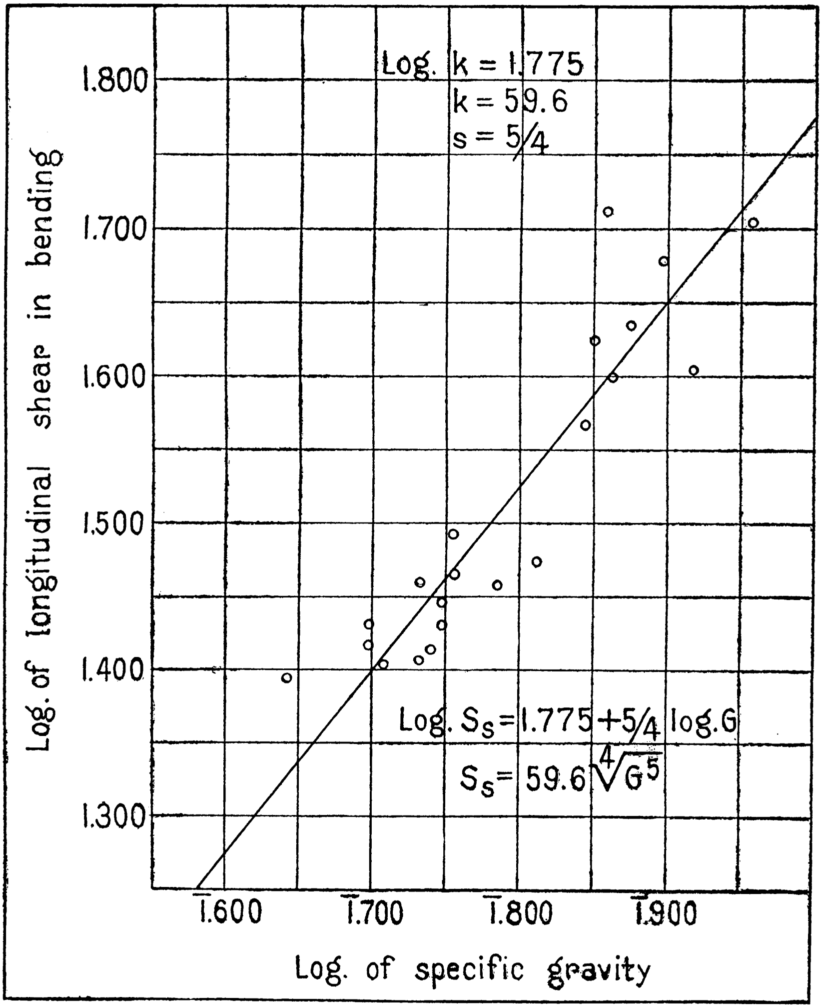


FIG. 2. Longitudinal shear at bending. Method of deriving the equation.

the relations between the strength properties and the specific gravity.

COMPARISON OF EQUATIONS DERIVED FOR AMERICAN WOODS, DUTCH EAST INDIAN WOODS, AND PHILIPPINE WOODS

In Table 1 are tabulated in metric units the equations of strength-specific gravity relations for American woods, Dutch East Indian woods, and Philippine woods.

TABLE 1.—*Equations of specific gravity-strength relation of wood, air dry.*

Strength property.	For Philippine wood, as included in this investigation.	For Dutch East Indian wood, by L. G. den Berger.	For American wood by J. A. Newman and T. R. C. Wilson.
Static bending:			
Fiber stress at elastic limit	$944 \sqrt[4]{G^5}$	$700\ G$	$1330 \sqrt[4]{G^5}$
Modulus of rupture	$1660 \sqrt[4]{G^5}$	$1,235\ G$	$1340 \sqrt[4]{G^5}$
Modulus of elasticity	$223,000\ G$	$172,000\ G$	$210,000\ G$
Longitudinal shear	$59.6 \sqrt[4]{G^5}$	----------	
Work to elastic limit	$0.29\ G^2$	----------	$0.63\ G^2$
Work to maximum load	$2.3\ G^2$	----------	$274\ G^2$
Compression parallel to the grain:			
Crushing strength at elastic limit	$626 \sqrt[4]{G^5}$	$405\ G$	$775 \sqrt[4]{G^5}$
Maximum crushing strength	$893 \sqrt{G^3}$	$705\ G$	$845\ G.$
Compression perpendicular to the grain:			
Crushing strength at elastic limit	$214\ G^2$	----------	$366 \sqrt[4]{G^9}$
Shearing strength parallel to the grain	$169\ G$	$120\ G$ radial	$255 \sqrt[3]{G^4}$ radial
		$140\ G$ tangential.	$282 \sqrt[3]{G^4}$ tangential
Hardness:			
End hardness	$1450\ G^2$	$965 \sqrt{G^3}$	$338 \sqrt[4]{G^9}$ end
			$253 \sqrt[4]{G^9}$ radial
Side hardness	$1410 \sqrt{G^5}$		$267 \sqrt[4]{G^9}$ tangential

Newman and Wilson [5] said:

> By analysis of over 200,000 tests, the Forest Products Laboratory, conducted in coöperation with the University of Wisconsin, Madison, Wis., has now definitely established these relations.

L. G. den Berger [6] said:

[5] Bull. U. S. Dept. Agr. Forest Service 676.

[6] Korte Mededeelingen va het Proefstation voor het Boschwezen No. 12, Department van Landbouw, nijverheid in Nederlandsch-Indie.

The extent of the work done on Philippine woods has already been mentioned. However, it is not out of place to state in this connection that, while numerous tests have already been performed, more tests of other species will be undertaken, because we are aware that further knowledge on the subject may change our figures. These values are the best available at present and are considered reliable for all practical purposes.

TABLE 2.—*Species of wood included in this investigation and their corresponding scientific names.*

Common name.	Scientific name.	Family.
Almon	*Shorea eximia* Scheff	Dipterocarpaceæ.
Amamanit	*Eucalyptus deglupta* Bl	Myrtaceæ.
Apitong	*Dipterocarpus grandiflorus* Blco	Dipterocarpaceæ.
Aranga	*Homalium luzoniense* F. Vill	Flacourtiaceæ.
Bagtikan	*Parashorea plicata* Brand	Dipterocarpaceæ.
Dulitan	*Palaquium merrillii* Dubard	Sapotaceæ.
Guijo	*Shorea guiso* Blco	Dipterocarpaceæ.
Ipil	*Intsia bijuga* O. Ktze	Leguminosæ.
Kalamansanai	*Neonauclea calycina* Merr	Rubiaceæ.
Lumbayao	*Tarrietia javanica* Blco	Sterculiaceæ.
Manggasinoro	*Shorea* sp	Dipterocarpaceæ.
Nato	*Palaquium luzoniense* Vid	Sapotaceæ.
Pahutan	*Mangifera altissima* Blco	Anacardiaceæ.
Palosapis	*Anisoptera thurifera* Bl	Dipterocarpaceæ.
Pototan	*Bruguiera* sp	Rhizophoraceæ.
Red lauan	*Shorea negrosensis* Foxw	Dipterocarpaceæ.
Supa	*Sindora supa* Merr	Do.
Tangile	*Shorea polysperma* Merr	Do.
Tindalo	*Pahudia rhomboidea* Prain	Leguminosæ.
White lauan	*Pentacme contorta* Merr	Dipterocarpaceæ.
Yakal	*Hopea basilanica* Foxw	Do.

I wish to state here clearly that the available data are insufficient in number for this purpose and that the results we have in this respect cannot be more than preliminary.

A general comparison of the equation for American, Dutch East Indian, and Philippine woods shows that, for woods of the same specific gravity, American woods give the highest strength value, Philippine woods give the next highest, and Dutch East Indian woods give the lowest. Exception is made for modulus of elasticity in bending and in end and side hardness, in which Philippine woods excel.

Luis J. Reyes, wood technologist of the Philippine Bureau of Forestry, is here quoted as saying that a possible explanation of the above-mentioned findings is that, in general, the fibers of Philippine woods are shorter than those of American woods.

Then, again, Philippine woods are as a general rule cross-grained, a condition which greatly reduces their strength. Obviously these explanations are at best relative, because it is impossible for anybody to give an accurate and satisfactory explanation of what actually occurs even in simple bending of a piece of wood.

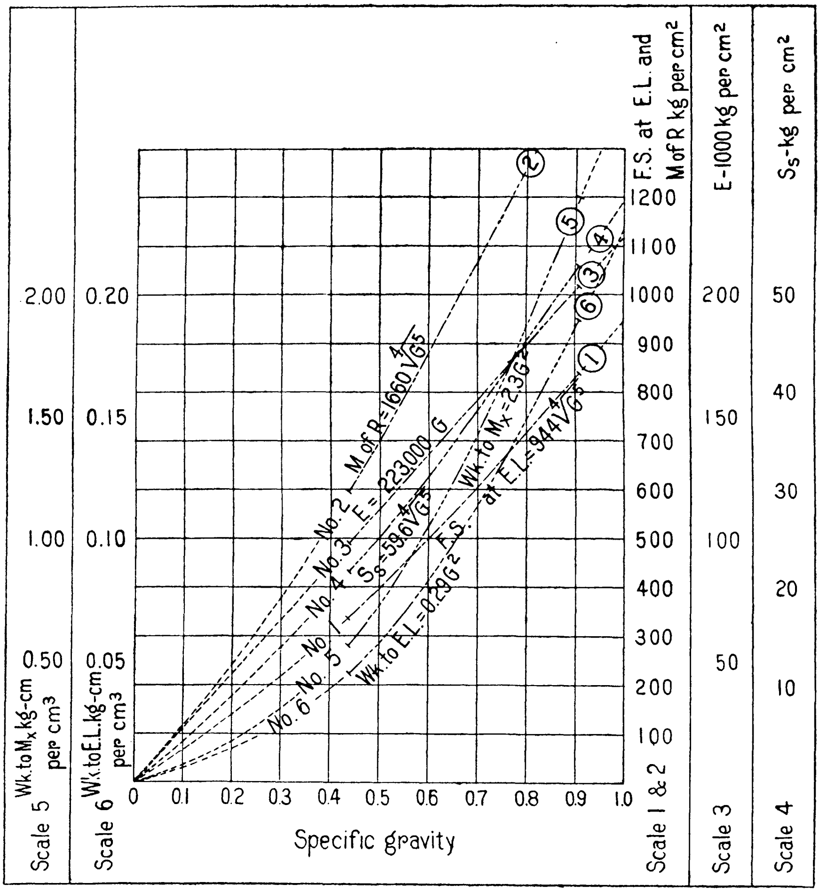


FIG. 3. Static bending; relation of strength properties to specific gravity.

NOMENCLATURE

Scale 1: F. S. at E. L. = fiber stress at elastic limit. Use curve 1.
Scale 2: M of R = modulus of rupture. Use curve 2 (same scale as curve 1).
Scale 3: E = modulus of elasticity. Use curve 3.
Scale 4: S_s = longitudinal shear. Use curve 4.
Scale 5: Wk. to M_x = work to maximum load. Use curve 5.
Scale 6: Wk. to E. L. = work to elastic limit. Use curve 6.

DISCUSSION OF TABLE 3

For clearness Table 3 has been divided into three parts, indicated by Roman numerals.

Part I gives the algebraic relations between the strength properties and the specific gravity.

Part II expresses the measure of accuracy of the equations, in percentages. As can be seen, the limits are fairly close and, for all practical purposes, the equation values are sufficiently accurate.

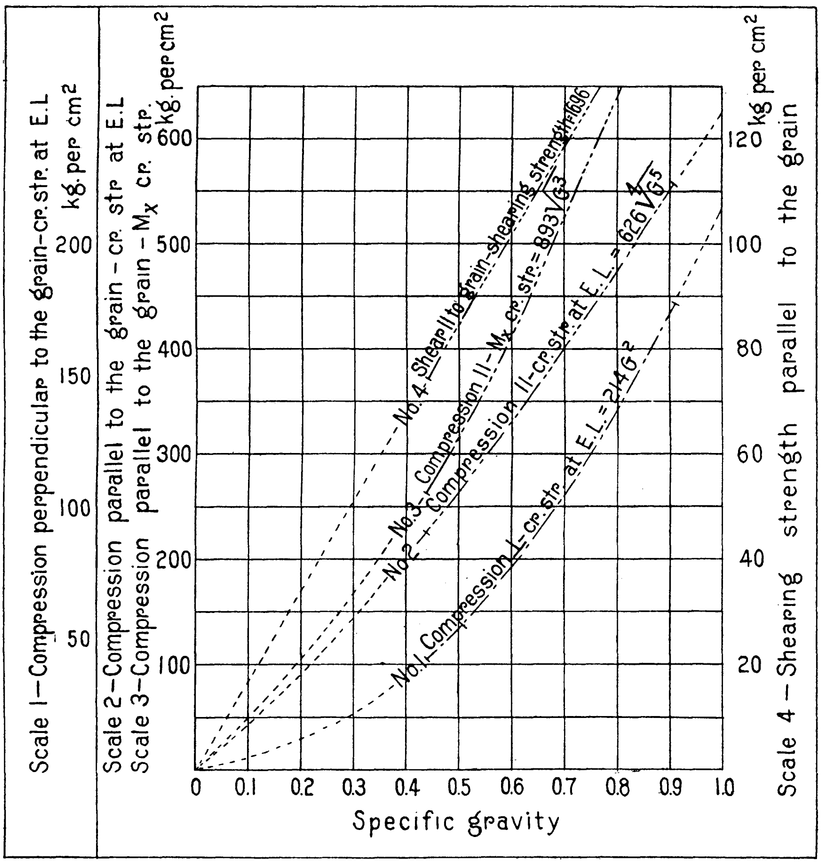


FIG. 4. Relation of strength properties in compression and shear to specific gravity.

GUIDE TO USE OF CURVES

Scale 1: Compression perpendicular to crushing strength at elastic limit. Use curve 1.
Scale 2: Compression parallel to crushing strength at elastic limit. Use curve 2.
Scale 3: Compression parallel to maximum crushing strength. Use curve 3.
Scale 4: Shearing strength parallel to the grain. Use curve 4.

Part III gives the comparison between the equation values and the experimental values. In one instance it can be pointed out that the variation is 202 per cent, as in work to maximum load for almon. This is to be expected, from the fact that wood is

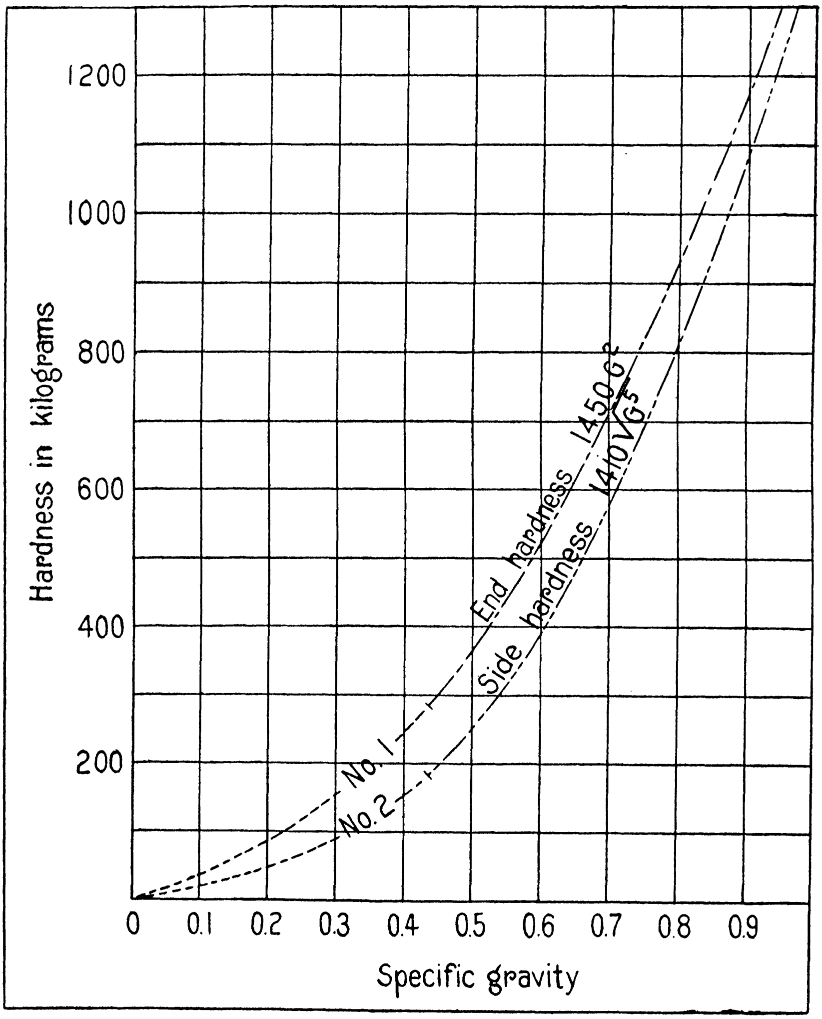


FIG. 5. Relation of end and side hardness to specific gravity.

EXPLANATORY NOTE

End hardness = load required to embed a 1.12-centimeter ball (7/16-inch diameter) one-half its diameter on an end surface. Use curve 1.

Side hardness = load required to embed a 1.12-centimeter ball (7/16-inch diameter) one-half its diameter on a side surface. Use curve 2.

TABLE 3.—*Relation of strength properties to specific gravity.*

[The equations are based on tests of standard clear specimens. The calculations are adjusted to 12 per cent moisture.]

	Static bending.							Compression parallel.		Compression perpendicular crushing strength at elastic limit.	Shear parallel to grain.	Hardness, end.	Hardness, side.
	Specific gravity, oven dry, based on volume at test.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity, 1,000 kg cm²	Longitudinal shear.	Work to elastic limit.	Work to maximum load.	Crushing strength at elastic limit.	Maximum crushing strength.				
	Part I.—Equations.												
Air-dry adjusted to 12 per cent moisture contents.	--------	$944\sqrt[4]{G^5}$ kg per cm²	$1660\sqrt[4]{G^5}$ kg per cm²	$223\ G$ 1000 kg per cm²	$59.6\sqrt[4]{G^5}$ kg per cm²	$0.29\ G^2$ kg-cm per cm³	$2.3\ G^2$ kg-cm per cm²	$626\sqrt[4]{G^5}$ kg per cm²	$893\sqrt{G^3}$ kg per cm²	$214\ G^2$ kg per cm²	$169\ G$ kg per cm²	$1450\ G$ kg	$1410\sqrt{G^5}$ kg
	Part II.—Measure of accuracy of respective equations (per cent of equation value).												
10 per cent of number of species are above—	--------	122	116	113	108	150	167	126	126	130	109	120	146
10 per cent of number of species are below—	--------	87	84	85	86	72	66	83	83	80	88	74	94
25 per cent of number of species are above—	--------	113	105	104	104	125	140	109	114	113	103	101	132
25 per cent of number of species are below—	--------	90	95	91	93	93	79	93	92	92	94	86	103
Common name.	Part III.—Comparison of actual value as obtained by tests with equation value.												
Almon:													
Experimental value	0.50	548	741	124	27.0	0.117	1.17	373	414	59.6	86.7	423	374
Equation value	--------	397	698	112	25.1	0.073	0.575	263	316	53.5	84.5	363	294
Per cent of equation value	--------	138	106	117	107	160	202	142	131	111	103	116	150

Amamanit:													
Experimental value	0.57	530	880	132	31.2	0.124	1.08	332	417	53.7			
Equation value		468	822	127	29.5	0.094	0.75	310	384	69.5			
Per cent of equation value		113	107	104	106	132	140	107	108	77			
Apitong:													
Experimental value	0.61	458	803	141	28.7	0.091	0.857	327	387	64.1	90.2	468	411
Equation value		509	895	136	32.1	0.108	0.856	337	425	79.6	103	540	410
Per cent of equation value		90	90	104	89	84	100	97	91	80	87	87	100
Aranga:													
Experimental value	0.83	661	1,153	157	40.3	0.145	0.813	432	619	151	127	984	817
Equation value		748	1,315	185	47.2	0.200	1.58	496	675	147	140	999	885
Per cent of equation value		88	80	85	85	72	51	87	92	103	91	98	92
Bagtikan:													
Experimental value	0.57	447	813	130	29.2	0.117	0.891	354	400	67.8	89.1	350	399
Equation value		468	822	127	29.5	0.094	0.747	310	384	69.5	96.3	471	346
Per cent of equation value		95	99	102	99	125	119	114	104	98	92	75	115
Dulitan:													
Experimental value	0.54	355	813	102	28.8	0.084	1.12	240	332	48.0			
Equation value		437	768	120	27.6	0.085	0.671	290	354	62.4			
Per cent of equation value		81	106	85	104	99	167	83	94	77			
Guijo:													
Experimental value	0.73	672	1,175	184	39.8	0.155	1.27	437	557	107	118	562	617
Equation value		637	1,120	163	40.2	0.155	1.23	422	557	114	123	773	642
Per cent of equation value		105	105	113	99	100	103	104	100	94	88	73	96
Ipil:													
Experimental value	0.72	1,002	1,452	175	51.5	0.316	1.32	646	741	142		750	929
Equation value		626	1,101	161	39.5	0.150	1.19	415	546	110		752	620
Per cent of equation value		160	132	108	130	210	111	156	136	129		100	150
Kalamansanai:													
Experimental value	0.71	711	1,253	159	42.2	0.215	1.66	442	627	141	132	893	832
Equation value		615	1,082	158	38.9	0.146	1.16	408	534	108	120	731	599
Per cent of equation value		116	106	100	108	147	143	108	117	130	110	122	139

TABLE 3.—*Relation of strength properties to specific gravity*—Continued.

Common name	Specific gravity, oven dry, based on volume at test.	Static bending. Fiber stress at elastic limit.	Static bending. Modulus of rupture.	Static bending. Modulus of elasticity, 1,000 kg cm^2	Static bending. Longitudinal shear.	Static bending. Work to elastic limit.	Static bending. Work to maximum load.	Compression parallel. Crushing strength at elastic limit.	Compression parallel. Maximum crushing strength.	Compression perpendicular crushing strength at elastic limit.	Shear parallel to grain.	Hardness, end.	Hardness, side.
	Part III. Comparison of actual value as obtained by tests with equation value.												
Lumbayao:													
Experimental value	0.56	425	785	111	27.9	0.095	0.724	264	378	61.9	90.5	392	342
Equation value		457	804	125	28.9	0.091	0.720	303	374	67.1	94.6	455	331
Per cent of equation value		93	98	89	97	104	100	87	101	92	96	86	103
Manggasinoro:													
Experimental value	0.44	402	694	111	24.8	0.084	0.750	244	330	48.2	81.0	349	281
Equation value		338	595	98	21.4	0.056	0.445	244	261	41.4	74.4	281	181
Per cent of equation value		119	116	113	116	150	168	109	126	116	109	124	155
Nato:													
Experimental value	0.56	428	821	108	27.0	0.090	0.682	256	336	74.1	90.2	459	431
Equation value		457	804	125	28.9	0.091	0.721	303	374	67.1	94.6	455	331
Per cent of equation value		94	102	86	93	99	95	85	90	110	95	101	131
Pahutan:													
Experimental value	0.65	489	813	132	29.8	0.086	0.643	372	468	83.2	115	603	560
Equation value		551	969	145	34.8	0.123	0.972	365	468	90.4	110	613	480
Per cent of equation value		89	84	91	86	70	66	102	100	92	105	98	117
Palosapis:													
Experimental value	0.54	379	732	111	25.6	0.079	0.757	269	342	58.9	94.7	369	373
Equation value		437	768	120	27.6	0.085	0.671	290	354	62.4	91.3	423	302
Per cent of equation value		87	95	92	93	93	113	93	97	94	104	87	124

Pototan:													
Experimental value	0.75	802	1,365	197	43.2	0.172	0.975	468	581	136	115	977	1,000
Equation value		659	1,159	167	41.6	0.163	1.29	437	580	120	127	816	687
Per cent of equation value		122	118	118	104	105	75	107	100	113	91	120	146
Red lauan:													
Experimental value	0.51	437	724	118	25.2	0.094	0.813	317	365	57.5	81.4	301	313
Equation value		407	715	114	25.7	0.075	0.598	270	324	55.7	86.2	377	262
Per cent of equation value		107	101	103	98	125	136	117	113	103	94	80	119
Supa:													
Experimental value	0.70	597	1,050	126	37.0	0.149	0.887	468	589	162	123	767	762
Equation value		604	1,063	156	38.2	0.142	1.13	401	523	105	118	711	578
Per cent of equation value		99	99	81	97	105	79	117	112	154	114	108	132
Tangile:													
Experimental value	0.55	420	735	116	25.9	0.086	0.698	284	303	55.0	81.3	309	297
Equation value		447	786	123	28.2	0.088	0.696	296	364	64.7	92.9	439	316
Per cent of equation value		94	93	94	92	98	100	96	83	85	88	70	94
Tindalo:													
Experimental value	0.79	716	1,272	130	47.9	0.216	1.37	462	716	193		1,122	1,054
Equation value		703	1,236	176	44.4	0.181	1.44	466	627	134		905	782
Per cent of equation value		102	103	74	108	119	95	99	114	144		124	135
White lauan:													
Experimental value	0.50	426	743	121	26.1	0.085	0.908	331	365	53.0	84.0	357	325
Equation value		397	698	112	25.1	0.073	0.575	263	316	53.5	84.5	363	249
Per cent of equation value		107	106	108	104	116	158	126	115	99	99	98	130
Yakal:													
Experimental value	0.91	800	1,426	209	50.7	0.188	1.35	450	634	147	132	891	937
Equation value		839	1,475	203	53.0	0.240	1.90	556	775	177	154	1,201	1,114
Per cent of equation value		95	97	103	96	90	71	81	82	83	86	74	84

so unhomogeneous, and for this reason the builder must determine the proper factor of safety for his particular construction.

USE OF THE EQUATIONS

No attempt is herein made to place within the limits of physical laws so nonhomogeneous a material as wood. There are so many factors involved, even in simple compression, that, in many instances, the values as found by actual test do not fall within 10 per cent of the equation values. This, however, need not to be regretted, because it is particularly by means of these deviations of the experimental values from the equation values that certain physical characteristics inherent in some species are explained.

A concrete example of the practical use of the equation is the following: Suppose it is desired to know the stiffness in bending of gisok, *Shorea balangeran* Dyer, Dipterocarpaceæ. Gisok is very similar to yakal, *Hopea basilanica* Foxworthy, Dipterocarpaceæ, and is known as such in the market. The oven-dry specific gravity of a certain specimen of gisok is found by experiment to be 0.80; the best measure or stiffness in bending is the modulus of elasticity; and the corresponding equation is 223,000 G, where G is the oven-dry specific gravity. Solving this equation for the specific gravity of 0.80, the modulus of elasticity in bending is 178,000 kilograms per square centimeter. It is seen from Table 3 that the experimental value for this particular strength property, in the case of yakal, is 103 per cent of the equation value. It is therefore reasonable to believe that the same would hold true with gisok, and the value sought is 103 per cent of 178,000, or 183,000 kilograms per square centimeter.

A simpler way of obtaining the value is by using the graph for modulus of elasticity in static bending. Here it is only necessary to strike off, for the specific gravity in question, the corresponding strength value, and to multiply the figure obtained by the correction factor to give the most probable value sought. In like manner the other strength figures can be found either graphically or by the use of the equations.

It is emphasized that no absolute accuracy is claimed for the figures obtained, following the methods herein presented, when innumerable factors are involved in the determination of the strength of wood. It is, however, true that these simple methods give a certain degree of precision, which is sufficient for all rough predictions of the properties of new species by simply determining the oven-dry specific gravity of the specimen. It is certain that the only reliable figures are those obtained from actual tests on the species; but to obtain these obviously requires a greater amount of time and expense than the purpose would justify, in as much as a large number of tests must be made in order to obtain reliable values.

ILLUSTRATIONS

TEXT FIGURES

ESTERS OF ALPHA LINOLENIC ACID HEXABROMIDE (ISOBUTYL, AMYL, N-PROPYL, AND ISOPROPYL) FROM PHILIPPINE LUMBANG OIL

By MARIA LUISA A. VICENTE

Assistant in Chemistry, University of the Philippines

and

AUGUSTUS P. WEST

Professor of Chemistry, University of the Philippines

Linolenic and linolic glycerides are the important constituents of vegetable drying oils, since these are the particular substances that absorb oxygen from the air and cause the oil to dry.[1] Linolenic glyceride [2] has a greater capacity for the absorption of oxygen than has any of the other compounds contained in drying oils. This glyceride and the corresponding free linolenic acid are, therefore, substances of considerable importance. Although linolenic glyceride and the free linolenic acid are substances which oxidize readily, they may be separated from an oil in the form of a stable crystallized hexabromide.[3]

$$CH_3CH_2\overset{Br}{\overset{|}{C}}H\text{-}\overset{Br}{\overset{|}{C}}HCH_2\overset{Br}{\overset{|}{C}}H\text{-}\overset{Br}{\overset{|}{C}}HCH_2\overset{Br}{\overset{|}{C}}H\text{-}\overset{Br}{\overset{|}{C}}H(CH_2)_7COOH$$

Alpha linolenic acid hexabromide

When this crystallized hexabromide is reduced with zinc a molecular rearrangement seems to occur and two linolenic acids are obtained; namely, alpha and beta. Bromination of these mixed linolenic acids gives the crystallized alpha linolenic hexabromide and the liquid beta linolenic hexabromide.[4]

[1] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes 2 (1922) 42.

[2] West, A. P., and A. I. de Leon, Philip. Journ. Sci. 24 (1924) 123.

[3] Lewkowitsch, J., op. cit. 1 (1921) 212.

[4] Smith, F. L., and A. P. West, Philip. Journ. Sci. 32 (1927) 297.
Erdmann, E., and F. Bedford, Ber. Deut. Chem. Gesell. 42 (1909) 1328.

Only very few derivatives of crystallized alpha linolenic hexabromide have ever been prepared. Erdmann and Bedford [5] prepared the potassium and barium salts of the hexabromide and also the methyl and ethyl esters. Imperial and West [6] prepared the barium, zinc, and lead salts and determined the melting point and the solubility of these salts in various solvents. The calcium, magnesium, strontium, and nickel salts have also been prepared.[7]

Since very few derivatives of alpha linolenic hexabromide have been made, it would seem desirable to make a few more derivatives of this substance in order to learn more of the chemistry of these important linolenic compounds.

In this investigation four new esters of alpha linolenic hexabromide were prepared; namely, isobutyl, amyl, *n*-propyl, and isopropyl. The melting point and the solubility of each of these esters in various solvents were determined.

EXPERIMENTAL PROCEDURE

Alpha linolenic hexabromide.—Philippine lumbang oil was used as the material for preparing a supply of alpha linolenic hexabromide. Lumbang oil [8] is obtained from the seeds of *Aleurites moluccana.* It consists almost entirely of glycerides of unsaturated acids; namely, linolenic, linolic, and oleic.[9] It is a drying oil and is used in making paints, varnishes, and similar products.[10] The lumbang oil was pressed from seeds of good quality and filtered first through glass wool and then through filter paper.

Alpha linolenic hexabromide was prepared from lumbang oil in accordance with the procedure adopted by Santiago and West [11] in a recent investigation of lumbang compounds. The lumbang oil was saponified with aldehyde-free alcoholic potassium hydroxide.[12] The mixed potassium salts thus obtained were converted into the mixed acids. The mixed acids were

[5] Ber. Deutsche Chem. Gesell. 42 (1909) 1330.
[6] Philip. Journ. Sci. 31 (1926) 441.
[7] Almoradie, P. R., and A. P. West, Philip. Journ. Sci. 33 (1927) 257.
[8] West, A. P., and W. H. Brown, Bull. P. I. Bur. Forestry 20 (1920) 112.
[9] West, A. P., and Z. Montes, Philip. Journ. Sci. 18 (1921) 619.
[10] West, A. P., and F. L. Smith, Bull. P. I. Bur. Forestry 24 (1923).
[11] Philip. Journ. Sci. 32 (1927) 41.
[12] Dunlap, F. L., Journ. Am. Chem. Soc. 28 (1906) 397.

brominated in ether solution according to the procedure used by Imperial and West [13] in preparing linolenic hexabromide. The ether solution of mixed acids was stirred mechanically by means of a hot-air motor and brominated at $-10°$ C. The insoluble linolenic hexabromide was removed by filtering. After crystallizing several times from ethyl acetate and benzene the melting point of the hexabromide was 179.5 to 180.5° C.

When the mixed acids of lumbang oil are brominated directly no liquid beta linolenic hexabromide is obtained but only the crystallized alpha linolenic hexabromide.

Esters of alpha linolenic hexabromide were prepared by treating the hexabromide with various alcohols in the presence of sulphuric acid.

Isobutyl ester of alpha linolenic hexabromide.—Five grams of alpha linolenic hexabromide were treated with about 600 cubic centimeters of hot isobutyl alcohol. The solution was heated on a boiling water bath and shaken occasionally until most of the hexabromide was dissolved. The solution was then filtered. The clear filtrate was cooled somewhat and treated with 8 cubic centimeters of concentrated sulphuric acid. The mixture of hexabromide, isobutyl alcohol, and sulphuric acid was then heated (reflux) on a wire gauze and allowed to boil gently for about two days. The mixture was then transferred to a distilling flask. The distilling flask containing the mixture was immersed in an oil bath, which was gradually heated to a temperature of about 130° C., and the excess isobutyl alcohol was removed by distilling. When the residue was cooled, the ester crystallized. The ester was then dissolved in ether and the ethereal solution was treated with a concentrated solution of potassium carbonate to neutralize the acid present. The ethereal solution was then separated from the aqueous carbonate solution, washed with water, and dehydrated with anhydrous sodium sulphate. The excess ether was then eliminated by distilling. The residue was crystallized several times from ether and twice from ethyl alcohol. The purified ester was obtained as white crystals which melted at 136 to 138° C. The yield was about 56 per cent.

The ester dissolved readily in the following hot solvents: Xylene, toluene, ethyl benzoate, ethyl acetate, acetone, methyl benzoate, benzene, chloroform, carbon bisulphide, and carbon tetrachloride. The ester was also soluble in hot ethyl alcohol

[13] Philip. Journ. Sci. 31 (1926) 441.

and isopropyl alcohol but insoluble in hot methyl alcohol and petroleum ether.

Analysis:

	Bromine. Per cent.
Calculated for $C_{22}H_{38}Br_6O_2$	58.94
Found	58.79

Amyl ester of alpha linolenic hexabromide.—Seven grams of alpha linolenic hexabromide were treated with about 250 cubic centimeters of hot amyl alcohol. The solution was boiled until most of the hexabromide was dissolved and then filtered. The clear solution was cooled somewhat and treated with 8 cubic centimeters of concentrated sulphuric acid. The mixture was heated (reflux) on a wire gauze and boiled gently for about two days. The excess amyl alcohol was removed by distilling the mixture over an oil bath. When cooled the ester crystallized. The ester was dissolved in ether and the ethereal solution neutralized with potassium carbonate, washed with water, and dehydrated with anhydrous sodium sulphate. The excess ether was then removed by distilling. The residue was crystallized several times from ether and twice from ethyl alcohol. The ester was obtained as white crystals and melted at 133 to 135° C. The yield was about 46 per cent.

Qualitative solubility experiments showed that the ester dissolved readily in hot xylene, toluene, ethyl benzoate, ethyl acetate, acetone, methyl benzoate, benzene, chloroform, carbon disulphide, and carbon tetrachloride. The ester was also soluble in hot ethyl alcohol, isopropyl alcohol, and isobutyl alcohol. It was found to be insoluble in hot methyl alcohol and petroleum ether.

Analysis:

	Bromine. Per cent.
Calculated for $C_{23}H_{40}Br_6O_2$	57.95
Found	57.47

N-propyl ester of alpha linolenic hexabromide.—Five grams of alpha linolenic hexabromide were boiled with about 600 cubic centimeters of *n*-propyl alcohol. The solution was filtered and treated with 6 cubic centimeters of concentrated sulphuric acid. The mixture was heated (reflux) on a wire gauze and boiled gently for about two days. The excess propyl alcohol was removed by distilling. The residue consisting mostly of the propyl ester crystallized when cooled. The ester was dissolved in ether and purified in the same manner as the isobutyl and amyl esters. The white crystals of *n*-propyl ester melted at 144 to 146° C. The yield was about 76 per cent.

The ester dissolved readily in hot xylene, toluene, ethyl benzoate, ethyl acetate, acetone, methyl benzoate, benzene, chloroform, carbon disulphide, and carbon tetrachloride. The ester was also soluble in hot methyl alcohol, ethyl alcohol, *n*-propyl alcohol, isopropyl alcohol, isobutyl alcohol, and amyl alcohol. The ester was only slightly soluble in hot petroleum ether.

Analysis:

	Bromine. Per cent.
Calculated for $C_{21}H_{36}Br_6O_2$	59.95
Found	59.36

Isopropyl ester of alpha linolenic hexabromide.—This ester was prepared in the same manner as were the other esters. Five grams of the hexabromide were boiled with about 600 cubic centimeters of isopropyl alcohol. The solution was filtered and treated with about 6 cubic centimeters of concentrated sulphuric acid. The mixture was boiled gently for about two days, after which the excess isopropyl alcohol was removed by distilling. When extracted with ether and the ethereal solution purified, the ester was obtained as white crystals which melted at 141 to 143° C. The yield was about 66 per cent.

The ester dissolved readily in the following hot solvents: Xylene, toluene, petroleum ether, ethyl benzoate, ethyl acetate, acetone, methyl benzoate, benzene, chloroform, carbon disulphide, carbon tetrachloride, methyl alcohol, ethyl alcohol, *n*-propyl alcohol, isopropyl alcohol, isobutyl alcohol, and amyl alcohol.

Analysis:

	Bromine. Per cent.
Calculated for $C_{21}H_{36}Br_6O_2$	59.95
Found	59.38

SUMMARY

Four new compounds, derivatives of crystallized alpha linolenic hexabromide, were prepared from Philippine lumbang oil. These new compounds are the isobutyl, amyl, *n*-propyl, and isopropyl esters of crystallized alpha linolenic hexabromide.

These esters were prepared by the interaction of alpha linolenic hexabromide with various alcohols in the presence of sulphuric acid.

The melting point of these esters was determined and also the solubility in various solvents.

NEW STEPHANIDÆ FROM BORNEO AND THE PHILIPPINE ISLANDS, V

By E. A. ELLIOTT

Fellow of the Zoölogical Society of London and of the Entomological Society of London

Subfamily FOENATOPUS Smith

This appears to be a somewhat widely distributed subfamily, chiefly recorded from the Indo-Australian Region and Africa. The number and the color of the hind femoral teeth furnish a convenient means of dividing the species into well-defined groups, and the sculpture of the head is perhaps the next most important feature.

Key to species of Foenatopus.

FEMALES

11. 1. Hind femora tridentate.
11. 2. Femoral teeth white.
6. 3. Frons arcuate striate.
5. 4. Vertex and occiput rugose punctate; anterior tubercle well developed .... **F. butuanus** sp. nov.
4. 5. Vertex and occiput not punctate; anterior tubercle very small. **F. gracilis** sp. nov.
3. 6. Frons transversely, not arcuately striate.
10. 7. Hind femora transaciculate.
9. 8. Vertex and occiput finely transstriate, superficially punctate. **F. varicolor** sp. nov.
8. 9. Vertex and occiput transrugose, not punctate. **F. aciculatus** sp. nov.
7. 10. Hind femora smooth; vertex and occiput laterally punctate. **F. rufitarsis** sp. nov.
2. 11. Hind femoral teeth concolorous with femora.
13. 12. Occiput sulcate; radius from apical fourth of stigma, distal section twice as long as the proximal .... **F. rubricaput** sp. nov.
12. 13. Occiput not sulcate, radius from near apex of stigma, both sections of the same length .... **F. insularis** sp. nov.
1. 14. Hind femora bidentate.
16. 15. Hind femoral teeth white; head transverse.... **F. transversus** sp. nov.
15. 16. Hind femoral teeth concolorous with femora.
18. 17. Terebra black .... **F. occellatus** Elliott.
17. 18. Terebra white or yellowish banded.
20. 19. Wings milky white; frons, vertex, and occiput arcuate striate, frons also punctate .... **F. lacteipennis** Schletterer.

19. 20. Wings hyaline.
28. 21. Sculpture of frons arcuate
25. 22. Neck normal.
24. 23. Neck coarsely transstriate; petiole longer than rest of abdomen; terebra longer than body.................................. F. **rufescens** sp. nov.
23. 24. Neck finely transstriate, petiole as long as rest of abdomen; terebra as long as body.. F. **dubius** sp. nov.
22. 25. Neck very elongate.
27. 26. Mesonotum apically smooth, basally obliquely striate, terebra longer than body.. F. **atripes** Kieffer.
26. 27. Mesonotum irregularly rugose throughout; terebra slightly shorter than body.. F. **intermedius** sp. nov.
21. 28. Sculpture of frons not arcuate.
34. 29. Frons transstriate.
31. 30. Vertex and occiput obliquely striate; metapleuræ rugose; terebra longer than body.. F. **longicollis** Cameron.
30. 31. Vertex and occiput finely transtriate; neck elongate.
33. 32. Metapleuræ and median segment coarsely and closely punctate; separated by a sulcus................................. F. **mazarredoi** Caballos.
32. 33. Metapleuræ and median segment cribate punctate, confluent. F. **terecollis** sp. nov.
29. 34. Frons otherwise sculptured.
36. 35. Frons indistinctly, subgranulately striate; mesonotum very short; metapleuræ and median segment confluent.... F. **sibuyanus** sp. nov.
35. 36. Frons rugose.
38. 37. Frons coriaceo-rugose; neck finely transrugose; terebra longer than body, white-banded............................ F. **indicus** (Westwood).
37. 38. Frons transversely rugose.
40. 39. Neck coarsely transrugose; terebra longer than body, yellow banded. F. **sumbanus** Enderlein.
39. 40. Neck feebly transrugose; terebra only as long as body, white banded... F. **glabricoxis** sp nov.

MALES

16. 1. Hind femora tridentate.
13. 2. Femoral teeth more or less white.
6. 3. Two basal teeth white.
5. 4. Mesonotum confluently punctate; metapleuræ and median segment coarsely punctate, confluent .... F. **flavifrons** Elliott.
4. 5. Mesonotum diffusely punctate, metapleuræ coarsely, median segment diffusely punctate, separated by a carina. F. **pictipes** sp. nov.
3. 6. All femoral teeth white.
10. 7. Hind femora transaciculate.
9. 8. Vertex and occiput transrugose; head rufotestaceous, vertex and occiput dark red...F. **aciculatus** sp. nov.
8. 9. Frons and vertex finely transstriate, superficially punctate; head flavescent... F. **varicolor** sp. nov.
7. 10. Hind femora smooth.
12. 11. Vertex and occiput punctate; median segment reticulate punctate; head mostly rufotestaceous.............................. F. **butuanus** sp. nov.

11. 12. Vertex and occiput not punctate; median segment alutaceous, diffusely punctate; head chiefly white................ **F. albiceps** sp. nov.
2. 13. Hind femoral teeth concolorous with femora.
15. 14. Hind coxæ strongly clavate, much longer than femora; metapleuræ and median segment coarsely punctate, confluent. **F. longicoxis** sp. nov.
14. 15. Hind coxæ normal; neck elongate, metapleuræ and median segment cribate punctate, separated by an incomplete carina. **F. insularis** sp. nov.
1. 16. Hind femora bidentate.
18. 17. Frons coriaceo-rugose; metapleuræ and median segment confluent; head red.. **F. indicus** (Westwood).
17. 18. Frons arcuate striate; metapleuræ and median segment separated by a carina; head mostly black............................ **F. dubius** sp. nov.

FOENATOPUS BUTUANUS sp. nov.

Female.—Frons arcuate striate, vertex and occiput with large superficial punctures, centrally more rugose, with fine longitudinal sulcus, occiput basally more or less smooth; ocellus situated at top of ocellar space, almost between the well-devéloped posterior tubercles; four carinæ on vertex, the posterior ocelli at the ends of the second and third; posterior margin of head strongly bordered. Scape as long as cheeks; second flagellar joint little longer than first, third longer than first and second together. Neck rather long, apically transrugose, basally almost smooth, semiannular short, apically and laterally punctate, basally smooth. Mesonotum rugose punctate, basally smooth, the three impressions distinct. Scutellum centrally smooth, lateral lobes rugose; metapleuræ smooth above, indistinctly sculptured beneath. Metapleuræ and median segment reticulate punctate, separated by a carina. Petiole finely and evenly transstriate, shorter than the smooth remainder of abdomen. Terebra shorter than body, black or rufescent. Hind coxæ transstriate, as long as the smooth tridentate femora; tibiæ no much longer than femora, compresed in basal three-fifths; metatarsi rather more than twice as long as the remaining joints. Radius emitted from apical fourth of stigma, its distal section twice as long as the proximal.

Black; head beneath, frons, cheeks, and temples, ocelar space, and first flagellar joint flavescent, vertex and occiput red to nigrescent, the carinæ paler; neck sometimes rufescent, petiole and abdomen ventrally more or less rufescent; anterior legs rufotestaceous, middle tibiæ and metatarsi basally white; hind legs red, their tarsi paler. Femoral teeth white. Stigma and nervures red-brown.

Length, 9 to 11 millimeters; abdomen, 5 to 6; petiole, 2 to 8; terebra, 8 to 9.

MINDANAO, Butuan (*Baker*).

Male.—Agrees in sculpture with the female, except that the metapleuræ are more smooth above, the petiole is much shorter than rest of abdomen, and the metatarsi about as long as the remaining joints.

Black; head beneath, cheeks, and temples flavescent; face, frons apically, and three longitudinal lines testaceous, the central line extends to and includes the apical tubercle, the others and the carinæ on vertex are red; anterior legs and hind tarsi rufotestaceous.

Length, 11.5 millimeters; abdomen, 7; petiole, 2.5.

MINDANAO, Iligan, Davao (*Baker*).

The hind femora are sometimes lightly transaciculate. In one male the frons is darker, the lines less distinct and a pale spot in the ocellar space.

FOENATOPUS GRACILIS sp. nov.

Female.—Frons finely arcuate striate, vertex and occiput coarsely transstriate, latter basally smooth: posterior margin of head bordered; three carinæ on vertex; anterior tubercle very small, the rest well developed, posterior ones broad. Scape as long as cheeks; antennæ long and slender, normal. Neck apically coarsely, centrally more finely transstriate, basally and semiannular smooth. Mesonotum apically smooth, basally rugose punctate, the impressions subobsolete. Scutellum centrally smooth, lateral lobes punctate; mesopleuræ smooth. Metapleuræ coarsely, median segment reticulately punctate, separated by a carina. Petiole finely transstriate, shorter than rest of abdomen. Terebra shorter than body, rufescent. Hind coxæ cylindrical, finely transstriate; femora transaciculate, tridentate; tibiæ much longer than femora, compressed in basal two-fifths; metatarsi scarcely three times as long as the remaining joints. Radius emitted from apical fourth of stigma, its distal section about twice as long as the proximal.

Rufotestaceous; mesonotum, scutellum, and abdomen from second segment dark rufescent; vertex rufescent, outer orbits flavescent; middle tibiæ basally whitish; hind legs rather darker than the anterior. Stigma and nervures rufescent. Femoral teeth white.

Length, 9.5 millimeters; abdomen, 5.5; petiole, 2.5; terebra, 3.

MINDANAO, Davao (*Baker*).

FOENATOPUS VARICOLOR sp nov.

Female.—Frons and vertex transstriate, occiput rugose punctate, with central smooth line; three carinæ on vertex; posterior margin of head bordered; ocellar space rugose; posterior tubercles obsolete. Scape about as long as cheeks; second flagellar joint short, third rather longer than first and second together. Pronotum transstriate, basally laterally smooth. Mesonotum short, smooth, impressions weak. Scutellum smooth; mesopleuræ large, smooth above, finely punctate beneath. Metapleuræ coarsely punctate, separated by a carina from the cribrate punctate median segment. Petiole finely and evenly transstriate, shorter than the rest of the smooth abdomen. Terebra shorter than body, with yellowish subapical band. Hind coxæ transstriate, about as long as the finely transstriate, tridentate femora; tibiæ longer than femora, compressed to middle; metatarsi not quite three times as long as the remaining joints. Radius emitted from apical fourth of stigma, its distal section about half as long again as the proximal.

Black; head dark red, frons and vertex nigrescent, a pale line under eyes, three or four basal antennal joints rufous; anterior legs rufescent, middle and hind metatarsi yellowish white, the extreme apex red. Femoral teeth white.

Length, 10 millimeters; abdomen, 6; petiole, 2.5; terebra, 9; band, 3; apex, 1.

Male.—Frons very finely, vertex and occiput more or less coarsely transstriate, the latter with a few superficial punctures. Third flagellar joint not longer than first and second together. Petiole transstriate, much shorter than rest of abdomen. Hind femora sometimes transaciculate; tibiæ compressed to beyond middle.

Black; head and three or four basal antennal joints flavous, the black ocelli very conspicuous; anterior legs rufotestaceous; middle and hind metatarsi white. Stigma and nervures rufescent.

Length, 7 to 10 millimeters; abdomen, 3.5 to 6; petiole, 1.5 to 2.5.

SINGAPORE (*Baker*).

Though differing greatly in color, the sexes agree in sculpture, and I have no doubt that they belong together. The white femoral teeth are less distinct in the males, and in one example are almost rufescent.

Apparently closely allied to my *F. ocellatus* from Sarawak.

FOENATOPUS ACICULATUS sp. nov.

Female.—Frons finely transstriate, vertex and occiput more or less distinctly transrugose, latter basally smooth; posterior tubercles small but distinct; three or four carinæ on vertex; posterior margin of head bordered. Scape shorter than cheeks; second flagellar joint little longer than first, third barely as long as first and second together. Neck irregularly transcarinate, semiannular closely punctate, basally narrowly smooth, not quite half as long as neck. Mesonotum very short, rugose. Scutellum centrally smooth, central lobe laterally finely punctate, lateral lobes closely and coarsely punctate; mesopleuræ smooth or finely transaciculate and shining above, finely punctate beneath. Metapleuræ rather small, rugose punctate, separated by a carina from the cribrate punctate median segment. Petiole finely transstriate, as long as the smooth rest of abdomen. Terebra shorter than body, black. Hind coxæ transstriate, femora and tibiæ transaciculate, the former tridentate, latter compressed in bassal two-thirds; matatarsi about three times as long as the remaining joints. Radius emitted from apical fifth of stigma, its distal section about half as long as again as the proximal.

Black; inclining to red beneath; head and three basal antennal joints rufotestaceous, vertex and occiput dark red; pronotum sometimes rufescent; anterior legs rufescent, middle tibiæ and metatarsi basally white; hind legs dark red, their metatarsi white or pale rufescent. Femoral teeth white.

Length, 9 to 11 millimeters; abdomen, 5 to 7; petiole, 2.5 to 3; terebra, 7 to 9.

MINDANAO, Butuan, Dapitan. BASILAN, male. SIBUYAN, male. BORNEO, Sandakan (*Baker*).

Male.—Third flagellar joint as long as first and second together; petiole shorter than rest of abdomen; hind metatarsi very little longer than the remaining joints. Otherwise as in female.

Black; head, three basal antennal joints, and anterior legs rufotestaceous, vertex more reddish, outer orbits broadly white. Stigma and nervures red-brown.

Length, 9 millimeters; abdomen, 5; petiole, 2.

MINDANAO, Iligan (*Baker*).

Especially characterized by the transaciculate hind femora and tibiæ.

FOENATOPUS RUFITARSIS sp. nov.

Female.—Frons and ocellar space finely transstriate, anterior tubercles subobsolete, posterior ones broad and obtuse; vertex and occiput indistinctly transstriate, with large superficial punctures laterally; three carinæ on vertex; posterior margin of head finely bordered. Scape as long as cheeks; antennal joints short, second little longer than first, third shorter than first and second together. Neck apically transcarinate, basally smooth, semiannular half as long as neck, basally finely transstriate. Mesonotum short, finely punctate, with three distinct impressions. Central lobe of scutellum smooth, lateral lobes finely punctate; mesopleuræ smooth above, finely punctate beneath. Metapleuræ rugose punctate, separated by a carina from the reticulate punctate median segment. Petiole finely transstriate, as long as, or slightly shorter than the remaining not very shining segments. Terebra shorter than body, black. Hind coxæ rather coarsely and irregularly transstriate, somewhat slender, trochanters inflated; femora about as long as coxæ tridentate; tibiæ not much longer than femora, compressed in basal two-thirds; metatarsi more than twice as long as the remaining joints. Radius emitted from apical fourth of stigma, its distal section half as long again as the proximal.

Black; head beneath, frons, cheeks, temples, and prothorax beneath testaceous, outer orbits slightly paler; frons and two basal antennal joints red; anterior legs and hind tarsi rufotestaceous, middle tibiæ and metatarsi basally white. Femoral teeth white. Nervures red-brown.

Length, 8 to 10 millimeters; abdomen, 4.5 to 6; petiole, 2 to 3; terebra, 7 to 9.

MINDANAO, Iligan. LUZON, Mount Limay (*Baker*).

Small denticulations behind the basal femoral tooth and those between it and the middle tooth are replaced by white bristles. In the example from Luzon the head is rather darker.

FOENATOPUS RUBRICAPUT sp. nov.

Female.—Frons apically transversely, basally arcuately, vertex and occiput very finely transversely striate, latter basally almost smooth with deep longitudinal sulcus; two carinæ on vertex; posterior margin of head bordered; posterior tubercles well developed. Scape longer than cheeks; antennæ normal. Neck elongate, finely transstriate, the semiannular smooth. Mesonotum transrugose, the impressions obsolete. Scutellum centrally mooth, lateral lobes irregularly rugose; mesopleuræ smooth, basally transaciculate. Metapleuræ and median segment coarsely punctate, separated by a carina. Petiole transstriate, shorter than the remaining smooth segments. Terebra slightly shorter than body, banded. Hind coxæ transstriate, femora tridentate, smooth, rather longer than the coxæ; tibiæ very slightly longer than the femora, compressed beyond middle; metatarsi three times as long as the remaining joints. Radius emitted from apical fourth of stigma, its distal section more than twice as long as the proximal.

Black; head red, with an indistinct paler line under eyes; anterior legs red, middle tibiæ and metatarsi basally white; scape rufotestaceous, flagellum basally rufescent.

Length, 19 millimeters; abdomen 13, petiole, 6; terebra, 18; band, 4.

BORNEO, Sandakan (*Baker*).

FOENATOPUS INSULARIS sp. nov.

Female.—Frons rather coarsely, vertex and occiput very finely transstriate, latter basally narrowly smooth; two carinæ between posterior ocelli; posterior margin of head finely bordered; posterior tubercles small but distinct. Scape shorter than cheeks; antennæ normal. Neck long and slender, transstriate, basally and the semiannular smooth. Mesonotum rugose, central impression indicated, lateral ones obsolete. Scutellum smooth, all lobes laterally punctate; mesopleuræ smooth above, otherwise punctate. Metapleuræ and median segment cribrate punctate, separated by an indistinct carina. Petiole very finely transstriate, shorter than the smooth rest of abdomen. Terebra slightly longer than body, white-banded. Hind coxæ finely transstriate, as long as the tridentate, apically transaciculate femora; tibiæ a little longer than femora, compressed about to middle; metatarsi three times as long as the remaining joints. Radius emitted from near apex of the long, narrow stigma, both sections of the same length.

Black; head red, ocellar space black, carinæ bright red, vertex nigrescent; antennæ basally, terebra, anterior legs, and hind tibiæ rufescent; middle tibiæ basally and basal half of their metatarsi whitish.

Length, 16.5 millimeters; abdomen, 11; petiole, 5; terebra, 17; band, 3.

Male.—Agrees with the female in sculpture in all essentials; the petiole is as long as rest of abdomen; hind femora entirely smooth, metatarsi about as long as the remaining joints.

Head red beneath base of antennæ, apex of frons and outer orbits testaceous, antennæ centrally rufescent, becoming black toward apex; anterior legs rufescent, middle metatarsi whitish.

Length, 13.5 millimeters; abdomen, 9; petiole, 4.5.

BASILAN (*Baker*).

This appears to be a purely insular variety. In both sexes the basal femoral tooth is small, and the male might almost be considered bidentate; but the sexes undoubtedly belong together.

FOENATOPUS TRANSVERSUS sp. nov.

Female.—Head very short, transverse; frons, vertex, and the extremely short occiput finely transstriate; two carinæ on vertex; posterior margin of head bordered finely. Scape longer than cheeks; first flagellar joint very short, second and third about equal in length, all antennal joints indistinctly discreted. Neck elongate, semiannular short, both smooth and shining. Mesonotum very short, indistinctly sculptured. Scutellum smooth; mesopleuræ smooth and very shining. Metapleuræ and median segment confluent, superficially and not very closely punctate, latter centrally almost smooth. Petiole feebly transstriate, shorter than rest of abdomen, which is very shining. Terebra shorter than body, slightly rufescent, white-banded. Hind coxæ transstriate, femora bidentate, finely transaciculate; tibiæ much longer than femora, smooth, compressed in basal two-thirds; metatarsi twice as long as the remaining joints. Radius emitted from very near apex of stigma, its distal section not quite half as long again as the proximal.

Rufescent; head and two basal antennal joints rufotestaceous, vertex and occiput nigro-rufous; anterior legs rufotestaceous, hind tarsi red. Femoral teeth white. Stigma and nervures blackish.

Length, 8.5 millimeters; abdomen, 4.5; petiole, 2; terebra, 6.5; band, 0.75.

PANAY, northwestern part (*Baker*).

This species is characterized by the transverse head, the formation of the antennæ, and the long smooth neck.

FOENATOPUS OCELLATUS Elliott.

Foenatopus ocellatus ELLIOTT, Entomologist 52 (1919) 131; Proc. Zool. Soc. London (1922) 784.

FOENATOPUS LACTEIPENNIS Schletterer.

Foenatopus lacteipennis SCHLETTERER, Berl. Ent. Zeit. 33 (1899) 119; ELLIOTT, Proc. Zool. Soc. London (1922) 790.

FOENATOPUS RUFESCENS sp. nov.

Female.—Frons arcuate striate with narrow central longitudinal sulcus; vertex and occiput finely subarcuate striate; ocellar space longitudinally carinate; two carinæ behind posterior ocelli; posterior margin of head bordered; posterior tubercles distinct. Scape as long as cheeks; antennæ normal. Neck coarsely transstriate, basally smooth, semiannular apically finely striate, basally smooth. Mesonotum finely transcarinate, with central impression only. Scutellum centrally smooth, lateral lobes coarsely punctate; mesopleuræ smooth above, punctate beneath. Metapleuræ coarsely punctate, apically smooth above, separated by an indistinct carina from the reticulate punctate median segment. Petiole extremely finely transstriate, longer than the remaining smooth segments. Terebra longer than body, yellow-banded. Hind coxæ transstriate, about as long as the smooth, bidentate femora; tibiæ a little longer than femora, compressed to middle; metatarsi three times as long as the remaining joints. Radius emitted from end of second third of stigma, its distal section little longer than the proximal.

Rufescent; anterior legs lighter; base of mandibles, face, cheeks and temples, scape and first flagellar joint, frons centrally longitudinally, and base of anterior tubercle rufotestaceous.

Length, 18.5 millimeters; abdomen, 12.5; petiole, 7; terebra, 20; band, 5.

BORNEO, Sandakan (*Baker*).

FOENATOPUS DUBIUS sp. nov.

Female and male.—Frons arcuate striate, vertex and occiput finely transstriate, latter basally smooth; a fine longitudinal sulcus on vertex and three carinæ; posterior margin of head bordered; posterior tubercles well developed. Scape almost shorter than cheeks; antennæ normal. Neck finely transstriate, basally smooth above, semiannular smooth, laterally diffusely punctate. Scutellum and mesopleuræ smooth. Metapleuræ and median segment rather superficially reticulate punctate, separated by a carina and a line of punctures. Petiole rather finely transstriate, as long as the rest of the somewhat dull abdomen. Terebra about as long as body, white-banded. Hind coxæ finely transstriate, as long as the extremely finely trans-aciculate, bidentate femora; tibiæ smooth, longer than femora, compressed to slightly beyond middle; metatarsi fully three times as long as the remaining joints in female, little longer in male. Radius emitted from apical fourth of stigma, its distal section not quite as long as the proximal.

Black; head red beneath, black above, the apices of the tubercles rufescent; frons light red in female, apically rufotes-taceous in male; base of antennæ light red; petiole, second abdominal segment, and hind legs red; anterior legs rufotestaceous, middle tibiæ basally and their metatarsi entirely white; hind metatarsi red.

Length, 12, to 13.5 millimeters; abdomen, 8; petiole, 4; terebra, in female, 12; band, 2.5; apex, 1.

MINDANAO, Davao (*Baker*).

Apparently closely allied to my *F. longicoxis*, but the hind coxæ, though similar in shape, are shorter and stouter, and the metapleuræ are separated from the median segment by a carina.

FOENATOPUS ATRIPES Kieffer.

Foenatopus atripes KIEFFER, Philip. Journ. Sci. § D 9 (1916) 410.

FOENATOPUS INTERMEDIUS sp. nov.

Female.—Frons arcuately, vertex and occiput very finely transversely striate; one carina between the posterior ocelli and another shorter one behind it; posterior margin of head bordered; all tubercles distinct. Scape barely as long as cheeks; antennæ normal. Neck very elongate, extremely finely transstriate, basally and the semiannular smooth. Mesonotum lightly, irregularly rugose, the central impunctate impression distinct, lateral ones obsolete. Scutellum and mesopleuræ smooth. Metapleuræ basally transrugose, apically, like the median segment cribrate punctate, separated basally only by an indistinct line of punctures. Petiole transstriate, shorter than rest of abdomen, second segment basally rugose. Terebra slightly shorter than body, white-banded. Hind coxæ fusiform, basally and apically finely transstriate, centrally smooth, rather longer than the bidentate femora, which are apically finely transaciculate; tibiæ not much longer than femora, trans-aciculate, compressed in basal three-fifths; metatarsi three times as long as the remaining joints. Radius emitted from apical fifth of stigma, the sections about equal in length.

Black; head beneath, cheeks, and temples red, frons and outer orbits flavescent, vertex and occiput black, scape flavescent, three or four basal flagellar joints red. Anterior legs red, their tibiæ and tarsi rufotestaceous; hind legs rufescent, tibiæ and tarsi slightly paler. Stigma and nervures red-brown.

Length, 11.5 millimeters; abdomen, 8; petiole, 3.5; terebra, 11; band, 2; apex, 0.75.

BASILAN (*Baker*).

The neuration of this species is intermediate between *Foenatopus* and *Diastephanus*, the portion of the median nervure beyond the basal cells being distinct but feebly pigmented. It is characterized by the elongate neck, shape of hind coxæ, sculpture of hind femora and tibiæ, and color.

FOENATOPUS LONGICOLLIS Cameron.

Foenatopus longicollis CAMERON, Trans. Am. Entom. Soc. Philadelphia 18 (1889) 32; ELLIOT, Proc. Zool. Soc. London (1922) 790.

FOENATOPUS MAZARREDOI Caballos.

Foenatopus mazarredoi CABALLOS, "Eos" II, 2 & 3, p. 144.

FOENATOPUS TERECOLLIS sp. nov.

Female.—Frons, vertex, and occiput finely transstriate, latter basally smooth; three costæ on vertex; ocellar space oblique striate; posterior margin of head bordered. Scape longer than cheeks; antennæ normal. Neck elongate, finely transstriate; basally smooth, as is the semiannular. Mesonotum short, irregularly rugose, central row of punctures indicated. Central lobe of scutellum smooth, lateral lobes dull and indistinctly sculptured; mesopleuræ smooth above, finely punctate beneath. Metapleuræ and median segment cribrate punctate, confluent. Petiole finely transstriate, shorter than rest of abdomen. Terebra about as long as body, yellow-banded. Hind coxæ finely transstriate, as long as the bidentate femora; tibiæ little longer than femora, compressed to beyond middle; metatarsi rather more than twice as long as the remaining joints. Radius emitted from apical third of stigma, its distal section twice as long as the proximal.

Black; head and base of antennæ red, vertex nigrescent; middle tibiæ and metatarsi rufescent, basally white. Stigma and nervures rufescent.

Length, 16 millimeters; abdomen, 10; petiole, 4.5; terebra, 16; band, 5; apex, 1.

BORNEO, Sandakan (*Baker*).

FOENATOPUS SIBUYANUS sp. nov.

Female.—Frons indistinctly, subgranulately, vertex and occiput finely transversely striate, two carinæ between posterior ocelli, ocellar space rugose, all tubercles well developed; posterior margin of head bordered. Scape as long as the cheek; antennæ normal. Neck elongate and very finely transstriate, semiannular apically transstriate, basally smooth, laterally punctate. Mesonotum very short, rugose, central row of punctures indicated, lateral one obsolete. Scutellum centrally smooth, marginal punctures fine, lateral lobes diffusely punctate; mesopleuræ smooth above, finely punctate beneath. Metapleuræ and median segment reticulate punctate, confluent. Petiole extremely finely punctate, shorter than the remaining segments. Terebra a little longer than body, white-banded. Hind coxæ finely and evenly transstriate, as long as the smooth bidentate femora; tibiæ as long as femora and trochanters, compressed to middle; metatarsi twice as long as the remaining joints. Radius emitted from apical third of the elongate stigma, its distal section about twice as long as the proximal.

Black; head rufotestaceous, face paler, vertex red; median segment, petiole, and hind legs rufescent, anterior legs rufotestaceous; stigma and nervures red-brown.

Length, 17 millimeters; abdomen, 11; petiole, 5; terebra, 18; band, 3.

SIBUYAN (*Baker*).

Characterized by the sculpture of the frons, the very short mesonotum, and confluent metapleuræ and median segment.

FOENATOPUS INDICUS (Westwood).

Stephanus indicus WESTWOOD, Ann. & Mag. Nat. Hist. 7 (1841) 588.
Foenatopus indicus ENDERLEIN Zool. Anz. 41 (1913) 290; ELLIOTT, Proc. Zool. Soc. London (1922) 784.

FOENATOPUS SUMBANUS Enderlein.

Foenatopus sumbanus ENDERLEIN ZOOL. Anz. 41 (1913) 209; ELLIOTT, Proc. Zool. Soc. London (1922) 785.

FOENATOPUS LABRICOXIS sp. nov.

Female.—Frons rugose, centrally subgranulately, vertex and occiput finely, transstriate, three strong carinæ behind posterior ocelli, all tubercles distinct; posterior margin of head finely bordered. Scape about as long as cheeks; antennæ normal. Pronotum smooth, neck elongate, with faint indication of transstriation behind the apical impression. Mesonotum short, indistinctly punctate, the usual rows of punctures obsolete. Scutellum smooth, sutures punctate; mesopleuræ basally finely aciculate, apically smooth above, diffusely punctate beneath. Metapleuræ and median segment cribrate punctate, separated by an indistinct carina. Petiole very finely transstriate, shorter than the remaining smooth segments. Terebra as long as body, whitish-banded. Hind coxæ so finely sculptured as to appear smooth; femora bidentate, as long as the coxæ; tibiæ little longer than the femora, compressed to slightly beyond middle; metatarsi nearly three times as long as the remaining joints. Radius emitted from apical third of stigma, its distal section twice as long as the proximal.

Black; head beneath, face and base of antennæ rufotestaceous, a pale line under eyes; neck, petiole, second and third abdominal segments rufescent or black; legs light rufescent, middle tibiæ and metatarsi basally whitish. Stigma and nervures rufescent.

Length, 14 millimeters; abdomen, 9; petiole, 4; terebra, 14; band, 2.5.

MINDANAO, Davao (*Baker*).

This species bears a strong resemblance to *F. indicus* (Westwood), but the petiole is shorter than rest of abdomen, terebra only as long as body, hind coxæ and femora smooth and polished.

FOENATOPUS FLAVIFRONS Elliott.

Foenatopus flavifrons ELLIOTT, Philip. Journ. Sci. 29 (1926) 525. Male.

To the original description add:

Length, 8.5 millimeters; abdomen, 5.5; petiole, 2.

FOENATOPUS PICTICEPS sp. nov.

Male.—Frons and vertex finely transstriate, occiput centrally indistinctly striate, laterally strongly punctate, basally narrowly smooth; three carinæ on vertex; posterior margin of head bordered; all tubercles distinct. Scape longer than cheeks; antennæ normal. Pronotum apically carinate, otherwise transstriate. Mesonotum short, diffusely punctate, with three deep impressions. Scutellum centrally smooth, lateral lobes punctate; mesopleuræ smooth above, finely punctate beneath. Metapleuræ coarsely punctate, separated by a carina from the median segment, which is apically smooth and shining, otherwise diffusely and superficially punctate. Petiole transstriate, shorter than rest of abdomen. Hind coxæ transstriate, femora tridentate and, like the tibiæ, very finely transaciculate; metatarsi nearly twice as long as the remaining joints. Radius emitted from apical fourth of stigma, its distal not twice as long as the proximal.

Black; head beneath, face, apical half of frons, outer orbits partly, and scape flavous, vertex and occiput red, upper half of frons and ocellar space black; anterior legs rufescent, middle tibiæ and metatarsi white. Stigma black bordered, nervures rufescent.

Length, 10 millimeters; abdomen, 6.5; petiole, 2.5.

SINGAPORE (*Baker*).

Resembles *F. flavifrons* in the color of the femoral teeth, but differs much in sculpture, especially of the vertex and occiput.

FOENATOPUS ALBICEPS sp. nov.

Male.—Frons rather elongate, finely subarcuate striate, five carinæ on vertex, behind which it is transstriate, occiput more or less rugose; posterior margin of head bordered. Scape shorter than cheeks; antennæ normal, first joint stout. Pronotum apically coarsely, basally more finely transstriate, semiannular rugose punctate. Mesonotum rugose, the three impressions distinct. Scutellum and mesopleuræ smooth, the former rather dull. Metapleuræ somewhat coarsely punctate, separated apically only by an indistinct sulcus and carina from the alutaceous, diffusely punctate median segment. Petiole finely and evenly transstriate, shorter than the rest of the smooth abdomen. Hind coxæ evenly transstriate, femora transaciculate, tridentate; tibiæ much longer than femora, compressed in basal two-thirds. Radius emitted from apical fourth of stigma, its distal section scarcely twice as long as the proximal.

Black; head beneath, frons more or less, outer orbits, cheeks, and temples white; mandibles basally, scape and first flagellar joints testaceous, rest of frons, ocellar space, and occiput black; tubercles, carinæ on vertex, and a central longitudinal line on frons red; prosternum, front coxæ, and femora teeth white; anterior legs rufotestaceous, middle metatarsi paler; hind legs rufescent, their tarsi rufous. Stigma and nervures black-brown.

Length, 9.5 to 10.5 millimeters; abdomen, 5 to 6.5; petiole, 2 to 2.5.

BASILAN (*Baker*).

The sculpture of the head, its color, and the white front coxæ are characteristic.

FOENATOPUS LONGICOXIS sp. nov.

Male.—Frons indistinctly rugose, vertex and occiput finely and indistinctly transstriate, with a broad central sulcus, not reaching the bordered posterior margin of head; three carinæ on vertex; posterior tubercles distinct. Scape as long as cheeks; antennæ normal. Neck elongate, transstriate, basally smooth, semiannular smooth and shining, with transverse line of fine punctures and lateral angles transstriate. Mesonotum smooth and shining, lateral rows of punctures distinct, the central one basally only. Scutellum smooth, central lobe with fine marginal punctures; mesopleuræ smooth, basally punctate, and a few apical punctures. Metapleuræ and median segment coarsely punctate, confluent. Petiole transstriate, as long as rest of abdomen, second segment basally rugose and dull, then smooth and shining, the rest rather dull. Hind coxæ strongly clavate, transstriate, longer than the transaciculate, tridentate femora; tibiæ a little longer than femora, compressed to middle; metatarsi scarcely longer than the remaining joints. Radius emitted from apical fourth of stigma, its sections about equally long.

Black; base of mandibles, apex of frons, five or six basal antennal joints, and outer orbits rufescent or red; anterior legs rufescent, middle metatarsi paler; hind legs, including the tarsi, black. Stigma and nervures red-brown.

Length, 11 to 16 millimeters; abdomen, 7 to 10; petiole, 3.5 to 5.

MINDANAO, Davao (*Baker*).

Especially characterized by the indistinct sculptures of the head, the long, clavate hind coxæ, and the black hind tarsi.

THE GOATFISHES, OR MULLIDÆ, OF THE PHILIPPINES

By ALBERT W. HERRE and HERACLIO R. MONTALBAN
Of the Division of Fisheries, Bureau of Science, Manila

SIX PLATES

MULLIDÆ

GOATFISHES, OR SURMULLETS

Ilocano name, *balaki;* Tagalog, *tuyo;* Tao Sug and Samal, *mangentut, tangbod, tiao, timbuñgan;* Visayan, *bayabao, tiao, timbungan.*

The members of this family may be recognized at a glance by their general physiognomy, and the presence of two long, firm, unbranched barbels below the chin, attached just behind the symphysis; the elongate, slightly compressed body is covered with large and usually slightly ctenoid scales; the profile of the head is more or less parabolic; the mouth is small, low, subterminal, the premaxillaries slightly protractile; the teeth are mostly small, weak, the dentition more or less complete, without canines, incisors, or molars; eye is of medium size, lateral, high up, near the middle or in the posterior half of the head; two dorsal fins, far apart, both short, the first of six to eight spines; anal similar to second dorsal, with one or two small spines; ventrals thoracic, I–5; lateral line continuous, the tubules often branched; a simple air bladder usually present; stomach siphonal, pyloric cæca, about 20; branchiostegals, 4; pseudobranchiæ present.

This family includes forty or fifty species, belonging to five very closely related genera. They are shore or reef fishes found in all warm seas, some representatives occurring in the temperate waters of Asia, Europe, North America, and Australia. The goatfishes are bottom dwellers, and as they creep about over the sea floor keep their barbels incessantly in motion, feeling and testing everything as they seek their food. They are carnivorous, and feed upon small animals, such as crustaceans and small fishes living on the bottom and around stones.

Many of the species are brilliantly colored, often with much red or golden, and usually with a red layer of pigment beneath, which appears when the fish is scaled or placed in alcohol. These colors however are not permanent, and are apt to disappear in most preserved specimens.

The flesh of the goatfishes is white, tender, and of very fine flavor. Several kinds are important and highly valued food fishes. Some of them are rather small, and none attains great size, the largest being little more than half a meter in length. They do not take the hook readily but may be caught in traps or bobos, in trammel and gill nets, and by the Japanese muro ami method.

Key to the genera of Mullidæ.

Only the first three genera are found in the Philippines.

a^1. Dentition complete; teeth in both jaws, on vomer, and on palatines. **Upeneoides.**

a^2. Dentition more or less incomplete, never complete.

b^1. Upper jaw with teeth.

c^1. No teeth on palate.

d^1. Teeth of jaws comparatively strong, in a single row.... **Upeneus.**

d^2. Teeth of jaws in several rows or in a villiform band **Mulloides.**

c^2. Vomer and both jaws with teeth, none on palatines.... **Upeneichthys.**

b^2. Upper jaw toothless; lower jaw, vomer, and palatines with teeth. **Mullus.**

Genus UPENEOIDES Bleeker

Upeneoides BLEEKER, Verh. Bat. Gen. 22 (1849) 64; Günther, Cat. Fishes 1 (1859) 397.

This genus is recognized at once by the presence of small acute teeth in several rows in both jaws, and on the vomer and palatines.

The species are not very numerous, distributed throughout the warmer regions of the Indian and Pacific Oceans, but absent from the west coast of tropical America. Six species are here described from the Philippines. A number of species live in sandy bays, where their brown mottled coloration blends perfectly with play of light and shadow on the gray and yellowish sea bottom.

Key to the Philippine species of Upeneoides.

a^1. Head completely scaled; a brown or blackish band from eye to caudal.

b^1. A brown saddle over anterior half of caudal peduncle; one or two dark crossbands on side; each lobe of caudal with six or more oblique dusky bands .... **U. luzonius.**

b^2. No saddle on caudal peduncle and no crossbands.

c^1. Body not spotted; first dorsal clear, unspotted; second dorsal with five longitudinal yellow stripes; upper lobe of caudal with four or five yellow crossbars .... **U. sundaicus.**

c^2. Head and body spotted with blackish; first dorsal black, with rounded pale spots; each lobe of caudal with four to six blackish bars .... **U. tragula.**

a^2. Head not completely scaled; preorbital partly or entirely naked; longitudinal bands yellow, or disappearing in alcohol.

d^1. A bright yellow band from eye to caudal; dorsals and upper lobe of caudal with alternate yellowish and blackish bands; preorbital partly naked .... **U. moluccensis.**

d^2. Two or more longitudinal stripes on body.

e^1. A bright yellow band from eye to caudal and one from axil of pectoral to caudal; preorbital partly naked; caudal not barred. **U. sulphureus.**

e^2. Four or five yellow longitudinal lines on side; caudal with four or five oblique black bands on each lobe; preorbital naked. **U. vittatus.**

UPENEOIDES LUZONIUS (Jordan and Seale). Plate 1, fig. 1.

Upeneus luzonius JORDAN and SEALE, Bull. Bur. Fisheries **26** (1907) 25, fig. 9.

Dorsal VIII–I, 8; anal I, 6; scales $2\frac{1}{2}$–32 to 34–$6\frac{1}{2}$.

Body moderately elongate, its greatest depth 3.8 to 3.9 times, head 3.3 to 3.4 times in length; the nearly flat interorbital space 3.6 to 3.7 times in head; eye located high up near upper profile of head and about midway between tip of snout and posterior margin of opercle, 4 to 4.4 times in head; snout 1.6 to 1.9 times in eye and about as long as maxillary which is 2.4 to 2.5 times in head and reaches posteriorly to almost below anterior rim of pupil; lower jaw slightly the shorter; teeth villiform in jaws, and on vomer and palate; 5 or 6 + 15 gill rakers on first arch, the longest about half the eye; the long slender barbels extend to a little beyond angle of the smooth preopercle; only a single spine at hind edge of opercle; head, including preorbital and maxillary, completely covered with scales; least depth of caudal peduncle 2.2 to 2.4 times in head.

Spinous dorsal rather high, its first spine minute, the second highest, 3.4 to 4 times in length of body; second dorsal and anal of nearly the same height, 1.7 to 1.9 times in head; pectoral very sligthly shorter than ventral, which is 1.3 to 1.5 times in head, the latter fin reaching to the vertical from axil of first dorsal; caudal about as long as head, 3.1 to 3.5 times in length of body.

Alcoholic specimens are dull yellowish to yellowish brown, with a dark brown longitudinal band running from eye to caudal; a brown saddle over anterior half of caudal peduncle; a rather indistinct vertical band of the same color descends the side from the anterior two-thirds of the rayed dorsal; another brown band sometimes present below the spinous dorsal; dorsals clouded indistinctly with dusky, these markings oftentimes inconspicuous; each lobe of caudal crossed by six or more oblique dusky bands which are rather fine and about as wide as the interspaces; all the other fins yellowish, unmarked; no dusky spots visible on sides of head and body.

This species is here described from thirty-one examples, 57 to 105 millimeters long, coming from the following loacalities:

Orani, Bataan, 11.
Manila, 4.
Pasay, Rizal Province, 1.
San Miguel, 3.
Capiz, Capiz, 1.
San Pedro Bay, 1.
Tacloban, Leyte, 1.
Cuyo, 1.
Sandakan, Borneo, 8.

This species is very closely allied to *Upeneoides vittatus* (Forskål) from which it differs in the presence of brown transverse bands above the lateral line, in the absence of dusky spots on sides, and in having finer dusky crossbands on each lobe of caudal. In many alcoholic examples of this species, the color markings on the dorsals have faded.

Jordan and Seale had specimens from Cavite, caught in Manila Bay. A living specimen in the Bureau of Science aquarium was mostly gray in color, the longitudinal band and fin markings dusky, but it died before complete color notes could be taken. This small inconspicuous species is of no particular importance as a food fish.

UPENOIDES SUNDAICUS Bleeker.

Upeneoides sundaicus BLEEKER, Act. Soc. Sci. Indo-Neerl. **2** (1857) 47; GÜNTHER, Cat. Fishes **1** (1859) 399.

Upeneus sundaicus BLEEKER, Verh. Akad. Amsterdam **15** (1875) Révis. Mulloides, 10; Atlas Ichth. **9** (1875) pl. 394, fig. 2; EVERMANN and SEALE, Bull. Bur. Fisheries **26** (1907) 88.

Dorsal VIII–I, 8 or 9; anal II, 6 or 7; scales 2–32 to 35–5.

Body elongate compressed, depth 3.75, head 3.5 times in length; height of head 1.25 to 1.2 times in its own length; anterior dorsal profile very strongly convex; eye 3.5 to 4 times in head; interorbital 4 in head; the convex abtuse snout almost entirely scaled; maxillary extends under anterior half of eye, 2.3 to 2.6 in head; the barbels touch or nearly touch posterior margin of preopercle.

Spinous dorsal equals or is a little lower than depth, dorsal rays much higher, first dorsal spine small, second spine highest; soft dorsal and anal subequal in height; pectoral and ventrals acutely rounded, 6 or somewhat less than 6 in length; caudal deeply incised, lobes acute, lower shorter than upper, 4.75 to 5 times in length.

Color above violaceous olive, paler on sides, belly golden rose; a moderately wide stripe from eye to tail, fuscous to violaceous dusky intersecting the lateral line under soft dorsal; eye yellowish; barbels golden; fins rosy hyaline; soft dorsal with 5 longitudinal yellow stripes; upper lobe of caudal with 4 or 5 yellow transverse stripes, posterior margin of lower lobe violet.

In alcohol it is yellowish, with an indistinct dusky line from eye to caudal.

The above description is compiled from Bleeker and Evermann and Seale. The latter had a specimen "5.1 inches in length" from Bacon, Sorsogon. We have seen no specimens.

Bleeker had 17 specimens, 115 to 181 millimeters in length, obtained in various localities from Sumatra to Celebes and Buru, one of the Moluccas.

UPENEOIDES TRAGULA (Richardson). Plate 2, fig. 1.

Upeneus tragula RICHARDSON, Ichth. China, Rept. Brit. Asso. Adv. Sci. (1845) 220; BLEEKER, Verh. Akad. Amsterdam **15** (1875) Révis. Mulloides, 11; Atlas Ichth. **9** (1878) pl. 392, fig. 2; JORDAN and SEALE, Proc. U. S. Nat. Mus. **28** (1905) 782; Bull. Bur. Fisheries **26** (1907) 26; JORDAN and EVERMANN, Bull. Bur. Fisheries **26** (1907) 88; WEBER, Fische, Siboga Exp. (1913) 293.

Upeneoides tragula GÜNTHER, Cat. Fishes **1** (1859) 398; Day, Fishes of India (1878) 121, pl. 30, fig. 4; JORDAN and RICHARDSON, Bull. Bur. Fisheries **27** (1908) 260; SEALE, Philip. Journ. Sci. § D **5** (1910) 278; **9** (1914) 68; FOWLER and BEAN, Proc. U. S. Nat. Mus. **62** (1922) 43.

Upeneoides variegatus BLEEKER, Verh. Bat. Gen. **22** (1849) 64.

Dorsal VIII–I, 8; anal I, 6; scales $2\frac{1}{2}$–31–$6\frac{1}{2}$.

The elongate body rather low, its greatest depth 4 to 4.5 times in length, upper profile gently arched from snout to first dorsal; head 3.2 to 3.7 times in length of body; interorbital space very slightly convex, its least width 3.4 to 3.8 times in head; eye located high up near upper profile of head, 4 to 4.9 times in head; snout moderate and rather obtuse anteriorly, 1.7 to 2.1 times eye or 2.3 to 2.4 times in head; maxillary round posteriorly and as long as snout, its posterior end beneath anterior margin of pupil; lower jaw slightly shorter than upper;

teeth villiform in jaws, vomer, and palate; 6 + 16 or 17 gill rakers on first arch; the barbels do not quite reach angle of preopercle; both inferior and posterior limbs of opercle smooth; two spines at hind border of opercle, upper one smaller and hidden under a scale; least depth of caudal peduncle 2.3 to 2.7 times in head; entire head, including preorbital, maxillary, and chin, covered with scales.

First dorsal spine minute, second spine highest, 1.4 to 1.6 times in head; soft dorsal and anal equal in height, 1.6 to 1.9 times in head; pectoral a little shorter than ventral, the latter 1.3 to 1.5 times in head and reaching about halfway from its origin to base of posterior anal rays; the deeply forked caudal longer than head, 3 to 3.5 times in length of body.

Living specimens are grayish yellow; head and body sparingly and irregularly spotted with brownish; upper half of spinous dorsal black, sprinkled with yellow rounded spots, basal half with two rather faint dusky broad bands; the soft dorsal has two or three rather indistinct dusky longitudinal bands; each lobe of the caudal has oblique dusky bands which are broader than the interspaces; all the other fins barred or spotted with brown; a dusky stripe runs from snout through eye to base of caudal fin; barbels deep coral red.

Living specimens at Calapan had the ground color pale or gray, thickly spotted with brownish above, each scale on lower half of body with a conspicuous brown spot; sides of head with brown spots; a brown band through eye to caudal; ventral region white or with a roseate flush; dorsals and caudal as already described; pectoral yellowish, with reddish brown spots; anal and ventrals yellow, crossbarred with red spots. The colors of this fish blend perfectly with the mottled sandy sea bottom.

The color in spirits is brownish above, passing into yellowish below; a dark brown to blackish band extends from snout through eye to caudal fin; head and body spotted with dark brown to blackish; first dorsal clouded with blackish, which is spotted with whitish, second dorsal clouded with blackish; each lobe of caudal with four to six oblique blackish bars, those on lower lobe broader; the number of these bars usually smaller in younger individuals; pectoral, ventral, and anal spotted or barred with dusky color.

We have examined numerous specimens of this species in the Bureau of Science collection, measuring 39 to 175 millimeters in length. They were obtained at the following localities:

Luna and Camp Walace, La Union, 8.
Alaminos, Pangasinan, 1.
Olongapo, Zambales, 3.
Malabon, Rizal, 2.
Puerto Galera and Calapan, Mindoro, 8.
Bacon, Sorsogon, 1.
Legaspi, Albay, 1.
Dicuayan Island and Concepcion, Busuanga, 2.
Culion Island, 2.
Catbalogan and Borongan, Samar, 2.
New Washington, Panay, 85.
Bantayan Island, 9.
Cuyo, 1.
Jordan, Guimaras, 1.
Cebu, Cebu, 1.
Puerto Princesa, Palawan, 2.
Palawan Island, 1.
Tagbilaran, Bohol, 2.
Dumaguete, Oriental Negros, 1.
Cagayan de Misamis, 7.
Balabac Island, 8.
Davao, Davao, 5.
Caldera Bay and Zamboanga, 10.
Basilan Island, 1.

One of the specimens, 172 millimeters in length, taken at Puerto Galera in April, 1912, is a female nearly ready to spawn. The Philippine examples are not different from several representatives from Hongkong and Sandakan, which are also in the Bureau of Science collection. The maximum size of this species is about 250 millimeters.

This fish has been reported previously from the Philippines by Günther; from Manila, Iloilo, and the southern coast of Negros by Jordan and Seale; from Bacon, Sorsogon, by Evermann and Seale; from Cuyo by Jordan and Richardson; and from Cebu and Zamboanga by Fowler and Bean.

This is an important food fish in some localities. It ranges from the southern coast of China, Amboina, westward to the Andamans, Hindustan, and the east coast of Africa.

UPENOIDES MOLUCCENSIS Bleeker. Plate 6, fig. 1.

Upeneoides moluccensis BLEEKER, Nat. Tijds. Ned. Ind. **8** (1855) 409; GÜNTHER, Cat. Fishes 1 (1859) 399; BLEEKER, Natuurk. Verh. Kon. Akad. Amsterdam 15 (1875) Révis. Mulloides 8; Atlas Ichth. 9 (1875) pl. 392, fig. 1; SEALE, Philip. Journ. Sci. § D **9** (1914) 68. pl. 392, fig. 1; SEALE, Philip. Journ. Sci. § D **9** (1914) 68.

Dorsal VIII–9; anal 7; scales 2–32 or 33 + 5 or 6–6.

Greatest depth of body 3.8 to 4.2 times in length; head contained 3 to 3.4 times in length, its upper outline strongly arched; the nearly flat interorbital space a little wider than eye, 3.4 to 3.8 times in head, with a low longitudinal depression along its middle portion; eye rather large, 3.8 to 4 times in head, its upper edge almost touching upper outline of head; the moderately short snout steep anteriorly, scaled above, 2.3 to 2.6 times in head, and 1.5 to 1.7 times eye; maxillary almost as long as snout, 2.5 to 2.6 times in head; mouth horizontal, with lower jaw very slightly included; teeth villiform on jaws, vomer, and palatines; first gill arch has 8 + 20 or 21 rakers which are rather long and slender; the barbels are rather short and barely reach vertical edge of preopercle; preopercle smooth, opercle armed behind with two flat weak spines; least depth of caudal peduncle 2.8 to 3.3 times in head, preorbital partially covered with scales, the rest of head completely scaly.

Second dorsal spine highest, 1.4 to 1.6 times in head, first very small; second dorsal and anal about equal in height, 2 to 2.7 times in head, their second rays the highest, pectoral much longer than ventral which is 1.6 to 1.8 times in head and extends halfway between its origin and that of anal; caudal deeply forked, its upper lobe slightly the longer, 3.4 to 3.8 times in length.

In life the ground color is pink to deep cherry red or purplish red above, bluish white on the middle of sides, and pinkish below; head red anteriorly, pearly bluish posteriorly, and below an extremely bright lemon yellow horizontal band runs from eye to caudal, a narrower and less-pronounced one above lateral line; one or two others may be present along lower half of body, dorsal pale pearly bluish, tipped with blackish and barred longitudinally with yellowish orange; second dorsal similarly colored, without the blackish tips; the pinkish caudal tipped with blackish, its upper lobe with seven reddish orange cross stripes; pectoral reddish, with a light wash of yellowish; rays of ventrals and anal yellowish, the membranous portions very pale pearly bluish.

In alcohol the ground color pinkish to yellowish; a bright lemon yellow lateral band runs from hind border of eye to caudal fin; upper lobes of caudal and dorsals have alternate yellowish and blackish bands; lower lobe of caudal edged posteriorly with blackish; pectoral nearly colorless, ventrals and anal whitish to yellowish.

We have examined seven specimens of this species in the Bureau of Science collection, ranging from 54 to 135 millimeters in length. They were collected at the following localities: Manila; Balayan Bay, Batangas; Pinamalayan, Mindoro; Tagbilaran, Bohol; Larena, Siquijor. The collection also contains 11 examples from Hongkong.

Bleeker had specimens from Celebes, Sumbawa, and Amboina. No one else seems to have collected it except Seale, who found specimens in the market at Hongkong.

UPENEOIDES SULPHUREUS (Cuvier and Valenciennes.) Plate 3, fig. 1.

Upeneus sulphureus CUVIER and VALENCIENNES, Hist. Nat. Poiss. **3** (1829) 331; BLEEKER, Natuurk. Verh. Kon. Akad. Amsterdam **15** (1875) Révis. Mulloides 4; Atlas Ichth. **9** (1878) pl. 393, fig. 4; JORDAN and SEALE, Bull. Bur. Fisheries **26** (1907) 26; EVERMANN and SEALE, Bull. Bur. Fisheries **26** (1907) 88; SNYDER, Proc. U. S. Nat. Mus. **32** (1907) 99; WEBER, Fische, Siboga Exp. (1913) 293.

Upeneoides sulphureus BLEEKER, Act. Soc. Sci. Indo-Neerl. **2** (1857) Vischfauna Amboina, 45; GÜNTHER, Cat. Fishes **1** (1859) 398; DAY, Fishes of India (1878) 120, pl. 30, fig. 3; STEINDACHNER and DÖDERLEIN, Fische Japan 2, Denks. Akad. Wiss. Wien **48** (1884) 23; JORDAN and RICHARDSON, Bull. Bur. Fisheries **27** (1908) 260; SEALE, Philip. Journ. Sci. § D **5** (1910) 279; (1914) 68.

Upeneus bivittatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. **7** (1831) 390.

Upeneoides fasciolatus DAY, Proc. Zool. Soc. (1868) 151.

Upeneus pinnifasciatus STEINDACHNER, Sitzber. Akad. Wiss. Wien **61** (1870) Abth. 1, 624.

Upeneoides belaque FOWLER, Proc. Akad. Nat. Sci. Phila. **70** (1918) 40, fig. 16.

Pangasinan name, *balaki*.

Dorsal VIII–I, 8; anal I, 6; scales 2½–35–6½.

Body evenly arched above, its greatest depth 3.2 to 3.5 times in length; head equal to or slightly longer than depth of body, 3.1 to 3.5 times in length; the almost flat interorbital space as wide as the moderately large eye, which is 3.6 to 4.1 times in head; upper edge of eye almost even with dorsal contour of head; snout fairly short, its length 1.3 to 1.7 times eye or 2.3 to 2.7 times in head, its upper outline steep anteriorly; maxillary equal to or slightly longer than snout, 2.3 to 2.4 times in head, and extending below anterior third or eye; mouth nearly horizontal, with the lower jaw very slightly the shorter; teeth in villiform bands on jaws, vomer, and palatines; gill rakers 8 or 9 + 20 or 21 on first arch, rather long and slender; barbels reach nearly to vertical edge of opercle; both inferior and posterior edges of preopercle entire; opercle armed with two spines at its hind border; least depth of caudal peduncle 2.5 to 2.8 times in length of head; preorbital partially naked, rest of head completely scaled.

First dorsal spine minute, second highest and contained 4 to 4.3 times in length of body or 1.2 to 1.4 times in that of head; first rays of soft dorsal and anal of the same height, each

1.7 to 2.2 times in head; pectoral 3.8 to 4.2 times in length of body; ventral is shorter than pectoral, 5 to 5.6 times in length of body or 1.6 to 1.7 times in that of head, and reaches halfway between its origin and middle of base of anal; the deeply forked caudal slightly shorter than head, 3.2 to 3.4 times in length of body.

Color in life pinkish above, silvery below lateral line, and yellow on ventral surfaces; a bright yellow line from eye to caudal and another from axil of pectoral to caudal; the spinous dorsal is rather broadly tipped with black and has two dusky longitudinal bands; the soft dorsal is edged with dusky and has two or three longitudinal lines of the same color; caudal tipped with dusky; anal and ventrals washed with yellowish. Young specimens bluish above and yellowish on sides, with dusky pectoral and caudal; ventrals and anal lightly washed with yellowish; dorsals longitudinally barred with blackish, the former having a dense black top; a pinkish wash above opercle; barbels dusky in color.

Alcoholic specimens gayish above with darker edges to the scales, yellowish below; traces of longitudinal stripes on upper portions of body; spinous dorsal yellowish to whitish with three longitudinal bands, upper one marginal and dense black; the second dorsal is edged above with blackish and has one or more rather indistinct longitudinal stripes of like color; the caudal fin has a black white-edged margin, which is more conspicuous on lower lobe; pectoral almost transparent, ventral and anal yellowish.

This small species is abundant throughout the Philippines. Our description is based upon the following specimens, ranging from 53 to 137 millimeters in length:

Vigan, Ilocos Sur, 1.
Damortis and Rabon, La Union, 9.
Alaminos, Pangasinan, 2.
Iba, Zambales, 1.
Orani, Bataan, 1.
Manila, 9.
Malabon and Pasay, Rizal, 3.
Cavite, Cavite, 1.
Manila Bay between Cavite and San Nicolas, 2.
San Miguel Bay, 12.
Bacon, Sorsogon, 1.
Mangarin, Mindoro, 8.
Capiz, Estancia, and Iloilo, Panay, 7.
Guinobatan, Masbate, 1.
Borongan, Samar, 15.
San Juanico Strait, 2.
Tacloban, Leyte, 2.
Tagbilaran and Loay, Bohol, 4.
Panacan, Palawan, 1.
Butuan Bay, Agusan River, Gingoog, and Zamboanga, Mindanao, 14.
Sandakan, Borneo, 1.

Four of these specimens, 70 to 112 millimeters in length, collected in 1904, May and June, 1907, and November 20, 1926, are females nearly ready to spawn.

Jordan and Seale had specimens from Cavite; Evermann and Seale from San Fabian, Pangasinan; and Jordan and Richardson from Manila. Seale had specimens from Sandakan, Borneo, and from Hongkong.

This species was originally described from the Strait of Sunda, and ranges from the coast of Hindustan throughout the East Indies eastward to the New Hebrides and north to China and Nagasaki, Japan.

UPENEOIDES VITTATUS (Forskål). Plate 4, fig. 1.

Mullus vittatus FORSKÅL, Descr. Anim. (1775) 31; LACÉPÈDE, Hist. Nat. Poiss. 3 (1798) 382, 401, pl. 14, fig. 1; SHAW, Gen. Zool. 4 (1800) 616, pl. 89.

Upeneus vittatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 329; SMITH and SEALE, Proc. Biol. Soc. Washington 19 (1906) 78; JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 273; SEALE, Occ. Papers Bishop Mus. 4 (1906) 51; STEINDACHNER, Sitz. Akad. Wiss. Wien. 115[1] (1906) 1385; SEALE and BEAN, Proc. U. S. Nat. Mus. 33 (1907) 245.

Upeneoides vittatus BLEEKER, Verh. Bat. Gen. 22 (1849) Perc., 63 ex parte; Act. Soc. Sci. Indo-Neerl. 2 (1857) Achtste Bijdr. Vischf. Amboina, 42; GÜNTHER, Cat. Fishes 1 (1859) 397; KLUNZINGER, Verh. Zool. Bot. Gessell. Wien 20 (1870) 742; GÜNTHER, Fische der Südsee 1 (1873) 55; BLEEKER, Natuurk. Verh. Kon. Akad. Amsterdam 15 (1875) Révis. Mulloides 7; DAY, Fishes of India (1878) 120, pl. 30, fig. 2; BLEEKER, Atlas Ichth. 9 (1878) pl. 392, fig. 3; JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 260.

Upeneoides philippinus FOWLER, Proc. Acad. Nat. Sci. Phila. 70 (1918) 37, fig. 15.

Mullus bandi SHAW, Gen. Zool. 4 (1800) 615.

Bandi goolivindi RUSSELL, Fishes Coromandel 2 (1803) 43, fig. 158.

Dorsal VII–I, 8; anal I, 6; scales 2½–35–6½.

Greatest depth of body at base of spinous dorsal, 3.7 to 3.9 times in length; head 3.3 to 3.5 times in length; interorbital space nearly flat, its least width 3.5 to 3.8 times in length of head; eye rather large, almost on a line with upper profile of head, 3.7 to 4 times in head; snout moderately short, 2.4 to 2.6 times in length of head or 1.4 to 1.6 times eye, its upper profile very steep anteriorly; the maxillary is broadest posteriorly, equal to snout and reaches below anterior half of pupil; mouth almost horizontal, with jaws almost even; teeth villiform, in bands on jaws, vomer, and palate; first arch containing 7 or

$8 + 17$ to 20 moderately long and slender gill rakers; the barbels extend to the vertical from angle of the smooth preopercle, 1.7 to 1.9 times in head; two spines at hind edge of opercle, the upper smaller and hidden under a scale; least depth of caudal peduncle nearly equal to length of snout or maxillary, 2.5 to 2.8 times in head; no scales on preorbital, rest of head completely covered with ctenoid scales.

Third dorsal spine the highest, 1.3 to 1.4 times in head and slightly higher than the one preceding, first spine minute and inconspicuous; second dorsal and anal equal in height, 2 to 2.1 times in head; pectoral 1.3 to 1.5 times in length of head, longer than ventral which extends to below vertical from axil of first dorsal fin; caudal deeply forked, very slightly shorter than head, 3.4 to 3.8 times in length of body.

The color in life of several specimens was as follows:

A specimen from Bantayan Island was brownish above, yellowish below, belly bright yellow, with two bright yellow longitudinal lines on sides and three darker ones above them; the two dorsals were black at top, with two dusky longitudinal bands through each fin; the caudal was yellowish with four or five oblique black bands on upper lobe, and three or four on lower; the last band on lower lobe was at tip, the second one from it broader than the rest; pectoral, ventrals, and anal uniformly yellowish.

Two examples from Sandakan, Borneo, were dull brownish silvery; there were four or five yellow longitudinal lines on each side of body; a black tip to spinous dorsal, a dusky longitudinal band through its middle, and a third one of like color near base; the soft dorsal had three dusky longitudinal bands; the caudal had five oblique black bands on upper lobe, and four on lower; the penultimate black band was wider than the rest.

Four specimens from Guam were pinkish yellow in life, with four dark yellow longitudinal lines on sides; the spinous dorsal with a large black tip, a rather wide black band through center, and a narrower one at base of fin; second dorsal had three rather faint dusky longitudinal bands; upper lobe of caudal had five oblique black bands, lower one four, the second from the last the widest. In the young all the color markings, excepting the bars on the fins, were usually absent.

In alcohol the ground color is slightly grayish above and yellowish below, with traces of the yellow longitudinal bands on sides; spinous dorsal black at top and barred longitudinally with dusky at its middle and base; the rayed dorsal has three dusky longitudinal bands the last one on the top; the caudal has four or five oblique black bands on its upper lobe, the lower three or four; the last black band of lower lobe or the one next to it usually broader than the rest; the other fins unmarked.

The above account is taken from seventy-six specimens, varying from 27 to 171 millimeters in length, taken at the following localities:

Aparri, Cagayan, 2.
Bangui, Ilocos Norte, 1.
Damortis and Rabon, La Union, 3.
Alaminos, Pangasinan, 2.
Iba, Zambales, 2.
Orani, Bataan, 1.
Pasay, Rizal, 1.
Manila, 1.
Nasugbu, Batangas, 1.
Puerto Galera and Mangarin, Mindoro, 3.
Borongan, Samar, 1.
New Washington and Capiz, Capiz Province, 10.
Bantayan Island, 1.
Iloilo, Iloilo, 1.
Cebu, Cebu, 2.
Tagbilaran and Loay, Bohol, 5.
Dumaguete, Oriental Negros, 1.
Agusan River, Mindanao, 1.
Cagayan de Misamis, 14.
Balabac Island, 3.
Davao, Davao, 1.
Zamboanga, Zamboanga, 5.
Southern coast of Cotabato Province, 4.
Jolo Island, 4.
Sandakan, Borneo, 2.
Guam, 4.

Günther had specimens from "the Philippines;" Smith and Seale's specimens came from the Rio Grande, Cotabato Province, Mindanao, and Seale and Bean's from Zamboanga, Mindanao; Jordan and Richardson recorded this species from Lubang Island and from Iloilo. Fowler's *U. philippinus* from the "Philippine Islands" does not seem different to us.

This species reaches a length of over 300 millimeters; it is common from the Red Sea and the east coast of Africa through the Indian Ocean and the East Indies on throughout Polynesia to Tahiti and the far-off Marquesas; it occurs northward to Kagoshima Bay, Japan.

Genus UPENEUS Cuvier

Upeneus CUVIER, Regne Anim. ed. 2 2 (1829) about 160; CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 428.

Pseudupeneus BLEEKER, Natuurk. Verh. Kon. Akad. Amsterdam 14 (1862) 134.

Parupeneus BLEEKER, Verh. Natuurk. Akad. Kon. Amsterdam 15 (1875) Révis. Mulloides 17.

This genus is separated from the rest of the goatfishes by the presence of but one row of teeth in the jaws, while the roof of the mouth is toothless. Dorsal spines VIII.

Body oblong or elongate, compressed laterally, head often large; the nearly horizontal mouth low, the jaws equal or nearly so, with thick lips; opercle armed with a spine on its posterior border, sometimes with two; interorbital space concave, narrow; barbels usually long, often nearly as long as head; scales very large, head covered with large scales; the bone forming a hook over maxillary is less developed than in *Mullus;* caudal fin forked.

This genus includes many species in tropical seas, many of them important food fishes. We recognize twelve species in our Philippine material. We have included *U. macronemus* in our key, as there is little doubt of its occurrence in the Philippines, though we have obtained no specimen.

Key to the Philippine species of Upeneus.

a^1. Barbels not extending beyond posterior margin of preopercle; a round black spot at caudal base.

  b^1. A wide black stripe from snout through eye to below soft dorsal; a yellow stripe usually above it; one opercular spine. **U. barberinus.**

  b^2. A broad yellow or pale saddle before the black blotch on caudal peduncle; a reddish or pale line from snout along upper margin of eye to soft dorsal, and another along lower margin to below second dorsal, the region between a more or less dusky band; two opercular spines .... **U. dispilurus.**

a^2. Barbels extending beyond posterior edge of preopercle.

  c^1. Barbels not reaching beyond posterior margin of opercle.

    d^1. No black spots or bands anywhere; color uniform yellowish or a golden spot on each scale of body .... **U. luteus.**

    d^2. Body with black spots, blotches, or crossbands.

      e^1. A rounded black spot at base of caudal or on side of caudal peduncle.

        f^1. A black band from tip of snout through eye to below middle of second dorsal; large lateral black spot on anterior part of caudal peduncle .... **[U. macronemus.]**

        f^2. No longitudinal black band through eye.

          g^1. A yellow spot on lateral line below posterior half of first and anterior part of second dorsal .... **U. indicus.**

          g^2. Red in life with three curved olive stripes from tip of snout to below soft dorsal, the middle one through eye; caudal peduncle with a blackish saddle, darker below and forming a round black spot on side; color uniform in alcohol, with a black spot on caudal peduncle. **U. spilurus.**

      e^2. No black spot on caudal peduncle.

        h^1. Body with three wide blackish crossbands, first below anterior part of spinous dorsal, second below solft dorsal, third on posterior half of caudal peduncle .... **U. bifasciatus.**

        h^2. Body not crossbanded with black or dusky, but with a black spot or blotch on lateral line.

i^1. A large black area on anterior part of body with a black line from its upper part through eye to tip of snout; black lateral spot below posterior rays of second dorsal. **U. barberinoides.**

i^2. The black lateral blotch between two dorsals, with a larger oblong yellow area behind it....................... **U. pleurostigma.**

c^2. Barbels reaching or almost reaching base of ventrals.

j^1. Color uniform, no markings on fins or body............ **U. cyclostomus.**

j^2. Color not uniform.

k^1. Body with four or five blackish crossbands; a broad yellow area between the black band below soft dorsal and the black saddle on caudal peduncle.. **U. moana.**

k^2. Body not crossbanded with blackish.

l^1. A yellow or whitish saddle on caudal peduncle behind soft dorsal; color usually livid purplish............ **U. chryserydros.**

l^2. No yellow area anywhere; a black spot between lateral line and posterior half of pectoral; head and snout with three pearly bluish longitudinal bands; soft dorsal, anal, and caudal barred with brown.. **U. pleurospilos.**

UPENEUS BARBERINUS (Lacépède). Plate 3, fig. 3.

Mullus barberinus LACÉPÈDE, Hist. Nat. Poiss. 3 (1798) 406, pl. 13, fig. 3.

Upeneus barberinus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 340; GÜNTHER, Cat. Fishes 1 (1859) 405; KNER, Reise Novara, Fische (1865) 70; KLUNZINGER, Verh. Zool. Bot. Gessell. Wien 20 (1870) 545; GÜNTHER, Fische der Südsee 1 (1873) 57, pl. 42; DAY, Fishes of India (1878) 124; MEYER, Ann., Soc. Esp. Hist. Nat. 14 (1885) 16; JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 260; SEALE and BEAN, Proc. U. S. Nat. Mus. 62 (1922) 44.

Parupeneus barberinus BLEEKER, Ned. Tijds. Dierk. 1 (1863) 234; Natuurk. Verh. Kon. Akad. Amsterdam 15 (1875) Révis. Mulloides 25; Atlas Ichth. 9 (1878) pl. 393, fig. 1; WEBER, Fische, Siboga Exp. (1913) 296.

Pseudupeneus barberinus JORDAN and SEALE, Proc. U. S. Nat. Mus. 28 (1905) 782; SEALE, Occ. Papers Bishop Mus. 4 (1906) 49; JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 276; Bull. Bur. Fisheries 26 (1907) 25; EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 88.

Local name at Cuyo, *amakan.*

Dorsal VIII–I, 9; anal I, 6; scales $2\frac{1}{2}$–28 + 2–$5\frac{1}{2}$.

Body rather deep, its greatest depth at origin and anterior part of spinous dorsal, 3.1 to 3.7 times in length; the pointed head much longer than deep, 2.7 to 3.1 times in total length; interorbital space moderately convex, its least width 3.8 to 4.2 times in head; the moderately small eye much nearer posterior margin of opercle than tip of snout and entirely in second half of head, 4.8 to 6.5 times in head or 2.5 to 4 times in snout; the long pointed snout 1.6 to 1.9 times in head and the much shorter maxillary 2.7 to 3.1 times, the latter extending nearly halfway between end of snout and vertical from hind border of eye; jaws about even, each with a single series of conical, moderate, rather widely spaced teeth; there are 6 (rarely 7) + 21 to 23 gill rakers on first arch; the long barbels are 1.3 to 1.6 times in head and just touch the vertical edge of the smooth preopercle; opercle armed with a single spine at its hind edge; least depth of caudal peduncle 2.5 to 3.1 times in head; scales large, finely and weakly ctenoid, absent on preorbital.

Third dorsal spine the highest, 1.4 to 1.8 times in head, second a little lower, and first minute; second dorsal and anal about the same height, 2.3 to 2.8 times in head, their last rays not much produced and equal to or much lower than anterior rays; pectoral nearly as long as ventral which is contained 1.3 to 1.6 times in head, the latter reaching the vertical midway between dorsals; caudal fin shorter than head, 3.2 to 3.5 times in length.

Some of the specimens were silvery in life, washed with yellowish or pink; they had a distinct black line from below second dorsal through eye to end of snout; a rounded black spot was present on middle of root of caudal fin.

Other examples were pinkish white, brownish on the nuchal region and on top of head; a wide deep black stripe from tip of snout through eye to below middle of soft dorsal; just above this black band was a deep yellow stripe, broadest at the center, extending from eye to below second dorsal; a round black spot at base of caudal fin; the first dorsal was bluish white, indistinctly blotched with vinous red; the soft dorsal was bluish, with a vinous blotch extending to tips of membranes; the caudal and the ventral were pinkish, the latter red at axil.

Still other specimens were pinkish white, with a black stripe from tip of snout to below soft dorsal and a round black spot near base of caudal fin; just above the black longitudinal stripe was a golden band extending from behind eye to below anterior half of second dorsal; both dorsal fins were pink.

In alcohol the ground color is yellowish to yellowish brown, darker along back; a wide black stripe runs longitudinally from tip of snout through eye to below soft dorsal, and there is only a trace of the yellow band from behind eye to about where the black band ends posteriorly, or it may be altogether absent;

a rounded black spot at middle of posterior end of caudal peduncle; all the fins are yellowish to whitish.

We have examined one hundred nine specimens of this species in the Bureau of Science collection, ranging from 21.5 to 280 millimeters in length, from the following localities:

Luna and Balaoan, 7.
Subic Bay, 1.
Manila, 12.
Puerto Galera and San Jose, Mindoro, 26.
Bacon, Sorsogon, 1.
Tablas Island, 2.
Bantayan Island, 3.
Agutaya Island, 1.
Tacloban, Leyte, 1.
Cuyo Island, 5.
Cebu, Cebu, 2.
Negros, 1.
Canigaran and Puerto Princesa, Palawan, 14.
Tagbilaran, Bohol, 2.
Dumaguete, Oriental Negros, 5.
Surigao, Surigao, 2.
Cagayan de Misamis, 3.
Balabac Island, 9.
Davao, Mindanao, 2.
Caldera Bay and Zamboanga, Mindanao, 3.
Tubigan, Jolo, Bungau, and Sibutu Islands, Sulu Archipelago, 7.

In this fish the last rays of the second dorsal and of the anal are not prolonged, as in *Upeneus macronemus* (Lacépède), in which they are much longer than the other rays. The rounded black spot in the latter is more anterior, located about midway in the length of the caudal peduncle, whereas in *U. barberinus* it immediately precedes the base of the caudal fin. Some of our specimens are very close to *U. macronemus*, but we have seen none that is unquestionably of that species.

Since writing the above we have received two very fine specimens from the Cuyo Islands, 360 and 390 millimeters long, the latter 485 millimeters, including the caudal fin. They are noticeable particularly for the elongation of the first dorsal, particularly of the second spine, which extends to or beyond the middle of the base of the second dorsal when depressed. In specimens of this size the eye is noticeably small in proportion to the head and snout.

This fine food fish is one of the largest goatfishes, and reaches a length of a little more than half a meter. It is common from the Red Sea eastward to the Pelew, Society, and Austral Islands, and all intervening islands.

UPENEUS DISPILURUS Playfair. Plate 3, fig. 2.

Mullus dispilurus PLAYFAIR, Fishes of Zanzibar (1866) 41, pl. 5, fig. 3.

Upeneus dispilurus DAY, Fishes of India (1878) 125, pl. 31, fig. 3.

Mullus pleurotaenia PLAYFAIR, Fishes of Zanzibar (1866) 41, pl. 5, fig. 4.

Upeneus pleurotaenia SNYDER, Proc. U. S. Nat. Mus. 42 (1912) 501; JORDAN and HUBBS, Mem. Carnegie Mus. 10 (1925) 246.

Pseudupeneus ischyrus SNYDER, Proc. U. S. Nat. Mus. 32 (1907) 90, fig. 2.

Upeneus ischyrus JORDAN, TANAKA, and SNYDER, Journ. Coll. Sci. Imp. Univ. Tokyo 33 (1913) 183, fig. 133.

Dorsal VIII–I, 8; anal I, 6; scales $2\frac{1}{2}$–28 + 2–$6\frac{1}{2}$.

Body markedly deep, its greatest depth at origin of spinous dorsal, 3.3 times in length, upper outline strongly elevated; head slightly longer than deep, 3 times in length; the evenly convex interorbital 3.2 times in head, much wider than eye which is contained 4.9 times; snout twice in head and more than twice eye, its upper profile almost straight; maxillary is 2.6 times in head and extends almost to below anterior nostril; jaws even, with rather thick lips; teeth conical and bluntish, rather thick lips; teeth conical and bluntish, rather stout and widely spaced, in a single row in both jaws; 7 + 22 gill rakers on first arch, the longest hardly half eye; the barbels are contained 1.5 times in head and reach below hind margin of the smooth preopercle; two opercular spines, the upper much the smaller; least depth of caudal peduncle equals length of maxillary; scales large and finely ctenoid; head completely scaled.

Third dorsal spine the highest, 1.6 times in head, the first one very small; second dorsal slightly higher than anal, 2.3 times in head; pectoral a trifle shorter than ventral, which is 1.3 times in head or 4 times in length of body and extends nearly to anus; caudal slightly shorter than head, 3.2 times in length of body.

An example from Zamboanga was yellowish white in life, with a blackish line from tip of snout through eye, fading out on lateral line above extremity of pectoral; above and below this black behind eye were a number of fine bright yellow lines; there was a large black blotch on caudal peduncle, almost entirely above lateral line and connected indistinctly with its fellow on the opposite side by a dusky area over the back; in front of the black blotch was a large yellowish saddle.

Another specimen from the same locality was reddish above, overlaid with brown and yellow; a pink line from upper posterior margin of eye to middle of base of soft dorsal; another line, rather wide and almost white, ran longitudinally from lower margin of eye, fading out near the board yellow saddle over caudal peduncle; there was a third pinkish line from distal half of maxillary to lower half of base of caudal, this line similar to belly in color and separated from it by an irregular wide yellowish area; behind the yellowish saddle on caudal peduncle was a large rounded black spot, entirely above lateral line but not connected above with its fellow; the dorsal spines were pink, the membranes yellow, the soft dorsal was pink, longitudinally bared with yellow; the anal was colored similarly to the second dorsal; the caudal, ventrals, and pectoral were pink.

A fresh specimen from Manila was colored as follows: The trunk pinkish white below the lateral line, pinkish above, the scales on upper half edged with brownish orange, imparting a dusky hue, the scales on lower part of body edged with orange; head pink to coral red; a wide bright coral red band extends from tip of snout backward over upper margin of eye to posterior part of base of second dorsal, gradually becoming pale pink posteriorly; a similar broad band extends from snout along lower margin of eye, terminating on side beneath origin of second dorsal, just after crossing lateral line; behind eye this second band rapidly becomes paler, changing to pink and then to pinkish white; behind eye the region between these two bands appeared as a rather dusky stripe; on the back of caudal peduncle immediately behind second dorsal is a bright pinkish white spot, followed by a rather dusky or deep brown saddle; dorsals and caudal deep coral red, first dorsal sprinkled over its middle and posterior part with pearly bluish white spots, second dorsal with some pink spots and a pink marginal band posteriorly; pectoral, ventral, and anal orange, pectoral unmarked, ventral edged anteriorly with pearl white, and anal with four longitudinal rows of pearl white spots.

In alcohol the ground color of the first specimen is deep yellowish brown and yellowish below; a yellow longitudinal band runs from lower edge of preorbital to the well-pronounced yellow saddle on caudal peduncle, broadly bordered above and below by two deep brown bands, the upper one from tip of snout through eye to the base of the rayed dorsal, and the lower from posterior end of maxillary, fading on lateral line under the black blotch on caudal peduncle.

Here described from three specimens, 98 to 260 millimeters long, collected at Manila; Calapan, Mindoro; and Zamboanga, Mindanao. The other Zamboanga specimen referred to above is not now in the collection.

Playfair described this species from specimens from the islands of Zanzibar and Pemba, on the east coast of Africa Snyder had a specimen from Tokyo, and later specimens from Naha and Okinawa, Japan. Jordan had a specimen from Kagoshima, obtained at Hongkong by Walter Fong. It is evidently a rare species, though widely distributed.

This species is close to *Upeneus signatus* Günther, from Port Jackson, Australia. As Day pointed out in the Fishes of India, *dispilurus* and *pleurotaenia* are merely the adult and young of the same fish. Our specimens are like Playfair's figure of *dispilurus*.

UPENEUS LUTEUS Cuvier and Valenciennes. Plate 5, fig. 1.

Upeneus luteus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 7 (1831) 392; BLEEKER, Verh. Bat. Gen. 22 (1849) 63; DAY, Fishes of India (1878) 125, pl. 31, fig. 2; EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 87.

Mullus luteus PLAYFAIR, Fishes of Zanzibar (1866) 41.

Pseudupeneus luteus EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 89.

Parupeneus luteus BLEEKER, Verh. Akad. Amsterdam 15 (1875) Révis. Mulloides, 32; Atlas Ichth. 9 (1878) pl. 394, fig. 1; KLUZINGER, Fische des Rothen Meeres (1884) 52; WEBER, Fische, Siboga Exp. (1913) 296.

Upeneus cyclostoma GÜNTHER, Cat. Fishes 1 (1859) 409 (not of Cuvier and Valenciennes).

Dorsal VIII–I, 9; anal I, 6; scales $2\frac{1}{2}$–26 + 3–$6\frac{1}{2}$.

The notably deep body is deepest at origin and along base of first dorsal, its upper profile strongly and evenly curved from tip of snout to origin of second dorsal, the greatest depth 3.3 to 3.4 times in length; head not much longer than deep, 3 to 3.1 times in length of body; the moderately convex interorbital 3.4 to 3.5 times in head; eye moderate, a little nearer posterior edge of opercle than tip of snout, 4.6 to 4.7 times in head; the moderate snout more than twice eye and 1.8 to 2 times in head; maxillary is 2.5 times in head and extends to almost below posterior nostril; mouth nearly horizontal, with even jaws; a row of conical, rather widely spaced teeth in each jaw; 6 + 19 to 21 slender gill rakers on first arch, the longest very slightly more than half eye; the long and slender barbels are 3.7 to 3.8 times in length of body and reach nearly to posterior edge of opercle, which is armed with a sharp-pointed, rather long spine on its hind border; least depth of caudal peduncle 2.7 to 3 times in head; scales large and finely ctenoid, present all over head excepting on preorbital.

Second and third dorsal spines equal, higher than the rest, 1.5 to 1.6 times in head; first spine very small; second dorsal as high as anal, 2.5 to 2.7 times in head; pectoral 4 times in head, longer than ventral which extends to a perpendicular halfway between dorsal; caudal fin equals head, its upper lobe slightly the longer.

A single specimen from Zamboanga was pinkish above in life, with several rather indistinct bluish lines on each side of head and body; the scales on body were each obscurely spotted with golden; all the fins were pinkish.

The ground color in alcohol of body and fins is uniformly yellowish brown, with no visible markings of any kind.

Here described from an example, 155 millimeters long, from Dumaguete, Oriental Negros, and one, 173 millimeters in length, from Zamboanga, Mindanao. Evermann and Seale had a specimen from Jolo and Weber had one also from the Sulu Archipelago.

This species is well distinguished by its deep body, the evenly well-rounded upper profile of head, and the longer upper lobe of caudal. It ranges from the Red Sea and Zanzibar through the East Indies to the Louisade Archipelago, off the southeast end of New Guinea. It attains a length of more than 300 millimeters.

UPENEUS INDICUS (Shaw). Plate 2, fig. 1.

Mullus indicus SHAW, Zoölogy 4[2] (1800) 614.

Upeneus indicus GÜNTHER, Cat. Fishes 1 (1859) 406; DAY, Fishes of India (1878) 126, pl. 31, fig. 4.

Pseudupeneus indicus JORDAN and SEALE, Bull. Bur. Fisheries 26 (1907); EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 88; SNYDER. Proc. U. S. Nat. Mus. 32 (1907) 93.

Parupeneus indicus BLEEKER, Natuurk. Verh. Kon. Akad. Amsterdam 15 (1875) Révis. Mulloides 28; Atlas Ichth. 9 (1878) pl. 394, fig. 5; WEBER, Fische, Siboga Exp. (1913) 296.

Upeneus russelli CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 342.

Upeneus waigiensis CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 343.

Upeneus malabaricus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 344; GÜNTHER, Cat. Fishes 1 (1859) 407; Fische der Südsee 1 (1873) 58 pl. 45, fig. B; WEBER, Fische, Siboga Exp. (1913) 297.

Upeneus griseofrenatus KNER, Sitz. Akad. Wiss. Wien. 58 (1868) 305, pl. 3, fig. 7.

Dorsal VIII–I, 8; anal I, 7; scales $2\frac{1}{2}$–28 or 29–$6\frac{1}{2}$.

Body deepest at origin and anterior part of first dorsal, depth 3.4 to 3.6 times, head 2.9 to 3.2 times in length; interorbital space evenly and slightly convex, its least width 3.6 to 4.2 times in head; the rather small eye nearly in middle of head in younger specimens, in older ones partly or entirely in posterior half, 4.4 to 5.5 times in head; snout somewhat pointed and elongate, 1.7 to 2 times in head or 2.3 to 3.1 times eye, its upper profile nearly straight, maxillary widest posteriorly, 1.5 to 1.7 times in snout; jaws equal; teeth conical and bluntish, widely spaced, in a single series in each jaw; first gill arch has 4 or 5 + 19 or 20 gill rakers, the longest about half eye; the long slender barbels reach slightly beyond angle of the smooth preopercle and are contained 1.3 to 1.4 times in head; opercle armed at its hind edge with a spine; least depth of caudal peduncle 2.4 to 2.8 times in head; scales finely ctenoid, extending on top of head to tip of snout, entire head scaly except preorbital.

First dorsal spine minute, third one highest, 1.5 to 1.7 times in head, only slightly higher than fourth; second dorsal slightly higher than anal, 2 to 2.3 times in head; pectoral about as long as barbel, ventral 1.2 to 1.5 times in head and extending to below axil of first dorsal; the deeply forked caudal a little shorter than head, 3.1 to 3.5 times in length of body.

The ground color in life is yellowish or olive green, each scale with a darker margin; a large ovate or oblong, rather elongate, bright golden yellow blotch on lateral line below posterior half of first dorsal and anterior portion of second; a large rounded black spot on lateral line before base of caudal fin; soft dorsal and anal yellowish, longitudinally barred with three to five pale blue stripes; the other fins of the same color, unmarked; each side of head has several longitudinal bluish streaks or yellowish blue margined stripes radiating from eye, the lower ones running lengthwise below eye, the barbels pinkish.

Living specimens at Calapan, Mindoro, had the head yellowish, the body pale, the scales edged with gold; posteriorly each scale with a bluish pearly spot, or some specimens with a violet spot on each scale, the lower part of body roseate; a large black spot on middle of caudal peduncle, above lateral line; a large elongate golden spot on side below posterior part of first dorsal and extending to below origin of second dorsal; two bright blue longitudinal lines on cheek and blue crosslines on occiput; several blue lines running downward on opercle; pectoral pink, the other fins golden violet; anal with two longitudinal blue lines; barbels dirty flesh color.

Alcoholic specimens are brownish to dusky above and yellowish brown below, with darker edges to the scales; an oblong yellow spot on lateral line above posterior half of pectoral and a blackish rounded blotch on each side of caudal peduncle; traces of longitudinal bluish streaks on dorsal rays, none on anal fin; the lines on head have faded.

We have examined forty-six specimens in the Bureau of Science collection, ranging from 59 to 285 millimeters in length. They were taken at the following localities:

Luna and Balaoan, La Union, 3.
Subic Bay, 4.
Calapan and Pinamalayan, Mindoro, 22.
Bacon, Sorsogon, 2.
Tacloban, Leyte, 1.
Bantayan Island, 2.
Cebu, Cebu, 3.
Puerto Princesa, Palawan, 2.
San Juan, Siquijor Island, 2.
Cagayan de Misamis, Mindanao, 1.
Zamboanga, Mindanao, 3.
Jolo, Sulu Province, 1.

Three of these are ripe females, 144 to 162 millimeters long, collected in February, April, and August, 1908.

Jordan and Seale had specimens from Iloilo, and Evermann and Seale from Bacon and Bulan, Sorsogon.

We agree with Bleeker, Day, and Snyder in uniting *U. malabaricus* with *U. indicus*. This species has an enormous range, occurring from Zanzibar on the east coast of Africa to Samoa and the Tonga Islands, far to the southeast in Polynesia, northward to Formosa, the Riu Kiu Islands, and southern Japan. It is an excellent food fish, and reaches a length of over 400 millimeters.

UPENEUS SPILURUS Bleeker.

Upeneus spilurus BLEEKER, Nat. Tijds. Ned. Ind. 6 (1854) 395; Verh. Bat. Gen. 26 (1854–1857) 68, pl. 2, fig. 2; GÜNTHER, Cat. Fishes 1 (1859) 406; SNYDER, Proc. U. S. Nat. Mus. 32 (1907) 91.

Parupeneus spilurus BLEEKER, Arch. Neerl. Sci. Nat. 13 (1878) 63; Natuurk. Verh. Kon. Akad. Amsterdam 18 (1879) 10.

Pseudupeneus spilurus EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 88.

Dorsal VIII–I, 8 or 9; anal II, 6 or 7; scales 2–28 or 29–6.

Depth of the oblong compressed body 3 times, head 3.2 times in length; dorsal outline strongly arched; depth of head 1.25 to 1.33 times in its own length; the long-pointed snout twice in head, its dorsal outline concave; interorbital space usually very convex, occasionally somewhat flattened, its width 3 times in head; eye 4 to 5.5 times in head; lower jaw slightly shorter than upper, lips very broad, upper partly covering anterior edge of the fleshy maxillary, which is 2.6 times in head, its upper edge largely covered by preorbital; jaws with a single row of 16 to 20 widely spaced stout teeth; the barbels extend to operculum or beyond; opercle with a sharp spine; head completely scaled, the scales on snout, maxillary, and chin deeply embedded and sometimes not visible; first dorsal spine very short, closely adnate to second; third and fourth spines longest, 1.6 times in head, extending beyond tips of other spines when fin is depressed; the longest soft dorsal ray 1.5 times in head, anal slightly lower than soft dorsal; caudal deeply divided, with pointed lobes, 1.875 times in head; pectorals and ventrals pointed, about 1.4 times in head; depth of caudal peduncle 8 times in length; lateral line arborescent; pseudobranchiæ large; gill rakers 6 + 23, slender, the longest equal to eye; peritoneum silvery; air bladder large.

Color in life bright carmine red, with three curved olive stripes, with a brassy sheen, extending from tip of snout to below end of soft dorsal, the median stripe passing through eye and along lateral line; caudal peduncle with a blackish saddle, the lower portions darker, forming a round black spot on each side of tail; two round dusky spots behind eye; fins pink, the pectorals and spinous dorsal darker than others; ventrals with indistinct basal and subterminal dark bands.

In alcohol the bright colors fade. Bleeker gives the color as violaceous rose on back and snout, rosy on sides, yellowish rose on belly; he does not mention longitudinal stripes, but does mention a violet-black spot on each side of tail above lateral line.

Evermann and Seale had a specimen, 100 millimeters long, from Bulan, Sorsogon. Bleeker described this species from one example, 160 millimeters long, from Nagasaki. Later he had one from New Guinea. Snyder had a number of specimens from Wakanoura and Nagasaki. He states that this species is rare and reaches a length of about 300 millimeters.

UPENEUS BIFASCIATUS (Lacépède). Plate 6, fig. 2.

Mullus bifasciatus LACÉPÈDE, Hist. Nat. Poiss. 3 (1801) 404, pl. 14, fig. 2.

Upeneus bifasciatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 344; GÜNTHER, Fische der Südsee 1 (1873) 59, pl. 44, fig. A; EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 88.

Pseudupeneus bifasciatus JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23[1] (1903) (1905) 258, fig. 107; JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 274.

Mullus trifasciatus LACÉPÈDE, Hist. Nat. Poiss. 3 (1801) 404, pl. 15, fig. 1.

Parupeneus trifasciatus WEBER, Fische, Siboga Exp. (1913) 295.

Dorsal VIII–9; anal I, 6; scales 2–28–6.

Body notably deep, the greatest depth at base of anterior dorsal spines, 3 to 3.2 times in length, the dorsal contour rather strongly arched anteriorly; the deep head equals depth of body; interorbital space very convex, its least width 3.3 to 3.7 times in head; eye fairly large, 4.2 to 4.3 times in head; the moderate snout 1.7 to 1.9 times in head or 2.2 to 2.5 times eye; the maxillary is very broad posteriorly and extends more than two-thirds the distance to anterior margin of orbit; jaws equal, lips thick and broad; a single row of rather bluntish conical teeth in each jaw; first gill arch contains 8 + 27 or 28 gill rakers; the barbels extend to slightly behind posterior edge of preopercle, each 1.6 to 1.7 times in head or 4.8 to 5.4 times in length of body; the preopercle edges entire and the opercle armed with two spines at its hind border; least depth of caudal peduncle 2.4 times in head.

Lips and preorbital bones naked, other parts of head, including maxillary, scaled; third spine of first dorsal the highest, 1.5 to 1.6 times in head; second ray of dorsal and anal highest, that of latter fin slightly the higher, 2.2 to 2.4 times in head; pectoral 1.2 to 1.4 times in head and shorter than ventral which reaches anal opening; the moderately forked caudal about as long as head, 3.1 to 3.2 times in length of body.

In life the general color is pinkish white with three wide blackish crossbands on each side extending down to middle of body, the first from anterior third of spinous dorsal, the second from entire base of soft dorsal, the third covering posterior half of caudal peduncle; the scales on the spaces between these bands edged with golden; top of head and snout drab; three whitish violet lines across preorbital; preopercle and lower portions of opercle lightly washed with reddish; spinous dorsal reddish, slightly washed with yellow on some of the membranes; soft dorsal dusky red at base, its outer portion with longitudinal lines of alternating yellow and bluish; the anal fin has longitudinal lines of alternating bluish and yellow; pectoral fin pinkish; rays of caudal yellow, membranous portions grayish; ventral reddish with membranes yellow; pectoral pinkish, with a reddish bar at its base.

Ground color in alcohol yellowish to yellowish brown; two wide blackish crossbands on each side of trunk, one below each dorsal fin; a third blackish band covers posterior half of caudal peduncle; a small blotch of like color behind each eye; second dorsal blackish near base and with blackish longitudinally on its upper portion; anal banded longitudinally with blackish; pectoral and spinous dorsal yellowish, the former having a blackish spot at its axil; ventral yellowish, with the spine blackish; caudal fin yellowish to slightly grayish.

This species, which has been reported previously from Bacon, Sorsogon, by Evermann and Seale, is here described from four examples, 43 to 192 millimeters long, coming from Luna, La Union; Cabusao, Camarines Sur; Zamboanga; and the southern coast of Cotabato Province, Mindanao. Weber had a specimen, 195 millimeters long, from Sulu.

This excellent food fish reaches a length of 300 millimeters or more, and is abundant at Hawaii and Samoa. It is found from Marcus Island at the northwest, through the Caroline and Solomon Islands to Raratonga. It was originally described from Réunion, in the Indian Ocean.

UPENEUS BARBERINOIDES Bleeker. Plate 4, fig. 3.

Upeneus barberinoides BLEEKER, Nat. Tijds. Ned. Ind. 3 (1852) 263; GÜNTHER, Cat. Fishes 1 (1859) 406.

Parupeneus barberinoides BLEEKER, Ned. Tijds. Dierk. 1 (1863) 234; Natuurk. Verh. Kon. Akad. Amsterdam 15 (1875) 22; Atlas Ichth. 9 (1878) pl. 392, fig. 5.

Dorsal VIII–I, 8 or 9; anal I, 6 or 7; scales $2\frac{1}{2}$–28–$6\frac{1}{2}$.

Greatest depth of the body 3.2 to 3.4 times in length, the dorsal contour gently sloping from origin of dorsal to tip of snout; head contained 2.8 to 3 times in length of body; the strongly convex interorbital 3.4 to 3.9 times in head; the moderately small eye 4.5 to 5.1 times in head and 2.5 to 2.8 times in the rather elongate snout, which is 1.8 times in head; the maxillary is 2.6 to 2.9 times in head and reaches about midway between anterior nostril and anterior margin of eye; jaws even, lips rather broad; teeth in each jaw a single row of small, rather bluntish, widely spaced conical teeth; 6 or 7 + 22 to 24 gill rakers on first arch; barbels contained 3.7 to 4 times in length of body, extending beyond posterior edge of the smooth preopercle but not quite reaching base of ventrals; the opercle has two spines at its hind border; least depth of caudal peduncle 2.6 to 2.9 times in head.

Head completely covered with scales; of the fins only the caudal is scaly; third and fourth dorsal spines the highest, each 4.2 to 5.1 times in length of body; the last rays of dorsal and anal are the highest, each 2 to 2.8 times in head; pectoral slightly shorter than ventral, the latter 1.2 to 1.4 times in head and extending to anus; the deeply forked caudal a little shorter than head, 3.1 to 3.2 times in length of body.

In life this fish is deep red along back of head and body, opercles deep purplish red, preopercles dusky reddish brown; on anterior part of trunk is a large black area, with a black line extending forward from its upper part through eye to tip of snout; a yellow band on posterior part of body below lateral line, ending in a yellow crossbar on base of caudal; a blackish spot on lateral line below posterior dorsal rays; some brilliant pearly bluish spots behind eye and two rows of like spots above lateral line, extending back below anterior part of soft dorsal; on posterior part of trunk are violet spots on the middle scales, back to caudal; a yellowish white band below eye from above upper end of gill opening nearly to angle of maxillary, widest anteriorly; opercles deep purplish red; preopercles dusky reddish brown; breast and belly pinkish to very pale pink; barbels deep red; anterior portion of spinous dorsal deep pink or reddish, posterior region dusky bluish; lower half of soft dorsal dusky blue, outer portion yellow, marked with longitudinal violet lines; the anal has longitudinal stripes of alternating yellow and pale violet; caudal yellow on the rays and reddish on the membranous portions, narrowly edged above with deep red, and broadly margined below with black; ventrals blackish, slightly washed with yellow and reddish; pectoral yellow, streaked on the membranes with reddish, its base with a black bar; a black spot on lateral line below base of posterior rays of second dorsal. Living specimens at Calapan, Mindoro, had a brilliant sapphire spot on each scale above the middle of body, these changing to violet on lower half.

Alcoholic specimens yellowish to dark violet-brown; a lateral blackish band through eye, extending to below the space between first and second dorsal fins and uniting with upper posterior part of the large blackish blotch on each side of body which extends forward to opercles; a blackish spot on lateral line below posterior rays of second dorsal; first dorsal blackish from third to last spine; second dorsal blackish on its lower half and with alternate yellowish and bluish stripes on its upper half; a blackish longitudinal band on the longest rays of lower caudal lobe; the yellowish anal has longitudinal blackish stripes; pectoral yellowish, its base and axil blackish, ventrals almost entirely grayish or blackish.

Here described from twenty-seven examples, 33.5 to 160 millimeters in length, from the following localities: Subic Bay; Puerto Galera and Calapan, Mindoro; Concepcion, Busuanga; Negros; Buenavista, Guimaras; Cebu, Cebu; Zamboanga, Mindanao.

This species, which has not been reported previously from the Philippines, is known only from Ceram, Celebes, Ternate, Amboina, and New Guinea.

UPENEUS PLEUROSTIGMA Bennett. Plate 5, fig. 2.

Upeneus pleurostigma BENNETT, Proc. Zool. Soc. London (1831) 59; GÜNTHER, Fische der Südsee 1 (1873) 58; BLEEKER, Natuurk. Verh. Kon. Akad. Amsterdam **15** (1875) Révis. Mulloides 29.

Mullus pleurostigma PLAYFAIR, Fishes of Zanzibar (1866) 40.

Parupeneus pleurostigma BLEEKER, Atlas Ichth. 9 (1878) pl. 393, fig. 3.

Parupeneus pleurostigma STEINDACHNER, Denkschr. Acad. Wiss. Wien **70** (1900) 486.

Pseudupeneus pleurostigma JENKINS, Bull. U. S. Fish Comm. 22 (1902) (1903) 456; JORDAN and EVERMANN, Bull. U. S. Fish Comm. **23**[1] (1903) (1905) 260, fig. 108.

Upeneus brandesi BLEEKER, Nat. Tijds. Ned. Ind. 2 (1851) 236; GÜNTHER, Cat. Fishes 1 (1859) 407.

Parupeneus brandesi BLEEKER, Ned. Tijds. Dierk. 2 (1865) 281.

Dorsal VIII–I, 8; anal I, 6; scales 2½–28–5½.

Body rather deep, its greatest depth about base of anterior dorsal spines, 3.4 to 3.7 times in length; head 3 to 3.2 times in length, its upper outline slightly arched; interorbital space evenly and moderately convex, its least width 3.4 to 3.7 times in head; the rather small eye high up, near upper profile of head, 4.8 to 5.4 times in head; snout 1.7 to 1.8 times eye, pointed and elongate, its upper outline nearly straight; maxillary widest posteriorly, its length 2.4 to 2.6 times in head or 1.3 to 1.5 times in snout; lips thick; lower jaw slightly shorter than upper; teeth conical, in a single series in both jaws; first gill arch has 6 or 7 + 22 or 23 fairly short gill rakers, the longest shorter than eye; the barbels extend to a little behind angle of entire preopercle; opercle armed posteriorly with two spines, upper one very small and rather inconspicuous; least depth of caudal peduncle 2.7 to 3 times in head; scales ctenoid and rather large; head completely covered with scales, excepting the partially naked preorbital.

Third or fourth dorsal spine highest, 1.4 to 1.5 times in head, first spine very small; second dorsal slightly lower than anal, which is 2.5 to 2.7 times in head; pectoral a little shorter than ventral, which is 3.8 to 4.2 times in length of body; caudal fin slightly longer than ventral, 3.5 to 3.6 times in length.

In life the ground color is pink, becoming paler below; a black rounded blotch on lateral line below the space between the two dorsals; immediately behind this blotch a larger, oblong, yellow area; dorsal spines pink, membranous portions yellowish; soft dorsal with a black basal blotch, its outer portion longitudinally barred with alternating yellowish and pink-edged whitish stripes; caudal yellowish brown, narrowly margined above with pink and broadly washed below with the same color; the anal has alternating yellow and pinkish longitudinal bands; the pectoral is pink and has a darker blotch at base, the ventrals much paler; several very pale lavender lines radiate forward, upward, and backward from eye; a longitudinal line of like color across orbital ring; barbels pinkish.

Color in alcohol dull whitish to yellow brown, with a rounded blackish spot on lateral line below the space between first and second dorsals, and a yellow oblong blotch immediately behind it; second dorsal blackish at its basal half, its outer portion yellowish, with rather faint longitudinal stripes of brown-violet; spinous dorsal almost colorless; caudal yellowish, indistinctly edged below with brownish; the other fins yellowish, unmarked; no traces of the very pale lavender lines from eye.

Here described from three specimens, 162 to 200 millimeters long, from Zamboanga, Mindanao. We also have an example from Honolulu.

This species, which was originally described from Banda Neira, was also recorded by Bleeker from Amboina. This is a very widely distributed goatfish; it is not rare at Zanzibar and Mauritius, and is common in the Hawaiian Islands. It is also known from the Gilbert Islands and from Tahiti.

UPENEUS CYCLOSTOMUS (Lacépède). Plate 6, fig. 3.

Mullus cyclostomus LACÉPÈDE, Hist. Nat. Poiss. 3 (1801) 404, pl. 19, fig. 3.

Upeneus cyclostomus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1831) 348.

Upeneus cyclostoma RÜPPELL, Neue Wirbelt., Fische (1835) 101.

Parupeneus cyclostomus BLEEKER, Ned. Tijds. Dierk. 2 (1865) 285.

Pseudupeneus cyclostomus JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 275.

Dorsal VIII–I, 9; anal I, 7; scales $2\frac{1}{2}$–28 + 2–$6\frac{1}{2}$.

Body rather deep and notably compressed, its greatest depth at origin and anterior base of first dorsal, 3.2 to 3.3 times in length; the pointed head much longer than deep, 2.7 times in length; the convex interorbital 4.4 times in length; the small eye in posterior half of head, 3.6 to 3.7 times in snout, 6.4 to 6.5 in head; the elongate, pointed snout 1.8 times in head, its upper outline straight or very slightly concave; maxillary 1.5 to 1.6 times in snout or 2.7 to 2.8 times in head, very broad posteriorly, and reaching to a vertical midway between anterior and posterior nostrils; lower jaw slightly included; teeth conical and rather small, in a single series in each jaw; first gill arch has 5 + 22 gill rakers, the longest slightly greater than half the eye; the barbels very long and slender, reaching to base of ventrals, 3 to 3.1 times in length of body; a single spine at hind border or opercle; least depth of caudal peduncle 3.1 times in head; large, finely ctenoid scales cover head and body, none present on preorbital and on anterior portion of snout.

Second and third dorsal spines about equal in height, each 1.6 times in head, first spine very small; soft dorsal and anal equal in height, their first rays the highest, 2.9 to 3.1 times in head, the latter fin having a minute spine; the ventral, which is slightly longer than pectoral, is 1.7 times in head and ends at second scale before anus; upper lobe of the deeply forked caudal slightly longer than lower, 3.2 to 3.4 times in length of body.

The color of the specimens when fresh was clear orange red, slightly deeper above, without markings anywhere on body.

In alcohol the fish is uniformly yellowish white, the fins concolorous.

We have two large examples of this species, 220 and 225 millimeters long, taken by Japanese fishermen by the muro-ami method at Tablas and Sibuyan Islands.

This species is here recorded for the first time from the Philippines; it occurs in the East Indies and Samoa. It is characterized by its notably compressed deep body, small eye, long snout, long barbels, and the absence of a yellow saddle on caudal peduncle.

UPENEUS MOANA (Jordan and Seale). Plate 4, fig. 2.

Pseudupeneus moana JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 274; SEALE, Occ. Papers Bishop Mus. 4 (1906) 48; EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907); SEALE and BEAN, Proc. U. S. Nat. Mus. 33 (1907) 245.

Upeneus trifasciatus GÜNTHER, Fische der Südsee 1 (1873) 59, pl. 44, fig. B.

Upeneus multifasciatus SEALE, Occ. Papers Bishop Mus. 1 (1901) 71; ? FOWLER, Proc. U. S. Nat. Mus. 62 (1922) 44.

Parupeneus multifasciatus BLEEKER, Natuurk. Verh. Kon. Akad. Amsterdam 15 (1875) Révis. Mulloides 20; Atlas Ichth. 9 (1878) pl. 394, fig. 4.

Dorsal VIII–I, 8; anal I, 6; scales 2–28 to caudal base–6.

Greatest depth of body at origin of first dorsal, 3.2 to 3.4 times in length, upper profile strongly convex; the compressed head 2.9 to 3.1 times in length, upper outline nearly straight or slightly concave before eyes; interorbital space very convex, its least width greater than eye, 3.4 to 4 times in head; eye rather small, 4.8 to 6.2 times in head; snout elongate and pointed, 1.7 to 1.9 times in head or 2.7 to 3.7 times eye; maxillary very broad posteriorly, reaching a vertical through middle of distance between anterior and posterior nostrils; jaws even, with very thick and broad lips; the bluntish conical teeth widely spaced, in a single series in each jaw; gill rakers 7 to 9 + 27 to 29; the long barbels extend to origin of ventrals, each about twice the length of maxillary or 3.6 to 4.1 times in that of body; edges of preopercle smooth; two spines on hind edge of opercle, the upper very much the smaller; depth of caudal peduncle 2.6 to 2.9 times in head; scales rather large, weakly ctenoid; head completely scaled excepting the naked lips and preorbital.

Third dorsal spine highest, 1.4 to 1.7 times in head; the last rays of soft dorsal and anal prolonged, the former slightly the higher, 1.6 to 2.9 times in head; pectoral equals distance from tip of snout to vertical edge of preopercle, 4.2 to 4.8 times in length of body; ventral slightly longer than pectoral and reaching to anus; the deeply forked caudal 3.5 to 3.9 times in length of body, its lobes obtusely pointed.

In life the general color is pinkish red, the scales above darker and edged with yellow; four darker crossbands on each side of body, the last on caudal peduncle and separated from third by a wide yellow saddle; first dorsal clouded with dusky, second dorsal black at basal half and with violet and yellow longitudinal stripes on its outer portion; anal barred longitudinally with alternating violet and yellow; ventral red, edged anteriorly with blackish; pectoral uniformly golden orange; caudal brownish, edged with black above and below; barbels golden; three of four blue or drab lines covering each side of snout, and four bluish lines extending backward from eye; lower portion of head deep pink.

Ground color in alcohol purplish above, yellowish below; a blackish horizontal band on snout, continued through eye to a little distance behind it; three well-defined broad blackish bands on each side of trunk, descending from back to below lateral line, the first rather faint, below spinous dorsal; it may be preceded by two more or less indistinct ones, sometimes appearing as one; the second band, a little narrower and darker, descends between the two dorsals; the third band is below anterior portion of second dorsal; behind it is a wide yellow area; a broad saddle of black forms a fourth band on caudal peduncle; spinous dorsal slightly dusky; basal half of second dorsal black, outer half with blackish longitudinal bands; anal yellowish, banded longitudinally with blackish; anterior portions of ventrals dusky, and upper and lower edges of caudal dusky; pectoral uniformly yellowish.

The above account is taken from the following specimens, 45 to 190 millimeters in length:

Santo Domingo de Basco, Batanes Province, 1.
Camp Wallace, La Union, 4.
Subic Bay, 1.
Monja Island, outside the entrance to Manila Bay, 3.
Hamilo, Batangas, 5.
Calapan and Puerto Galera, Mindoro, 7.
Sibuyan Island, 1.
Bantayan Island, 1.
Agutaya Island, 1.
Jordan, Guimaras, 1.
Puerto Princesa, Palawan, 1.
Zamboanga, Mindanao, 4.
Samal Island, Davao, 1.

The three examples from Monja Island, collected April 23, 1922, are females nearly ready to spawn. They are 127 to 172 millimeters in length.

Evermann and Seale had a specimen from Bacon, Sorsogon, and Seale and Bean had three specimens from Zamboanga. Fowler and Bean had two specimens from Zamboanga, which they called *Upeneus multifasciatus*.

This species has been confused with other banded goatfishes, from all of which it is separated by the presence of a bright yellow area in alcoholic specimens, between the black saddle on the caudal peduncle and the black band descending from the soft dorsal. It is widely distributed in the tropical Pacific, and occurs everywhere from the East Indies to Guam, the Austral and Marquesas Islands.

UPENEUS CHRYSERYDROS (Lacépède). Plate 5, fig. 3.

Mullus chryserydros LACÉPÈDE, Hist. Nat. Poiss. 3 (1801) 406.

Upeneus chryserydros CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 346.

Upeneus chryserythrus GÜNTHER, Fiche der Südsee 1 (1873) 60, pl. 45, fig. A.

Upeneus chryseredros JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 260.

Parupeneus cherserydros BLEEKER, Natuurk. Verh. Kon. Acad. Amsterdam 15 (1875) Révis. Mulloides 35; Atlas Ichth. 9 (1878) pl. 393, fig. 2; WEBER, Fische, Siboga Exp. (1913) 296.

Parupeneus chryserythrus KLUNZINGER, Fische de Rothen Meeres (1855) 52.

Pseudupeneus chryserydros JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23[1] (1903) (1905) 255, fig. 106; JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 275.

Upeneus oxycephalus BLEEKER, Act. Soc. Sci. Indo-Neerl. 1 (1856) Vischs. Manado, 45; GÜNTHER, Cat. Fishes 1 (1859) 409.

Dorsal VIII–I, 8; anal I, 7; scales $2\frac{1}{2}$–26 + 3–$6\frac{1}{2}$.

Body long, with the back considerably elevated, its greatest depth at base and origin of spinous dorsal, 3.5 times in length; the long pointed head much longer than deep, 2.9 to 3 times in length, its upper outline low and evenly curved from anterior end of snout to origin of first dorsal; interorbital space moderately convex, its least width 3.9 to 4.2 times in head; the small eye in posterior half, 5.5 to 6 times in head; the long bluntly pointed snout nearly straight above, 1.7 to 1.8 times in head or 3.1 to 3.4 times eye; maxillary is broadest posteriorly and extends to a little past a vertical midway between anterior and posterior nostrils, very slightly more than twice eye; jaws approximately equal, with thick fleshy lips; teeth bluntly conical and rather widely spaced, in a single row in each jaw; 6 + 21 to 23 moderately slender gill rakers on first arch, the longest a trifle greater than half eye; barbels elongate, reaching to base of ventrals, each 3.4 to 3.5 times in length of body; third dorsal spine longest, 1.6 to 1.7 times in head, first spine very short; second dorsal 2.5 to 2.8 times in head, and about as high as anal, which has a minute rather inconspicuous spine in front; ventral fin longer than pectoral, which is 1.6 to 1.7 times in head and extends to a vertical midway between the two dorsals; caudal fin deeply forked, about as long as the barbels, contained 3.5 to 3.6 times in total length.

According to Jordan and Richardson, this fish in life is white below and bluish above, with a rosy wash on opercle, preopercle, and tail, and with a yellow saddle on caudal peduncle; several lines of dark yellow and lavender run from snout through eye, and a number of lines radiate from upper side of eye; the rays of spinous dorsal lavender in color, the membranes yellow; second dorsal irregularly striped with lemon yellow and lavender; pectorals and ventrals clear. Smaller specimens uniformly yellow, darker above, a little paler below, and brighter on the fins.

An example from Zamboanga was bright yellow in life, with a whitish saddle on the caudal peduncle immediately behind the soft dorsal, the fins orange red.

According to Jordan, this species is well distinguished by its peculiar violaceous coloration, like the lees of wine as Commerson, its discoverer, phrased it. Jordan and Evermann describe a living specimen as dark leaden purple, shaded with red on side; a large conspicuous orange-yellow blotch on caudal peduncle above; another one was purplish rose inclining to red rather than the usual livid purplish lead color; back of tail bright golden shaded with orange. In the Honolulu market its livid purplish colors contrast strongly with those of other species of goatfishes.

In alcohol the color of the body and fin is uniformly yellowish to yellowish brown, with a conspicuous paler saddle on the caudal peduncle.

There are two examples of this species in the Bureau of Science collection, measuring 166 and 211 millimeters in length. They were collected at Zamboanga, Mindanao.

This beautiful species, which reaches a length of 380 millimeters, is widespread, occurring from the Red Sea to the Hawaiian, Samoa, and Society Islands.

UPENEUS PLEUROSPILOS Bleeker. Plate 1, fig. 2.

Upeneus pleurospilos BLEEKER, Nat. Tijds. Ned. Ind. **4** (1853) 110; Verh. Bat. Gen. **26** (1854–1857) 69; GÜNTHER, Cat. Fishes **1** (1859) 407; MEYER, Ann. Soc. España Hist. Nat. **14** (1885) 16.

Parupeneus pleurospilos BLEEKER, Natuurk. Verh. Kon. Akad. Amsterdam **15** (1875) Révis. Mulloides 31; Atlas Ichth. **9** (1878) pl. 191, fig. 5.

Pseudupeneus pleurospilos SNYDER, Proc. U. S. Nat. Mus. **32** (1907) 96.

Dorsal VIII–I, 8; anal I, 6; scales $2\frac{1}{2}$–28 + 3–$5\frac{1}{2}$.

Body rather deep, its greatest depth at origin of first dorsal and base of anterior dorsal spines, 3.4 to 3.5 times in length; upper profile evenly arched from snout to spinous dorsal; head

3 to 3.1 times in length of body; least width of the convex interorbital 3.6 to 3.8 times in head; eye moderate in size, 3.8 to 4.6 times in head and very slightly nearer posterior margin of opercle than tip of snout; snout moderate, 1.8 to 2.3 times in head; maxillary extends nearly below posterior nostril, 2.4 to 2.8 times in head; mouth slightly oblique, with jaws even; a single row of conical, rather widely spaced teeth in each jaw; 6 + 21 or 22 gill rakers on first arch, the longest about equal to or a trifle more than half eye; the long slender barbels extend almost to base of ventrals, 3.7 to 4.3 times in length of body; preopercle entire, opercle armed posteriorly with two spines; least depth of caudal peduncle 2.9 times in length of head; no scales on preorbital, those on remaining portions of head and body moderate in size.

Second and third dorsal spines highest, 1.7 times in head, the first one very small; second dorsal and anal equal in height, 2.3 to 2.9 times in head; pectoral 1.3 to 1.6 times in head, slightly shorter than ventral which is 1.5 times; the deeply forked caudal 3.3 to 3.6 times in length of body, with the lower lobe a trifle the shorter.

Two of our specimens are more or less rose colored, but the rest are uniformly yellowish to yellowish olive, with a blackish spot between lateral line and posterior half of pectoral; three pearly bluish bands on snout and head, the first along upper edge of eye, the second opposite middle of eye, the third along lower edge of eye; the second dorsal has two logitudinal lines; anal and caudal indistinctly barred with brown, the other fins colored as body. In life this species is rose colored, darker above, paler below.

Here described from the following examples, 64 to 130 millimeters long: Polillo, 2; Calapan, 1; Cebu, Cebu, 1; Cagayan de Misamis, 3; and Davao, Mindanao, 1.

This species differs from *Upeneus pleurostigma* Bennett, which it closely resembles, in having the lateral black spot more anterior and not followed by a yellow area, in having stripes on head and snout, and in having the soft dorsal, anal, and caudal barred. It was first recorded in the Philippines by Meyer from Cebu. Bleeker had specimens from Amboina, Bali, and Saparoua in the East Indies, and Nagasaki, Japan. It must be rather rare, as no record of it has been published since the records of Bleeker and Meyer.

Genus MULLOIDES Bleeker

Mulloides BLEEKER, Verh. Bat. Gen. 22 (1849) 12.

The small acute teeth are in several rows or form a narrow band in both jaws; none on vomer and palatines. Head convex, the obtuse snout scaled, opercle terminating in a flat spine.

A dozen or more species are known, mostly confined to the tropical Pacific.

Key to the Philippine species of Mulloides.

a^1. Body with a longitudinal band or bands.
  b^1. A yellow band from snout or eye to caudal.
    c^1. A conspicuous yellow band on fresh and preserved specimens; depth 3.5 to 3.8 in length; maxillary 2.7 to 2.8 in head. **M. auriflamma.**
    c^2. Fresh specimens with a bright yellow stripe from eye to caudal, a narrow one above; two or three below it on head; none present on alcoholic specimens; a blackish blotch usually present below lateral line; depth 4.1 to 4.6; maxillary 3.3 to 3.4 in head. **M. samoensis.**
  b^2. An indistinct dusky line from head to caudal; three or four oblique dusky bands on caudal; depth 3.85 to 4.4 in length...... **M. japonicus.**
a^2. Body uniform in color.
  e^1. Caudal not barred.
    f^1. Fresh specimens reddish above, yellow below; preserved ones yellowish, dorsal region and top of head brown; no lateral spot, depth 3.6 to 3.9 in length; maxillary 2.8 to 3 in head. **M. vanicolensis.**
    f^2. Alcoholic specimens uniformly yellowish white to yellowish brown; a blackish lateral spot often present; depth 4.1 to 4.6 in length; maxillary 3.3 to 3.4 in head.. **M. samoensis.**
  c^2. Caudal with three or four oblique dusky bands; lateral band often disappearing, specimens then brownish above, silvery below; depth 3.85 to 4.4 in length... **M. japonicus.**

MULLOIDES AURIFLAMMA (Forskål). Plate 2, fig. 3.

Mullus auriflamma FORSKÅL, Descr. Anim. (1775) 30.

Upeneus auriflamma CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 339.

Mulloides auriflamma KLUNZINGER, Verh. Zool. Bot. Ges. Wien 20 (1870) 742; STEINDACHNER, Denkschr. Akad. Wiss. Wien 70 (1900) 485; JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23[1] (1903) (1905) 250, fig. 103; JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 276; Proc. U. S. Nat. Mus. 28 (1905) 782; SEALE, Occ. Papers Bishop Mus. 4 (1906) 48; FOWLER and BEAN, Proc. U. S. Nat. Mus. 62 (1922) 44.

Mullus flavolineatus LACÉPÈDE, Hist. Nat. Poiss. 3 (1801) 406.

Upeneus flavolineatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 336; RÜPPELL, Neue Wirbelt., Fische (1835) 101, pl. 26, fig. 1.

Mulloides flavolineatus BLEEKER, Nat. Tijds. Ned. Ind. 3 (1852) 697; GÜNTHER, Cat. Fishes 1 (1859) 403; Fische der Südsee 1 (1873) 56; BLEEKER, Natuurk. Verh. Kon. Akad. Amsterdam 15 (1875) Révis. Mulloides 15; DAY, Fishes of India (1878) 122, pl. 30, fig. 6; BLEEKER, Atlas Ichth. 9 (1878) pl. 394, fig. 3; SEALE, Occ. Papers Bishop Mus. 1 (1901) 71.

Upeneus zeylonicus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 338.

Mulloides zeylonicus BLEEKFR, Act. Soc. Sci. Ind. Neerl. 6 (1859) 8; Verh. Akad. Amsterdam 15 (1875) Révis. Mulloides, 16.

Dorsal VII–I, 8; anal I, 6; scales $2\frac{1}{2}$–36 + 3 or 4–$6\frac{1}{2}$.

Body somewhat slender, its greatest depth at base of spinous dorsal, 3.5 to 3.8 times in length, upper profile evenly arched; head notably longer than deep, 3.2 to 3.3 times in length of body; the very slightly convex interorbital space somewhat wide, its least width 3.1 to 3.4 times in head; the large eye a little nearer to posterior edge of opercle than to tip of snout, 3.7 to 3.9 times in head or 1.6 to 1.9 times in the rather short snout, which is slightly arched above and 2 to 2.2 times in length of head; maxillary very wide posteriorly, 2.7 to 2.8 times in head; the very wide preorbital forms a rather deep notch with the extremely narrow suborbital; jaws even, with thick and broad lips; teeth very small, in several series in each jaw; first gill arch with 8 + 23 or 24 gill rakers (7 + 18 according to Fowler and Bean), not longer than half eye, on first arch; the barbels touch the vertical limb of the smooth preopercle; only one spine at hind edge of opercle; least depth of caudal peduncle 2.7 to 3.2 times in head; scales finely and weakly ctenoid, none present on preorbital.

First dorsal spine highest, not much higher than second and contained 1.4 to 1.5 times in head; second dorsal equals anal in height, 1.8 to 2.3 times in head; ventral fin extends to vertical from axil of first dorsal and is as long as pectoral, which is 1.4 to 1.6 times in head; caudal is deeply forked and almost equals head in length.

An example from Puerto Galera was yellowish white in life, a little darker above; it had a lemon yellow longitudinal stripe from snout to caudal; the cheeks had some lemon yellow dots; dorsals and caudal lemon yellow, the other fins whitish overlaid with pink.

Another example, from Tablas Island, when fresh was pinkish yellow, with a bright lemon yellow longitudinal band from eye to base of caudal; head pinkish red above and yellowish pink below; pectoral very pale pink, all the other fins light orange yellow; the barbels were pinkish.

Alcoholic specimens are deep brown above, yellowish to yellowish brown on sides and abdomen; the yellow longitudinal band on each side of body quite conspicuous; the barbels and all the fins yellowish, unmarked.

Here described from eleven examples, 83 to 260 millimeters long, taken at Luna, La Union; Monja Island, Corregidor; Puerto Galera and Calapan, Mindoro; Tablas; Dicuayan Island, Busuanga; and Bungau and Banaran Islands, Sulu Archipelago.

Jordan and Seale had two specimens from the southern coast of Negros and Fowler and Bean had two from Zamboanga. This species was originally described from the Red Sea and occurs southward to Madagascar, Île de France, Ceylon, and the Adamans in the Indian Ocean. It occurs in the East Indies, particularly in the Moluccas, and is abundant throughout the tropical Pacific, from Guam and Hawaii to Samoa, the Austral Islands, Tahiti, and the Marquesas. It reaches a length of 300 millimeters and is an important food fish.

MULLOIDES SAMOENSIS Günther. Plate 3, fig. 4.

Mulloides samoensis GÜNTHER, Fische der Südsee 1 (1873) 57, pl. 43, fig. B; JENKINS, Bull. U. S. Fish Comm. 22 (1903) 453; SNYDER, Bull. U. S. Fish Comm. 22 (1903) 527; JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23[1] (1905) 253, fig. 105; SEALE, Occ. Papers Bishop Mus. 4 (1906) 47; EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 87; WEBER, Fische, Siboga Exp. (1913) 294.

The name in Pangasinan is *tubac;* in Tagalog, *tuyo.*

Dorsal VIII–I, 9; anal I, 7; scales $2\frac{1}{2}$–35 + 3–$6\frac{1}{2}$.

The greatest depth of the elongate slender body is at origin and anterior end of spinous dorsal, 4.1 to 4.6 times in length; head much longer than deep, 3.1 to 3.3 times in length, its upper profile evenly arched; interorbital space nearly flat, its least width 3.1 to 3.6 times in head; eye large, 3.7 to 4.5 times in head, located nearer posterior edge of opercle than tip of snout; snout bluntly pointed, steep above, 1.9 to 2.1 times in head or 1.8 to 2.2 times eye; maxillary 1.6 to 1.8 times in snout or 3.3 to 3.4 times in head, extending to a perpendicular halfway between anterior and posterior nostrils; mouth rather small, nearly horizontal, with lower jaw a little included; teeth in a villiform band in each jaw; first gill arch contains 7 or 8 + 18 to 20 short, rather stout gill rakers; barbels 1.5 to 1.7 times in head, reaching to vertical margin of smooth preopercle; opercle armed posteriorly with a single spine; least depth of caudal peduncle 3.1 to 3.4 times in head; scales large, finely ctenoid, completely covering head with the exception of the naked preorbital.

First dorsal spine highest, 1.4 to 1.7 times in head and slightly higher than second; soft dorsal and anal slightly concave, the latter a trifle lower, 2.5 to 2.6 times in head; pectoral and ventral equal in length, 1.4 to 1.7 times in head; the deeply forked caudal equal to or shorter than head, 3.3 to 3.6 times in length of body.

In life this fish is white below and gray-drab above; a bright yellow longitudinal stripe runs from eye to base of caudal; above this stripe is a narrower and less-distinct one and below it are two or three yellow longitudinal lines on each side of snout and two others on check; the pinkish red opercle edged posteriorly with yellow; dorsal whitish orange anteriorly; both soft dorsal and caudal yellow, the latter pinkish red at its base; the remaining fins whitish, with a slight wash of pinkish on their membranes; the pectoral has a reddish bar at its base; an obscure blackish blotch is oftentimes present immediately below the lateral line at about posterior third of pectoral.

Alcoholic specimens are uniformly yellowish white to yellowish brown; no trace is left of the yellow longitudinal stripes on sides; the blackish spot below spinous dorsal immediately under lateral line is present in many of the examples; all the fins are colored like the body.

Here described from fifty-four specimens, 70 to 253 millimeters in length, from the following localities:

Manila, 1.
Bacon, Sorsogon, 1.
Romblon, 1.
Borongan, Samar, 1.
Cebu, Cebu, 1.
Camiguin Island, Misamis, Mindanao, 2.
Samal Island and Davao, Mindanao, 3.
Caldera Bay and Zamboanga, Mindanao, 7.
Guam, 37.

Evermann and Seale recorded this species from San Fabian, Pangasinan, and Bacon, Sorsogon. It was originally described from Samoa where it is common, later from Hawaii where it is equally abundant. It has been collected at the Marquesas, Tahiti, the New Hebrides, and Salibabu, one of the Karkelong Islands, south of Mindanao. It is one of the larger goatfishes, reaching a length of a third of a meter.

MULLOIDES JAPONICUS (Houttuyn).

Mullus japonicus HOUTTUYN, Verh. Holl. Maat. Weet. Haarlem **20**[2] (1782) 334.

Upeneus japonicus CUVIER and VALENCIENNES, Hist. Nat. Poiss. **3** (1829) 339.

Mulloides japonicus GÜNTHER, Cat. Fishes **1** (1859) 404; SNYDER, Proc. U. S. Nat. Mus. **32** (1907) 96; EVERMANN and SEALE, Bull. Bur. Fisheries **26** (1907) 88; JORDAN and HUBBS, Mem. Carnegie Mus. **10** (1925) 246.

Dorsal VIII or VII–I, 8; anal I, 6; scales 3–37–5.

Depth 3.85 to 4.4, head 3.5 times in length; eye 3.5 times in head, slightly nearer tip of snout than margin of opercle; interorbital space not strongly convex, its width equal to eye; the pointed snout 2.6 times in head, the jaws equal; about two-thirds of upper margin of maxillary concealed by preorbital, its evenly rounded posterior end not quite reaching a vertical through anterior margin of orbit, its length 3.33 times in head; the minute teeth in two or three rows in upper jaw, in a narrow band in lower jaw; the barbels extend to posterior margin of preopercle; angle of opercle has a small flat spine, preopercle entire; head, including snout, maxillary, and chin, covered with scales; dorsal spines very slender, the first longest, 1.5 times in head, apparently not preceded by a minute embedded spine; soft dorsal and anal of equal height, the longest ray 2.2 times in head; lobes of caudal acutely pointed, about equal to length of head; ventrals slightly longer than pectoral, 1.4 times in head; tubes of lateral line with three or four branches; pseudobranchiæ large; gill rakers 7 + 23, long and slender; peritoneum dusky.

Color in alcohol brownish above, silvery below. The above description is taken from Snyder, as we have seen no specimen. Evermann and Seale had four specimens, "4.75 inches in length," from Bulan, Sorsogon. Otherwise it has only been recorded from Japan, and is not abundant there.

Evermann and Seale state "3 or 4 dusky oblique bands on caudal, almost obliterated on lower lobe, an indistinct dusky line on side from head to caudal." Their specimens were compared with authentic specimens from Japan.

Jordan and Hubbs state that in all their material, obtained at Kagoshima, the dorsal spines are seven, not eight as found by Snyder in his two specimens from Misaki. They report an additional minute spine in front of these as sometimes present but often absent. They give the color as "bright yellow, becoming pink along the middle of the sides, above the large blackish opercular blotch, along the anterior free margin of the subopercle (which otherwise, like the interopercle, is silvery) and on the postorbital region."

MULLOIDES VANICOLENSIS (Cuvier and Valenciennes). Plate 1, fig. 3.

Upeneus vanicolensis CUVIER and VALENCIENNES, Hist. Nat. Poiss. 7 (1831) 391; SMITH and SWAIN, Proc. U. S. Nat. Mus. 5 (1882) 131.

Mulloides vanicolensis BLEEKER, Nat. Tijds. Ned. Ind. 4 (1853) 601; GÜNTHER, Cat. Fishes 1 (1859) 404; BLEEKER, Natuurk. Vehr. Kon. Akad. Amsterdam 15 (1875) Révis. Mulloides 14; Atlas Ichth. 9 (1878) pl. 392, fig. 6; JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23[1] (1903) (1905) 254; WEBER, Fische, Siboga Exp. (1913) 294.

Dorsal VIII–I, 8; anal I, 6; scales $2\frac{1}{2}$–37 + 3–$6\frac{1}{2}$.

Body slender, deepest at base and origin of spinous dorsal, its depth 3.6 to 3.9 times in length; dorsal outline gently and evenly curved from snout to second dorsal and not much more elevated than ventral contour; head much longer than deep, 3.3 to 3.4 times in length of body; interorbital space moderately convex, about as wide as the large eye, which is 3.2 to 3.4 times in head and located a little nearer to posterior margin of opercular bone than to tip of snout; the short, bluntish snout 1.3 to 1.5 times eye or 2.2 to 2.5 times in head; maxillary very broad posteriorly, 2.8 to 3 times in head, extending to below anterior rim of orbit; the small mouth slightly oblique, with nearly even jaws; teeth in both jaws in villiform bands; 8 + 22 to 24 gill rakers on first arch, the longest less than half eye; the slender barbels 1.4 to 1.5 times in head, extending to vertical edge of the smooth preopercle; opercle armed at its hind border with a single spine; caudal peduncle tapers posteriorly, its least depth 2.7 to 2.8 times in head; scales moderate in size, ctenoid, absent on preorbital.

First dorsal rather high, 1.4 times in head, its first spine minute, second higher than the rest; second dorsal and anal a little concave above, equal in height, 2 to 2.1 times in head, their first rays higher than the others; ventral ends below axil of spinous dorsal and is a little longer than pectoral, which is 1.4 to 1.5 times in head; caudal fin is deeply forked and equals head in length.

Ground color in alcohol yellowish; top of head and upper portions of its sides deep brown; all the fins yellowish, the caudal with brownish tips.

Here described from three specimens, 106 to 183 millimeters in length, from Zamboanga, Mindanao, and Tambagaan Island, Sulu Archipelago. The only other Philippine record is that by Evermann and Seale, who had two specimens from Zamboanga.

This species does not have a golden longitudinal band on each side of the body, thus differentiating it from *Mulloides auriflamma* (Forskål) which it otherwise resembles very closely. It reaches a length of 250 millimeters.

This seems to be a rather rare mullet. Cuvier and Valenciennes described it from material collected by Quoy and Gaimard at Vanicolo, one of the Santa Cruz Islands; Smith and Swain had it from Johnson Island, an outlying dependency of the Hawaiian Islands, far to the southwest of Honolulu. In the east Indies it has been found in but few localities, all in the Moluccas and northward to Mindanao, and the Sulu Archipelago.

SUMMARY OF THE PHILIPPINE GOATFISHES, OR MULLIDÆ, DESCRIBED IN THIS PAPER

1. Genus UPENEOIDES Bleeker

1. **luzonius** (Jordan and Seale).
2. **sundaicus** Bleeker.
3. **tragula** (Richardson).
4. **moluccensis** Bleeker.
5. **sulphureus** (Cuvier and Valenciennes).
6. **vittatus** (Forskål).

2. Genus UPENEUS Cuvier

7. **barberinus** (Lacépède).
8. **dispilurus** Playfair.
9. **luteus** Cuvier and Valenciennes.
10. **indicus** (Shaw).
11. **spilurus** Bleeker.
12. **bifasciatus** (Lacépède).
13. **barberinoides** Bleeker.
14. **pleurostigma** Bennett.
15. **cyclostomus** (Lacépède).
16. **moana** (Jordan and Seale).
17. **chryserydros** (Lacépède).
18. **pleurospilos** Bleeker.

3. Genus MULLOIDES Bleeker

19. **auriflamma** (Forskål).
20. **samoensis** Günther.
21. **japonicus** (Houttuyn).
22. **vanicolensis** (Cuvier and Valenciennes).

ILLUSTRATIONS

PLATE 1

FIG. 1. *Upeneoides luzonius* (Jordan and Seale). (Drawing by Pablo Bravo.)
2. *Upeneus pleurospilos* (Bleeker). (Drawing by Pablo Bravo.)
3. *Mulloides vanicolensis* (Cuvier and Valenciennes). (Drawing by A. L. Canlas.)

PLATE 2

FIG. 1. *Upeneus indicus* (Shaw). (Drawing by A. L. Canlas.)
2. *Upeneoides tragula* (Richardson). (Drawing by A. L. Canlas.)
3. *Mulloides auriflamma* (Forskål). (Drawing by Pablo Bravo.)

PLATE 3

FIG. 1. *Upeneoides sulphureus* (Cuvier and Valenciennes). (Drawing by Pablo Bravo.)
2. *Upeneus dispilurus* Playfair. (Drawing by A. L. Canlas.)
3. *Upeneus barberinus* (Lacépède). (Drawing by Pablo Bravo.)
4. *Mulloides samoensis* Günther. (Drawing by A. L. Canlas.)

PLATE 4

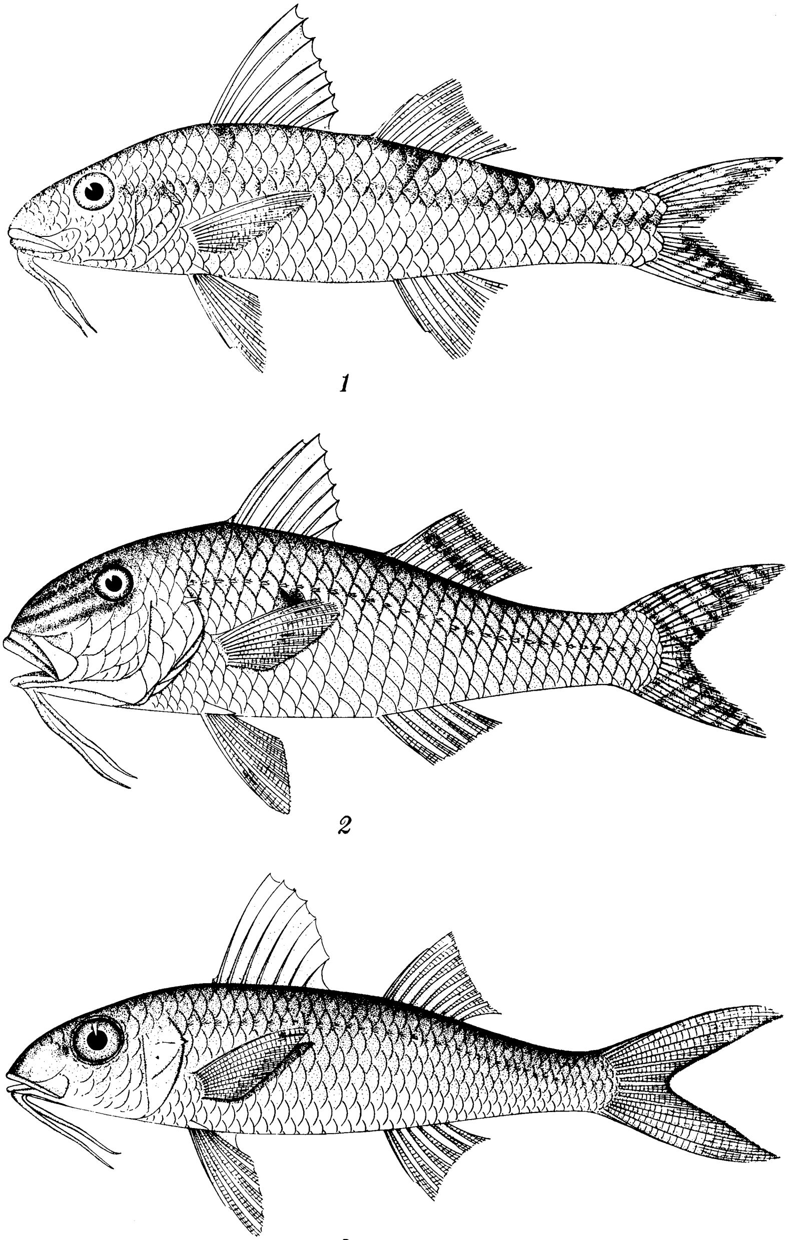
FIG. 1. *Upeneoides vittatus* (Forskål). (Drawing by Pablo Bravo.)
2. *Upeneus moana* (Jordan and Seale). (Drawing by Pablo Bravo.)
3. *Upeneus barberinoides* Bleeker. (Drawing by A. L. Canlas.)

PLATE 5

FIG. 1. *Upeneus luteus* Cuvier and Valenciennes. (Drawing by Pablo Bravo.)
2. *Upeneus pleurostigma* Bennett. (Drawing by Pablo Bravo.)
3. *Upeneus chryserydros* (Lacépède). (Drawing by A. L. Canlas.)

PLATE 6

FIG. 1. *Upeneoides moluccensis* Bleeker. (Drawing by A. L. Canlas.)
2. *Upeneus bifasciatus* (Lacépède). (Drawing by Pablo Bravo.)
3. *Upeneus cyclostomus* (Lacépède). (Drawing by Pablo Bravo.)

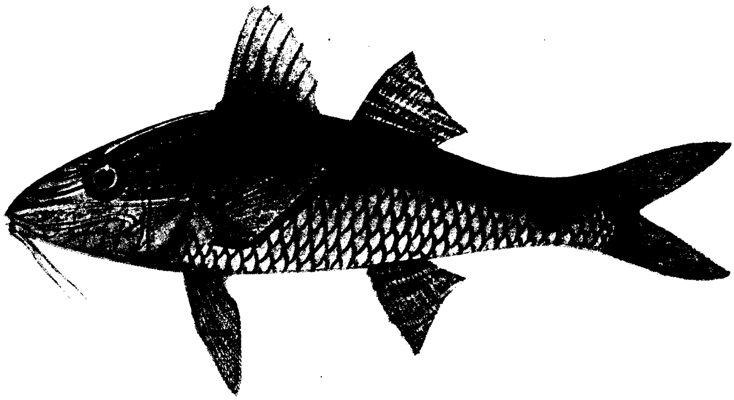


1

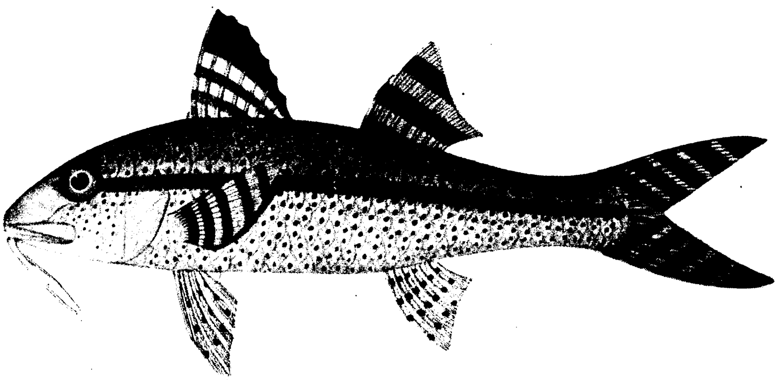
2

3

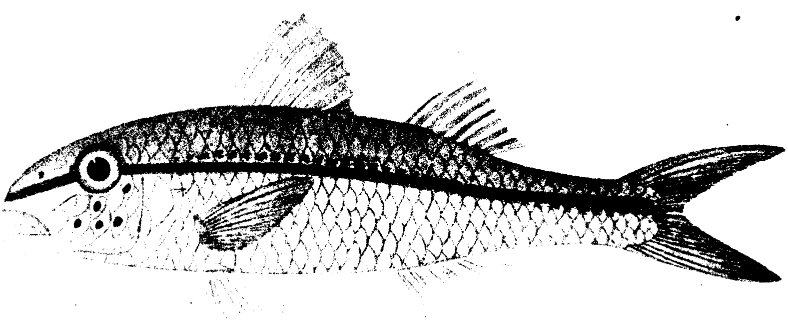
PLATE 1.



1



2



3

PLATE 2.

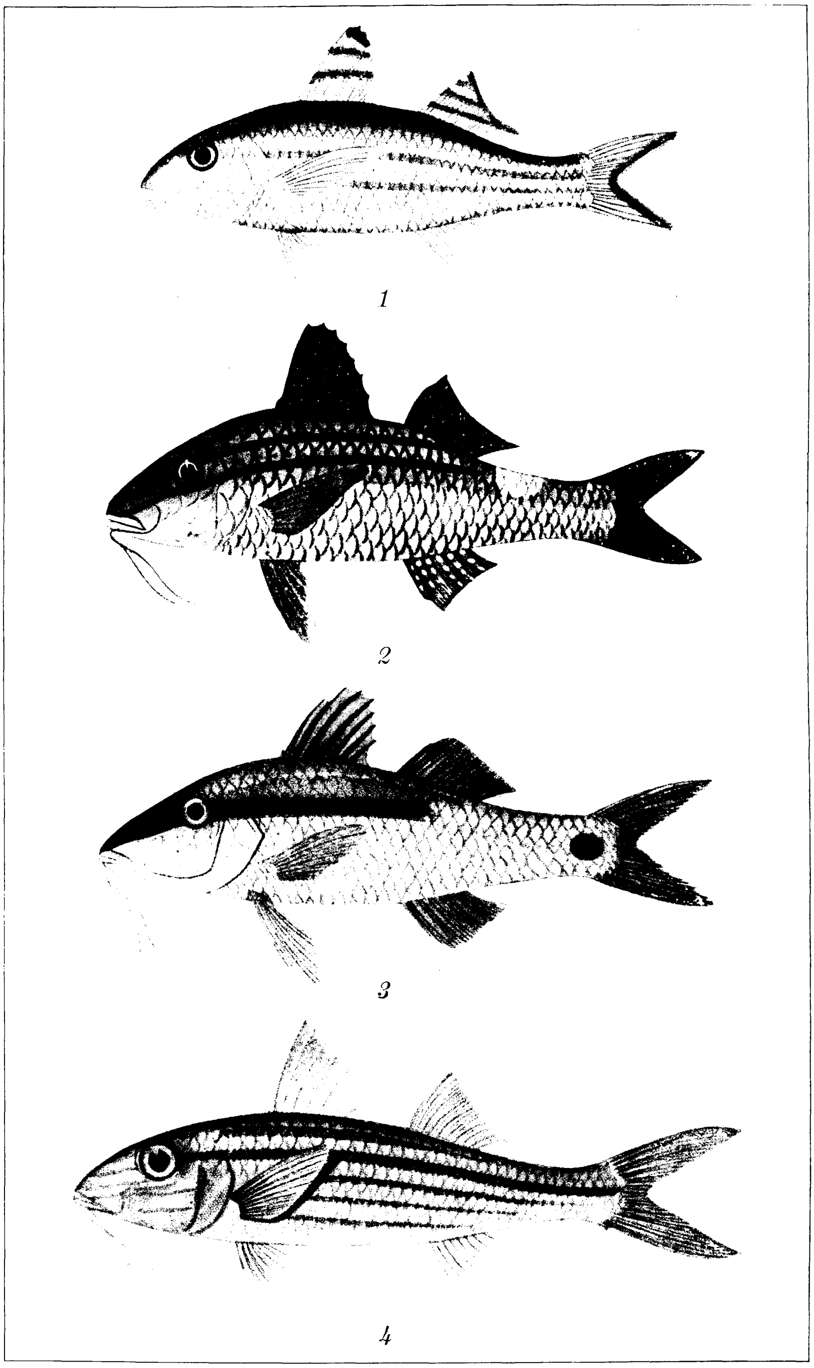
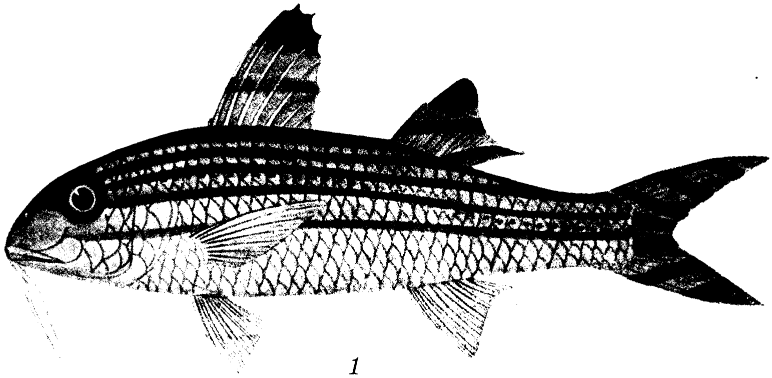
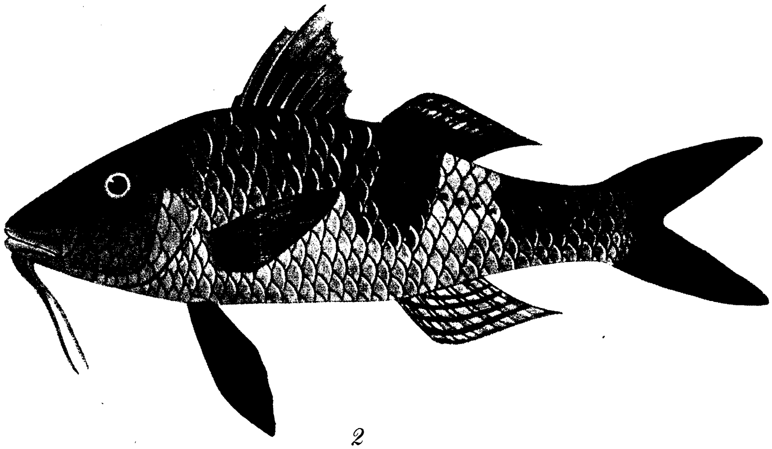


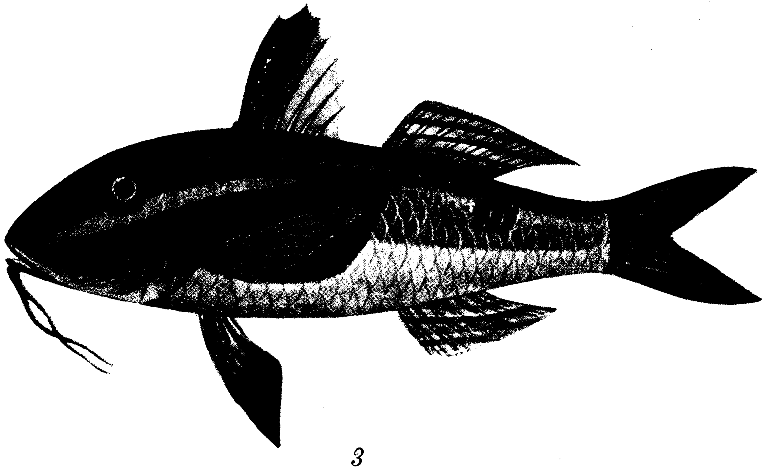
PLATE 3.



1

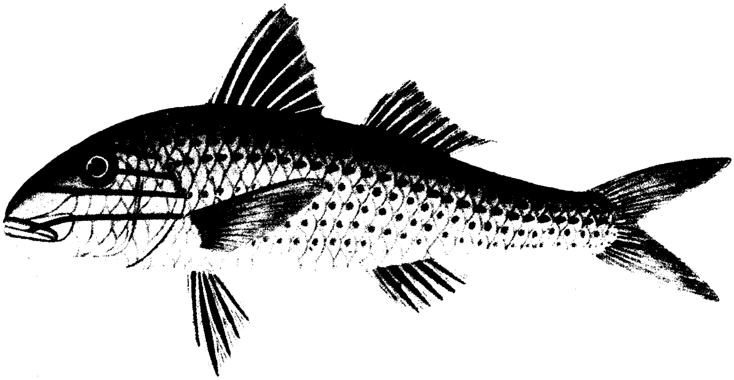


2

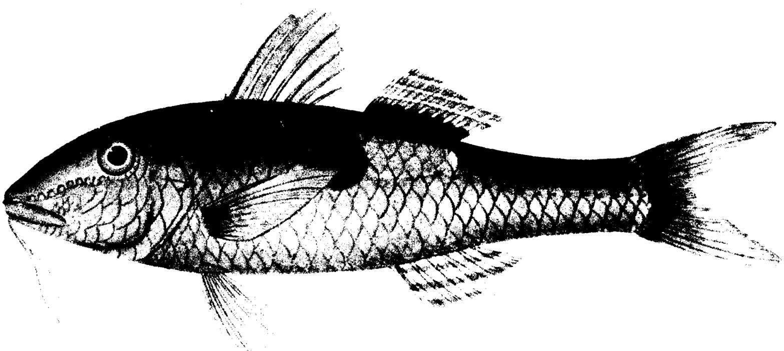


3

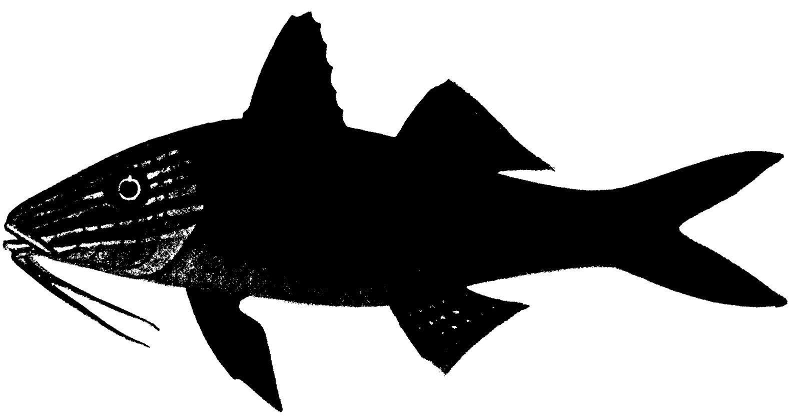
PLATE 4.



1



2



3

PLATE 5.

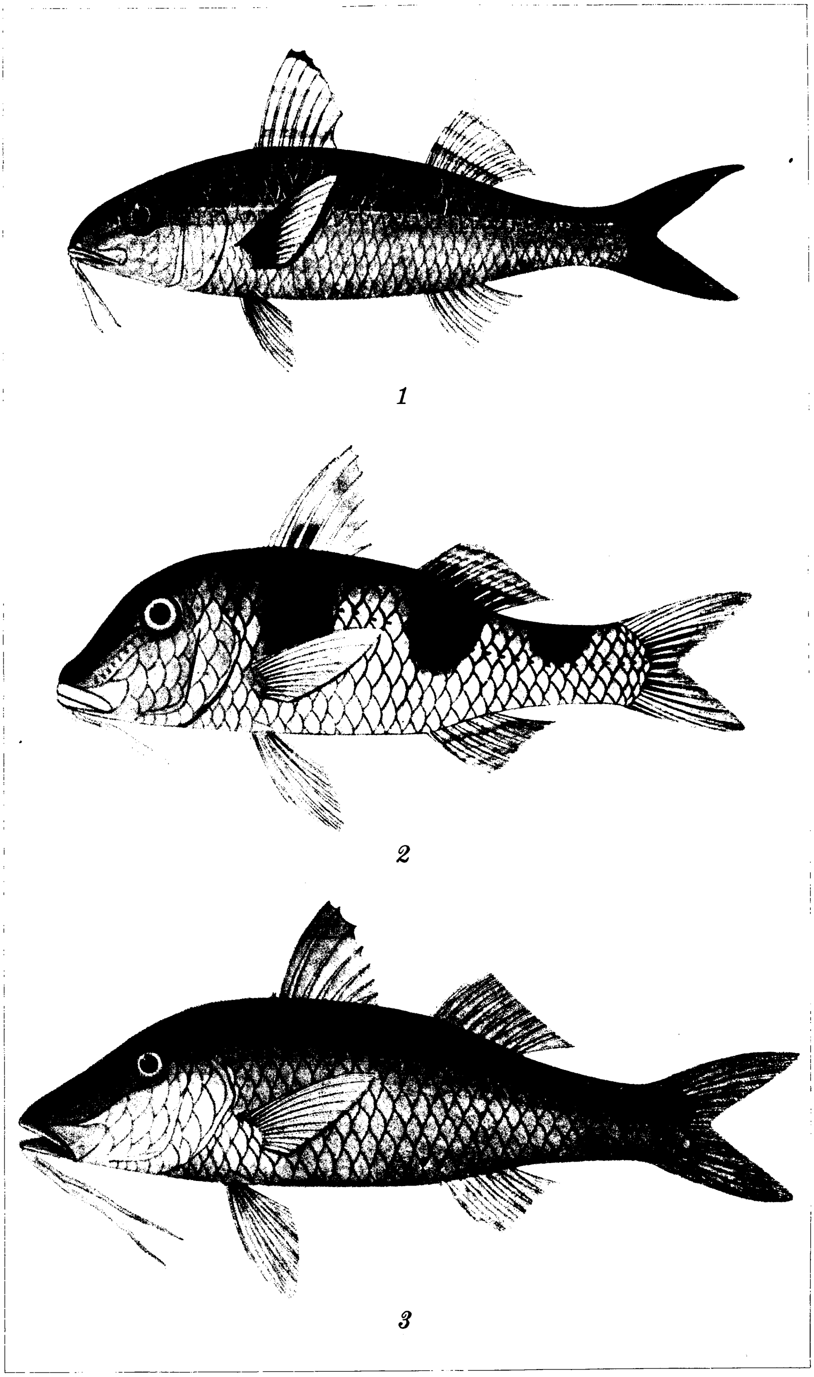


PLATE 6.

CONTENTS

The Philippine Journal of Science is issued twelve times a year. The sections were discontinued with the completion of Volume XIII (1918).

Yearly subscription, beginning with Volume XIV, 5 dollars United States currency. Single numbers, 50 cents each.

Publications sent in exchange for the Philippine Journal of Science should be addressed: Library, Bureau of Science, Manila, P. I.

Subscriptions may be sent to the BUSINESS MANAGER, Philippine Journal of Science, Bureau of Science, Manila, P. I., or to any of the agents listed on the third page of this cover.

Entered at the post office at Manila, P. I., as second-class matter.

THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 36 JUNE, 1928 No. 2

THE LIME INDUSTRY OF THE PHILIPPINE ISLANDS

By F. D. REYES

Chemist, Bureau of Science, Manila

TWO PLATES

The calcination of limestone and oyster and other marine shells for the production of lime has been practiced in the Philippines from time immemorial. The old adobe-stone wall surrounding the Walled City, which was built by the Spaniards over three centuries ago, was constructed with lime mortar. Adobe-stone buildings in the Walled City, some of them over a century old, were likewise laid in common lime mortar.

Two methods are used in burning the calcareous materials. One method consists of erecting a bundle of dried bamboo, about 30 centimeters in diameter and from 2 to 2.5 meters in height, in the center of an area of level ground. Wood fuel, 20 centimeters in diameter or less and about 1 meter long, is piled in circular form around the bamboo bundle as a center to a thickness of about 30 to 60 centimeters. A layer of calcareous material from 15 to 30 centimeters in thickness, depending upon the class of material to be burned, is uniformly spread over the pile of wood. Another layer of wood 30 centimeters thick is next put over the calcareous material, and so on, wood and calcareous material alternating until the end of the bamboo bundle is reached. The diameter of the pile is gradually decreased toward the top, so that the pile resembles a beehive. Provision is made for air channels radiating from the center to the circumference of the pile, to supply the necessary air for combustion. When everything is ready the fire is started by kindling the bundle of dried bamboo. When the bamboo is consumed the space it formerly occupied serves as a chimney.

The pile is allowed to burn until all the wood is consumed, which generally takes from two to three days. An attendant is always at hand to take care of the fire. When the burning is completed the pile is allowed to cool and, while still warm, the lime is slaked by pouring water into the several holes made through the mass of lime and afterward closing the openings. The surface of the pile is from time to time tamped with a shovel to prevent too rapid loss of steam. The amount of water added is just sufficient to pulverize the lime but not completely to hydrate it. The result is a dry white powder which, after sieving to remove pieces of charcoal and large lumps, is ready for use or for the market.

The other method, which is used only when burning limestone or coral rock, consists of first piling the larger pieces of stone to a beehive shape. The outer surface is filled with the smaller pieces of the rock. At one side of the base a hollow arc or dome reaching nearly to the center of the pile is provided which serves as a fireplace. The pile is then continuously fired, using wood as fuel. When the stones are considered to be sufficiently calcined, which usually takes from three to six days, depending upon the size of the pile, the firing is stopped and the lime later slaked in the usual way. It will be seen that in the first method the lime is mixed with the fuel ash, while in the second the lime is not contaminated to any great extent with the fuel ash. To be sure, a considerable portion of limestone is underburned; but, because the lime is slaked, any cores of unburned limestone are retained by the sieve. It will be readily appreciated that the fuel consumption in the two methods described must necessarily be excessive. On the other hand, the kilm can be put up at any convenient place and requires the minimum amount of capital. In small communities where lime is used only for local consumption it is still made by these primitive methods.

The excessive amount of fuel consumed in lime burning and the increasing cost of fuel led to the introduction of intermittent egg-shaped kilns in Guimaras Island and later in Baguio and elsewhere. Some kilns are 3.5 meters in largest diameter and 7.5 to 9 meters high. The kiln is generally located on the side of a hill to facilitate loading, and usually lined with common red brick, sandstone blocks, or adobe stone. In charging the kiln the largest pieces, seldom exceeding 30 centimeters in diameter, are arranged in the bottom of the kiln, forming an arc which serves as a fireplace. Instead of having an arc for a fireplace some kilns are constructed with grates made of blocks of sandstone to support the column of limestone. The wood is burned under the sandstone grate. The kiln is charged with stone of gradually decreasing size until completely filled. The burning is conducted in the same manner as in the native method until the burners consider the stone sufficiently calcined. The kiln is then allowed to cool and the lime raked out and subsequently slaked. This method is undoubtedly more economical of fuel than the native method of burning in the open air and results in considerably fewer underburned stones. However, the intermittent nature of the operation requires that the kiln be cooled to allow recharging. The reheating and cooling of the kiln cause considerable loss of heat and consequently entail greater fuel consumption than the continuous kiln. In Baguio about 3 cubic meters of pine wood are required to produce 1 ton of lime.

Another method of lime burning, introduced by the Chinese and used at the present time, consists of a circular kiln (Plate 1) 3 to 4 meters in diameter and about 1.5 meters high. It is made entirely of adobe-stone blocks. From a point on the side of the bottom of the kiln radiate several air channels which serve to supply the air necessary for combustion. A circular wooden fan, operated either by man power or by an electric motor, forces the air into the air channels in the bottom of the kiln. Various fuels are used; such as, spent tanbark, rice husks, and coke breeze. The calcareous material used is generally oyster or other marine shells, although hard limestone in small pieces has occasionally been used. To charge the kiln, the air channels are filled first with wood shavings loosely covered with blocks of adobe stone in order to allow the passage of air. If coke dust is used as fuel, a layer 5 to 8 centimeters thick of rice husks is first spread over the bottom of the kiln, followed by a layer of coke dust. It is said that the object of using rice husks is to start the fire uniformly over the entire bottom of the kiln. A layer of marine or oyster shells is spread uniformly over the coke dust and so on, fuel and shells alternating in the ratio of one volume of coke dust to every four to five volumes of shells, until the kiln is full. Some operators mix the fuel and the shells in small batches and charge the mixture into the kiln over the first layer of coke dust until the kiln is completely filled.

To start the kiln the wood shavings near the fan are set afire and then the fan is started. The blast of air gradually drives the flame farther and farther into the air channels, thereby kindling the rice husks immediately above. Three men are required to operate the kiln. Two operate the fan, and one extra man replaces those turning the fan with their feet whenever one of them feels tired. He also looks after the burning operations, particularly to prevent the formation of fire holes, by filling the openings with shell or with a mixture of shell and fuel. After ten to fourteen hours of continuous burning, the process is completed and the kiln is allowed to cool overnight. The calcined shell is generally sieved through a half-inch mesh. The portion passing through the sieve contains most of the impurities, consisting of burnt mud or fine particles of earth, originally adhering to the shells and ash from the fuel used. This impure product is slaked and finds a good market for making common lime mortar. The portion retained on the sieve is separately slaked. It is relatively pure and therefore commands a higher price in the market. It is used to some extent in sugar manufacture, for making lime-oil (lumbang) paste, used extensively in wooden-boat construction, and as a depilating agent in leather manufacture. The following data were collected in an investigation of one of these kilns located on the banks of Estero de Vitas in Tondo, Manila, during October, 1927.

CALCAREOUS MATERIAL

The raw material used is a variety of sea shells obtained from the fishery beds in Bulacan and Pampanga Provinces. A smaller quantity is obtained from the shallow water of Manila Bay along the shores of those two provinces. The shells are loaded into river boats and sent direct to the kilns. The shells as delivered are wet and contain considerable quantities of adhering mud. No effort is made at the kiln to clean them before calcination on account of the expense involved. The shell costs from 50 to 55 centavos per cavan of 75 liters delivered at the kiln site and weighs 77.25 kilograms. One cubic meter, therefore, weighs 1,030 kilograms and costs from 6.66 to 7.33 pesos,[1] or from 6.47 to 7.12 pesos per ton.

FUEL

The fuel generally used is coke dust, obtained from the Manila Gas Corporation as a by-product in the manufacture of coal gas. The coke costs 11.50 pesos per ton, delivered at the kiln

[1] One peso Philippine currency equals 50 cents United States currency.

site. A few bags of wood shavings and rice husks are also used in order to start the calcination process properly. The coke pile is in the open air and frequently becomes wet on account of the rain. When dry the heat value is from 5,500 to 6,000 calories and from 16 to 17 per cent ash. The cost of manufacturing lime from marine shells, using coke dust as fuel, is as shown in Table 1.

TABLE 1.—*Cost of manufacturing lime from shells, Chinese process.*

Materials:		Pesos.
110 cavanes (8.5 tons) of shells, at 0.55 peso per cavan		60.50
1.23 tons of coke dust, at 11.50 pesos per ton		14.00
Rice husks and wood shavings		1.50
Total cost of materials		76.00
Labor:	Pesos.	
Three men for loading the kiln one day, at 2 pesos	6.00	
Three men for burning the charge one day, at 2 pesos	6.00	
Three men for unloading the charge and slaking the lime one day, at 2 pesos	6.00	
Total cost of labor		18.00
Total cost of slaked lime		94.00
Total slaked lime produced, cavanes		170.00
Cost of slaked lime per cavan (75 liters), peso		0.55
Lime per kilogram of fuel, kilograms		4.20
Weight of unslaked lime per cavan, kilograms		45.25
Weight of slaked lime per cavan, kilograms		42.00

It will be observed that the cost of 0.55 peso per cavan of slaked lime does not include interest and depreciation on the investment. The capital required to operate a kiln of this capacity in the City of Manila is approximately as follows:

	Pesos.
Land	2,000
Building	1,500
Adobe-stone kiln and fan	1,000
Working capital	1,000
Total investment	5,500

Assuming ninety burnings per year, of 170 cavanes of slaked lime each, there would be a total production of 15,300 cavanes. Interest on 5,500 pesos at 10 per cent per year would amount to 0.036 peso per cavan. Repairs and depreciation, 2,500 pesos at 10 per cent per year would be 0.016 peso per cavan, making a total fixed charge of 0.05 peso per cavan. The total cost of manufacturing slaked lime from marine shells is therefore about 0.60 peso per cavan.

In Malabon and Navotas, Rizal Province, and in Meycauayan, Bulacan Province, spent tanbark is used in burning lime. It is considered as a waste product from the tanneries and is given away free to lime burners. In spite of the fact that spent tanbark can be delivered to the kiln for about 1 peso per cubic meter, the total costs of production is not very much less than when coke dust is used. This is due to the fact that spent tanbark occupies a large space and the kiln production is about one-third less than when coke dust is used.

As would be expected, the purity of the quicklime is very low, due to the adhering mud in the raw material and to the ash of coke dust used and also to incomplete calcination. The average quicklime content is about 70 per cent (see Table 2). The fuel-lime ratio on the basis of 95 per cent lime would be 3.1 kilograms of lime per kilogram of fuel, instead of 4.2 as given in Table 1.

Table 2 shows the analyses of the raw material and of the lime and the slaked lime produced.

TABLE 2.—*Analyses of marine shells and resulting lime.*

Constituent.	Shells as usually delivered.		Shells considered dirty.			
	Unburned shell.	Common slaked lime produced.	Unburned shell.	Unslaked lime produced.	Extra-quality slaked lime produced.	Common slaked lime produced.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Loss on ignition	41.20	27.48	40.58	9.44	29.52	25.02
Silica (SiO_2)	6.40	11.21	7.74	7.50	4.48	16.93
Aluminum and iron oxides (R_2O_3)	1.20	2.68	1.74	2.88	1.08	3.34
Calcium oxide (CaO)	50.44	56.51	48.86	79.34	63.38	52.76
Magnesia (MgO)	0.38	0.60	0.46	0.65	0.50	0.49
Carbon dioxide (Co_2)	--------	7.11	--------	7.84	4.64	7.10
Approximate composition:						
Moisture	1.3	4.8	1.6	--------	6.2	3.8
Sand and siliceous material	6.4	11.2	7.7	7.5	4.5	16.9
Iron oxide and alumina (Fe_2O_3-Al_2O_3)	1.2	2.7	1.7	2.9	1.1	3.3
Calcium carbonate ($CaCO_3$)	89.9	16.1	87.4	17.8	10.5	16.2
Magnesium carbonate ($MgCO_3$)	0.8	--------	0.9	--------	--------	--------
Calcium oxide	--------	--------	--------	64.6	--------	--------
Calcium hydroxide	--------	62.7	--------	6.5	76.0	57.6

It will be seen from the table that the unslaked lime contains only about 70 per cent of actual lime and 30 per cent of impurities. The slaked lime of "extra quality," which was obtained by slaking that portion of the quicklime retained on a half-inch mesh, contained 76 per cent of hydrated lime; while the portion that passed through the sieve, which contained most of the impurities, the resulting hydrated lime was only 57 per cent. However, if limestone of good quality were used and the resulting lime were passed through a sieve so as to remove most of the fuel ash, the lime remaining on the sieve would undoubtedly be suitable for chemical purposes.

CONTINUOUS LIME KILNS

In 1913, the establishment of modern sugar centrals may be said to have started in the Philippines. They required a high grade of lime which could not be satisfactorily furnished by the lime kilns then in operation. Lime was, therefore, imported from America, Japan, and China. In 1914, I constructed a small, vertical, continuous kiln from a design made in the Bureau of Science to supply the necessary lime required by the two sugar centrals, one at Calatagan and the other in Look, Batangas Province.

The raw material used was coral rock obtained from the shore of Balayan Bay, and the fuel was mountain wood. The kiln had an internal diameter of 75 centimeters and a total height of 5 meters, and had two fireplaces. The capacity of the kiln was from 0.75 to 1 ton of lime per day. The kiln has given entire satisfaction, and I understand that it is still being used.

During the World War a considerable number of sugar centrals were erected in the Philippines, particularly in Negros. Large quantities of lime were imported from abroad to supply the high-quality lime demanded by the sugar centrals.

To study the commercial feasibility of manufacturing a high-quality lime from Philippine materials, the Bureau of Science made practical burning tests of limestone obtained from several available deposits. In 1915 Thurlow,[2] using a vertical continuous kiln with a sirocco suction fan, demonstrated that lime of superior quality could be obtained from this type of kiln.

In 1917, a new kiln was constructed in the Bureau of Science, embodying certain improvements which previous experience had shown to be desirable. A sketch of the kiln is given in Plate 2.

[2] Philip. Journ. Sci. § A 11 (1916) 129.

In this kiln only the flame comes in contact with the limestone, so that the lime does not become contaminated with ash from the fuel.

The analyses of limestone and fuel used in the burning tests made in 1918 by the division of general, inorganic, and physical chemistry, of the Bureau of Science, are given in Table 3.

TABLE 3.—*Chemical analyses of limestones used in tests.*

Constituent.	Palsanbañgan, Tayabas.	Montalban, Rizal.	Binañgonan, Rizal.	Cebu.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*
Loss by ignition	43.48	43.98	43.70	42.36
Silica (SiO_2)	0.69	0.26	0.61	2.62
Alumina iron oxide (R_2O_3)	0.35	0.09	0.52	1.08
Calcium oxide (CaO)	54.68	54.97	53.98	53.28
Magnesia (MgO)	0.48	0.62	1.12	0.50

The computed composition of the quicklimes obtainable from the above limestones, assuming complete calcination, are given in Table 4.

TABLE 4.—*Computed composition of quicklimes.*

Constituent.	Palsanbañgan, Tayabas.	Montalban, Rizal.	Binañgonan, Rizal.	Cebu.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*
Silica (SiO_2)	1.2	0.4	1.0	4.5
Alumina iron oxide (R_2O_3)	0.6	0.2	0.9	1.8
Calcium oxide (CaO)	97.2	98.0	95.7	92.5
Magnesia (MgO)	0.8	1.1	1.9	0.8

Geerlings[3] gives the maximum impurities allowable in lime for use in sugar manufacture as follows:

	Per cent.
Silica (SiO_2)	2
Iron and aluminum oxides (Fe_2O_3 and Al_2O_3)	2
Magnesia (MgO)	2
Carbon dioxide (CO_2)	2
Sulphuric anhydride (SO_3)	0.5

It will be seen from the analyses of the limestones used that, with the exception of one from Cebu, all are sufficiently pure

[3] Geerlings, H. C. Prinsen, Cane Sugar and Its Manufacture, 2d ed.

so that, if properly calcined, the resulting lime would be well within the above requirements.

The Palsanbañgan deposit in Tayabas Province is a continuation of the limestone deposit at Binañgonan and Montalban in Rizal Province. They are hard crystalline limestones, sufficiently pure to produce lime of high purity. The southern line of the Manila railroad to Hondagua passes near the Palsanbañgan deposit. The lime produced in that district is shipped by rail to Manila.

The Binañgonan deposit is located about 5 kilometers from the town of Binañgonan. Limestone is carried by carabao carts to the town to be calcined. The Rizal Cement Factory, located near the shore of Laguna de Bay near the town of Binañgonan, obtained the limestone from the same deposit by means of an aërial cable about 5 kilometers long.

The Montalban limestone deposit is about 29 kilometers from Manila and can be reached by automobile over a first-class road. It is located on both banks of the Marikina River at Montalban, just below the dam of the Metropolitan Water District. The limestone is of a lighter color than that found in Binañgonan or Palsanbañgan and, unlike them, has the property of cracking when subject to the action of heat. This property allows the heat to penetrate the stone more quickly, and for this reason it is easier to calcine.

The Cebu limestone is coralline in nature, and analysis shows that it has less purity than have those already described.

Various fuels have been used in the tests to determine their relative efficiency. The analyses and the costs of the various fuels used are given in Tables 5 and 6. The results of the burning tests are given in Table 7.

TABLE 5.—*Analyses of various fuels.*

	Coconut shell.	Coconut husk.		Fushun coal.	Mangrove wood (rajas).
		Green.	Air dried.		
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Moisture (105° C.)	9.20	64.82	6.92	7.51	34.87
Combustible matter	73.45	25.25	66.80	41.91	
Fixed carbon	15.72	18.68	22.97	42.99	
Ash	1.63	1.25	3.31	7.58	1.14
Sulphur (separately determined)		0.07	0.19	0.64	
Total calorific value	4,418	1,674	4,430	6,657	3,254

TABLE 6.—*Cost of fuel in Manila.*

Kind of fuel.	Per ton delivered.	Per 1,000 pieces.	Per cubic meter.
	Pesos.	*Pesos.*	*Pesos.*
Fushun coal	20.00		
Coke dust	11.50		
Coconut shell and husk	12.00		
Mangrove wood (green); diameter, 7 to 15 centimeters	15.20	85.00	8.20
Mountain wood, large size; diameter, 10 to 20 centimeters			7.00
Mountain wood, mixed sizes			4.00

TABLE 7.—*Results of burning tests made in the Bureau of Science.*

Number of days run.	Fuel used.		Limestone.		Lime produced.	Underburned lime drawn.
	Kind.	Quantity.	Source.	Quantity.		
		Kg.		*Kg.*	*Kg.*	*Kg.*
11⅓	Fushun coal	7,047	Palsanbañgan, Tayabas	28,770	16,086	1,510
2	Mangrove wood	2,881	do	7,009	3,764	352
1	Coconut shell	1,477	do	3,400	1,732	
4⅓	Fushun coal	2,574	Montalban, Rizal	13,311	7,164	1,044
2	do	897	Binangonan, Rizal		2,136	
1	do	640	Cebu	3,370	1,670	245

Number of days run.	Fuel used.		Lime per 100 of limestone.	Lime per kilogram of fuel.	Lime produced per day of twenty-four hours.	Refuse from fuel.	
	Kind.	Quantity.				Weight.	Refuse per 100 of fuel.
		Kg.	*Kg.*	*Kg.*	*Kg.*		
11⅓	Fushun coal	7,047	55.8	2.27	1,415	1,628	23.1
2	Mangrove wood	2,881	53.7	1.31	1,882	113	3.6
1	Coconut shell	1,477	51.0	1.17	1,732	98	6.6
4⅓	Fushun coal	2,574	53.8	2.78	1,650	385	15.0
2	do	897		2.38	1,068	182	18.4
1	do	640	49.5	2.60	1,670	112	17.5

The pieces of limestone used in the burning tests varied from 8 to 15 centimeters in diameter. Natural draft was used. It was found that with this size of charge there was no necessity of having any chimney over the kiln, as the draft was sufficient after the kiln was thoroughly heated.

It will be noted from Table 7 that the refuse obtained from Fushun coal when Palsanbañgan stone was burned amounted to 23.1 per cent of the coal used, showing that a considerable amount of fuel was lost in the form of unburned carbon in the coal ash. This was due to the inexperience of the men handling the fire and explains the low ratio of lime to fuel obtained. The best ratio was obtained with Montalban limestone in which 2.78 kilograms of lime were obtained per kilogram of Fushun coal. It has already been pointed out elsewhere that Montalban limestone cracks under the action of heat, although the stone is not actually split apart. The good lime-fuel ratio obtained in all probability is due to that property.

It is apparent from Table 7 that the kiln capacity is considerably increased when wood or coconut husk is the fuel used. Both fuels produce a long flame which raises the temperature of the stone to its decomposition temperature farther up the kiln than when the fuel gives a shorter flame. It was also observed that partially dried wood gave better results than did well-dried wood, perhaps due to the large quantity of water vapor produced by the combustion of partially dried wood by reducing the gaseous pressure in the kiln.

Three men per shift are required to operate the kiln, provided the fuel and the limestone are within reasonable distance from the kiln. Their work includes charging and firing the kiln and drawing and packing the lime produced. If we assume that the limestone of the required size delivered in Manila costs 10 pesos per cubic meter (about 1,300 kilograms) and that the capacity of the kiln is 1,500 kilograms per day when coal is used as fuel and 1,800 kilograms when wood is used, the relative costs of manufacturing a ton of lime in a vertical continuous kiln would be approximately as shown in Table 8.

TABLE 8.—*Cost of manufacturing one ton of lime, using various fuels.*

Fuel used.	Fushun coal.	Mangrove wood.	Coconut shells.
	Pesos.	*Pesos.*	*Pesos.*
1.4 cubic meters of stone at 10 pesos per cubic meter	14.00	14.00	14.00
0.4 ton of coal at 20 pesos (lime-fuel ratio 2.5 : 1)	8.00		
1.41 cubic meters of mangrove wood (762 kilograms) at 15.20 pesos per ton		11.58	
0.854 ton of coconut shell at 12 pesos per ton			10.25
Six men per 24 hours (two shifts per day of 3 men each) at 1.50 pesos each, per ton	6.00	5.00	5.00
Total cost of material and labor per ton of lime in bulk	28.00	30.58	29.25
Volume of 1 ton of lime ... cubic meters	1.02	1.02	1.02
Do ... cavanes	13.6	13.6	13.6
Slaked lime produced per ton of lime ... do	37.8	37.8	37.8
Weight per cavan (75 liters) of slaked lime ... kilograms	34.9	34.9	34.9
Cost per cavan of slaked lime ... peso	0.74	0.81	0.77

It will be seen from Table 8 that in Manila coal is a cheaper fuel than wood for use in lime burning. However, in places where wood is plentiful and near to the limestone deposit, wood will be cheaper to use than coal. Local conditions should, therefore, govern the choice of fuel to be used.

Three methods are now commercially used in lime burning; namely, egg-shaped intermittent kilns; intermittent low circular kilns (Chinese kiln) in which the fuel, usually coke, and calcareous material are alternately charged; and vertical continuous kilns with separate fireplaces. The Chinese process has been found to be more economical in fuel when the calcareous material used is marine or oyster shell, in which the thickness of the material is rarely over half a centimeter. If hard limestones are used they will have to be crushed to 1-centimeter size or less. The labor or power required in crushing the stones to such a small size is considerable, and this is believed to be the greatest disadvantage of the Chinese kiln. On the other hand, if larger pieces of limestone are charged, a large percentage of the resulting lime is underburned. The continuous vertical kiln, like that used in conducting the burning tests at the Bureau of Science, requires stone of a definite size to be calcined, if a satisfactory draft is to be maintained. A continuous kiln is more economical in fuel than is the egg-shaped kiln, but the latter is capable of utilizing stones as large as 30 to 35 centimeters in diameter, which is a decided advantage. The labor required in breaking up the stones for use in the egg-shaped kilns is, therefore, less than that used for the continuous kiln.

Where the calcareous material is naturally found in small pieces, such as marine or oyster shells, the Chinese kiln can be advantageously used. The continuous kiln is better adapted to supply a more or less continuous demand. However, if the demand is irregular, an egg-shaped kiln will probably be more suitable.

As a result of the burning tests conducted by the Bureau of Science, a lime kiln similar to that used in the Bureau of Science was erected at Malicboy, Tayabas, by a private company. The kiln has an inside diameter of 6 feet, is 28 feet high, and has two fire boxes 4 by 5 feet. The capacity of the kiln is from 4 to 5 tons of lime per day. Another kiln of similar design was erected on Guimaras Island, Iloilo Province. Two other kilns were erected about 7 kilometers beyond Antipolo, Rizal Province, Luzon. The deposit itself is about 3 to 4 kilometers from the provincial road and can be reached by automobile during the dry season only. The limestone occurs in scattered bowlders more or less buried in the ground and is of the same quality as is that found in Binañgonan. It seems that the business was not a financial success as the two kilns have ceased operations.

As a rule, the sugar centrals demand unslaked lime, and the lime burners are therefore compelled to use air-tight containers to supply the demand. The cost of the container is a large item in the total cost. If second-hand wine or oil barrels of 55 gallons each are used, one ton of lime will require about six and one-half barrels which, at 1.50 pesos each, would total 9.75 pesos, excluding transportation of the empty containers to the kiln. Where second-hand 5-gallon tin cans are available, they can be used as lime containers, but they would cost more than oil barrels per ton of lime.

Slaked lime is easier and therefore cheaper to ship to the consumer than unslaked lime. Ordinary jute, palmleaf, or paper bags can be safely used. Slaked lime may be stored in bulk by the consumer and a rebate allowed on the return of containers in good condition.

The only possible objection to the delivery of slaked lime is the fact that freight has to be paid for the water added in slaking when the water can just as well be added at the central. However, containers for quicklime must be air tight and therefore are expensive, whereas the container for slaked lime need not be air tight. The difference in the cost of containers more than counterbalances the extra freight paid due to the water added in slaking. To be sure, the slaked lime should be of the same purity as the unslaked lime. The following specifications for lime and slaked lime for use in the sugar industry are given in the specifications of the American Society of Testing Materials.

SPECIFICATIONS FOR QUICKLIME AND SLAKED LIME FOR USE IN THE SUGAR INDUSTRY

1. Quicklime or slaked lime should be clean and free from gritty substances.

2. The quicklime or slaked lime should conform to the following requirements as to chemical composition, calculated to the nonvolatile basis:

	Per cent.
Calcium oxide (CaO), minimum	94
Magnesium oxide (MgO), maximum	2
Iron and aluminum oxide (F_2O_3 and Al_2O_3) and insoluble matter, maximum	2
Carbon dioxide (CO_2), maximum:	
(*a*) If sample is taken at place of manufacture—	
(1) Quicklime	3
(2) Slaked lime	5
(*b*) If sample is taken at other than place of manufacture—	
(1) Quicklime	5
(2) Slaked lime	7

SUMMARY AND CONCLUSIONS

1. The native methods of burning lime in the open air are described. They are wasteful of fuel and considerable underburned lime is produced. They are still used in small communities to produce slaked lime for local consumption.

2. The introduction of egg-shaped, intermittent kilns was a great improvement over the native method. The kiln is more economical in fuel than the native method, and perhaps the greatest advantage of this kind of kiln is the fact that it can utilize pieces of limestone as large as 30 to 35 centimeters in diameter.

3. For the calcination of calcareous material in small pieces the Chinese kiln, on account of its simplicity and fuel efficiency, is to be recommended. Oyster shells and other marine shells cannot be satisfactorily burned by any method now used except in the Chinese kiln, shown in Plate 1.

4. A vertical, continuous kiln, operating with natural draft has been introduced by the Bureau of Science with success. The largest size of this type of kiln in operation is 6 feet (about 1.83 meters) in its largest diameter and contains two opposite firing doors. The capacity per day is between 4 and 5 tons of lime. This size seems to be the limit for two firing doors and, if kilns of larger capacity are desired, three equidistant firing doors should be provided.

5. The cost of manufacturing common slaked lime in the City of Manila from marine shells in the Chinese kiln is 0.55 peso per cavan of 75 liters (42 kilograms). In calcination tests made at the Bureau of Science, using crystalline limestone with various fuels, the cost of manufacturing quicklime varied from 28 to 31 pesos per ton. This is equivalent to from 0.74 to 0.81 peso per cavan of slaked lime, of 75 liters. The cost given above is for materials and labor only, and does not include taxes, interest, depreciation, etc.

ILLUSTRATIONS

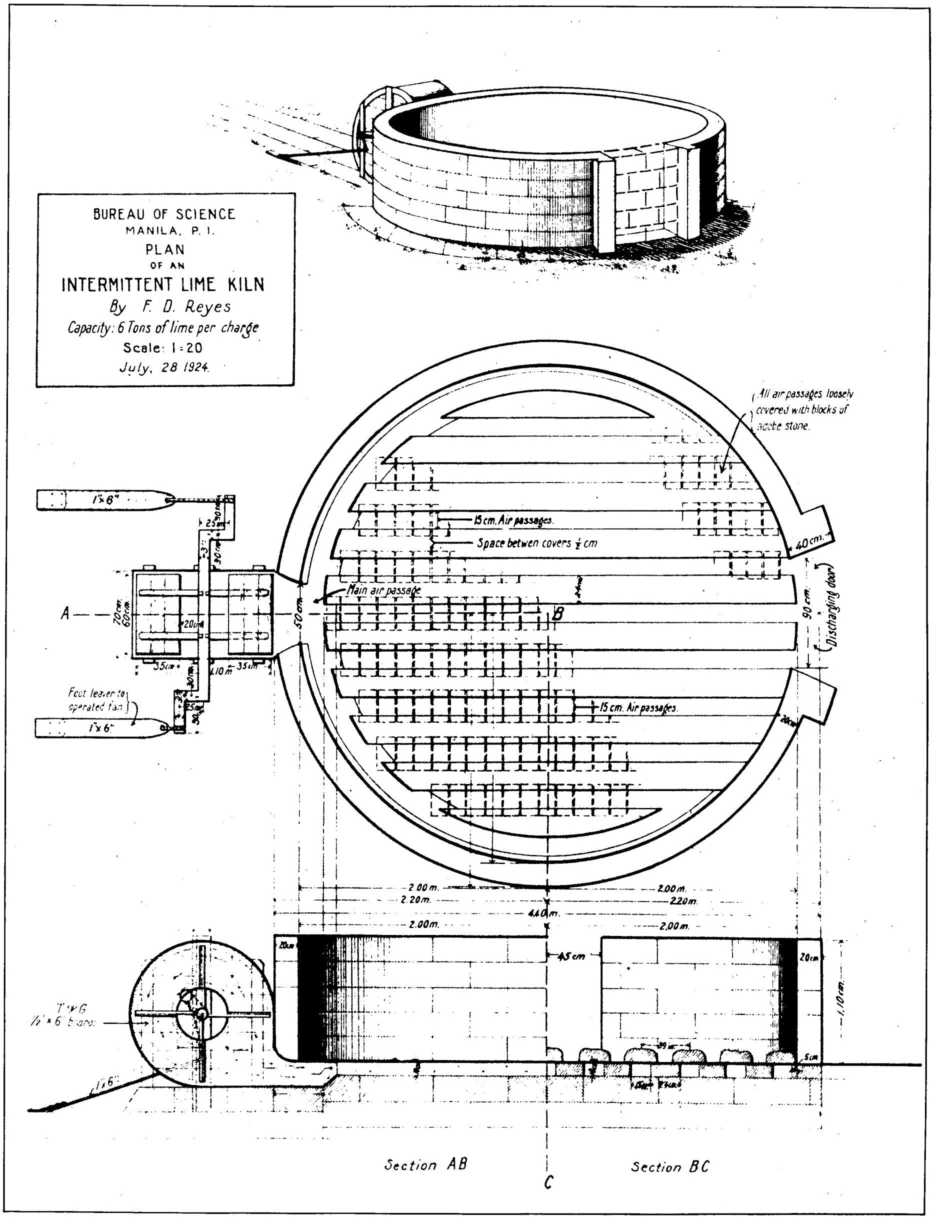


PLATE 1. AN INTERMITTENT LIME KILN.

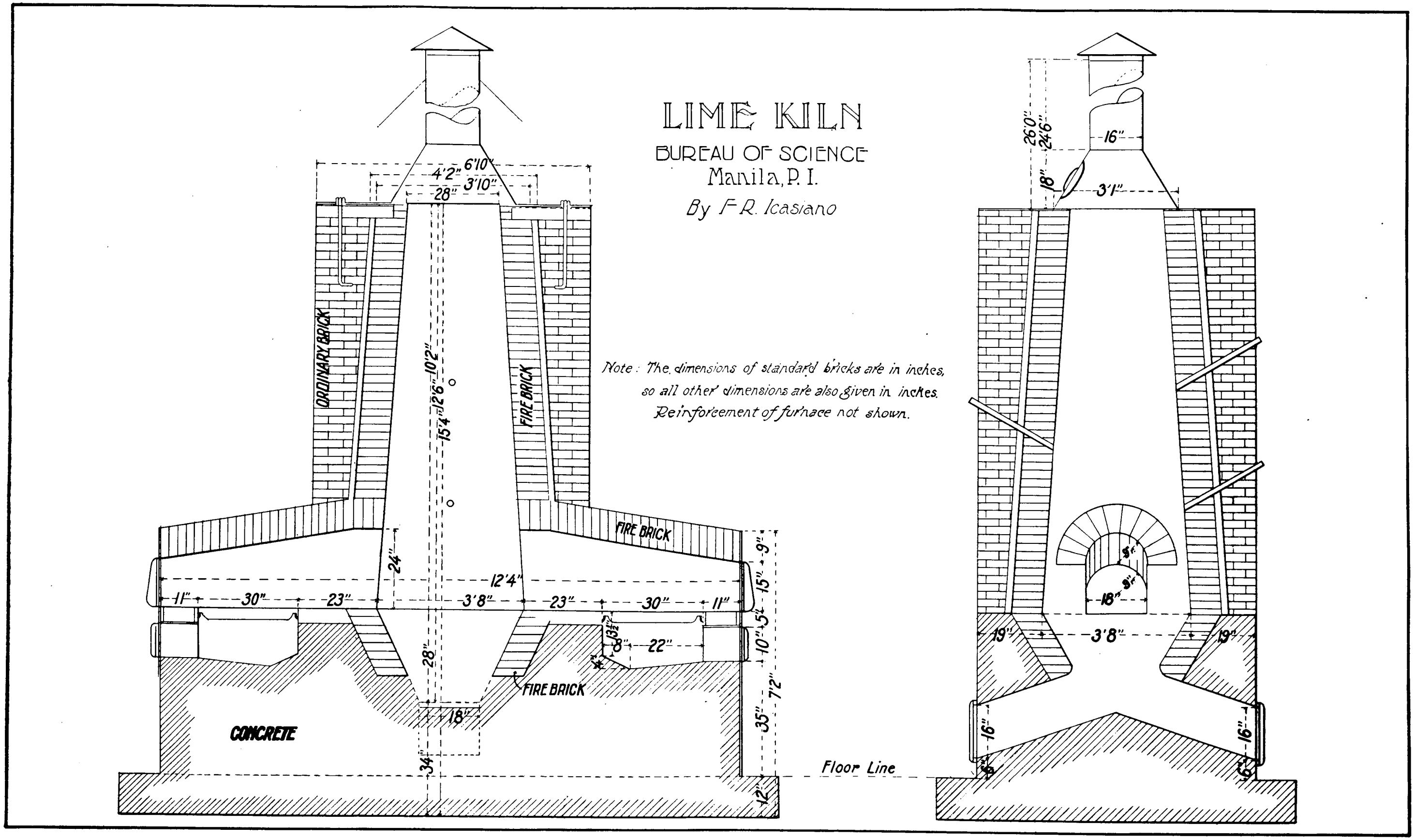


PLATE 2. AN IMPROVED CONTINUOUS LIME KILN.

COMPOSITION OF PHILIPPINE PINEAPPLES

By A. H. WELLS, F. AGCAOILI, H. TAGUIBAO, and A. VALENZUELA
Of the Division of Organic Chemistry, Bureau of Science, Manila

TWO PLATES

Early in April, 1927, it was realized that pineapple material brought to the laboratories of the Bureau of Science for specific analyses in connection with investigations in plant pathology might readily be utilized for making complete analyses of introduced varieties of pineapples and comparing the results with data obtained on native varieties as well as the same varieties grown in other countries. The purposes of this paper are to outline briefly the growth of pineapple culture in the Philippines; to give complete analyses of pineapples and their products grown under Philippine conditions; and to furnish comparative data and other information relative to the subject of the composition of pineapples, which will be of value for the marketing and canning of this fruit.

Pineapples were grown in the Philippines at a very early date. As early as 1595, Spanish priests were teaching the people the weaving of piña cloth and other fabrics from the fine fibers taken from the pineapple plant. It is understood that pineapples were introduced into the Philippines from Mexico by the Spaniards. In 1571, Miguel Lopez de Legaspi found the natives were using a fiber that was afterward identified by Dominican missionaries as coming from leaves of the small native pineapple, which was growing wild in many of the provinces of the Philippines. It appears that even up to the time of the American occupation pineapples were grown very little for their fruit. In 1912, Bataan was the only province producing any great quantity of fruit for the market.

The Bureau of Agriculture reports for 1902 and 1903 that there were only a few hundred hectares of land devoted to pineapple culture. At that time, the Manila market was supplied with native fruits brought from the barrio of Dumulong, Orion, Bataan. The Bureau of Agriculture[1] informs us that Samar,

[1] Bureau of Agriculture Circular No. 16.

Occidental Negros, Tayabas, Bulacan, Leyte, Cebu, and Zambales grew the plant more for its fiber than for its fruit. That bureau also states that a comparison of the soil and the climate of the Philippines with those of pineapple-growing countries in other parts of the world, and a consideration of the behavior of the pineapple in the Philippines, give assurance that with proper care the pineapple will succeed equally well in many parts of the Archipelago.

In 1911 and 1912, the Smooth Cayenne variety of pineapple was introduced into the Philippines. In 1911, the Abucay Plantation Company set out 10,000 Smooth Cayenne plants obtained from Hawaii, and so succesful was the result of this trial planting that later 40,000 more plants were imported from Hawaii, in two lots. The fruit grown at Abucay is in great demand on the Manila market as a substitute for the small inferior native variety. In the past, attempts have been made to introduce other varieties and to grow plants brought from Singapore, but for certain reasons Smooth Cayenne has advanced more rapidly than any of the others and is one of the best grades of pineapples found on the Manila market.

At present the two classes of pineapples found in quantity on the market are the native varieties and the Smooth Cayenne. We have been informed that the Black Prince variety has been introduced and is successfully grown for the trade; one company shows a production of approximately 85 per cent Smooth Cayenne and 15 per cent Black Prince.

The native pineapples (Plates 1 and 2) are smaller than the Smooth Cayenne. Unlike the Smooth Cayenne many of the native fruits taper toward the base. Except for size, some of the native varieties resemble Smooth Cayenne in being cylindrical or barrel-shaped. In general appearance native pineapples may be described as follows: Somewhat elliptical in shape; height, 8 to 17 centimeters; diamter, from 6 to 12 centimeters; color, orange, orange red, green, greenish yellow.

From one hundred nine assorted native Philippine pineapples the weights shown in Table 1 were obtained.

The eyes are set from 1 to 1.8 centimeters deep and display plenty of large seeds. The eyes vary in width from 1.5 to 3 centimeters. In general, per unit surface the native pineapple has more and deeper eyes than has Smooth Cayenne. The edible portion of the ripe fruit varies from opaque whiteness to translucent orange. The core of the native variety is proportionally thicker and harder than that of the Smooth Cayenne.

TABLE 1.—*Showing weights of native Philippine pineapples.*

Fruits.	Class.	Weight.	Weight of edible portion.
		g.	*g.*
1	Smallest fruit	640	340
109	Average fruit	995	630.6
1	Largest fruit	1,330	615.3

Plate 1 gives a general idea of the appearance of some common types of native pineapples found on the market. There is a great difference in the number of eyes found in the native species as well as in the flavor of the various fruits. In purchasing native pineapples some people prefer those of an orange or orange red color, while others select those that have a green surface when ripe. Plate 2, fig. 2, shows the difference in size of a large native pineapple and a large Smooth Cayenne.

The Smooth Cayenne grown in the Philippines is not unlike that found in Hawaii, in general appearance and in texture of the edible portion. This fruit often grows to a very large size. Pangasinan Province produced a fruit weighing 13 pounds (5.89 kilograms), while the largest pineapple grown by the Abucay Plantation Company weighed 16 pounds (7.25 kilograms). Plate 2, fig. 1, shows a field of Smooth Cayenne variety growing in Laguna Province at a possible altitude of 6 meters above sea level. Smooth Cayenne pineapples grown in the Philippines are in no way inferior to those grown in other parts of the world. Table 2 shows the weights of the smallest and the largest fruits, as well as the average weight of one hundred sixty-seven fruits analyzed in this work.

Smooth Cayenne pineapples are successfully grown in the Philippines at elevations of 200 to 250 meters above sea level. Approximately 20,000 selected suckers are planted per hectare. A hectare produces approximately 14,000 pineapples or, in other words, approximately 70 per cent of the plants planted bring in fruit either during the winter season of October to November, or the summer season of April, May, June, and July. This yield could undoubtedly be increased by the proper use of the correct artificial fertilizers. Table 3 shows the percentages of fruits of standard grades obtained per hectare (native pineapples are not graded).

The cost of planting a hectare, harvesting, and placing the pines on the market, not including cost of clearing the land, is

TABLE 2.—*Showing weights of Smooth Cayenne pineapples.*

Fruits.	Class.	Weight.	Weight of edible portion.
		g.	*g.*
1	Smallest fruit	1,150	1,067
167	Average fruit	2,567	1,808
1	Largest fruit	4,027	3,039

TABLE 3.—*Showing grades and values of Philippine-grown Smooth Cayenne pineapples.*

Grade.	Weight.	Per cent.	Pines per crate.	Wholesale price per crate.
	kg.			*Pesos.*
X	3 or over	0.8	8	9.00
No. 1	2.20 to 3	8.9	10	9.00
No. 2	1.50 to 2.20	31.3	14	8.00
No. 3	1.00 to 1.50	39.0	18	4.50
No. 4	0.75 to 1.00	18.3	35	3.50
No. 5	Under 0.75	1.7	50	3.50

approximately 700 pesos,[2] from the time of first plowing to the gathering and shipping of the fruit. For the clearing of ordinary foothill land, 180 pesos must be added per hectare. It is estimated that the cost of cultivation and weeding for the second and third crops after the first plant crop—that is, the two ratton crops—is approximately 300 pesos per hectare. The gross income per hectare from the first crop is approximately 1,200 pesos; the cost of production (not including clearing of the land) amounts to 700 pesos. The gross profit from the first crop is, therefore, approximately 500 pesos; the gross proceeds from the second and third crops amount to approximately 1,000 pesos per hectare for each crop, with a cost for cultivation, etc., of approximately 300 pesos per hectare for each crop, yielding a gross profit of 700 pesos per hectare for each of the second and third crops. In other words, during a cycle of three and one-half to four years, or from the time of starting the preparation of the ground up to the harvesting of the third crop, the cost per hectare is approximately 1,300 pesos, the gross income is 3,200 pesos, and the gross profit is 1,900 pesos. From this profit must then be deducted the cost of tearing up and clearing the land in preparation for the second cycle. It has been

[2] One peso Philippine currency equals 50 cents United States currency.

found from experience that the land should either be allowed to lie fallow for a year or be planted with some cover crop rich in nitrogen, which should then be plowed under before replanting to pineapples is done. It is estimated that this process of tearing up and clearing the land after harvesting the last, or third crop, planting it in cover crops, and bringing it to the point of first plowing for an additional cycle of pineapples, will cost approximately 300 pesos per hectare which, deducted from the gross profit of 1,900 pesos, will show a gross profit of 1,600 pesos during a period of approximately five years, or an annual profit of 333 pesos per hectare. From this amount there should be deducted taxes, depreciation, and overhead.

The above figures were obtained from a company growing Smooth Cayenne pineapples for the Manila market and are assumed to represent conditions for pineapple growing in central Luzon at the present time.

Table 4,[3] showing the cost of setting out a hectare of pineapples, is also given as another estimate, made by the Bureau of Agriculture. Either estimate shows that growing the Smooth Cayenne for market purposes is decidedly the more profitable.

TABLE 4.—*Estimate of the outlay per hectare from the first year to the first harvest.*

Item.	Hawaiian pineapple plantation, Abucay.	Native pineapple plantation at Orion.
	Pesos.	*Pesos.*
Land	80.00	80.00
Clearing	250.00	50.00
Plants at 10 centavos (Hawaiian, 10,000 plants)	1,000.00	-----------
Plants at 1 centavo (native, 20,000 plants)	-----------	200.00
Plowing (three times)	37.90	-----------
Harrowing (three times)	18.00	-----------
Planting (Hawaiian, 1 by 1 meter)	18.00	-----------
Planting (native, 1 by 0.5 meter)	-----------	30.50
Cultivation and weeding for two years	300.00	-----------
Weeding alone (once a year for two years)	-----------	28.50
Irrigation and drainage twice a month during the dry season, for two years	65.00	-----------
Harvesting (Hawaiian, 9,000 fruits)	27.00	-----------
Harvesting (native, 15,000 fruits)	-----------	54.00
Packing and packing materials	130.00	-----------
Hauling	66.00	26.40
Shipping	30.00	35.00
Miscellaneous expenses	100.00	30.00
Total expenses	2,121.90	534.70

[3] Philip. Agr. Rev. No. 1, 18 (1925).

Smooth Cayenne pineapples are grown near Manila by the single-row method in well-drained reddish clay loam and in mixed alluvial and sedentary soil of basaltic and andesitic origin.

Near Manila there are two distinct seasons, a dry and a rainy season; dry in winter and spring, wet in summer and autumn. Only the summer rainfall prevails, the other being scarcely noticeable. Father José C. Coronas, chief of the meteorological division, Philippine Weather Bureau, states that, strictly speaking, by a dry month in the Philippines should be understood a month with less than 50 millimeters of rain; yet sometimes a month with even more than 100 millimeters is considered a dry month, especially if it comes after three or more very dry months. The average annual rainfall ranges from 1,800 to 2,500 millimeters.

Pineapples show favorable growth not only in places that have a dry and a wet season, but also in regions of the Philippines where no distinctive dry season occurs but where there is a pronounced maximum rainy period in winter; in places with no very pronounced maximum rain period and a short dry season lasting only one to three months; and in regions of no pronounced maximum rain period but no dry season, such as certain parts of Tayabas, Basilan, Jolo, Leyte, and a great portion of Mindanao.

Table 5 gives figures of rainfall [4] in districts claimed to be especially adapted to pineapple growing in the Philippines.

TABLE 5.—*Mean annual rainfall in localities in the Philippines adapted to pineapple growing.*

Month.	Isabela, Basilan.	Jolo, Sulu.	Cotabato, Cotabato.	Ormoc, Leyte.	Tayabas, Tayabas.	Santa Cruz, Laguna.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
January	54.5	89.1	98.8	176.7	135.1	64.4
February	89.2	122.4	88.8	100.7	42.2	47.3
March	58.2	85.2	68.1	78.3	60.2	38.1
April	89.2	118.2	164.9	65.8	23.8	48.4
May	108.0	160.2	218.5	72.8	99.3	131.8
June	210.6	203.3	237.3	177.2	83.8	145.0
July	208.4	172.0	292.0	324.8	96.6	306.2
August	205.8	170.4	271.8	288.0	93.9	289.3
September	201.6	184.4	248.6	308.5	116.5	267.2
October	261.7	222.9	255.1	257.5	239.0	245.7
November	168.4	193.0	231.7	219.6	283.2	183.8
December	138.6	144.8	133.5	180.7	195.4	123.9
Total	1,794.1	1,865.9	2,309.1	2,250.7	1,449.0	1,891.1

[4] Bureau of Agriculture Circular No. 16.

In a study of the area in the Philippines planted to Smooth Cayenne pineapples it was found that not more than 50 hectares produced fruit for the market during the past season of 1927. There are definite prospects of the area being greatly increased in the near future.

Specimens selected for analysis during the season of April to July amounted to 685, consisting of 376 Smooth Cayenne pineapples, 105 Smooth Cayenne cores, 129 native pineapples, and 75 native pineapple cores.

All of the Smooth Cayenne and many of the native varieties of fruits used for these analyses were picked from fields of known age and were analyzed within twenty-four hours after picking. There were a few fruits that were allowed to stand in the laboratory for ripening for specific determinations. As nearly as possible uniformity of ripeness was maintained in selecting these fruits.

The following explanations are given to permit clear interpretation of the tables found in this article:

Total weight.—The figures for total weight indicate the weight of the fruit after all parts of the crown and stem had been removed.

Percentage of edible portion.—By edible portion we mean the part of the pineapple remaining after cutting off the skin, the outer portions of the base, and the crown to the extent where no traces of the color of the fiber of the outer portions remain on the fruit. The edible portions were prepared for analysis by passing the whole portions, less the cores, through a large-sized meat grinder in such a manner as to lose none of the juice. Thus a true composite of the whole fruit or fruits was obtained, any possible error due to variations in composition of sections having been eliminated.

Percentage of waste.—The percentage of waste indicates the portion that had been removed from the fruit, not including the crown or any portion of the stem or the core.

The juice.—In all cases where analyses of juice were desirable a part or aliquot parts of the ground edible portion were taken, passed through a high-power basket centrifuge, and strained through muslin before determinations of Brix, total solids, sucrose, etc., were made.

Brix.—The Brix of the juice was determined by the use of spindles calibrated at the tropical temperature of 27.5° C. Brix is expressed as a corrected Brix for this temperature.

Total solids.—Determinations of the total solids were made directly by weighing and drying on a steam bath and then in an electric oven at 100 to 105° C., to constant weight.

All other analyses were made in accordance with the methods of the Association of Official Agricultural Chemists, with but few changes to suit tropical conditions.

Table 6 gives analyses of the juice and the edible portion of the native Philippine and the Smooth Cayenne pineapples obtained from various sources.

Thirty-nine fruits were purchased in the market places; no record to time of picking was obtainable. Reference to Table 6 shows the Brix, total sugars, total solids, percentage of fiber, protein, and ash of these fruits to be lower and the acidity higher than those of the remaining native specimens, which were taken directly from the plantations. The native fruits grown at Silang, Cavite, have a higher total solids and sugar content than have those grown at Guiguinto, Bulacan. This variation in composition is probably due not so much to soil and climate as to variation in the stock and to cultivation. Often the native pineapples are very poorly cultivated and the stock is greatly deteriorated. It is not believed that native pineapples kept in the Manila market for a week or ten days would show as great an increase in acidity by aging as is found in the case of the thirty-nine pineapples obtained from the Manila market. It is of interest that seven Smooth Cayenne pineapples obtained from Silang, analyses of which are found in Table 6, show a very close resemblance in composition to the analyses of twenty fruits of the native barrel-shaped, greenish yellow variety obtained from the same place. Investigation shows that these pineapples were large Smooth Cayenne pineapples obtained from deteriorated stock. Large attractive pineapples may be obtained from deteriorated stock planted under the best soil, climatic, and cultivation conditions, and yet such fruits when analyzed show their inferiority for canning or table purposes. As is the case with native pineapples, so it is with Smooth Cayenne grown in various localities; that is, the slight variations in composition are due probably more to differences in stock than to climatic and soil conditions. Cultivation and rainfall also seem to be strong factors that indirectly influence the composition of the ripening fruit. Ripening or ripe fruits that remain in the fields after the beginning of the rainy season are inferior in flavor to those harvested during the dry season.

The rich aroma seems to decrease rapidly, the fruits become less solid, and they taste less sweet. Fruits harvested after the rainy season has set in often show a low sucrose content, a change in the ratio between the sucrose and invert sugars, and an increase in acidity. Reference to the averages obtained from one hundred nine native and one hundred sixty-seven Smooth Cayenne fruits plainly shows the inferiority in size, content of sugars, acidity, fiber, and other factors of the native variety compared with the Smooth Cayenne. The Smooth Cayenne is larger, has a higher percentage of edible portion and less waste, is sweeter and less acid in taste, and has a higher content of inorganic salts, with a slightly higher alkalinity of its ash; also, the percentage of water is noticeably higher in the native varieties. The ratio between sucrose and invert sugars is, roughly, 2 : 1.

It may be stated that the average pineapple of Hawaiian stock grown near Manila or in the vicinity of central Luzon has a corrected Brix of about 14.80, a total sugar of about 13 per cent, and an acidity (as citric) of about 0.70 per cent. Since the Smooth Cayenne is the more important from the standpoint of suitability for table and canning purposes, very little reference to native fruits will be made hereafter in this paper.

In isolated cases Smooth Cayenne pineapples were found to have higher percentages of sucrose and invert sugars, and lower percentages of fiber and acidity than are expressed in Table 6 of composites. However, the averages indicate that these fruits have about the same content of sugars as have the Smooth Cayenne fruits grown in Florida and Hawaii, and slightly lower percentages of acidity. The expressed percentages of edible portion are much higher than those found in other places. This may be partly due to the fact that the crowns were not included in the total weight of the fruit rather than to the method of paring. Obviously, the low fiber content shown in the introduced Smooth Cayenne varieties indicates a better edible condition of the fruit. There is no great variation in composition of Smooth Cayenne pineapples grown in the various localities of central Luzon when the fruits are obtained from stocks that have not deteriorated.

Two groups of large and small ripe Smooth Cayenne pineapples were selected for analysis, to determine any differences that might occur in the chemical analyses of the juice and the edible portion due to size.

TABLE 6.—*Comparison of different varieties of ripe native pineapples and ripe Smooth Cayenne.*

Fruits.	Total fruit (less crown). Average weight.	Edible portion.	Waste.	Juice analysis. Corrected Brix. 27.5° C.	Sucrose.	Invert sugars.	Total sugars as invert.	Polarization direct.	Polarization invert.	Acidity as citric.	Edible portion. Total solids.	Moisture.	Fiber.	Sucrose.
	g.	P. ct.	P. ct.		P. ct.	P. ct.	P. ct.			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
39	847	61.56	38.44	11.01	5.9	3.19	9.4	+5.0	—2.4	1.08	12.23	87.77	0.44	4.88
20	1,132	67.41	32.59	13.48	7.66	3.51	11.57	+6.9	—2.8	0.66	14.22	85.78	0.54	6.87
16	1,122	67.39	32.61	12.71	7.03	3.11	10.51	+6.3	—2.6	0.94	13.47	86.53	0.51	6.40
12	846	59.15	40.85	10.87	6.08	3.19	9.59	+5.5	—2.2	0.84	12.42	87.58	0.52	5.68
12	923	65.59	34.41	10.94	6.16	3.13	9.61	+5.6	—2.2	0.85	12.42	87.58	0.55	4.19
10	1,098	59.19	40.81	12.29	7.34	3.18	10.91	+6.8	—2.6	0.85	13.14	86.86	0.51	6.79
Average of 109 fruits	995	63.38	36.62	11.88	6.70	3.22	10.27	+6.0	—2.5	0.87	12.98	87.02	0.51	5.80
7	2,727	74.46	25.54	13.67	7.53	3.40	11.33	+6.6	—3.0	0.94	13.49	86.51	0.49	6.98
5	2,238	76.07	23.93	--------	9.17	4.41	14.06	+8.3	—3.4	0.74	15.90	84.10	--------	7.90
12	1,799	75.90	24.10	--------	8.53	4.41	13.38	+7.2	—3.6	0.67	15.88	84.12	0.45	8.45
9	2,639	77.21	22.79	15.02	8.39	4.78	13.61	+7.0	—3.6	0.57	15.51	84.49	0.54	6.89
6	2,204	76.46	23.54	15.88	8.94	4.28	13.69	+8.1	—3.2	0.60	16.50	83.50	0.37	8.23
12	2,223	75.24	24.76	15.57	9.31	4.55	14.35	+8.1	—3.6	0.61	16.59	83.41	0.55	8.16
1	3,062	78.48	21.52	15.53	9.22	4.21	13.91	+8.3	—3.4	0.57	16.17	83.83	0.40	8.43
4	2,979	77.81	22.19	14.53	8.68	3.78	12.65	+7.8	—3.4	0.67	15.30	84.70	0.45	7.83
10	3,565	69.54	30.46	14.84	8.58	5.00	14.03	+7.8	—3.2	0.78	15.65	84.35	0.47	7.57
10	2,793	70.10	29.90	15.04	8.16	4.04	12.63	+7.4	—3.0	0.61	15.47	84.53	0.52	7.62
13	1,593	71.90	28.10	15.80	9.51	3.86	13.87	+8.5	—3.6	0.76	16.46	83.54	0.46	8.87
10	2,865	71.63	28.37	14.11	8.01	4.32	12.74	+6.8	—3.4	0.67	--------	--------	0.48	6.59
9	2,319	71.51	28.49	14.48	7.56	3.83	11.79	+6.2	—3.4	0.75	15.35	84.65	0.44	6.61
16	2,354	76.52	23.48	14.57	7.88	3.75	12.04	+7.2	—2.8	0.59	14.82	85.18	0.40	7.08
10	3,123	70.50	29.50	14.31	7.38	4.55	12.33	+6.0	—3.4	0.74	--------	--------	0.46	6.51
10	2,488	76.50	23.50	14.01	7.95	3.78	12.15	+6.7	—3.4	0.92	--------	--------	0.47	6.69
23	2,673	75.71	24.29	14.88	7.64	4.59	12.63	+6.3	—3.4	0.74	15.21	84.79	0.49	7.08
Average of 167 fruits	2,567	74.44	25.56	14.82	8.38	4.21	13.01	+7.3	—3.3	0.70	15.59	84.41	0.47	7.50

Total fruit (less crown).				Edible portion.						
Fruits.	Average weight.	Edible portion.	Waste.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Protein (Nx6.25).	Ash.	Alkalinity of ash K_2CO_3.	Variety, shape, color, source.
	g.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		
39	847	61.56	38.44	3.16	8.30	0.95	0.45	0.41	0.15	Native; barrel; orange; Manila markets.
20	1,132	67.41	32.59	3.40	10.63	0.62	0.49	0.50	0.16	Native; barrel; greenish yellow; Silang.
16	1,122	67.39	32.61	3.01	9.75	0.58	0.48	0.42	0.14	Native; cylindrical; orange red; Silang.
12	846	59.15	40.85	3.04	9.02	0.72	0.50	0.45	0.14	Native (costa); cylindrical; orange red; Guiguinto.
12	923	65.59	34.41	3.04	7.45	0.75	0.49	0.49	0.17	Native; barrel; greenish yellow; Guiguinto.
10	1,098	59.19	40.81	2.68	9.83	0.73	0.47	0.49	0.15	Native; cylindrical; green (ripening stage); Silang.
Average of 109 fruits	995	63.38	36.62	3.06	9.16	0.73	0.48	0.46	0.15	
7	2,727	74.46	25.54	3.09	10.44	0.78	0.47	0.52	0.15	Smooth Cayenne; Silang.
5	2,238	76.07	23.93	3.57	11.93	0.66	0.38	0.53	0.23	Smooth Cayenne; Laguna.
12	1,799	75.90	24.10	3.98	12.87	0.63	0.33	0.54	0.22	Smooth Cayenne; Bataan.
9	2,639	77.21	22.79	4.89	12.15	0.46	0.39	0.60	0.26	Smooth Cayenne; Laguna.
6	2,204	76.46	23.54	3.81	12.47	0.49	0.41	0.50	0.19	Smooth Cayenne; Bataan.
12	2,223	75.24	24.76	4.43	13.02	0.51	0.39	0.57	0.24	Do.
1	3,062	78.48	21.52	4.18	13.05	0.47	0.39	0.48	0.18	Do.
4	2,979	77.81	22.19	3.72	11.96	0.54	0.42	0.61	0.22	Do.
10	3,565	69.54	30.46	4.90	12.87	0.69	0.41	0.56	0.22	Smooth Cayenne; Laguna.
10	2,793	70.10	29.90	3.95	11.97	0.56	0.41	0.64	0.25	Do.
13	1,593	71.90	28.10	3.83	13.17	0.58	0.37	0.71	0.27	Do.
10	2,865	71.63	28.37	3.83	10.77	-------	0.57	0.51	0.20	Do.
9	2,319	71.51	28.49	3.77	10.73	-------	0.48	0.68	0.24	Do.
16	2,354	76.52	23.48	3.67	11.12	0.54	0.39	0.67	0.22	Do.
10	3,123	70.50	29.50	4.25	11.10	-------	0.53	0.50	0.19	Do.
10	2,488	76.50	23.50	3.68	10.70	-------	0.54	0.66	0.23	Do.
23	2,673	75.71	24.29	4.51	11.96	0.55	0.45	0.77	0.23	Do.
Average of 167 fruits	2,567	74.44	25.56	4.00	11.90	0.57	0.43	0.59	0.22	

Table 7 gives the analyses of the two groups mentioned and the average of the twenty-three fruits used. The percentage of edible portion is found to be slightly larger in smaller fruits; while the ratio of sucrose to invert sugars remains approximately 2 : 1 in the larger fruits, it is somewhat disturbed in favor of sucrose in the smaller fruits. The higher percentages of edible portion, sucrose, total sugars as invert, and the lower percentages of fiber indicate that the smaller fruits are pleasanter to the taste. The smaller fruits show a higher acidity than do the larger ones. Table 7 tends to illustrate the fact that the largest fruits are not always the best for canning and for table purposes.

A portion of the field was partially shaded during the plowing season. The shade was produced by placing a thin layer of coconut leaves on a frame 2.5 meters above a section of the field.

Table 8 shows the analyses of these two groups. There are no consistent variations in these figures. Apparently partial shading from the beginning of the flowering stage to ripening does not materially affect the composition or the size of the fruit.

Fruits were selected as near as possible to the age expressed in Table 9, and analyzed to find the variations in composition following growth from one month to five months of age. With growth there is a concomitant increase in weight and percentage of edible portion of the total fruit with a decrease in percentage of waste. The juice analyses show a gradual increase in Brix, sucrose, invert sugars, and acidity. Moisture and percentage of fiber in the edible portion decrease with growth and ripening. Obviously the total solids of the edible portion increase along with the total sugars. From the age of one month to full growth or maturity, the juice increases from 0.78 per cent sucrose to 8.69 per cent, with an approximate increase of 1 per cent sucrose in ripening. During a period of three and one-half to four months the juice increases from 0.22 acidity to 0.79 per cent.

Equal numbers of mature yellow and green Smooth Cayenne pineapples were selected from a shipment, and analyses were made of the two groups to determine whether or not the color of the fruit can be used as a criterion of ripeness. Fruits were selected as nearly as possible of the same size, firmness, and weight; four were entirely green, and four others yellow or orange.

TABLE 7.—*Analyses of large and small ripe Smooth Cayenne pineapples from Laguna Province.*

Number of fruits.	Total fruit (less crown). Average weight.	Edible portion.	Waste.	Juice analysis. Corrected Brix at 27.5° C.	Sucrose.	Invert sugars.	Total sugars as invert.	Polarization direct.	Polarization invert.	Acidity as citric.	Edible portion. Total solids.	Moisture.
	g.	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*			*P. ct.*	*P. ct.*	*P. ct.*
10	2,793	70.10	29.9	15.04	8.16	4.04	12.63	+7.4	—3.0	0.61	15.47	84.53
13	1,593	71.90	28.1	15.80	9.51	3.86	13.87	+8.5	—3.6	0.76	16.46	83.54
Average of 23 fruits	2,193	71.00	29.0	15.42	8.84	3.95	13.25	+8.0	—3.3	0.69	15.97	84.04

Number of fruits.	Total fruit (less crown). Average weight.	Edible portion.	Waste.	Edible portion. Fiber.	Sucrose.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Protein (Nx6.25).	Ash.	Alkalinity of ash K_2CO_3.	Size.
	g.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		
10	2,793	70.10	29.9	0.52	7.62	3.95	11.97	0.56	0.41	0.64	0.25	Large.
13	1,593	71.90	28.1	0.46	8.87	3.83	13.17	0.58	0.37	0.71	0.27	Small.
Average of 23 fruits	2,193	71.00	29.0	0.49	8.25	3.89	12.57	0.57	0.39	0.68	0.26	

TABLE 8.—*Analyses of ripe Smooth Cayenne pineapples growing in the shade and exposed to direct sunshine.*

Total fruit (less crown).				Juice analysis.							Edible portion.	
Number of fruits.	Average weight.	Edible portion.	Waste.	Corrected Brix 27.5°C.	Sucrose.	Invert sugars.	Total sugars as invert.	Polarization direct.	Polarization invert.	Acidity as citric.	Total solids.	Moisture.
	g.	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*			*P. ct.*	*P. ct.*	*P. ct.*
10	3,123	70.50	29.50	14.31	7.38	4.55	12.33	+6.0	—3.4	0.74		
10	2,488	76.50	23.50	14.01	7.95	3.78	12.15	+6.7	—3.4	0.92		
23	2,673	75.71	24.29	14.88	7.64	4.59	12.63	+6.3	—3.4	0.74	15.21	84.79
Average of 43 fruits	2,761	74.24	25.76	14.40	7.66	4.31	12.37	+6.3	—3.4	0.80		
10	2,865	71.63	28.37	14.11	8.01	4.32	12.74	+6.8	—3.4	0.67		
9	2,319	71.51	28.49	14.48	7.56	3.83	11.79	+6.2	—3.4	0.75	15.35	84.65
16	2,354	76.52	23.48	14.57	7.88	3.75	12.04	+7.2	—2.8	0.59	14.82	85.18
Average of 35 fruits	2,513	73.22	26.78	14.72	7.82	3.97	12.19	+6.7	—3.2	0.67		

Total fruit (less crown).				Edible portion.								Shaded or exposed.
Number of fruits.	Average weight.	Edible portion.	Waste.	Fiber.	Sucrose.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Protein (Nx6.25).	Ash.	Alkalinity of ash. K_2CO_3.	
	g.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		
10	3,123	70.50	29.50	0.46	6.51	4.25	11.10		0.53	0.50		Shaded.
10	2,488	76.50	23.50	0.47	6.69	3.68	10.70		0.54	0.66	0.23	Do.
23	2,673	75.71	24.29	0.49	7.08	4.51	11.96	0.55	0.45	0.77	0.23	Do.
Average of 43 fruits	2,761	74.24	25.76	0.47	6.76	4.15	11.25		0.51	0.64		Shaded.
10	2,865	71.63	28.37	0.48	6.59	3.83	10.77		0.57	0.51		Exposed.
9	2,319	71.51	28.49	0.44	6.61	3.77	10.73		0.48	0.68	0.24	Do.
16	2,354	76.52	23.48	0.40	7.08	3.67	11.12	0.54	0.39	0.67	0.22	Do.
Average of 35 fruits	2,513	73.22	26.78	0.44	6.76	3.76	10.87		0.48	0.62		Exposed.

TABLE 9.—*Showing changes in composition with the growth of Smooth Cayenne fruits.*

Total fruit (less crown).				Juice analysis.							Edible portion.		
Number of fruits.	Average weight.	Edible portion.	Waste.	Corrected Brix at 27.5° C.	Sucrose.	Invert sugars.	Total sugars as invert.	Polarization direct.	Polarization invert.	Acidity as citric.	Total solids.	Moisture.	Fiber.
	g.	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*			*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
20	541	62.34	37.66	6.58	0.78	2.63	3.45	+0.4	—0.6	0.22	7.14	92.86	0.80
10	1,843	69.65	30.35	6.11	2.37	2.26	4.75	+2.2	—0.8	0.37	7.89	92.11	0.56
10	438	60.85	39.15	7.84	2.21	2.75	5.08	+2.2	—0.6	0.50	9.04	90.96	0.56
20	1,183	67.74	32.26	7.04	3.28	2.58	6.03	+3.2	—1.0	0.53	8.70	91.30	0.52
10	2,664	71.09	28.91	7.61	3.41	2.65	6.24	+3.3	—1.0	0.48	9.38	90.62	0.58
10	1,420	68.25	31.75	10.34	5.37	2.68	8.33	+5.2	—1.6	0.67	10.95	89.05	0.54
2	2,017	70.74	29.26	10.01	6.00	2.96	9.27	+5.2	—2.4	0.78	11.62	88.38	0.49
2	2,486	72.19	27.81	12.04	6.72	3.63	10.70	+6.1	—2.4	0.85	13.15	86.85	0.47
9	2,208	71.51	28.49	14.48	7.56	3.83	11.79	+6.2	—3.4	0.75	15.35	84.65	0.44
4	2,979	77.81	22.19	14.53	8.68	3.78	12.65	+7.8	—3.4	0.67	15.30	84.70	0.45
9	2,639	77.21	22.79	15.02	8.39	4.78	13.61	+7.0	—3.6	0.57	15.51	84.49	0.54
12	2,223	75.24	24.76	15.57	9.31	4.55	14.35	+8.1	—3.6	0.61	16.59	83.41	0.55
2	2,576	75.74	24.26	15.37	9.65	4.72	14.88	+8.2	—4.0	0.79	16.31	--------	0.47

TABLE 9.—*Showing changes in composition with the growth of Smooth Cayenne fruits*—Continued.

Total fruit (less crown).				Edible portion.								
Number of fruits.	Average weight.	Edible portion.	Waste.	Sucrose.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Protein (Nx6.25).	Ash.	Alkalinity of ash K_2CO_3.	Age.	Source.
	g.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		*Months.*	
20	541	62.34	37.66	0.63	2.53	3.19	0.22	0.55	0.70	0.37	1–1.5	Laguna.
10	1,843	69.65	30.35	2.14	2.19	4.44	0.27	0.40	0.51	0.21	2	Do.
10	438	60.85	39.15	1.89	2.58	4.57	0.31	0.49	0.72	0.35	2	Lamao.
20	1,183	67.74	32.26	3.05	2.56	5.77	0.39	0.35	0.50	0.15	2.5	Laguna.
10	2,664	71.09	28.91	3.08	2.55	5.79	0.36	0.39	0.54	0.22	3–3.5	Do.
10	1,420	68.25	31.75	4.58	2.63	7.50	0.53	0.37	0.54	0.20	3–3.5	Bataan.
2	2,017	70.74	29.26	5.53	2.93	8.75	0.61	0.35	0.51	0.18	3–3.5	Silang.
2	2,486	72.19	27.81	6.32	3.45	10.10	0.65	0.38	0.58	0.20	4	Do.
9	2,208	71.51	28.49	6.61	3.77	10.73	--------	0.48	0.68	0.24	4	Laguna.
4	2,979	77.81	22.19	7.83	3.72	11.96	0.54	0.42	0.61	0.22	4	Bataan.
9	2,639	77.21	22.79	6.89	4.89	12.15	0.46	0.39	0.60	0.26	4.5–5	Laguna.
12	2,223	75.24	24.76	8.16	4.43	13.02	0.51	0.39	0.57	0.24	4.5–5	Bataan.
2	2,576	75.74	24.26	8.86	4.51	13.84	0.62	0.34	0.53	0.17	4.5–5	Silang.

TABLE 10.—*Analyses of the juice of green fruits and yellow fruits (Smooth Cayenne) from Bataan Province.*

Color.	Sucrose.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Polarization direct.	Polarization invert.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*		
Green	7.82	3.44	11.77	0.72	+7.1	—2.8
Do	8.29	4.18	12.91	0.63	+7.5	—3.0
Do	8.30	4.25	12.99	0.61	+7.3	—3.2
Do	9.56	4.28	14.34	0.69	+8.7	—3.4
Average	8.49	4.04	13.00	0.66	+7.7	—3.1
Yellow	7.35	3.49	11.13	0.69	+6.7	—2.6
Do	7.98	4.21	12.61	0.62	+7.1	—3.0
Do	8.61	4.25	13.31	0.54	+7.1	—3.8
Do	9.87	4.25	14.64	0.65	+8.9	—3.6
Average	8.45	4.05	12.92	0.62	+7.45	—3.3

Table 10 shows no important differences in the composition of the two groups. The figures indicate that the green color of a pineapple is not always a true indication of its immaturity or lack of ripeness.

Six pineapples, having an average weight of 2,980 grams, with 75.63 per cent of edible portion and 24.37 per cent of waste, were halved as nearly vertically as possible into green and yellow halves, and the edible portion of each half was separately analyzed for sugars and acidity.

TABLE 11.—*Sugars and acidity in green and yellow halves of Smooth Cayenne pineapples, halved vertically.*

Half.	Sucrose.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Polarization direct.	Polarization invert.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*		
Yellow side	8.77	4.25	13.48	0.49	+7.1	—4.0
Green side	9.16	4.32	13.96	0.41	+7.6	—4.0
Yellow side	7 34	4.67	12.40	0.44	+6.3	—3.0
Green side	7.74	4.72	12.87	0.50	+6.6	—3.2
Yellow side	7.58	4.47	12.45	0.51	+6.2	—3.4
Green side	8.53	4.51	13.49	0.52	+7.4	—3.4
Yellow side	9.01	4.95	14.43	0.43	+7.4	—4.0
Green side	8.68	4.90	14.04	0.44	+7.2	—3.8
Yellow side	8.77	4.72	13.95	0.46	+7.3	—3.8
Green side	8.85	4.72	14.03	0.49	+7.4	—3.8
Yellow side	8.37	3.83	12.56	0.61	+7.0	—3.6
Green side	7.82	3.86	12.09	0.61	+6.5	—3.4
Average yellow	8.31	4.37	13.23	0.49	+6.9	—3.6
Average green	8.46	4.51	13.41	0.50	+7.1	—3.6

The highest sucrose was found in a green side and the highest invert sugars in a yellow side. The highest total sugar was found in a yellow side. The lowest acidity was found in a green side. The averages show slightly higher results in all cases for the green sides; the variations were not great enough to indicate inferiority of quality in either portion of average fruit. Not only do individual fruits vary greatly in sugar content and acidity, but also portions of the same fruit show variations in percentages.

Two composites of ten fruits each and five individual fruits were analyzed to determine the difference in sugars and acidity in the upper and lower halves when cut horizontally.

Table 12 shows the lower half of the fruit in both the composites and the individual fruits to contain consistently a higher percentage of sucrose and total sugars and a lower percentage of acidity, regardless of the source or the varieties of pineapples used. These factors, with the data obtained in the analyses of the cores, indicate that the sweetest portion of the pineapple (the part containing the highest percentage of sugars) is found in the center of the base of the edible portion. It is quite probable that the sugar content gradually decreases outward and upward from this point, while the acidity increases in the same directions.

One hundred eighty ripe fruits of three types of native pineapples and some Smooth Cayennes from various sources were analyzed in groups of composites as outlined in Table 13 in order to find if any variations existed in composition of the cores and of the edible portions.

The core of the native pineapple is in most cases so hard that it is not edible. It is regretted that the determination of fiber content was neglected in this work. However, it is quite obvious that the fiber content is much higher in the native pineapple than in the Smooth Cayenne. Juice analyses of a composite of an assortment of thirty-nine small native pineapples of indefinite storage in the Manila markets show the edible portion to be higher than the core in all determinations. The cylindrical fruit from Silang shows the edible portion to be higher in Brix, sucrose, and acidity, but lower in invert sugars and total sugars as invert, while the barrel-shaped fruit from the same place shows the edible portion to be higher in Brix, invert sugars, total sugars, and acidity, but lower in sucrose.

TABLE 12.—*Brix-sugars and acidity in upper and lower halves of pineapples.*

Number of fruits.	Part.	Juice analysis. Sucrose.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Polarization direct.	Polarization invert.	Corrected Brix 27.5°C.
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*			
1 {10	Upper	7.41	2.61	10.41	0.85	+6.1	—3.4	10.89
1 {10	Lower	7.96	2.77	11.16	0.85	+7.4	—2.8	12.69
Average		7.69	2.69	10.79	0.85	+6.8	—3.1	11.79
2 {10	Upper	6.64	3.44	10.43	0.87	+6.1	—2.4	12.67
2 {10	Lower	9.84	5.00	15.36	0.72	+9.0	—3.6	16.77
Average		8.24	4.22	12.90	0.80	+7.6	—3.0	14.72
3 {1	Upper							
3 {1	Lower							
4 {1	Upper							
4 {1	Lower							
5 {1	Upper							
5 {1	Lower							
6 {1	Upper							
6 {0	Lower							
7 {1	Upper							
7 {1	Lower							
Average Smooth Cayenne, Laguna	Upper							
	Lower							

TABLE 12.—*Brix-sugars and acidity in upper and lower halves of pineapples*—Continued.

Juice analysis.		Edible portion.						Variety and source.
Number of fruits.	Part.	Sucrose.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Polarization direct.	Polarization invert.	
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*			
1 { 10	Upper	5.93	2.56	8.8	0.75	+5.4	—2.8	Native.
1 { 10	Lower	7.65	2.52	10.57	0.71	+7.0	—2.8	Do.
Average		6.79	2.54	9.69	0.73	+6.2	—2.8	
2 { 10	Upper	5.93	2.27	8.51	0.75	+5.2	—2.4	Smooth Cayenne; Laguna.
2 { 10	Lower	9.21	4.95	14.64	0.63	+8.2	—3.6	Do.
Average		7.57	3.61	11.58	0.69	+6.7	—3.0	
3 { 1	Upper	6.96	3.98	11.31	0.57	+6.0	—2.6	Smooth Cayenne; Laguna.
3 { 1	Lower	8.85	4.39	13.71	0.38	+8.0	—3.2	Do.
4 { 1	Upper	6.01	3.72	10.05	0.63	+5.2	—2.4	Do.
4 { 1	Lower	8.93	4.32	13.72	0.44	+8.1	—3.2	Do.
5 { 1	Upper	6.64	3.69	10.68	0.63	+6.0	—2.4	Do.
5 { 1	Lower	9.17	4.43	14.08	0.44	+8.0	—3.4	Do.
6 { 1	Upper	6.88	3.92	11.16	0.61	+6.1	—2.6	Do.
6 { 1	Lower	10.20	4.40	15.14	0.42	+8.3	—3.6	Do.
7 { 1	Upper	7.03	3.69	11.09	0.68	+6.1	—2.8	Do.
7 { 1	Lower	9.49	4.18	14.17	0.48	+8.4	—3.6	Do.
Average Smooth Cayenne, Laguna.	Upper	6.7	3.8	10.86	0.62	+5.88	—2.56	
	Lower	9.33	4.34	14.96	0.43	+8.16	—3.40	

TABLE 13.—*Analyses of juices of cores of ripe pineapples with composition of edible portions.*

Part.	Total fruit (less crown).				Juice analysis.							Class, shape, color, and source.
	Number of fruits.	Average weight.	Edible portion.	Waste.	Corrected Brix at 27.5° C.	Sucrose.	Invert sugars.	Total sugars as invert.	Polarization direct.	Polarization invert.	Acidity as citric.	
		g.	P. ct.	P. ct.		P. ct.	P. ct.	P. ct.			P. ct.	
Core	39	847	61.56	38.44	9.61	4.95	3.09	8.3	+4.3	—2.0	0.75	Native; barrel; orange; Manila markets.
Edible portion	39	847	61.56	38.44	11.01	5.9	3.19	9.4	+5.0	—2.4	1.08	Do.
Core	16	1,122	67.39	32.61	11.58	6.95	3.23	10.55	+6.2	—2.6	0.43	Native; cylindrical; orange red; Silang.
Edible portion	16	1,122	67.39	32.61	12.71	7.01	3.11	10.49	+6.3	—2.6	0.94	Do.
Core	20	1,132	67.41	32.59	13.38	7.82	3.27	11.50	+7.3	—2.6	0.58	Native; barrel; greenish yellow; Silang.
Edible portion	20	1,132	67.41	32.59	13.48	7.66	3.51	11.57	+6.9	—2.8	0.66	Do.
Core	4	2,979	77.81	22.19	12.44	8.43	2.24	11.11	+7.6	—3.2	0.80	Bataan.
Edible portion	4	2,979	77.81	22.19	14.53	8.68	3.78	12.65	+7.8	—3.4	0.67	Do.
Core	35	2,513	73.22	26.78	14.01	8.96	3.31	12.74	+8.4	—3.0	0.38	Laguna; exposed Smooth Cayenne.
Edible portion	35	2,513	73.22	26.78	14.72	7.82	3.97	12.19	+6.7	—3.2	0.67	Do.
Core	43	2,761	74.24	25.76	13.74	8.65	3.49	12.59	+8.0	—3.0	0.41	Laguna; shaded Smooth Cayenne.
Edible portion	43	2,761	74.24	25.76	14.40	7.66	4.31	12.37	+6.3	—3.4	0.80	Do.
Core	10	2,793	70.10	29.9	13.91	9.05	3.44	12.96	+9.0	—3.4	0.31	Laguna; large Smooth Cayenne.
Edible portion	10	2,793	70.10	29.9	15.04	8.16	4.04	12.63	+7.4	—3.0	0.61	Do.
Core	13	1,593	71.90	28.1	14.64	10.12	3.31	13.96	+9.3	—3.6	0.32	Laguna; small Smooth Cayenne.
Edible portion	13	1,593	71.90	28.1	15.80	9.51	3.86	13.87	+8.5	—3.6	0.76	Do.

Apparently the native varieties are not consistent in their variations in the composition of the core and of the edible portion, even when the fruits are obtained from the same source and as nearly as possible in the same condition of ripeness.

Although only four Smooth Cayenne pineapples were obtainable from Bataan, yet it is interesting to note that the composite edible portion of these has a higher Brix, sucrose, invert sugar, total sugar, and lower acidity than has the core. On the other hand, Smooth Cayenne pineapples obtained from Laguna, both those grown under shade and those exposed, and also the large and small fruits, consistently show an edible portion having a juice of higher Brix reading, lower sucrose content, lower total sugars as invert, and higher percentages of invert sugars and acidity. This indicates that from the core to the outer portion of the fruit there is a gradual increase in Brix, invert sugars, and acidity, and a decrease in sucrose content of the juice.

The cores of the Smooth Cayenne are more succulent and sweeter than are those of the native varieties. When the hard native cores are compared with the soft, sweet ones of the Smooth Cayenne and the quantity of core remaining in the slices of canned pineapple is considered, it seems rather doubtful that a hybrid of these two varieties would be a highly suitable product for canning purposes from the standpoint of edibility of the remaining core. The analyses and taste indicate that the barrel-shaped greenish yellow variety would be the most acceptable of the three classes of native pineapple as to flavor.

A brown rot caused in the fruitlets of Smooth Cayenne pineapples by an undescribed yellow facultative anaërobe has been reported by Mr. F. Serrano, of the coöperative plant pathology laboratory, Bureau of Science and Bureau of Agriculture. The fruits used in his investigation were analyzed as part of this work. During the progress of our analyses we noticed that as the rainy season progressed the diseased condition of the fruit appeared to develop more rapidly; that is, the area of disease in the fruits was more extensive and pronounced at this time than in fruits cut during the dry season.

Table 14 shows analyses of forty-one fruits at different stages of the disease. The sucrose content in the badly diseased fruits varies from 8.53 to 10.29 per cent. A comparison of Tables 6 and 14 and their averages shows that the composition of the diseased and the sound healthy fruits of approximately the same

TABLE 14.—*Analyses of diseased Smooth Cayenne pineapples.*

Total fruit (less crown).				Juice analysis.							Edible portion.			
Number of fruits.	Average weight.	Edible portion.	Waste.	Corrected Brix at 27.5°C.	Sucrose.	Invert sugars.	Total sugars as invert.	Polarization direct.	Polarization invert.	Acidity as citric.	Total solids.	Moisture.	Fiber.	Sucrose.
	g.	P. ct.	P. ct.		P. ct.	P. ct.	P. ct.			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7	1,550	74.09	25.91	15.01	8.53	4.59	13.56	+7.2	—3.6	0.74	15.97	84.03	0.47	8.21
5	2,428	78.05	21.95	15.26	8.15	4.92	13.50	+7.1	—3.2	0.64	16.12	83.88	0.53	7.75
12	2,162	74.05	25.95	15.43	8.79	4.59	13.84	+7.7	—3.4	0.65	16.67	83.33	0.47	7.92
13	2,802	75.39	24.61	15.86	7.99	5.33	13.74	+6.4	—3.7	0.67	16.42	83.58	0.52	7.32
1	2,138	73.99	26.01	16.38	10.29	4.55	15.38	+9.2	—3.8	0.63	17.72	82.28	0.48	9.58
3				14.44	8.53	4.01	12.99	+7.3	—3.4	0.73	15.33	84.67	0.50	7.51
Average of 41 diseased fruits	2,216	75.11	24.89	15.40	8.71	4.67	13.84	+7.5	—3.5	0.68	16.37	83.63	0.50	8.05
Average of 167 sound fruits	2,567	74.44	25.56	14.82	8.38	4.21	13.01	+7.3	—3.3	0.70	15.59	84.41	0.47	7.50

Total fruit (less crown).				Edible portion.						Condition of disease.	Source.
Number of fruits.	Average weight.	Edible portion.	Waste.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Protein (Nx6.25).	Ash.	Alkalinity of ash K_2CO_3.		
	g.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.			
7	1,550	74.09	25.91	4.16	12.80	0.70	0.33	0.57	0.22	Slight	Bataan.
5	2,428	78.05	21.95	4.79	12.95	0.46	0.40	0.59	0.25	do	Laguna.
12	2,162	74.05	25.95	4.25	12.58	0.55	0.34	0.48	0.19	do	Bataan.
13	2,802	75.39	24.61	4.93	12.63	0.60	0.41	0.63	0.27	Diseased	Laguna.
1	2,138	73.99	26.01	4.51	14.59	0.52	0.37	0.54	0.20	Badly diseased	Bataan.
3				3.98	11.99	0.42	0.34	0.53	0.19	do	Laguna.
Average of 41 diseased fruits	2,216	75.11	24.89	4.44	12.92	0.54	0.37	0.56	0.22	Diseased	Average.
Average of 167 sound fruits	2,567	74.44	25.56	4.00	11.90	0.57	0.43	0.59	0.22	Sound	Do.

condition of ripeness does not differ sufficiently to indicate any marked depreciation in the quality or flavor of the fruit. The averages show no great consumption of sugars or increase in acidity that might be attributed to the action of the bacteria.

Variations in composition of healthy and of diseased halves of ripe Smooth Cayenne pineapples are not sufficiently great to be attributed to any factor other than the natural variations in composition of the fruits, or in parts of the fruits. It is almost impossible to select diseased pineapples without cutting them. Consequently it was found necessary to utilize such material as was available for this work.

Although the fruits were mature and for all practical purposes ripe, it is quite possible that some of the specimens analyzed in Table 15 possessed green and yellow surfaces. Consequently slightly larger differences in composition are probably due to the naturally varying content of sugars and acidity in such halves (Table 16).

Only the diseased spots were cut from four badly diseased fruits and analyses made of the healthy and the diseased parts, to determine whether the fruit mass actually in contact with the disease showed any great change in composition attributable to bacterial action. The area in intimate contact with the disease gives a juice of lower Brix reading, lower percentages of sugars, acidity, fiber, total solids, and protein, with higher moisture and ash percentages. Considering the slight differences in the acidity and the higher purity of the juice of the diseased parts, it may be inferred that the juice of the diseased portion is not inferior in flavor to that of the healthy portion, unless the bacteria themselves impart a distinctive flavor to the fruit. Diseased sections were tasted and no difference in flavor was observed. It seems plausible to conclude that the disease injures the value of the fruit from the standpoint of appearance rather than by any change in chemical composition.

A search of available literature for data from other countries for comparative purposes resulted in the following incomplete table (Table 17).

The difference in the percentages of edible portion may be due to the fact that the crowns were not included as a portion of the fruit in our analyses. Table 17 shows a marked difference in the percentages of protein. No doubt, if averages were now obtained on the same numbers of Smooth Cayenne pine-

TABLE 15.—*Analyses of diseased and healthy halves of the same pineapples (Smooth Cayenne, from Laguna) halved vertically.*

Total fruit (less crown).		Juice analysis.							Edible portion.	
Number of fruits.	Half.	Corrected Brix at 27.5°C.	Sucrose.	Invert sugars.	Total sugars as inverts.	Polarization direct.	Polarization invert.	Acidity as citric.	Total solids.	Moisture.
			P. ct.	*P. ct.*	*P. ct.*			*P. ct.*	*P. ct.*	*P. ct.*
4	Healthy	13.48						0.68	14.14	85.86
	Diseased	14.21						0.67	15.27	84.73
2	Healthy	14.54	8.36	3.49	12.29	+7.4	—3.2	0.57	15.07	84.93
	Diseased	14.94	8.66	3.75	12.86	+7.8	—3.2	0.56	15.67	84.33
4	Healthy	15.27	9.13	3.75	13.36	+8.2	—3.4	0.57	15.81	84.19
	Diseased	13.14	7.08	3.80	11.25	+6.0	—3.0	0.48	13.74	86.26
1	Healthy								16.88	
	Diseased									
Average healthy		14.43	8.75	3.62	12.83	+7.8	—3.3	0.61	15.48	84.99
Average diseased		14.09	7.87	3.78	12.06	+6.9	—3.1	0.57	14.87	85.11

Total fruit (less crown).		Edible portion.							
Number of fruits.	Half.	Fiber.	Sucrose.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Protein (Nx6.25).	Ash.	Alkalinity of ash K_2CO_3.
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	
4	Healthy	0.42	6.45	4.17	10.96		0.50	0.62	0.21
	Diseased	0.41	6.45	4.14	10.93		0.55	0.71	0.25
2	Healthy	0.35	7.2	3.42	11.04	0.34	0.42	0.76	0.22
	Diseased	0.46	8.18	3.69	12.30	0.48	0.47	0.72	0.21
4	Healthy	0.45	7.71	3.64	11.76	0.48	0.38	0.65	0.21
	Diseased	0.47	6.53	3.75	10.62	0.40	0.36	0.64	0.20
1	Healthy	0.47	9.25	4.55	14.29	0.38	0.34	0.63	0.20
	Diseased	0.39	7.90	4.14	12.46	0.39	0.32	0.59	0.21
Average healthy		0.42	7.65	3.95	12.01	0.40	0.41	0.66	0.21
Average diseased		0.43	7.27	3.93	11.58	0.42	0.43	0.67	0.22

TABLE 16.—*Analyses of diseased and healthy portions of the same pineapples.*

Total fruit (less crown).		Juice analysis.							Edible portion.	
Number of fruits.	Part.	Corrected Brix at 27.5°C.	Sucrose.	Invert sugars.	Total sugars as invert	Polarization direct.	Polarization invert.	Acidity as citric.	Total solids	Moisture.
			P. ct.	*P. ct.*	*P. ct.*			*P. ct.*	*P. ct.*	*P. ct.*
4	Healthy	16.04	8.79	4.51	13.77	+8.0	—3.2	0.49	16.76	83.24
4	Diseased	13.84	8.55	4.32	13.32	+7.7	—3.2	0.45	13.71	86.29

Total fruit (less crown).		Edible portion.							
Number of fruits.	Part.	Fiber.	Sucrose.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Protein (Nx6.25).	Ash.	Alkalinity of ash K_2CO_3.
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	
4	Healthy	0.45	7.85	4.43	12.69	0.43	0.38	0.75	0.26
4	Diseased	0.40	7.85	4.25	12.51	0.39	0.37	0.88	0.30

TABLE 17.—*Comparison of analyses of Smooth Cayenne pineapples grown in Florida, Hawaii, and the Philippines.*

Source.	Variety.	Edible portion.	Waste.	Sucrose.	Invert sugars.	Acidity as citric.	Ash.	Protein (Nx6.25).
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Florida (1 sample) [a]	Smooth Cayenne	62.8	37.2	8.86	4.05	0.85	0.42	0.56
Hawaiian (19 samples) [b]	do			7.88	4.23	1.05		0.50
Philippines (167 samples)	do	74.44	25.56	8.38	4.21	0.70	0.59	0.43

[a] Data from H. H. Hume, Bul. 70, Florida Agr. Exp. Sta.   [b] Data from W. P. Kelley, Laboratory of Hawaiian Exp. Sta., Paper No. 3.

apples grown in Hawaii, Florida, and the Philippines, such averages would show very close resemblance to each other.

SUMMARY AND CONCLUSIONS

1. The growth of pineapple culture in central Luzon is briefly outlined.

2. Figures are given showing the cost of planting a hectare, harvesting and placing the pines on the Manila market, and the net profits therefrom.

3. The methods of grading and the approximate percentages of each grade obtainable, per hectare, are given, with the wholesale price per crate of each grade.

4. Climate and soil conditions are discussed.

5. Smooth Cayenne and native pineapples are described and their differences in chemical composition shown.

Tabulated analyses are given showing:

(*a*) Variations in composition with size of the fruit.
(*b*) Composition of shaded and exposed fruits.
(*c*) Changes in composition with growth of the fruit.
(*d*) Composition of the juices of mature green and mature yellow fruits.
(*e*) Variations in composition of green and of yellow halves of the same fruits, halved vertically.
(*f*) Variations in composition of upper and lower halves of the same fruits.
(*g*) Variations in composition between the cores and the edible portions of the same fruits.
(*h*) Composition of diseased fruits and a comparison of determinations made on diseased portions with healthy portions of the same fruits.
(*i*) Composition of Smooth Cayenne pineapples grown in Florida, Hawaii, and the Philippines.
(*j*) Composition of fruits grown from deteriorated stock.

The Smooth Cayenne is the accepted best variety grown in the Philippines for table and canning purposes. The average ripe fruit of this type grown from stock introduced from Hawaii has approximately a corrected Brix reading of 14.80, total sugars as invert of about 13 per cent, and an acidity as citric of about 0.70 per cent.

Fruits ripening during the rainy season in central Luzon rapidly decrease in aroma and become less solid and inferior in flavor with a concomitant increase in area of infection from an undescribed bacterium.

One of the oldest plantations reports the percentage of infected fruits to be not over 1 to 2 per cent.

With proper precautions in the selection of stock and soil and with good cultivation and care, Smooth Cayenne pineapples of uniformly fine quality, practically free from disease, should be obtained in the Philippines with high percentages of yields and with low costs for land and for labor.

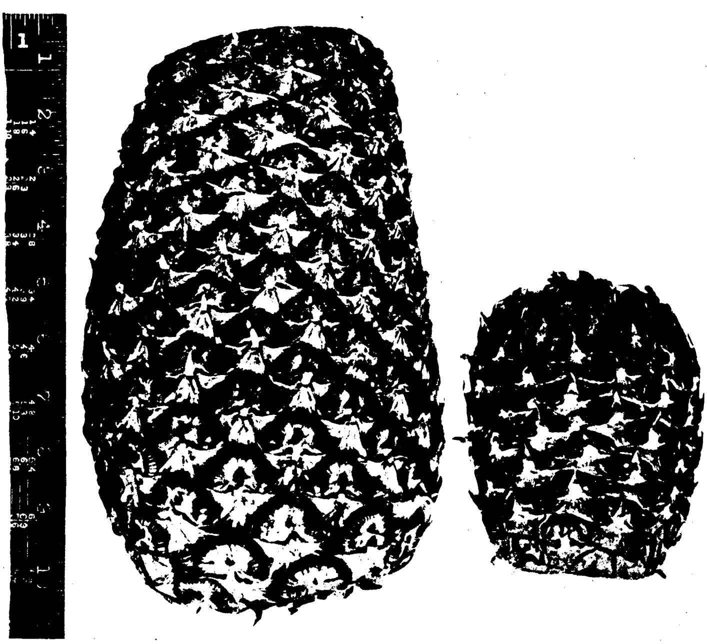
ILLUSTRATIONS

1

2

PLATE 1. COMMON PHILIPPINE PINEAPPLES.

1



2

PLATE 2. SMOOTH CAYENNE PINEAPPLES.

NOTES ON THE SEROLOGICAL RELATIONSHIP OF THE CHOLERALIKE VIBRIOS ISOLATED FROM HUMAN BEINGS AND FROM WATERS IN MANILA

By ONOFRE GARCIA

Of the Division of Biology and Serum Laboratory
Bureau of Science, Manila

Following the cholera outbreak of 1925 in the City of Manila and neighboring provinces, an attempt was made by the Philippine Health Service to trace the probable source of infection in the Manila water resources. From September 23, 1925, to April 8, 1926, about 1,500 samples of water were submitted to the Bureau of Science and examined for the presence of vibrios. A very extensive survey was made by the special representative of the Philippine Health Service in Manila Bay, of the water samples taken from which vibriolike microörganisms were frequently found.

In connection with the study of choleralike organisms a special investigation was made of the possible relationship of cholera-like vibrios isolated from water with those isolated from human beings, and that investigation forms the topic of this paper.

SOURCES AND HISTORY OF CULTURES OF VIBRIOS

I. Three choleralike vibrios isolated from human fæces:

- H–1. Isolated from the intestine of an autopsied case on October 7, 1925. Diagnosed as chronic interstitial nephritis.
- H–7. Isolated from the intestine of an autopsied case. Request No. 466–5B.
- H–14. Isolated from a food handler on May 15, 1925.

II. Five choleralike vibrios isolated from water:

- WT–9. From a dug well in Malabon. Isolated on October 13, 1925.
- WT–58. Isolated from sea water (Manila Bay); sample taken a half mile away from shore at a place called Bahay Pare, on October 23, 1925.
- WT–83. Isolated from sea water a half mile offshore, opposite Maytubig, on October 31, 1925 (Manila Bay).
- WT–110. Isolated from sea water opposite a place called Baclaran, on October 31, 1925 (Manila Bay).
- WT–137. Isolated from estero Reina Regente, a branch of Pasig River, on December 10, 1925.

III. True cholera vibrios, two strains:

Ch. 22. A strain used for the production of Bureau of Science anti-cholera serum.

Ch. 480. Isolated at autopsy from a clinically and anatomically typical case of cholera, on September 21, 1925.

METHODS OF STUDY

The three human choleralike vibrios were used for the production of specific sera and marked according to their respective cultures. These are referred to as human choleralike sera (H–1, H–7, H–14). Cross agglutination tests were made with the three sera (see Table 1).

A dilution of 1: 50 of each of the three sera thus produced was used in agglutination tests performed with 250 strains of vibriolike organisms isolated from fish (12 strains), shrimp (1 strain), shell fish (4 strains), sewage (2 strains), drinking water (121 strains), and sea water (110 strains). Sixteen of the 250 strains were found agglutinable; eleven by the serum H–1, five by the serum H–14, and none by the serum H–7. Higher dilutions (up to 1: 1600) were prepared of the sera H–1 and H–14. These were tested with the sixteen previously employed strains of vibrios. The interesting result was that only four strains were agglutinated by serum H–1 and one strain by serum H–14, giving complete agglutination in both sera in the dilution 1: 1600.

Agglutination tests were made using an emulsion of about two thousand millions of the organisms per cubic centimeter so that the addition of an equal volume of diluted serum would result in a transparency of about one thousand millions per cubic centimeter. The total volume in case of both the agglutination and absorption tests was 2 cubic centimeters. In the absorption tests a 1: 25 dilution of the serum was prepared and absorbed by the organism concerned, and incubated at 37° C. for about three hours. After that time all tubes showing marked agglutination were centrifuged, and the clear supernatant fluid was again similarly treated with the respective vibrios. Incubation overnight followed. When the upper portion of the liquid remained turbid or slightly cloudy the absorption was considered as completed. Then all tubes were centrifuged at a high speed to throw down the bacteria, and the clear supernatant fluids were decanted, properly diluted, and used for agglutination tests. Dilutions were made with 0.9 per cent sodium chloride and 24-hour-old cultures on alkaline agar (—1 per cent phenolphthalein) were used.

STUDY OF AGGLUTINATION AND ABSORPTION TESTS OF THE CULTURES WITH THEIR CORRESPONDING SERA

The agglutinability of the cultures of human and water choleralike vibrios and the true cholera vibrios was tested against the following sera: Bureau of Science anticholera serum, H–1, H–14, WT–58, WT–83, WT–110, and WT–137. Tables 2 and 3 show clearly that in high dilution these sera agglutinated only their respective homologous cultures and the ones that are similar to them with respect to agglutination.

In the absorption tests the following procedure was followed:

First, the sera used for agglutination tests (B. Sc. H–1, H–14, WT–58, WT–83, WT–110, and WT–137) were absorbed by their homologous cultures and tested against the human and the water choleralike vibrios and the true cholera vibrios. Table 4 clearly shows that the agglutinins of each serum were absorbed by the homologous cultures, leaving practically no agglutinins for itself nor for the others which were previously agglutinated.

Second, serum H–1 was absorbed by its homologous culture and tested against all water choleralike vibrios (see Table 5, I). Again, each serum prepared from water vibrios was separately absorbed by the other water choleralike cultures, and tested with the same cultures used for absorption (see Table 6, I, II, III, and IV), and again each water choleralike serum was absorbed by the human choleralike vibrio H–1, and tested afterward with culture H–1 (see Table 7). Lastly, the human choleralike serum (H–1) was absorbed by each of the choleralike vibrios from waters (see Table 8) and tested with the same water choleralike cultures.

Third, human choleralike serum H–1 and Bureau of Science anticholera serum were each absorbed separately by one strain of water choleralike vibrio (WT–9), by three strains of human choleralike vibrios (H–1, H–7, and H–14), and by two strains of true cholera vibrios (Ch. 22 and Ch. 480). The sera thus absorbed were then tested with the cultures used for absorptions and controlled by homologous cultures (H–1 and Ch. 22). (See Table 9.)

Fourth, serum H–14 was absorbed by its homologous culture and was then tested against the water choleralike vibrio (WT–9), which was previously found to be agglutinated by serum H–14 (see Table 5, II). Culture H–14 absorbed the agglutinins of its homologous serum H–14 leaving no agglutinins for itself and for culture WT–9. When culture WT–9 was used for the absorption of serum H–14 it gave the same result as did its own homologous culture.

FINDINGS

Sera were prepared with the human choleralike vibrios (H–1, H–7, and H–14). In carrying out the cross-agglutination with these three human choleralike vibrios, it was found that they were serologically different from each other (see Tables 1, 2, and 3). A dilution of 1:50 was prepared of each of the three human choleralike sera (H–1, H–7, and H–14). Only sixteen of the 250 strains isolated from waters of different sources were agglutinated in this dilution. These sixteen strains were subjected to agglutination test using higher dilutions (1:1600) of the same sera. Of these sixteen strains four (WT–58, WT–83, WT–110, and WT–137) were agglutinated by the serum H–1, and one (WT–9) by the serum H–14. None was agglutinated by the serum H–7 in this high dilution. These five strains that were agglutinated to a higher dilution than 1:50 were vibrios isolated from waters and were the ones selected as the material for study.

The absorption test showed that the human choleralike vibrios absorbed their own agglutinins and those for water choleralike vibrios that were found previously agglutinable by their respective sera (see Tables 4 and 5, I and II). Each water choleralike vibrio absorbed the agglutinins for itself and for the other water choleralike vibrios of the same serological group (see Table 6). Human choleralike vibrios absorbed the agglutinins for the water choleralike vibrios completely. As Tables 7 and 8 show, they gave reciprocal absorption reaction. Human choleralike vibrios and water choleralike vibrios did not absorb the agglutinins of the anticholera serum. The agglutinins of the human choleralike serum (H–1) were not absorbed by the true cholera vibrios (Ch. 22 and Ch. 480). Nor were they absorbed by either the water choleralike vibrio (WT–9) or by the human choleralike vibrios (H–7 and H–14) that belonged in a different serological group (see Table 9).

DISCUSSION

From the standpoint of the history of the choleralike vibrios isolated from the water, it is interesting to note the wide distribution of this choleralike organism, the places from which the samples were taken being widely separated. Their serological affiliation with the choleralike vibrios isolated from human stools is evidently shown by the result of the serological study of the cultures herein employed.

By agglutination tests, Greig (1) found it possible to classify into six groups most of the vibrios isolated from the water, but some remained ungrouped. He endeavored to correlate the choleralike organisms isolated from the water with high titer agglutinating sera prepared with choleralike vibrios isolated from stools of cholera cases in Calcutta, but none reacted with the sera prepared with the stool vibrios. He then studied 39 strains of choleralike vibrios isolated from water. It should be noted that our samples of water were collected at the end of the 1925 cholera outbreak. In connection with this, it is worth while to quote the statement of Schöbl (2) in regard to the study of viability of the cholera vibrios by inoculating fresh and sea water with cholera stool. He says:

> The theoretical possibility in the Philippine Islands of introducing Asiatic cholera from port to port by means of water carried on ships and of maintaining a source of infection in waters polluted with human excreta finds experimental corroboration.

He demonstrated that cholera vibrios may survive in sterile sea water inoculated with cholera fæces for as long as one hundred six days.

The serological qualities of the choleralike vibrios as distinct from true cholera vibrios define their present status as non-agglutinable and agglutinable cholera vibrios when high-titer cholera serum is used. The cultural and sugar reactions of the eight cultures of choleralike vibrios that were studied and are presented in this paper were the same as those of true cholera vibrios. The water and human choleralike vibrios were strongly hæmolytic. The theoretical consideration of the possible alteration of the receptors of the bacterial cell remains as yet to be investigated.

SUMMARY AND CONCLUSIONS

Five choleralike vibrios isolated from water were found serologically and otherwise identical with choleralike vibrios isolated from human beings. Both the human and the water choleralike vibrios were strongly hæmolytic. Their sugar reactions were identical with those of true cholera vibrios.

In many instances choleralike vibrios were frequently found in stools of healthy persons in the beginning or toward the end of outbreaks of cholera. Furthermore, nonagglutinable choleralike vibrios may be found simultaneously or alternatively with agglutinable cholera vibrios in cholera patients and convalescents. The finding of nonagglutinable choleralike vibrios in waters that are culturally and serologically identical with those found in human fæces may be significant from the epidemiological standpoint. In as much as these water choleralike vibrios were found in the sea water and in the water from a dug well, in sea food, and in certain drinking waters, the presence of these vibrios must be considered as a source of infestation by means of those so frequently encountered in the Philippines in healthy carriers. By analogy with the interpretation of the finding of *Bacillus coli* in drinking waters as an indicator of fæcal contamination the finding of the nonagglutinable choleralike vibrios, particularly those that are not only culturally but also serologically identical, can be safely used as an indicator of pollution with carrier fæces.

KEY TO TABLES

++++, complete agglutination.
+++, almost complete agglutination.
++, weak agglutination.
+, very weak agglutination.
±, trace (ocular).
—, negative.

ACKNOWLEDGMENT

Thanks are due to Dr. Otto Schöbl, chief of the division, for his kind advice and valuable sugestions.

REFERENCES

1. GREIG, E. D. W. The serological investigation and classification of choleralike vibrios isolated from water in Calcutta. Ind. Journ. Med. Res. **3** (1915–1916) 628–637.
2. SCHÖBL, O. The vitality of the cholera vibrio in Manila waters. Philip. Journ. Sci. § B **9** (1914) 479–481.

TABLE 1.—*Showing the results of cross-agglutination tests of the three human choleralike-vibrio sera with their corresponding cultures.*

Culture, human choleralike vibrio.	Human choleralike serum (H-1).								Human choleralike serum (H-7).			
	1:50	1:100	1:200	1:400	1:800	1:1600	1:3200	Control.	1:50	1:100	1:200	1:400
H-1	++++	++++	++++	++++	++++	++++	++++	—	—	—	—	—
H-7	—	—	—	—	—	—	—	—	++++	++++	++++	++++
H-14	—	—	—	—	—	—	—	—	—	—	—	—

Culture, human choleralike vibrio.	Human choleralike serum (H-7).				Human choleralike serum (H-14),							
	1:800	1:1600	1:3200	Control.	1:50	1:100	1:200	1:400	1:800	1:1600	1:3200	Control.
H-1	—	—	—	—	—	—	—	—	—	—	—	—
H-7	++++	++++	++++	—	—	—	—	—	—	—	—	—
H-14	—	—	—	—	++++	++++	++++	++++	++++	++++	++++	—

TABLE 2.—*Showing the agglutination tests of human and water choleralike vibrios and true cholera vibrios by one cholera serum, two human choleralike sera, and four water choleralike sera.*

Culture employed.	Anticholera serum.		Serum H-1.		Serum H-14.		Serum WT-58.		Serum WT-83.		Serum WT-110.		Serum WT-137.	
	Dilution 1 to—	Reading.	Dilution 1 to—	Reading.	Dilution 1 to—	Reading.	Dilution 1 to—	Reading.	Dilution 1 to—	Reading.	Dilution 1 to—	Reading.	Dilution 1 to—	Reading.
H-1	25	+	1600	++++	25–100	++ ±	1600	++++	1600	++++	1600	++++	1600	++++
H-7	25	—	25–50	++ +	25–100	++ ±	25	—	25	—	25	—	25	+
H-14	25–50	+ ±	25–200	++ ±	1600	++++	25–400	+++ +	25–200	++ +	25–200	++ +	25–400	+++ ±
WT-9	25	—	25–200	++ ±	1600	++++	25–50	+ ±	25	+	25	+	25	—
WT-58	25–50	++ ±	1600	++++	25	±	1600	++++	1600	++++	1600	++++	1600	++++
WT-83	25–100	+ ±	1600	++++	25	—	1600	++++	1600	++++	1600	++++	1600	++++
WT-110	25–50	+ +	1600	++++	25	—	1600	++++	1600	++++	1600	++++	1600	++++
WT-137	25	+	1600	++++	25	—	1600	++++	1600	++++	1600	++++	1600	++++
Chol. 22	1600	++++	25–200	+++ ±	25–200	++ +	25	±	25	+	25–50	+ ±	25	±
Chol. 480	1600	++++	25–200	++ ±	25–200	++ +	25	—	25	—	25	—	25	—

TABLE 3.—*Showing the results of cross-agglutination test of the ten cultures by the use of their corresponding sera.*

Choleralike and anticholera serum.	Human and water choleralike vibrios and true cholera vibrios.											
	WT-58	WT-83	WT-110	WT-137	H-1	H-7	H-14	WT-9	Ch-22	Ch-480	Titer.	Dilution employed.
WT-58	++++	++++	++++	++++	++++	—	—	+	—	—	1600	1:200
WT-83	++++	++++	++++	++++	++++	—	—	±	—	—	1600	1:200
WT-110	++++	++++	++++	++++	++++	—	—	+	—	—	1600	1:200
WT-137	++++	++++	++++	++++	++++	—	—	+	—	—	1600	1:200
H-1	++++	++++	++++	++++	++++	—	+	+	—	—	3200	1:200
H-7	—	—	—	—	—	++++	—	+	—	—	1600	1:200
H-14	+	—	—	—	—	—	++++	++++	—	—	3200	1:200
Ch-22	—	—	—	±	—	—	±	++	++++	++++	1600	1:200
Control	—	—	—	—	—	—	—	—	—	—	(a)	(a)

[a] Salt solution.

TABLE 4.—*Showing the results of absorption test of human and water choleralike sera and cholera serum by their homologous cultures.*

Serum—	Absorbed by culture—	H-1	H-7	H-14	WT-9	WT-58	WT-83	WT-110	WT-137	Ch-22	Ch-480	Dilution.	Titer sera.
Ch-22	Ch-22	—	—	—	—	—	—	—	—	±	—	1:200	1600
H-1	H-1	—	—	—	—	—	—	—	—	—	—	1:200	3200
H-14	H-14	—	—	±	—	—	—	—	—	—	—	1:200	3200
WT-58	WT-58	—	—	—	—	±	—	—	—	—	—	1:200	1600
WT-83	WT-83	—	—	—	—	—	—	—	—	—	—	1:200	1600
WT-110	WT-110	—	—	—	—	—	—	—	—	—	—	1:200	1600
WT-137	WT-137	—	—	—	—	—	—	—	—	—	—	1:200	1600

TABLE 5.—*Showing the results of absorption test of human choleralike sera (H-1 and H-14) by their homologous cultures and tested against choleralike vibrios from water.*

Culture.	1:50	1:100	1:200	1:400	1:800	Control.
I. Absorbed H-1 serum by culture H-1.						
WT-58	—	—	—	—	—	—
WT-83	—	—	—	—	—	—
WT-110	—	—	—	—	—	—
WT-137	—	—	—	—	—	—
H-1	+	—	—	—	—	—
II. H-14 serum absorbed by culture H-14.						
WT-9	—	—	—	—	—	—
H-14	±	—	—	—	—	—

TABLE 6.—*Showing the results of absorption test by making each water choleralike serum separately absorbed by others.*

Culture.	1:50	1:100	1:200	1:400	1:800	Control.
I. Serum WT-58 absorbed by—						
WT-83	—	—	—	—	—	—
WT-110	—	—	—	—	—	—
WT-137	—	—	—	—	—	—
II. Serum WT-83 absorbed by—						
WT-58	—	—	—	—	—	—
WT-110	—	—	—	—	—	—
WT-137	—	—	—	—	—	—
III. Serum WT-110 absorbed by—						
WT-58	—	—	—	—	—	—
WT-83	—	—	—	—	—	—
WT-137	—	—	—	—	—	—
IV. Serum WT-137 absorbed by—						
WT-58	—	—	—	—	—	—
WT-83	—	—	—	—	—	—
WT-110	—	—	—	—	—	—

TABLE 7.—*Showing the results of absorption test of water choleralike sera by human choleralike culture (H-1).*

Serum WT-58 absorbed by—						
Dilution.	1:50	1:100	1:200	1:400	1:800	Control.
Culture H-1	±	—	—	—	—	—
Serum WT-83 absorbed by—						
Culture H-1	—	—	—	—	—	—
Serum WT-110 absorbed by—						
Culture H-1	—	—	—	—	—	—
Serum WT-137 absorbed by—						
Culture H-1	—	—	—	—	—	—

TABLE 8.—*Showing the results of human choleralike serum (H-1) absorbed by the choleralike vibrios from water.*

Culture.	Absorbed serum H-1 diluted to 1 to—					
	50	100	200	400	800	Control.
WT-58	—	—	—	—	—	—
WT-83	—	—	—	—	—	—
WT-110	—	—	—	—	—	—
WT-137	—	—	—	—	—	—

TABLE 9.—*Showing results of absorption tests of human choleralike serum (M-1) and anticholera serum "Bureau of Science," by one strain of water choleralike vibrio (WT-9), three strains of human choleralike vibrios, and two strains of true cholera vibrios.*

Dilution employed.	H-1 serum absorbed by—										
	WT-9		H-7		H-14		Chol. 22		Chol. 480		H-1
	WT-9	H-1	H-7	H-1	H-14	H-1	Ch. 22	H-1	Ch. 480	H-1	H-1
1-25	±	+++	—	++++	±	+++	+	+++	+	+++	++
1-50	—	++++	—	++++	—	+++	±	++++	±	++++	+
1-100	—	++++	—	++++	—	++++	—	++++	—	++++	—
1-200	—	++++	—	++++	—	++++	—	++++	—	++++	—
1-400	—	++++	—	++++	—	++++	—	++++	—	++++	—
1-800	—	++++	—	++++	—	++++	—	++++	—	++++	—
Control	—	—	—	—	—	—	—	—	—	—	—

Dilution employed.	Anticholera serum "Bureau of Science" absorbed by—										
	H-1		H-7		H-14		WT-9		Chol. 480		Chol. 22
	H-1	Ch. 22	H-7	Ch. 22	H-14	Ch. 22	WT-9	Ch. 22	Ch. 480	Ch. 22	Chol. 22
1-25	—	+++	—	+++	—	+++	—	+++	—	—	++
1-50	—	++++	—	++++	—	+++	—	+++	—	—	+
1-100	—	++++	—	++++	—	++++	—	++++	—	—	±
1-200	—	++++	—	++++	—	++++	—	++++	—	—	—
1-400	—	++++	—	++++	—	++++	—	++++	—	—	—
1-800	—	++++	—	++++	—	++++	—	++++	—	—	—
Control	—	—	—	—	—	—	—	—	—	—	—

ENVIRONMENTAL FACTORS OF PHILIPPINE BEACHES WITH PARTICULAR REFERENCE TO THE BEACH AT PUERTO GALERA, MINDORO

By RAYMOND KIENHOLZ [1]

Of the University of Illinois, Urbana

FOUR FIGURES

Environmental factors, climatic, eadphic, physiographic, and biotic, all have a profound effect upon the distribution, form, and structure of the plants growing in any given area. The last two of these sets of factors, however, act primarily through the first two, and it is these that are given emphasis here. In any attempt to determine this effect upon plants it is first necessary to know what these factors are, and the intensity of each. This has been done in part for the plants of the beach, and in the following pages are recorded the results of observations and readings made during the months of April and May at Puerto Galera, Mindoro, as well as the findings of others working in various parts of the Islands.

The effect of these factors upon the vegetation, and particularly upon the structure of its principal transpiring organ, the leaf, has been fully discussed in another publication. (3)

Temperature.—The climate of the Philippine Islands is essentially a tropical one, except at high altitudes. The presence of great bodies of water, which are kept at an even but high temperature by ocean currents, (4, p. 10) makes the air temperature of the beach throughout the Islands particularly uniform. The seasonal as well as the daily fluctuations are very slight. This applies particularly to the temperature conditions on the beach at Puerto Galera. The nearest weather station at which meteorological readings have been taken for a long

[1] The author gratefully acknowledges the help of Flora Carbonell, Manuel T. Cruz, Gabriel D. Madrazo, Juan F. Pascasio, Vicente M. Perez, Gregorio T. Velasquez, all at that time from the Department of Botany, University of the Philippines; William W. McConel, then of the Bureau of Education, Manila; and Mrs. Kienholz, in the reading of the instruments, under his supervision.

period and which is most nearly comparable in climatic features to Puerto Galera is Calapan, 32 kilometers to the south.(1) At this station the mean annual range, from the hottest month, May—28° C. (82.4° F.)—to the coldest month, February—25.6° C. (78.1° F.)—is only 2.4° C. (4.3° F.). This uniformity is partly due to the sea breezes sweeping up and down the coast, for at Batangas, only 16 kilometers distant but in a deep, protected bay, the mean annual range is 3.2° C. (5.8° F.), while the temperature is uniformly higher. The average monthly and annual temperatures for Calapan based on ten years' observations are as shown in Table 1.

TABLE 1.—*Average temperatures at Calapan, Mindoro.*

Month.	Degrees C.	Degrees F.	Month.	Degrees C.	Degrees F.
January	25.7	78.3	July	27.5	81.5
February	25.6	78.1	August	27.6	81.7
March	26.8	80.2	September	27.2	81.0
April	27.7	81.9	October	27.2	81.0
May	28.0	82.4	November	26.9	80.4
June	27.9	82.2	December	26.2	79.2
Average annual				27.0	80.6
Mean annual range				2.4	4.3

Standard Weather Bureau type maximum and minimum thermometers, properly installed in the shade, at about 1 meter above the ground, on the beach at Puerto Galera, were read at 6 p. m. daily, and for a part of the period at 6 a. m. The average minimum temperature for the period recorded (March 27 to June 5) was 75.8° F., the average maximum (May 4 to June 5) was 88.6° F., while the air temperature at the 6 p. m. reading averaged 82.6° F. The air temperature readings from May 21 to May 31 at 6 a. m. averaged 76.7° F., while those taken at 6 p. m. during the same period averaged 80° F. Copeland(2) summarizes the temperature on the beach at San Ramon, Zamboanga Province, Mindanao, as shown in Table 2.

These averages indicate fairly cool nights and days that are only occasionally excessively hot.

Rainfall.—The rainfall of the Islands is an extremely variable one, reducible, however, to two main types and two intermediate types.(1) One main type consists of "two pronounced seasons, wet and dry;" the other main type consists of "no dry season, with a very pronounced maximum rain period in winter." Puerto Galera is in an area characterized

TABLE 2.—*Temperature on the beach at San Ramon, Zamboanga Province, Mindanao.*

Month.	Temperature at—					
	6 a. m.		12 noon.		4 p. m.	
	°C.	°F.	°C.	°F.	°C.	°F.
November	24.4	74.9	27.4	81.3	26.8	80.2
	7.30 a. m.		11.30 a. m.		4 p. m.	
December	25.7	78.2	28.0	82.4	27.7	81.9
January	25.3	77.5	28.3	82.9	27.4	81.3
February	23.1	73.5	28.1	82.58	28.1	82.58
March	24.9	74.8	29.0	84.2	28.4	83.1
April	26.5	79.7	29.9	85.8	29.5	85.1

by an intermediate type of rainfall; namely, "no very pronounced maximum rain period and no dry season." This is true of Calapan also and, as no year-long rainfall measurements were taken at the former place, the weather records for Calapan covering a ten-year period are here indicated (Table 3).

TABLE 3.—*Rainfall in Calapan, Mindoro, over a period of ten years.*

Month.	Millimeters.	Inches.	Month.	Millimeters.	Inches.
January	117.8	2.99	July	227.1	5.76
February	77.7	1.97	August	101.2	2.56
March	75.2	1.91	September	235.4	5.97
April	110.2	2.76	October	252.2	6.40
May	170.1	4.32	November	310.5	7.88
June	242.7	6.16	December	205.0	5.2
Annual				2,125.1	53.44

These figures indicate a fairly uniform supply of rainfall throughout the year, as contrasted with Batangas, in Luzon, where the average monthly rainfall for the four driest months, from January to April, is only 20.4 millimeters (0.52 inch). The months of February and March are considerably drier than are the other months of the year, and evidences of this drier period are visible even in the vegetation at Puerto Galera, affecting particularly the grasses and other herbaceous vegetation. When the rains begin in May and June, many plants begin to show increased vigor, new leaves being put out, and the whole taking on a greener, more flourishing appearance.

This is especially true of some of the ferns (*Drynaria*) and of the herbaceous vegetation growing among the rocks and in the scanty soil of the rocky beaches and rocky headlands where they are almost wholly dependent on the current rainfall for their water supply.

That this varying seasonal distribution of the rainfall in different parts of the Islands, even in closely contiguous areas, has an effect on the distribution of the vegetation cannot be doubted.(4, p. 11) This would apply much more to the interior of the Islands than to the beaches, particularly the sandy beaches, and the mangrove and nipa areas. I do not believe, however, that it would materially effect the distribution of the large perennials such as trees, woody vines, and shrubs growing on the beach which usually root deeply enough to secure a perpetual supply of water; nor would it affect the herbaceous species found on the beach or their form and structure, though it would probably limit their appearance on the beach to the seasons of higher rainfall. Thus, herbaceous species growing on the beach at Puerto Galera the year round would be limited to the wetter months of the year at Batangas with its "dry season." The effect of seasonal rainfall with its accompanying high humidity is shown by the behavior of epiphytes.(4, p. 14) Many epiphytes, particularly ferns and orchids, are found growing along the beach at Puerto Galera, where the uniform rainfall and constant high humidity make this distribution possible. These epiphytes are not found growing on the Batangas side of Verde Island Passage, except at a high altitude, because of the dry season that prevails there during January to April.

Relative humidity.—Relative humidity is high in most parts of the Philippines, even during the drier periods of the year. This is particularly true of the beaches, and may be attributed to the high evaporation from the seas surrounding the Islands, to the rich vegetation, and to the abundant yearly rainfall. The mean monthly and annual relative humidity for Manila may be cited as an example (Table 4).

The weather station at Manila is some distance removed from the beach itself. This fact makes the above-cited readings slightly lower than they would be if read directly on the beach.

This factor will vary with local conditions, such as prevailing winds, exposure to sun and wind, temperature, and vegetation, as well as the exact time and place at which the readings are taken. A limited number of readings made with the

TABLE 4.—*Mean relative humidity at Manila.*

Month.	Per cent.	Month.	Per cent.
January	78.7	July	85.2
February	73.8	August	85.3
March	70.8	September	86.2
April	69.3	October	85.0
May	75.1	November	82.9
June	80.3	December	82.4
Annual			79.6

Weather Bureau type sling psychrometer on the open beach at Puerto Galera gave an average relative humidity of 80 per cent, even in the early afternoon with a temparature of 82° F.

Copeland(2) gives data on relative humidity on the beach at San Ramon, Zamboanga, which may be summarized as shown in Table 5.

TABLE 5.—*Relative humidity on the beach at San Ramon, Zamboanga Province, Mindanao.*

Date.	6 a. m.	12 noon.	4 p. m.
	P. ct.	*P. ct.*	*P. ct.*
November 15 to 30	88.8	79.9	83.3
	7. 30 a. m.	11. 30 a. m.	4 p. m.
December	84.27	79.2	80.52
January	84.74	75.65	80.28

November marks the close of the rainy season at San Ramon; hence, the higher relative humidity. Puerto Galera would show a higher relative humidity on the beach than would either San Ramon or Manila, because of the absence of a pronounced dry season, which San Ramon has for a short period and which Manila has for a longer period.

Evaporation.—The amount of evaporation at Puerto Galera, at five different stations (the sandy beach, the rocky headland, and three places in the mangrove swamp), was measured by standardized Livingston white spherical atmometers. The period from March 30 to May 8 was practically without rain, and the recorded evaporation for that period is entirely correct. The later observations are somewhat inaccurate, due to the lack of rain-correcting valves; but, wherever possible, the atmometers were read immediately after a rain and, as most of the rain fell at night and in spells alternating with rainless days,

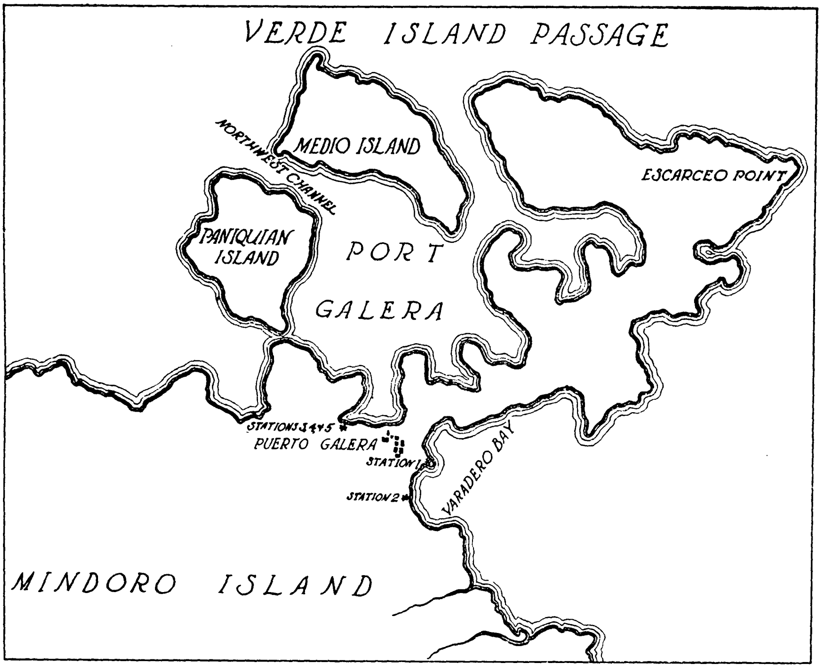


FIG. 1. Puerto Galera, Mindoro, and the surrounding region, showing the location of Stations 1 to 5.

the corrections made at 6 a. m. make the evaporation reading for the day accurate. In fig. 4 the periods of rain are indicated. Part of the low evaporation rate during the rainy periods is due of course to increased humidity and part of it to absorption by the bulb.

Burettes were used as water reservoirs in each case and these allowed daily readings of extreme accuracy. These burettes were plugged with cotton to prevent loss of water through evaporation and were covered with a glass phial to keep out rain and dust. The whole reservoir was protected also from direct sunlight. Distilled water was used in all cases.

Sandy beach (*Station 1*).—An atmometer was set up on the gently sloping sandy beach about 10 meters back from the water's edge and about 1.2 meters above its average level. The atmometer bulb was placed about 10 centimeters above the surface of the sand at the same level as the leaves of *Ipomoea pes-capræ* among which it was located. The burette was partly sunken in a pit dug in the sand. A second atmometer, similarly placed but having a wide-mouthed bottle as a reservoir, read substantially the same as the first atmometer, and the greater accuracy of the burette readings caused the data from the burette only to be used in Table 6 and in figs. 2 and 4.

Rocky headland (*Station 2*).—An atmometer was also set up at the edge of a rocky headland not far from the beach described above. This headland was a small hill with a sloping landward side and a steep, almost vertical, rocky seaward side. The waves washed its base on the seaward side at high tide. The headland towered about 15 to 25 meters above the sea, and on its extreme top on the seaward edge the atmometer was placed, fully exposed to all the winds coming from the east and the north. A sparse cover of trees provided some shade in the afternoon, but the rest of the day the bulb was exposed to the sun. The vegetation near the atmometer was brown and parched from lack of soil moisture and from the severe environmental conditions prevailing.

Mangrove swamp (*Stations 3, 4, and 5*).—In a small patch of young mangrove growing along the shore of the protected bay to the west of Puerto Galera, three atmometers were set up. This mangrove swamp consisted chiefly of *Rhizophora mucronata* and *R. candelaria* and covered several acres where a low flat valley bordered the bay. The trees were not large or tall but were in a thrifty condition, and showed evidence of encroaching on the mud flats formed by alluvial deposits brought down from the surrounding hills. The trees averaged 7.5 meters high and formed a dense canopy of foliage. The top of one of these trees was cut off and both an anemometer and a white spherical atmometer were placed so they were at the general level of the foliage of the canopy (Station 3).

A second atmometer was placed at the extreme outer edge of the mangrove and at all times except during extreme low tide the water covered the mud in which the mangrove grew and caused a reflection of light on the bulb from below. A very characteristic feature of the young advancing mangrove vegetation is the very sharp, clean-cut line above which a mass of foliage is displayed and below which no leaves are borne. This line is very noticeable, particularly at a distance, the lowermost foliage being always at a certain distance above the average level of the water, as if all the foliage below a certain line had been clipped off. At the level of this line the bulb of the second atmometer was placed to determine the possible added effect of reflection of light from the water below. The bulb was exposed to the sun during part of the afternoon (Station 4).

The third atmometer was placed within the mangrove swamp, under the canopy at the level of the greatest mass of aërial brace roots, about 1 meter above the mud surface (Station 5).

TABLE 6.—*Daily evaporation on the sandy beach, rocky headland, and mangrove swamp, averaged by weeks.*

[Evaporation in cubic centimeters]

Week.	Sandy beach, Station 1.	Rocky headland, Station 2.	Mangrove swamp.		
			Station 3.	Station 4.	Station 5.
April 8–14	31.0	----------	26.3	19.2	17.2
April 15–21	30.9	52.9	24.2	18.5	17.6
April 22–28	33.7	52.9	25.4	20.0	18.0
April 29–May 5	33.8	49.1	26.9	19.9	17.9
May 6–12	26.2	48.4	22.6	15.5	14.7
May 13–19	24.9	47.2	21.8	17.5	16.0
May 20–26	10.3	18.4	9.4	4.7	6.0
May 27–June 2	5.0	10.8	----------	----------	----------
Average	24.5	39.9	22.4	16.5	15.3

Table 6 indicates the average evaporation per twenty-four hours by weekly periods for the five stations. This is shown graphically in fig. 2. The evaporation for the rocky headland is consistently higher than that for any of the other stations. The rapid decline in the evaporation rates of all of the stations is due in part to an abundance of rain and to lessened wind movement from May 13 to June 2. This decline is especially evident in the case of the atmometer on the rocky headland. The rate of evaporation on the rocky headland was very high, averaging 52.9 cubic centimeters per twenty-four hours for the two weeks that were practically rainless. On some days when the wind was strong and the temperature high this rose to 72 cubic centimeters, a very high figure. The evaporation on the open sandy beach, not far from the rocky headland station, was second in amount, while the atmometers located at the top of the mangrove trees (Station 3), at the outer edge of the mangrove swamps (Station 4), and underneath the mangrove trees (Station 5) evaporated a decreasing amount in the order named. For the week April 22 to 28, when no rain whatever fell and the readings are entirely accurate, the ratio for the different stations was as follows: Rocky headland, 100; sandy beach, 64; at top of mangrove, 48; at edge of mangrove, 38;

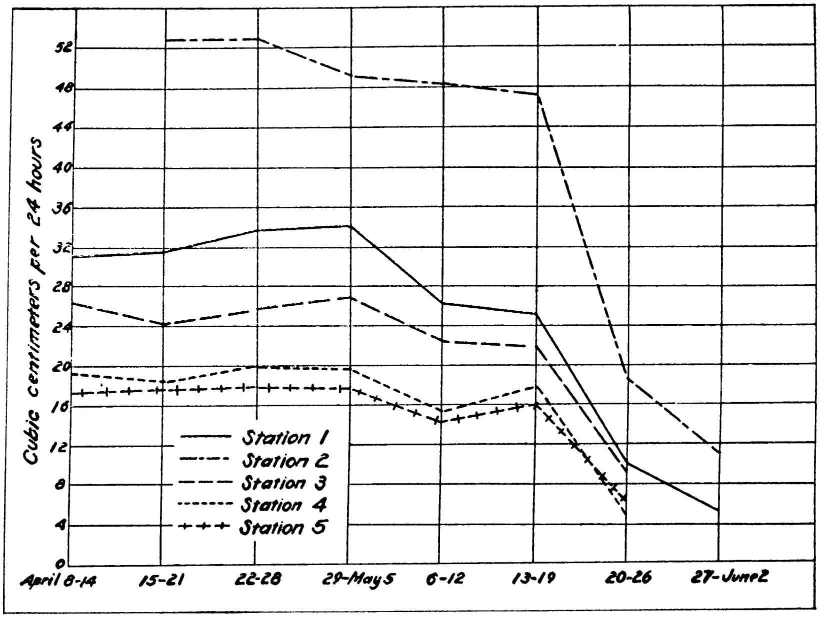


FIG. 2. Daily evaporation averaged by weeks for the sandy beach (Station 1), the rocky headland (Station 2), at the top of the mangrove trees (Sation 3), at the edge of the mangrove (Station 4), and underneath the mangrove trees (Station 5).

under the mangrove, 34. The ratio for the entire period, April 8 to June 2, was: 100, 61, 56, 41, 38.

Figures 3 and 4 show the very close correlation that exists between the amount of wind per twenty-four hours as measured on the beach and the amount of evaporation of the rocky headland and the sandy beach, respectively. The correlation is closer for the rocky headland than for the beach, as wind had a relatively greater influence on the headland than on the beach. If the data for the day (twelve hours) and the night (twelve hours) are compared separately a much closer correlation is found to exist between the night wind and the night evaporation. During the day sunlight enters to destroy the correlation. If data on sunshine were available they would explain some of the lack of correlation between wind and evaporation shown in figs. 3 and 4, just as the data for the rainy periods of April 12, April 19, and May 8 to 10 explain the lack of correlation in fig. 4.

This high evaporation rate in spite of the fairly high humidity gives a hint as to the reason for certain structural adaptations of the leaf for conserving its water supply.

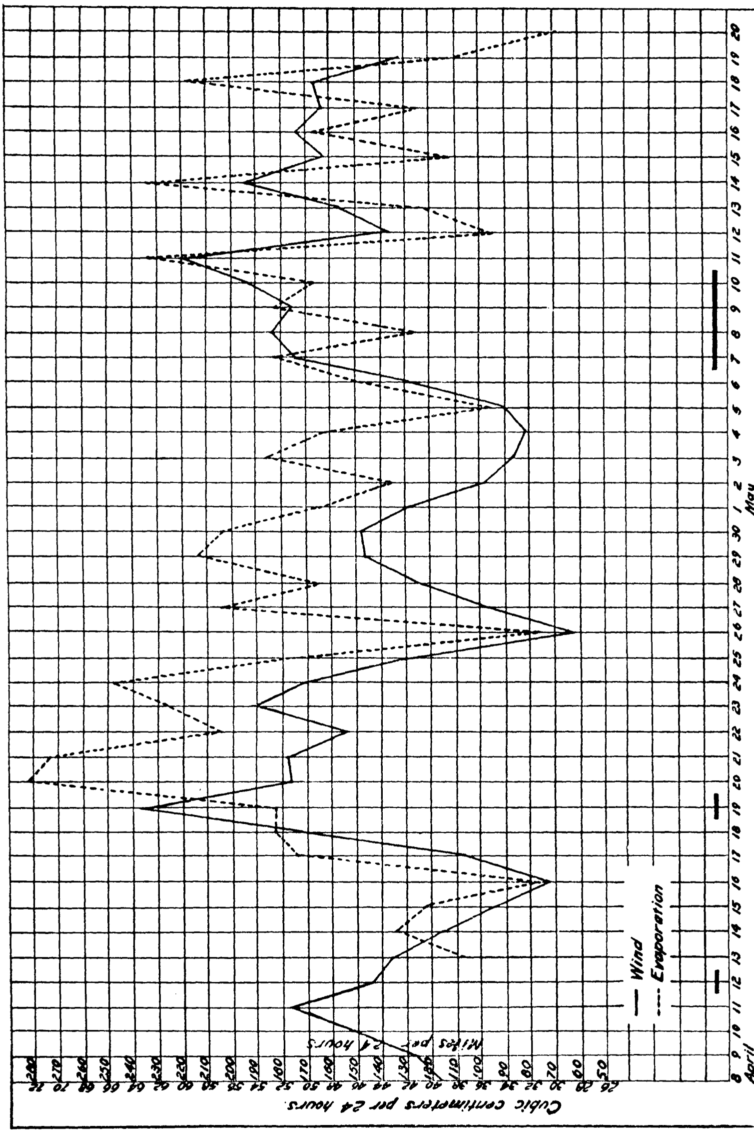


FIG. 3. Daily evaporation on the rocky headland and wind movement recorded on the beach. Rain indicated by black bars at base of graph.

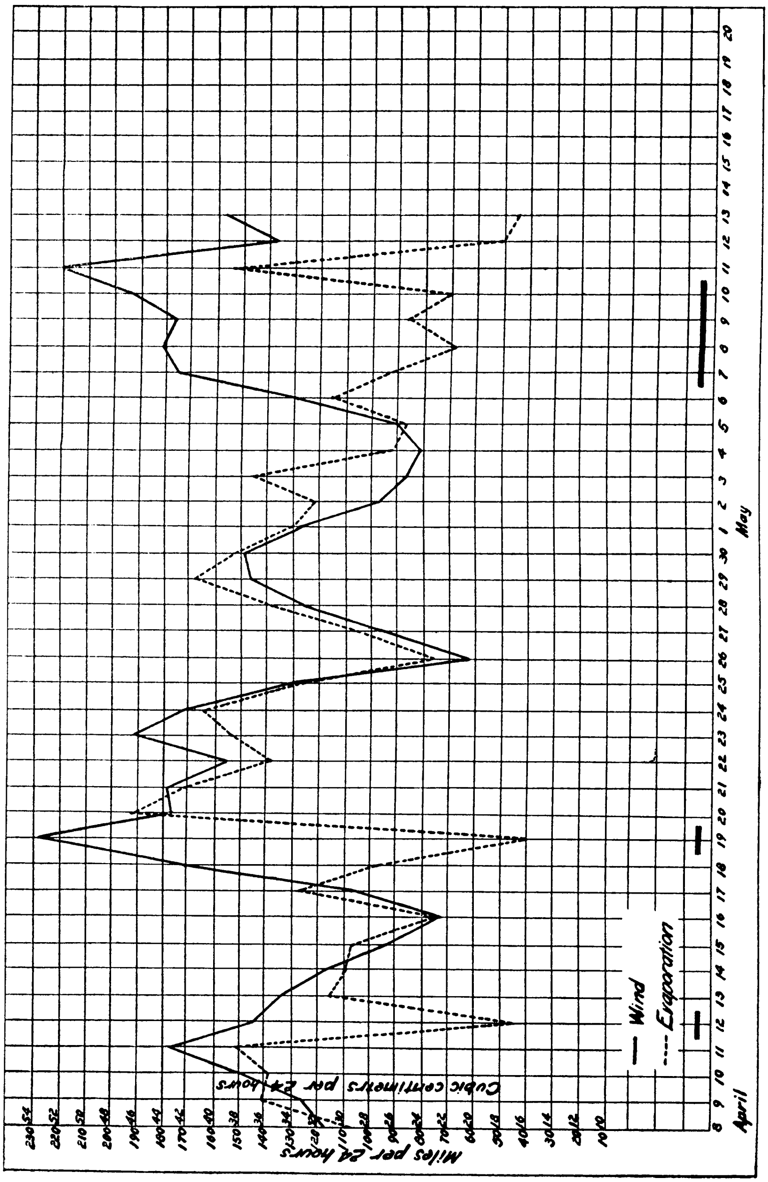


FIG. 4. Daily evaporation on the beach and wind movement recorded on the beach. Rain indicated by black bars at base of graph-

Wind.—Anemometers of the Freas type were set up on the sandy beach about 30 centimeters above the surface of the soil, and at Station 3 at the level of the tops of the mangrove trees. The wind was fairly strong and constant except during the later period of the readings when the rains were abundant. The average wind velocity in miles per twenty-four hours for the entire period of observation (March 25 to June 5) was 91.0 miles, while that for the period April 10 to April 22 was 146.8. The average daily wind movement averaged by weeks follows:

March 25 to 31, 158.2 miles; April 1 to 7, 96.3; April 8 to 14, 138.6; April 15 to 21, 146.9; April 22 to 28, 132.9; April 29 to May 5, 112.1; May 6 to 12, 173.3; May 13 to 19, 163.7; May 20 to 26, 28.5; May 27 to June 2, 29.5. The decided falling off in the evaporation rate, as shown in fig. 2, coincides with the greatly lessened wind movement of May 20 to June 2 and accounts in part for the falling off, the greatest decrease occurring where the wind was most effective in increasing the evaporation rate; namely, the rocky headland.

The wind movement at the top of the mangrove trees was very much less than that on the beach because of the protected position of the mangrove swamp. For the period May 14 to 29 the average daily wind movement on the beach was 72.8 miles as compared to 24.9 miles in the mangrove.

Sunshine.—No data are available on the amount of sunshine at Puerto Galera, but the data for Manila indicate an average annual cloudiness of 6.9 which reaches its minimum in April, with a figure of 4.6.

Soil.—The sandy soil of the beach allows water to drain away rapidly and, even when saturated, it holds but 20 to 22 per cent of water. It likewise contains very little humus. Whitford(5) gives the figure of 0.22 per cent of humus for sand near the water's edge. The sandy beach contains little salt, sometimes less than some cultivated soils. Whitford states that the sand of the Lamao beach, Bataan Province, Luzon, just above high-tide limits contained 0.25 per cent of sodium chloride and the amount was much less farther back on the beach. The water level on the sandy beach is often within a meter or two of the surface and deep-rooting plants thrive even through the dry season. This is not true of the rocky headland where the effects of the dry season are often marked.

REFERENCES

1. CORONAS, J. The climate and weather of the Philippines, 1903 to 1918. Philippine Census (1918). Reprint (1920) 1–195.
2. COPELAND, E. B. On the water relations of the coconut palm (Cocos nucifera). Philip. Journ. Sci. 1 (1906) 6–82.
3. KIENHOLZ, R. An ecological-anatomical study of beach vegetation in the Philippines. Proc. Am. Phil. Soc. 65 (1926) No 5, Supplement, 58–100, pls. 1–6.
4. MERRILL, E. D. An Enumeration of Philippine Flowering Plants. Bureau of Science, Manila 4 (1926) 1–515.
5. WHITFORD, H. N. The vegetation of the Lamao Forest Reserve. Philip. Journ. Sci. 1 (1906) 373–431, 637–682.

ILLUSTRATIONS

TEXT FIGURES

THE PHILIPPINE GARS OR NEEDLEFISHES

By ALBERT W. HERRE

Chief, Division of Fisheries, Bureau of Science, Manila

FOUR PLATES

BELONIDÆ

GARFISH; NEEDLEFISH; BILLFISH; HOUNDFISH

Vernacular names.—Bicol, *baló, dugsó;* Ilocano, *siriu;* Pangasinan, *pingka;* Tagalog, *batalay;* Tagbanua, *tambalauang;* Tao Sug and Samal, *selo, tambuauang;* Visayan, *balo, dugso, gonggong, tambilauan;* Spanish, *agujon, aguja de casta, peixe agulha, sierrita.*

A small family of very elongate and slender fishes, with laterally compressed or cylindrical bodies, covered with small to minute cycloid scales. The premaxillaries and mandibles are greatly prolonged to form a slender beak, both jaws filled with bands of small teeth in which are set numerous exceedingly sharp canines; teeth may be present or absent on tongue and vomer; the maxillary is more or less concealed by the large preorbital when the mouth is closed. The dorsal and anal are both very far back, the origin of the dorsal above or behind that of the anal, both fins rather long, without detached finlets; the pectorals are rather high, usually of medium size; the caudal may be forked, emarginate, truncate, or rounded; the ventrals are near the middle of the combined length of the trunk and head exclusive of the beak.

The lateral line is very low down, sometimes forming a low keel on the caudal peduncle; the gill openings are wide, the gill membranes not united with the isthmus; gill rakers present in one genus, absent or vestigial in the rest; the third pair of upper pharyngeals moderately enlarged, separate; second and fourth pairs present or absent; lower pharyngeals united into one plate; pharyngeal teeth usually villiform or granular; intestinal tract simple, without pyloric appendages; air bladder large; vertebræ with zygapophyses.

Fishes of tropical and temperate seas, some attaining a length of 1.66 meters, a few species entering fresh water. All the species are more or less green during life, with silvery sides or a silvery longitudinal band, and often with a blue or blackish blue stripe from the shoulder to the caudal fin. The green color extends inward, so that the flesh and bones are green too. The flesh turns white in cooking and is excellent eating. The larger species are important food fishes where sufficiently abundant.

Gars swim at or near the surface offshore, in tidal currents, or in the open sea. In spite of their enormous jaws and terrible armament of needlelike teeth, gars can prey only on comparatively small fishes, since the gullet is too narrow to permit swallowing fish of any size. Silversides (Atherinidæ), anchovies (Engraulidæ), sardines (Clupeidæ), young caesios, and other small slender fishes seem to comprise the bulk of their food, at least around the reefs of the Sulu and Celebes Seas. If a half stick of dynamite is fired near a wharf in the Sulu Archipelago large numbers of silversides are always killed or stunned. At once several large gars will appear like magic from the stream, where their green backs harmonize perfectly with the color of the water, and in an incredibly short time they will snap up all the floating silversides and other small disabled fishes.

Gars swim with an undulating motion of the body and are exceedingly active. When startled they move with astonishing speed and may leap from the water several times or may skip over the surface in gigantic leaps like a ricochetting flat stone, or may rise out of the water until only the tail or posterior part of the body is left in it, just as a modern speed boat travels, shooting forward with incredible swiftness and all but flying. It sometimes happens on such occasions that a whizzing gar strikes a person with its hard bill which penetrates like an arrow, inflicting dangerous wounds, horribly lacerating the abdomen, or causing death. A snapping gar may also inflict very severe wounds with its large needlelike teeth.

Unless otherwise specified, the lengths given in this paper do not include the caudal fin.

Key to the Philippine genera of Belonidæ.

a^1. Premaxillaries swollen at base, jaws arched and not closing posteriorly; body bandlike, its height twice the breadth or more............*Ablennes.*

a^2. Premaxillaries not swollen at the base; jaws arched and not meeting posteriorly; body scarcely or moderately compressed, height less than twice the breadth.. *Tylosurus.*

Genus ABLENNES Jordan and Fordice

Athlennes JORDAN and FORDICE, Proc. U. S. Nat. Mus. **9** (1886) (1887) 342; error for *Ablennes;* correct form approved by International Commission of Zoölogical Nomenclature.

The very elongate body greatly compressed laterally, almost ribbon-shaped in some specimens; premaxillaries and mandibles extended into a very long slender beak; premaxillaries slightly constricted near their base and strengthened by a conical swelling of the bone, with the point directed forward; upper jaw strongly arched upward at its base so that the mouth cannot be closed; each jaw with a band of conical pointed teeth, sprinkled with larger slender canines; no teeth on vomer, origin of anal in advance of that of dorsal, all the dorsal and anal rays connected by a membrane; caudal forked; scales minute, adherent; lateral line very low down on body, not forming a distinct keel on caudal peduncle; gill openings wide; no gill rakers; lower pharyngeal long and narrow; second, third, and fourth pairs of upper pharyngeals with teeth.

Only one species known, of very wide distribution, in the Indian, Pacific, and Atlantic Oceans.

ABLENNES HIANS (Cuvier and Valenciennes). Plate 1, fig. 1.

Belone crocodila BLEEKER, Nat. Geneesk. Arch. Ned. Ind. **2** (3) (1845) 512; not of Lesueur.

Belone hians CUVIER and VALENCIENNES, Hist. Nat. Poiss. **18** (1846) 321, pl. 548; GÜNTHER, Cat. Fishes **6** (1866) 248; Fische der Südsee **3** (1910) 353.

Athlennes hians JORDAN and FORDICE, Proc. U. S. Nat. Mus. **9** (1886) (1887) 342; JORDAN and EVERMANN, Fishes N. and M. Am., part 1 (1896) 718; JENKINS, Bull. U. S. Fish Comm. **22** (1902) (1904) 433; JORDAN and EVERMANN, Bull. U. S. Fish Comm. **23**[1] (1903) (1905) 125, fig. 40; WEBER and BEAUFORT, Fishes Indo-Aust. Arch. **4** (1922) 131, fig. 49.

Ablennes hians JORDAN and JORDAN, Memoirs Carnegie Mus. **10** (1922) 18.

Belone melanostigma CUVIER and VALENCIENNES, Hist. Nat. Poiss. **18** (1846) 334; GÜNTHER, Cat. Fishes **6** (1866) 241; KLUNZINGER, Synopsis Fische des Rothen Meeres (1871); DAY, Fishes of India (1878) 509.

Tylosurus melanostigma JORDAN and EVERMANN, Proc. U. S. Nat. Mus. **25** (1902) 329.

Belone gracilis SCHLEGEL, Fauna Japonica, Poissons (1846) 246; not of Lowe; BLEEKER, Verh. Bat. Gen. **26** (1854–1857) Niew. nal. Japan, 116.

Belone schismatorhynchus BLEEKER, Nat. Tijds. Ned. Ind. **1** (1850) 95; KNER, Fische Novara Exp. (1865) 322; GÜNTHER, Cat. Fishes **6** (1866) 239; MEYER, Ann. Soc. España Hist. Nat. **14** (1885) 38.

Mastacembelus schismatorhynchus BLEEKER, Atlas Ichth. 6 (1866–(1867) 49, pl. 258, fig. 2.

Tylosurus schismatorhynchus JORDAN and STARKS, Proc. U. S. Nat. Mus. 26 (1903) 528.

Tylosurus caeruleofasciatus STEAD, New Fishes New South Wales, No. 1 (1908) 3.

Athlennes caeruleofasciatus OGILBY, Mem. Queensland Mus. 5 (1916) 130; MCCULLOCH, Check List Fishes New South Wales, part 2 (1919) 36.

Dorsal II–21 to 23; anal II–22 to 24; pectoral 1–13; lateral line about 410.

Body very strongly compressed, often bandlike, breadth 2 to 2.3 times in depth, which is 11.5 to 13.25 times in length in my specimens; the flattened sides of head strongly appressed below so that it is triangulate in section, 3.4 to 3.87 times in length; the very elongate and slender snout 1.37 to 1.47 times in head; the large eye very high up, 10.66 to 11.4 times in head, 7.3 to 8.1 times in snout, 1.15 to 1.3 times in interorbital space, and 2.25 to 2.65 times in postorbital part of head; mandible very broad posteriorly, its depth below pupil almost equal to diameter of eye; on top of posterior part of head is a broad, smooth, shallow depression, much narrower and triangulate anteriorly, with a median ridge above eye, the anterior half scaled; the supraorbital region strongly striated; a small median groove on beak, extending to its tip; the small numerous canines directed backward in upper jaw, and in large specimens the posterior canines of lower jaw also; tongue smooth; maxillary entirely covered by preorbital when the mouth is closed, or its margin may be barely visible; opercles naked, preopercles scaled; the large falcate elongate pectorals much longer than the postorbital region of head, 2.25 to 3.5 times in head; the lower lobe of the strongly forked caudal is the longer, and always exceeds pectoral; depth of caudal peduncle a third to a half more than its breadth; anterior part of caudal and anal elongate and strongly falcate, origin of dorsal opposite third to fifth divided anal ray, separated by 28 to 32 scales from lateral line; middle dorsal rays shorter than anterior or posterior ones, the last sometimes extending to caudal base; middle and posterior anal rays subequal in length; origin of ventrals midway between caudal base and anterior part of eye; lateral line does not form a keel on caudal peduncle.

Color of fresh specimens greenish above, the sides brilliant silvery whitish to pearly white; three to six broad vertical blackish spots or bands on posterior part of body behind origin of anal; dorsal blackish, the other fins all with blackish tips, pectorals and anal yellowish.

In alcohol the dorsal region is brown, distinct from the silvery white or more or less silvery yellowish sides; all the fins more or less blackish; the black spots or bands on posterior region tend to disappear in alcohol.

Here described from four specimens from Manila Bay, 480 to 875 millimeters in length, the largest one 975 millimeters long with the caudal fin. During November this fish is common in the Manila markets, and is often seen during the cooler months. The only previous Philippine record is that by Meyer, who collected it from Manila Bay and at Cebu.

This species, which reaches a length of more than a meter, occurs from the Red Sea to Japan, the Hawaiian Islands, and across the Pacific to Acapulco on the west coast of Mexico. It also occurs in the Atlantic, from North Carolina to Brazil.

Genus TYLOSURUS Cocco

Tylosurus COCCO, Giorn. Sci. Lett. Sicilia 42 (1833) 18.

Body very elongate and slender, cylindrical or laterally compressed, the laterally flattened head with a very long toothed beak, formed from the greatly extended premaxillaries and dentary; maxillaries united to premaxillaries; each jaw has a band of small sharp teeth, interspersed with much larger, widely spaced, very sharp conical teeth or canines; no vomerine teeth; origin of dorsal opposite or behind that of anal, both fins very far back and rather long, without finlets, all the rays connected by a membrane; caudal fin forked, truncate, or rounded; ventrals small, inserted behind middle of body; scales small to very small; lateral line very low, usually forming a fold along side of belly and sometimes forming an elevated keel on caudal peduncle; gill openings wide; no gill rakers; air bladder large; the lower pharyngeals unite in a long narrow flat plate, covered with small pointed teeth; upper pharyngeals distinct, second and third pairs each with unequal pointed teeth; fourth pair usually distinct, with similar teeth.

Greedy carnivorous fishes of tropical and temperate seas, of moderate to large size, esteemed as food. In early life the jaws are not prolonged and until maturity is nearly reached the lower jaw is much in advance of the upper; in *T. philippinus* Herre, the lower jaw extends beyond the upper in the adult stage.

234183——6

The fishes of this genus usually swim at or near the surface, singly or in small groups, less often in schools of greater numbers, up to several hundred. When a school of Atherinidæ, young caesios, or other small fishes is broken up by a blast of dynamite, several large gars will immediately appear where none was visible before, and snap up the dead and dying fishes with great rapidity.

The larger species are much feared by fishermen, as when frightened they may skip along the surface of the water at terrific speed, hurtling through the air in great leaps and inflicting frightful injuries upon or even killing anyone unlucky enough to be in the way. They also damage small nets, through which they easily tear their way.

Key to the Philippine species of Tylosurus.

a^1. Caudal truncate or rounded; lateral line not forming keel on caudal peduncle.
- b^1. Dorsal I-12 or 14 to II-11 or 12; anal I-14 or 15 to II-13 to 16.
  - c^1. Lateral line 150–170; caudal with a basal circular black or deep blue spot .... *T. strongylurus.*
  - c^2. Lateral line 126–138; no dark spot on caudal base.... *T. macrolepis.*
- b^2. Dorsal I-17 or II-16 to 18; anal II-20 to 22.
  - d^1. Origin of dorsal above second divided anal ray.............. *T. incisus.*
  - d^2. Origin of dorsal above seventh divided anal ray................ *T. leiurus.*

a^2. Caudal forked; lateral line forming a more or less evident keel on caudal peduncle.
- e^1. Canines of upper jaw inclined forward.......................... *T. giganteus.*
- e^2. All the canines perpendicular.
  - f^1. Mandible with a large thick spongy tip; lateral line 194; tongue mostly smooth.......................... *T. philippinus.*
  - f^2. No conspicuous spongy tip on mandible; lateral line more than 250.
    - g^1. Dorsal II-19 or 22; anal II-18 or 20; pectoral I-13; lateral line 270; tongue covered with large rounded hard tubercles. *T. crocodilus.*
    - g^2. Dorsal II-23 or 24; anal II-20 or 21; pectoral I-11 or 12; lateral line 300 to 350; tongue more or less covered with very small granular teeth.......................... *T. melanotus.*

TYLOSURUS STRONGYLURUS (van Hasselt). Plate 1, fig. 2.

Belone strongylura VAN HASSELT, Alg. Konst-en Letterbode, Deel 1 (1823) 130; WEBER, Fische Siboga Exp. (1913) 122.

Belone caudimacula CUVIER, Regne Anim., Disciples ed. 7 (1836) 234, footnote; CUVIER and VALENCIENNES, Hist. Nat. Poiss. 18 (1846) 336; CANTOR, Journ. Asiat. Soc. Bengal 18 (1850) 1228; BLEEKER, Verh. Bat. Gen. 24 (1852) Snoekachtige Visschen, 12.

Mastacembelus caudimacula BLEEKER, Ned. Tijds. Dierk. 2 (1865) 176, 194.

Mastacembelus strongylurus BLEEKER, Ned. Tijds. Dierk. 3 (1866) 220; Atlas Ichthy. 6 (1866–1872) 45, pl. 257, fig. 3.

Belone caudimaculata GÜNTHER, Cat. Fishes 6 (1866) 245; MEYER, Ann., Soc. España Hist. Nat. 14 (1885) 38.

Belone strongylurus GÜNTHER, Cat. Fishes 6 (1866) 246; Day, Fishes of India (1878) 512, pl. 118, fig. 6.

Tylosurus caudimaculatus JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 242; SEALE, Philip. Journ. Sci. § D 9 (1914) 60.

Tylosurus strongylurus WEBER and BEAUFORT, Fishes Indo-Aust. Arch. 4 (1922) 121.

Dorsal I–12 or 14 to II–12; anal I–14 or 15 to II–14 to 16; pectoral 1–9 or 10; lateral line 150–170.

The elongate body slightly to moderately compressed, its breadth three-fourths the depth to nearly equal the depth; depth 14 to 17 times in length; head 2.5 to 2.9 times in length, its sides and top strongly flattened, the nearly circular eye 12 times in head, 2.4 to 4.1 times in postorbital part of head, 8.1 to 8.5 times in snout, and equal or nearly equal to the interorbital space; top of head with a well-developed median groove and a few striæ on region above eye; maxillary more or less concealed by preorbital, varying with age, largely hidden in the young; operculum and preopercle from eyes back covered with scales; canines small, erect or inclined slightly backward; tongue smooth; pectorals are usually shorter than postorbital part of head, but may be equal to or longer than it; base of ventrals midway between eye and base of caudal or a little nearer eye or caudal; anterior dorsal and anal rays highest, middle and posterior rays much shorter and of nearly uniform length; origin of dorsal over second to fourth anal ray; caudal peduncle slightly keeled, the lateral line not forming a keel; caudal rounded or lower rays longest, 9.2 to 9.7 times in length.

The color is a beautiful green to yellowish green above, thickly punctulated with minute brown specks, merging into silvery on sides and pearly white on abdomen; a deep blue longitudinal stripe on posterior half of sides, beneath is a wide silver band from head to tail; sides of head bright silver; dorsal, pectorals, and ventrals clear, dorsal and anal with a roseate margin, anal sometimes yellowish; caudal pearly to greenish or yellowish, with a deep blue circular spot on its base; upper surface of eye very dark bluish.

Color in alcohol brown, brownish, or yellowish above, paler to nearly white below, with a broad longitudinal silver band on side, very distinct on posterior third or half of body, where it is bordered above by a more or less evident dark or blue-black stripe; a large black or bluish black circular spot on caudal base; fins colorless, or yellowish, or posterior half of caudal dusky.

Here described from the following specimens, ranging from 155 to 350 millimeters in length:

Bulacan, Bulacan Province, 1.	Cagayan, Misamis, Mindanao, 1.
Manila, 11.	Davao, Mindanao, 1.
Calabanga, Camarines Sur, 1.	Sandakan, Borneo, 2.
Tacloban, Leyte, 1.	Amoy, China, 1.

Specimens 250 millimeters or more in length are sexually mature; a female collected in February was ready to spawn. Dr. A. B. Meyer collected this species from Manila Bay and at Cebu; Jordan and Richardson had a specimen from Iloilo.

This species ranges from the coasts of Ceylon and Hindustan throughout the East Indies, north to the southern coast of China, and southeast to Thursday Island and North Australia, occurring in the sea and in estuaries. It is common in the Manila market during the winter months. It is said to reach a length of 450 millimeters, but I have seen none so large.

TYLOSURUS MACROLEPIS (Bleeker).

Belone macrolepis BLEEKER, Nat. Tijds. Ned. Ind. 12 (1856) 225.
Mastacembelus macrolepis BLEEKER, Ned. Tijds. Dierk. 3 (1866) 221; Atlas Ichthy. 6 (1866–1872) 45, pl. 258, fig. 1.
Belone macrolepis GÜNTHER, Cat. Fishes 6 (1866) 246; MEYER, Ann., Soc. España Hist. Nat. 14 (1885) 38.
Tylosurus macrolepis WEBER and BEAUFORT, Fishes Indo-Aust. Arch. 4 (1922) 122.

Dorsal II–11; anal II–13 or 14; pectoral 1–9 (1–10 according to other authors); scales in lateral line 126–138.

Body nearly cylindrical, depth and breadth equal, 14.8 times in length; head strongly compressed laterally and flattened above, about 2.25 times in length; eye about 12.6 times in head, about 8.4 times in snout, 1.1 to 1.2 times in interorbital, and 3 times or a little less than 3 times in postorbital part of head; top of head has a wide and very shallow scaly groove, broadest anteriorly; striæ on top of head not very well developed; maxillary two-thirds concealed by preorbital when mouth is closed; opercle and preopercle scaled; canines numerous, small, those of upper jaw more or less inclined backward; tongue smooth; pectorals pointed, narrow, a little more or less than length of postorbital region of head; ventral base midway between caudal base and middle or anterior margin of pupil; origin of dorsal over second or third anal ray, the anterior rays of both fins highest, the others much shorter and of nearly equal length, the last ending at a considerable distance from caudal base; depth of caudal peduncle equals or is a third greater than its breadth; caudal more or less rounded to truncate, the lowermost rays longest, a little longer than postorbital region of head.

Color in alcohol brown, or grayish brown above, paler to yellowish below, sides of head silvery; a silvery longitudinal band on posterior half of body, much broader on last third, bordered above by a dark or blue-black line extending from shoulder to caudal; a large blackish patch on basal portion of pectoral, larger and plainer on inner side; a series of elongate dark spots on middle of dorsal and anal, forming a longitudinal band; a dark spot above each eye on top of head; hind margin of caudal dusky.

Here described from two specimens, one 268 millimeters long, and a larger one with the beak broken, but otherwise in fine condition. The smaller specimen is from Zamboanga, the other from Gingoog, Misamis Province, Mindanao. I also have three specimens from Zamboanga, one about 125 millimeters in length, another about 175, both with the beak broken; the third one, 160 millimeters long, is in perfect condition. In the Stanford University collection are two specimens collected by Alvin Seale at the mouth of Agusan River, Mindanao.

This rare species reaches a length of 420 millimeters. It is only known from a very few specimens, collected at Nias, Menado in Celebes, and the Sangir Islands.

TYLOSURUS INCISUS (Cuvier and Valenciennes).

Belone incisa CUVIER and VALENCIENNES, Hist. Nat. Poiss. 18 (1846) 335; WEBER, Fische Siboga Exp. (1913) 123.

Tylosurus incisus WEBER and BEAUFORT, Fishes Indo-Aust. Arch. 4 (1922) 125.

Belone leiuroides BLEEKER, Nat. Tijds. Ned. Ind. 1 (1851) 479; GÜNTHER, Cat. Fishes 6 (1866) 243.

Mastacembelus leiuroides BLEEKER, Atlas Ichthy. 6 (1866–1872) 50, pl. 255, fig. 1.

Tylosurus leiuroides JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 206; EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 58; SEALE and BEAN, Proc. U. S. Nat. Mus. 33 (1907) 240.

Belone liuroides, GÜNTHER, Fische der Sudsee 3 (1910) 352.

Strongylura leiuroides FOWLER, Proc. Acad. Nat. Sci. Phila. 71 (1919) 5.

Local name.—Doal at Iba, Zambales.

Dorsal II–17 or 18; anal II–20 or 21; pectoral 1–10 or 11; lateral line 168–190.

The elongate, rather thick body deepest and widest anteriorly in the region of the pectorals, body rather four-sided, breadth 75 to 85 per cent of the depth, which is 13 to 16 times in length; sides of head strongly flattened, its length 2.25 to 2.5 times in total, its upper surface more or less dished or nearly flat, with a wide shallow scaly median depression, not broadening anteriorly; the large eye placed high up, 10.7 to 11.3 times in head, 1.1 times in interorbital, 2.4 to 2.6 times in postorbital region, and 7.3 to 7.9 times in the long, slender, pointed snout, which is 1.45 to 1.5 times in head; top of head densely striated; beak also striated longitudinally, with a deep central longitudinal groove; diameter of eye much greater than depth of mandible below pupil; when the mouth is closed the preorbital covers all of the maxillary except the lower margin; scales on preopercle very large, those on opercle smaller and easily rubbed off; canines numerous, straight, very sharp, those of upper jaw stronger; tongue smooth; postorbital portion of head about 0.9 of pectoral length; origin of ventrals midway between caudal base and center or anterior portion of eye; middle and posterior dorsal and anal rays short, subequal in length, much shorter than anterior ones, which are long and boldly falcate; posterior dorsal and anal rays end some distance before caudal base; origin of dorsal above second divided anal ray; caudal moderately forked, about 9 times in length, longer than postorbital region of head; depth of caudal peduncle slightly exceeds its breadth.

Color in alcohol brown above, pale yellowish and silvery below, with a very distinct blue or blue-black stripe from shoulder to caudal, above an indistinct silvery band; a median black line from nape to origin of dorsal and another on each side of it; a curved blackish line on base of pectoral rays; preopercles and opercles silvery, and sprinkled with pale brown spots, which may disappear with age; central portion of caudal dusky.

Here described from the following specimens, 245 to 480 millimeters in length:

Polillo, 1.
Iba, Zambales, 1.
Estancia, Panay, 1.
Bantayan, 1.
Tandubas, Sulu Province, 1.
Bato Bato, Tawitawi, 2.
Sitankai, 2.

Evermann and Seale had a specimen from Bacon, Sorsogon, and Seale and Bean had four specimens from Zamboanga; Fowler had a specimen from the Philippines.

This species, which reaches a length of 600 millimeters, occurs from the Indian Ocean throughout the East Indies to New Guinea, the Pelew and Admiralty Islands, and southeast in the Pacific to Samoa.

TYLOSURUS LEIURUS (Bleeker). Plate 2.

Belone leiurus BLEEKER, Nat. Tijds. Ned. Ind. 1 (1850) 94; KNER, Fische Novara Exp. (1865) 321; DAY, Fishes of India (1878) 511.
Mastacembelus leiurus BLEEKER, Atlas Ichthy. 6 (1866–1872) 46, pl. 257, fig. 2.
Tylosurus leiurus JORDAN and EVERMANN, Proc. U. S. Nat. Mus. 25 (1903) 329; JORDAN and SEALE, Bull. Bur. Fisheries 26 (1907) 8; SEALE and BEAN, Proc. U. S. Nat. Mus. 33 (1907) 240; JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 243; WEBER and BEAUFORT, Fishes Indo-Aust. Arch. 4 (1922) 124.
Belone liurus GÜNTHER, Cat. Fishes 6 (1866) 250.
Strongylura leiura FOWLER, Proc. Acad. Nat. Sci. Phila. 71 (1919) 5.
Mastacembelus anastomella BLEEKER, Ned. Tijds. Dierk. 3 (1866) 244; (not of Cuvier and Valenciennes).

Local name.—*Batalay* in Tagalog.

Dorsal II–16 to 18 or I–17; anal II–21 or 22; pectoral I–10 or 11; lateral line 200–220.

The depth of the elongate, laterally compressed body 16 to 20 times in length and 1.4 to 1.6 times its breadth; head contained 2.7 to 3.1 times in length, its sides and top flattened; eye 10 to 13 times in head, 2.7 to 3.1 times in postorbital part of head, 1 to 1.2 times in interorbital, 8.4 to 9 times in snout; the depth of the short caudal peduncle greater than its width; a broad shallow median scaly groove on top of head, much broader anteriorly, with a very low median longitudinal ridge, which disappears anteriorly; top of head but little striated; two-thirds or more of maxillary hidden by preorbital; postorbital region of head scaly; canines slender, inclined backward; tongue smooth; pectorals equal to or a little more or less than postorbital portion of head; origin of ventrals a little nearer base of caudal than to hind border of eye or sometimes midway; dorsal and anal both falcate, anterior rays much longer than the others, which are subequal in height; origin of dorsal much behind that of anal, above seventh anal ray; caudal fin subtruncate, inferior rays longest, 9.25 to 10 times in length.

Color in alcohol light brown above, pale yellowish brown on sides, with a broad silvery lateral band, bordered above by a dark line, from above origin of pectoral to base of caudal; a large black or dusky subterminal blotch on pectoral; posterior two-thirds of caudal dusky; dorsal and anal dusky to yellowish or colorless; ventrals yellowish or colorless.

Here described from the following specimens, 350 to 400 millimeters in length: Santa Maria, Ilocos Sur, 1; Manila, 2; Hoihow, Hainan, 1. It was listed by Jordan and Richardson from Aparri, from Cavite by Jordan and Seale, and from Zamboanga by Seale and Bean.

This species, which reaches a length of over half a meter, occurs from Ceylon and Hindustan eastward to the Aru Islands, and north to Formosa.

TYLOSURUS GIGANTEUS (Schlegel). Plate 4, fig. 1.

Belone gigantea SCHLEGEL, Fauna Japonica, Poissons (1842) (1846) 245; BLEEKER, Act. Soc. Sci. Indo-Neerl. **3** (1858) Japan, 21; GÜNTHER, Fische der Südsee **3** (1910) 350; WEBER, Fische Siboga Exp. (1913) 122.

Mastacembelus giganteus BLEEKER, Ned. Tijds. Dierk. **1** (1863) 236.

Tylosurus giganteus JORDAN and STARKS, Proc. U. S. Nat. Mus. **26** (1903) 529; JORDAN and EVERMANN, Bull. U. S. Fish Comm. **23**[1] (1903) (1905) 124, fig. 39; JORDAN and SEALE, Proc. U. S. Nat. Mus. **28** (1905) 773; Bull. Bur. Fisheries 26 (1907) 8; EVERMANN and SEALE, Bull. Bur. Fisheries **26** (1907) 58; JORDAN and RICHARDSON, Bull. Bur. Fisheries **27** (1908) 242.

Belone annulata CUVIER and VALENCIENNES, Hist. Nat. Poiss. **18** (1846) 332, pl. 550; CANTOR, Journ. Asiat. Soc. Bengal **18** (1850) 1226; GÜNTHER, Cat. Fishes **6** (1866) 240; DAY, Fishes of India (1878) 510, pl. 120, fig. 1.

Mastacembelus annulatus BLEEKER, Ned. Tijds. Dierk. **3** (1866) 229; Atlas Ichthy. (1866–1872) 48, pl. 258, fig. 3.

Tylosurus annulatus WEBER and BEAUFORT, Fishes Indo-Aust. Arch. **4** (1922) 126; SEALE, Philip Journ. Sci. § D **5** (1910) 267.

Belone melanurus BLEEKER, Verh. Bat. Gen. **22** (1849) Bijdr. Ichth. Madura, 11.

Belone timucodes BLEEKER, Journ. Ind. Arch. **3** (1849) 67 and 68.

Belone cylindrica BLEEKER, Verh. Bat. Gen. **24** (1852) Snoekacht. Visschen. 13; KNER, Fische Novara Exp. (1865) 321.

Mastacembelus choram BLEEKER, Ned. Tijds. Dierk. **3** (1866) 277; not of Rüppell.

Local name.—Tagalog, *batalay.*

Dorsal II–20 to 22; anal II–18 to 20; pectoral 1–12 to 14; lateral line scales 350–380

Depth of the moderately compressed body 14.4 to 15.2 times in length, breadth 1.3 to 1.5 times in depth; head 3 to 3.25 times in length; eye 9.3 to 10 times in length, 5.9 to 6.4 times in snout, 2.3 to 2.6 times in postorbital portion of head, and 1.2 to 1.3 times in interorbital space; depth of mandible below eye equals half the longitudinal diameter of eye and is a little more than half the vertical eye diameter; top of head flat, with a wide shallow median groove, with a patch of very small scales at forward end; sides of groove strongly furrowed and ridged; supraorbital region covered with very feeble striæ; maxillary hidden or only posterior portion of its lower margin visible when mouth is closed; preopercle covered with small scales, opercle naked or with a few small scales, anteriorly or on lower part; canines well developed, awl-shaped, inclined forward; tongue covered with granular teeth or middle of anterior portion naked; the broad pointed pectoral a trifle shorter than postorbital region of head; base of ventrals midway between caudal base and anterior portion of eye; origin of dorsal above second undivided or first divided anal ray; middle dorsal rays shortest, anterior portion falcate, posterior rays elongate and in the young extending upon caudal, but never as long as the highest anterior rays; anal falcate anteriorly, the first rays longer than the anterior dorsal rays; the middle and posterior anal rays much shorter and of nearly equal length; caudal forked, the lower lobe the longer, damaged in all my specimens; caudal peduncle flattened above, somewhat four-sided, its breadth equal to or a little less than its height; lateral line elevated on caudal peduncle, forming a more or less evident keel, especially on base of caudal fin; 23 or 24 scales between lateral line and origin of dorsal.

Greenish to deep green above, sides silvery, white beneath, a broad bright silver band from shoulder to base of caudal, top of head and upper jaw dusky or blackish, sides of head bright silvery, the toothed margin of lower jaw black; a black vertical mark on posterior margin of preopercle; posterior part of dorsal and middle of caudal blackish; pectorals and anal blackish posteriorly.

In alcohol the color is brownish or brownish gray above, silvery on sides, belly white or yellowish; fins yellowish or clear, more or less blackish posteriorly; middle of caudal blackish. Specimens in formalin show a blue-black stripe from shoulder to caudal base, much broader on posterior half.

Here described from the following specimens, 140 to 620 millimeters in length:

Manila, 3.
Calapan, Mindoro, 1.
Mangarin, Mindoro, 1.
Bacon, Sorsogon, 1.
Bantayan Island, 2.
Estancia, Panay, 2.
Culion, 2.
Dumaguete, 1.
Panacan, Palawan, 2.
Zamboanga, 1.
Sitankai, 1.

Jordan and Seale had specimens from southern Negros and Cavite; Evermann and Seale from Bacon, Sorsogon; and Jordan and Richardson from Manila and Iloilo. It is common in Philippine waters and is a food fish of some value.

This large species, which reaches a length of 1,200 millimeters, is perhaps the most widely dispersed of the East Indian species. It occurs from the Seychelles and the coast of India to North Australia, Samoa, and the Austral Islands, north to the Hawaiian Islands and Japan.

The name *giganteus* takes precedence over *annulatus*. My copy of Pisces, Fauna Japonica, is dated 1842. According to Sherborn and Jentink,[1] parts X to XIV, including pages 173 to 169, of Pisces, were published in 1846. In the same year Valenciennes published *annulata,* on page 332 in the edition used by me. As *gigantea* appears on page 245 it precedes Valenciennes's name.

TYLOSURUS PHILIPPINUS Herre. Plate 3.

Tylosurus philippinus HERRE, Philip. Journ. Sci. **35** (1928) 31, pl. 2.

Dorsal II–18, 19, or 20; anal II–18 or 19 or I–20; pectoral 14 to 15; ventral 6; lateral line about 194 + 10; about 22 scales between origin of dorsal and lateral line.

The compressed elongate body roughly pentagonal, head nearly triangular in cross section; depth 11.25 to 11.3 times in length, breadth of body 1.56 to 1.6 times in its own depth, which is greatest just before dorsal; head 2.88 to 2.93 times in length, its flat upper surface with a wide deep median scaleless channel and a small narrow elongate groove on each side of it; space between these and outer margin of interorbital with longitudinally divergent striæ; median channel narrows abruptly anteriorly and is prolonged in a narrow median groove to tip of beak; the large lateral eye placed high up, 9 to 10 times in head, 2.68 to 2.75 times in postorbital part of head, 1.25 to 1.375 times in interorbital, 6 to 6.25 times in snout; the strong mandible 1.36 to 1.44 times in head; extending beyond end of snout in a thick, spongy, somewhat flexible tip which rises above so that upper jaw rests upon it and dorsal profile of latter is continuous with that of lower jaw tip when mouth is closed; upper margin of mandible, except its fleshy tip, in line with middle of pupil of eye; mouth abundantly supplied with long, strong, needle-pointed vertical canines, those of lower jaw out-

[1] Proc. Zool. Soc. (1895) 149.

side upper jaw when mouth is closed; tongue smooth except margin of posterior constricted part, which has some hard tubercles; fourth upper pharyngeals not distinct from third; maxillary not entirely hidden by preorbital; preorpercle entirely covered with fine scales, opercle and top of head naked; pectorals broad, 3.3 to 3.5 times in head; ventrals a little shorter than pectorals, more or less falciform; origin of dorsal opposite first undivided anal ray; anterior dorsal and anal rays elongate, equal to or a fourth longer than pectoral, both fins boldly falcate, anal rays longest in two specimens, dorsal rays in another; height of dorsal 3 to 3.2 times, of anal 2.66 to 3.5 times in head; breadth of short caudal peduncle 1.6 times in its depth; the lower lobe of the lunate caudal much the longer, 2.4 to 2.5 times in head; lateral line forms a low keel on caudal peduncle.

Color in alcohol brownish above, silvery below, opercles and underside of head white; fins colorless except upper half of dorsal, which is more or less dusky, and central portion of caudal which is dusky to blackish at outer margin.

Known from four specimens, 390 to 462 millimeters long. The type and cotype are from Coron, Busuanga, one specimen is from Bato Bato, Tawitawi, and one from Sitankai.

This species differs notably from other representatives of the genus in Philippine waters.

TYLOSURUS CROCODILUS (Lesueur). Plate 4, fig. 2.

Esox belone FORSKÅL, Descr. Anim. (1775) 67, not of Linné.

Belone crocodilus LESUEUR, Journ. Acad. Nat. Sci. Phila. 2 (1821) 129; CUVIER and VALENCIENNES, Hist. Nat. Poiss. 18 (1846) 327, pl. 549.

Tylosurus crocodilus FOWLER, Journ. Acad. Nat. Sci. Phila. 12 (1904) 501, pl. 9, upper fig.; WEBER and BEAUFORT, Fishes Indo-Aust. Arch. 4 (1922) 128.

Strongylura crocodila FOWLER, Proc. Acad. Nat. Sci. Phila. 71 (1919) 5.

Belone choram RÜPPELL, Neue Wirbelthiere, Fische (1835) 72; GÜNTHER, Cat. Fishes 6 (1866) 239; KLUNZINGER, Synopsis Fische des Rothen Meeres (1871) 578; DAY, Fishes of India (1878) 510 (not figure); GÜNTHER, Fische der Südsee 3 (1910) 351.

Tylosurus choram SEALE, Occ. Papers Bishop Mus. 4 (1906) 12 (doubtful).

Dorsal 22–23 according to authors, II–21 and 22 in my specimens; anal 19–21 according to authors, II–20 in my specimens; pectoral 1–13 lateral line about 270.

The breadth of the thick, robust, elongate body equals or is 1.25 times in its depth, which is 12.75 times in the length;

head very broad, strongly flattened above and on sides, 3.33 to 3.5 times in length; the large eye slightly elongate, 7.75 to 10 times in head, 2.25 to 3 times in postorbital region, 4.54 to 6.4 times in snout, and 1.375 to 1.7 times in the broad interorbital space; suborbital depth 1.9 to 1.35 times in eye, maxillary entirely hidden or its lower margin may be visible when mouth is closed; a wide shallow median groove on top of head, with a patch of scales at anterior end, and a narrow shallow groove on each side of it; supraorbital bone very finely striated; a conspicuous median groove on top of snout, the rest of its upper surface minutely pitted and roughened; preopercle scaled, opercle naked; canines large, strong, conical, erect, those of lower jaw outside upper jaw when mouth is closed, and very conspicuous; tongue entirely covered with rather large, hard, rounded tubercles; the broad pectorals equal to or a little shorter than postorbital portion of head; ventrals eight-ninths of pectorals, their base about midway between caudal base and anterior part of eye; origin of dorsal opposite base of first divided anal ray; dorsal and anal falcate anteriorly, middle and posterior rays much shorter, slender, and with prolonged tips, dorsal not extending to caudal, anal ending some distance before caudal; the lower lobe of the forked caudal the larger, 8.5 times in length, 1.45 times the postorbital part of head; caudal peduncle flatened above and below, its breadth nearly equal to its depth; lateral line forms a very slight keel on caudal base; 24 scales between origin of dorsal and lateral line.

Color in alcohol brown above, with a bluish dusky band from shoulder to caudal, yellowish brown below; pectorals dusky on outer half; other fins greenish yellow, dorsal with blackish margin.

Here described from a specimen 620 millimeters long, with damaged snout and caudal, from Tacloban, Leyte, and one 850 millimeters long, from Manila Bay. The Bureau of Science collection also contains a specimen 232 millimeters long, from Sitankai, and one 108 millimeters long, from Zamboanga. It is the bulkiest of the Philippine gars, and an important food fish at times.

This species reaches a length of more than 1,200 millimeters and occurs from the Red Sea and the east coast of Africa, through the Indian Ocean and the East Indies to the Bismarck Archipelago, the Solomon Islands, and Tahiti, north to Tonkin.

TYLOSURUS MELANOTUS (Bleeker).

Belone coromandelica VAN HASSELT, Alg. Konst. en Letterbode 1 (1823) 130 (nomen nudum).
Belone timucoides VAN HASSELT, Bull. de Férussac 2 (1824) Zool. 374 (no description).
Belone melanotus BLEEKER, Nat. Tijds. Ned. Ind. 1 (1850) 94; GÜNTHER, Cat. Fishes 6 (1866) 238; MEYER, Ann., Soc. España Hist. Nat. 14 (1885) 38; GÜNTHER, Fische der Südsee 3 (1910) 352.
Mastacembelus melanotus BLEEKER, Atlas Ichthy. 6 (1866–1872) 47.
Tylosurus melanotus FOWLER, Journ. Acad. Nat. Sci. Phila. 12 (1904) 501; WEBER and BEAUFORT, Fishes Indo-Aust. Arch. 4 (1922) 127, fig. 47.
Mastacembelus choram BLEEKER, Atlas Ichthy. 6 (1866–1872) pl. 256, fig. 1.
Tylosurus coromandelicus JORDAN and STARKS, Proc. U. S. Nat. Mus. 26 (1903) 530.
Strongylura coromandelica FOWLER, Proc. Acad. Nat. Sci. Phila. 71 (1919) 5.

Dorsal II–23 or 24; anal II–20 or 21; pectoral 1–11 or 12; lateral line about 300–350.

The elongate body strongly compressed, its breadth 1.45 to 1.7 times in depth, which is greatest just before ventrals and contained 13.3 to nearly 17 times in length; the broad head flattened above and on sides, 3.1 times in length; the large, slightly elongate eye very high, 9.1 to 9.7 times in head, about 7 times in the very long slender snout, 1.95 to 2 times in postorbital region, and equal or nearly equal to interorbital breadth; depth of mandible below eye about 3 times in longitudinal diameter of eye; maxillary entirely covered by preorbital when mouth is closed; top of head flat, much striated, with a very shallow and little developed median depression; preoporcle scaled, opercle naked except for a row or two of scales along its front margin; canines numerous, small, straight; tongue more or less covered with very small granular teeth; the broad pectorals equal or slightly exceed postorbital part of head; ventrals five-sixths of or nearly equal to postorbital region, their base about halfway between hind margin of eye and base of caudal; origin of dorsal above first divided ray in my specimens, anterior rays falcate and longer than the others, middle rays a little the shortest, last ray not quite reaching caudal base; anterior anal rays falcate, scarcely as long as anterior dorsal rays, the other anal rays much shorter and subequal; lateral line forms a more or less elevated dark or blackish keel on caudal peduncle; breadth of caudal peduncle equals its depth, caudal forked, lower lobe much the longer, 1.33 to 1.66 times length of pectoral; 22 to 24 scales between lateral line and origin of dorsal.

Color in alcohol brown above, silvery on sides, the two colors sharply defined; in one specimen a dark blue band from shoulder to base of caudal and a similar, less well-defined line along median line of back; dorsal fin brown to blackish, anal brownish anteriorly, the rest of it with a dusky margin; outer half of pectorals more or less blackish; caudal dusky or yellowish; a blackish elongate spot on upper part of eye.

Here described from three specimens, one 455 millimeters long from Vigan, Ilocos Sur; one 610 millimeters long from Gingoog, Misamis Province, Mindanao; and one 505 millimeters long from Sitankai. Meyer recorded this species from Cebu.

This species occurs throughout the East Indies, north to Japan, and southeast to New Caledonia and North Australia.

SUMMARY OF THE PHILIPPINE GARFISHES DESCRIBED IN THIS PAPER

Family 1. BELONIDÆ

Genus 1. ABLENNES Jordan and Fordice

1. *Ablennes hians* (Cuvier and Valenciennes).

Genus 2. TYLOSURUS Cocco

2. *Tylosurus strongylurus* (van Hasselt).
3. *Tylosurus macrolepis* (Bleeker).
4. *Tylosurus incisus* (Cuvier and Valenciennes).
5. *Tylosurus leiurus* (Bleeker).
6. *Tylosurus giganteus* (Schlegel).
7. *Tylosurus philippinus* Herre.
8. *Tylosurus crocodilus* (Lesueur).
9. *Tylosurus melanotus* (Bleeker).

ILLUSTRATIONS

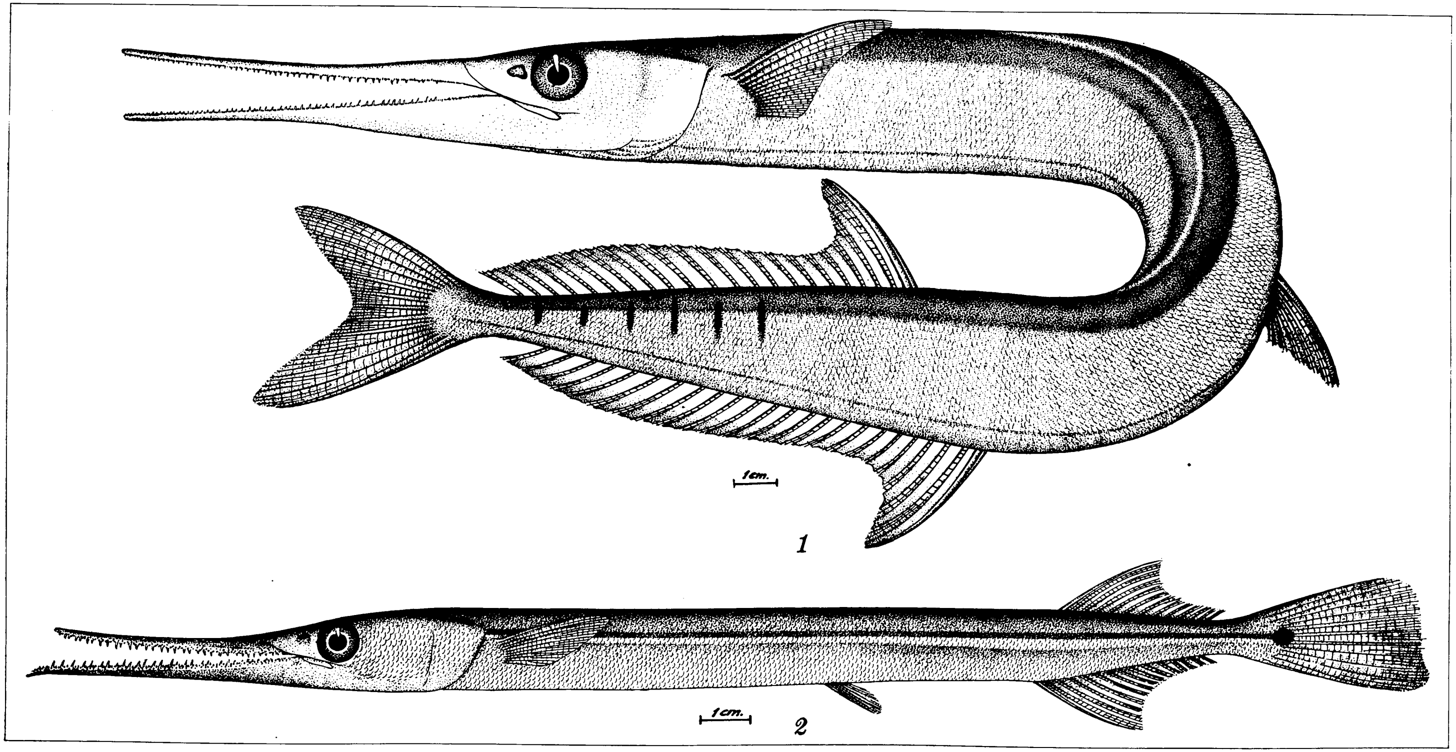


PLATE 1.

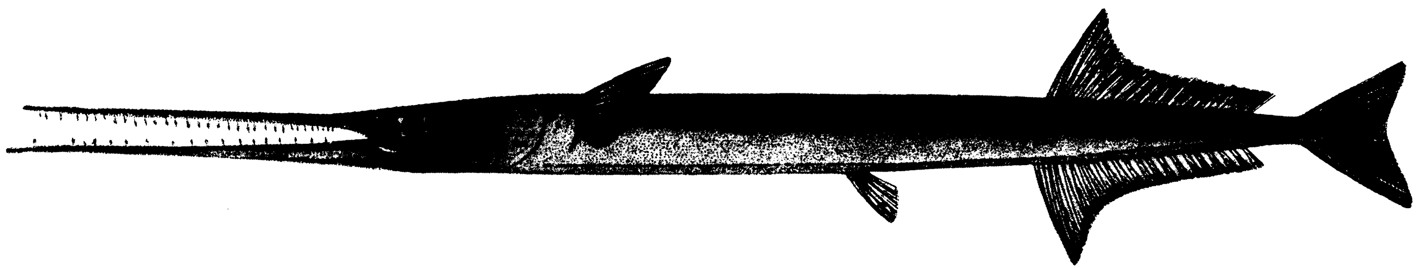


PLATE 2. TYLOSURUS LEIURUS (BLEEKER).

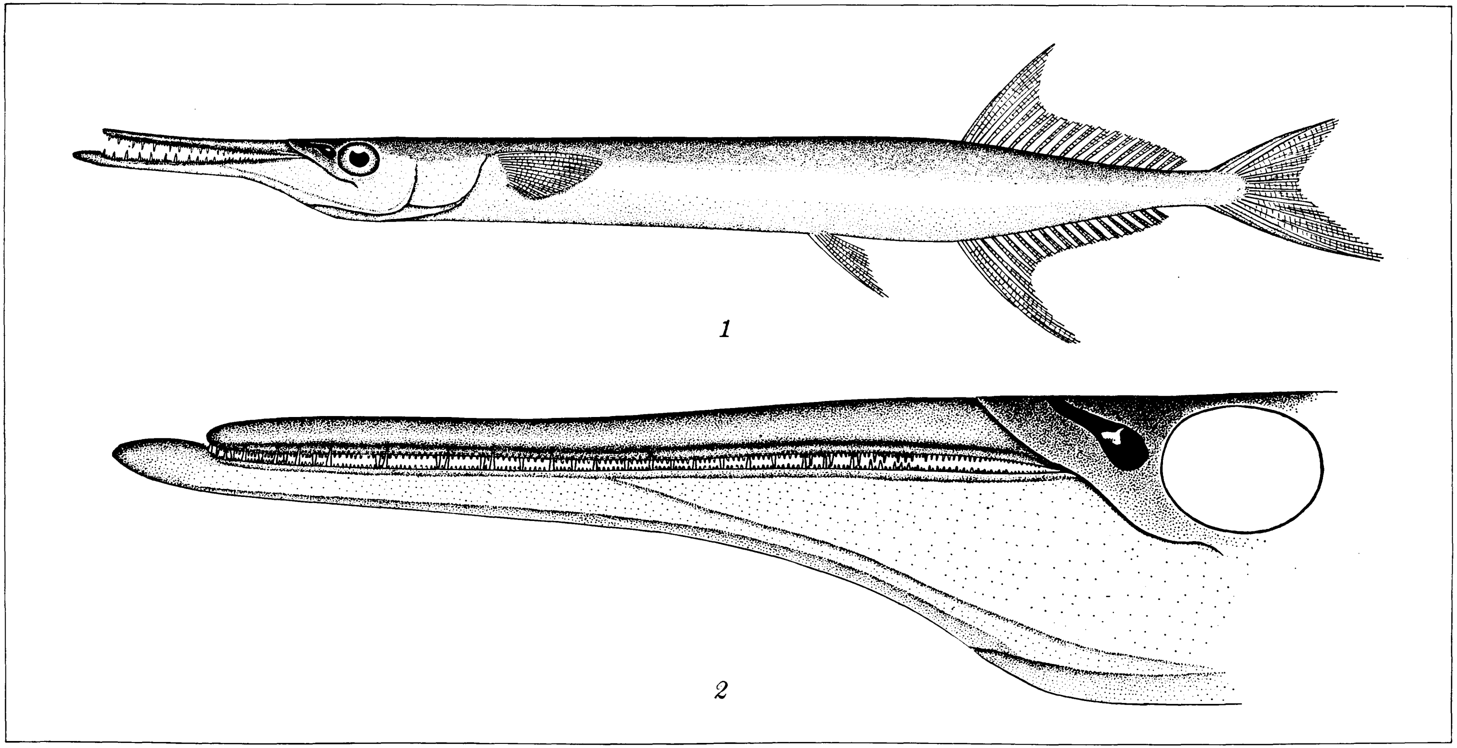


PLATE 3. TYLOSURUS PHILIPPINUS HERRE.

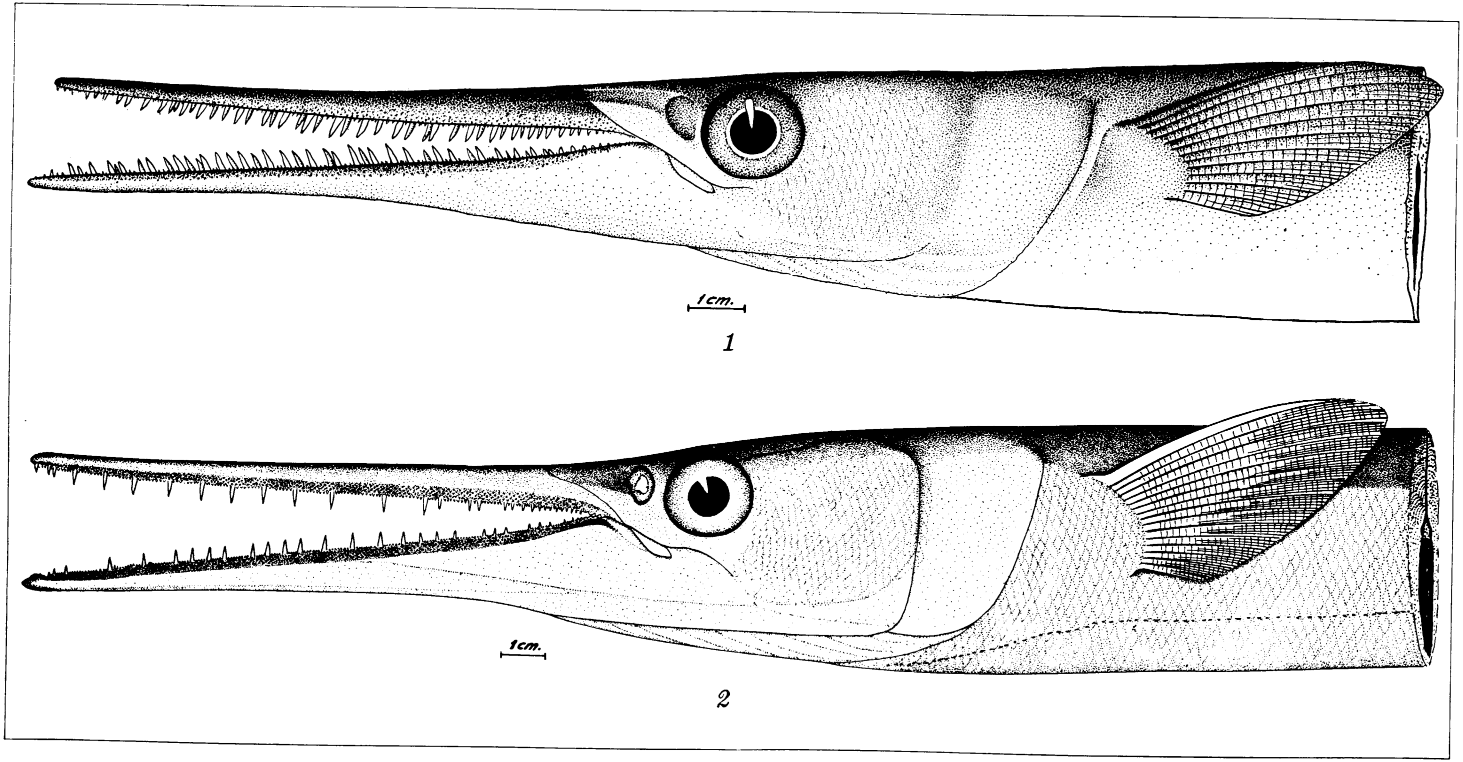


PLATE 4.

COMPOSITION AND NUTRITIVE VALUE OF PHILIPPINE FOOD FISHES

By ABELARDO VALENZUELA

Of the Bureau of Science, Manila

Fish constitutes the principal protein food of a large majority of the people of the Philippine Islands. According to Herre,[1] approximately one-tenth of all the known kinds of fishes, or about 2,000 species, are found in Philippine waters. Most of these are edible.

SPECIES OF FISHES EXAMINED

Forty species of fresh fishes that are commonly found in the markets were examined. Some species were represented by more than one fish, like herring, snapper, etc. Table 1 is a list of the species of fishes that were analyzed in a fresh condition as they were purchased from various markets in Manila.

The following dried or smoked fishes were analyzed:

English name.	Tagalog name.
Slipmouth.	Sapsap.
Young mullet.	Talilong.
Goatfish.	Tuyo.
Anchovy.	Dilis.
Herring.	Tinapa, Tamban.

The following shellfishes were analyzed: Shrimps, lobsters, crabs, clams, and oysters; they are the ones most commonly eaten. Likewise, squid (pusit), and shrimp bagoong, a local sauce, were analyzed.

Calorific value.—The calorific or fuel value of each fish per 100-gram sample was obtained by using the standard physiological fuel values of the food constituents given by Rubner,[2] as follows: Carbohydrates, 4.1 calories per gram; fats, 9.3; protein, 4.1. The highest number of calories per 100 grams of the fish was obtained from the fish called mayamaya (red snapper), which gave 145.5 calories, and the lowest, 72.7 calo-

[1] Herre, Albert W., Fishery Resources of the Philippine Islands, Bureau of Science Popular Bull. 3 (1927) 9.

[2] Sherman, Chemistry of Foods and Nutrition (1918) 143.

TABLE 1.—*Names of fishes that were analyzed in a fresh condition.*

Serial No.	English name.	Tagalog name.	Scientific name.
1	Albacore, tuna	Tulingan	Thunnidæ.
2	Anchovy	Dilis	Engraulidæ.
3	Aso-os	Asohos	*Sillago sihama.*
4	Barracuda	Torsillo, babayo	Sphyraenidæ sp.
5	Basling, bastard shad	Kabasi	*Anadontostona chacunda* and *Konosirus thrissa.*
6	Billfish	Siriu (Ilocano)	Belonidæ.
7	Butterfly fish	Paro-paro dalag bukid	Chaetodontidæ.
8	Catfish	Kanduli	*Arius* sp.
9	Cavalla	Talakitok	Carangidæ.
10	Chub mackerel	Hasahasa	*Scomber microlepidotus.*
11	Climbing perch	Liwalo	*Anabas testudineus.*
12	Drepane	Mayang	*Drepane punctata.*
13	Eel, marine	Palos, pindanga	Ophichthyidæ.
14	Flounder	Dapa, palad	Pleuronectidæ.
15	Flathead	Sunog	Platycephalidæ.
16	Goby	Bia	*Glossogobius giruus.*
17	Grouper	Lapo-lapo	Serranidæ.
18	Grunt	Redillo, bisugo	Theraponidæ.
19	Herring	Tulis, tunsoy, siliñasi, tamban	Clupeidæ.
20	Jackfish	Talangtalang	Carangidæ.
21	Kingfish	Tanguingue	*Scomberomorus* sp. and *Acanthocybium* sp.
22	Leather jacket	Kassisung	*Scomberoides* sp.
23	Lizard fish	Kalaso	Synodontidæ.
24	Milkfish	Bañgos	Chanidæ.
25	Moray	Malabanos	Muraenidæ.
26	Mullet	Banak, talilong	Mugilidæ.
27	Murrel	Dalag, bakule	*Ophicephalus striatus.*
28	Pampano	Malapito, manipis, muslo	*Caranx* sp.
29	Parrot fish	Molmol	Scarichthyidæ.
30	Porgy	Bacoco	Sparidæ.
31	Red snapper, gray snapper	Mayamaya	Lutianidæ.
32	Sea bass	Apahap	*Lates calcarifer.*
33	Slipmouth	Hiwas, sapsap	Leiognathidæ.
34	Spadefish	Kitang	*Scatophagus argus.*
35	Surgeon fish	Indañgan, labahita, samaral	Acanthuridæ, *Siganus javus.*
36	Swordfish	Malasugi (Bicol)	*Xiphias gladius.*
37	Tarpon	Buan buan	*Megalops cyprinoides.*
38	Thread fin	Mamali	Polynemidæ.
39		Malakapas	*Xystaema abbreviatus.*
40	Ten-pounder	Bidbid	*Elops saurus.*

ries, from anchovy (dilis). Dried fishes gave very high calorific values, due to the highly concentrated condition of the fish.

Table 2 shows the composition of the different species of fresh fishes examined. There is great variation in the percentage of composition of moisture, fats, and protein. Carbohydrates were obtained by difference. In most of the samples, the carbohydrate content is nil, while in others it amounts to a very small quantity.

These differences may be attributed to various factors. According to Carter, Howe, and Mason,[3] the fat content of fish varies at the time of spawning, the different seasons of the year, and with changes in feeding conditions. Fishes are found to have deposited the maximum amount of fat just before the spawning season, and to have a minimum fat content a few weeks afterward. The food supply also affects the composition of fish. When they are forced away from their accustomed feeding grounds by storm or by natural enemies, they often arrive on our shores in a very lean condition.

Table 3 shows the composition of a few varieties of dried and smoked fishes analyzed. Attention is invited to the high protein and ash content. These fishes have been salted, and dried or smoked.

Table 4 shows the composition of some shellfishes (shrimps, lobsters, crabs, clams, and oysters) analyzed in order to compare them with fish. Shrimps are an important daily food of the Filipinos, either cooked alone or as an addition to vegetables and rice. Crabs, clams, and lobsters are likewise considered important sea foods, and have assumed a new importance in the light of nutrition studies.[4]

Fish is held to be more easily digested than other types of flesh food and meats. Estimation of its digestibility[5] shows that the protein is absorbed to the extent of 96 per cent, and the fats 97 per cent. It contains practically no carbohydrates. In mollusks, such as oysters, clams, and mussels, carbohydrates exist as glycogen.[5]

SUMMARY

1. The nutritive value of forty species of fresh fishes, six kinds of preserved fishes, and a few common shellfishes (crustaceans and mollusks) has been determined.

2. Fresh fish has an average protein content ($N \times 6.25$) of 20.15 per cent, while smoked or dried fish has as much as 44.92 per cent.

3. Fresh fish has an average fuel value of 99.02 calories, while smoked or dried fish has 237 calories per 100 grams.

4. Shrimps have 22.7 per cent protein and a fuel value of 98.8 calories per 100 grams; lobsters, 21.64 per cent protein

[3] Nutrition and Clinical Dietetics (1923) 202.

[4] McCollum and Simmonds, The newer knowledge of nutrition, Chap. IX p. 160.

[5] Carter, Howe, and Mason, Nutrition and Clinical Dietetics (1923) 204.

TABLE 2.—*Composition of Philippine food fishes.*

Fishes as found in the market.		Edible portion.	Refuse (entrails, skins, bones, etc.).	Edible portion.						Calories per 100 grams.	Remarks.
English name.	Tagalog name.			Water.	Water-free substance.	Protein (N×6.25).	Fats (ether extract).	Carbohydrates (by difference).	Ash.		
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*		
Albacore, tuna	Tulingan	55.93	44.07	72.91	27.09	23.91	1.77	0.19	1.22	115.3	Fresh, edible portion analyzed.
Anchovy	Dilis			81.01	18.99	15.66	0.78	0.31	2.24	72.7	Eaten whole; entire fish analyzed.
Aso-os	Asohos	47.35	52.65	73.82	26.18	18.59	5.67	0.66	1.26	131.6	Fresh, edible portion analyzed.
Barracuda	Torsillo, babayo			77.29	22.71	20.09	0.77	0.43	1.42	91.3	Large fish; section analyzed.
Basling	Kabasi	47.06	52.94	77.03	22.97	19.36	1.67	0.28	1.66	96.0	Fresh, edible portion analyzed.
Bill fish	Siriu (Ilocano)	55.77	44.23	78.00	22.00	20.58	0.32		1.38	87.3	Do.
Butterfly fish	Dalag bukid	52.82	47.18	75.12	24.88	20.96	2.86		1.32	112.5	Do.
Catfish	Kanduli	43.22	56.78	81.09	18.91	17.16	0.16	0.55	1.04	74.1	Do.
Cavalla	Talakitok	52.65	47.35	76.86	23.14	21.44	0.66		1.29	94.0	Do.
Chub mackerel	Hasahasa	53.29	46.71	73.85	26.15	22.83	1.95	0.32	1.05	113.0	Do.
Climbing perch	Liwalo	35.93	64.07	78.62	21.38	18.69	1.60		1.09	76.4	Do.
Drepane	Mayang	36.30	63.70	78.51	21.49	18.96	1.32		1.22	90.0	Do.
Eel, marine	Palos			78.76	21.24	16.72	3.10	0.29	1.13	98.6	Large fish; section analyzed.
Flounder	Dapa, palad	52.00	48.00	76.81	23.19	19.98	0.97	1.08	1.16	88.6	Fresh, edible portion analyzed.
Flathead	Sunog	40.16	59.84	79.19	20.81	19.96	0.18		1.12	83.5	Do.
Goby	Bia	49.50	50.50	81.03	18.97	17.59	0.11	0.32	0.95	74.4	Do.
Grouper	Lapo-lapo			76.33	23.67	20.22	0.69	1.04	1.72	93.8	Large fish; section analyzed.
Grunt	Rodillo, bisugo	38.58	61.42	79.64	20.36	18.83	0.59		0.98	82.7	Fresh, edible portion analyzed.
Herring	Tulis	([a])	([a])	77.31	22.69	18.91	1.25	1.08	1.45	93.6	Eaten whole; entire fish analyzed.
Do	Tunsoy	([b])	([b])	71.32	28.68	20.39	3.58	2.74	2.07	128.1	Do.
Do	Siliñasi	([c])	([c])	74.36	25.64	19.13	2.63	0.22	3.66	103.8	Do.
Do	Tamban	28.6	71.4	79.16	20.84	19.12	2.70		1.01	103.5	Edible portion analyzed.
Jackfish	Talangtalang	49.9	50.1	77.15	22.85	20.90	0.21	0.39	1.35	89.2	Do.

Kingfish	Tanguingue			75.66	24.36	20.36	2.67		1.32	108.3	Large, fish; section analyzed.
Leather jacket	Kassisung	52.03	47.97	77.65	22.35	20.28	0.07	0.48	1.52	85.7	Fresh, edible portion analyzed.
Lizard fish	Kalaso	61.64	38.36	79.17	20.83	19.40	0.45		1.50	83.7	Do.
Milkfish	Bañgos	70.56	29.44	73.80	26.20	19.24	5.57	0.10	1.29	131.1	Do.
Moray	Malabanos	([d])	([d])	77.71	22.29	19.08	1.28		3.35	90.1	Eaten whole; entire fish analyzed.
Mullet	Banak	44.5	55.5	74.78	25.22	20.68	4.23		1.23	124.0	Fresh, edible portion analyzed.
Young mullet	Talilong	30.00	70.0	77.20	22.80	20.15	2.65		1.23	103.0	Do.
Murrel	Dalag	85.00	15.0	80.10	19.90	16.95	0.48	1.48	0.99	80.0	Do.
Pampano	Malapito	52.96	47.04	76.00	24.00	20.18	2.17	0.28	1.37	104.0	Do.
Parrot fish	Lorita, molmol	47.62	52.38	75.76	24.24	20.95	2.03		1.46	104.7	Fresh, edible portion analyzed.
Porgy	Bacoco	46.40	53.60	77.37	22.63	19.87	0.63	0.74	1.39	90.4	Do.
Gray snapper	Mayamaya	58.33	41.67	78.26	21.74	17.62	1.57	1.33	1.22	92.3	Do.
Red snapper	do			72.72	27.28	18.44	7.42	0.24	1.18	145.5	Large fish; section analyzed.
Striped snapper	do	39.15	60.85	78.75	21.25	20.42	0.65		1.21	89.8	Fresh, edible portion analyzed.
Sea bass	Apahap	67.00	33.00	74.81	25.19	20.77	1.94	1.03	1.45	89.5	Do.
Slipmouth	Sapsap	41.80	58.20	79.09	20.91	19.23	0.54		1.28	83.8	Do.
Spade fish	Kitang	46.85	53.15	72.24	27.76	20.11	6.57		1.08	143.5	Do.
Surgeon fish	Labahita, samaral	76.05	23.95	74.35	25.65	19.19	3.75	1.34	1.37	119.0	Do.
Swordfish	Malasugui (Bicol)	54.79	45.21	77.52	22.48	20.30	0.10	0.68	1.40	86.9	Do.
Tarpon	Buan buan	44.08	55.92	77.21	22.79	20.16	1.70		1.13	84.2	Do.
Threadfin	Mamali	52.02	47.98	78.15	21.85	19.12	0.41	1.04	1.28	86.4	Do.
	Malakapas	41.49	58.51	75.48	24.52	21.01	2.02	0.18	1.31	105.6	Do.
Ten-pounder	Bidbid	55.57	44.43	79.15	20.85	19.37	0.29		1.41	82.1	Do.
Young barracuda	Torsillo	59.40	40.60	78.56	21.44	18.74	0.34	1.10	1.26	84.5	Do.

[a] Average weight of each fish, 29.0 grams.
[b] Average weight of each fish, 29.3 grams.
[c] Average weight of each fish, 10.0 grams.
[d] Average weight of each fish, 8.8 grams.

TABLE 3.—*Composition of Philippine food fishes.*

Salted, dried and smoked fishes as found in the market.		Fishes analyzed.	Average weight of each fish.	Edible portion.						Calories per 100 grams.	Remarks.
English name.	Tagalog name.			Water.	Water-free substance.	Protein (N×6.25).	Fats (ether extract).	Carbohydrates (by difference).	Ash.		
		Per cent.	*g.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Slipmouth	Sapsap	12	20	41.39	58.61	45.64	2.46		10.52	210.0	Salted, dried fish: edible portion analyzed.
Young mullet	Talilong	10	15.25	44.49	55.51	37.44	6.24		12.20	211.5	Do.
Goatfish	Tuyo	12	9.80	42.63	57.37	40.74	4.09		12.39	205.0	Do.
Anchovy	Dilis	20	1.55	20.69	79.31	67.49	3.30		8.42	307.4	Do.
Herring	Tinapa	10	6.40	36.60	63.40	53.31	3.60		7.04	252.0	Smoked fish; edible portion analyzed.
Milkfish	Bañgos	1	462.0	64.94	35.06	30.29	3.84		1.59	159.9	Roasted fish; edible portion analyzed.
Shrimp sauce	Bagoong aiamang			58.38	41.62	12.45	1.13	1.90	26.14	69.3	Salted, fermented shrimps analyzed.

TABLE 4.—*Composition of Philippine shellfishes.*

Shellfishes (crustaceans and mollusks) as found in the markets.		Edible portion.	Refuse (shell, bones, etc.).	Edible portion.						Calories per 100 grams.	Remarks.
English name.	Tagalog name.			Water.	Water-free substance.	Protein (N×6.25).	Fats (ether extracts).	Carbohydrates (by difference).	Ash.		
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Shrimp	Hipon	58.36	41.64	75.43	24.57	22.70	0.62	--------	1.63	98.8	Fresh, edible portion analyzed.
Lobster	Ulang	60.45	39.55	75.48	24.52	21.64	0.64	0.81	1.43	98.0	Do.
Crab	Alimango	48.63	51.37	80.07	19.93	12.79	5.04	--------	2.49	99.3	Do.
Small crab	Talangka	20.10	79.90	61.02	38.98	15.81	12.50	9.29	1.38	219.2	
Oyster	Talaba	19.25	80.75	87.97	12.03	6.76	1.26	3.44	0.57	53.5	Do.
Clam	Halaan	14.91	85.09	78.89	21.11	9.68	3.12	4.41	3.90	86.8	Do.
Squid	Pusit	98.16	1.84	76.46	23.54	18.39	0.52	3.00	1.63	80.2	Do.

and 98 calories; crabs, 12.79 per cent protein, 5.04 per cent fats, and 99.3 calories; clams, 9.68 per cent protein, 3.12 per cent fats, and 86.8 calories; oysters, 6.76 per cent protein, 3.44 per cent carbohydrates, and 53.5 calories; and squid (pusit), 18.39 per cent protein and 80.2 calories.

5. Plain roasted bañgos, or milkfish, has 30.29 per cent protein, 3.84 per cent fats, and 159.9 calories per 100 grams. Bagoong alamang, a partly fermented Filipino food made from small shrimps, has 12.45 per cent protein and 69.3 calories per 100 grams.

6. It is of great importance to know the dietary values of the various Philippine foodstuffs, so that it may be easily possible to make combinations that will provide highly nutritious diets for all classes of people.

PHILIPPINE LITTORAL ECHINOIDA

By Hilario A. Roxas

Of the Department of Zoölogy, University of the Philippines, Manila

SEVEN PLATES

This report on echinoids is based upon the littoral sea urchins and sand dollars in the collection of the Department of Zoölogy, University of the Philippines. The heart urchins are not included, as the few specimens in the collection are mostly broken and empty tests, probably picked up dead along sandy beaches. Collections are dated as early as 1913 and, as they have remained untouched for a long time, many of the specimens are now in a poor state of preservation. Credit is due to L. E. Griffin, R. P. Cowles, S. F. Light, and A. L. Day, who have contributed material to the collection.

This report is not meant to be a complete check list of Philippine littoral Echinoida, but is published in the hope that it may stimulate the interest of other workers and collectors. A much more extensive and intensive survey of Philippine waters is needed to bring this list to perfection. The aid of other workers and collectors is therefore solicited. All of the Philippine species of sea urchins and sand dollars have been described by specialists of other countries, and the types are deposited in foreign museums and laboratories. References to Echinoida of the Philippines are found in scattered papers dealing with larger areas or in general works, as in A. Agassiz's (1881) Challenger Echinoidea, Clark's (1925) Catalogue of Recent Sea Urchins in the Collection of the British Museum, and others. Most of these works are either out of print or inaccessible to most students. Philippine Echinoida are inadequately described and good illustrations are usually wanting. This paper may perhaps aid students and collectors in the Philippines to identify the material they find and enable foreign workers to determine whether or not the forms they have are identical with Philippine forms.

The echinoderms have not been observed to be as numerous in the Philippines as in temperate waters; but, as if to compensate for this, the number of species is very large. At Puerto Galera, Mindoro, there are no less than eleven species of sea urchins and five of sand dollars. When this number is compared with two species of sea urchins and two of sand dollars found around the Marine Biological Station at Woods Hole, Massachusetts, the difference between the number of species found in tropical and in temperate waters is at once seen. Only three of the eleven species of sea urchins at Puerto Galera can be said to be abundant; these are *Tripneustes gratilla, Echinotrix calamaris*, and *Echinometra oblonga*. The others are rare and can be collected in very small numbers. The sand dollars are much less abundant. At Puerto Galera, Esanada seems to be the best collecting ground of *Arachnoides placenta* and *Ehinodiscus auritus*, and Medio Island toward the northwest channel for the two species of *Laganum;* yet none of these sand dollars appears in as great numbers as does the common sand dollar of the temperate waters of the American and Japanese coasts, *Echinarachnius parma*.

For purposes of identification living or freshly killed sea urchins and sand dollars are the best. I have found that the method recommended by Clark (1904) is the best. The animal is first narcotized by placing it in a solution of magnesium sulphate and then killed in 50 per cent alcohol or stronger. For preservation 70 per cent alcohol is used. To retain the typical color the animal should be killed in 50 per cent alcohol and then dried rapidly in the sun or by artificial heat, and care should be taken that the interior is saturated with alcohol before drying. Formalin should not be used, as it causes the tissues to swell and become slimy, and it dissolves the calcareous portions that are essential for proper identification. For the same reason, acid of any kind should be avoided. Pedicillariæ are best studied after they have been removed from the animal, soaked in a 10 per cent solution of potassium hydroxide, and mounted in glycerine or balsam.

The following is a list of Recent Echinoida reported by A. Agassiz (1881) with the Philippines as one of the principal localities where they were found:

GOMOCIDARIDÆ

Dorocidaris papillata.
Phyllacanthus annulifera.
Phyllacanthus baculosa.
Porocidaris elegans.

SALENIDÆ

Salenia hastigera.

ARBACIADÆ

Arbacia nigra.
Podocidaris prionigera.
Coelopleurus maillardi.

DIADEMATIDÆ

Diadema setosum.
Aspidodiadema tonsum.
Echinotrix calamaris.
Micropyga tuberculatum.
Astropyga radiata.

ECHINOTHURIDÆ

Asthenosoma gracile.
Asthenosoma grubii.
Asthenosoma pellucidum.
Asthenosoma tassellatum.
Phormosoma asterias.
Phormosoma luculentum.

ECHINOMETRIDÆ

Echinometra lucunter.
Echinometra oblonga.
Strongylocentrotus albus.
Pseudoboletia indiana.

TEMNOPLEURIDÆ

Temnopleurus hardwickii.
Temnopleurus reynadi.
Temnopleurus toreumaticus.
Prionechinus sagittiger.
Microcyphus zigzag.
Salmacis bicolor.
Salmacis rarispina.
Mespilia globulus.

TRIPLECHINIDÆ

Echinus angulosus.
Toxopneustes pileolus.
Hipponoe variegata.

CLYPEASTRIDÆ

Fibularia ovulum.
Clypeaster humilis.
Clypeaster scutiformis.

LAGANIDÆ

Laganum bonani.
Laganum depressum.
Peronella decagonalis.
Peronella peronii.

SCUTELLIDÆ

Echinodiscus auritus.

The following is a list of Philippine sea urchins and sand dollars in the collection of the British Museum of Natural History as reported by H. L. Clark (1925). The majority of these were collected during the voyage of H. M. S. *Challenger*, 1873 to 1876:

CIDARIDÆ

Prionocidaris baculosa, Zamboanga.
Prionocidaris verticillata, Mindoro.
Stylocidaris reini, east of Mindoro.
Stereocidaris grandis, north of Mindanao.
Discocidaris florigera, east of Mindoro.
Histocidaris elegans, no locality.

ASPIDODIAMETIDÆ

Micropyga tuberculata, off Cebu.

ECHINOTHURIDÆ

Phormosoma bursarium, northwest of the Philippines.

Echinosoma luculentum, near the Philippine Islands.

Asthenosoma varium, Zamboanga.

Araesoma gracile, no locality.

Araesoma pellucidum, near Cebu.

Araesoma tessellatum, near the Philippine Islands.

ARBACIADÆ

Pygmaeocidaris prionigera, Philippine Islands.

Coelopleurus longicollis, Basilan Strait.

TEMNOPLEURIDÆ

Prionechinus sagittiger, no locality.

Temnopleurus toreumaticus, Negros.

Salmacis bicolor, Zamboanga.

Salmacis dussumieri, near Zamboanga.

Salmacis sphaeroides, Cebu, Mactan Reef, Mindanao.

Mespilia globulus, Zamboanga.

ECHINIDÆ

Toxopneustes chlorocanthus, Masbate.

Toxopneustes pileolus, Siquijor, Zamboanga.

Tripneustes gratilla, Masbate, Zamboanga.

STRONGYLOCENTROTIDÆ

Pseudoboletia indiana, Zamboanga.

Pseudoboletia maculata, Zamboanga.

Evechinus chloroticus, Mindoro.

ECHINOMETRIDÆ

Echinometra mathei, Zamboanga.

Heterocentrotus mammillatus, Luzon, Negros.

CLYPEASTRIDÆ

Clypeaster humilis, no locality.

ARACHNOIDIDÆ

Arachnoides placenta, near Tabaco, Albay.

LAGANIDÆ

Laganum depressum, Siquijor, west of Panay.

Laganum laganum, Siquijor.

Peronella orbicularis, near Zamboanga.

In the key for the animals reported in this paper and in the descriptions of the various species the following terms and abbreviations are used:[1]

Abactinal system.—The group of plates at the apex of the test (or near the apex). The genital and ocular plates and, in true urchins, the anal plates compose this system.

Ambitus.—The largest horizontal circumference of the bare test.

Auricles.—Ossicles on the actinal edge of the test situated internally, which serve for the attachment of muscles controlling the movements of the Aristotle's lantern.

Compound plates.—Plates containing more than one elementary plate, primary and demi-plates. The number of elementary plates is shown by the number of pore pairs.

Coronal plates.—Any vertical series of plates running from the abactinal system to the peristome.

D.—Longest diameter of test.

Epiphyses.—A pair of ossicles connecting the upper ends of the alveoli of each pyramid of the Aristotle's lantern. Epiphyses are narrow when they do not meet each other above to form an arch.

Genital plates.—The five large plates at the abactinal end of the interambulacral areas.

Gill cuts.—Indentations of the test around the peristome, situated between the ambulacral and interambulacral areas.

H.—Height of test.

Imbricate plates.—Plates that are more or less overlapping.

Imperforate tubercles.—Tubercles without any central depression or vertical perforations.

Interporiferous areas.—Areas between the poriferous areas of the ambulacral regions.

Lunules.—Slitlike opening through the test, usually in the case of sand dollars and heart urchins.

Miliary spines.—The smallest spines found on the test, usually on very tiny tubercles.

Ocular plates.—Small plates of the abactinal system at the end of the ambulacral areas.

Petals.—The figures formed by the poriferous areas of the ambulacra, in sand dollars and heart urchins.

Poriferous areas.—Areas occupied by the pores of the tube feet.

Primary spines.—The largest spines on the largest tubercles.

Secondary spines.—Medium-sized spines, smaller than the primaries and larger than the miliaries.

Simple plate.—A plate containing one elementary plate (as shown by the number of pore pairs).

Sphæridia.—Small globular bodies on the oral surface. There are modified spines, supposed to be static in function.

[1] The terms used, their definitions, and the system employed in the descriptions are patterned after the work of H. L. Clark (1904).

Key to the Philippine littoral Echinoida.

a^1. Test more or less spherical, spines large or moderate, periproct at center of upper side, opposite mouth.

b^1. Ambulacral plates simple, peristome plated, sphæridia and peristomial gills absent.

c^1. Primary spines large and blunt with three or four whorls of projecting ridges, color, greenish................ *Prionocidaris verticillata.*

c^2. Primary spines small, without projecting ridges, but with small granules, color purplish.............................. *Prionocidaris baculosa.*

b^2. Coronal plates usually compound, forming two columns in each ambulacrum and each interambulacrum. Peristomial gills and sphæridia present.

c^1. Teeth grooved, primary tubercles perforate, epiphyses of lantern narrow.

d^1. Primary spines long, rough, and hollow.

e^1. Primary spines large, banded white and green, with numerous secondary tubercles on ambulacra........ *Echinotrix calamaris.*

e^2. Primary spines slender, extremely long, banded black and white or solid black, without secondary tubercles on ambulacra .... *Diadema setosum.*

d^2. Primary spines short, rough but more or less solid, banded purple and yellow.. *Astropyga radiata.*

c^2. Teeth keeled, epiphyses of lantern wide, primary tubercles imperforate.

d^1. Ambitus circular; ambulacral plates usually with three elements.

e^1. Test with pits on coronal plates; small; primary spines small.

f^1. Primary tubercles crenulate.................. *Salmacis sphaeroides.*

f^2. Primary tubercles not crenulate................ *Mespilia globulus.*

e^2. Test without sculpturing or pits; usually large; primary spines large.

f^1. Poriferous area not half as wide as interporiferous; pore pairs in arcs of three; spines green and white. *Toxopneustes chlorocanthus.*

f^2. Poriferous area more than half the interporiferous; pore pairs in three well-separated vertical areas; spines white or orange .... *Tripneustes gratilla.*

d^2. Ambitus more or less elliptical; ambulacral plates with more than three elements.

e^1. Pore pairs in arcs of four, spines tapering.

f^1. Test long, narrow, and high..................... *Echinometra oblonga.*

f^2. Test wide and flat.. *Echinometra picta.*

e^2. Pore pairs in arcs of eight to eleven, spines large, heavy, and stout; secondary spines truncated, flat topped. *Heterocentrotus mammillatus.*

a^2. Test flattened, spines minute; periproct outside the genito-ocular ring; more or less bilaterally symmetrical.

b^1. Test without marginal slits or lunules, size small.

c^1. Auricles separate.

d^1. Anus inframarginal, test flattened but concave orally; margin thick, genital pores five; petals nearly closed. *Clypeaster reticulatus.*

d^2. Anus supramarginal, test very flat; margin thin, genital pores four; petals straight and divergent........ *Arachnoides placenta.*

c^2. Auricles fused.

d^1. Test longer than wide; ambitus elliptical; anus much wider than long .... *Laganum depressum.*

d^2. Test roughly with circular ambitus; anus much longer than wide. *Laganum laganum.*

b^2. Test with two marginal slits, one at the end of each posterior petal, size large .... *Echinodiscus auritus.*

DESCRIPTIONS OF SPECIES

Family CIDARIDÆ J. Müller

PRIONOCIDARIS VERTICILLATA (Lamarck). Plate 1, fig. 2.

Cidarites verticillata LAMARCK, Anim. s. Vert. 3 (1816) 56.

Prionocidaris verticillata DÖDERLEIN, Abh. Senck. Nat. Ges. 34 (1911) 243; A. AGASSIZ, Rev. Ech. (1873) pt. 3; CLARK, The Cidaridæ, Mus. Comp. Zool. 51 (1907) No. 7, 187 (as *Phyllacanthus verticillata*); H. L. CLARK, Cat. Recent Sea Urchins (1925) 17.

Description.—Test regular, ambulacral plates simple; peristome plated; ambulacral plates extending to the mouth; no sphæridia and no peristomial gill present; test more or less flattened with a diameter between 28 and 32 millimeters and a height between 18 and 23; D = 1.6 H; periproct large with many plates covered with miliaries; genitals black and more or less rectangular; oculars green, covered with a few miliaries; entire abactinal system 14 to 15 millimeters, about one-half of the entire test diameter. Peristome somewhat smaller than abactinal system. Primary spines large, between 28 and 30 millimeters long, with an unspotted collar. These bear three to four axial whorls and one terminal whorl of projecting ridges; from nine to fifteen ridges in each whorl. Largest primary spines situated abactinally; those around the peristome smaller and without ridges. Secondary spines wanting. Miliaries flattened, mostly distributed around the bases of primaries. Two distinct rows of miliaries in each interporiferous area of the ambulacral region. Primary tubercles smooth and perforate, two rows of five or six in each interambulacral area. Tertiary tubercles fine and almost inconspicuous. Interambulacral areas about three times as wide as ambulacral areas at ambitus. Interporiferous areas as wide as poriferous. Pores straight or nearly so, connected with each other by a shallow groove.

Range—This species has been reported from British East Africa, Zanzibar, Mauritius, Chagos, Andaman Islands, Samoa, and the Philippines.

Remarks.—This species is rather rare and cannot be obtained in large quantities. Most of our specimens were obtained from Boaya Point, Puerto Galera, under stones or in the crevices of rocks. In life they are green. This color soon disappears in preserved specimens and the animal turns whitish yellow.

PRIONOCIDARIS BACULOSA (Lamarck). Plate 1, fig. 1.

Cidarites baculosa LAMARCK, Anim. s. Vert. 3 (1816) 55.
Prionocidaris baculosa MORTENSEN, Deutsch. Südpolar-Exp. Ech. (1909) 50; A. AGASSIZ, Rev. Ech. (1873) pt. 3, pl. 1, f, figs. 4, 5 (as *Phyllacanthus baculosa*).

Description.—Test rounded but very slightly flattened, ambitus circular; ambulacral plates simple; peristome plated; no sphæridia and no peristomial gills. Diameter of test, 18 to 25 millimeters; height, 11 to 16; D = 1.4 to 1.5 H. Periproct more or less pentagonal and bare; anal system 3 to 5 millimeters wide; boundary of abactinal system circular and 8 to 10 millimeters, about 0.44 to 0.48 of test diameter; longest spines, 20 to 33 millimeters. Genitals more or less rectangular, oculars triangular, both free from miliary spines. Peristome about the same in diameter as abactinal system. Primary spines more or less blunt, with purple lines on the collar. Greater length of primary spines usually covered by fine serrations arranged in fifteen or sixteen longitudinal rows. Longest spines dorsal around the abactinal system. Those around the peristome are more or less flattened with distinct longitudinal ridges around them. Secondary spines wanting; miliaries short and flat, arranged in circles around the primaries and in double rows in each interporiferous area. Peristome densely covered with minute miliaries. Primary tubercles smooth and perforate, arranged in double rows of five or six in each interambulacrum. Miliary tubercles almost insignificant. Interambulacral area about 3.2 times as wide as ambulacral. Pores horizontal or nearly so and yoked together by a shallow groove. Interporiferous area a little wider than poriferous.

In life *Prionocidaris baculosa* is purplish brown. The primary spines, when clean, have a purplish tinge banded with narrow, well-separated, whitish yellow lines. They may be covered with dirt at times and appear dirty white. The purple miliaries give the characteristic coloration to the animal.

Range.—This species has been reported from the Indian seas, Red Sea, and East Africa, Madras, Singapore, East Indies, Japan, Macclesfield Bank, and the Philippines.

Remarks.—I find this form to be extremely hard to classify, due to its variable features. Philippine specimens usually lack the white spots on the collar typical of *P. baculosa;* instead, we find longitudinal purple lines resembling *P. baculosa* var. *lineata* of Clark. However, the latter form is known only from the east coast of Africa, south of Mozambique, so that it is doubtful if Philippine specimens belong to this variety.

Family DIADEMATIDÆ Peters

DIADEMA SETOSUM (Leske). Plate 1, figs. 3 and 4; Plate 5, fig. 24.

Echinometra setosa LESKE, Add. ad Klein (1778) 36.
Diadema setosa GRAY, Ann. Phil. 10 (1825) 4; H. CLARK, Carnegie Inst. Mar. Bio. Papers (1921) 10, pl. 17, figs. 3, 4 (as *Centrechinus setosus*).

Description.—Test regular; ambulacral plates compound; coronal plates more or less imbricate; base of corona resorbed; peristome not plated; diameter of test, 34 to 50 millimeters; height of test, 16 to 22, $D = 2.1$ to $2.3\ H$; length of longest spines, 150 to 163 millimeters; diameter of anal system, 4 to 7 millimeters, 12 to 14 per cent of test diameter; diameter of entire abactinal system, 8 to 13 millimeters; diameter of peristome, 18 to 23. Test somewhat flattened, with a circular ambitus. Gill cuts shallow, but broad. Oculars small and insert except ocular I. Each bears two or three miliary spines. Genitals large, the madreporic plate largest and most prominent, black, and more or less rectangular. Ambulacra narrow and much narrower abactinally than at ambitus. Interambulacra broad, about three times as wide as ambulacra at ambitus. Poriferous areas narrow, about half as wide as interporiferous areas. Pore pairs in arcs of three ventrally, but in single pairs toward the abactinal system. Primary spines long and slender, longest at and above ambitus. Ambulacral and interambulacral primaries almost the same. Secondary spines few abactinally, mostly distributed actinally, and absent in ambulacra. Both primaries and secondaries fragile and hollow with twenty-four to thirty-two longitudinal series of teeth. Miliary spines evenly distributed throughout. Primary tubercles perforate. There are two rows in each interporiferous area of the ambulacra and four rows at each interambulacrum. Ambulacral primary tubercles smaller than interambulacral. Second series (inner pair) of interambulacral tubercles beginning on the seventh or eighth coronal plate. Secondaries forming a single row of widely separated tubercles on either side of the ambulacral areas; most numerous actinally. Miliaries forming a more or less irregular line between the primary tubercles.

In life the primary spines are black in old individuals, but with wide bands of white and black in young specimens. Abactinally the secondary spines are usually black, but actually they may have olive green bases, until they become entirely white (or whitish purple) around the peristome. Miliaries are black abactinally and white actinally. The anal tube is black with an orange yellow terminal end. Around the anal tube five purple dots are clearly visible in living specimens. In addition to this typical coloration, this species is easily differentiated from any other *Diadema* by the presence of five white spots at the interradii dorsally, just above the second series of interambulacral tubercles. The series of blue spots bordering the interambulacra, as pointed out by Clark (1921), usually can only be seen with great difficulty.

Range.—This is an Indo-Pacific species, having been collected in the Gulf of Suez, the Gulf of Akabah, the Gulf of Aden, Mauritius, East Africa, Ceylon, Singapore, Billiton, Macclesfield Bank, Japan, the Philippines, Java, Torres Strait, Australia, and Hawaii.

Remarks.—Next to *Echinotrix calamaris,* this species is the commonest poisonous sea urchin in the Philippines. It is found partly covered by rocks at low water to 36 fathoms.

ECHINOTRIX CALAMARIS (Pallas). Plate 2, figs. 5 and 6; Plate 5, fig. 23.

Echinus calamaris PALLAS, Spic. Zool. 1 fasc. 10 (1774) 31.

Echinotrix calamaris A. AGASSIZ, Rev. Ech. (1872) pt. 1, 119; DÖDERLEIN, Denkschr. Ges Gena 8 (1903) pl. 59, fig. 9, pl. 63, fig. 6; H. L. CLARK, Cat. Recent Sea Urchins (1925) 44.

Description.—Diameter of medium-sized test, 58 millimeters; height of test, 27; $D = 2.15$ H; length of longest spine, 75 millimeters; diameter of anal system, 8; diameter of the entire apical system, 15; diameter of peristome, 25. Test thin, flexible, and flattened, sloping slowly toward the ambitus, the latter more or less pentagonal in cross section. Actinal surface slightly resorbed and the peristome slightly sunken. Gill cuts shallow and broad. Peristome not plated, sphæridia and peristomial gills present. Central abactinal ambulacral areas depressed toward the apical system. Anal tube very conspicuous and in life bulging balloonlike out of the circumanal ring. It is usually spotted white, due to the presence of many small calcareous plates. Genital plates large; oculars small. The black madreporite most conspicuous, as it is raised above the level of the other genitals. Interambulacra wide, about five times as wide as the ambulacra at the region of the ambitus. Ambulacral areas wider actinally than at ambitus. Pore pairs arranged in arcs of three. Primary spines situated in the interambulacral areas fragile and hollow, with a cavity more than half the diameter of the spine. Minute teeth arranged in separate whorls cover these spines.

The color in life is an alternation of white and green or white and brown, but these characteristic colors may change into a uniform black or uniform white in old specimens. The secondary spines located mostly in the ambulacral areas toward the aboral side are smooth except at the tips. They are yellowish green with purple tips due to the presence of a purple fluid in them. The miliary spines are scattered throughout. The bare depressed abactinal interambulacral areas of the test are apple green, while the rest of the test is light brown. Primary tubercles are perforate and are arranged in six to eight rows in each interambulacrum below the region of the ambitus. Secondary tubercles are also perforate and they form two to four rows in the interporiferous area of each ambulacrum.

Range.—This species has been reported from the Society Islands, East Indies, Kandavu Reef, the Philippines, Samoa, Fiji, Mauritius, Maldive Islands, Minokoi, Andaman, Macclesfield Bank, and Rotuma.

Remarks.—This species is rather common in Port Galera and is found most numerous in Honduras (Varadero Bay), Boaya Point, and Plateau among stones and eelgrass. It is famous for being beautiful but "poisonous." When touched the tips of the secondary spines break easily and remain embedded with their secretion under the skin of the hands or fingers. The "sting" is very painful and will remain so for several days unless the ends of the spines are removed and the fluid injected is neutralized with lemon, vinegar, or some other weak acid.

ASTROPYGA RADIATA (Leske). Plate 2, fig. 7.

Cidaris radiata LESKE, Add. ad Klein (1778) 52.
Astropyga radiata GRAY, Ann. Phil. 10 (1825) 4; PETERS, Abhandl. Akad. Berlin (1855) (1854) fig. 1 (as *A. mossambica*).

Description.—Diameter of test, 60 to 80 millimeters; height, 18 to 23 millimeters; D = 3 to 3.5 H; length of longest spines, 40 to 42 millimeters; diameter of anal system, 9 to 11; diameter of whole abactinal system, about 20; diameter of peristome, 24, about 0.28 to 0.35 diameter of test. Test very thin and flexible and distinctly flattened, the extent of flattening depending upon the habitat of the animal during life or the pressure exerted during preservation. Actinal and abactinal surfaces flat; both the peristome and the abactinal system slightly sunken. Peristome not plated; peristomial gills and branchiæ present; gill cuts shallow but with thick border. Anal tube more or less conical, extending out of the circumanal ring; purplish with a black terminal surface. Circumanal ring composed of many small plates bearing small miliary spines. Oculars small and all exsert. Genitals large, more or less triangular, and each, with the exception of the madreporic plate, bearing a prominent black spot at the center. Ambitus more or less pentagonal, the interambulacra forming the sides, and the ambulacra the angles of the pentagon. Interambulacral areas four times as wide as ambulacral. Poriferous areas, which are almost as wide as the interporiferous, become slightly wider actinally. Pore pairs in arcs of three. Primary spines slender but short, with the central cavity filled with a calcareous network making the center of the spines look solid macroscopically. Minute teeth arranged in distinctly separated whorls cover these spines. In life they are distinctly banded with alternate purple and white, either throughout the entire length or at the base only; in the latter case, the tips may be uniform purplish black. Secondary spines similar but smaller and shorter. Miliaries very slender and fine. Primary tubercles perforate, arranged in eight to ten rows and two rows in the interambulacral and ambulacral areas, respectively. The outer rows of interambulacral tubercles (next to the poriferous areas) extend to the abactinal system, although here the tubercles may be much smaller. Between the two rows of tubercles next to the poriferous area and the other primary tubercles is a bare area in each interambulacrum, extending from the abactinal system. The coronal plates of these bare areas bear in life large, brilliant violet spots. There are twelve to seventeen of these spots on either side of each abactinal interambulacrum extending to the ambitus. Secondary tubercles are present on the interambulacra and ambulacra, alternating with the primaries. Miliaries scattered throughout.

Range.—This is an Indo-Pacific species and has been reported from British and German East Africa, Wasin Island, Mozambique, Mauritius, East Indies, the Philippines, and the Hawaiian Islands.

Remarks.—This species is very rare and most of our specimens were obtained at Calapan, among eelgrass and sand. This is the only *Astropyga* known from the Philippine Islands, and it cannot be mistaken for any other form due to the bright violet spots on the outer margin of the abactinal interambulacral plates.

Family TEMNOPLEURIDÆ Desor

SALMACIS SPHAEROIDES (Linné). Plate 3, figs. 10 and 11.

Echinus sphaeroides LINNÉ, Syst. Nat. ed. 10 (1758) 664.
Salmacis sphaeroides LOVEN, Bih. Svensk. Vet.-Akad. Handl. 13 (4), No. 5 (1887) 69; DÖDERLEIN, Denkschr. Ges. Jena 8 (1903) pl. 63, figs. 1–4*a*.

Description.—Average diameter of test, 60 millimeters; height, 38; D = 1.6 H, more or less; length of longest spines, 11 to 13 millimeters; diameter of anal system, 5 to 7; diameter of whole abactinal system, 10 to 12; diameter of peristome, 15 to 17. Test regular, with small pits between coronal plates; ambitus circular; abactinal side rounded, while the actinal surface is flattened with slightly sunken peristome. Gill cuts deep, with narrow everted edges. Anal plates numerous and largest toward genitals IV and V. All oculars, except II, exsert; genital plates small. Ambulacra slightly over half as wide as the interambulacra at the region of the ambitus. Poriferous area wide, about one-fourth as wide as an entire ambulacrum. Pore pairs arranged in three more or less vertical series. Spines fine and short and more or less uniformly distributed throughout; largest at the region below the ambitus. Primary and secondary spines with deep green bases with alternate bands of purple and light green or white toward the ends. Miliary spines white. Primary tubercles crenulate and imperforate, largest below the ambitus where there are four or five large tubercles in horizontal series on each coronal plate. Above the ambitus each coronal plate contains only one large primary tubercle. Each interambulacral plate contains, however, between four and nine subequal primary tubercles. A specimen with D = 59 millimeters, H = 38 millimeters, has thirty or thirty-one coronal plates. In life the animal as a whole is dark green. Bare tests are cream colored with a slight tinge of light purple.

Range.—Gulf of Siam, Billiton, Singapore, the Philippines, Australia, New Guinea, Queensland, and Solomon Islands.

Remarks.—The deep gill cuts and purple bands place this material without a question in this species. Our specimens were collected by Mrs. R. S. Filoteo, on Mactan Reef, near Cebu, where the material in the British Museum was also collected.

MESPILIA GLOBULUS (Linné). Plate 2, figs. 8 and 9.

Echinus globulus LINNÉ, Syst. Nat. ed. 10 (1758) 664.
Mespilia globulus AGASSIZ and DESOR, Ann. Sci. Nat. III 6 (1846) 358; A. AGASSIZ, Rev. Ech. pt. 3 (1873) pl. 8*a*, figs. 13, 14.

Description.—Test regular, ambulacral plates compound with three elements; coronal plates with pits; base of corona not resorbed; peristome not plated; diameter of test, 38 to 45 millimeters; height of test, 29 to 33, $D = 1.3$ H; length of longest spines, 6 to 7 millimeters; diameter of anal system, about 3; diameter of entire abactinal system, 6 to 7; diameter of peristome, 11 to 12. Test high; ambitus circular; gill cuts shallow. Oculars small and all exsert; genitals larger, usually with eighteen secondary and miliary tubercles; ambulacral areas narrower than interambulacral; poriferous areas about one-third as wide as interporiferous; pore pairs medium in size, arranged in a continuous vertical series on each side near the margin of the ambulacra. Between the pore pairs and the margin of the ambulacra one or two miliary tubercles are present. Primary spines small, short, and slender, and confined at the meeting points of the ambulacral and interambulacral plates on either side of the pore pairs. Three or four spines on each side of an ambulacral and interambulacral plate. Median portions of the plates free from any spines at and above the ambitus. Pits situated at the inner edges of the ambulacral and interambulacral plates. Secondary and miliary spines aggregated around the primaries, especially numerous at the actinal side of the corona. Primary tubercles crenulate, usually three or four on each outer margin of the interambulacral and one or two on each ambulacral plate.

In life the test is olive green. The spines are greenish yellow or cream color with white and brown bands toward the tip. The spines around the actinostome have a tendency to be light gray or brown with white bands at the tip.

Range.—This species has been reported from Japan (Misaki), Korean Strait, Macclesfield Bank, Penang, the Philippines, Celebes, New Guinea, Loyalty Islands, and Samoa.

Remarks.—The species is small and delicate. It is rarely found on collecting trips. The material that forms the basis for the above description was collected by A. L. Day at Boco Island in 1913, and by R. P. Cowles and L. E. Griffin at Laoc, Cavite, in 1915. The absence of any dark spines and the presence of oculars, which are all exsert from the anal system, place these specimens in this species without any doubt.

Family ECHINIDÆ Agassiz

TOXOPNEUSTES CHLOROCANTHUS Clark. Plate 3, figs. 12 and 13.

Toxopneustes chlorocanthus CLARK, Mem. Mus. Comp. Zool. 34 (1912) 283; H. L. CLARK, Cat. Recent Sea Urchins (1925) 522.

Description.—Large specimens have the test 107 millimeters in diameter, and 95 millimeters in height; D = 2.1 H. Spines small and short, the longest 10 to 15 millimeters; diameter of anal system, 4 to 7; diameter of whole abactinal system, 9 to 16; diameter of peristome, 24 to 33, about 0.35 of the diameter of test; test more or less flattened, curving slightly at first and then deeply to the ambitus, the latter circular; actinal side flattened with the peristome only slightly sunken; branchial incisions (gill cuts) long, deep, and with prominent interambulacral edges; many anal plates present, the largest toward genitals III and IV; ocular plates small, I and V insert, II, III, and IV usually exsert; genital plates larger, the madreporic plate the largest. All these plates, except the madreporic, bear miliaries. Ambulacra broad, about 0.8 interambulacra; poriferous areas narrow, much less than half of the interporiferous area; pore pairs in arcs of three. Spines numerous, all over the test; primaries green, white tips, pointed but not sharp. Spines more or less uniform in length, but slightly longer toward the actinostome, below the ambitus. Secondaries similar but shorter and smaller. Miliaries very small and white. Primary tubercles small and imperforate; in the ambulacral areas they are found on every other plate toward the poriferous area. In each interambulacral area there are two double or quadruple rows of white or yellow primary tubercles, each double or quadruple row surrounded by a row of secondaries at and below the ambitus. Miliary tubercles are very numerous on both the ambulacral and the interambulacral plates. A specimen with D = 75 millimeters and H = 28 has twenty-five coronal plates, while another with D = 107 millimeters has thirty-two coronal plates. The pedicillariæ are numerous and many of them stalked. Color in life is green; the test is light purple or green with transverse blotches of white, most noticeable around the abactinal system. Miliaries, pedicillariæ, and tube feet are white.

Range.—The range is very limited, this animal having been reported only from Samoa, Billiton, and the Philippines. The specimen in the British Museum is labeled *T. pileolus,* from Masbate.

Remarks.—This species is very scarce and its local range is not known. It is probably a deep-sea form and is encountered very seldom in shallow waters. Our largest specimens were obtained from Puerto Galera by L. E. Griffin in 1912, while the small ones came from the sand bars of Calapan, Mindoro. H. L. Clark, who described this species, doubts its validity and suggests that it may be a variation of *T. pileolus.*

TRIPNEUSTES GRATILLA (Linné). Plate 3, figs. 14 and 15; Plate 4, figs. 16 and 17.

Echinus gratilla LINNÉ, Syst. Nat. ed. 10 (1758) 664.

Tripneustes gratilla LOVÉN, Bih. Svensk. Vet. Akad. Handl. 13 (1887) (4) No. 5, 77; H. L. CLARK, Carnegie Inst. Mar. Biol. Papers 10 (1921) pl. 17, fig. 6; Cat. Recent Sea Urchins (1925) 124.

Description.—Diameter of medium-sized adult test, 65 to 72 millimeters; height of test, 35 to 45; D = 1.5 H; length of longest spines, 10 millimeters; diameter of peristome, 18 to 22, about 0.26 to 0.28 diameter of test; test regular, the greatest diameter below the ambitus; actinal surface more or less flattened, and the peristome only slightly sunken; gill cuts long and deep; anal plates numerous; ocular plates large, the two on either side of the madreporic plate (II and III) not touching the circumanal ring; genital plates larger, the madreporic plate largest; interambulacral regions almost as wide as ambulacral at ambitus, but become much narrower at abactinal region; interporiferous areas of ambulacra wider at ambitus than poriferous areas; pore pairs in three more or less well-separated vertical areas. Primary spines numerous, small, and slender, usually orange yellow, and longest around the ambitus. Secondaries almost as long, miliaries short and very fine. Primary tubercles imperforate; there are two rows present at each ambulacrum and interambulacrum above the ambitus and four rows below. Secondary tubercles most numerous at the actinal region, and few or wanting at the abactinal. Miliary tubercles found throughout. Between thirty and thirty-three coronal plates. Buccal membrane with numerous small plates.

Color in life is usually an alternation of purplish black at interambulacral and interporiferous regions due to the color of numerous pedicellariæ with whitish green at poriferous regions. The spines are usually orange yellow, while the tube feet are white with a more or less dark purple basal part. Color variations exist, in the commonest the poriferous areas and spines are white. White and orange yellow spines may be found side by side in the same animal.

Range.—This species has been reported from the Red Sea, Suez Canal, German East Africa, Cape of Good Hope, Mauritius Islands, Rodriguez Islands, Borneo, Celebes, New Guinea, Australia, and the Philippines.

Remarks.—This species is very common at Puerto Galera and can be obtained in great numbers from Varadero Bay. The animals are found, when adult, on open intertidal bottoms with scanty eelgrass, but may be found also living hidden under rocks when very young. We find this species to be the best for class use. The largest specimens we have of *Tripneustes gratilla* were obtained from the sandy bar of Calapan. The bare tests of these measure 90 millimeters in diameter and 68 in height.

Family ECHINOMETRIDÆ Gray

ECHINOMETRA PICTA A. Agassiz and Clark. Plate 4, fig. 18; Plate 5, fig. 22.

> *Echinometra picta* A. AGASSIZ and CLARK, Bull. Mus. Comp. Zool. **50** (1907) 241; H. L. CLARK, Mus. Comp. Zool. **34** (1914) No. 4, 373.

Description.—Test flattened, ambitus elliptical; long diameter of test, around 40 to 46 millimeters; width of test, 32 to 36, about 80 per cent test length; height, 18 to 21 millimeters, less than half of test length; gill cuts shallow; ocular plates V and I insert, II, III, and IV exsert; genitals seldom have more than one secondary tubercle; diameter of entire abactinal system about 0.20 of test length; interambulacral region almost twice as wide as ambulacral, and interporiferous areas also almost twice as wide as poriferous areas; pore pairs in arcs of four. Primary spines pointed and most numerous and longest around the ambitus. The width of the base of these spines is less than 0.10 of the length. Secondary spines are shorter and are most numerous below the ambitus. Those surrounding the peristome distinctly flattened. Miliary spines fine and evenly distributed around the primaries. Primary tubercles imperforated, two rows in each interambulacrum and interporiferous area. Secondary tubercles most numerous in the region below ambitus. Coronal plates ranging from twelve to fifteen. In life, the spines are fawn color or green with very light tips. The test is dark brown.

Range.—This species has been reported only from the Hawaiian, the Society, and the Philippine Islands.

Remarks.—*Echinometra picta* is very common in the Philippines, especially at Mariveles and in Mindoro. The animals are located in rock crevices, from which they are hard to remove. They appear together with *Echinometra ablonga* from which they can easily be distinguished by the wider and more-flattened test, and by the longer, more-tapering, and less-crowded spines. In a recent paper Clark (1925) suggests that *E. picta* may be an extreme variation of *E. matthei.* Measurements of Philippine specimens, however, agree with those of *E. picta,* which leads me to believe that *E. picta* is a valid species.

ECHINOMETRA OBLONGA de Blainville. Plate 4, figs. 19 and 20; Plate 5, fig. 21.

Echinus oblongus DE BLAINVILLE, Dict. Sci. Nat. 37 (1825) 95.
Echinometra oblongus DE BLAINVILLE, Dict. Sci. Nat. 60 (1830) 206; H. L. CLARK, Mus. Comp. Zool. 34 (1912) pl. 114, figs. 3, 1, and 2; Cat. Recent Sea Urchins (1925) 144.

Description.—Long diameter of test, 39 to 42 millimeters; width, 29 to 33, about 0.70 to 0.76 of test length; height of test, 20 to 23 millimeters, about 0.51 to 0.53 of test length. Length of longest spines, around 17 millimeters, with a diameter from 0.12 to 0.22 of spine length; all oculars exsert; genitals usually have only one secondary tubercle; diameter of entire apical system about 9 millimeters, or 0.22 of test length; diameter of peristome 0.20; test oblong in shape, narrow but high; gill cuts shallow and insignificant, but auricles prominent; ambulacral region wide, about 1.5 as wide as interambulacra; pore pairs in distinct arcs of four. Primary spines stout, tapering to a point; two rows of large ones in each ambulacrum and interambulacrum. Secondary spines are smaller and shorter, these most abundant below the ambitus. Those surrounding the peristome have a tendency to become flattened. Miliary spines tiny and scattered around the primaries of the interambulacra. All tubercles smooth, nonperforate, and large, and much more crowded than in *E. picta,* especially toward the actinal side. In life the spines are uniform light fawn, light green, or dark, while the test is brown. They can be distinguished from *E. picta* by their high oblong test and short, stout spines.

Range.—This species has been encountered in the Hawaiian Islands, Mauritius, Funafuti, and the Philippines.

Remarks.—Philippine specimens do not have the usual very stout spines of *E. oblonga.* The abactinal system is small with a greenish madreporite. The genitals usually have only one secondary spine. Like *E. picta, E. oblonga* is considered by Clark as a variation of *E. matthei.* As we have no specimen of the latter an accurate comparison cannot be made.

HETEROCENTROTUS MAMMILLATUS (Linné). Plate 5, figs. 25 and 26.

Echinus mammillatus LINNÉ, Syst. Nat., ed. 10 (1758) 667.
Heterocentrotus mammillatus BRANDT, Prod. Descr. Anim. (1835) 266; H. L. CLARK, Mem. Mus. Comp. Zool. 34 (1912) pls. 115–117.

Description.—Test regular, ambulacral plates compound with usually ten elements; long diameter of test, 45 to 55 millimeters; short diameter, 20 to 26; D = 2.2 H; length of longest spines, 75 millimeters; diameter of anal system, 7 to 10; diameter of peristome, 23 to 29; test somewhat flattened; ambitus elliptical; gill cuts shallow; oculars all exsert, each bearing one secondary tubercle; genitals large, madreporite largest, each bearing two to four secondary tubercles; ambulacra narrow, widest at the region of the ambitus; interambulacra wide, about twice as wide as ambulacra at ambitus; poriferous areas narrow, about half as wide as interporiferous; pore pairs in arcs of ten actinally, but this number may be reduced to eight abactinally. Primary spines long and heavy; longest and heaviest at or slightly above the ambitus. Interambulacral primaries larger than the ambulacral. Primary spines more or less circular in cross section at the base, but triangular toward the end, the three angles coming together at the tip. Actinal primary spines flatened and much smaller than the abactinal and ambital spines. Secondary spines small, short, flaring and truncated at tip; most numerous at and around the abactinal system. Smaller and flattened secondary spines are found on the peristomial membrane, arranged in five groups, each group corresponding with an ambulacral region. Primary tubercles few, heavy, and nonperforate; usually seven or eight pairs in each ambulacrum and interambulacrum. Ambulacral primary tubercles aggregated toward the actinal side. Secondary tubercles also nonperforate. Most of them are located at or toward the abactinal side of the test.

In life the spines are deep purple or red, the redness most distinct at the tips. Large primary spines have narrow white bands toward the end. These white bands range from one to as many as five on each spine. The smaller spines are solid red or deep purple. Tube feet are large and, in preserved specimens, white, most easily visible toward and around the peristome.

Range.—This species has been reported from the Red Sea, German East Africa, Rodriguez, Mauritius, the Philippines, the Bonin Islands, New Guinea, the Loyalty Islands, and the Fiji and Hawaiian Islands.

Remarks.—The only other species of *Heterocentrotus* known is *H. trigonarius*, most frequently met with around the southern Pacific Islands. Many of our specimens of *H. mammillatus* in spines and coloration resemble *H. trigonarius*, but the number of pore pairs (usually 10) and the flat-topped secondary spines of our specimens place them without any doubt in *H. mammillatus*. The majority of our examples of this species were collected from the Northwest Channel and Small Balatero Cove, near Puerto Galera, Mindoro.

Family CLYPEASTRIDÆ Agassiz

CLYPEASTER RETICULATUS (Linné). **Plate 6, figs. 27 and 28.**

> *Echinus reticulatus* LINNÉ, Syst. Nat. ed. 10 (1758) 666.
> *Echinodiscus reticulatus* LESKE, Add. ad Klein (1778) 143.
> *Clypeaster reticulatus* DESMOULINS, Etude sur les Ech. Tab. Syn. (1837) 214; LAMARCK, Anim. sans Vert. 3 (1816) 14; A. AGASSIZ, Rev. Ech., pt. 4 (1874) pl. 13 f, figs. 1, 2 (as *C. scutiformis*).

Description.—Test small, flattened, but strongly concave on the oral side; auricles separate; margin thick, swollen and distinct from the petaloid area; test uniformly covered with closely set fine secondary spines and larger and fewer primary spines. Test with brown spottings, more intense on the actinal side. Petals wide and short, and all practically closed. Usually less than thirty pore pairs on each side of a petal and usually two primary tubercles in the ridges between pore pairs. Marginal ends of petals depressed, below the level of the margin, although the apical system is much elevated. Five genital pores very close to the madreporite. Actinostome at the center of the concave oral side, anus inframarginal. Grooves marking the ambulacra on the ventral side inconspicuous and not extending to the periphery.

A medium-sized specimen has the following measurements: Long diameter, 55 millimeters; longest transverse diameter, 35;

vertical diameter, 120; diameter of abactinal system, 3; length of anterior petal, 14; length of posterior petal, 14; length of longest spines (around mouth), 3. Petaloid area about 28 millimeters long, 63 per cent of test length. Petal I slightly longer than III and V and much longer than petals II and IV, which are the shortest. Width of petals from 47 per cent (long petals) to 72 per cent (short petals) of the length.

Range.—This species has been reported from Suez, Red Sea, British East Africa, Durban Bay, Mauritius, Seychelles, Mascarenes, Providence Island, Saya de Malha, Macclesfield Bank, Boluthuria Bank, and the Hawaiian and Philippine Islands. The bathymetrical range is from 13 to 253 fathoms.

Remarks.—This species is commonly found in shallow waters. Our collection includes material from Puerto Galera, collected by L. E. Griffin, 1912.

Family ARACHNOIDIDÆ Gregory

ARACHNOIDES PLACENTA (Linné). Plate 7, figs. 33 and 34.

Echinus placenta LINNÉ, Syst. Nat. ed. 10 (1758) 666.

Arachnoides placenta AGASSIZ, Mon. Echin. Mon. Scut. (1841) 94; MORTENSEN, Vid. Medd. (1921) 73, pl. 6, figs. 21, 27; H. L. CLARK, Cat. Recent Sea Urchins (1925) 154.

Description.—Test flattened discoidal; margin thin; abactinal surface slightly convex, actinal surface flat; auricles separate; test covered with closely arranged fine spines, shortest and most uniform abactinally and longest actinally. Longest spines situated at interradial areas toward the margin. Ambulacral areas on the abactinal side elevated toward the center of the test. Poriferous areas of petals straight and divergent, extending about halfway to the margin. Actinally a deep, straight, unbranched furrow appears at the center of each ambulacrum which is slightly wider toward the actinostome. This groove extends abactinally and reaches almost to the abactinal system. Abactinal interambulacra slightly depressed and each composed of two rows of plates. Only one pair of plates on the dorsal side, at the margin of the test in each interradius. Interambulacra about one-third as wide as the ambulacra at the margin. Abactinal system central; genital pores four; anal opening supramarginal (abactinal side of margin). A large specimen has the following measurements: Longitudinal diameter, 58 millimeters; transverse diameter, 59; vertical diameter, 8; diameter of abactinal system, 24; length of anterior petal, 18; length of posterior petal, 17; length of spines at margin, 2; length of spines at peristome, 2. The greatest transverse diameter passes through the abactinal system. The width between the outer borders of the petals varies from 0.18 to 0.22 per cent of the test length. In life, the animal is yellowish green on both sides. Bare unbleached tests are dark brown abactinally and very light brown actinally.

Range.—The principal localities in which this species is found are the Andaman Islands, the Philippines, New Britain, Torres Strait, and Australia.

Remarks.—This is the commonest sand dollar found at Puerto Galera. The animals are most abundant at Esanada on fine sand just above the eelgrass line. They are large enough for class study of the test of sand dollars, but cannot be used for the study of internal structures.

Family LAGANIDÆ A. Agassiz

LAGANUM DEPRESSUM A. Agassiz. Plate 6, figs. 31 and 32.

Laganum depressum A. AGASSIZ, Mon. Ech., Mon. Scut. (1841) 110, pl. 23 figs. 1–7; H. L. CLARK, Rev. Recent Echinoderms (1921) 157.

Description.—Test with a more or less pentagonal ambitus, length much greater than width; test flat, but with a slightly thickened margin and with a broad shallow depression between the margin and the abactinal system; auricles fused into a single piece on the interambulacrum; body covered with spines, short and dense abactinally, long and sparse actinally; test smooth dorsally and slightly rough ventrally. The ambulacra distinct dorsally, with prominent, practically close, petaloid areas. Usually two or three primary tubercles on ridges between pore pairs. Actinally the ambulacral areas are marked by shallow furrows extending more than halfway to the margin. Abactinal system and peristome slightly anterior to center of the test. Genital pores five. Anal opening actinal, nearer the margin than the peristome, and much wider than long. A medium-sized individual has the following measurements: Longitudinal diameter, 48 milimeters; longest transverse diameter (across peristome), 40; vertical diameter, 6; diameter of abactinal system, 5; length of anterior petal, 15; length of posterior petals, 14.5; length of longest spine, 3.

Petaloid area large, about 62 per cent of the test length. Petals I, III, and V almost the same in length, and longer than petals II and IV. Width of petals variable, ranging from 34 to 50 per cent of length. In life uniform light olive yellow on both sides; bare unbleached tests pale yellow. On the actinal side a fine tuberculation can be seen.

Range.—This species has been collected from the following points: Gulf of Suez, Red Sea, East Africa, Zanzibar, Mauritius, Amirantes, Maldives, Gulf of Manaar, Singapore, Macclesfield Bank, Philippines, Torres Strait, and Tongatabu, Australia. It is found at low tide level to 48 fathoms on sand or mud.

Remarks.—This species is known to grow as large as 80 by 72 by 7 millimeters, but Philippine specimens are usually of the size described above. Some specimens without genital pores and others with six pores have been reported.

LAGANUM LAGANUM (Leske). **Plate 6, figs. 29 and 30.**

Echinodiscus laganum LESKE, Add. ad. Klein (1778) 140.
Laganum laganum DE BLAINVILLE, Dict. Sci. Nat. **60** (1830) 196; A. AGASSIZ, Rev. Ech. pt. 3 (1873) pl. 13*e*, figs. 6, 7 (as *Laganum bonani*); CLARK, Cat. Recent Sea Urchins (1925) 158.

Description.—Test flat but thick and more or less pentagonal in outline, and slightly longer than wide; auricles fused; test white or with brown spots, covered with uniformly distributed short small white spines; a few longer spines surrounding the peristome; margin elevated and petaloid area slightly sunken; petals not quite close at ends. Usually only one or two primary tubercles on the ridges between pore pairs. Five genital pores, close to the madreporite at the center of the test. On the oral surface, the ambulacral areas marked by narrow deep grooves, most prominent in their inner portions next to the peristome. Alternating with these are five wide, very shallow depressions of the test, widest and easily visible at the margin. Anal opening about midway between mouth and margin and almost twice as long as it is wide.

An average-sized animal has the following measurements: Longitudinal diameter, 36 millimeters; longest transverse diameter, 33; vertical diameter, 6; diameter of abactinal system, 2; length of longest spines, 1.5.

Petaloid area large, about 68 per cent of test length. Anterior petals II, III, and IV practically the same in length and slightly shorter than posterior petals (I and IV). Width of petals from 30 to 40 per cent of length.

Range.—The range of this species extends from the Philippines east to the Carolines and south to Tasmania; the species is represented in the British Museum by specimens collected from the Indo-Pacific area, eastern seas, the Philippines, Siquijor, Timor Laut, West Australia, and Dirk Hartog Island.

Remarks.—Specimens as large as 46 by 44 by 9 millimeters have been reported, but most of our specimens are about 36 by 33 by 6.5 millimeters. Spotted and unspotted individuals are collected together in many places, and they do not seem to differ except in spotting. This species is very common at Taytay, Palawan, where most of our specimens were collected by S. F. Light in 1913.

Family SCUTELLIDÆ Agassiz

ECHINODISCUS AURITUS Leske. Plate 7, figs. 35 and 36.

Echinodiscus auritus LESKE, Add. ad. Klein (1778) 138; A. AGASSIZ, Rev. Ech., pt. 3 (1873) pl. 13*c*, figs. 1, 2.

Description.—Test very flat; margin thin with two long marginal slits situated in each posterior ambulacrum; auricles fused, situated on the interambulacrum; test covered with minute spines, shortest and most uniform abactinally and longest and most variable in length actinally, the longest at the edge of test and on interradial areas around the peristome. Abactinally, the ambulacra very distinct, with poriferous areas in the form of closed petals extending halfway to the margin of the test. Petal III (anterior) longest, and II and IV longer than I and V. Actinally, the five ambulacra appear as deep furrows around the peristome. About 6 or 7 millimeters from the peristome, each furrow splits into two primary branches which extend almost to the margin. About halfway between the peristome and the margin a secondary branch, also extending almost to the margin, is given off from each of the primary branches at an angle between 85° and 90° toward the interambulacra. Posterior primary branches may give off more than one secondary branch. Both main and secondary branches give off small tertiary branches mostly toward the interambulacra. No furrows extend abactinally. The abactinal system is approximately central and there are four genital pores. The anal opening is actinal, between the two posterior ambulacra, nearer the margin than the peristome.

Our specimens are more or less uniform in size, the test often longer than wide. These have the following measurements: Longitudinal diameter, 116 to 122 millimeters; transverse diameter (through peristome), 107 to 118; vertical diameter, 7 to 10; diameter of abactinal system, 6 to 7; length of anterior petal, 32; length of posterior petals, 25; length of longest spine, 4.

The peristome and the abactinal system are usually a little in front of the center of the test, and the longest transverse diameter is posterior to the center, between the peristome and the inner angle of the marginal slits. Thus, a specimen with 110 millimeters as a transverse diameter (across the abactinal system) has 121 millimeters as the longest transverse diameter. The greatest width of the petals is usually between 0.62 and 0.72 per cent of the longitudinal test diameter. In life, the abactinal side is grayish, while the actinal side is yellowish gray with very pale yellow lines marking the partitions between plates. Bare tests are purplish with a dirty white region between the halves of the petals abactinally and at the interambulacra around the peristome actinally.

Range.—This species has been reported from Suez, Red Sea, Persian Gulf, East Africa, Mombosa, Zanzibar, Mauritius, India, Madras, and the Philippines.

Remarks.—We find this species to be most abundant in Esanada, Puerto Galera, Mindoro, on sandy shores above the eelgrass line, on the same type of substratum as that on which *Arachnoides placenta* is found. At low water the animals can be seen half buried under the sand.

REFERENCES

AGASSIZ, A. Report on the Scientific Results of the Voyage of H. M. S. Challenger, Zoölogy 3[9] (1881). Report on the Echinoidea, 4to, 321 pp., 65 pls.

AGASSIZ, A., and H. L. CLARK. Hawaiian and other Pacific Echini. Mem. Mus. Comp. Zoöl. 34 (1907–1909) Nos. 1–3, 4to, 203 pp., 98 pls.

BELL, F. J. Echinodermata. Report on the Zoölogical Collections made in the Indo-Pacific Ocean during the Voyage of H. M. S. Alert, 1881–1882 (1884).

CLARK, H. L. The Echinoderms of the Woods Hole Region. U. S. Fish Comm. Bull. for 1902 (1904) 545–576, pls. 1–14.

CLARK H. L. The Cidaridae. Bull. Mus. Comp. Zool. **51** (1907) No. 7, 8vo, 66 pp., 11 pls.

CLARK, H. L. Hawaiian and other Pacific Echini. Mem. Mus. Comp. Zoöl. **34** (1912–1917) No. 4, 4to, 174 pls., and Vol. **46**, Nos. 1 and 2, 4to, 283 pp., 40 pls.

CLARK, H. L. The Echinoderm Fauna of Torres Strait: Its Composition and Its Origin. Carn. Inst. Mar. Biol. Papers 10 (1921) No. 214, 223 pp., 38 pls.

CLARK, H. L. Catalogue of the Recent Sea Urchins in the Collection of the British Museum of Natural History. Oxford University Press, London (1925).

MEIJERI, J. C. H. Die Echinoidea der Siboga-Expedite (1904), 4to, 252 pp., 23 pls.

MORTENSEN, H. The Danish Ingolf Expedition 4 (1903) Echinoidea (Part I), 4to, 193 pp., 21 pls.

MORTENSEN, H. The Danish Ingolf Expedition 4 (1907) Echinoidea (Part II), 4to, 200 pp., 19 pls.

ILLUSTRATIONS

[All photographs were prepared by Mr. Juan Fontanoza, of the Bureau of Forestry.]

PLATE 1

FIG. 1. *Prionocidaris baculosa* (Lamarck); aboral side, $\times \frac{6}{7}$.
2. *Prionocidaris verticillata* (Lamarck); dorsolateral view, $\times \frac{6}{7}$.
3. *Diadema setosum* (Leske); aboral side, $\times \frac{3}{7}$.
4. *Diadema setosum* (Leske); side view, $\times \frac{3}{7}$.

PLATE 2

FIG. 5. *Echinotrix calamaris* (Pallas); aboral side; most of the spines are broken and only basal halves remain, $\times \frac{1}{2}$.
6. *Echinotrix calamaris* (Pallas); oral side, $\times \frac{1}{2}$.
7. *Astropyga radiata* (Leske); aboral side of a much distorted small specimen, $\times$ 1.
8. *Mespilia globulus* (Linné); aboral side of a whole animal, $\times$ 1.
9. *Mespilia globulus* (Linné); aboral side of bare test showing pits on coronal plate, $\times$ 1.

PLATE 3

FIG. 10. *Salmacis sphaeroides* (Linné); aboral side, $\times \frac{2}{3}$.
11. *Salmacis sphaeroides* (Linné); oral side, $\times \frac{2}{3}$.
12. *Toxoneuptes chlorocanthus* Clark; whole animal, aboral side, $\times \frac{1}{2}$.
13. *Toxoneuptes chlorocanthus* Clark; bare test, aboral side, $\times \frac{1}{2}$.
14. *Tripneustes gratilla* (Linné); aboral side of bare test, $\times \frac{2}{3}$.
15. *Tripneustes gratilla* (Linné); oral side of bare test, showing deep gill cuts, $\times \frac{2}{3}$.

PLATE 4

FIG. 16. *Tripneustes gratilla* (Linné); aboral side of whole animal, $\times \frac{2}{3}$.
17. *Tripneustes gratilla* (Linné); oral side of whole animal, $\times \frac{2}{3}$.
18. *Echinometra picta* A. Agassiz and Clark; aboral side of an exceptionally large specimen, $\times \frac{1}{2}$.
19. *Echinometra oblonga* (de Blainville); aboral side, $\times$ 1.
20. *Echinometra oblonga* (de Blainville); oral side, $\times$ 1.

PLATE 5

FIG. 21. *Echinometra oblonga* (de Blainville); bare test, aboral side, $\times$ 1.
22. *Echinometra picta* A. Agassiz and Clark; bare test, aboral side, $\times$ 1.
23. *Echinotrix calamaris* (Pallas); bare test, aboral side, $\times$ 1.
24. *Diadema setosum* (Leske); bare test, aboral side, $\times$ 1.
25. *Heterocentrotus mammillatus* (Linné); oral side, $\times \frac{5}{8}$.
26. *Heterocentrotus mammillatus* (Linné); aboral side, $\times \frac{5}{8}$.

PLATE 6

FIG. 27. *Clypeaster reticulatus* (Linné); oral side, × 1.
28. *Clypeaster reticulatus* (Linné); aboral side, × 1.
29. *Laganum laganum* (Leske); bare test, aboral side, × 1.
30. *Laganum laganum* (Leske); bare test, oral side, × 1.
31. *Laganum depressum* A. Agassiz; bare test, aboral side, × 1.
32. *Laganum depressum* A. Agassiz; bare test, oral side, × 1.

PLATE 7

FIG. 33. *Arachnoides placenta* (Linné); whole animal, aboral side, × 1.
34. *Arachnoides placenta* (Linné); bare test, oral side, × 1.
35. *Echinodiscus auritus* Leske; bare test, oral side, × 1.
36. *Echinodiscus auritus* Leske; bare test, aboral side, × 1.

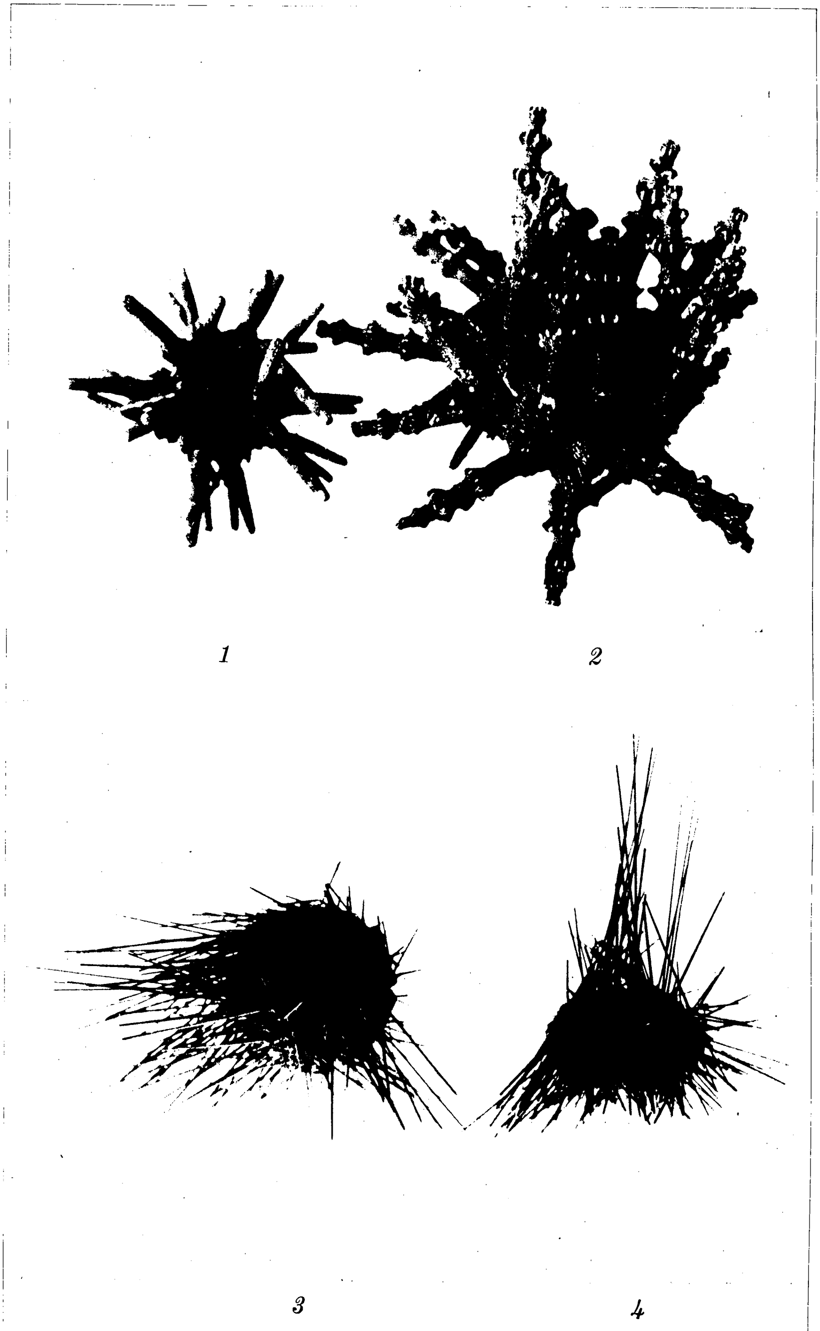
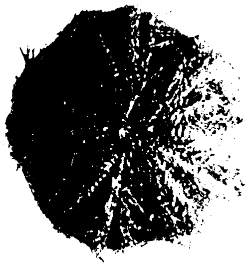
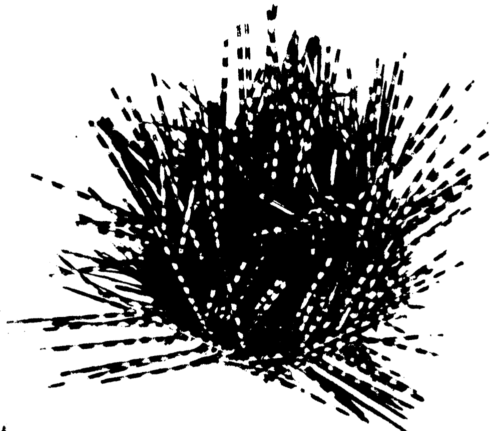


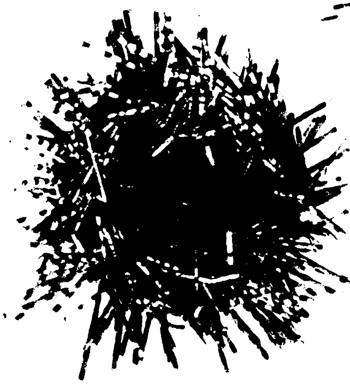
PLATE 1.



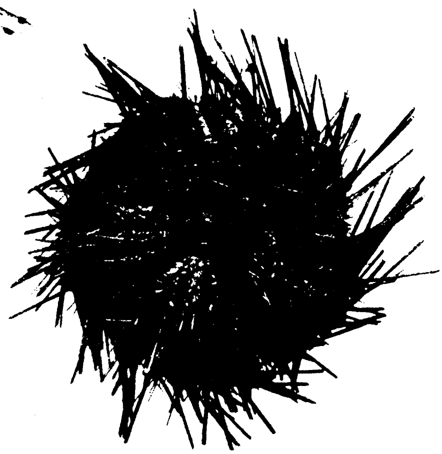
8



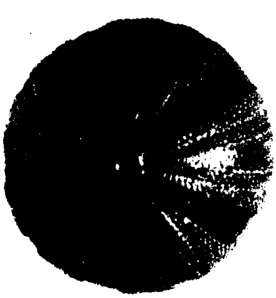
5



6

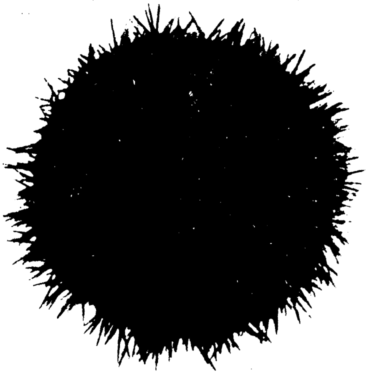


7

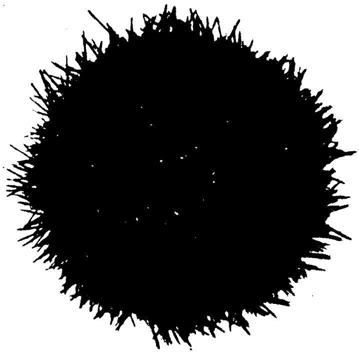


9

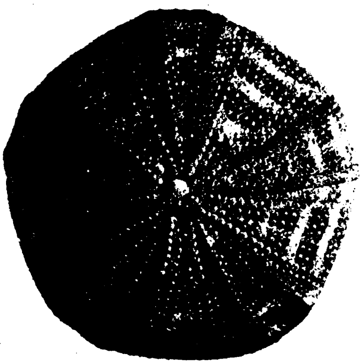
PLATE 2.



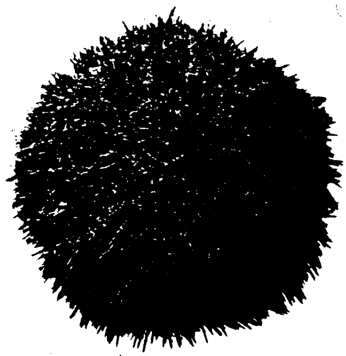
10



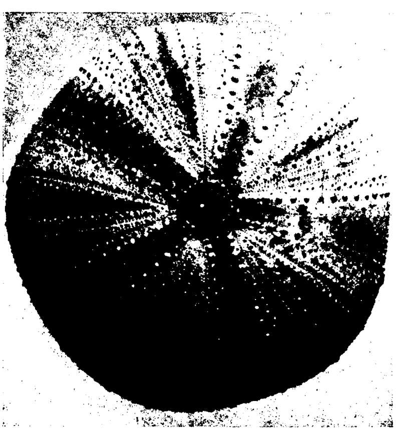
11



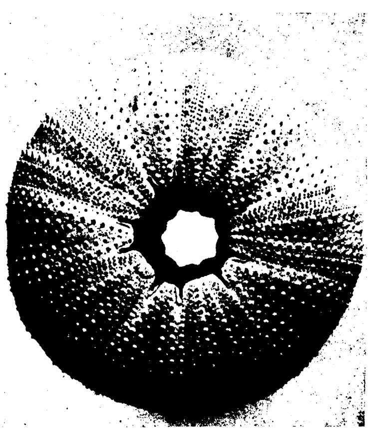
12



13

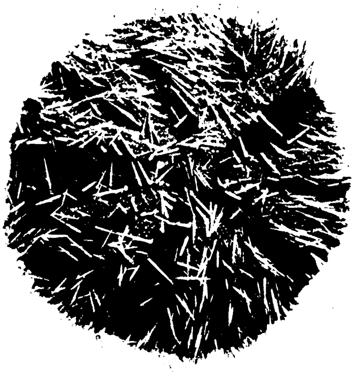


14



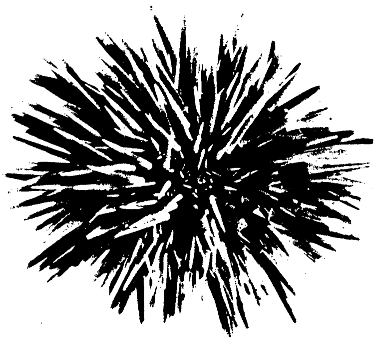
15

PLATE 3.

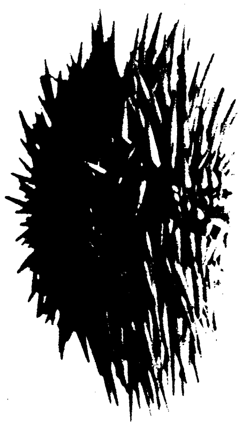


16

17



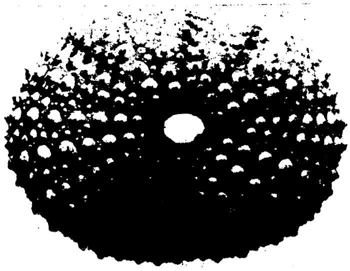
18

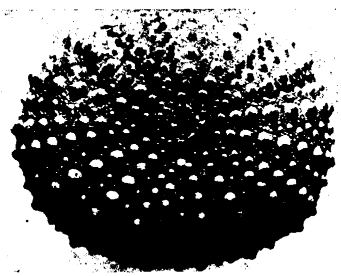


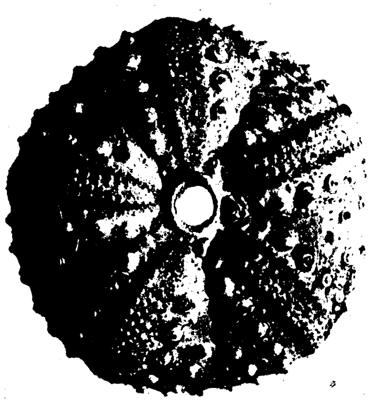
19

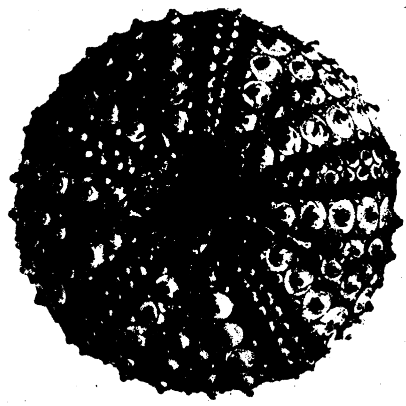
20

PLATE 4.


21


22


23


24


25

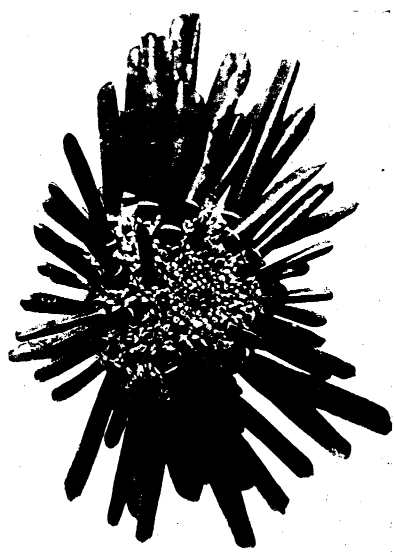
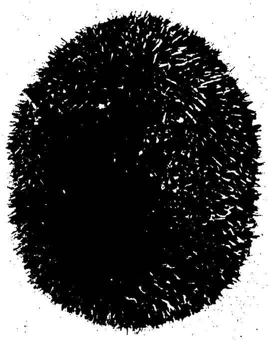
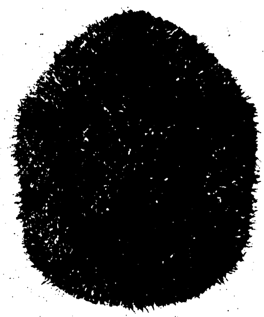

26

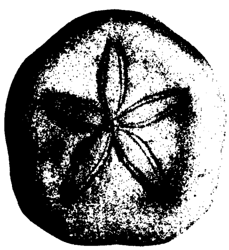
PLATE 5.



27



28



29

30

31

32

PLATE 6.

33

34

35

36

PLATE 7.

CONTENTS

The Philippine Journal of Science is issued twelve times a year. The sections were discontinued with the completion of Volume XIII (1918).

Yearly subscription, beginning with Volume XIV, 5 dollars United States currency. Single numbers, 50 cents each.

Publications sent in exchange for the Philippine Journal of Science should be addressed: Library, Bureau of Science, Manila, P. I.

Subscriptions may be sent to the BUSINESS MANAGER, Philippine Journal of Science, Bureau of Science, Manila, P. I., or to any of the agents listed on the third page of this cover.

Entered at the post office at Manila, P. I., as second-class matter.

THE PHILIPPINE
JOURNAL OF SCIENCE

VOL. 36 JULY, 1928 No. 3

BACTERIAL FRUITLET BROWN-ROT OF PINEAPPLE IN THE PHILIPPINES [1]

By F. B. SERRANO

Assistant Pathologist, Coöperative Plant Pathology Laboratory
Bureaus of Science and Agriculture, Manila

NINETEEN PLATES AND ONE TEXT FIGURE

THE DISEASE

HISTORICAL

This disease was first noted by the writer during the latter part of June, 1924, when fruits of the Smooth Cayenne variety [2] were examined and found infected. Isolations made from the specimens yielded a primuline yellow bacterium and a species of *Penicillium*. Because of lack of the necessary materials, owing to the close of the pineapple season, and because no complaint was received the following year, the investigation was not resumed until towards the latter part of May, 1926, when further diseased Smooth Cayenne fruits were secured from Calauan, Laguna Province, Luzon. Since the disease was ap-

[1] The writer is grateful to Dr. C. J. Humphrey, mycologist and plant pathologist in charge, Bureau of Science, for his valuable advice and criticisms during the progress of the work; to the organic chemistry division of the Bureau of Science for the analysis of the fruits; to the inorganic chemistry division, Bureau of Science, for the hydrogen ion determinations; and to Messrs. E. Cortes and M. Ligaya, photographer and illustrator, respectively, of the Bureau of Science, for aid in the preparation of the illustrations.

[2] From the Lamao Experiment Station of the Bureau of Agriculture, and from Mr. M. Lichauco, a pineapple planter in Tayug, Pangasinan Province, Luzon.

parently quite serious, especially at Calauan, it was then decided to continue the investigation with the view of determining its true nature and working out a feasible means of control.

GEOGRAPHICAL DISTRIBUTION

The disease seems to have a general distribution in the central and southern provinces of Luzon, particularly in Pangasinan, Bulacan, Bataan, Cavite, Laguna, and Batangas. Further survey may also reveal the disease in other parts of the Archipelago, since the three leading and commonly grown native varieties of pineapples (Costa, Pula, and Puti) are also affected, although none of them suffer as heavily as the Smooth Cayenne.

In 1898, Tryon (13) reported from Queensland a disease of pineapple he called "fruitlet core-rot" which resembles in many ways the disease under discussion. The Prickly Queen was found by him to be more severely attacked than the Smooth Cayenne. He claimed that a red mite (*Tarsonemus ananas*), found in abundance in the eye cavities of diseased fruits, originated the disease, although a species of *Monilia,* allied to *Monilia candida,* was considered a secondary factor, this fungus entering the fruits through injuries made principally by the mites, but in some instances by mealy bugs and thrips.

During the summer of 1924 Barker (1) reported a disease at Cap Haitien, Haiti, that affected 50 to 75 per cent of Smooth Cayenne fruits. This disease, which he calls "fruitlet black rot," appears from the description to be quite similar to the Philippine bacterial fruitlet brown-rot if not identical with it. Barker claims that a pale yellow bacterium, which has been constantly isolated from affected fruits, would produce the disease when inoculated under aseptic conditions into sound maturing fruits. In as much as no description of the casual bacterium was given, comparison with the Philippine organism is not possible.

SYMPTOMS

External signs of the disease.—The disease is very difficult to diagnose without cutting the fruits. When the infection is only slight to moderate no external signs that may indicate unhealthiness are visible (Plate 1). With very severe infections, however, the ripening color may be distinctly dull and often marked with minute purplish dots. Greenish patches may also occasionally be present, producing the appearance of uneven ripening. If such sickly-looking fruit be extraordinarily hard, which can be noted by pressing with the hands, it is safe to declare it a total loss (Plate 2). These characteristics, however, may easily be overlooked.

Malformations and gummosis, on the other hand, are not significant characteristics of the disease.

Internal signs of the disease.—Diseased fruit when cut open reveals one or many (sometimes all) affected fruitlets in which there are brown [3] to dusky brown or bone brown spots and patches, depending apparently on the stage of infection. In young infections the color is brown, turning to dusky brown and finally bone brown with age. In general the discoloration appears to originate in the placentæ where the three slits or fissures running down from the base of the three alternate stamens end their course. Thence it extends as brown to dusky brown, more or less granular, radiations into a limited portion or to all of the inner surfaces of the individual fruitlets; in the latter case the entire fruitlet may be thoroughly blackened.

The affected tissues are at first as juicy and soft as the healthy ones, but as the disease progresses they become dry and hard, so much so in fact that in advanced cases infected fruits can be distinguished by their resistance to cutting. The disease appears to be a rot of the fruitlets rather than a general rot of the entire fruit, a characteristic which may be noted even in the severer cases of infection. It develops only during the process of ripening and does not seem to spread after ripening or during storage. In green or immature fruits rarely can any trace of the disease be found.

In many instances the disease does not appear to affect the connective tissues, although occasionally the fibrovascular bundles in the core of the fruits are distinctly browned (Plate 3). This discoloration, however, can always be traced to the diseased fruitlets. The browning of the fibrovascular bundles in the core seems to be invariably associated with the hardened condition of severely infected fruits.

This disease must not be confused with several somewhat similar but less serious fruitlet spots or fruit rots that occasionally occur in pineapples.

[3] The colors indicated here and elsewhere in this paper are those of Ridgway's Color Standards and Color Nomenclature. Washington (1912).

ECONOMIC IMPORTANCE

Observations made on four hundred forty-seven fruits, including both Smooth Cayenne and native varieties, from Calauan, Laguna Province; Abukay, Bataan Province; Silang, Cavite Province; and Guiguinto, Bulacan Province, showed that an average of 42.4 per cent of them were diseased. Of the native varieties examined (Costa, Pula, and Puti) 33 to 62 per cent were infected; the total loss, however, was slight. As high as 54.4 per cent of the Smooth Cayenne fruits from Calauan were found to be infected, slightly less than one-third of these (17 per cent) being a total loss (Table 1). Moreover, information from reliable sources indicates that the disease was even worse in 1926 than in 1927.

TABLE 1.—*General pathological observation on Smooth Cayenne and native pineapple fruits from Luzon.*

Source of data.	Healthy.	Slightly infected.	Moderately infected.	Total loss.	Diseased.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Calauan; 147 Smooth Cayenne	45.6	37.4	15.0	2.0	54.4
Abukay; 96 Smooth Cayenne	58.3	35.4	4.2	2.1	41.7
Silang; 44 Smooth Cayenne	86.4	13.6	0	0	13.6
Silang; 50 Pula	48.0	52.0	0	0	52.0
Silang; 50 Puti	38.0	62.0	0	0	62.0
Guiguinto; 30 Costa	60.0	40.0	0	0	40.0
Guiguinto; 30 Puti	66.7	33.3	0	0	33.3

THE CAUSAL ORGANISM

ISOLATION

From diseased Smooth Cayenne fruits from Calauan hundreds of cultures[4] were made weekly during the pineapple season of 1927 by transferring discolored blocks of diseased tissue to tubes of glucose bouillon +10 (Fuller's scale). As soon as cloudiness appeared in the bouillon, generally after six to twelve hours, dilution plates were made on potato glucose agar +10. In all cases, whether blocks were taken from the discolored thin placental covering, from the ovaries, or from browned connective tissues in the core, pure cultures of the primuline yellow bacterium, often in uniform colonies free from contamination, were obtained.

[4] In all cases the isolations were made from diseased fruits which had been kept in the laboratory not more than two days after picking. Often the work was done on the same day that the fruits were picked.

A species of *Penicillium* which is present in the floral parts in the eye cavity in nine cases out of ten has also been isolated at times when the blocks were taken from the characteristic hard, dry, tumorlike formations at some point along the open channels or fissurelike slits originating at the base of the three alternate stamens in the eye cavity and leading into the placental region. From these infected areas the *Penicillium* was in some cases isolated pure, but usually there were contaminations. In general, fungus infection was rare and usually met with only in the dry hardened parts of the diseased fruits.

In order to find out at what stage the fruit becomes infected, isolations were made at different stages of maturity. All isolations from fruits with flowers still closed gave negative results, while some of those in bloom yielded the primuline yellow bacterium. It was obtained by direct planting, without sterilization, of healthy-looking petals, stigmas, anthers, styles, and stamens of already opened flowers into glucose bouillon +10, some of the cultures showing turbidity after six to twelve hours. In the dilution plates made from these cultures, however, the primuline yellow bacterium was oftentimes associated with other microörganisms. Isolations from browned ovaries (which are quite common in immature fruits with flowers already dried and "eyes" more or less tightly closed), as well as from semimature fruits showing no visible sign of infection internally or otherwise, yielded the same primuline yellow bacterium in pure culture. This would indicate that the pathogen gains entrance into the fruit as early as the blooming period.

This same organism has been isolated from diseased Smooth Cayenne fruits from Bataan, Cavite, and Pangasinan and from native pineapples from Guiguinto, Bulacan Province; Lipa, Batangas Province; and Silang, Cavite Province.

TAXONOMY AND MORPHOLOGY

The pathogen is believed to be a new species and has the following characteristics:

ERWINIA ANANAS sp. nov.[5]

Short rod, with more or less round ends, measuring 0.9 by 0.6 micron; occurring singly and in pairs, but occasionally in

[5] Following the recent proposals by the Society of American Bacteriologists (2, p. 168 and 3, p. 189) this pineapple pathogen is classed under *Erwinia*, and the name *Erwinia ananas* is here proposed. If the classification of either Smith (10) or Migula (7) is followed it should be *Bacillus ananas*.

chains; motile by means of peritrichous flagella numbering from 4 to 8 (shown by both Van Ermengeru's, and Plimmer's(9) method of staining); encapsulated and grouping in clumps at times; nonspore-forming, Gram-negative by Burke's(4) method, not acid fast, staining readily with carbol fuchsin, gentian violet, methyl violet, but faintly with methylene blue. It stains bipolarly with carbol fuchsin but may show opposite reaction when old and degenerating. Paired bacteria, as clearly shown with Zien's carbol fuchsin, generally appear as a single organism with Verhoeff's carbol fuchsin (see Plate 17).

Using the most recent chart prepared by the Society of American Bacteriologists(8, p. 148), the index number is 5311–32125–1222.

CULTURAL CHARACTERS

Potato-glucose agar +10.—After twenty to twenty-four hours plate dilutions at room temperature (25° to 30° C.) produced surface colonies about 3 millimeters in diameter, circular, convex, dense, homogeneous, entire, moist, straw yellow, usually showing "mottling." They became primuline yellow and glistening in forty-eight hours, and when the plate was held in a vertical position some of the colonies ran down over the surface like a tear drop. On the fourth day they doubled in size and produced a butyrous concentric ring; some were umbilicate. After about ten days the colonies showed a tendency to spread, thus forming crenate margins. Deep colonies were elliptical to fusiform, with a straw yellow, granulated thin center (Plate 3). Odor is similar to fermenting tikitiki or molasses.

On slants there were produced at first straw yellow raised streaks which later became primuline yellow, moist, and glistening. Globules ran to the bottom of the tubes after twelve to twenty-four hours. At the lower end of the streak, and in the bacterial mass accumulating at the bottom, a greenish gray to violet-gray color was occasionally observed, while a delicate metallic tint of yellowish blue-violet was generally noted at the surface. The edges of the growth became crenate after five days. Zoöglœalike formations occasionally developed on the lower portion of the streaks.

In stab cultures the bacterium produced a moderate, glistening, straw yellow to primuline yellow growth on top of the agar, filiform within.

Beef-peptone gelatin.—Stratified liquefaction was noted after two days and was complete after five days. At first the liquid remained clear, with flocculi, but later became turbid, and a deep chrome-colored sediment was deposited. To determine the presence or amount of liquefaction the tubes held at room temperature (25° to 30° C.) were solidified at intervals of twelve hours by cooling for ten minutes at 10° C.

Löffler's blood serum.—After twenty-four hours a streak of moderate growth developed. It was slightly raised, mustard yellow to primuline yellow, and had crenate edges. No liquefaction was noted even after three months.

Beef bouillon +10.—This became turbid within twelve hours, more so after a day, with granular growth on top which developed during the second day into a thin, fragile, straw yellow pellicle with a ring adhering along the sides of the tube. Slight jarring caused the ring to break away and settle to the bottom.

Glucose bouillon +10.—In order to determine the relation of the organism to the amount of available sugar in the medium, which in turn may throw light on its behaviour toward fruits, bouillon was prepared with varying amounts of glucose; namely, 1, 5, 10, 15, and 20 per cent. These concentrations were inoculated, in duplicate, with a loop of one-day-old culture and incubated at room temperature. The results are as follows:

TABLE 2.—*Relation of sugar to growth of the pathogen.*

Glucose.	Growth.				
	First day.	Second day.	Third day.	Fourth day.	Fifth day.
Per cent.					
1	Luxuriant	Luxuriant	Waning	Moderate	Faint.
5	Very luxuriant	Very luxuriant	Luxuriant	Luxuriant	Waning.
10	Luxuriant	More luxuriant	Very luxuriant	Very luxuriant	Luxuriant.
15	Moderate	Luxuriant	More luxuriant	do	Very luxuriant.
20	Faint	Moderate	Moderate	Luxuriant	Do.

After six hours turbidity in all tubes was noted, with a decreasing intensity from the third lowest concentration to the highest. A thin, fragile, granulated pellicle and straw yellow ring adhering along the sides of the tubes developed after twenty-four hours, becoming slimy after forty-eight hours. As shown in the tabulation the bacterium responds more quickly to a 5 per cent concentration than to higher ones. The solution became sulphine yellow in color.

Litmus milk.—The blue color of the medium began to fade from the top after twenty-four hours and completely disappeared in five days. The reaction was faintly acid at first, later becoming alkaline; medium coagulated and turbid, with delicate flocculent clots.

Congo red agar stab.—After twenty-four hours scanty growth developed at the top of the puncture, a bluish color appearing on the fifth day along the line of puncture, denoting the formation of free acid. After nine days granular, bluish black, minute specks radiating from the line of puncture and taking a downward course upon hitting the walls of tubes were visible.

Cohn's solution.—No appreciable growth was noted after forty-eight hours or even after ten days.

Omeliansky's nutrient fluid.—Negative even after ten days.

Pineapple plugs.—A copious growth, straw yellow to primuline yellow, developed after twenty-four hours. In four days colonies of varied form arose from the mass on the surface of the plug and later coalesced to form primuline yellow globules of bacterial ooze which settled to the bottom. A delicate metallic tint of yellowish blue-violet was generally observed at the surface.

Sugar-cane plugs.—In forty-eight hours moderate moist slimy growth developed on the surface of the medium. As the medium dried it gradually changed to clay color or snuff brown in the case of Cebu Purple and Hawaii 109, later becoming dusky brown to bone brown with a delicate metallic tint of yellowish blue-violet. No discoloration of Luzon White variety was noted.

Banana plugs.—Yellow, glistening, moist, spreading growth developed after twenty-four hours, with apparent discoloration commencing from the top. In two weeks the plugs were completely discolored from pale olive buff to olivaceous black or fuscous black, with a delicate metallic tint of yellowish blue-violet. The varieties used may be grouped in the order of their susceptibility to color changes as follows: Tondoc, Sabá, Boleró, and Latundan. The discoloration produced here was very similar to that of typically diseased pineapple fruit.

Potato plugs.—Copious, glistening, moist, spreading, homogeneous, primuline yellow to aniline yellow growth developed after about twenty-four hours. No discoloration of the plugs was observed.

CHEMICAL PRODUCTS FORMED

In determining the biochemical activities of the pathogen the methods given by Eyre (5, p. 276), unless otherwise stated, were followed, with slight modification in some instances to suit actual conditions.

Fermentation.—With Dunham's peptone water and Andrade's indicator (12, p. 40) three series of 2 per cent solutions of twenty-four different substances, principally carbohydrates, were prepared in seventy-two fermentation tubes. Each of the first series was inoculated with a young active culture of the primuline yellow bacterium, designated as A, by introducing into each a loop of the inoculum in water suspension. The second and the third series, respectively, were inoculated in an identical manner with the primuline yellow bacterium isolated from the native varieties and designated as B, and with a gray strain (supposedly a "mutant" from A) designated as C. The first observation was taken after one day, the second after five days, and the third after ten days. The results are given in Table 3.

TABLE 3.—*Fermenting capacity of the pathogen.*

A. Primuline yellow bacterium from Smooth Cayenne.
B. Primuline yellow bacterium from native varieties.
C. Gray bacterium (mutant?) from A.
a. Bacterial growth both *aërobic* and *anaërobic*, reddening the medium, which becomes acid to litmus paper.
b. Same as "a," but *strongly* acid to litmus paper.
c. Bacterial growth *aërobic* only, reddening the medium, which becomes acid to litmus paper.
d. Same as "c," but strongly acid to litmus paper.
e. Medium not reddened; *alkaline* to litmus paper.

Carbohydrate used.	One day.			Five days.			Ten days.		
	A	B	C	A	B	C	A	B	C
Saccharose	b	b	d	b	b	d	b	b	d
Manite	b	d	e	b	b	d	b	b	d
Raffinose	b	d	e	b	b	d	b	b	d
Glycerine	d	d	e	b	e	d	b	b	d
Salicin	d	d	e	b	b	e	b	b	c
Lactose	b	d	e	b	b	d	cd	cd	c
Dextrin	b	d	d	b	b	d	cd	cd	c
Maltose	b	d	d	b	b	d	a	a	c
Levulose	b	d	d	b	b	c	a	a	c
Mannose	b	d	d	cd	cd	c	a	a	c
Glucose	a	c	c	a	a	c	a	a	c
Sorbitol	c	c	e	a	a	c	a	a	c
Galactose	c	c	c	c	c	c	c	c	c
Arabinose	e	e	e	c	c	c	c	c	c
Xylose	e	e	e	c	c	c	c	c	c
Amygdalin	e	e	e	c	e	e	a	e	e
Rhamnose	e	e	e	e	e	e	e	e	e
Inositol	e	e	e	e	e	e	e	e	e
Inulin	e	e	e	e	e	e	e	e	e
Nutrose	e	e	e	e	e	e	e	e	e
Dulcitol	e	e	e	e	e	e	e	e	e
Adonitol	e	e	e	e	e	e	e	e	e
Asparagin	e	e	e	e	e	e	e	e	e
Amylum	e	e	e	e	e	e	e	e	e

As shown in the first three columns of Table 3, culture A was, in general, the most active within the first 24-hour period, while B was second and C third. After five days practically the same course of events was observed, with B approaching A and C trailing behind. Except with amygdalin where A produced a trace of acid while B did not, the reactions of A and B were identical throughout the series after ten days; that is, both demonstrated power to produce acid from the first fifteen substances, both indicated ability to grow in the absence of free oxygen in the first twelve, and both showed ability to grow in the last eight, apparently with alkali production instead of acid. Culture C demonstrated the same activities as B with the exception that B could apparently grow anaërobically while C could only develop in the presence of air.

The cultures that did not show any red (deep rose) coloration were alkaline to litmus paper on the fifth day. It was also noted that at this time acid production began to subside in some of the cultures. By the tenth day some of them had more or less completely faded out and were alkaline to litmus paper, while sucrose, mannite, raffinose, glycerine, and salicin were still deep rose in color and strongly acid in reaction. It was also noted that no gas was produced in any of the tubes.

In addition to these substances 1 per cent solutions of sodium citrate, sodium lactate, sodium tartrate, and sodium formate in peptone were tested. The three inocula showed moderate growth in all of these cultures except sodium formate, which remained negative even after ten days.

All these results tend to show that A and B are apparently identical, the slight difference in their reactions to amygdalin being perhaps nothing more than a result of host specialization or slight degeneration due to unfavorable environment. It can be seen offhand that C is in essential agreement with the others except with respect to oxygen relations. However, the latter fact, coupled with its apparent inability to produce a yellow pigment, may be sufficient grounds for considering it a different strain or variety.

Acid production.—Following the procedure given in Eyre's pathological technic it was found that the yellow bacterium could produce in twenty-four hours from 100 cubic centimeters glucose bouillon +15, containing 2 grams glucose, approximately 0.00645 gram of acetic acid equivalent to 1.0859 cubic centimeters of 0.1 *N* sodium hydroxide. The presence of the acid was demonstrated by the unpleasant smell of cacodyl produced when residues of the distillate were mixed with arsenious oxide in equal parts and heated on platinum foil.

In addition to this the yellow bacterium showed the following characteristics:

Alcohol production.—It has the power to produce a small amount of alcohol and aldehyde, as shown by Lugol's iodine test and Schiff's reagent.

Enzyme production.—It was found to be capable of producing diastase, invertase, and traces of rennin and "lab" enzymes but not protease.

Ammonia production.—It has demonstrated ability to produce a small amount of ammonia, as shown by Nessler's test.

Indol production.—Negative by Rindol reaction.

Phenol production.—Negative by Millon's reagent.

Pigment production.—It was found to produce yellow pigment of different intensities, depending to some extent on the temperature at which the culture was incubated. At 7° to 10° C. it produced a sulphur yellow color which gradually increased in intensity until it became ochraceous yellow when about one month old. At room temperature (25° to 30° C.) the bacterium became primuline yellow in twenty-four to forty-eight hours. On banana plugs it produced a color (olive buff to olivaceous black) quite similar to the color of typically diseased pineapple fruits. In the absence of free oxygen, as in Buchner's tubes, pigmentation was very feeble. Light seemed to favor pigmentation to a slight extent. The pigment dissolves slightly in hot and cold water and in sulphuric acid, but not in sodium hydroxide.

Reduction of nitrates.—In twenty-four hours nitrates were reduced to nitrites, as shown by the brownish red color produced when the culture was treated with sulphuric acid and metaphenylene diamine. The check culture remained negative.

Gas production.—No formation of either carbon dioxide or hydrogen was shown in the fermentation tubes even after sixty days. In lead peptone solution, however, the yellowish white precipitate was converted into brownish black after approximately two weeks' incubation. This would seem to indicate very slight liberation of hydrogen sulphide gas. The control tubes remained practically unchanged.

OTHER PHYSIOLOGICAL CHARACTERISTICS

Relations to oxygen.—The yellow bacterium has shown best growth in the presence of oxygen and only very faint growth under anaërobic conditions. This power to grow anaërobically (though very faintly) was demonstrated by the pyrogallic acid method in Buchner's tubes.

Reactions to temperature.—It has shown growth on potato glucose agar +10 at a temperature ranging from 6° to 45° C., with an optimum at about 30° to 35° C. In tubes of 10 cubic centimeters beef bouillon +10 it was killed by a ten-minute exposure at 56° to 57° C. .

Reactions to media.—It has shown best growth at +10 to +20 (Fuller's scale), the cultures becoming turbid atter six hours. Only a trace of growth was observed in the neutral and —10 media, and none at all in either +30 or —20. It would seem that its optimum acidity lies around +15.

Resistance to sodium chloride.—Sodium chloride in small amounts has not shown any deleterious effect on growth. Bouillon tubes containing 1 and 2 per cent, respectively, showed decided turbidity after twenty-four hours, while those containing 3, 4, and 5 per cent were only slightly turbid. After forty-eight hours a thin, creamy pellicle commenced to form on top of the 1 and 2 per cent concentrations, but there was only faint turbidity in the 6, 7, 8, and 9 per cent and none in 10 per cent concentration, even after ten days.

Resistance to desiccation.—It has shown extreme resistance to desiccation. Films of the yellow bacterium were made aseptically on cover slips, placing the preparations in sterile plates as soon as made. The plates were then kept in a desiccator at room temperature. At twelve-hour intervals the cover slips were placed aseptically one at a time into tubes of glucose bouillon +10 to determine the viability of the organism. This procedure was continued for seven days, the organism being alive at the end of the period. Following this, the remaining cover slips were placed in tubes at weekly intervals until the last three successive plantings showed negative results, verified by poured platings. In this manner it was determined that the bacterium could remain alive under desiccator conditions for at least four and one-half months, but not for five months.

Resistance to light.—It proved fairly resistant to direct sunlight, but five hours' exposure (on ice) was fatal (Plate 3, fig. 6). Diffuse daylight in the laboratory did not produce any appreciable effect, except perhaps slightly deeper pigmentation.

Resistance to freezing.—Freezing (—10° C.) for one day has not shown any appreciable destructive effect, two to three days being necessary to effect degeneration and a slackening of its growth rate, while fifteen days were required to kill. These data were secured by keeping a bouillon tube freshly inoculated with the very young, active, primuline yellow bacterium on the cooling coil in an electric refrigerator at an average temperature of —10° C. Streak cultures were made from this daily on potato glucose agar +10 until three negative results were obtained in succession.

Resistance to disinfectants and sprays.—In order to gain a rough idea of the relative toxicity to the yellow bacterium of copper sulphate, mercuric chloride, and lime-sulphur solution several duplicate tests were made with these substances by mixing them in definite proportion with beef bouillon +10 and inoculating them with a loop from a two-day old culture of the yellow bacterium growing in beef bouillon +10.

The dilutions shown in Table 4 were made as follows: One gram of copper sulphate crystals was dissolved in 10 cubic centimeters of distilled water. From this stock solution 1 cubic centimeter was transferred by means of a sterile pipette to a test tube containing 9 cubic centimeters of sterile bouillon. This gave a concentration in the medium of 1: 100. The next step was to transfer 1 cubic centimeter from the tube so prepared to another tube likewise containing 9 cubic centimeters of sterile bouillon. This gave a concentration of 1: 1,000; the process was continued up to a concentration of 1: 100,000,000.

The dilutions of mercuric chloride were made in a similar manner except the 10 per cent stock solution of the powdered crystals which was prepared by dissolving in hot water.

The lime sulphur was first made up to a gravity of 32° B. and allowed to stand about two days, the clear orange liquid then being decanted. This liquid was then diluted with the bouillon to make concentrations from 1: 10 to 1: 1,000.

One check culture, without the addition of chemical, was prepared for each series of dilutions for purposes of comparison.

Three days after inoculation observations were made and poured plates prepared on potato glucose agar +10 from the tubes free from turbidity. All such tubes gave negative results, showing that the organism was not only inhibited but killed. Positive results were determined without plating, by observing the turbidity of the cultures and the characteristic growth of the organism.

TABLE 4.—*Effect of disinfectants.*

Disinfectant.	Dilution.	Result.	Disinfectant.	Dilution.	Result.
Copper sulphate	1:100	—	Mercuric chloride	1:10,000,000	+
Do	1:1,000	—	Do	1:100,000,000	+
Do	1:10,000	+	Do	Check	+
Do	1:100,000	+	Lime sulphur, 32° B.	1:10	—
Do	1:1,000,000	+	Do	1:20	—
Do	1:10,000,000	+	Do	1:40	—
Do	1:100,000,000	+	Do	1:60	—
Do	Check	+	Do	1:80	—
Mercuric chloride	1:100	—	Do	1:100	+
Do	1:1,000	—	Do	1:250	+
Do	1:10,000	—	Do	1:500	+
Do	1:100,000	—	Do	1:1,000	+
Do	1:1,000,000	—	Do	Check	+

As shown in Table 4, 1:1,000 copper sulphate, 1:1,000,000 mercuric chloride, and 1:80 lime-sulphur solutions were strong enough to kill the bacterium, but greater dilution did not show any considerable effect, as seen from the intensity of turbidity. Therefore, of the three chemical solutions mercuric chloride has shown the most toxic effect and copper sulphate the next.

Vitality in artificial cultures.—The vitality of the organism in artificial cultures was found to depend a great deal on the composition of the media as well as on the environment. Being a sugar-consuming organism, it was found to grow better and remain viable longer on media containing sugar, such as glucose bouillon +10, potato glucose agar +10, etc., than on protein media. Conserving the moisture of the culture by partially sealing the test tube with paraffin and incubating it at room temperature (25° to 30° C.), also lengthened the life of the pathogen. Poured plates made from cultures twelve months old in glucose bouillon +10 and on potato glucose agar +10 have shown that it was still viable (although very much degenerated, as indicated by colonies of varied form and pigmentation).

Degeneration and variation.—Like most other bacterial organisms this bacterium is prone to pass into unusual forms called "degenerates," either as a result of continuous cultivation on artificial media, or incubation under unfavorable environment, or both.

The effect of growing it continuously on artificial culture media was demonstrated by making dilution plates daily for thirty days from a newly isolated culture on potato glucose agar +10 incubated at room temperature. The first visible sign of degeneration was observed on the third day, when one or two olive yellow colonies appeared amongst the primuline yellow colonies. With greater age more-degenerated individuals were noted, these departing so much from the original typical primuline yellow bacterium that the pure culture appeared as if contaminated with a foreign organism. The degeneration was finally such that dilution plates from a one-year-old culture in glucose bouillon +10 showed only about 30 per cent primuline yellow colonies, 30 per cent olive yellow, 35 per cent minute, pale olive-buff (later becoming rugose and umbonate, with olive lake center), and 5 per cent grayish olive with conical surface (Plate 4).

The effect of unfavorable environment upon degeneration was found to be even more decisive and quicker than the results just cited. A culture incubated for a month at 7° to 10° C. has shown as much degeneration as the culture kept for a year in the laboratory at a temperature varying from 25° to 30° C. Such degenerate effect was very clearly observed when three badly diseased fruits were kept in an electric refrigerator at 7° to 10° C. for the same period. From these fruits the typical primuline yellow bacterium was obtained in pure culture in all the plates on the first day (before they were placed in the electric refrigerator) and even after two days; but when dilution plates were repeated on the fifteenth day one yielded a pure culture of uniform, minute, ivory yellow colonies instead of the original primuline yellow, and repeated platings failed to recover the primuline yellow bacterium. On the twenty-third day an identical phenomenon was observed with the second fruit, followed on the thirtieth day by the third. Repeating the isolations from the same materials, forty, fifty, and sixty days after, the same results were obtained. It was noted that the fruit that showed the first transformation of the organism was the smallest, the second was medium sized, and the third was the largest.

In view of the fact that cultures of the primuline yellow bacterium have been found still viable after one month incubation at 7° to 10° C., it seems unbelievable that in fresh pineapple fruit (its natural host) it should die earlier than this and be completely replaced by an ivory yellow organism which had never been met in previous isolations. The results have been thus far uniform, but still the problem seems puzzling and certainly needs further study before a definite conclusion can be safely drawn.

Morphologically, the ivory yellow organism has shown characters seemingly indistinguishable from the primuline yellow one, but in cultural behavior the two differ greatly. While it took four to five days for the primuline yellow strain to completely liquefy peptone gelatin, the ivory yellow one completed it in two days; and unlike the primuline yellow strain it showed a preference for invert sugar over saccharose, as shown by its good growth in the former and decidedly feeble growth in the latter. The ivory yellow organism also proved to be an obligate aërobe and produced no acid in fermentation tubes of different sugars, even after ten days.

At room temperature colonies of the ivory yellow bacterium on plates of potato glucose agar +10 are at first minute, opalescent, convex, circular, entire, becoming ivory yellow, wrinkled, with crenate margins after two or three days, then finally becoming round, creamy, wet, glistening, pulvinate to hemispherical, free from wrinkles, abundant after five to six days, and diffusing a pale green-yellow color into the agar. At 7° to 10° C. the colonies were very small and poorly developed.

A pearl gray to deep green-blue gray strain which may perhaps be considered a "mutant" or "sport" was occasionally isolated from two- to three-week cultures on potato-glucose agar +10. This gray organism might be considered identical with the primuline yellow organism were it not for the difference in their color and their relations to oxygen, the former having lost the power to grow in the absence of free oxygen, thus becoming an obligate aërobe while the yellow organism remains a facultative anaërobe. Moreover, unlike the primuline yellow organism, it has shown a considerable degree of stability and no tendency to revert, an important criterion, according to Jordan,(6, p. 122) for designating a "mutant." Platings and replatings from a year-old culture of this, and hundreds of test tube transfers made therefrom, gave uniform results, thus proving its permanence under ordinary conditions (Plate 4).

PATHOGENICITY: INOCULATION AND REISOLATION EXPERIMENTS

In the laboratory.—On June 26, 1926, the first set of preliminary inoculations was made in the laboratory. Eighteen fresh, 2-kilogram, apparently healthy, fully mature Smooth Cayenne fruits just showing very faint signs of ripening were selected and inoculated by needle punctures with five-day-old pure cultures of the primuline yellow bacterium and *Penicillium* sp. grown on potato glucose agar +10. The fruits were first washed with tap water to free them from dust, and when dry the surfaces were disinfected with 1:1,000 mercuric chloride in 70 per cent alcohol. On one side of each of the first six fruits six fruitlets were punctured with a needle previously sterilized in the flame of an alcohol lamp. Into these punctures were introduced by means of another sterile needle a pure culture of the primuline yellow bacterium. Another set of six fruits was inoculated with the *Penicillium.* The remaining six serving as a check were punctured without introducing any inoculum. In each case care was exercised that no puncture passed the eye cavity, thus avoiding contamination with various organisms generally present therein. The punctures were then coated with paraffin to prevent the entrance of outside organism; later, the inoculated fruits were set aside on a table in the laboratory for fifteen days, after which they were opened for observation.

All fruits inoculated with the primuline yellow bacterium showed light but characteristic lesions, while the checks remained negative; those inoculated with *Penicillium* were questionably positive. The results, therefore, strongly indicate: first, that the fruitlet brown-rot disease can be reproduced by artificially infecting healthy, mature Smooth Cayenne fruits with a pure culture of the primuline yellow bacterium by means of needle punctures (Plate 5); second, that, although the *Penicillium* could cause discoloration when inoculated into the fruitlets, the lesions produced thereby were far from being typical of the fruitlet brown-rot (Plate 6).

From positive inoculations the original primuline yellow bacterium and the *Penicillium* were both easily recovered by reisolation.

On June 7, 1927, the preceding experiment was repeated, following exactly the same procedure and technic, except that ripe fruits were used instead of mature ones. The purpose was to find out the relation of the stage of maturity or ripening to the virulence or pathogenicity of the causal organism.

Results quite different from the preceding were obtained from this series. With the exception of the two inoculations with the yellow bacterium, which were not decisive, all the bacterial inoculations gave negative results in spite of the fact that the original bacterium was still alive at the time of examination, as shown by reisolations. The control punctures were all negative, while those inoculated with *Penicillium* were all questionably positive, although not by any means typical of the fruitlet brown-rot lesions. These results would seem to indicate that certain metabolic processes in the course of development of the fruit, probably taking place during the maturing to ripening stage, exercised some influence upon the power of the organism to cause the disease. This may perhaps explain the writer's observation that the disease has not shown a tendency to advance in storage.

In the field.—Series I. The first field tests were conducted in a plantation at Calauan, Laguna Province, Luzon, on February 14, 1927. Inoculations were made in the following manner: Four uniform, alternate rows of about sixty plants each were selected. With a compressed-air sprayer the first row was sprayed with tap water alone; the second, with a water suspension of the primuline yellow bacterium (5 days old); the third, with a water suspension of the spores of *Penicillium* sp.; and the fourth, with a water suspension of both organisms combined. This was repeated weekly for the two months covering the blooming period (February 14, 1927, to April 4, 1927). In all cases care was exercised to spray the fruits thoroughly.

The fruits from each row were harvested separately as they ripened, and brought to the laboratory for observation. Each fruit was sliced into cross sections about 1 centimeter thick, and the number and the severity of infections therein were noted. The fruits thus examined were marked as "Healthy" when they were absolutely free from any visible characteristic infection; "Slightly infected," when not more than six of their fruitlets were badly infected or not more than ten slightly infected, or, in case deep and shallow infections were both present, the number was not half as many as the two combined; "Moderately infected," when the infection was more severe than the preceding; and "Total loss," when it was so severe that the entire fruits were unfit for table use. The results of these observations are given in Table 5.

As high as 75.7 per cent of the fruits sprayed at the blooming period with a water suspension of the pathogen became infected, while those sprayed with *Penicillium* showed only 35.5 per cent. Those sprayed with the two organisms combined gave 71 per cent, while the control (sprayed with tap water alone) sustained an infection of 36.1 per cent. Such positive results in the check may be attributed to the natural infection which ordinarily occurred under field conditions.

TABLE 5.—*Results of field inoculations, Series I.*

Sprayed with—	Fruits examined.	Healthy.	Diseased.			
			Slightly infected.	Moderately infected.	Total loss.	Total infected.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Tap water only	36	63.9	16.7	16.7	2.7	36.1
Yellow bacterium	37	24.3	24.3	29.7	21.7	75.7
Spores of *Penicillium* sp.	31	64.5	16.1	12.9	6.5	35.5
Yellow bacterium and *Penicillium* sp.	31	29.0	16.1	38.7	16.2	71.0

It will be seen from the same data (Table 5) that although inoculation with *Penicillium* did not in any way increase the number of fruits infected, still the percentage of total loss (6.5) was nearly two and one-half times as high as in the controls (2.7). This, coupled with the writer's experience that all very badly diseased fruits which were dry and hard have shown at the same time the unfailing presence of *Penicillium* in many lesions would seem to indicate that its presence increased the damage to the fruitlets.

More striking still is the fact that despite the heavy artificial infection secured by spraying a water suspension of the pathogen upon the fruits during the blooming period (which is considered as the susceptible stage of the fruits) an average of 26.7 per cent of fruits from the two inoculated rows were absolutely healthy and free from any sign of infection, while some were very resistant, showing but one or two infections. It may be supposed, therefore, that certain individuals possess a considerable degree of immunity to this particular disease. This apparent immunity may be of great significance in devising a permanent means of control.

Series II. The second inoculations in the field were made on March 21, 1927, in the same plantation at Calauan. Thirty uniform mature Smooth Cayenne fruits of about 3 kilograms each were selected and tagged. The surface (facing the east) of each fruit was sterilized with a 1: 1,000 solution of mercuric chloride in 70 per cent alcohol and as soon as dry a puncture on each of six fruitlets, on a vertical line from top to bottom, was made with a sterile needle, taking care to prevent the needle from passing through the eye cavity. Into these punctures were introduced with a sterile needle a pure culture of the primuline yellow bacterium 4 days old; then all punctures were sealed immediately with a paraffin coating to prevent the entrance of external organisms. Using this procedure and technic nine fruits were inoculated with the yellow bacterium, the next ten with the gray bacterial strain, and the last ten were left without inoculum to serve as check.

Observations were made about a month later. All inoculations with the primuline yellow bacterium as well as the gray strain (supposedly "mutant") were positive, while all the control punctures, with the exception of one fruit which apparently had a uniform natural infection, were negative. It was observed, nevertheless, that the lesions produced by the gray strain were not as distinct and characteristic as those caused by the original primuline yellow organism.

Series III. With the same number and kind of fruits and the same method and technic a third series of inoculations was made on April 4, 1927, using both the *Penicillium* sp. and the primuline yellow bacterium.

All the bacterial inoculations were positive and tend to confirm those obtained from the first of the laboratory inoculations, therefore pointing to the conclusion that it is the primuline yellow bacterium and not *Penicillium,* with which it has in some instances been found associated, that is responsible for the trouble. Three of the fruits inoculated with *Penicillium* also showed characteristic bacterial lesions in some of the punctures; one of the controls also developed bacterial lesions, all of which may be considered chance infection.

Series IV. In order to find out the effect of the age of the casual bacterium on its virulence or pathogenicity, further inoculations into mature fruits, using 40-day-old cultures instead of 4-day-old ones (Series II) were made on April 11, 1927.

Observations were made about a month and a half after. While the results obtained from this series have proved beyond reasonable doubt that the primuline yellow bacterium as well as the gray strain can reproduce the fruitlet brown-rot disease when introduced by needle punctures into the fruitlets, yet there are indications that old age causes a decrease in the pathogenicity of the organisms as shown by the five negative results, three from the gray and two from the yellow out of a total of thirty inoculations. This is paralleled by the fact that in artificial culture media, even under ordinary conditions, the pathogen gradually loses its power to produce acid and to utilize saccharose, as already mentioned.

Another interesting phenomenon observed in this series is that in a number of reisolations from the positive inoculations with the gray strain both the gray and the primuline yellow organisms were obtained. Whether this was due to a chance contamination, to natural infection of the fruit with the yellow strain, as has been the case with other inoculations carried out under the same field conditions, or to a reversion of the gray strain to the original primuline yellow bacterium only further tests can determine.

Results from laboratory and field inoculations would seem to indicate that the incubation period of the pathogen ranges from about fifteen to thirty days.

PATHOLOGICAL ANATOMY

In cutting thin slices of diseased fruits the discoloration or browning in the fruitlet, as well as the occasional browning of the connective tissues in the core, can readily be traced backward to the placental region (Plate 7). Thence, if search be carried farther, connections will be found either with the style or with the fissures or open channels running down from the base of the stamens. This indicates that the pathogen probably gets into the fruit through the flower parts during the blooming period.

It may be presumed that the germs fall by chance on the stigma or anthers (Plates 8 and 10), whence they pass downward into the style or stamens as the flowers dry out, then down into the placental cavity of the fruitlet. Positive isolations from these parts have confirmed these views. Then as the fruit matures and accumulates more sugar the infection spreads much more rapidly in a more or less radial manner, but limiting itself to the fruitlet in the majority of cases, although sometimes running down into the vascular bundles of the core, a characteristic which seems to be almost always associated with dry, hard, severe infections. In some instances, however, the disease may extend through the thin membrane of the placental region into the adjacent fruitlet (Plates 9 to 14).

It has been observed that infection takes place through ruptures of the open channels or fissures (three in number) running from the eye cavity downward into the placental lobes (Plates 10 to 12) or through the mechanical cracks generally present at the base of the three alternate stamens (Plate 7). The cause of these ruptures is not definitely known. In any case the line of tissues connecting the stamens and the slits or fissures with the ovaries generally shows discoloration (Plate 11), accompanied by extracellular or intracellular bacterial masses in the discolored tissues (Plate 13).

Generally the infected cells are intact, with their contents apparently partly consumed by the bacteria, which usually congregate along the cell wall (Plate 13).

INFECTION OF SUGAR CANE BY THE PINEAPPLE ORGANISM

As the pathogen is a sugar-consuming type, it seemed reasonable that it could also infect sugar cane under favorable conditions; therefore, on July 28, 1927, inoculations were made by two needle punctures in young, tender internodes of mature canes of each of the fourteen varieties indicated in Table 6. The surfaces of the internodes were first sterilized with mercuric chloride solution in alcohol (1: 1,000) before puncturing. After inoculation, paraffin was applied to protect them from outside organisms. Control punctures were made with a sterile needle on canes of practically the same age and treated similarly. On August 30, 1927, they were harvested and each cane was cut longitudinally into halves through the punctures.

TABLE 6.—*Infection of fourteen varieties of sugar cane, arranged in order of susceptibility.*

Variety name.	Results.	
	Inoculated.	Control.
Luzon Purple	Red streaks in 5 nodes	Negative.
Hambledon	do	Do.
Big Tanna	do	Do.
Hawaii 109	do	Do.
Negros Purple	Red streaks in 4 nodes	Do.
Cebu Purple	do	Do.
Guru	do	Do.
Yellow Caledonia	do	Do.
Barbados	do	Do.
Java 247	Red streaks in 3 nodes	Do.
Badila	do	Do.
New Guinea 24–A	do	Do.
New Guinea 24–B	Red streaks in 2 nodes	Do.
Rose Bamboo	do	Do.

As given in Table 6, all cane varieties tested became infected to a greater or less degree. In the length and the number of red streaks and the extent of discoloration running radially from the punctures (Plate 15) the individual varietal ability to resist the disease differs greatly. In many respects the red streaks produced by the activities of the pineapple parasite in the vascular bundles of the cane resemble those produced by the cane diseases known as "red vascular bundle disease," "gummosis," "sereh," or "leaf scald," the true cause or causes of which are not very definitely known.

The original organism with some degenerated colonies was recovered by reisolation from the red streaks far from the punctures; for example, in adjacent internodes.

With favorable conditions obtaining, sugar cane may therefore be infected by the fruitlet brown-rot pathogen and hence may possibly serve as an intermediate host.

EFFECT OF THE DISEASE ON THE CHEMICAL COMPOSITION OF THE FRUITS [6]

The changes in the chemical constituents of the fruit depend on the extent of infection. These were determined by analyzing representative samples of sound and diseased fruits for Brix, acid content, protein, and sugar.

TABLE 7.—*Comparative analyses of sound and diseased Smooth Cayenne fruits, using the entire fruit.*[a]

Sample.	Brix of juice corrected to 27.5° C.	pH value.	Protein.	Sugars.		
				Sucrose.	Reducing.	Total as invert.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*
Sound [b]	15.93	3.61	0.39	8.27	4.14	12.84
Diseased [c]	12.98	4.30	0.32	7.83	2.60	10.84

[a] Ten healthy and ten diseased ripe fruits showing general yellowing of one-half from the base.

[b] Entirely free from infection.

[c] Moderately infected.

Table 7 shows that diseased fruits contain less sugar, protein, and acid than the healthy, indicating that the pathogen consumes all of the three constituents, with preference for sugar. Repetition of the analysis on diseased and healthy parts of the same fruits gave results tending in the same direction (Table 8).

[6] All chemical and hydrogen ion determinations herein recorded were made by the divisions of organic and inorganic chemistry, Bureau of Science.

TABLE 8.—*Comparative analyses of diseased Smooth Cayenne fruits with healthy parts separated from affected parts.*[a]

Sample.	Brix of juice corrected to 27.5° C.	pH value.	Protein.	Sugars.		
				Sucrose.	Reducing.	Total as invert.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*
Healthy parts	15.66	4.30	0.38	8.96	4.13	13.57
Diseased parts	13.39	4.45	0.37	7.82	4.06	12.29

[a] Composite sample of ten diseased ripe fruits.

DISEASE RESISTANCE

Individual pineapple plants thoroughly sprayed weekly during the blooming period with a water suspension of the pathogenic bacterium vary greatly in their ability to resist or withstand the disease; some seem to be specially predisposed to attack, others are relatively immune.

In the case of both native and introduced pinapples the opening of the "eyes," the relative thickness and early or delayed lignification of the covering of the eye cavity may play an important part in aiding or hindering the penetration of the bacteria. Native pineapples, in spite of their greater percentage of infection, due, perhaps in part, to loosely closed "eyes," sustain less damage from the attack. Comparative analyses[7] of these native varieties, as given in Table 9, show that their sugar content on the average is more than 2 per cent less than that of Smooth Cayenne (Tables 7, 9, and 10). They contain, however, more protein and acid. The chemical composition may, therefore, be one reason why the native fruits suffer less damage from the disease.

Another reason may be that the Smooth Cayenne pineapple is much more juicy than the native varieties; according to Smith (11, p. 12) juiciness in plants is one of the factors favoring bacterial infection. Size of fruits seems also to have an effect, since the heavier fruits are the more severely infected. This may be due to the larger fruits having the tissue-covering of their eye bowls usually less completely lignified, as shown by the mechanical cracks frequently found in them. Such imperfect lignification may be due perhaps to rapid growth of the host, enhanced by favorable conditions of climate and soil.

[7] In all analyses, unless otherwise stated, each sample consisted of twenty ripe fruits.

TABLE 9.—*Comparative analyses of native pineapple varieties from Silang, Cavite Province, and Guiguinto, Bulacan Province.*

Sample.	Brix of juice corrected to 27.5° C.	PH value.	Protein.	Sugars.		
				Sucrose.	Reducing.	Total as invert.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*
Pula [a]	12.71	3.90	0.48	7.01	3.11	10.49
Puti [b]	13.48	4.30	0.49	7.66	3.51	11.57
Costa [c]	10.87	3.80	0.50	6.08	3.19	9.59
Puti [d]	10.94	3.90	0.49	6.16	3.13	9.61
Average	12.00	3.97	0.49	6.72	3.23	10.32

[a] Cylindrical, reddish yellow, with small eyes.
[b] Barrel-shaped, greenish yellow, hard, with large eyes.
[c] Cylindrical, reddish yellow, with small eyes.
[d] Barrel-shaped, greenish purple, with large eyes.

In this connection, changes in chemical constitution during the growth of the fruits may throw some light on their behavior toward infection. Table 10 presents data on Smooth Cayenne fruits at four stages of development.

TABLE 10.—*Comparative analyses of Smooth Cayenne fruits at four stages of development.*

Sample.	Brix of juice corrected to 27.5° C.	PH value.	Protein.	Sugars.		
				Sucrose.	Reducing.	Total as invert.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct*
Immature [a]	7.21	4.24	0.52	1.25	2.55	3.85
Semimature [b]	7.32	3.89	0.40	3.06	2.55	5.79
Mature [c]	10.34	3.51	0.39	4.58	2.63	7.50
Ripe [d]	15.52	4.07	0.39	7.49	4.84	12.73

[a] Two months old (with an average diameter of about 9 centimeters).
[b] Three months old (with an average diameter of about 11 centimeters).
[c] Four and one-half months old (with an average diameter of about 14 centimeters).
[d] Five and one-half months old (with an average diameter of about 15 centimeters).

It will be noted from Table 10 that sugars, particularly sucrose (cane sugar), increase during the development of the fruit, and that in the immature stage the quantity present is comparatively small. On the other hand, protein diminishes in quantity as the fruit becomes maturer. Acid production of the fruit, as shown by the determinations of the citric acid equivalent, seems to be greater during the maturing stage, but the amount present does not appear sufficient to cause much change, if any, in the behavior of the pathogen.

Among other conditions that may render the fruit more or less liable to infection temperature may be considered. It is said that the pineapple grows better in a tropical climate than in a temperate one. The primuline yellow bacterium likewise grows more luxuriantly at a rather high temperature, 30° to 35° C. being its optimum.

In order to compare the internal temperature of the pineapple fruit with the surrounding atmosphere (both exposed and shaded) and with the soil at different times of day at Calauan and Silang a mercury thermometer was thrust 15 centimeters into the middle of a maturing pineapple fruit, another was suspended nearby in the air about 75 centimeters above the soil, a third was inserted to a depth of 15 centimeters in the soil, and a fourth self-recording hygrothermograph was placed under a shed with free circulation of air. Readings were made every two hours from 6 a. m. to 6 p. m. at both places over an interval of ninety days. The corrected computations are plotted in text fig. 1.

From these graphs it will be seen that the temperature in the pineapple fruit is practically the same as that of the atmosphere exposed to the sun; in the shade it is lower. The soil temperature is the lowest, and also the most uniform.

It is said that in 1926 the disease was severe in all the provinces of Luzon where the Smooth Cayenne variety is grown. The relative high temperatures that prevailed during the summer months of that year as reported for Manila by Rev. Miguel Selga, director of the Philippine Weather Bureau, may perhaps account for the serious outbreak.

SURVIVAL AND DISSEMINATION OF THE PATHOGEN

The pathogen can perhaps persist in the soil from the end of the picking season to the succeeding blooming season (August to January), and then live as a parasite in the fruits from February, when most of the plants begin to bloom, to July, when the picking season ends.

Diseased fruits, which are abandoned to rot in the field, may assist the pathogen in living over and are certainly a great source of infection. Slips, suckers, and crowns obtained from diseased fields may also possibly spread the disease to new fields if not given proper treatment to destroy the organisms.

The pathogen may also be disseminated by wind, dashing rain, and insects. It was found that the pathogen was present in the air and the soil in the plantation at Calauan. This was de-

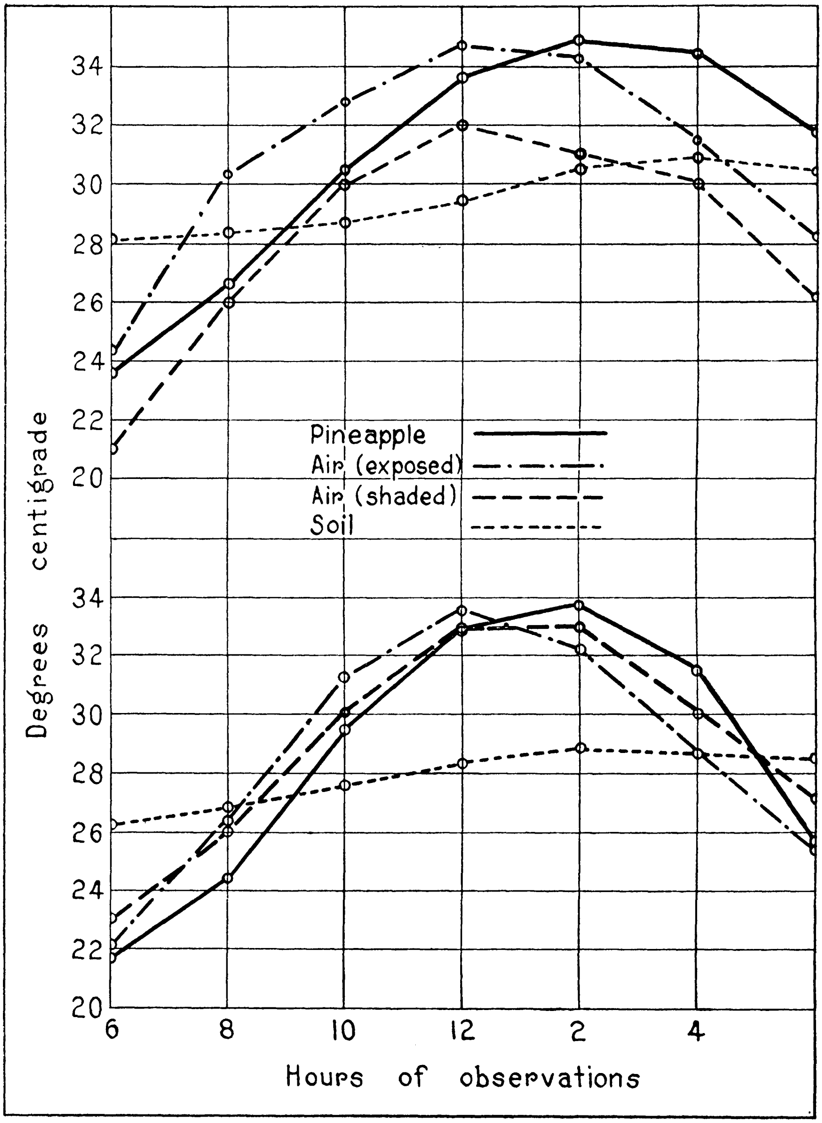


FIG. 1. Temperature studies. Graphs representing temperature relations (from 6 a. m. to 6 p. m.) between the pineapple, the soil, and the environment in correlation with the prevalence of the disease. Upper graph from data collected in Calauan, Laguna Province; lower graph from Silang, Cavite Province.

termined by exposing several agar plates for an hour among pineapple plants in bloom. A water infusion of several samples of surface soil obtained near the bases of the pineapple plants also yielded the organism. It was found also that red mites, mealy bugs, thrips, and ants, which are sometimes found in the crevices of the fruit, especially in the eye cavities, usually carry the pathogen, together with several other microorganisms, on their feet. There is, therefore, a possibility that the germ may be introduced into the plant by any one of these means. Again, the injuries they cause to the eye bowls and other parts of the flower will naturally help to facilitate infection by the causal bacterium as well as by other secondary organisms that might also be present at the time.

Experiments looking toward the control of the disease are under way.

SUMMARY

1. A bacterial fruitlet brown-rot disease of the pineapple hitherto unreported from the Philippines is described. The disease is not as serious on the native varieties as on the Smooth Cayenne. It is more or less generally distributed in Bataan, Bulacan, Cavite, Laguna, and Pangasinan Provinces, Luzon.

2. The disease is very difficult to diagnose without cutting the fruit. Slight to moderate infections cannot be detected externally. Severe infections, however, show a distinct dull ripening color generally marked with minute purplish black dots. Such fruits appear to be extraordinarily hard.

The disease may be characterized by the brown, dusky brown, or bone brown discoloration of one or more of the fruitlets. Such discolorations may be limited to the placental area or may involve the entire fruitlet; occasionally they extend to the fibrovascular bundles of the core, a characteristic which appears to be invariably associated with the hardened condition of severely diseased fruits. In this type of infection dryness of the tissues is also apparent. All infected tissues are found more or less filled with bacterial masses.

3. The average percentage of infected fruit from Calauan, Abukay, Silang, and Guiguinto was 42.4. Smooth Cayenne fruits from Calauan alone had as high as 54.4 per cent, slightly less than one-third (17 per cent) being a total loss.

4. The disease can be reproduced by artificial infection with a primuline yellow bacterium, designated *Erwinia ananas* sp. nov., with or without previous injury to the fruits.

5. The fruits are susceptible to natural infection only during the blooming stage. The pathogen penetrates through the floral parts and through mechanical cracks or fissurelike slits in the eye cavity. Owing to lack of sufficient food during the

immature stage of the fruit, the bacterial parasite remains more or less inactive before maturity. As the fruits begin to ripen, however, the disease becomes manifest by the discoloration of the invaded tissues.

6. Since the pathogen lives mainly on sugar, although using up some acid and protein, diseased fruits contain relatively less of these substances than healthy ones.

7. Warm weather favors severe infection. The rapid succulent growth of large fruits apparently increases their susceptibility to attack.

8. The pathogen can produce red streaks in sugar cane when inoculated through needle puncture. There is a possibility, therefore, that sugar cane may harbor the disease when favorable conditions obtain.

9. The disease may be spread by wind and dashing rain, by infected fruits, crowns, slips, and suckers from diseased plantations, as well as by red mites, mealy bugs, thrips, and other insects that flit from plant to plant.

10. The red mites are not in any way associated with the production of the disease except perhaps in the dissemination and penetration of the pathogen.

The causal organism, *Erwinia ananas* sp. nov. is described as a short rod, with more or less rounded ends; occurring singly and in pairs, but occasionally in chains; motile by means of peritrichous flagella; nonspore-forming; Gram-negative; facultative anaërobe; variable, and producing abundant yellow growth on natural as well as artificial culture media, but with preference for sugar. Numerous physiological reactions are described.

LITERATURE CITED

1. BARKER, H. D. Fruitlet black rot disease of pineapple. Phytopathology 16 (1926) 359–363.
2. BERGEY, D. H., and others. Bergey's Manual of Determinative Bacteriology (1923).
3. BERGEY, D. H. Bergey's Manual of Determinative Bacteriology, 2d ed. (1925).
4. BURKE, VICTOR. Notes on the Gram stain with description of a new method. Journ. Bact. 7 (1922) 159–182.
5. EYRE, J. W. H. The Elements of Bacteriological Technique, 2d ed. (1920).
6. JORDAN, E. O. A Text Book of General Bacteriology, 6th ed. (1920).
7. MIGULA, W. System der Bakterien 1 (1897).
8. PARK, H. P., and A. W. WILLIAMS. Pathogenic Microorganisms, 8th ed. (1924).

9. PLIMMER, H. G., and S. G. PAINE. A new method for the staining of bacterial flagella. Journ. Path. and Bact. Edinb. 4 (1921) 286–288.

10. SMITH, E. F. Bacteria in Relation to Plant Diseases, vol. 1. Publ. Carnegie Inst. Washington No. 27 (1905).

11. SMITH, E. F. Bacterial Diseases of Plants (1920).

12. STITT, E. R. Practical Bacteriology, Blood Work, and Animal Parasitology, 7th ed. (1923).

13. TRYON, H. Fruitlet core-rot of pineapple. Queensland Agr. Journ. (December, 1898).

ILLUSTRATIONS

PLATE 1

A healthy looking, 4-kilogram Smooth Cayenne fruit, showing severe infection within. About $\frac{1}{3}$ natural size.

PLATE 2

FIG. 1. An unhealthy looking, 4-kilogram, Smooth Cayenne fruit with dull, uneven ripening color, sparingly dotted with purplish spots, and with an extraordinarily hard consistence. More than 0.5 natural size.

2. Longitudinal section showing a more or less thorough infection and with discoloration extending into the vascular bundles of the core. More than 0.5 natural size.

PLATE 3

Erwinia ananas sp. nov., plate cultures showing colonies of different ages.

FIG. 1. Colonies 24 hours old with straw yellow color. $\times$ 5.

2. Colony 24 hours old showing "mottled" primuline yellow color. The bacterial mass ran down when the plate was held in a vertical position for photomicrographing. $\times$ 40.

3. Colonies 3 days old, some umbilicate and some convex, with primuline yellow center and straw yellow margins. $\times$ 1.

4. Colonies 5 days old with primuline yellow center and butyrous concentric ring. Note the small elliptical to fusiform deep colonies. About $1\frac{1}{3}$ natural size.

5. A 15-day-old colony photographed from below to show characteristic markings and crenate margins. About 7 times natural size.

6. *Erwinia ananas*, agar plate culture, 4 days old, exposed on ice to direct noon sunlight (June 29, 1926) for five hours, with the lower half covered with black paper. Note that practically all of the exposed colonies were killed and most of those that survived were at the bottom of the plate and partially protected by a layer of agar. Taken four days after. About $\frac{2}{3}$ natural size. All cultures exposed for less time showed practically no effect.

PLATE 4

Erwinia ananas, agar plate cultures, showing degeneration and variation.

FIG. 1. Subculture 6 days old taken from 15-day agar slant, showing two branching colonies such as were occasionally observed. About natural size.

FIG. 2. Subculture 6 days old taken from 1-year agar slant, showing colonies of varied form and color (primuline yellow, straw yellow, olive yellow, sulphine yellow, ivory yellow, pale olive buff, olive gray, etc.). About natural size.

3. Subculture 3 days old taken from colony "x" of fig. 2, showing minute, uniform, pale olive buff, conical, more or less rugose colonies with crenate margins. About natural size.

4. Same as fig. 3 but enlarged and photomicrographed from below to show characteristic markings. About 30 diameters.

5. Culture 5 days old of a pearl gray to puritan gray strain supposedly mutant. Note light-colored concentric ring similar to that of the primuline yellow bacterium, and the elliptical to fusiform deep colonies. The bacterial mass ran down the surface when the plate was vertically placed for photomicrographing. Characteristic "mottling" is also visible. About natural size.

PLATE 5

Longitudinal section of Smooth Cayenne fruit with six positive needle-puncture inoculations with *Erwinia ananas* in *a* and six negative needle punctures (check) in *b*. Note characteristic discolorations in *a* and healthiness in *b*. About $\frac{2}{3}$ natural size.

PLATE 6

Longitudinal section of Smooth Cayenne fruit with six positive needle-puncture inoculations with *Penicillium* sp. in *a* and six negative needle punctures (check) in *b*. The discolorations in *a* are not characteristic of the bacterial disease; the cavities are filled with mycelial threads of this organism, which is not the case with typically diseased fruits. About $\frac{2}{3}$ natural size.

PLATE 7

FIG. 1. Cross section of four eye bowls showing mechanical cracks (indicated by the arrows) through which the pathogen and other secondary organisms may enter the fruit. Only one shows such cracks although all are diseased, as shown in fig. 2. The infection in this case must have passed through either the floral parts or ruptures at some point along the fissurelike slits connecting the eye cavity with the placental region.

2. Longitudinal section of four eyes.

3. Four fruitlets showing mixed infection with bacteria and molds. The course of penetration is traceable through the fissurelike slits and mechanical cracks. About natural size.

4. Two fruitlets showing early and old infections, the former passing through the rupture along the fissurelike slit (shown by the arrow), and the latter apparently through the floral parts. About twice natural size.

5. Infected fruitlets showing the characteristic nonspreading behavior of the rot, with fuscous black coloration. About 1.5 natural size.

PLATE 8

Four Smooth Cayenne fruits at the blooming stages most critical for infection.

FIG. 1. With five or six flowers at the base just beginning to open (about 4 weeks old).

2. With all the flowers of the basal half of the fruit opened (about 5 weeks old).

3. With flowers at the base drying and those at the middle just opening (about 6 weeks old).

4. With all the flowers dried except a few at the topmost part (about 7 weeks old). Blooming is generally over at the age of 2 months.

PLATE 9

FIG. 1. Longitudinal section of an infected fruitlet showing course of bacterial penetration as indicated by the arrows. At *1* is the base of the style from which two lines of infection, as at *2* and *3*, originate; at *4* is one of the three fissurelike slits leading into the placental regions along which is shown a rupture at *5*. Through this rupture infection may also take place. × 43.

2. Highly magnified section of *3* showing penetration of bacteria from cell to cell. × 1400.

PLATE 10

FIG. 1. Diagramatic illustration of a pineapple flower in cross section. At *a* is represented the whorl of bracts covering the eye cavity *b;* at *c* one of the three anthers; at *d* one of the three stamens; at *e* one of the three double petals; at *f* the triple style; at *g* the triple stigma; and at *h* one of the three fissurelike slits that lead into the placental cavity.

2. Photomicrograph of a cross section of the eye cavity, showing the seemingly impenetrable thickness of lignified external covering which protects the fruitlet from external factors. × 80.

PLATE 11

FIG. 1. Photomicrograph of a cross section of a fruitlet just below the eye cavity, showing the three eye slits leading down to the placental cavity. Note thickness of lignified external covering. × 43.

2. Same as fig. 1 but just below it and at the midsection, showing line of connection (*1–2–3*) between the triple style and the ovaries. × 80.

PLATE 12

FIG. 1. Cross section of an eye slit below the midsection, showing rupture at one end. Note discoloration due to infection. × 142.

2. As in fig. 1 but without visible rupture. × 142.

PLATE 13

FIG. 1. As in Plate 12, fig. 2 (*1–2–3*), highly magnified, showing bacterial masses in clumps, especially along the cell walls, × 1100.

FIG. 2. As in fig. 1 but with ruptured cells forming a cavity *x*. Note short bacterial filaments. × 1100.

PLATE 14

FIG. 1. Thin placental covering of diseased fruitlet, showing presence of bacterial masses in clumps in all the cells. × 1100.

2. Photomicrograph of a longitudinal section of a discolored vascular bundle at the core, showing masses of the bacteria in one of the pitted vessels at the center of the picture. All other tubes in top and bottom were apparently free. × 1100.

PLATE 15

FIG. 1. Sugar cane (Luzon Purple) inoculated by needle puncture with *Erwinia ananas*. Note red streaks and radial discoloration. The red streaks extending to the two adjacent internodes are not visible in the photograph.

2. Guru shows practically the same reaction as Luzon Purple.

3. Negros Purple shows practically the same reaction as Guru and Luzon Purple. Figs. 1, 2, and 3 are about natural size.

4. Photomicrograph of a longitudinal section of a discolored vascular bundle in the adjacent internodes, showing masses of the bacteria in one of the bundle-sheath cells at the center of the picture. All cells on left and right were apparently not infected. × 1100.

PLATE 16

Portion of a pineapple field at Calauan, Laguna Province, Luzon.

PLATE 17

FIG. 1. *Erwinia ananas* sp. nov., smear preparation from 20-hour-old culture, stained with gentian violet. × 1700.

2. Same as fig. 1, but showing bipolar staining with Verhoeff's carbol fuchsin. × 2000.

3. Same as fig. 1, but stained by Welch's (6) method to show presence of capsule. × 2000.

4. Same as fig. 1, but 4 days old. Stained with Verhoeff's carbol fuchsin, showing unstained areas usually on two poles. Most of the bacteria are in pairs. × 2000.

5. Same as fig. 1, but stained by van Ermengem's (6) method to show flagella. × 1550.

6. Same as fig. 5, but more highly magnified. × 4000. Note peritrichous flagella shown in both preparations.

7. Same as fig. 1, but stained by Plimmer's (10) method to show flagella. This confirms the evidence of figs. 5 and 6 that the pathogen is a peritricheate bacterium. × 3400.

PLATE 18

Fig. 1. *Erwinia ananas* sp. nov., smear preparation from 3-day-old slant culture, showing zoöglœalike formation at some point along the streak. Stained by Welch's (6) method. Note covering of mucuslike matrix on most of the bacterial cells. × 2000.

FIG. 2. *Erwinia ananas* sp. nov. smear preparation from 3-day-old slant culture, showing patches of mineral gray to tea green color at some point of the streak instead of zoöglœalike matrix. Note variation in size and form of the rods, suggestive of degeneration. × 2000.

PLATE 19

FIG. 1. *Erwinia ananas* sp nov., smear preparation from 4-day-old slant culture. Note elongated rods and irregular staining with Verhoeff's carbol fuchsin. × 2000.

2. *Erwinia ananas* sp. nov., smear preparation from 3-day-old slant culture. Note long filaments with irregular staining with Verhoeff's carbol fuchsin, and the more or less deformed rods. × 2000.

TEXT FIGURE

FIG. 1. Temperature studies. Graphs representing temperature relations (from 6 a. m. to 6 p. m.) between the pineapple, the soil, and the enviroment in correlation with the prevalence of the disease. Upper graph from data collected in Calauan, Laguna Province; lower graph, from Silang, Cavite Province.

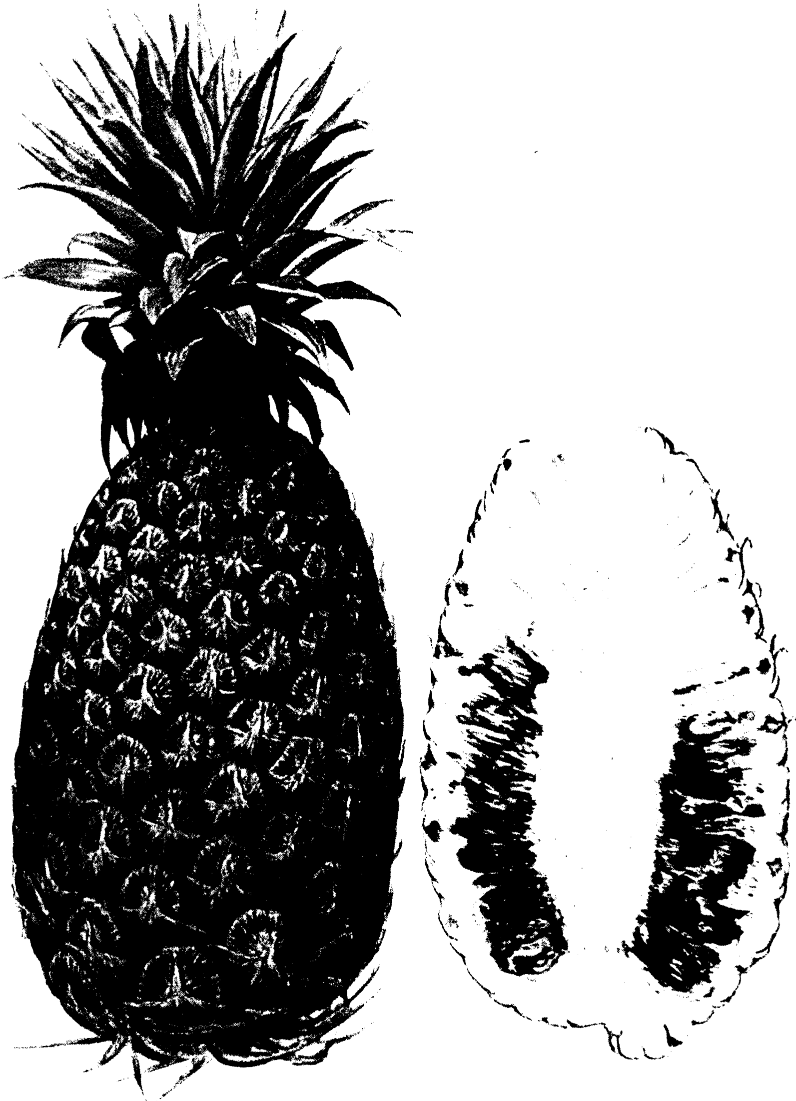
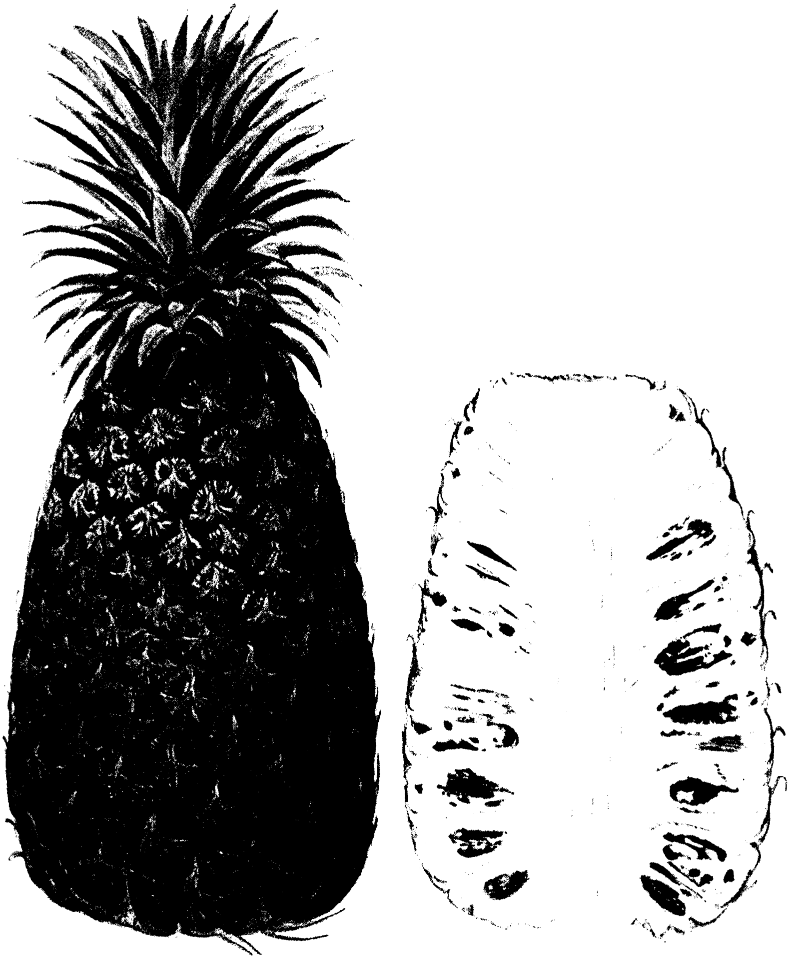


PLATE 1.



1 2

PLATE 2.

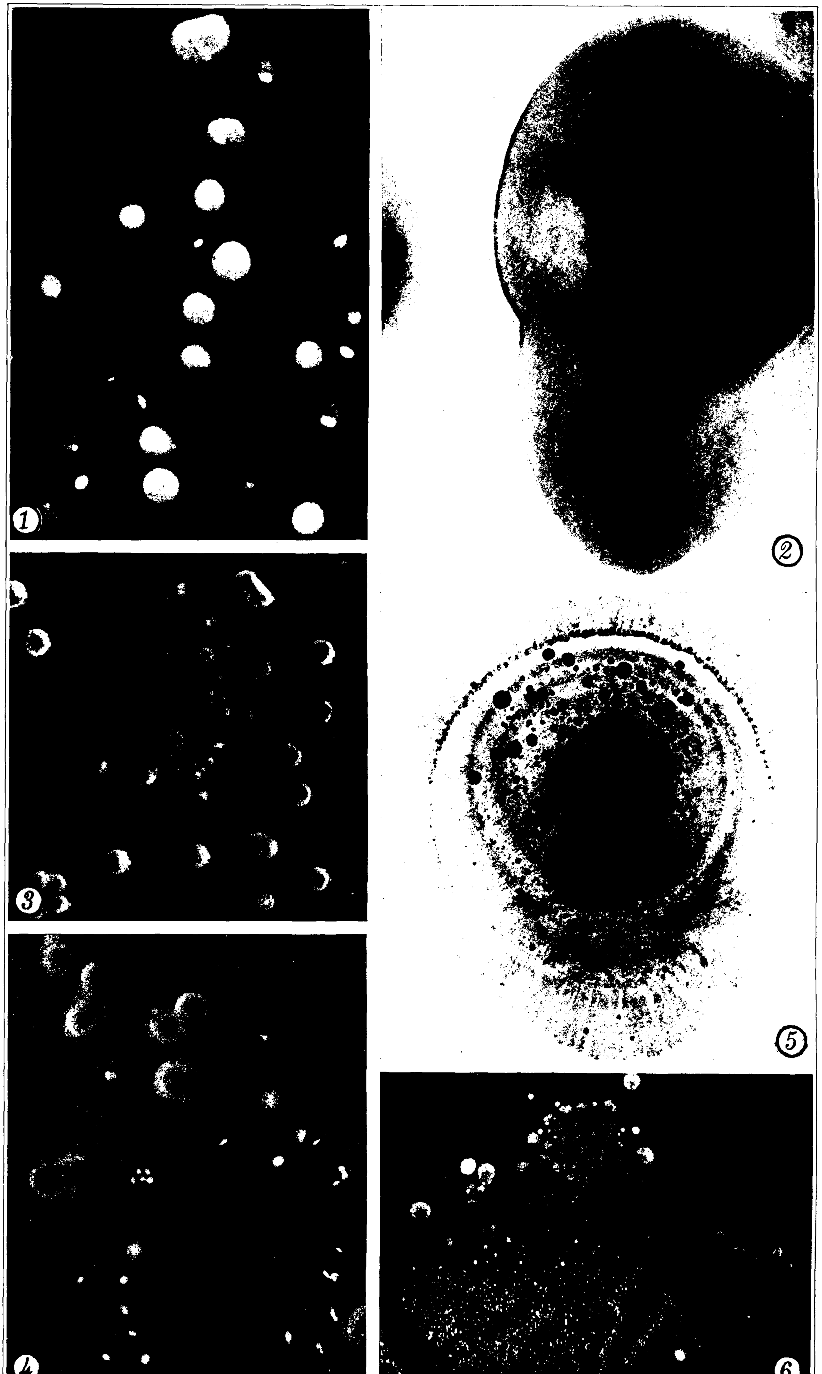


PLATE 3.

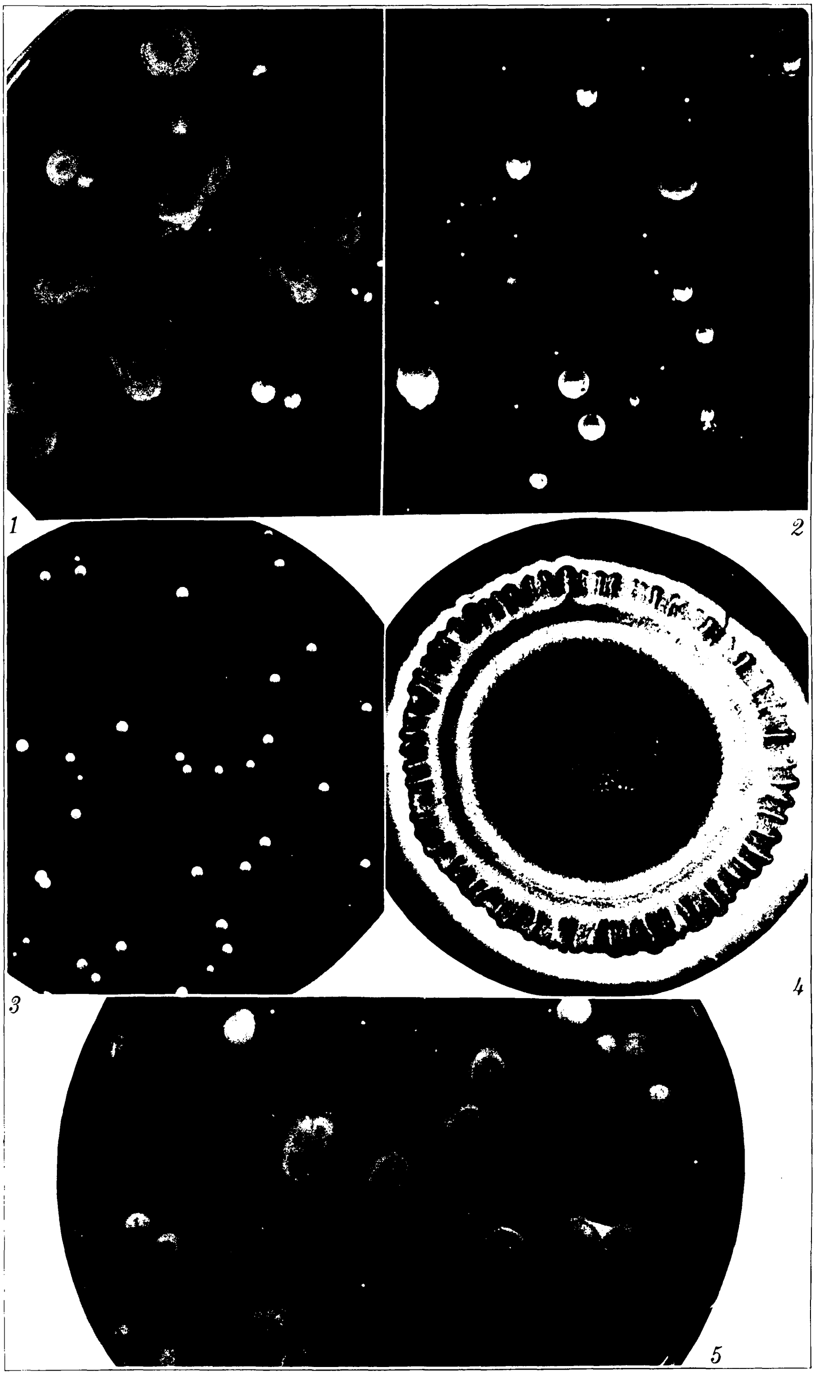
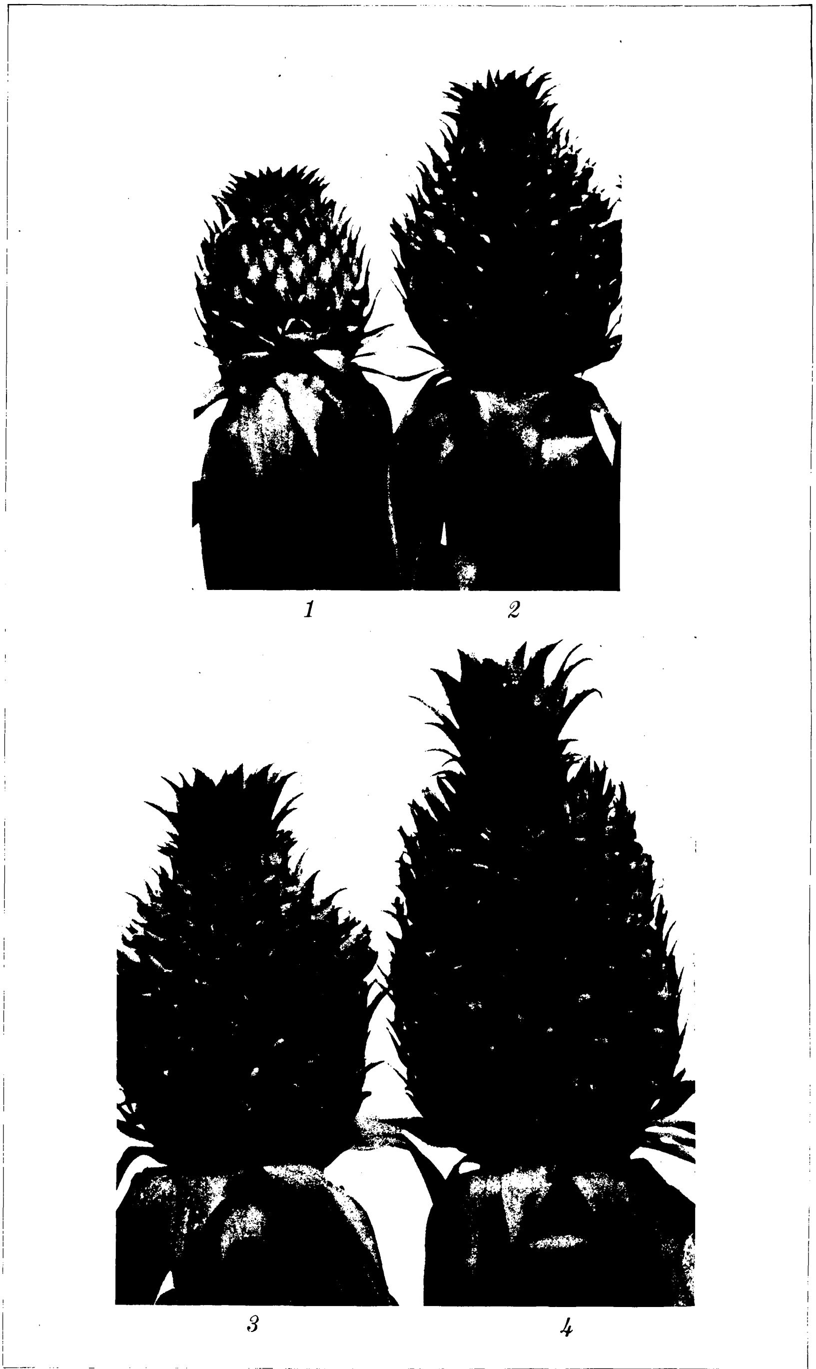


PLATE 4.

PLATE 5.

PLATE 6.

PLATE 7.



1 2

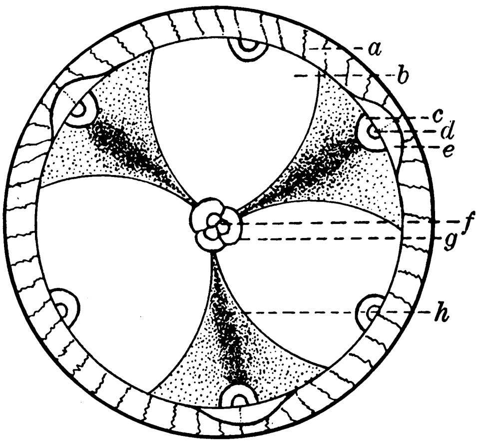
3 4

PLATE 8.

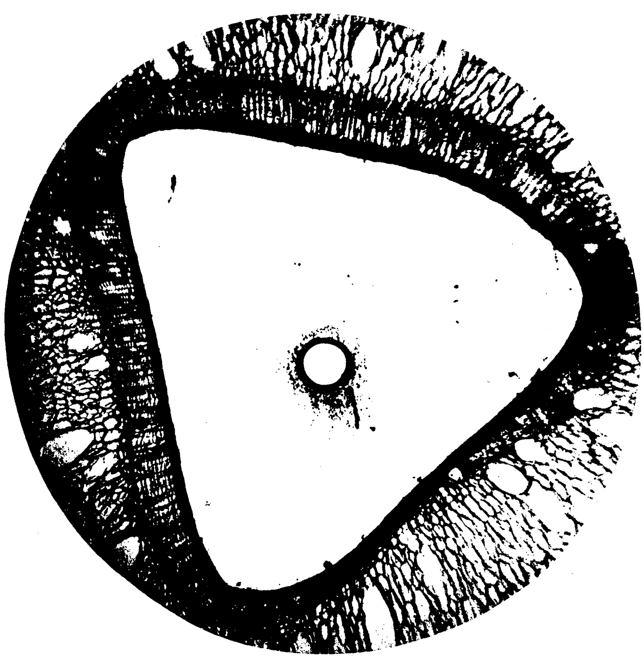
1

2

PLATE 9.



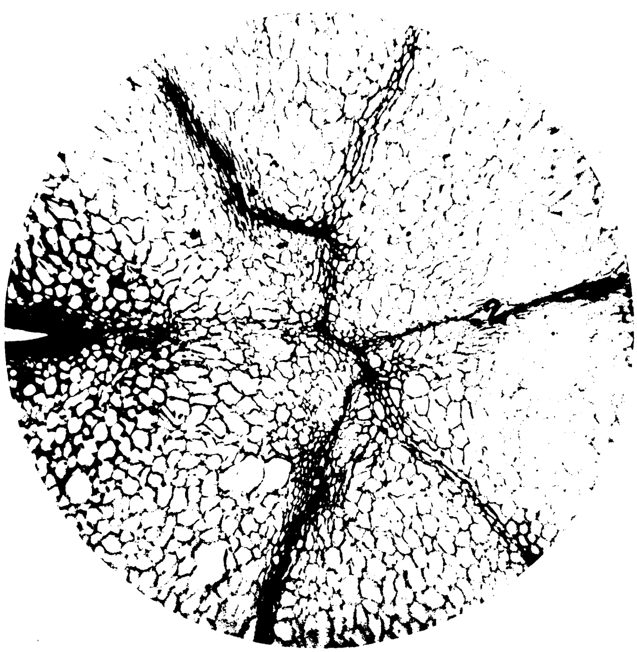
1



2

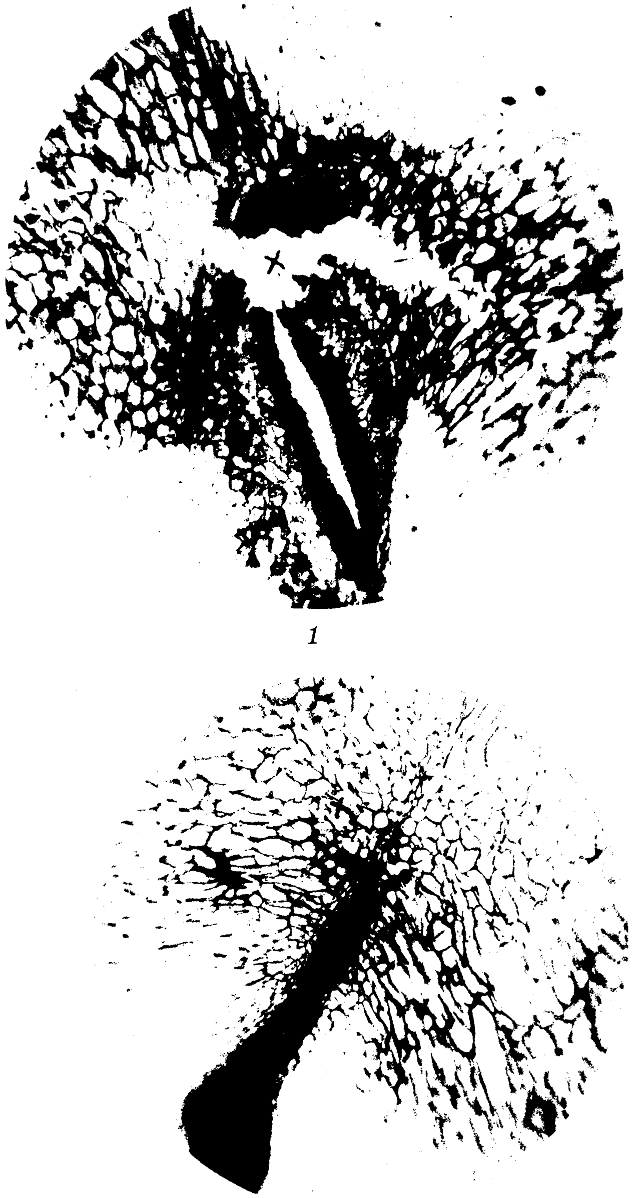
PLATE 10.

1



2

PLATE 11.



1

2

PLATE 12.

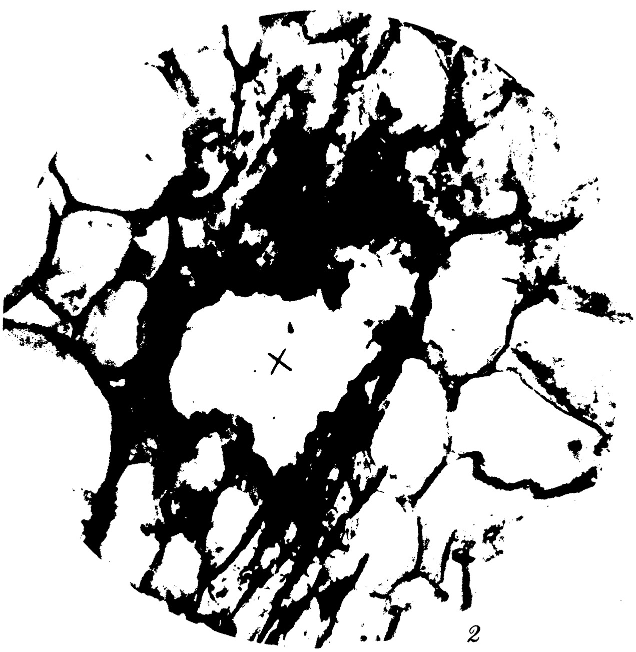
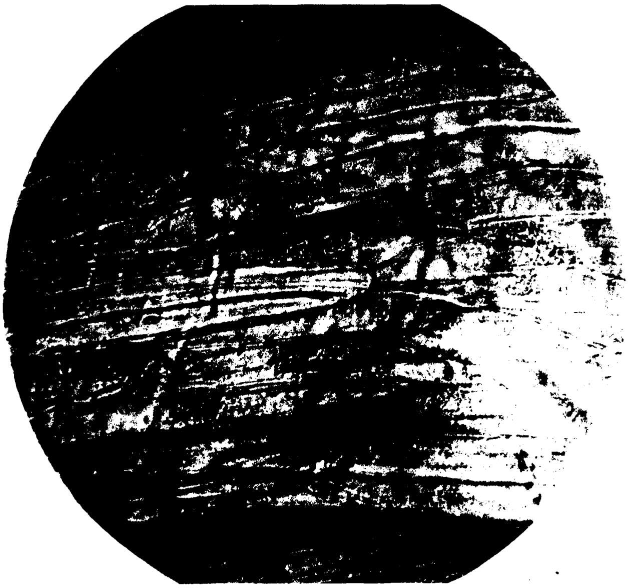
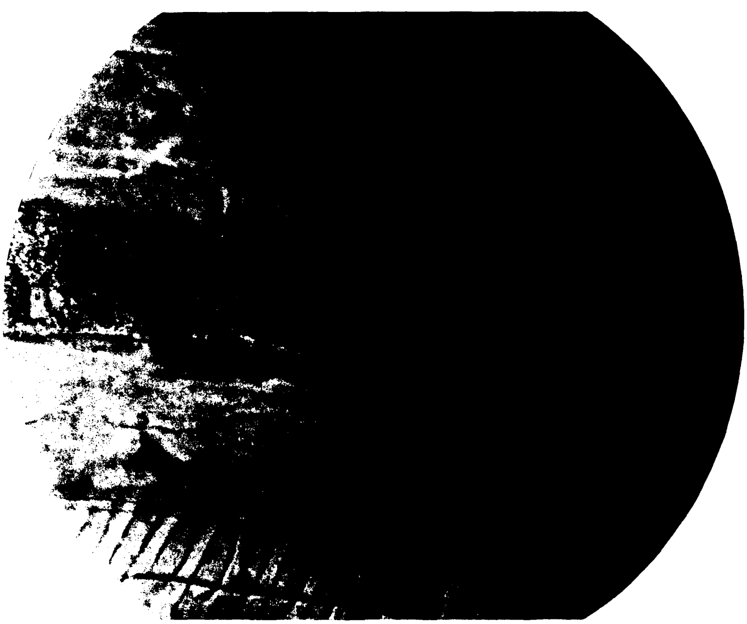


PLATE 13.

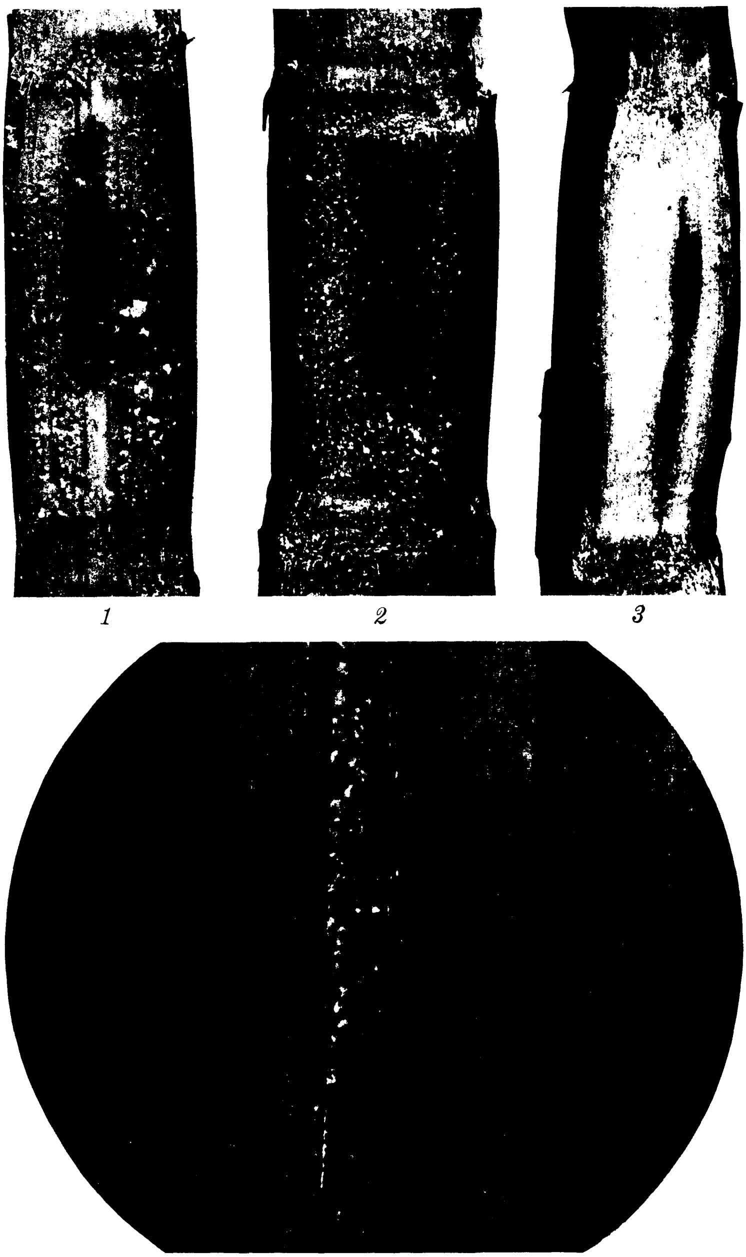


1



2

PLATE 14.



1 2 3 4

PLATE 15.

PLATE 16.

PLATE 17.

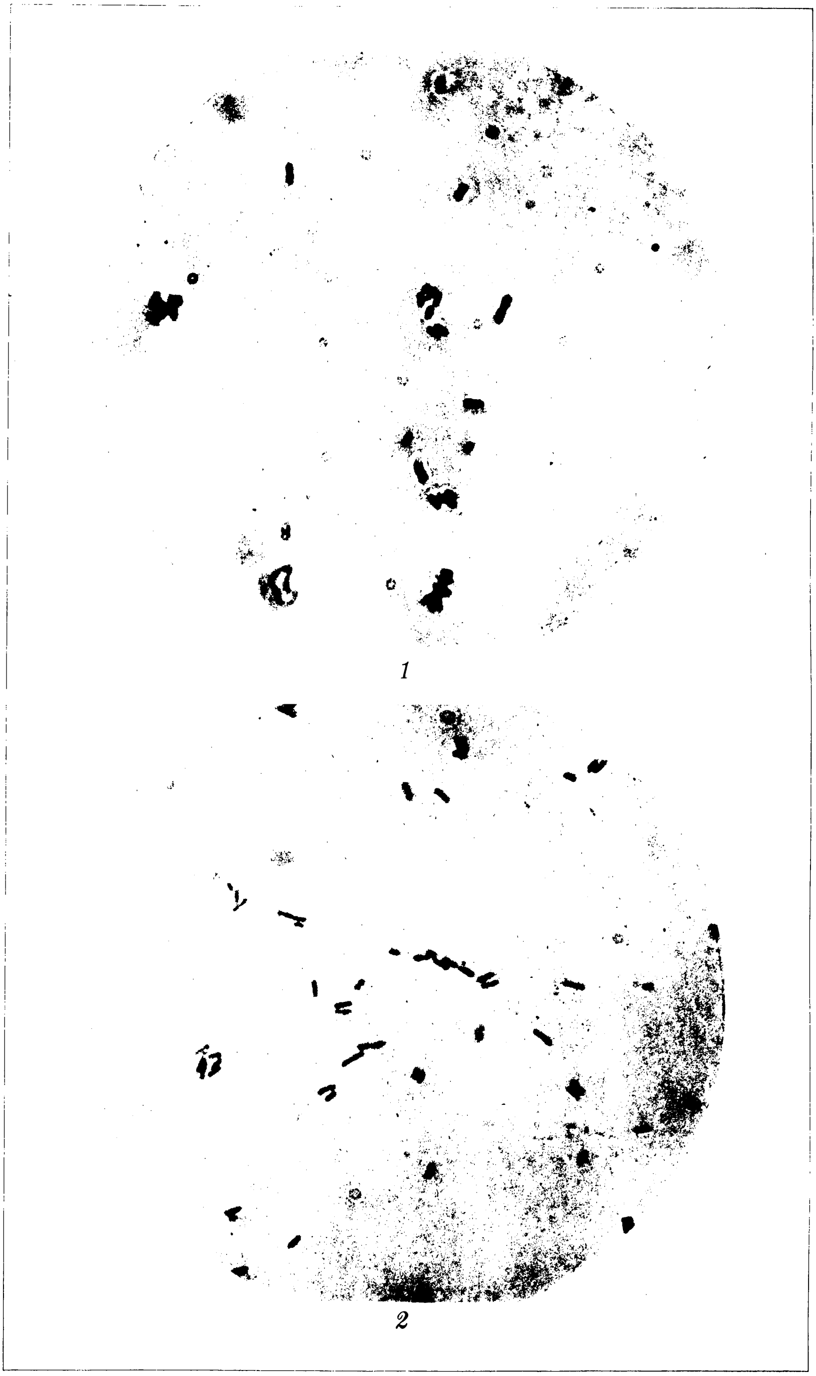
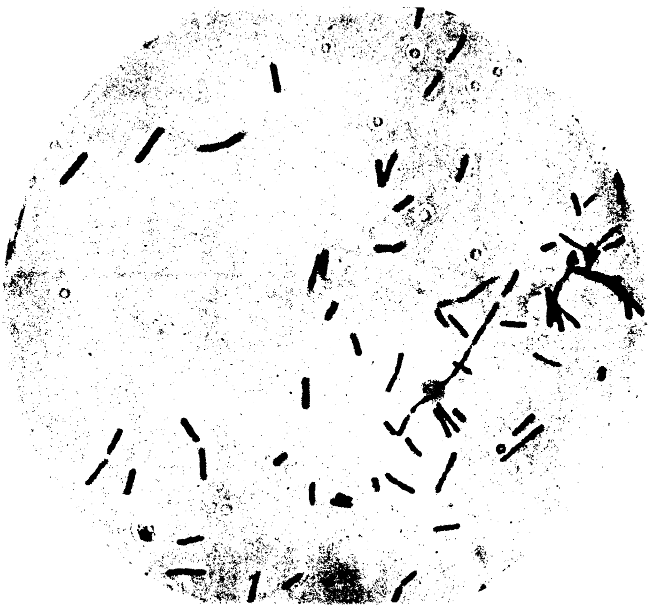


PLATE 18.



1

2

PLATE 19.

REVISION OF THE PHILIPPINE SPECIES OF THE CLYTINI (COLEOPTERA, LONGICORNIA)

By CHR. AURIVILLIUS

Of the Riksmuseum, Stockholm, Sweden

ONE PLATE

The main part of the material used for the compilation of this revision was received from Mr. C. F. Baker, Los Baños, Luzon. Other specimens were collected by G. Boettcher and are now deposited in the Riksmuseum, Stockholm.

Eight genera are represented in the Philippine fauna. They may be easily separated by the characters given in the following synopsis (essentially after Gahan [1]).

Key to the Philippine genera of Clytini.

a^1. Antennæ widely separated at base; the head between them not at all raised (front and vertex without limit passing in each other) or only slightly raised at the sides.

- b^1. Head carinate in front. Prothorax not or only slightly asperate. *Xylotrechus* Chevrolat.
- b^2. Head not at all carinate in front. Forehead broad. Prothorax strongly asperate above the middle.................... *Perissus* Chevrolat.

a^2. Antennæ not widely separated at the base; head between them with two subapproximate divergent elevations.

- b^1. First joint of hind tarsi much longer than second and third united.
  - c^1. Antennæ not spined.
    - d^1. Antennæ with the third joint not or hardly longer than first. *Chlorophorus* Chevrolat.
    - d^2. Antennæ with the third joint distinctly longer than first. Elytra long and narrow. Episterna of metathorax with straight inner margin .... *Rhaphuma* Pascoe.
  - c^2. Antennæ spined at least at apex of third joint.
    - d^1. Third joint only spined at apex; this joint not longer than fourth. *Psilomerus* Chevrolat.
    - d^2. Third and fourth joints spined at apex; third joint longer than fourth. Fifth and sixth joints also sometimes with a short spine.. *Demonax* Thompson.
- b^2. First joint of hind tarsi very little or not longer than the following joints united. Elytra with the shoulders not carinate. Third and fourth joints of the antennæ with short apical spine. *Oligoenoplus* Chevrolat.

[1] Fauna Brit. India Coleoptera 1 (1906) 240.

Genus XYLOTRECHUS Chevrolat

All the species known from the Philippine Islands belong to the division with noncarinate femora. The subgenus *Xylotrechus* (type *X. pulcher* Aurivillius) has the middle femora only and the subgenus *Dendrotrichus* (type *X. decoratus* Pascoe) both the middle and the hind femora carinate.

Key to the species of Xylotrechus Chevrolat.

a[1]. Eyes large, extended on the front. The face contracted in the middle between the eyes or at least very narrow. The front in the middle with two very distinct carinæ, which converge downward and unite so as to form a single median carina on the lower part of the face. Markings yellowish or grayish. Elytra each with five markings. Prothorax above with black markings.
  b[1]. Elytra without humeral stripe, but behind the shoulders with a transverse, externally angulate, free spot or short fascia. Prothorax above with two large black spots and a median black stripe, which often are united to a crosslike marking.......... *X. phidias* Newman.
  b[2]. Elytra with a humeral stripe, directed obliquely against the suture but not reaching the second transverse band.
X. antennarius Heller.
a[2]. Eyes smaller. Front broader with one to three very fine lines.
  b[1]. Front broad and flat with three very fine parallel lines.
    c[1]. Elytra with large cinereous humeral spot....*X. humeralis* sp. nov.
    c[2]. Elytra without humeral spot................ *X. mindanaonis* sp. nov.
  b[2]. Front with a median furrow including a single obsolete carina.
X. luzonicus sp. nov.

XYLOTRECHUS PHIDIAS Newman.

Clytus phidias NEWMAN, Entomologist 1 (1842) 246.
Xylotrechus phidias WATERHOUSE, Proc. Ent. Soc. London (1874) 27.
Xylotrechus phidias AURIVILLIUS, Ent. Tidskr. 14 (1898) 163.

PALAWAN. LUZON. MINDANAO.

XYLOTRECHUS ANTENNARIUS Heller.

Xylotrechus antennarius HELLER, Tijdschr. v. Ent. 69 (1926) 24, pl. 5, fig. 17.

MINDANAO.

I do not see how this species may be differentiated from *X. pedestris* Pascoe from Borneo.

XYLOTRECHUS HUMERALIS sp. nov. Plate 1, fig. 1.

Femora haud carinata. Elytra apice omnino rotundata inermia. Frons aequilata, lineis tribus tenuibus instructa. Tarsorum posticoram articulus basalis reliquis simul sumtis parum longior. Prothorax elytris haud vel vix angustior. Articuli 9–11 aut 8–11 antennarum pallidi, albicantes. Fusco-niger, cinereo-pubescens elytris signaturis cinereo-tomentosis ornatis.

Vertex discrete punctatus. Prothorax elongatus, latitudine basali multo longior, ellipsoideus vel subcylindricus, supra longitudinaliter convexus, lateribus leviter arcuatis, punctatus punctis pube fere obtectis, unicolor cinereus vel fascia transversa fusca obsoleta instructus. Scutellum albidum. Elytra subnuda, nigra, plaga magna diffusa humerali, ante medium fascia lineari oblique a margine versus suturam et ad suturam usque ad scutellum adscendente, plaga communi pone medium antice ad suturan basin versus plus minusve producta apiceque cinereo-tomentosis ornata. Corpus infra cinereum, episternis meso- et metathoracis nee non later abdominis albis aut albidis. Long. corporis 5–10 mm.

SAMAR. NEGROS, Cuernos Mountains (*C. F. Baker*). Collectio Baker, Riksmuseum, Stockholm.

Nearly allied to *X. mindanaonis* sp. nov., but differing by the great humeral spot on the elytra.

XYLOTRECHUS MINDANAONIS sp. nov.

Frons aequilata, plana, lineis tribus tenuibus elevatis instructa. Femora haud carinata. Niger, ex parte cinereo-pubescens. Caput et prothorax dense cinereo-pubescentia; pronotum fascia lata transversa denudata nigricante ornatum et interdum fere ad basin nigricans, logitudinaliter convexum, elytris vix angustius. Scutellum album. Elytra subnitida, fere nuda, nigra, minute punctulata, fasciis maculisque cinereo-tomentosis ornata; fascia angusta basali interdum utrinque dilatata, ad humeros fere extensa, fascia obliqua lineari ante medium juxta suturam usque ad scutellum extensa, plaga communi trigona pone medium ad suturam antrorsum acuminata fasciaque transversa apicali. Antennae breves, medium elytrorum attingentes articulis tribus ultimis pallidis. Latera metasterni et segmenta duo basalia abdominis dense albo-hirsuta. Long. corporis 6–7 mm.

MINDANAO, Surigao, Kolambugan (*C. F. Baker*). Collectio Baker, Riksmuseum, Stockholm.

Nearly allied to *X affinis* Gahan, but differing in basal and apical markings of the elytra.

XYLOTRECHUS LUZONICUS sp. nov. Plate 1, fig. 2.

Femora haud carinata. Frons aequilata, latitudine altior, in medio sulcata et obsolete unicarinata. Nigricans, cinereo-pubescens, signaturis albido-tomentosis ornatus, praesertim in pedibus erecte pilosus. Antennae breves, articulo 8° humeras attigentes, ante medium fuscescentes, articulis 6–11 dense albido-pubescentes; scapus articulo 3° brevior. Prothorax elongatus, pone medium latior, sat nude punctulatus, cinerascente hirsutus maculis tribus rotundatis nigris denudatis, una basali, singula utrinque discali, in medio obsolete carinatus. Scutellum albido-hirsutum, late rotundatum. Elytra denudata, nigra, apice late rotundata, inermia, dense punctulata, ad basin parum diffuse cinereo-hirta, fasciis binis maculaque apicali cinereo-albidis ornata; fascia prima ante medium leviter curvata ad suturam basin versus producta, scutellum tamen haud attingente, fascia secunda paullo pone medium transvera lineari ad suturam longe producta, angulum subrectum formante. Latera pectoris abdominisque dense albido-hirsuta. Femora postica apicem abdominis parum superantia. Articulus basalis tarsorum posticorum compressus, reliquis simul sumtis parum vel vix longior. Long. corporis 10–12 mm.

LUZON, Mount Banahao. Riksmuseum, Stockholm.

Genus PERISSUS Chevrolat

The species of this genus are nearly allied to the species of *Xylotrechus,* but always easily known by the very broad forehead, entirely smooth without carinæ, the strongly asperate prothorax, and the spined outer apical angle of the elytra. The basal joint of the hind tarsi much longer than the other three taken together.

Only one somewhat variable species hitherto known from the Philippine Islands.

PERISSUS SCUTELLATUS Chevrolat.

Perissus scutellatus CHEVROLAT, Mém. Soc. Sc. Liége **18** (1863) 267 (sep. 15).

The elytra have nearly the same cinereous marking as in *Xylotrechus humeralis,* but the first fascia does not reach the scutellum. Prothorax usually with two black spots. Length, 7 to 13 millimeters.

Male.—Hind femora extending past the apex of the elytra. Antennæ longer, reaching past the second fascia of the elytra.

Female.—Hind femora hardly reaching past the elytra. Antennæ shorter, not reaching past the second fascia of the elytra.

PALAWAN. LUZON. SAMAR. NEGROS. SIBUYAN. MINDANAO.

Genus CHLOROPHORUS Chevrolat

(*Caloclytus* Gahan)

The type of this genus is the well-known *Clytus annularis* Fabricius. The species are easily recognized by the narrow head between the antennæ, the front being distinctly separated from the vertex by an elevation between the antennæ. Antennæ unarmed. The middle femora are, in all the Philippine species, furnished with a fine carina along each side.

Key to the species of Chlorophorus Chevrolat.

a^1. Covered above with yellow or yellowish pubescence and varied with black or blackish markings. Elytra with four pale fasciæ, the first basal or at least represented by a humeral spot.
  b^1. Hind femora not carinate. Pronotum with a median posteriorly bifurcated black spot .... *C. annularis* Fabricius.
  b^2. Hind femora carinate. Pronotum with a median, posteriorly somewhat enlarged black line, reaching neither the base nor the apex. *C. palavanicus* Aurivillius.
a^2. Pubescence and markings above gray, whitish, or white.
  b^1. Pronotum not bordered with white at base. Larger species, 8 to 16 millimeters.
    c^1. Elytra without pale basal fascia or humeral gray spot. Subbasal pale fascia interrupted at the suture, broader than the linear median fascia .... *C. bakeri* Aurivillius.
    c^2. Elytra with a pale, gray or whitish, spot behind the shoulder.
      d^1. This spot entirely free.
        e^1. Hind femora, at least behind the middle, with a very fine lateral carina.
          f^1. Humeral spot of the elytra large and broad. Markings of the elytra gray.................................. *C. manillae* Aurivillius.
          f^2. Humeral spot of the elytra small linear. Markings of the elytra white or whitish.. *C. manillae* var. *lineifer* var. nov.
        e^2. Hind femora not carinate. Humeral spot of the elytra large, produced nearer to base than the sutural vitta. *C. aurivillii* Schwarzer.
      d^2. Humeral spot of the elytra posteriorly united to the subbasal fascia .... *C. basilanus* Heller.
  b^2. Pronotum bordered with white at base. Small species, 5 to 6 millimeters .... *C. nigerrimus* Chevrolat.

CHLOROPHORUS ANNULARIS Fabricius.

Callidium annulare FABRICIUS, Mant. Ins. 1 (1787) 156.
Caloclytus annularis GAHAN, Fauna Brit. Ind. Col. 1 (1906) 261.

LUZON. NEGROS. SIBUYAN. CEBU. BOHOL. MINDANAO. (Teste W. Schultze.)

CHLOROPHORUS PALAVANICUS Aurivillius.

Chlorophorus palavanicus AURIVILLIUS, Tijdschr. v. Ent. 65 (1922) 161.

Northern PALAWAN, Binaluan.

CHLOROPHORUS BAKERI Aurivillius.

Chlorophorus bakeri AURIVILLIUS, Arkiv f. Zoöl. 14 [18] (1922) 4, fig. 84.

LUZON, Mount Banahao.

CHLOROPHORUS MANILLAE Aurivillius.

Chlorophorus manillae AURIVILLUS, Arkiv f. Zoöl. 7 [19] (1911) 6.

LUZON.

CHLOROPHORUS MANILLAE var. LINEIFER var. nov.

A forma typica differt macula humerali elytrorum brevi, lineari et signaturis elytrorum albis.

MINDANAO, Bukidnon.

CHLOROPHORUS AURIVILLII Schwarzer.

Chlorophorus manillae, ab. *aurivillii* SCHWARZER, Ent. Mitt. 15 (Jan. 1, 1926) 7.

Chlorophorus bakeri subsp. *orbiculifer* HELLER, Tijdschr. v. Ent. 69 (April 15, 1926) 27.

MINDANAO.

CHLOROPHORUS BASILANUS Heller.

Chlorophorus bakeri subsp. *basilanus* HELLER, Tijdschr. v. Ent. 69 (1926) 26.

BASILAN.

CHLOROPHORUS NIGERRIMUS Chevrolat.

Anthobascus nigerrimus CHEVROLAT, Mém. Soc. Sc. Liége 18 (1863) 302 (sep. 50).

MINDANAO.

Genus RHAPHUMA Pascoe

Long and narrow, often vividly colored species, which differ from the species of *Chlorophorus* only by the long third joint of the antennæ.

Key to the species of Rhaphuma Pascoe.

a^1. Pronotum and elytra testaceous red or yellowish. Each elytron only with one black spot (near the white apex). Body beneath banded with white pubescence. Lateral margins of the elytra distinctly sinuate in the middle. Femora not carinate.

- b^1. Pronotum without white lines; only with a white dot on each side at base. Elytra without median white spot. Hind legs blackish. *R. quadricolor* Laporte and Gory.
- b^2. Pronotum with two short white lines. Elytra each with a small white median spot. Legs testaceous................ *R. fallax* Chevrolat.

a^2. Pronotum and elytra black, with grayish or yellowish green markings.

- b^1. Elytra with gray or whitish gray markings, which are short and partly transverse and free. Middle femora carinate. *R. campanulifera* Aurivillius.
- b^2. Elytra with greenish markings, which are long and more rectilinear. *R. semiclathrata* Chevrolat.

RHAPHUMA QUADRICOLOR Laporte and Gory.

Clytus quadricolor LAPORTE and GORY, Monogr. des Clytus (1835) 104, pl. 19, fig. 123.

Rhaphuma quadricolor CHEVROLAT, Mém. Soc. Sc. Liége **18** (1863) 276 (sep. 24).

LUZON.

RHAPHUMA FALLAX Chevrolat.[2]

Rhaphuma fallax CHEVROLAT, Mém. Soc. Sc. Liége **18** (1863) 276 (sep. 24).

LUZON. PALAWAN (teste W. Schultze).

RHAPHUMA CAMPANULIFERA Aurivillius.

Rhaphuma campanulifera AURIVILLIUS, Arkiv f. Zool. **14**[18] (1922) 8, fig. 90.

LUZON, Mount Banahao.

RHAPHUMA SEMICLATHRATA Chevrolat.[2]

Arcyphorus semiclathratus CHEVROLAT, Mém. Soc. Sc. Liége **18** (1863) 289 (sep. 37).

"Philippine Islands."

Genus PSILOMERUS Chevrolat

Slender and rather small species with the prothorax nearly cylindrical or narrowed in front, much longer than broad. The spine of the third antennal joint long and cylindrical with its apex blunt.

Only one species is known from the Philippine Islands.

PSILOMERUS BRACHIALIS Chevrolat.

Psilomerus brachialis CHEVROLAT, Mém. Soc. Sc. Liége **18** (1863) 258 (sep. 6).

MINDANAO. NEGROS.

Black with the hind border of the pronotum and three spots on each elytron white. The first spot small longitudinal before the middle, the second a transverse straight fascia near the middle, the third oblique and nearly apical.

Genus DEMONAX Thomson

This genus is very rich in species and is in great need of a thorough monographic revision. About thirty species are already known from the Philippine Islands, nearly all probably endemic.

[2] Unknown to me from the Philippines.

Key to the Philippine species of Demonax Thomson.

a^1. Body at least in part yellowish or yellowish red. Elytra clothed with yellowish pubescence and marked with black bands or lateral spots. Spines of the antennæ short and acute.

b^1. Elytra above from base to beyond middle unicolorous, clothed with a yellow pubescence; each behind the middle with two elongate lateral black spots .... *D. longicollis* Heller.

b^2. Elytra also before middle with black markings.

c^1. The first, second, and third yellow bands of the elytra united at suture, but separated at margin by large black spots.

d^1. First lateral black spot of the elytra oblique, curved basad. *D. nigroscutellaris* Heller.

d^2. First lateral black spot of the elytra transverse. *D. diversofasciatus* Heller.

c^2. The first, second, and third yellow bands of the elytra entirely separated from each other by black transverse bands.

d^1. Basal yellow band of the elytra represented by two separate spots .... *D. protogenes* Newman.

d^2. Basal yellow band of the elytra continuous, including the scutellum .... *D. strangaliomimus* Heller.

a^2. Body black or fuscous with grayish or somewhat yellowish pubescence. Elytra with gray or white (rarely yellowish or greenish) markings.

b^1. Third and fourth joints of the antennæ at apex with an acute spine.

c^1. Elytra only with two or three pale bands; the basal band wanting.[3] Small species, 5 to 7 millimeters long.

d^1. Elytra with a common sutural white spot or short streak behind the scutellum. Pronotum with a white or whitish basal ring.

e^1. Spines of the antennæ rather long. Subbasal band of the elytra represented by a rounded, somewhat transverse spot. Basal band sometimes slightly indicated. *D. lineola* Chevrolat.

e^2. Spines of the antennæ very short. Subbasal white band of elytra oblique, angulated, and nearly continuous at suture. *D. triguttatus* Schwarzer.

d^2. Elytra without common white sutural spot behind the scutellum. Spines of the antennæ very short.

e^1. Subbasal white band of the elytra continuous or nearly so, forming an angle at the suture or a $\wedge$-shaped figure.
D. collaris Chevrolat.
D. similis Schwarzer.

e^2. Subbasal band represented on each of the elytra by a white spot.

f^1. Basal margin of the pronotum not or slightly clothed with white pubescence. Subbasal spot of the elytra rounded. *D. biguttatus* Aurivillius.

f^2. Basal margin of the pronotum densely clothed with white tomentum.

[3] Rarely slightly indicated.

g^1. Subbasal spot of the elytra rounded.
D. aurivillii Schwarzer.
g^2. Subbasal spot of the elytra elongate.
h^1. Placed obliquely .... *D. ater* Aurivillius.
h^2. Placed longitudinally......................... *D. frater* Aurivillius.
c^2. Elytra with four grayish or greenish bands, of which the first is basal.
d^1. First and second bands of the elytra united at the suture behind the scutellum, but broadly separated on the outer side, usually forming with each other an X-shaped sign.
e^1. Elytra with the second and third bands narrow, united at the suture; the second recurved at outer end. Antennæ with very short spines.................................. *D. recurvus* Aurivillius.
e^2. Second and third bands of the elytra not united at the suture; the third broad, more or less triangular.
f^1. Bands of the elytra distinctly greenish. Transverse part of second band interrupted near the suture, forming a free discal spot.. *D. virescens* sp. nov.
f^2. Bands of the elytra gray. Antennæ with the spines of the third and fourth joints long.
g^1. Antennæ with the fifth joint unarmed. Prothorax more elongate .... *D. dubius* sp. nov.
g^2. Fifth joint of the antennæ with a very short spine at apex. Prothorax broad, subglobular.
D. triaculeatus Aurivillius.
d^2. First and second bands of the elytra united as well at the suture as at the outer (lateral) side, inclosing a black spot or marking.
e^1. The inclosed spot forms a straight, somewhat oblique, black stripe from the scutellum to the middle of the disk. Antennæ with rather long spines.
f^1. The inclosed black stripe ends bluntly posteriorly and is not recurved... *D. angusticollis* sp. nov.
f^2. The inclosed black stripe is recurved at its posterior end and reaches the shoulder as a fine black line.
D. detortus Pascoe.
e^2. The inclosed black spot is broad, irregular, and sends a narrow branch to the shoulder. Antennæ with short spines.
D. robustus sp. nov.
? D. incanus Newman.
b^2. Third and fourth joints of the antennæ with a long, nearly filiform spine which is blunt at the apex.
c^1. Elytra only with three pale bands, the basal band wanting or only slightly indicated. Small species, 6 to 8 millimeters.
d^1. Subbasal band of the elytra produced at the suture to the scutellum .... *D. trifasciatus* sp. nov.
d^2. Subbasal band of the elytra not reaching the scutellum.
D. coriaceocollis Aurivillius.
c^2. Elytra with four grayish brands, the first basal. Larger species, 9 to 14 millimeters.

d^1. Basal and subbasal bands of the elytra entirely separated by a broad and straight black fascia........ *D. parallelus* Aurivillius.

d^2. Basal and subbasal bands of the elytra united along the suture.

e^1. Broadly separated on the outer side, forming with each other an X-shaped sign.

f^1. Basal band of elytra nearly straight on the posterior side. *D. samarensis* sp. nov.

f^2. Basal band of elytra strongly recurved at shoulders.

g^1. Antennæ not paler in apical half.
D. seriatopunctatus Aurivillius.
D. confinis Aurivillius.

g^2. The last four or five joints of the antennæ pale, whitish .... *D. angulifascia* Aurivillius.

e^2. Also on the outer (lateral) side, completely including a triangular black spot, which is shortly projecting against the scutellum .... *D. includens* sp. nov.

DEMONAX LONGICOLLIS Heller.

Demonax longicollis HELLER, Deutsche Ent. Zeitschr. (1916) 302, pl. 3, fig. 11.

LUZON, Mount Maquiling.

DEMONAX NIGROSCUTELLARIS Heller.

Demonax nigrofasciatus nigroscutellaris var. n. ? HELLER, Deutsche Ent. Zeitschr. (1916) 304, pl. 3, fig. 10.

LUZON, Mount Maquiling. SIBUYAN.

This was described by Heller as a variety of *D. nigrofasciatus* Thomson from Batjan, but is probably a different species. The specimens before me differ in having the prothorax broadly blackish above and the episterna of mesothorax and metathorax clothed with a dense white tomentum. Antennal spines acute, moderately long. Femora noncarinate; posterior femora bispinous at apex.

DEMONAX DIVERSOFASCIATUS Heller.

Demonax diversofasciatus HELLER, Deutsche Ent. Zeitschr. (1916) 303, pl. 3, fig. 12.

MINDANAO, Butuan.

DEMONAX PROTOGENES Newman.

Clytus protogenes NEWMAN, Entomolog. 1 (1842) 246.
Clytus protogenes WHITE, Cat. Col. Brit. Mus. 8 (1855) 284.
Clytus protogenes WATERHOUSE, Aid Identif. Ins. 2 (1884) 149, fig. 5.

"Philippine Islands." LUZON. (?)

DEMONAX STRANGALIOMIMUS Heller.

Demonax strangaliomimus HELLER, Tijdschr. v. Ent. **69** (1926) 27, pl. 5, fig. 13.

MINDANAO, Davao.

DEMONAX LINEOLA Chevrolat.

Demonax lineola CHEVROLAT, Mém. Soc. Sc. Liége **18** (1863) 274 (sep. 22).

LUZON, Manila and Imugan.

DEMONAX TRIGUTTATUS Schwarzer.

Demonax triguttatus SCHWARZER.

MINDANAO, Kolambugan.

DEMONAX(?) PUDICUS Newman.

Clytus pudicus NEWMAN, Entomolog. **1** (1842) 246.

Philippine Islands. LUZON. (?)

Unknown to me. Probably allied to the following species.

DEMONAX COLLARIS Pascoe.

Demonax collaris PASCOE, Trans. Ent. Soc. London III **3** (1869) 636.

LUZON, Los Baños.

The species was described from Ceram. I have not seen any specimens from that island, but the description agrees very well with the specimens from Luzon before me.

DEMONAX SIMILIS Schwarzer.

Demonax similis SCHWARZER (not yet published).

MINDANAO, Momungan.

DEMONAX BIGUTTATUS Aurivillius.

Demonax biguttatus AURIVILLIUS, Arkiv f. Zool. **14**^{18} (1922) 18, fig. 88.

LUZON, Mount Banahao.

DEMONAX AURIVILLII Schwarzer.

Demonax aurivillius SCHWARZER (not yet published).

MINDANAO, Momungan.

DEMONAX ATER Aurivillius.

Demonax ater AURIVILLIUS, Arkiv f. Zool. **14**^{18} (1922) 18, fig. 89.

MINDANAO, Dapitan.

DEMONAX FRATER Aurivillius.

Demonax frater AURIVILLIUS, Arkiv f. Zool. **15**^{25} (1923) 10, fig. 117.

MINDANAO, Bukidnon.

DEMONAX RECURVUS Aurivillius.

Demonax recurvus AURIVILLIUS, Arkiv f. Zool. 15[25] (1923) 11, fig. 118.

PALAWAN, Binaluan.

DEMONAX TRIACULEATUS Aurivillius.

Demonax triaculeatus AURIVILLIUS, Arkiv f. Zool. 14[18] (1922) 13, fig. 100.

MINDANAO, Dapitan. BASILAN.

DEMONAX DUBIUS sp. nov.

A doubtful and somewhat variable species, agreeing in the markings of the elytra very nearly with *D. angulifascia* Aurivillius from Luzon, but differing by the acute spines of the antennæ and the rather broader prothorax. From *D. triaculeatus* Aurivillius it differs by the narrower body and prothorax and much larger third fascia of the elytra, which has the same form as in *D. angulifascia.* The color of the last joint of the antennæ is somewhat variable; joints 8 and 9 are usually whitish and much paler than 10 and 11, but in one specimen from Samar all the four apical joints are whitish, and in another all dark. Length, 9 to 10 millimeters.

SIBUYAN. SAMAR. NEGROS (*C. F. Baker*). Collectio Baker, Riksmuseum, Stockholm.

DEMONAX VIRESCENS sp. nov. Plate 1, fig. 3.

♀. Nigro-fusca, infra cinereo-pubescens, supra subnuda signaturis elytrorum virescente-tomentosis. Frons subquadrata. Antennae corpore breviores, nigro-fuscae, spinis mediocribus; scapus subcylindricus, articulo 3° brevior. Prothorax ellipsoideus, latitudine longior, subnudus, nigricans, unicolor, minute reticulatus. Scutellum triangulum, niger. Elytra apicem versus sensim leviter angustata, apice truncata angulo externo breviter dentato, virescente signata; fascia basalis ad humeros retrorsum producta, fascia secunda postice transversa sed prope suturam interrupta, juxta suturam usque ad scutellum producta linearis; fascia tertia elongata, triangularis, apice lata; quarta lata apicalis. Episterna et latera abdominis albido-tomentosa. Long. corporis 8 mm.

LUZON, Imugan. Riksmuseum, Stockholm.

DEMONAX ANGUSTICOLLIS sp. nov. Plate 1, fig. 4.

Nigro fuscus, cinereo-pubescens; elytra fasciis 4 cinereis ornata, prima et secunda ad suturam et extus connexa striga obliqua nigra includentibus. Antennæ maris corpore paullo longioribus, articulis 3° et 4° apice longe aculeatis, 8–11 albidis. Prothorax angustus, elongatus, latitudine longior, ad basin constrictus, punctatus aut leviter reticulatus, in medio punctis duobus nigris ornatus. Scutellum cinereum. Elytra angusta, linearia, apice truncata et extus spina brevi armate, margine laterali inter humerum et fasciam nigram mediam nigro. Corpus infra cinereo-pubescens, segmentis duobus apicalibus abdominis certo luce infuscatis. Femora haud carinata; postica apicem elytrorum longe superantia. Articulus basalis tarsorum posticorum elongatus, reliquis simul sumtis fere duplo longior. Long. corporis 6–8 mm.

NEGROS, Cuernos Mountains (*C. F. Baker*). Coll. Baker. Riksmuseum, Stockholm.

Nearly allied to *D. gregalis* Gahan, but differing by the longer and narrower prothorax.

DEMONAX ANGUSTICOLLIS var. SIBUYANUS var. nov.

A forma typica tantum differt lateribus elytrorum inter basin et fasciam nigram primam cinereis, antennisque apice vix pallidioribus.

SIBUYAN (*C. F. Baker*). Collectio Baker. Riksmuseum, Stockholm.

DEMONAX DETORTUS Pascoe.

Demonax detortus PASCOE, Trans. Ent. Soc. Lond. III 3 (1869) 624.

LUZON. SIBUYAN. SAMAR. NEGROS. MINDANAO. BASILAN.

Specimens from the Philippine Islands are as a rule larger than specimens from Borneo, but seem otherwise not to differ, either in markings or in structural characters.

DEMONAX (?) INCANUS Newman.

Clytus incanus NEWMAN, Entomolog. 1 (1842) 246.

LUZON. (?)

I have not seen Newman's type specimen, but think his species must be nearly allied to the following form.

DEMONAX ROBUSTUS sp. nov. Plate 1, fig. 5.

Niger, supra flavido-tomentosus, infra cinerascente-tomentosus, episternis albido-hirtis. Frons lata, subquadrata. Genae lobis inferioribus aculorum vix breviores. Antennæ corpore breviores, fasciam tertiam elytrorum vix superantes, fuscae;

scapus crassus articulo 3° parum brevior; articuli 3–5 apice breviter aculeati. Prothorax latus, convexus, subglobosus, flavido-tomentosus, maculis tribus nigris serie transversa pasitis ornatus. Scutellum magnum, nigrum. Elytra ad basin pronoto haud latiora, apicem versus leviter angustata, apice truncata angulo exteriore breviter spinoso, fasciis 4 flavido-tomentosis ornata; fascia basali lata, secunda angustior pone scutellum et ad humerum cum prima connexa maculam obliquam curvatam humeras fere tangentem sigram omnino includens; fascia 3ª lata triangula, fascia 4ª lata, apicalis. Femora haud carinata; postica elytra superantia apice bispinosa. Articulus basalis tarsorum posticorum reliquer simul sumtis parum longior. Long. corporis 14 mm.

SIBUYAN (*C. F. Baker*). Collectio Baker.

The unique specimen is probably a female.

DEMONAX TRIFASCIATUS sp. nov. Plate 1, fig. 6.

Nigro-fuscus, cinereo-pubescens; elytra fasciis tribus cinero-albidis (basali deficiente aut valde obsoleta) ornata. Frons subplana, latitudine altior. Antennae brunneae scapo pallidiore; scapus, cylindricus articulo 3° vix brevior; articulo 3 et 4 spina longa, subfiliformi, apice obtusa armati. Prothorax supra convexus, basin et apicem versus aequaliter angustatus lateribus arcuatis, tenue cinereo-pubescens, immaculatus, ad basin anguste leviter albido-cingulatus. Scutellum fere nigram. Elytra pronoto vix latiora, brunneo-nigra, trifasciata; fascia prima antemedium sita, linearis, arcuata ad suturam usque ad scutellum producta, marginem lateralem haud ommino atterigens fascia secunda transversa, fere recta, ad suturam haud vel parum dilatata, tertia lata, apicalis. Episterna meso- et metasterni nec non segmenta duo basalia abdominis albo hirsuta, reliqua nigricantia. Pedes antici brunnei, posteriores nigro-fusci. Femora haud carinata, postica apicem elytrorum superantia. Articulus basalis tarsorum posticorum reliquis simul sumtis haud duplo longior. Long. corporis 6.5–7 mm.

NEGROS, Cuernos Mountains (*C. F. Baker*). Collectio Baker, Riksmuseum, Stockholm.

DEMONAX CORIACEOCOLLIS Aurivillius.

> *Demonax coriaceocollis* AURIVILLIUS, Arkiv f. Zoöl. 14[18] (1922) 13, fig. 99.

MINDANAO, Kolambugan. NEGROS.

The antennæ are sometimes yellowish at base.

DEMONAX PARALLELUS Aurivillius.

Demonax parallelus AURIVILLIUS, Arkiv f. Zool. 14[18] (1922) 11, fig. 97.

MINDANAO, Kolambugan.

DEMONAX SAMARENSIS sp. nov. Plate 1, fig. 7.

Elongatus, nigricans, dense cinereo-pubescens, elytris fasciis 4 cinereo-tomentosis ornatis. Frons lata subquadrata. Antennae feminae corpore breviores fuscae, ad basin nigricantes, articulis 7–11 pallidis albidis; scapus crassus subcylindricus, articulo 3° multo brevior; articuli 3 et 4 apice spina longa, subfiliformi, apice obtusa armati. Prothorax subcylindricus, ad basin modice constrictus, dense punctulatus, utrique prope basin punctis aliquot discretis instructus, dense pubescens, nigro-bimaculatus, elytris vix angustior. Scutellum magnum, triangulare, cinereum. Elytra apice truncata, extus breviter dentata, fasciis 4 cinereis ornata; fascia basalis lata, extus haud retrorsum producta, fascia secunda linearis, usque ad scutellum producta, postice curvata; fascia tertia lata, triangula; quarta apicalis. Corpus infra dense pubescens. Femora haud carinata; postica apicem elytrorum superantia, apice breviter bispinosa. Articulus basalis tarsorum posticorum reliquis fere duplo longior. Long. corporis 14 mm.

SAMAR (*C. F. Baker*). Collectio Baker.

Described from a single female specimen.

DEMONAX SERIATOPUNCTATUS Aurivillius.

Demonax seriatopunctatus AURIVILLIUS, Arkiv f. Zool. 14[18] (1922) 12, fig. 98.

LUZON, Mount Banahao.

DEMONAX CONFINIS Aurivillius.

Demonax confinis AURIVILLIUS, Arkiv f. Zoöl. 15[25] (1923) 10.

LUZON, Mount Maquiling.

Differs from *D. seriatopunctatus* Aurivillius only by having the prothorax entirely reticulate, and may be the female of that species. Compare Gahan[4] and Schawarzer.[5]

DEMONAX ANGULIFASCIA Aurivillius.

Demonax angulifascia AURIVILLIUS, Arkiv f. Zool. 14[18] (1922) 11, fig. 101.

LUZON, Mount Maquiling and Mount Banahao.

[4] Ann. Mus. Civ. di Storia Nat. Genova III 3 (1907) 77.
[5] Suppl. Entomol. 15 (1927 60.

DEMONAX INCLUDENS sp. nov. Plate 1, fig. 8.

Nigro-fuscus, cinereo-pubescens; elytra fasciis 4 cinereis ornata, quorum prima et secunda ad suturam et extus conjunctae maculam subtrigonam nigram includentes. Antennae corpore multo (♂) vel vix (♀) longiores, articulis 3 vel 4 ultimis albidis; spinae articuloram 3 et 4 longae, filiformes, apice obtusae. Prothorax elongatus, ad basin constrictus, latitudino longior, elytris param angustior, dense granulato-punctatus, in maribus saepe lineis 2–3 elevatis leviter granulatis instructus, maculis duobus nigris interdum connexis, ornatus. Scutellum cinereum. Elytrorum fascia 2ª marginem haud attingens ad suturam pone scutellum et extus pone humeram cum fasciam basalem connexa, maculam nigram includens; fascia 3ª antice ad suturam plus minusve producta et acuminata; fascia apicalis antice rotundata vel subtruncata. Femora haud carinata; postica apicem elytrorum sat longe superantia, apice breviter bispinosa. Articulus basalis tarsorum posticorum reliquis simul sumtis fere duplo longior. Long. corporis 8–13 mm.

SIBUYAN. SAMAR. NEGROS (*C. F. Baker*). Collectio Baker. Riksmuseum, Stockholm.

Easily distinguished from *Demonax angusticollis* by the form of the included subbasal black spot of the elytra and the blunt spines of the elytra.

Genus OLIGOENOPLUS Chevrolat

One species only is known from the Philippine Islands.

OLIGOENOPLUS LUZONICUS Schwarzer.

Oligoenoplus luzonicus SCHWARZER, Ent. Mitt. 15 (1926) 9.

LUZON, Imugan and Mount Banahao.

Black with white markings. Hind border of pronotum and three spots on each elytron white; first spot transverse before the middle, second linear forming a curved transverse fascia behind the middle and produced at the suture; third large, apical. Femora strongly punctured, not carinate. Prothorax and legs with erect hairs. Length, 7 to 9 millimeters.

Genus SCLETHRUS Newman

(*Neocollyrodes* W. Schultze)

This genus is distinguished from all other Philippine genera of Clytini by the elytra being convex posteriorly and strongly sloping at apex. Antennæ with joints 3 and 4 spined at apex, the spines short. Femora not carinate. First tarsal joint of hind legs longer than the following joints together.

Key to the species of Sclethrus Newman.

a^1. Pronotum with four bluish white dots, two near base, two at middle. Elytra in basal part to behind middle dark and opaque, densely covered with deep punctures.. *S. amoenus* Gory.

a^2. The dots of the pronotum on each side united to a white or bluish stripe. Elytra in basal part subnitid, greenish or bluish with smaller and more distant punctures................................ *S. newmani* Chevrolat.

The species are somewhat variable and only doubtfully distinct.

SCLETHRUS AMOENUS Gory.

Ibidion amœnum GORY, Mag. de Zoöl. 3 (1833) Ins. t. 58.

Sclethrus amœnus PASCOE, Trans. Ent. Soc. London III 3 (1869) 619.

LUZON. (?) MINDANAO. SIBUYAN.

SCLETHRUS NEWMANI Chevrolat.

Sclethrus newmani CHEVROLAT, Mém. Soc. Sc. Liége 18 (1863) 284 (sep. 32).

Neocollyrodes mcgregori W. SCHULTZE, Philip. Journ. Sci. 16 (1920) 196, pl. 1, fig. 2.

LUZON. MINDANAO.

ILLUSTRATIONS

PLATE 1

FIG. 1. *Xylotrechus humeralis* sp. nov.
2. *Xylotrechus luzonicus* sp. nov.
3. *Demonax virescens* sp. nov.
4. *Demonax angusticollis* sp. nov., type.
5. *Demonax robustus* sp. nov.
6. *Demonax trifasciatus* sp. nov.
7. *Demonax samarensis* sp. nov.
8. *Demonax includens* sp. nov.

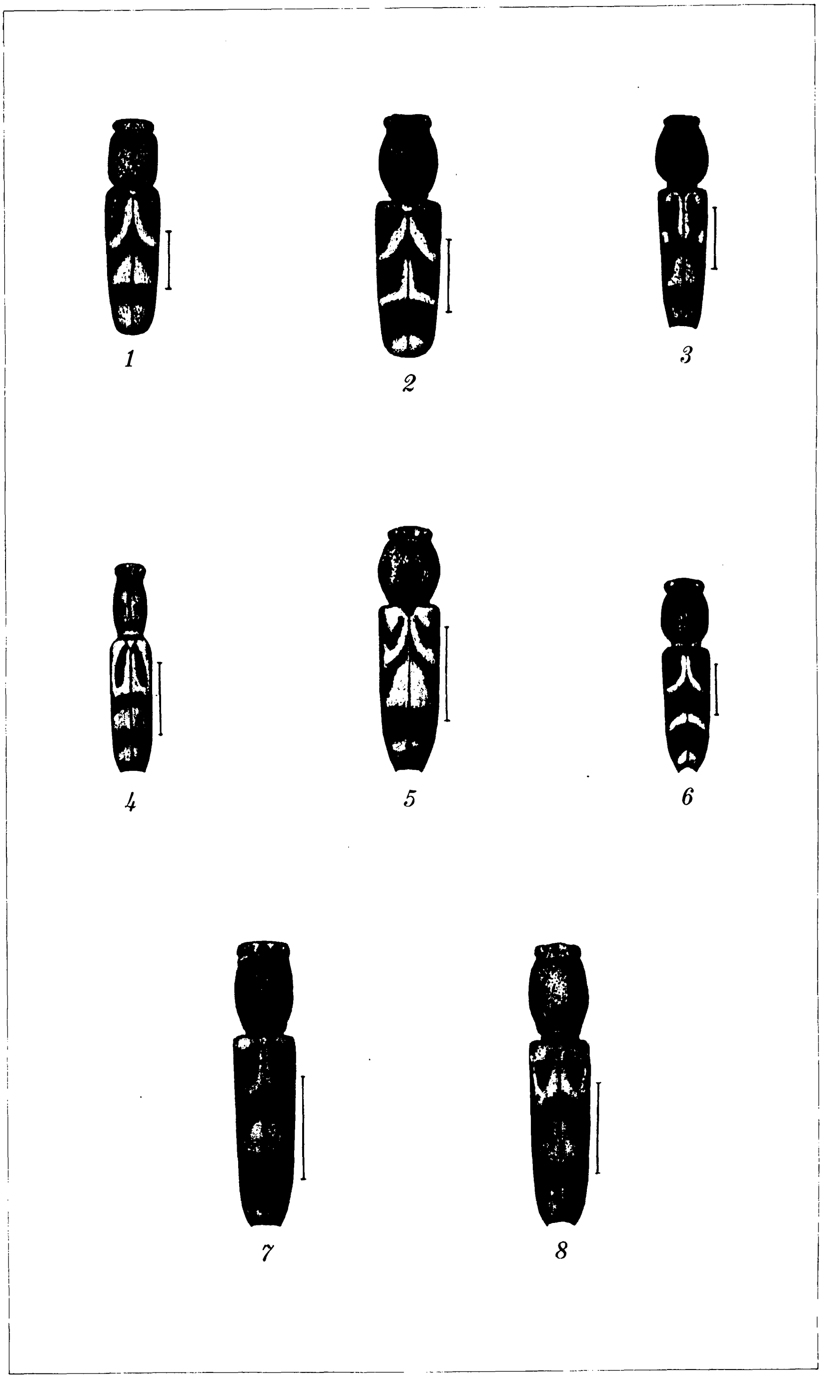


PLATE 1.

COCCIDÆ OF FORMOSA

By Ryoichi Takahashi

Of the Department of Agriculture, Research Institute
Taihoku, Formosa

ONE PLATE

INTRODUCTION

The family Coccidæ is very rich in species and these are mostly decidedly polyphagous, attacking fruit and ornamental trees, as well as other cultivated plants, and sometimes causing serious damage to them. For example, *Icerya purchasi* Mask., *I. aegyptiaca* Dougl., *I. seychellarum* Westw., *Pseudococcus citri* Risso, *P. adonidum* Linn., *P. lilacinus* Ckll., *P. filamentosus* Ckll., *Trionymus sacchari* Ckll., *Ferrisia virgata* Ckll., *Pulvinaria psidii* Mask., *Coccus viridis* Green, *Saissetia hemisphaerica* Targ., *S. formicarii* Green, *Aulacaspis cinnamoni* Newst., *Chrysomphalus aonidum* Linn., *Parlatoria ziziphus* Lucas, and several others are among the worst pests, and there are now twenty-four species of these insects known to occur on *Citrus* and six on sugar cane in Formosa.

Notwithstanding their economic importance, the insects of this family in Formosa have never been thoroughly studied by any entomologist, only about fifty species having been recorded by Chamberlin, Ferris, Green, Kuwana, Maki, Maskell, Shiraki, and others from the island; numerous species of economic importance remain undetermined or misidentified.

The present paper is the first report of my studies on this group of insects in Formosa. Fifty species and two varieties of the non-diaspine Coccidæ are here recorded, of which five species and one variety seem to be new to science.

The food plants recorded in this paper are only those which have been ascertained by me to be fed upon by each species in Formosa. All the material, including the types, examined by me will be preserved in the entomological laboratory, Department of Agriculture, Government Research Institute, Taihoku, Formosa.

I express here my cordial thanks to Prof. S. Isshiki and Dr. T. Shiraki, for their kind help in various ways; and to Dr. J. C. Chamberlin, Mr. E. E. Green, and Dr. I. Kuwana, for their kindness in examining some of my specimens. I am also very much indebted to Messrs. S. Akasaka, Y. Horikawa, M. Kato, M. Matsuda, H. Sakurai, K. Sawada, J. Sonan, S. Takano, K. Toyota, and M. Yanagihara, who have been kind enough to collect valuable specimens for me. Mr. F. C. Hadden, of the Sugar Experiment Station at Honolulu, Hawaii, has kindly corrected errors in English in a part of the manuscript of this paper and I extend my sincere gratitude to him.

MONOPHLEBINÆ

DROSICHA MASKELLI Cockerell.

Drosicha maskelli (Cockerell), MORRISON, Proc. U. S. Nat. Mus. 62, Art. 17 (1923) 2.

Host.—*Ficus retusa.*

Habitat.—Taihoku.

Hitherto unrecorded from Formosa. Some adult females and grown nymphs were collected by me in January, February, April, and December, the characters of which answer closely to Morrison's description and figures of Cockerell's species. The antennæ are usually 8-jointed, but 7-jointed in some examples. Some of my specimens have been kindly examined by Mr. Green.

DROSICHA CONTRAHENS Walker.

Drosicha contrahens Walker, GREEN, Ann. & Mag. Nat. Hist. IX 12 (1923) 168.

Host.—*Persea gratissima.*

Habitat.—Kagi.

Previously known only from China. Some adult females were collected by Mr. K. Toyota on May 14, 1927. These specimens agree with Green's redescription and figures of the type. The antennæ are 8-jointed; the fifth joint is almost as large as the fourth; the sixth and the seventh with rounded sides, the sixth somewhat smaller than the fifth, but somewhat larger than the seventh; the eighth a little longer than the sixth and the seventh taken together, swollen on the basal one-third.

Some males of a *Drosicha* collected on June 3, 1927, at Kagi, Formosa, may belong to this species. They are allied to *Monophlebus philippinensis* Green,[1] but differ from it in possessing five pairs of much longer appendages on the abdomen.

[1] Not. Ent. 4: 2.

DROSICHA DALBERGIAE Green.

Monophlebus dalbergiae GREEN, Ind. Mus. Not. 5 [3] (1902) 101; Proc. 5th Ent. Meet. Pusa 1923 (1924) 338.

Drosicha dalbergiae VAYSSIERE, Ann. Epiph. 12 (1926) 274.

Host.—Unknown.

Habitat.—Tansui.

Hitherto recorded only from India. Two females were collected by the late Mr. Nitobe in January, 1910. These specimens agree with Vayssiere's notes and figures.

ICERYA AEGYPTIACA Douglas.

Hosts.—*Artocarpus incisa, Celtis* sp., *Croton* sp., *Mallotus philippensis, Psidium guyava, Psychotria elliptica.*

Habitat.—Shirin, Tainan, Heito, Taito, Chippon.

This species is very common in the southern half of Formosa, but is quite rare in the northern.

ICERYA SEYCHELLARUM Wood.

Hosts.—*Areca catechu, Chrysophyllum cainito, Citrus* spp., *Eugenia javanica, Ficus wightiana, Maba buxifolia, Mangifera indica, Machilus* sp., *Morus alba, Podocarpus macrophylla, Persea gratissima, Psidium guyava, Sapium sebiferum.*

Habitat.—Taihoku, Shinten, Tosei, Kagi, Tainan, Botel Tobago.

Very common throughout Formosa.

ICERYA PURCHASI Maskell.

Hosts.—*Acacia confusa, Artemisia capillaris, Citrus* spp., *Rosa* sp., *Vitex negundo.*

Rather common throughout the island, sometimes occurring in large numbers in July and August. More than seventy species of plants in about thirty families have been recorded as being fed upon by this insect in Formosa, of which *Acacia confusa, Citrus* spp., and *Artemisia capillaris* are most favored. This pest was imported into the island about twenty-five years ago and caused serious damage to *Acacia confusa* and other plants, but since the introduction of its enemy, *Novius cardinalis,* in 1909, it has been kept in check.

DACTYLOPIINÆ

PSEUDOCOCCUS CITRI Risso.

Hosts.—*Artocarpus incisa, A. integrifolia, Acacia confusa, Calathea tubispatha, Carludovica palmata, Clausena wampi, Citrus* spp., *Lespedeza* sp., *Morus alba, Persea gratissima, Psidium guyava, Tectona grandis, Tetrapanax papyrifera, Thea chinensis.*

Habitat.—Hokuto, Taihoku, Kagi, Shinkwa, Heito, Karenko, Riran, Taito, Koshun.

Very common in almost any season.

PSEUDOCOCCUS ADONIDUM Linnæus.

Hosts.—*Areca catechu, Citrus* sp., *Ficus retusa, Prunus communis.*

Habitat.—Tansui, Taihoku, Heito.

This species is very common in Formosa and is most so on *Ficus retusa* in summer. *Pseudococcus longispinus* Targ. is generally considered to be a synonym of this species, and the Formosan specimens agree well with the descriptions of that species given by several investigators, but differ from Green's description and figures of it [2] in the following characters: Tibia of middle leg about 2.5 as long as tarsus; setæ of anal ring distinctly stouter than anal setæ.

PSEUDOCOCCUS COMSTOCKI Kuwana.

This species was recorded by G. F. Ferris [3] from *Citrus* in Formosa, but I have never collected it in the island.

PSEUDOCOCCUS LILACINUS Cockerell.

Hosts.—*Callicarpa formosana, Croton* sp., *Gardenia florida, Heritiera littoralis, Macaranga* sp., *Mallotus japonicus, Mallotus* sp., *Rhododendron* sp., *Terminalia* sp.

Habitat.—Hokuto, Taihoku, Shinten, Taichu, Kagi, Toko, Domon, Karenko.

Hitherto unrecorded from Formosa. This species is very common near Taihoku, and its colonies are almost always protected by *Cremastogaster rogenhoferi* (Formicidæ). Some of my specimens have been compared with material from Ceylon by Mr. Green.

PSEUDOCOCCUS BREVIPES Cockerell.

Host.—*Ananas sativus.*

Habitat.—Shirin, Kagi, Hozan.

New to Formosa. This species is common on the pineapple, but is not a serious pest.

PSEUDOCOCCUS FILAMENTOSUS Cockerell.

Hosts.—*Artocarpus integrifolia, Broussonetia papyrifera, Citrus* spp., *Coffea arabica, Ficus retusa, Gardenia florida, Mussaenda luteola, Nerium odorum, Zizyphus* sp.

[2] Cocc. Ceylon 5: 383.
[3] Bull. Ent. Res. 12: 211.

Habitat.—Taihoku, Kagi, Heito.

Near Taihoku this species is very common; it is most abundant in summer.

PSEUDOCOCCUS SACCHARICOLA sp. nov. Plate 1, fig. 1.

Adult female.—Yellowish brown. Body oval, covered with white secretion not forming tassels. Antennæ 8-jointed, with some bristles which are almost as long as, or longer than, the fourth antennal joint; the first joint as long as wide, stouter than the second; the second a little stouter than the third, with a very small circular sensorium at the apex; the second and the third almost cylindrical, but the fourth, the fifth, and the seventh narrowed towards the base; the eighth as long as the front tarsus, with longer bristles; the relative length of joints about as follows: I, 13; II, 15; III, 12; IV, 6; V, 9; VI, 6; VII, 9; VIII, 21. Eyes almost marginal, as large as the fourth antennal joint. Beak conical, 2-jointed, a little longer than wide. Legs usual; hind coxæ with numerous minute pores over the whole length; trochanters with four bristles of which one at the apex is much longer; femora with some bristles of which two are a little longer; hind femora as long as the tibia, with some faint areolations; tibiæ about twice as long as the tarsus in the front legs, but 2.4 times in the hind legs, with some bristles of which two near the apex are much stouter, but are a little shorter; hind tibiæ with about twenty minute pores mostly on the distal half, of which one or two near the distal end are sometimes larger; claws without denticles; tarsal digitules long, slender, scarcely knobbed, but those of the claw distinctly knobbed, longer than the claw. Hind spiracles somewhat larger than the front. Series of cerarii almost complete, one pair on the head and fourteen or fifteen posterior pairs present; each of those on the head composed of more than ten small triangular pores, an accessory seta and three spines one of which is sometimes longer; the apical abdominal pair each large, with two or three spines of equal length, a loose cluster of many tringular pores and several long bristles, not underlaid by any definite chitinous thickening, the spines about 2.7 times as long as wide, somewhat shorter than the hind claw; the penultimate pair each with two spines which are much smaller than those of the last pair, but longer than those of the remaining pairs; all the antepenultimate pairs each with two or rarely three spines, about eight to ten triangular pores and one or more accessory setæ; these spines almost equal in length. Anal lobes hardly protruding, apical setæ very long, about 1.5 times as long as the seta of the anal ring, a little shorter than the hind tibia. Anal ring usual, with two rows of pores and six setæ which are longer than the diameter of the ring. Body with numerous pores of two types and ducts; triangular pores small, numerous, distributed over the dorsum and venter; large multilocular pores confined to the ventral abdominal region, in a large cluster around the genital opening and two transverse rows anterior to the genital cluster; these rows and cluster not reaching the body margin; tubular ducts short, distributed over the dorsum and venter of the abdomen, abundant on the posterior portion and on the side. Body with some bristles of various length which are mostly shorter than the first antennal joint. Ventral cicatrix not distinct. Anterior and posterior glandular foveæ distinct.

Length of body, about 2.5 to 3 millimeters; antenna, about 0.415; hind tibia, about 0.268.

Host.—*Saccharum officinarum*, attacking the lower side of the leaf.

Habitat.—Shinkwa.

A few specimens were collected in August, 1927, by Mr. S. Takano, who writes me that this species sometimes occurs in large numbers on sugar cane in green houses at Shinkwa. This species is very closely allied to *Pseudococcus boninsis* Kuwana, the distribution of the pores on the body agreeing almost exactly with Morrison's description and figure of Kuwana's species,[4] but is distinguishable from it by the number of the cerarii, as well as by the characters of the antennæ. This species is also closely related to *Pseudococcus variabilis* Hall and *P. calceolariæ* Mask., but is different from them in the number of the cerarii, the shorter setæ of the anal ring, or the distribution of the pores on the body.

TRIONYMUS DIMINUTUS Leonardi.

Trionymus diminutus MORRISON, Journ. Agr. Res. 31 (1925) 495.

Host.—*Saccharum officinarum.*

Habitat.—Kori, Byoritsu.

Hitherto unrecorded from Formosa. Many adult females were collected by Mr. M. Yanagihara in May and November. Some specimens are not provided with pores on the hind femora and trochanters.

[4] Journ. Agr. Res. 31: 490.

TRIONYMUS SACCHARI Cockerell.

Pseudococcus sacchari MORRISON, Philip. Journ. Sci. 17 (1920) 173.
Trionymus sacchari MORRISON, Journ. Agr. Res. 31 (1925) 497.

Hosts.—*Saccharum officinarum, Miscanthus* sp.

Habitat.—Kori, Shinkwa.

This species is very common at Shinkwa, causing serious damage to sugar cane, but is hitherto unrecorded from Formosa. The spines in the last cerarus are usually two in number, but there are three in a few examples in my collection; the antennæ are 7- or 8-jointed.

TRIONYMUS PULVERARIUS Newstead var. BAMBUSAE Green.

Pseudococcus pulverarius Newstead subsp. *bambusae* GREEN, Cocc. Ceylon 5 (1922) 374.

Host.—*Bambusa stenostachya.*

Habitat.—Taihoku.

Previously known only from Ceylon. Many adult and immature females were collected by me in September, 1927. They were concealed between the stipules and the stalk of a young shoot. The adult possesses large circular multilocular pores distributed over the body, but abundant around the genital opening, some very short ducts on the posterior portion, some small triangular pores, and a quadrate cicatrix with rounded corners at the middle of the abdomen. This species is related to *T. diminutus* Leonardi, but is distinguishable from it by the number of the cerarii on the posterior abdominal segments, as well as by the shorter tibiæ. I have no specimens from Ceylon for comparison, but the Formosan ones answer to Green's figures and description.

TRIONYMUS MISCANTHI sp. nov. Plate 1, fig. 2.

Adult female.—Yellowish brown, with a slightly pinkish tinge. Body oval, about twice as long as wide in mounted specimens, somewhat convex on the dorsum, covered with white powder, the secretion forming no tassels. Eyes very small, smaller than the shortest antennal joint, marginal. Antennæ small, 6-jointed, provided with some bristles which are as long as, or longer than, the fourth antennal joint; the first joint much stouter than the second; the second and the third somewhat longer than wide; the fourth very slightly wider than long; the fifth narrowed towards the base; the sixth slightly longer than the tarsus, with some longer bristles; the relative length of joints about as follows: I, 9; II, 7; III, 6; IV, 4; V, 5; VI, 12. Beak stout, conical, 2-

jointed, almost as long as wide. Legs small, with a few hairs; hind coxæ with numerous rather large or medium-sized circular pores mostly on the basal half; trochanters with a very long bristle at the apex which is as long as the trochanter; femora almost as long as tibia and tarsus taken together, without areolations; tibiæ about 1.5 times as long as the tarsus, lacking pores, with about five bristles of which two near the tip are sometimes slightly stouter; tarsal digitules very long, but shorter than the tarsus, slightly knobbed; claws without denticles, the digitules slender, knobbed. Spiracles stout, without pores on the sides of orifice; the hind pair slightly larger than the front. Cerarii present only on the last two segments; the last pair each with two spines which are a little shorter than the hind claw and two accessory long bristles, but without pores, not underlaid by a definite chitinous thickening; the penultimate pair each with two or sometimes one spine which are as long as, or a little shorter than, those of the last pair, and two bristles; two or three antepenultimate segments each with a spine on the side. Anal lobes slightly protruding, with a very long seta which is shorter than the antenna, almost as long as the hind tibia and tarsus taken together. Anal ring with pores almost in two rows and six setæ which are almost as long as, but slightly stouter than, the apical seta. Body with many circular multilocular pores of almost equal size, but lacking triangular pores and tubular ducts; multilocular pores distributed over the dorsum and venter, numerous along the side and around the spiracles and abundant around the genital opening, but very few on the middle areas of the dorsum and venter, those around the spiracles variable in size. Body with some bristles, of which those on the posterior portion, especially around the genital opening area, are stouter. Anterior dorsal glandular foveæ absent, the posterior ones rather small. Abdomen with four or five very large oval cicatrices in a longitudinal row, of which the anterior one is smaller; the larger ones larger in diameter than the anal ring or the glandular fovea, about 0.074 millimeter in the largest diameter.

Length of body, about 4 millimeters; antenna, about 0.189; hind tibia, about 0.0766.

Host.—*Miscanthus* sp.

Habitat.—Taihoku.

This species is closely allied to *Trionymus pulverarius* Newstead, but is distinguishable from it by the stouter body, as well as by possessing large circular cicatrices on the abdomen and only multilocular circular pores of almost equal size on the body. It is different from all other species of the genus in the wider body. Individuals of this species are abundant near Taihoku; they are found concealed between the stalks and the basal parts of the leaves of the host plant, and are sometimes protected by ants of the genus *Cremastogaster.*

RIPERSIA CELLULOSA Hall.

Ripersia cellulosa HALL, Minist. Agr. Egypt. Tech. Sci. Serv., Bull. 36 (1923) 7; Bull. 72 (1926) 30.

Host.—*Bambusa* sp.

Habitat.—Taihoku.

Hitherto known only from Egypt. This species is found between the stalk and the stipules of the host. The Formosan specimens differ from the type in having a series of four conspicuous oval medioventral cicatrices, but otherwise the characters agree completely. Mr. Green has kindly compared the specimens with the type.

FERRISIA VIRGATA Cockerell.

Pseudococcus virgatus FERRIS, Journ. Econ. Ent. 12 (1919) 297; MORRISON, Philip. Journ. Sci. 17 (1920) 171; FERRIS, Bull. Ent. Res. 12 (1921) 211; GREEN, Cocc. Ceylon 5 (1922) 371.

Ferrisia virgata FULLAWAY, Proc. Hawaii. Ent. Soc. 5 (1923) 311; MORRISON, Journ. Agr. Res. 31 (1925) 497.

Hosts.—*Acalypha* sp., *Anona squamosa, Calliandra haematocephala, Casuarina equisetifolia, Croton* sp., *Eugenia javanica, Bauhinia* sp., *Inocarpus edulis, Persea gratissima, Psidium guyava, Punica granatum, Thea japonica.*

Habitat.—Tosei, Kagi, Kwanshirei, Shinkwa, Tainan, Heito, Koshun, Taito, Karenko.

Very common in the southern half of Formosa, but has never been collected in the northern.

PHENACOCCUS SPINOSUS Robinson.

Phenacoccus spinosus ROBINSON, Philip. Journ. Sci. 13 § D (1918) 145; GREEN, Cocc. Ceylon 5 (1922) 394.

Puto spinosus MORRISON, Philip. Journ. Sci. 17 (1920) 165.

Host.—Unknown.

Habitat.—Hatsune near Karenko.

This species has never been recorded from Formosa. I observed this species entirely covering the stem and branches of a large tree at Hatsune on November 13, 1925. The species is peculiar in the truncate spines on the body, being provided with thirty-four spiniferous marginal cerarii and in a denticle on the inner edge of the claw.

PHENACOCCUS HIRSUTUS Green.

Phenacoccus hirsutus GREEN, Mem. Dept. Agr. Ind. II 2 (1908) 25; MORRISON, Philip. Journ. Sci. 17 (1920) 169; HALL, Minist. Agr. Egypt. Tech. Sci. Serv., Ent. Ser., Bull. 17 (1921) 1–28.

Hosts.—*Morus alba, Hibiscus* sp.

Habitat.—Hokuto, Taihoku.

Hitherto known from India, Egypt, Tasmania, and the Philippine Islands, and new to Formosa. This species is rather scarce in Formosa, though it is a serious pest in Egypt. *Phenacoccus hirsutus* Green var. *cressae* Hall and the allied species, *P. glomeratus* Green, are not found in Formosa.

Genus MIZOCOCCUS novum

Adult female.—Subterranean, forming a complete sac. Body globular, the ventral side longitudinally deeply sunken. Antennæ small, not stout, 6-jointed, not placed close together. Mentum 2-jointed. Legs small, usual in structure. Anal ring rather small, placed a little distant from the posterior extremity, with six setæ and many pores almost in two rows. Derm rather hard throughout, with many small triangular pores, lacking tubular ducts and larger pores. Cerarii not developed, only the last abdominal pair represented by a few spinelike setæ. Anal lobes absent, but a pair of long setæ present near the posterior extremity. Dorsal glandular foveæ small.

Genotype, *Mizococcus sacchari* sp. nov.

This genus is very peculiar and is apparently distinct from other proposed genera. *Mizococcus sacchari* sp. nov. is known to entomologists in Formosa under the Japanese name of "Mizo-kaigara," from which the generic name has been derived.

MIZOCOCCUS SACCHARI sp. nov. Plate 1, fig. 3.

Adult female.—Lemon yellow with a pinkish tinge, or pink, slightly covered with white powder. Subterranean, forming a sac as in *Geococcus radicum* Green. Body almost globular, the ventral side longitudinally deeply sunken; division of segments indicated on the dorsum by moderately deep transverse furrows; longitudinally somewhat convex on the middle of the dorsum where the furrows are obscure. Derm rather hard throughout, more chitinized than in *Pseudococcus* and its allies, without cicatrices on the ventral side. Eyes marginal, very small, smaller than the fourth antennal joint. Antennæ small, not stout, a little longer than tibia and tarsus taken together, 6-jointed, with some rather stout setæ which are nearly as long as the fourth antennal joint, situated on the ventral side near the front, not placed close together; the first joint much stouter than the second; the second longer than wide; the third somewhat narrowed towards the base; the fourth and the fifth almost as long as wide, constricted at the base; the sixth slightly shorter than the tarsus, with some longer setæ at the apex; the relative length of joints about as follows: I, 8; II, 8; III, 9; IV, 5; V, 6; VI, 15. Beak stout, conical, somewhat longer than wide, 2-jointed; the basal joint with a pair of rather long bristles near the distal end on the lower surface; the apical joint with two pairs of bristles on the upper surface and eight pairs on the distal part of the lower side, of which a pair almost on the side is much longer. Spiracles lacking pores, the hind ones very slightly larger than, but similar in shape to, the front. Legs short, with some rather long setæ; trochanters with five long setæ of which one near the apex is much longer; femora stout, swollen, slightly longer than the tibia; tibiæ very slightly longer than the tarsus, with two stout setæ near the apex, wanting pores; tarsi without knobbed hairs; claws with no denticle, digitules slender, scarcely knobbed. Anal ring rather small, about 0.074 millimeter in diameter, situated a little distant from the posterior end of the abdomen, with six very stout setæ which are shorter than the diameter of the anal ring, and more than seventy small circular pores arranged almost in two rows, pores in the outer row not regularly arranged. Anterior and posterior dorsal glandular foveæ inconspicuous, smaller than the anal ring. Body with many very small triangular pores scattered over the surface and numerous on the side, lacking tubular ducts and larger pores. Only the last abdominal cerarii present, each composed of two or three spinelike setæ which are shorter and more slender than the seta of the anal ring, and seven or eight pores similar to those on other parts of the body, not underlaid by any chitinous thickening nor more chitinized. Anal lobes not developed. Abdomen near the posterior extremity with a pair of long setæ which are nearly as long as the hind tibia, and much longer, but more slender, than the seta of the anal ring. Body with some setæ of various lengths on the side and venter, the longer ones almost as long as the sixth antennal joint; the dorsum scarcely with shorter setæ.

Length of body, about 4 millimeters; antenna, about 0.23; hind tibia, about 0.11.

First instar.—Body somewhat elongate ovate, about twice as long as wide in mounted specimens, with many setæ and small triangular pores mostly on the dorsum. Antennæ somewhat longer than tibia and tarsus taken together; 6-jointed, with long setæ which are longer than the third antennal joint; the relative length of joints about as follows: I, 6; II, 7; III, 5; IV, 5; V, 5; VI, 15. Legs stout; femora slightly longer than the tarsus; tarsi slightly longer than the tibia, without capitate hairs. Anterior and posterior dorsal glandular foveæ present. Anal ring with six (?) setæ. Anal lobes scarcely protruding, each with an apical seta which is almost twice as long as the seta of the anal ring. Last cerarii each represented by two spinelike setæ which are much shorter than the seta of the anal ring.

Length of body, about 1 millimeter; antenna, about 0.2.

Hosts.—*Saccharum officinarum, Miscanthus* sp., a plant of the Gramineæ.

Habitat.—Kori.

Some specimens attached to roots were collected by Mr. M. Yanagihara in May and July.

This species is common on the hosts and is very injurious to the sugar cane. The color notes were made by Mr. M. Yanagihara. In an adult female in my collection the anal ring has seven setæ. Some of my specimens have been kindly examined by Mr. Green.

ANTONINA CRAWI Cockerell.

Antonina crawi COCKERELL, Psyche 9 (1900) 70; KUWANA, Illust. Mon. Japan Cocc. 2 (1917) 127; FERRIS, Bull. Ent. Res. 12 (1921) 211.

Host.—*Bambusa* sp.

Habitat.—Taihoku.

In Formosa this species is very rare, some specimens having been collected by Mr. M. Maki long ago.

ANTONINA INDICA Green.

Antonina indica GREEN, Mem. Dept. Agr. Ind. Ent. Ser. II 2 (1908) 27; Cocc. Ceylon 5 (1922) 395.

Host.—A plant of the Gramineæ.

Habitat.—Kori, Taihoku.

Previously known only from India, Ceylon, and Hawaii, and a variety of it from Egypt. Some adult females were collected by Mr. M. Yanagihara at Kori and by Mr. M. Kato at Taihoku.

ANTONINA BAMBUSAE Maskell.

Antonina bambusae FERRIS, Bull. Ent. Res. 12 (1921) 211; GREEN, Cocc. Ceylon 5 (1922) 397.

Chaetococcus bambusae MORRISON, Proc. U. S. Nat. Mus. 60, Art. 12 (1922) 55.

Host.—*Bambusa stenostachya.*

Habitat.—Taihoku.

Near Taihoku this species is rather rare, occurring in restricted numbers.

ASTEROLECANIINÆ

ANOMALOCOCCUS MULTIPORI Morrison.

Anomalacoccus multipori MORRISON, Philip. Journ. Sci. 18 (1921) 641.

Hosts.—*Glochidion fortunei, G. hypoleuca, Glochidion* sp., *Adinandra formosana.*

Habitat.—Sozan, Taihoku.

Previously recorded only from Singapore. Near Taihoku this species is very common on *Glochidion* and is always found in the nest of *Cremastogaster rogenhoferi* (Formicidæ). Some of my specimens have been kindly examined by Mr. Green.

CEROCOCCUS FICOIDES Green.

Cerococcus ficoides GREEN, Ent. Mth. Mag. II 10 (1899) 225; Mem. Dept. Agr. Ind. I 5 (1907) 338; FERRIS, Bull. Ent. Res. 12 (1921) 212.

Hosts.—*Ficus retusa,* attacking the aid root; *Gardenia florida, Mallotus japonicus, Thea chinensis.*

Habitat.—Taihoku, Heitin, Koheki.

This species is rather common.

ASTEROLECANIUM BAMBUSAE Boisduval var. TUBERCULATA var. nov.

Adult female.—Differs from typical *A. bambusae* Boisd. in the presence of a transverse tubercular ridge across about the middle of the scale, as well as in lacking paired pores on the dorsum.

Host.—*Bambusa,* attacking the stalk.

Habitat.—Taihoku.

Very common near Taihoku. Typical *A. bambusae* has never been collected in Formosa. The new name has been suggested by Mr. Green who has kindly compared Formosan specimens with some representing the typical species.

ASTEROLECANIUM CORALLINUS sp. nov. Plate 1, fig. 4.

Adult female.—Test dark green, almost circular, not narrowed nor elevated at the posterior extremity, flattened, with no furrows and ridges, with numerous short whitish filaments over the surface, the margin with a complete fringe of long coral red filaments.

Body almost circular, somewhat narrower on the posterior end, with about one hundred forty pairs of pores arranged in a single row on the whole margin excepting the posterior extremity, these paired pores of equal size, somewhat larger than those on the dorsum; a single ventro-marginal row of simple minute circular pores present close to the marginal row of the paired pores; another single row of simple minuter circular pores present along the whole margin on the ventral side; the dorsum with many paired pores of equal size scattered over the surface excepting the middle area of the apical portion of the abdomen, intermixed with very minute paired pores scattered over the whole surface, and with numerous long tubular ducts distributed over the whole surface, these ducts of equal length, very slightly dilated towards the base, scarce in number on the apical portion of the abdomen; the venter with a few very short setæ along the margin and four transverse irregular rows of circular pores on the middle area of the posterior portion of the abdomen, these pores somewhat variable in size, the larger ones almost as large as the dorsal paired pore, about sixty-five in number in all. Antennæ very small, not jointed, submarginal, much smaller than the spiracle, wider than long, broadly rounded on the apex, with a few short and two much longer setæ, the longer ones longer than the antenna, but shorter than the tubular duct on the dorsum. Spiracles stout, nearly as long as wide, at a considerable distance from the margin, of equal size, almost as long as the tubular duct on the dorsum, with about ten or thirteen very small pores in a cluster on the side of the orifice; many similar pores connecting the spiracles with the margin. Abdominal extremity slightly cleft; anal lobes stout, with about four very short setæ; apical setæ very long, stout, about three times as long as the tubular duct on the dorsum. Anal ring with six long stout setæ which reach the margin, but are shorter than the apical seta.

Length of body, about 0.807 millimeter; antenna, about 0.0095; tubular duct on dorsum, about 0.023; apical seta, about 0.07; test, about 1.1; marginal filament, about 0.166.

Host.—*Sideroxylon ferrugineum,* attacking the twig.

Habitat.—Keelung.

Very common in August on this host near the beach. Some of my specimens have been kindly examined by Mr. Green.

COCCINÆ

COCCUS HESPERIDUM Linnæus.

Hosts.—*Carica papaya, Citrus* sp., *Thea chinensis.*

Habitat.—Keelung, Taihoku, Sankyo, Gyochi, Tainan, Hozan. This species is rather rare in Formosa, but I observed it in large numbers on a papaya fruit at Tainan in October. The colonies of this *Coccus* are sometimes found in the nests of *Cremastogaster rogenhoferi* (Formicidæ).

COCCUS BICRUCIATUS Green.

Lecanium bicruciatus GREEN, Cocc. Ceylon (1904) 214.
Coccus bicruciatus FERRIS, Bull. Ent. Res. 12 (1921) 212.

Host.—*Murraya exotica.*

Habitat.—Taihoku.

In Formosa this species is very rare, and no specimens have been discovered by me.

COCCUS VIRIDIS Green.

Hosts.—*Achros sapota, Aegle marmelos, Citrus* sp., *Carissa* sp., *Clausena lunulata, Coffea arabica, Gardenia florida, Genipa americana, Heritiera littoralis, Ixora chinensis, Plumeria acutifolia, Psidium guyava.*

Habitat.—Kagi, Heito.

Very common in Kagi, but has never been collected in the northern part of the island.

COCCUS ACUMINATUS Signoret.

Lecanium acuminatus GREEN, Cocc. Ceylon (1904) 195.

Host.—*Gardenia florida.*

Habitat.—Taihoku.

Hitherto unrecorded from Formosa. A few adult females with from 6- to 8-jointed antennæ were collected by me on the lower sides of the leaves.

COCCUS MANGIFERAE Green.

Lecanium mangiferae GREEN, Ent. Mth. Mag. 25 (1889) 249; Cocc. Ceylon (1904) 216.
Coccus mangiferae MORRISON, Philip. Journ. Sci. 17 (1920) 190.

Host.—*Psychotria elliptica.*

Habitat.—Taihoku.

New to Formosa. A few adult females were collected by me in August.

COCCUS CAUDATUS Green.

Lecanium caudatum GREEN, Ind. Mus. Not. 4 (1896) 10; Cocc. Ceylon (1904) 223.

Host.—Unknown.

Habitat.—Toyohara.

Previously recorded only from Ceylon. An adult female was taken by Mr. M. Kato on September 1, 1927.

COCCUS ELONGATUS Signoret.

Hosts.—*Acacia confusa, Anona squamosa, Codiaeum variegatum, Calliandra haematocephala, Casuarina equisetifolia, Citrus* spp., *Derris laxiflora, Hibiscus rosasinensis, Morus alba, Myrica rubra, Nephelium litchi, Osmanthus fragrans, Pithecolobium dulce, Pometia pinnata, Rhus* sp.

Habitat.—Taihoku, Itabashi, Kagi, Heito, Karenko, Tamasato, Botel Tobago.

This species is very common in Formosa, sometimes occurring in large numbers. The specimens on *Citrus* spp. are a little smaller and are mostly form *frontale* Green, but the long series of them shows a complete chain connecting *frontale* Green with *elongatus* Signoret.

SAISSETIA HEMISPHAERICA Targioni Tozzetti.

Hosts.—*Adiantum coneatum, Adiantum* sp., *Anona* sp., *Ardisia quinquegona, Bischoffia javanica, Carissa carandas, Chrysophyllum cainito, Citrus* spp., *Cucurbita moschata, Cycas revoluta, Eugenia unifolia, Ficus wightiana, Gardenia florida, Ixora chinensis, Lagerstroemia indica, Mangifera indica, Psidium guyava, Plumeria acutifolia, Psychotria elliptica, Osmanthus fragrans, Rhus vernicifera, Rhus* sp., *Tabernaemontana* sp., *Thea chinensis.*

Habitat.—Tansui, Taihoku, Urai, Itabashi, Heitin, Koheki, Kori, Kagi, Shinkwa, Heito, Koshun, Taito, Chippon, Botel Tobago.

Very common in Formosa; sometimes protected by *Cremastogaster rogenhoferi* (Formicidæ).

SAISSETIA NIGRA Nietner.

Hosts.—*Ardisia quinquegona, Artemisia capillaris, Bischoffia javanica, Canna indica, Chrysophyllum cainito, Citrus* sp., *Croton* sp., *Ficus carica, F. gibbosa, F. retusa, Ficus* sp., *Gossypium herbaceum, Psidium guyava, Sapium sebiferum, Terminalia catappa,* a plant of the Leguminosæ.

Habitat.—Tansui, Taihoku, Tainan, Heito, Karenko, Taito, Botel Tobago.

Very common in Formosa, but found in small numbers.

SAISSETIA OLEAE Bern.

Hosts.—*Gossypium herbaceum, Nerium odorum, Terminalia catappa.*

Habitat.—Taihoku.

Very rare, and occurring in very small numbers.

SAISSETIA FORMICARII Green.

Lecanium formicarii GREEN, Cocc. Ceylon (1904) 190.

Hosts.—*Aglaia odorata, Bischoffia javanica, Cinnamomum camphor, C. ceylanicum, Diospyros kaki, Eugenia javanica, Ficus vasculosa, F. wightiana, Gordonia axillaris, Heptapleurum octophyllum, Eriodendron anfractuosum, Grevillea robusta, Lagerstroemia flos-reginae, Machilus* sp., *Mangifera indica, Michelia alba, Michelia* sp., *Melicope triphylla, Olea europea, Palaquium formosanum, Persea gratissima, Quercus* sp., *Rhus* sp., *Sapium sebiferum.*

Habitat.—Taihoku, Shinten, Shirin, Suisha, Kagi.

Hitherto recorded only from Ceylon and India.

The Formosan specimens differ from the original description in the number of the stigmatic spines. They are variable from three to six, but usually four or five, in my specimens, though three according to Green.

This species is very common in Formosa and its habitat is always inclosed in the nest of *Cremastogaster rogenhoferi* (Formicidæ), never having been found outside of the nest of this ant, and sometimes occurs in abundance, causing serious damage to the host plant. Mr. Green has kindly compared the Formosan specimens with his material from Ceylon.

EUCALYMNATUS TESSELLATUS Signoret.

Hosts.—*Aglaia formosana, Calophyllum inophyllum, Cinnamomum* sp., *Euphoria longana, Heritiera littoralis, Palaquium formosanum.*

Habitat.—Taihoku, Kagi, Shinkwa.

Hitherto unrecorded from Formosa. The Formosan speciments are tessellated all over the dorsum, with 8-jointed antennæ. This species is very common in Kagi, but is rare in Taihoku.

PARALECANIUM EXPANSUM Green.

Lecanium expansum GREEN, Ind. Mus. Not. IV 1 (1896) 9.

Lecanium (*Paralecanium*) *expansum* GREEN, Cocc. Ceylon (1904) 235.

Hosts.—*Ficus retusa, Machilus* sp.

Habitat.—Taihoku, Shirin.

Hitherto unrecorded from Formosa. This species is very rare, occurring in very small numbers near Taihoku. *Paralecanium expansum* var. *quadratum* Green and other varieties have never been discovered in Formosa.

PULVINARIA PSIDII Maskell.

Hosts.—*Artocarpus integrifolia, Chrysophyllum cainito, Coffea arabica, Euphoria longana, Gardenia florida, Mangifera indica, Psidium guyava, Psychotria elliptica.*

Habitat.—Hokuto, Taihoku, Kagi.

This species is common in any season, occurring in abundance, and the foliage of the plants infested by this pest are black from a fungus growing in the honey dew. Maskell [5] recorded this species from *Citrus* in Formosa, but I have never collected it on *Citrus* in Formosa.

PULVINARIA POLYGONATA Cockerell.

Pulvinaria polygonata COCKERELL, Proc. Davenport Acad. Sci. 10 (1905) 131; MORRISON, Philip. Journ. Sci. 17 (1920) 184.

Pulvinaria cellulosa GREEN, Cocc. Ceylon (1909) 262.

Orthezia insignis SHIRAKI (nec Dougl.), Agr. Expt. St. Formosa, Spec. Rept. 8 (1913) 104; NITOBE, Rept. Stud. Citrus Ins. Formosa (1916) 44.

Pulvinaria aurantii MAKE (in part) (nec Ckll.), Forest Expt. St. Formosa, Spec. Rept. 1 (1915) 24; NITOBE, Rept. Stud. Citrus Ins. Formosa (1916) 51.

Hosts.—*Citrus* spp., *Murraya exotica.*

Habitat.—Taihoku, Shinchiku, Kagi.

The specimens identified as *Orthezia insignis* Dougl. or *Pulvinaria aurantii* Ckll. by Shiraki, Maki, or Nitobe proved to be *Pulvinaria polygonata* Ckll. This species sometimes occurs in large numbers on *Citrus* in the island. The immature forms on *Murraya exotica* are sometimes protected by *Cremastogaster rogenhoferi* (Formicidæ), some specimens of which have been compared by Mr. Green with his specimens from Ceylon. According to Morrison *Pulvinaria cellulosa* Green is a synonym of this species.

PULVINARIA THESPESIAE Green.

Pulvinaria thespesiae GREEN, Cocc. Ceylon (1909) 259; MORRISON, Philip. Journ. Sci. 17 (1920) 183.

[5] Ent. Mth. Mag. II 8: 243.

Host.—*Morus acidosa.*

Habitat.—Hakumo.

Hitherto unrecorded from Formosa. I observed this species in abundance on a *Morus* in September, 1926. These specimens agree exactly with Green's description and figures.

CEROPLASTES FLORIDENSIS Comstock.

Ceroplastes floridensis Comstock, KUWANA, Dept. Agr. Comm., Imp. Plant Quar. St., Bull. 3 (1923) 34.

Hosts.—*Carissa carandas, Citrus* sp., *Machilus* sp., *Maesa sinensis, Poncirus trifoliata, Psidium guyava, Schima confertiflora, Thea chinensis.*

Habitat.—Taihoku, Shimpo, Tsusho, Jukirin.

In Formosa this species is rather common, occurring, however, in very small numbers and is not a serious pest.

CEROPLASTES CERIFERUS And.

Ceroplastes ceriferus And., KUWANA, Dept. Agr. Comm., Imp. Plant Quar. St., Bull. 3 (1923) 43.

Hosts.—*Artemisia capillaris, Citrus* spp., *Melastoma candidum, Morus alba, Polygonum* sp., *Pometia pinnata, Rhodomyrtus tomentosa, Thea chinensis, Pygeum preslii.*

Habitat.—Taihoku, Kinpori, Sozan, Kagi, Botel Tobago.

This species is rather common, but is not abundant.

CEROPLASTES RUBENS Maskell.

Ceroplastes rubens Maskell, KUWANA, Dept. Agr. Comm., Imp. Plant Quar. St., Bull. 3 (1923) 18.

Host.—*Citrus* sp.

Habitat.—Taihoku, Heito, Shimpo, Shinten.

In Formosa this species is rare, occurring usually in very small numbers and is not of economic importance, though it is very injurious to *Citrus* in Japan.

CEROPLASTODES CHITON Green.

Ceroplastodes chiton GREEN, Cocc. Ceylon 4 (1909) 287.

Host.—*Ficus retusa,* attacking the air roots.

Habitat.—Keelung, Tansui, Taihoku.

Hitherto unrecorded from Formosa. Very common, sometimes occurring in abundance. Some of my specimens have been examined by Mr. Green.

LECANOPSIS SACCHARI sp. nov. Plate 1, fig. 5.

Adult female.—Dirty yellowish brown to blackish brown in specimens preserved in alcohol, surrounded and partially covered with a white felted test as in *Lecanopsis ceylanica* Green. Body ovate, narrower in front, strongly convex on the dorsum, with about four transverse shallow furrows on the dorsum. Antennæ short, stout, 6-jointed, almost as long as the tibia and tarsus taken together, with a few moderate setæ; the second, fourth, fifth, and sixth joints each almost as long as wide; the third cylindrical, stouter than the tibia, with a faint trace of division near the base; the sixth with some longer setæ; the relative length of joints about as follows: I, 10; II, 9; III, 19; IV, 5; V, 5; VI, 5. Spiracles equal in size and shape, with many pores on the side of orifice. Legs slender, with a few setæ, lacking pores; trochanters with a very long seta near the tip; femora almost as long as the tibia; tibiæ and tarsi usually fused together, sometimes with a trace of division; hind tibiæ almost three times as long as the tarsus; tarsal digitules long, slender, knobbed; claws without denticle, with two stout distinctly capitate hairs. Anal plates rounded on the outer edge and at the apex, not incurved at the apex, with five setæ on the apical portion, the base slightly longer than the outer edge. Anal ring with eight long setæ. Margin of the body with some long setæ of various length not arranged in a single row, numerous on the posterior portion, the longer ones almost as long as the third antennal joint. Anal lobes with several stouter setæ on the distal portion, of which one is longer, longer than the third antennal joint and about as long as the seta of the anal ring. Stigmatic clefts not developed; two stigmatic spines, widely separated, conical, about twice or thrice as long as wide, acuminate, not curved, shorter than the marginal seta. Body with many small circular multilocular pores and numerous tubular ducts scattered over the body; tubular ducts long, very abundant on the side and anal lobes.

Length of body, about 3.5 to 4.5 millimeters; antenna, about 0.25; hind tibiotarsus, about 0.25.

Hosts.—*Saccharum officinarum*, *Miscanthus* sp., a plant of the Gramineæ.

Habitat.—Kori, Taichu.

Some adult females and nymphs attached to the roots were collected by Mr. M. Yanagihara in May and October. This species is closely allied to *Lecanopsis ceylanica* Green,[6] but is distinguishable from it by the not incurved anal plates.

[6] Journ. Bombay Nat. Hist. Soc. 28: 1026.

The body is variable in length and is more heavily chitinized in the old females and the antennæ are sometimes 7-jointed. The antennæ of the larvæ are 6-jointed, with a quite long seta on the last joint and the tibiæ and tarsi are fused together as in the adult female.

TACHARDIINÆ

TACHARDINA THEAE Green and Mann.

Tachardina decorella var. *theae* GREEN and MANN, Mem. Dept. Agr. Ind., Ent. Ser. I 5 (1907) 348; II 2 (1908) 28.
Tachardina decorella FERRIS, Bull. Ent. Res. 12 (1921) 212.
Tachardina theae CHAMBERLIN, Bull. Ent. Res. 14 (1923) 210.
Kermes sp. MAKI, Forest Expt. St. Formosa, Spec. Rept. 1 (1915) 30.

Hosts.—*Ardisia sieboldi, Ficus retusa, Machilus* sp., *Michelia compressa, M. fuscata, M. longifolia, Myrica rubra, Thea chinensis, Rhodomyrtus tomentosa.*

Habitat.—Taihoku, Heitin, Kagi.

This species is fairly common in any season in Taihoku, occurring in abundance. Some specimens on *Myrica rubra* and *Michelia longifolia* have been examined by Dr. J. C. Chamberlin.

LACCIFER sp.

Tachardia sp. CHAMBERLIN, Bull. Ent. Res. 14 (1923) 173.
Laccifer sp. CHAMBERLIN, Bull. Ent. Res. 16 (1925) 39.

Host.—*Citrus* sp.

Habitat.—Heito (formerly Ako).

Chamberlin described the immature stage of this species from Formosa. A species of this genus collected by me on *Calliandra haematocephala, Averrhoa carambola, Ficus wightiana,* and *Machilus* sp. at Kagi, Formosa, may belong to this species.

ILLUSTRATIONS

PLATE 1

FIG. 1. *Pseudococcus saccharicola* sp. nov., adult female; *a*, outline of body; *b*, antenna; *c*, hind tibia and tarsus.

2. *Trionymus miscanthi* sp. nov., adult female; *a*, antenna; *b*, hind leg; *c*, posterior spiracle and pores; *d*, last cerarus and apical seta.

3. *Mizococcus sacchari* sp. nov., adult female; *a*, dorsal view; *b*, hind leg; *c*, antenna; *d*, pore; *e*, beak; *f*, hind spiracle; *g*, last cerarus; *h*, apical part of abdomen, showing the positions of anal ring, cerarii, and apical setæ.

4. *Asterolecanium corallinus* sp. nov., adult female; *a*, marginal pores; *b*, duct.

5. *Lecanopsis sacchari* sp. nov., adult female; *a*, anal plates; *b*, stigmatic spines; *c*, two types of multilocular pores; *d*, ducts.

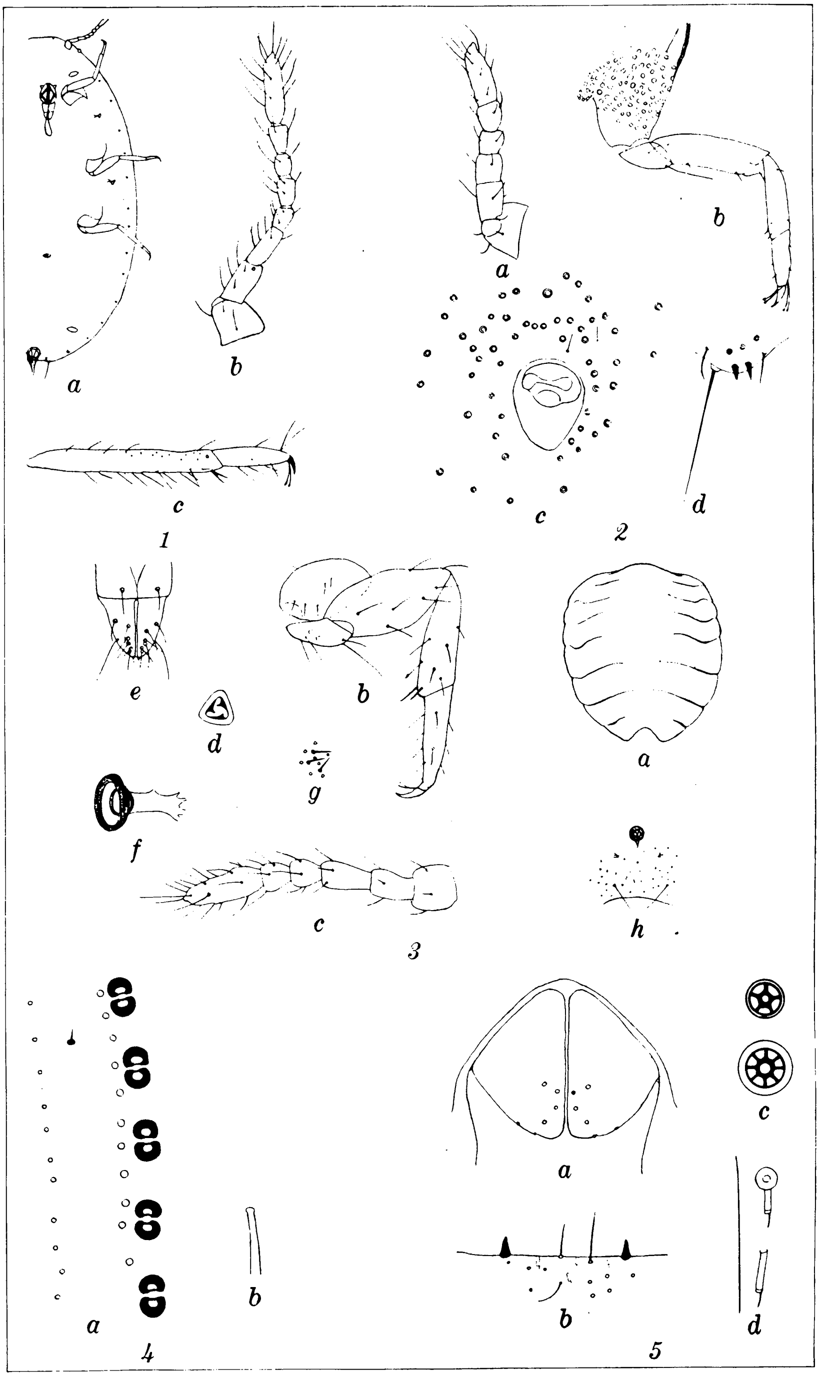


PLATE 1.

TREMATODE PARASITES OF PHILIPPINE VERTEBRATES

By MARCOS A. TUBANGUI

Of the University of the Philippines, Los Baños

FIVE PLATES

The trematodes of Philippine vertebrates, aside from those infesting man and the domesticated animals, are practically unknown. The parasites dealt with in this paper were collected from representative vertebrate hosts, which, with the exception of a species of bird caught in Cainta, Rizal Province, Luzon, were obtained from or near Los Baños, Laguna Province, Luzon, Philippine Islands. For convenience, they are arranged below according to their hosts.

FISH TREMATODES [1]

OPECOELUS MINIMUS sp. nov.. Plate 1, figs. 1 and 2.

This is one of those rare trematodes, in which the intestinal branches do not end blindly in the body parenchyma but open outside through a ventrally located anus. It bears a close resemblance to *Opecoelus lobatus* Ozaki, 1925, but it may be distinguished from that species by the more posterior location of its acetabulum, the extent of its vitellaria, and the close approximation of its testes and ovary.

Description.—Body from 1.13 millimeters in length by 0.27 millimeter in maximum width across acetabulum to 2.09 by 0.50; somewhat spindle-shaped, rounded posteriorly and tapering anteriorly from level of acetabulum. Cuticle smooth. Oral sucker subterminal, moderately developed, circular in outline, 0.10 to 0.15 millimeter in transverse diameter. Acetabulum better developed and larger than oral sucker, 0.19 to 0.27 millimeter across, located between anterior and middle thirds of body length.

[1] For the determination of the vertebrate hosts mentioned in this paper, I am gratefully indebted to Mr. R. C. McGregor, of the Philippine Bureau of Science (birds), and to Dr. D. Villadolid and Mr. C. Manuel, of the College of Agriculture, University of the Philippines (fishes, frogs, and bats).

Mouth ventro-subterminal; prepharynx present, 0.023 millimeter long; pharynx well developed, 0.70 to 0.10 millimeter across; œsophagus 0.17 to 0.23 millimeter long, bifurcating at level about midway between pharynx and acetabulum. Intestinal cæca unite at level about midway between posterior testis and posterior end of body, forming a narrow common canal which leads outside through a ventral anal opening near posterior end of body. Genital pore conspicuous, located to one side of median line at level of œsophageal bifurcation.

Testes intercæcal, globular or slightly oval, 0.10 to 0.23 millimeter across, one immediately behind the other in fourth fifth of body length. Vasa efferentia short, terminating at about middle level of acetabulum. Cirrus pouch thin-walled, elongated, dilated at both extremities when extended and bottle-shaped when moderately contracted; 0.35 to 0.41 millimeter in length by 0.04 to 0.06 millimeter in maximum width; located to one side of median line, beside, and anterior of, acetabulum; incloses entire length of seminal vesicle, pars prostatica, and inconspicuous cirrus.

Ovary elliptical, 0.07 to 0.09 millimeter across, median, pretesticular, either in contact with, or separated by a very narrow space from, first testis. Shell gland diffuse, in front of ovary; receptaculum seminis and Laurer's canal not seen. Uterus poorly developed, containing only very few eggs, lying between ovary and acetabulum. Vagina leads to left side of genital opening. Vitellaria in distinct follicles on both sides of body, extending from level of acetabulum or even anterior of that level to posterior end of body; they overlap intestinal cæca and behind second testis they coalesce. Vitelline ducts prominent, emptying into oval vitelline reservoir situated anterodorsally of ovary. Eggs oval, operculated, yellowish to yellowish brown in color, 0.078 to 0.080 millimeter by 0.056 millimeter in size.

The excretory bladder, which opens outside through a median posterodorsal excretory pore, is Y- or T-shaped and reaches anteriorly to anterior level of ovary (Plate 1, fig. 2). Each horn of the bladder is continued as a main lateral collecting tube, which soon divides into anterior and posterior collecting tubules. Each collecting tubule in turn is converted into four capillary branches, each of which terminates into a flame cell. The excretory formula is, therefore, $2 \times 8 \times 1 = 16$ flame cells in all.

Hosts.—*Glossogobius giurus* (Hamilton-Buchanan), *G. biocellatus* Cuvier and Valenciennes, and *Pristipoma hasta* Bloch.

Location.—Intestine.

Locality.—Laguna de Bay, Los Baños, Laguna Province, Luzon.

METADENA MICROVATA sp. nov. Plate 1, fig. 3.

There are in the available literature three genera of fish trematodes, namely, *Metadena* Linton, 1910, *Stepoda* Linton, 1910, and *Exorchis* Kobayashi, 1921, with the members of which the small distome under consideration presents certain affinities. It has been decided to place it in *Metadena* in preference to one of the other genera because, in the first place, it does not conform to the important diagnostic feature of *Exorchis*, which is the extracæcal position of the testes; and, in the second place, the description of *Stepoda*, as Linton himself admits, is so incomplete that it is difficult to recognize the genus.

Description.—Body small, oval, from 0.70 millimeter in length by 0.32 millimeter in maximum width across middle of body to 0.90 by 0.44. Cuticle covered with minute posteriorly directed spines. Oral sucker moderately developed, circular in outline, 0.10 to 0.14 millimeter across. Acetabulum weak, very much smaller than oral sucker, 0.03 to 0.05 millimeter across, situated in posterior portion of anterior third of body length. Mouth subterminal; pharynx immediately behind oral sucker, 0.06 to 0.08 millimeter in transverse diameter; œsophagus 0.05 to 0.07 millimeter long, its point of bifurcation at level of acetabulum. Intestinal cæca moderately dilated, reaching as far as posterior level of testes. Genital pore median, inconspicuous, immediately in front of acetabulum.

Testes slightly oval, 0.07 to 0.09 millimeter across, intercæcal, symmetrically placed on both sides of median line, at or immediately behind equator of body. Seminal vesicle slightly coiled, voluminous, in front of ovary and testes. Cirrus pouch apparently absent.

Ovary median or nearly median in position, distinctly trilobed, between seminal vesicle and testes. Uterus moderately developed, postovarian, posttesticular, reaching to posterior end of body. Vitellaria in distinct follicles, extending from level of genital pore to anterior border of testes. Eggs yellowish brown in color, oval, operculated, from 0.018 millimeter by 0.011 millimeter to 0.022 by 0.012 in size.

Excretory pore terminal, its position marked by an indentation at posterior end of body. Excretory bladder V-shaped, reaching anteriorly up to posterior margin of testes.

Hosts.—*Glossogobius giurus* (Hamilton-Buchanan), *G. biocellatus* Cuvier and Valenciennes, and *Pristipoma hasta* Bloch.

Location.—Intestine.

Locality.—Laguna de Bay, Los Baños, Laguna Province, Luzon.

AZYGIA PRISTIPOMAI sp. nov. Plate 1, fig. 4.

The general characters of this fluke place it in the genus *Hassallius* Goldberger, 1911. It is referred, however, to *Azygia* Looss, 1899, following the opinion of Ward (1920), who considers the two generic names as synonymous. It is nearly related to *Azygia* (*Hassallius*) *hassalli* Goldberger, 1911, but it may be distinguished at once from the latter species by the position of its vitellaria which do not pass posteriorly beyond the level of the second testis.

Description.—Body from 1.93 millimeters in length by 0.86 millimeter in maximum width at or near equator of body to 3.20 by 1.00; plump, short to long oval in shape, rounded at both extremities. Cuticle smooth. Oral sucker ventro-subterminal, large and muscular, almost spherical, 0.34 to 0.45 millimeter across. Acetabulum spherical, well developed but smaller than oral sucker, 0.31 to 0.38 millimeter in transverse diameter, situated between anterior and middle thirds of body length. Mouth ventroterminal; prepharynx absent; pharynx well developed, 0.16 to 0.18 millimeter across; œsophagus absent. Intestinal cæca at first make a straight transverse line behind pharynx and then curve posteriorly, each describing a right angle, and pass in moderate zigzags to posterior end of body. Genital pore immediately preacetabular, median.

Testes entire, oval, from 0.20 millimeter by 0.11 millimeter to 0.25 by 0.13 in size; intercæcal but slightly overlapped by corresponding intestine, asymmetrical, at middle of last fourth of body length, with left testis usually more advanced anteriorly than right testis. Cirrus sac circular, thin-walled, 0.23 to 0.25 millimeter in diameter; incloses slightly coiled and dilated seminal vesicle, pars prostatica, and ejaculatory duct.

Ovary entire, transversely oval, intertesticular, on a level with left testis and slightly to one side of median line; 0.18 millimeter by 0.12 millimeter in size. Shell gland appears compact, at anterior inner border of ovary. Laurer's canal and receptaculum seminis not seen. Uterus in transverse coils, occupying nearly all the space bounded by acetabulum, intestinal cæca, ovary, and testes. Vitellaria in distinct rounded follicles, extracæcal, extending from immediately behind posterior level of acetabulum to testes. Eggs yellowish in color, oval, operculated, from 0.066 millimeter by 0.044 millimeter to 0.068 by 0.040 in size.

Excretory pore caudoterminal; excretory bladder moderately dilated, reaching anteriorly up to or beyond region of testes, at which point it bifurcates. The arrangement of the excretory tubes could not be made out.

Host.—*Pristipoma hasta* Bloch.

Location.—Intestine.

Locality.—Laguna de Bay, Los Baños, Laguna Province, Luzon.

AMPHIBIAN TREMATODES

GLYPTELMINS STAFFORDI sp. nov. Plate 2, fig. 1.

This trematode differs from *Glyptelmins quieta* Stafford, 1900, the type species of the genus, as well as from three Brazilian species reported by Travassos (1924) in the extent of its vitellaria, in the arrangement of the testes and ovary, and in the size of the eggs. It is named after Dr. Joseph Stafford, American helminthologist.

Description.—Body ovoid or elongated, depending upon the state of preservation, with rounded extremities, from 2.09 millimeters in length by 0.63 millimeter in maximum width across testes to 4.15 by 1.01. Cuticle covered with conspicuous spines which become scarce from middle of body length to posterior end. Oral sucker ventroterminal, moderately developed, 0.19 to 0.29 millimeter across. Acetabulum smaller than oral sucker, 0.15 to 0.18 millimeter across, between anterior and middle thirds of body length or immediately anterior of that level. A very short prepharynx separates globular pharynx, 0.10 to 0.15 millimeter across, from oral sucker; œsophagus 0.04 millimeter long; intestinal branches nearly reach posterior end of body. Genital pore immediately in front of acetabulum, median in position or at most slightly inclined towards one side of median line.

Testes rounded, 0.18 to 0.22 millimeter across, nearly symmetrical with left testis usually slightly more advanced anteriorly than its fellow; postacetabular, in second fourth of body length. Cirrus sac from 0.26 millimeter by 0.06 millimeter to 0.33 by 0.09 in size, obliquely placed, partly overlapping acetabulum; incloses coiled seminal vesicle, short pars prostatica, and protrusible cirrus.

Ovary rounded, 0.13 to 0.18 millimeter across; at left of, at the same plane as, and partly overlapping, acetabulum. Shell gland diffuse, median, between testes and acetabulum. Receptaculum seminis and Laurer's canal not seen. Uterus with numerous transverse coils, between testes and posterior end of body, intercæcal although overlapping intestinal branches at certain places. Vitellaria in distinct follicles, not arranged into groups; extracæcal, oftentimes asymmetrical: those on left side of body fewer in number and more advanced anteriorly, extending from level of genital pore to anterior portion of last third of body length; those on right side more numerous and extending from middle level of acetabulum to anterior portion of last fourth of body length. Eggs oval, operculated, yellowish brown to brown in color, from 0.031 millimeter by 0.018 millimeter to 0.033 by 0.015 in size.

The excretory bladder, which opens outside through a median posterodorsal pore, is Y-shaped and located behind the blind ends of the intestinal branches. Each horn of the bladder is continued anteriorly as a narrow collecting tubule to the lateral aspect of the pharynx. I was unable to determine from the study of living specimens even the approximate number of capillary branches arising from the collecting tubules and I succeeded in finding only two pairs of flame cells located on the sides of the pharynx.

Host.—*Rana vittigera* Wiegmann.

Location.—Intestine.

Localities.—Los Baños and Bay, Laguna Province, Luzon.

PLEUROGENES TAYLORI sp. nov. Plate 2, figs. 2 and 3.

This trematode is named for Mr. E. H. Taylor, authority on Philippine amphibians and reptiles. According to the key of Kleine (1905) to the known species of the genus *Pleurogenes* Looss, 1896, it is closely allied to *P. gastroporus* Luehe in the apparent absence of an œsophagus, in the position of the genital pore beside the oral sucker, and in the ventral location of the excretory pore near the posterior end of the body. It differs, however, from that species in the position of its testes, which lie anterior to the terminations of the intestinal branches.

Description.—Body oval, rounded at both extremities with posterior end broader; from 0.60 millimeter in length by 0.38 millimeter in maximum width across acetabulum or a little posterior of that level to 0.80 by 0.50. Cuticle armed with conspicuous posteriorly directed spines arranged in transverse rows. Oral sucker circular, ventro-subterminal, 0.13 to 0.16 millimeter across. Acetabulum also circular, a trifle smaller than oral sucker, 0.12 to 0.15 millimeter across, located in middle of body length or a little posterior of that level. Prepharynx absent; pharynx well developed, 0.06 to 0.08 millimeter across; œsophagus absent. Intestinal branches moderately dilated but hidden by genital organs in ventral view; they end in front of middle level of acetabulum. Genital pore sinistral, beside oral sucker.

Testes large, round to oval, from 0.11 millimeter by 0.09 millimeter to 0.17 by 0.13 in size (compressed specimens); located symmetrically immediately in front of middle level of acetabulum. Cirrus sac bottle- or Indian-club-shaped, from 0.21 millimeter by 0.09 millimeter to 0.39 by 0.13 in size; when not retracted, it extends obliquely from median line in front of acetabulum to genital pore; it incloses coiled vesicula seminalis, pars prostatica, and protrusible cirrus.

Ovary rounded or slightly oval, 0.07 to 0.10 millimeter in transverse diameter, dextral, located anteromesially of, and overlapped by, right testis. Receptaculum seminis elongated, beside acetabulum, on the same side as ovary; Laurer's canal present. Uterus well developed, occupying most of space behind acetabulum and testes. Vagina opens behind cirrus. Vitellaria composed of 7 to 9 large, round to oval follicles in anterior part of body in front of testes and ovary. Vitelline follicles not symmetrically placed, those on left side being displaced internally towards median line by cirrus sac. Vitelline reservoir between receptaculum seminis and acetabulum. Eggs elongated, operculated, yellowish to dark brown in color, 0.031 millimeter by 0.015 millimeter in size.

The excretory bladder, which opens outside through a median posteroventral pore, is V-shaped. From each horn of the bladder an anterior and a posterior collecting tubule are given off. As shown in Plate 2, fig. 3, the anterior and posterior collecting tubules each ends in five capillary branches and each capillary is connected to a flame cell. The excretory formula is, therefore, $2 \times 10 \times 1 = 20$ flame cells in all.

Host.—*Rana vittigera* Wiegmann.

Location.—Intestine.

Localities.—Los Baños and Bay, Laguna Province, Luzon.

REPTILIAN TREMATODES

PARADISTOMUM MAGNUM sp. nov. Plate 3, fig. 1.

In specimens killed in hot corrossive sublimate-acetic acid solution without pressure, this fluke conforms to the diagnostic characters of the genus; namely, the oval outline and the symmetrical position of the testes. When fixed, however, under the pressure of a cover glass, it assumes a form somewhat similar to that possessed by the members of the genus *Eurytrema;* that is, it becomes broader and longer and tapers towards both extremities.

This parasite is similar in many respects to the European form, *Paradistomum mutabile* (Molin), but it differs from it in two important characters. In the first place, the ovary of the European species, according to Luehe (1900) and to Rizzo (1902), is spherical or globular, that of the Philippine form being distinctly lobed. In the second place, the eggs of *P. mutabile* are from 0.040 to 0.050 millimeter by 0.025 to 0.026 millimeter in size, those of the present species being from 0.035 by 0.022 to 0.038 by 0.024 in size.

Description.—Body in specimens killed without pressure, oval in general shape, thick, broadly rounded posteriorly, narrower anteriorly, from 1.91 millimeters in length by 1.40 millimeters in maximum width to 2.60 by 1.63; in pressed specimens the body is broad, attenuated towards both ends, from 3.85 by 2.06 to 4.50 by 2.18 in measurements. Cuticle smooth. Oral sucker subterminal, poorly to moderately developed, 0.36 to 0.38 millimeter across. Acetabulum circular in outline, weak, 0.43 to 0.45 millimeter in diameter, situated between anterior and middle thirds of body length. Mouth subterminal; prepharynx absent; pharynx 0.13 to 0.15 millimeter across; œsophagus narrow, 0.19 millimeter long. Intestinal cæca unusually wide in diameter, thin-walled, filled with yellowish to brownish fæcal material; extend to about 0.7 millimeter from posterior end of body. Genital pore preacetabular, median, immediately in front of point of origin of intestinal cæca.

Testes relatively small, oval or pyriform in shape, from 0.23 millimeter by 0.17 millimeter to 0.32 by 0.20 in size; symmetrical, immediately behind posterior level of acetabulum. Seminal vesicle poorly developed; inclosed in elongated cirrus sac, 0.40 millimeter by 0.06 millimeter in size.

Ovary distinctly 3-lobed, 0.13 millimeter by 0.20 millimeter in size, lying to one side of median line immediately behind posterior level of testes. Shell gland distinct, median, slightly lobed. Receptaculum seminis and Laurer's canal present. Uterus in loose irregular coils, mostly posttesticular and post-ovarian, overlapping intestinal branches. Vitellaria in small, round to oval follicles, extracæcal, occupying middle third of body length. Eggs oval, operculated, yellowish or dark brown in color, 0.035 millimeter by 0.022 millimeter to 0.038 by 0.024 in size.

The excretory bladder, which opens outside through a median posterodorsal pore, is voluminous. I was unable to follow its course anteriorly.

Host.—*Hemidactylus frenatus* Duméril and Bibron.

Location.—Gall bladder.

Locality.—Los Baños, Laguna Province, Luzon.

POSTORCHIGENES OVATUS g. et sp. nov. Plate 2, fig. 4.

This trematode presents affinities with the members of the subfamily Pleurogenetinæ Looss, 1899, owing to the arrangement of the genital glands and the location of the genital pore away from the median line. The vitellaria extend, as in the genus *Loxogenes* Stafford, 1905, across the entire body from the pharynx to the acetabulum. In other important respects, however, the species does not fit into any of the genera listed in the subfamily, for which reason a new genus is proposed for its reception.

Generic diagnosis.—Pleurogenetinæ: small distomes with thick, oval or pear-shaped body and with spinous cuticle. Suckers small, poorly developed; acetabulum smaller than oral sucker, in front of equator of body. Pharynx present; œsophagus very short; intestinal branches reach to and beyond center of body. Ovary round to oval, on right side of acetabulum. Bulk of vitellaria dorsal; extend across entire body from pharynx to acetabulum. Laurer's canal and receptaculum seminis present; shell gland diffuse. Uterus postacetabular, postovarian, posttesticular. Testes entire, postacetabular, postovarian, nearly symmetrical on both sides of body. Cirrus sac on left side of acetabulum opposite ovary. Genital pore ventral, sinistral, about midway between center and margin of body at level of acetabulum. Ova small, numerous.

Type species, *Postorchigenes ovatus* sp. nov.

Description of type species.—Body oval or pear-shaped, thick, with rounded ends, from 1.55 millimeters in length by 0.88 millimeter in maximum width across posterior third of body length to 1.66 by 1.10. Cuticle with transverse rows of posteriorly directed spines. Oral sucker subterminal, weak, oval in outline, from 0.15 millimeter by 0.12 millimeter to 0.20 by 0.15 in size. Acetabulum smaller than oral sucker, from 0.11 millimeter by 0.09 millimeter to 0.17 by 0.13 in size, between anterior and middle third of body length. Pharynx weak, 0.06 to 0.07 millimeter across; œsophagus very short, almost nil; intestinal branches slightly wavy in outline, reach to and beyond center of body. Genital pore ventral, sinistral, at posterior level of acetabulum, about midway between center and margin of body.

Testes large, oval, postacetabular, from 0.29 millimeter by 0.24 millimeter to 0.37 by 0.27 in size, nearly symmetrical (left testis usually slightly more advanced anteriorly than its fellow), at or near middle of body length; right testis not as conspicuously seen as left testis in ventral view, being overlapped by uterine coils. Cirrus sac slightly oval, 0.18 to 0.26 millimeter across, sinistral, lying beside, and partly overlapped by, acetabulum; incloses coiled seminal vesicle, pars prostatica, and long muscular cirrus.

Ovary oval, entire, from 0.22 millimeter by 0.16 millimeter to 0.26 by 0.23 in size, dextral, in the same plane as cirrus sac and also slightly overlapped by acetabulum. Receptaculum seminis small, pyriform, postovarian; Laurer's canal present; shell gland diffuse. Uterus profusely developed, occupies nearly all of space in body behind ovary, acetabulum, and left testis. Vitellaria in distinct follicles, the bulk of which occupy a dorsal position across body from pharynx to acetabulum. Eggs oval, operculated, yellowish to dark brown in color, measuring 0.024 millimeter by 0.012 millimeter.

Excretory pore median, posteroventral, its position often marked by an indentation. Excretory bladder V-shaped, its lateral branches being inflated and terminating behind testes.

Host.—*Hemidactylus frenatus* Duméril and Bibron.

Location.—Intestine.

Locality.—Los Baños, Laguna Province, Luzon.

AVIAN TREMATODES

METORCHIS CAINTAENSIS sp. nov. Plate 3, figs. 2 and 3.

This parasite differs from the already known members of the genus *Metorchis* in the position of the vitellaria, which extend from immediately behind the level of the acetabulum to the posterior end of the body. In the other members of the genus the vitellaria do not reach posteriorly beyond the level of the first testis. For this reason, if one were to follow the example of Barker (1911), who divided the related genus *Opisthorchis* (Blanchard) into *Opisthorchis* s. str. and *Amphimerus* on the basis of the extent of the vitellaria, it would be justifiable to erect a new genus for the species under discussion. For the present, however, it seems best to refer it to *Metorchis*.

Description.—Body flat, elongated, tapering anteriorly, from 0.94 millimeter in length by 0.46 millimeter in maximum width to 2.00 by 0.81. Cuticle armed with prominent spines. Oral sucker spherical, from 0.08 to 0.12 millimeter in diameter. Acetabulum weak, from 0.06 to 0.08 millimeter across, situated in very close proximity to oral sucker, sometimes almost at the same level as pharynx. Mouth subterminal; pharynx inconspicuous, 0.05 to 0.08 millimeter in transverse diameter; œsophagus very short or absent; intestinal branches extend to near posterior end of body. Genital pore median, immediately in front of acetabulum.

Testes large, slightly indented so that there are recognizable five lobes in the anterior, and four lobes in the posterior testis; they are placed slightly obliquely one behind the other, filling up most of the space between intestinal cæca and vitelline glands in posterior half of body length. Seminal vesicle prominent and much convoluted.

Ovary rounded, 0.09 to 0.13 millimeter across, partly hidden by uterine coils, anterior of first testis, towards right side of median line. Receptaculum seminis on the same plane as ovary, as large as, and on the left side of, that organ. Laurer's canal present; shell gland diffuse. Uterus conspicuous, occupying most of the space bounded by anterior testis, intestinal cæca and acetabulum in anterior half of body length. Vagina opens on left side of ejaculatory duct. Vitellaria profuse, extracæcal, extending from behind level of acetabulum to posterior end of body, from which point they curve mesoanteriorly to posterior border of second testis. Eggs oval, operculated, yellowish to yellowish brown in color, 0.036 millimeter by 0.021 millimeter in size.

Excretory bladder narrow, opens outside through genital pore at extreme posterior end of body.

Host.—*Hypotænidia philippensis.*

Location.—Intestine.

Locality.—Cainta, Rizal Province, Luzon.

LEUCOCHLORIDIUM DASYLOPHI sp. nov. Plate 4, figs. 1 and 2.

This interesting trematode was obtained in large numbers on two occasions from the cloaca of the rough-crested cuckoo, *Dasylophus superciliosus* (Cuvier). It apparently represents a new species, for it differs in several important respects from the *Leucochloridium* species described by Witenberg (1925) in his monograph on the trematode subfamily Harmostominæ, of which *Leucochloridium* is a member. From *L. insigne* (Looss, 1899) and *L. turanicum* (Soloviev, 1912) it can be recognized at once by the posterior extent of the vitellaria, which do not pass beyond the blind terminations of the intestinal branches. In the position of the vitelline glands and in the location of the acetabulum, it is similar to *L. macrostomum* (Rudolphi, 1802), but it may be separated from that and other related species by the distribution of its uterine coils which reach to the posterior end of the body, thus obscuring or totally hiding the presence of the cirrus sac.

Description.—Body elongated, with rounded extremities, thicker anteriorly than posteriorly, from 2.72 millimeters in length by 1.07 millimeters in maximum width across acetabulum to 3.30 by 1.10. Cuticle armed with delicate spines. Suckers very well developed: oral sucker ventro-subterminal, 0.50 to 0.57 millimeter across; acetabulum in equator of body, 0.70 to 0.75 millimeter across. Mouth ventroterminal; prepharynx absent; pharynx strong, 0.13 to 0.18 millimeter across; œsophagus absent. Intestinal cæca describe a graceful curve anterolaterally before passing posteriorly; they end slightly beyond posterior level of second testis. Genital pore median, dorsal, located at about 0.1 millimeter from posterior end of body.

Testes round, 0.18 to 0.31 millimeter in diameter, obliquely placed on each side of median line in middle of last third of body length; separated by a space equivalent to one-half of their diameters. Cirrus sac very small, oval, near posterior end of body, 0.090 millimeter by 0.072 millimeter in size.

Ovary round, 0.15 to 0.18 millimeter in diameter, to one side of median line in front of second testis. Shell gland diffuse, on posteromesial side of ovary. Receptaculum seminis not seen; Laurer's canal present, open on dorsal surface at about 0.5 millimeter from posterior end of body. Uterus very profuse, extending anteriorly to intestinal arches and posteriorly to near posterior end of body. Laterally the uterine coils overlap intestinal cæca, being bounded for the most part by vitelline glands. Vitellaria in distinct, oval or elongated follicles, extending from level of pharynx to posterior level of anterior testis. Eggs oval, operculated, light to dark brown in color, 0.031 to 0.033 millimeter by 0.18 millimeter in size.

Host.—*Dasylophus superciliosus* (Cuvier).

Location.—Cloaca.

Locality.—Los Baños, Laguna Province, Luzon.

Among the mature forms of *Leucochloridium dasylophi* is a single specimen, which is believed to represent the immature stage of this species in its final host. The body (Plate 5, fig. 2) is pyriform in shape, more rounded anteriorly than posteriorly, measuring 0.92 millimeter in length by 0.37 millimeter in maximum width across the acetabulum. It is thus very much smaller than the immature stage of *Leucochloridium problematicum* Magath, 1920. The cuticle is sparsely covered with delicate spines. The suckers are well developed: oral sucker cup-shaped, ventroterminal, 0.16 millimeter by 0.19 millimeter in size; acetabulum slightly oval, 0.23 by 0.20 in size, at equator of body. Mouth ventroterminal; prepharynx absent; pharynx 0.07 millimeter across; œsophagus absent. Intestinal cæca describe the same graceful curve at point of origin as in the mature form and zigzag moderately towards posterior end of body. Testes rounded, large, arranged obliquely in posterior third of body length. Ovary rounded, anterior of second testis, at about same level as first testis. Cirrus sac in the form of a faint oval structure in median line, posterior of blind ends of intestines. Vitelline glands in distinct follicles, ten to eleven in number; extracæcal, extending from behind level of pharynx to middle level of anterior testis.

HARMOSTOMUM sp. Plate 4, fig. 3.

Numerous immature specimens of a fluke were obtained from the cloaca of the rough-crested cuckoo in company with *Leucochloridium dasylophi.* They are believed to represent a species of *Harmostomum* due to the arrangement of the reproductive glands and to the position of the genital pore.

Description.—Body elongated, rounded at both extremities, 1.64 millimeters in length by 0.29 millimeter in maximum width across pharynx to 1.75 by 0.36. Cuticle armed with small spines. Oral sucker ventroterminal, oval in outline, 0.29 millimeter by 0.18 millimeter to 0.32 by 0.22 in size. Acetabulum slightly oval, 0.26 millimeter by 0.21 millimeter to 0.28 by 0.24 in size, located anterior to middle of body length. Pharynx globular, 0.11 to 0.13 millimeter across; œsophagus absent. Intestinal cæca pass anterolaterally on both sides of pharynx, describe acute angles, and then pass in moderate zigzags to posterior end of body. Genital pore median, immediately in front of first testis.

Testes round to oval, 0.11 to 0.15 millimeter long by 0.09 to 0.10 millimeter wide, one behind the other in last fourth of body length. Cirrus sac pear-shaped, immediately in front of first testis.

Ovary oval, 0.08 to 0.09 millimeter by 0.06 to 0.07 millimeter in size, between, and slightly overlapped by, testes. Uterus represented by a narrow canal going from ovary towards acetabulum, from which point it doubles on itself and runs posteriorly towards genital pore. Vitellaria extracæcal, in groups of eight to nine minutely granular follicles, extending from immediately behind acetabulum to anterior or middle level of cirrus pouch.

Excretory bladder narrow, opens outside through a posteroterminal excretory pore.

Host.—*Dasylophus superciliosus.*

Location.—Cloaca.

Locality.—Los Baños, Laguna Province, Luzon.

STOMYLOTREMA ROTUNDA sp. nov. Plate 4, fig. 4.

Among the members of the genus *Stomylotrema* Looss, 1900, this parasite appears to be most similar to *S. bijugum* Braun, 1901, but it may be differentiated from the latter by the appearance and extent of its vitellaria and by the size of its eggs. In *S. bijugum* the vitelline follicles are in the form of a "3" or an "8" and extend posteriorly beyond the middle level of the acetabulum; in the present form the vitelline glands are irregularly shaped and do not reach beyond the middle level of the acetabulum. In *S. bujugum* the eggs are brown in color and measure 0.019 millimeter by 0.014 to 0.018 millimeter; in *S. rotunda* they are yellowish in color and measure 0.032 to 0.034 by 0.020.

Description.—Body round to oval, curved ventrally, with rounded extremities, from 1.32 millimeters in length by 0.70 millimeter in maximum width across testes or immediately posterior of that level to 1.64 by 0.96. Cuticle smooth. Suckers very strongly developed; oral sucker subterminal, 0.41 to 0.52 millimeter across; acetabulum posteroventral, immediately behind testes, 0.45 to 0.55 millimeter across. Pharynx immediately behind oral sucker, globular, 0.14 to 0.19 millimeter across; œsophagus absent; intestinal branches reach to posterior end of body behind acetabulum. Genital pore lateral, dextral, in front of anterior level of pharynx.

Testes rounded or very slightly oval, 0.18 to 0.21 millimeter across, symmetrically placed immediately behind middle of body length. Cirrus sac slender, pointed at distal end, from 0.41 millimeter by 0.07 millimeter to 0.55 by 0.09 in size.

Ovary rounded, 0.13 to 0.15 millimeter across, to one side of median line opposite base of cirrus sac. (Another way of describing the location of the ovary is to state that it is between the pharynx and the left testis, a straight line drawn through the two organs touches the ovary.) Diffuse shell gland and vitelline reservoir near center of space bounded by testes, ovary, and cirrus sac. Uterine coils well distributed between different genital glands, crossing and hiding intestinal branches in several places and looped around acetabulum posteriorly. Vagina opens behind male organ into genital pore. Vitelline glands in irregularly shaped follicles, seven on right side and nine on left, not reaching posteriorly behind middle level of acetabulum. Eggs oval, operculated, yellowish in color, 0.032 to 0.034 millimeter by 0.020 millimeter in size.

Host.—*Hypotænidia philippensis* (Linnæus).

Location.—Intestine.

Locality.—Cainta, Rizal Province, Luzon.

MAMMALIAN TREMATODES

LECITHODENDRIUM OVIMAGNOSUM Bhalerao, 1926. Plate 5, fig. 1.

Specimens collected from the Philippine bat *Scutophilus temminckii* (Horsfield) bear such a very close resemblance to a species of fluke described from the Burmese bat *Nyctinomus plicatus*, by Bhalerao (1926), that I think they are of the same species in spite of apparent differences in total size, egg measurements, and size of ovary. The following description is based on Philippine material.

Description.—Body pyriform to oval, depending upon the state of preservation; usually broadly rounded posteriorly in specimens fixed without pressure in corrosive sublimate acetic acid solution and moderately attenuated anteriorly; from 0.36 millimeter in length by 0.26 millimeter in maximum width across acetabulum or immediately posterior of that level to 0.104 by 0.80. Cuticle unarmed. Oral sucker circular, 0.06 to 0.12 millimeter in transverse diameter. Acetabulum smaller than oral sucker, 0.05 to 0.10 millimeter across, located at or near equator of body. Mouth subterminal; pharynx immediately behind oral sucker, 0.03 to 0.05 millimeter across; œsophagus absent; intestinal cæca very short, reaching posteriorly as far as anterior borders of testes. Genital pore median, about midway between pharynx and acetabulum.

Testes transversely oval, from 0.10 millimeter by 0.15 millimeter to 0.12 by 0.20 in size; symmetrically placed on both sides of acetabulum and on a level with that organ. Cirrus sac prominent, circular, 0.07 to 0.14 millimeter in diameter, situated between pharynx and acetabulum; incloses a much-coiled seminal vesicle, pars prostatica, and apparently nonprotrusible cirrus.

Ovary relatively large, 0.20 to 0.25 millimeter across, distinctly lobed, somewhat like an acanthus leaf in shape; lies between testes, inclined towards one side of median line. Shell gland diffuse, receptaculum seminis small, and Laurer's canal present. The latter structures and the vitelline reservoir are located posterior of the ovary. Uterus posttesticular, postacetabular. Vitellaria in distinct, few, but relatively large follicles, arranged symmetrically on both sides of pharynx anterior of testes. Eggs oval, operculated, yellowish brown in color, 0.026 millimeter by 0.014 millimeter in size.

Excretory bladder V-shaped, voluminous, opening outside through a median posterior excretory pore. Arms of bladder reach anteriorly to level of acetabulum.

Host.—*Scutophilus temminckii.*

Location.—Intestine.

Locality.—Los Baños, Laguna Province, Luzon.

LECITHODENDRIUM LUZONICUM sp. nov. Plate 5, figs. 2 and 3.

This species differs from *L. ovimagnosum* by its elongated shape and larger size, by its well-developed and cup-shaped oral sucker, and by its unlobed ovary. It seems not to fit into the key of *Lecithodendrium* species prepared by Bhalerao (1926), for which reason it is here considered as a new species.

Description.—Body elongated, from 1.10 millimeter in length by 0.44 millimeter in maximum width at, or immediately behind, acetabulum to 1.37 by 0.46. Cuticle unarmed. Oral sucker ventroterminal, well developed, measuring from 0.26 millimeter by 0.16 millimeter to 0.28 by 0.17. Acetabulum much smaller than oral sucker, circular in outline, 0.14 to 0.15 millimeter across, lying at about middle of body length or a little anterior of that level. Mouth ventroterminal; pharynx, 0.07 to 0.09 millimeter across, immediately follows oral sucker; œsophagus absent; intestinal cæca short, with a posterolateral course, ending in front of testes. Genital pore median, between acetabulum and pharynx but closer to latter.

Testes round to oval, 0.10 to 0.12 millimeter across, symmetrically placed on each side of median line in front of acetabulum. Cirrus sac large, circular in outline, 0.13 to 0.16 millimeter across, pretesticular, preoverian, partly overlapping latter organs. Seminal vesicle much coiled, inclosed in cirrus sac.

Ovary round to oval, median, intertesticular, 0.07 to 0.08 millimeter across. Shell gland distinct, circular or oval in outline (Plate 7, fig. 2). Receptaculum seminis flasked-shaped; Laurer's canal dilated. Uterus postacetabular, posttesticular. Vitellaria in distinct follicles on each side of pharynx, reaching anteriorly as far as middle level of oral sucker and posteriorly to testes. Eggs oval, operculated, yellowish brown in color, 0.037 millimeter by 0.016 millimeter in size.

Excretory pore median, terminal. Excretory bladder roomy, V-shaped, reaching anteriorly as far as acetabulum.

Host.—*Scutophilus temminckii* (Horsfield).

Location.—Small intestine.

Locality.—Los Baños, Laguna Province, Luzon.

PLATYNOSOMUM PHILIPPINORUM sp. nov. Plate 5, fig. 4.

This distome presents two features that are unusual for a member of the subfamily Dicrocoellinæ; namely, its location in the small intestine of the host, the other members of the subfamily, with the exception of *Eurytrema ovis* Tubangui, 1925, inhabiting the gall bladder or pancreatic duct of their hosts; and the posession of a spinous cuticle, the cuticle of the known members of the subfamily, with the exception of *Dicrocoelium macaci* Kobayashi, 1921, being unarmed.

Description.—Body elongated or lancet-shaped, from 1.93 millimeters in length by 0.54 millimeter in maximum width at middle of body length or slightly anterior of that level to 2.27 by 0.56. Cuticle armed with small spines which become scarce from the middle of the body length to posterior end. Oral sucker subterminal, cup-shaped, 0.16 to 0.22 millimeter across. Acetabulum smaller than oral sucker, 0.11 to 0.17 millimeter across, situated in anterior portion of middle third of body length. Mouth subterminal; pharynx, 0.07 to 0.09 millimeter across, immediately behind oral sucker; œsophagus about 0.05 millimeter long. Intestinal cæca often wider in diameter near point of origin, reaching to near posterior end of body. Genital pore median, preacetabular.

Testes relatively large, oval (seldom pear-shaped), symmetrical, immediately postacetabular; measure from 0.27 millimeter by 0.13 millimeter to 0.34 by 0.16 in size. Cirrus sac pear-shaped, median, immediately preacetabular, from 0.11 millimeter by 0.09 millimeter to 0.15 by 0.11 in size; incloses the much-coiled seminal vesicle, pars prostatica, and cirrus.

Ovary round to oval, median, immediately posttesticular, 0.09 to 0.14 millimeter across. Shell gland distinct, of about the same shape and size as ovary and situated behind that organ. Receptaculum seminis and Laurer's canal present. Uterus in transverse coils behind testes, partly overlapping intestinal cæca and reaching posteriorly beyond blind terminations of latter. Vitellaria in distinct rounded follicles, extending from middle or posterior level of ovary to about 0.30 to 0.34 millimeter from posterior end of body. Transverse vitelline ducts unite to form a roundish vitelline reservoir lying dorsal to shell gland. Eggs oval, operculated, yellowish brown in color, 0.026 millimeter by 0.016 millimeter in size.

Excretory pore median, posterodorsal. Excretory bladder narrow; divides into two lateral branches in the region of shell gland, each lateral branch in turn dividing into anterior and posterior vessels.

Host.—*Scutophilus temminckii* (Horsfield).

Location.—Small intestine.

Locality.—Los Baños, Laguna Province, Luzon.

LITERATURE CITED

BARKER, F. D. The trematode genus Opisthorchis. Studies from the Zool. Lab., Univ. Nebr. No. 103 (1911) 514–561.

BHALERAO, G. D. The intestinal parasites of the bat (Nyctinomus plicatus) with a list of the trematodes hitherto recorded from Burma. Journ. Burma Res. Soc. 15 (1926) 181–195.

BHALERAO, G. D. A new species of trematode from Nycticejus pallidus, with a key to the species of Lecithodendrium. Ann. & Mag. Nat. Hist. 18 (1926) 299–304.

BRAUN, M. Fascioliden der Vogel. Zoöl. Jahrb., Abt. f. Syst. 16 (1902) 1–99.

GOLDBERGER, J. Some known and three new endoparasitic trematodes from American fresh-water fish. Hyg. Lab. Bull. No. 71 (1911) 5–35.

KLEINE, W. Neue Distomen aus Rana hexadactyla. Zoöl. Jahrb., Abt. f. Syst. 22 (1905) 59–80.

KOBAYASHI, H. On some digenetic trematodes from Japan. Parasit. 12 (1921) 380–410.

LINTON, E. Helminth fauna of the Dry Tortugas. II. Trematodes. Papers from the Tortugas Laboratory of the Carnegie Institution of Washington 4 (1910) 11–98.

LOOSS, A. Weitere Beitrage zur Kenntniss der Trematoden-Fauna Aegyptens, zugleich Versuch einer naturlichen Gliederung des Genus Distomum Retzius. Zoöl. Jahrb., Abt. f. Syst. 12 (1899) 521–784.

LUEHE, M. Ueber einege Distomen aus Schlangen und Eidechsen. Centralbl. f. Bakteriol., Parasitenk. 1. Abt. 28 (1900) 555–566.

MAGATH, T. B. Leucochloridium problematicum n. sp. Journ. Parasit. 6 (1920) 105–114.

OZAKI, Y. Preliminary notes on a trematode with anus. Journ. Parasit. 12 (1925) 51–53.

RIZZO, A. La fauna elmintologica deì rettili nella Provincia di Catania. Archives de Parasit. 6 (1902) 26–41.

TRAVASSOS, L. Contribucoes para o conhecimiento dos helminthos dos batraquios do Brasil. I. Trematodeos intestinais. Sciencia Medica 2 (1924) 1–11.

TUBANGUI, M. A. Metazoan parasites of Philippine domesticated animals. Philip. Journ. Sci. 28 (1925) 11–37.

WARD, H. B. Parasitic flatworms. In: Fresh-Water Biology, by Ward and Whipple, 1st ed. John Wiley and Sons, Inc., New York (1918) 365–453.

WITENBERG, G. Versuch einer Monographie der Trematodenunterfamilie Harmostominae Braun. Zoöl. Jahrb., Abt. f. Syst. 51 (1925–26) 167–254.

ILLUSTRATIONS

ABBREVIATIONS

ac, acetabulum.
an, anus.
cir, cirrus.
cp, cirrus pouch.
cs, cirrus sac.
eb, excretory bladder.
ep, excretory pore.
gp, genital pore.
int, intestine.
lc, Laurer's canal.
od, oviduct.
oes, œsophagus.
oo, oötype.
os, oral sucker.
ov, ovary.
ph, pharynx.
pph, prepharynx.
rs, receptaculum seminis.
sg, shell gland.
sp, spines.
t, testis.
ut, uterus.
vag, vagina.
vd, vitelline duct.
ve, vas efferens.
vg, vitelline gland.
vr, vitelline reservoir.
vs, vesicula seminalis.

PLATE 1

FIG. 1. *Opecoelus minimus* sp. nov., ventral view.
2. *Opecoelus minimus* sp. nov., ventral view showing details of excretory system.
3. *Metadena microvata* sp. nov., ventral view.
4. *Azygia pristipomai* sp. nov., ventral view.

PLATE 2

FIG. 1. *Glyptelmins staffordi* sp. nov., ventral view.
2. *Pleurogenes taylori* sp. nov., ventral view.
3. *Pleurogenes taylori* sp. nov., ventral view showing details of excretory system.
4. *Postorchigenes ovatus* g. et sp. nov., ventral view.

PLATE 3

FIG. 1. *Paradistomum magnum* sp. nov., ventral view.
2. *Metorchis caintaensis* sp. nov., ventral view.
3. *Metorchis caintaensis* sp. nov., median section through anterior part of body.

PLATE 4

FIG. 1. *Leucochloridium dasylophi* sp. nov., ventral view (mature form).
2. *Leucochloridium dasylophi* sp. nov., ventral view (immature form).
3. *Harmostomum* sp., ventral view.
4. *Stomylotrema rotunda* sp. nov., ventral view.

PLATE 5

FIG. 1. *Lecithodendrium ovimagnosum* Bhalerao, 1926; ventral view.
2. *Lecithodendrium luzonicum* sp. nov., ventral view.
3. *Lecithodendrium luzonicum* sp. nov., female reproductive system in ventrolateral aspect.
4. *Platynosomum philippinorum* sp. nov., ventral view.

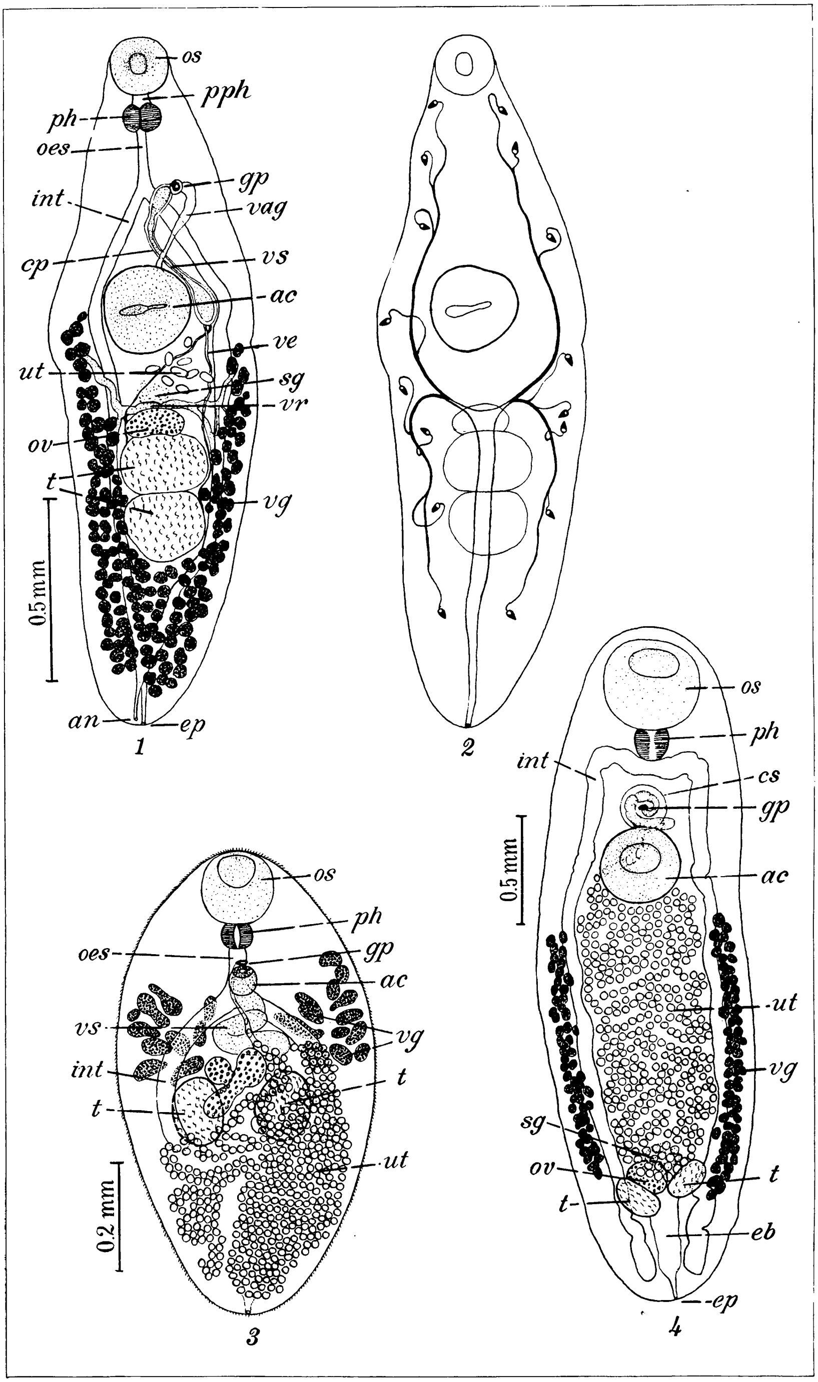

os
pph
ph
oes
gp
int
vag
cp
vs
ac
ve
ut
sg
vr
ov
t
vg
0.5 mm
an
ep
1
2
os
ph
int
cs
gp
0.5 mm
ac
ut
vg
sg
ov
t
eb
ep
4
os
ph
oes
gp
ac
vs
vg
int
t
ut
0.2 mm
3

PLATE 1.

[PHILIP. JOURN. SCI., 36, No. 3.

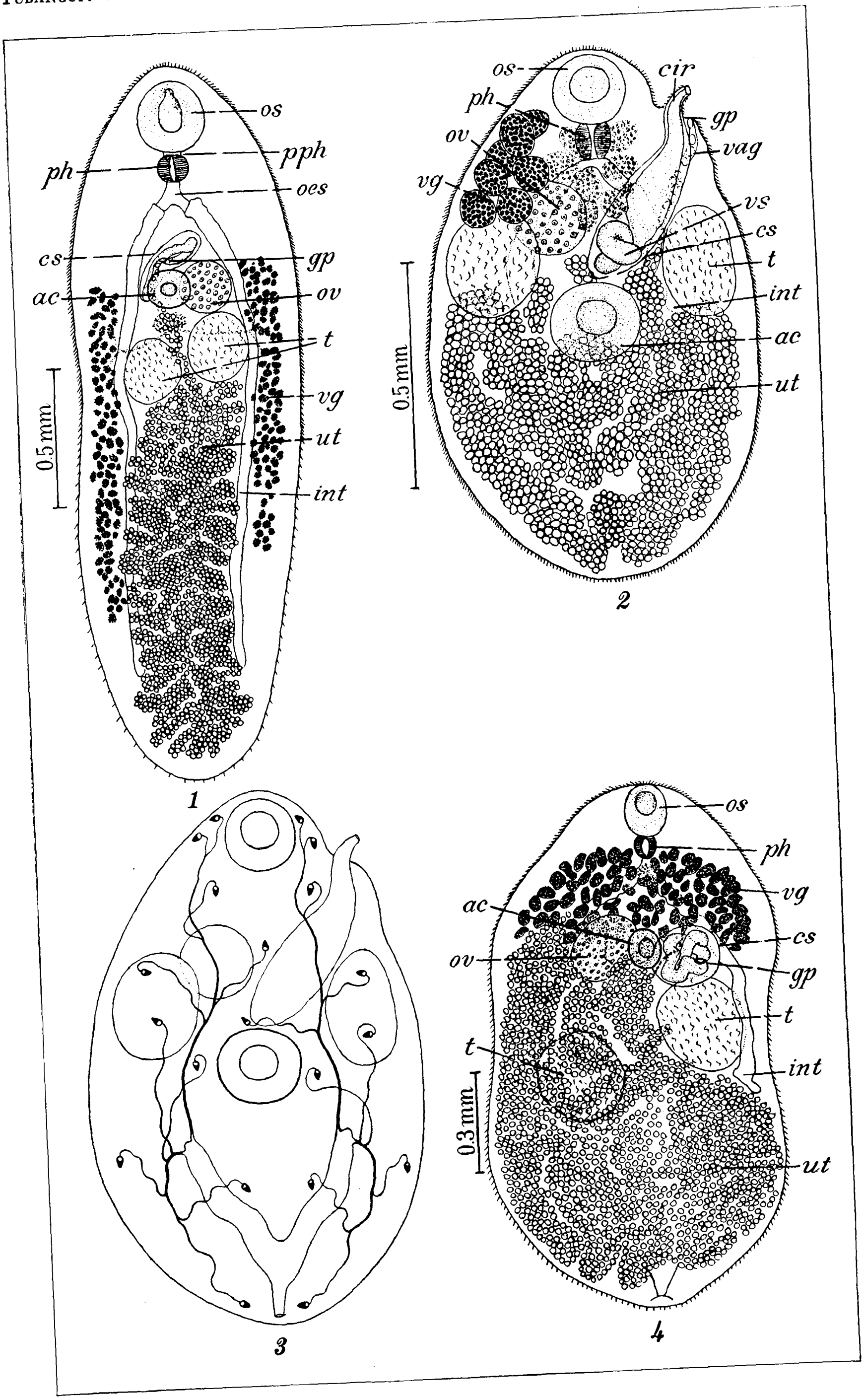


PLATE 2.

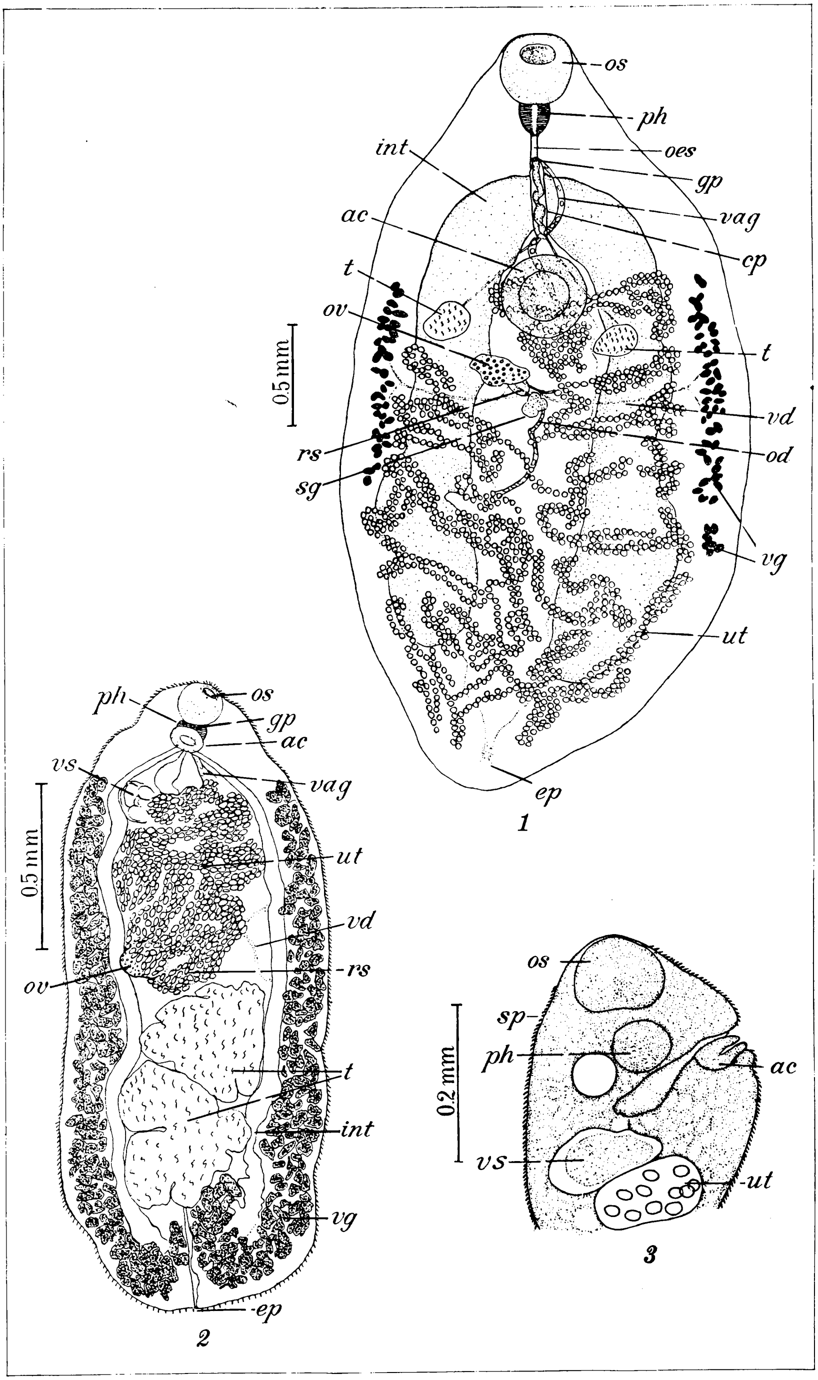
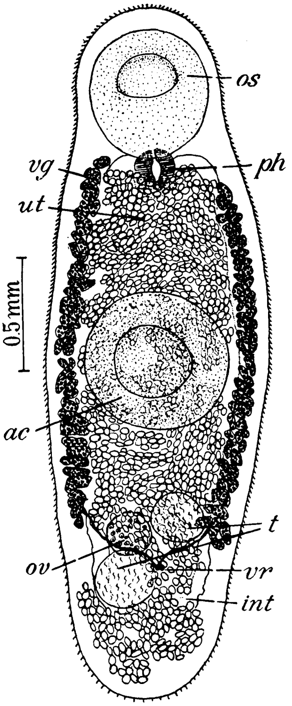
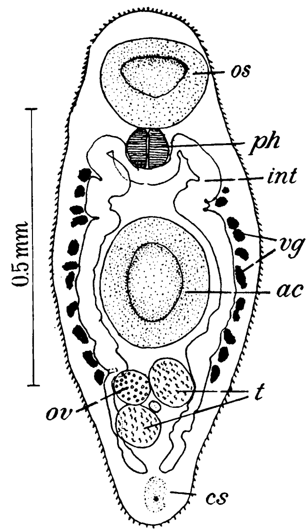

os
ph
oes
int
gp
vag
ac
cp
t
ov
0.5 mm
t
vd
rs
od
sg
vg
ut
ep
1
ph
os
gp
ac
vs
vag
0.5 mm
ut
vd
ov
rs
t
int
vg
ep
2
os
sp
ph
ac
0.2 mm
vs
ut
3

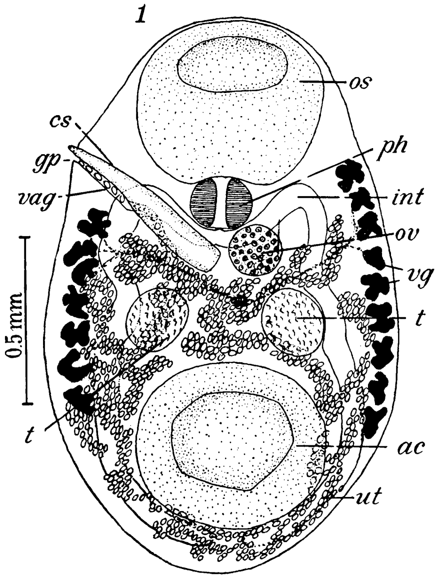
PLATE 3.


os
vg
ph
ut
0.5 mm
ac
t
ov
vr
int

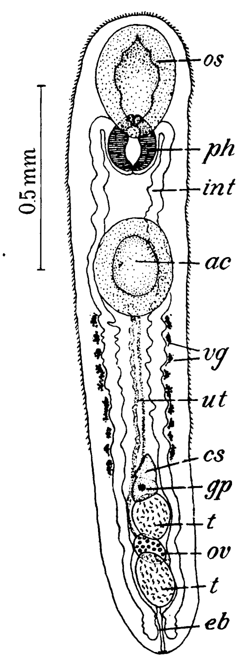
1


os
ph
int
0.5 mm
vg
ac
t
ov
cs

2


os
cs
gp
ph
vag
int
ov
vg
0.5 mm
t
t
ac
ut

3


os
ph
0.5 mm
int
ac
vg
ut
cs
gp
t
ov
t
eb

4

PLATE 4.

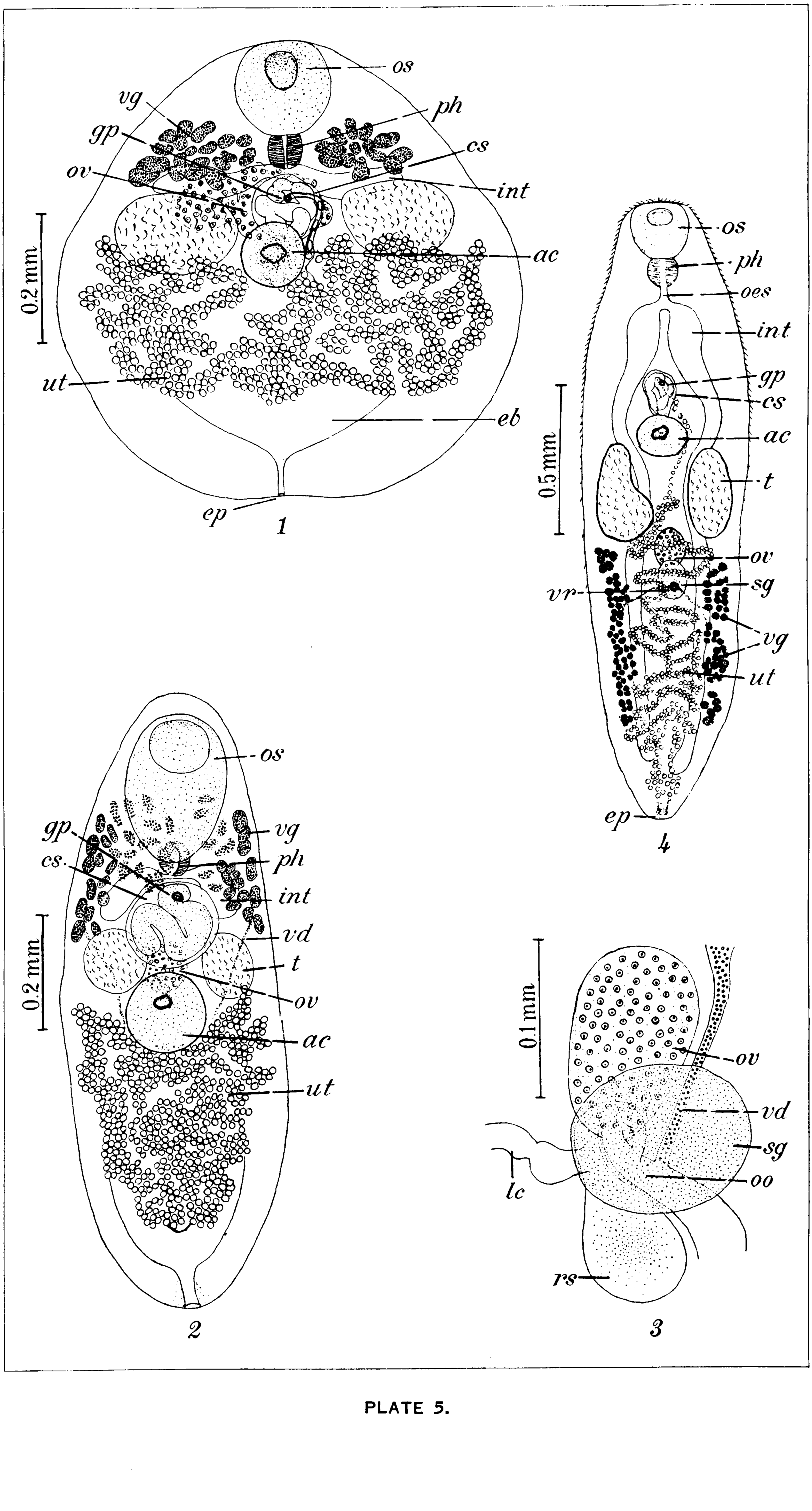

os
vg
ph
gp
cs
ov
int
ac
0.2 mm
ut
eb
ep
1
os
ph
oes
int
gp
cs
ac
0.5 mm
t
ov
vr
sg
vg
ut
ep
4
os
gp
vg
cs
ph
int
vd
0.2 mm
t
ov
ac
ut
2
0.1 mm
ov
vd
sg
lc
oo
rs
3

PLATE 5.

CONTENTS

The Philippine Journal of Science is issued twelve times a year. The sections were discontinued with the completion of Volume XIII (1918).

Yearly subscription, beginning with Volume XIV, 5 dollars United States currency. Single numbers, 50 cents each.

Publications sent in exchange for the Philippine Journal of Science should be addressed: Library, Bureau of Science, Manila, P. I.

Subscriptions may be sent to the BUSINESS MANAGER, Philippine Journal of Science, Bureau of Science, Manila, P. I., or to any of the agents listed on the third page of this cover.

Entered at the post office at Manila, P. I., as second-class matter.

THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 36 AUGUST, 1928 NO. 4

AN IMPROVED VACCINE FOR IMMUNIZATION AGAINST RINDERPEST [1]

By R. A. KELSER

Major, Veterinary Corps, United States Army, and member of the United States Army Medical Department Research Board
Manila

WITH THE COLLABORATION OF

STANTON YOUNGBERG and TEODULO TOPACIO

Of the Bureau of Agriculture, Manila

FOUR TEXT FIGURES

In the Philippine Islands agriculture constitutes the very backbone of the country's resources. Thus, any factor that impedes or in any way interferes with agricultural development, to an equivalent extent, hinders the economic development of the Islands generally.

In his agricultural pursuits the Filipino farmer finds the carabao (water buffalo) an indispensible factor. Take away his carabao and his ability to work his rice paddies and sugarcane fields, and transport his products is seriously interferred with. Thus, in the present order of things in the Philippines the carabao is a real necessity, and any agent or condition that threatens the well-being of this animal is a serious menace to agriculture.

While quite resistant to many of the ailments of the lower animals, the carabao is highly susceptible to rinderpest, an acute,

[1] Published with permission of the Surgeon General, United States Army, who is not responsible for any opinion expressed or conclusions reached herein.

febrile, contagious disease, caused by an ultramicroscopic, filterable virus. The mortality rate is exceedingly high, the disease proving fatal in a high percentage of cases. Thus, rinderpest has proven a serious menace to the common type of work animal employed in the promotion of agriculture in the Philippines.

Cattle are likewise very susceptible to rinderpest and readily succumb to its ravages. The disease has proven by far the biggest obstacle in the development of cattle raising and dairying in the Philippines.

It is believed that rinderpest was first introduced into the Philippine Islands in 1886 or 1887, presumably from Indo-China. It has since spread to various islands of the Archipelago and to date has taken a toll in animal lives amounting to hundreds of thousands. According to figures compiled by the Philippine Bureau of Agriculture, over 180,000 deaths from rinderpest were officially reported during the ten years preceding 1927. This figure represents actually reported deaths from the disease. Obviously, some cases occur that are not reported, so in reality the loss has, without doubt, been greater than that indicated.

Figures on the animal population of the Philippines indicate that in 1926 there were 1,824,842 carabaos and 1,021,169 cattle in the Islands. During the ten years ending with 1926 (the last year for which we have figures) the average annual increase in carabaos and cattle was approximately 97,500 animals. The average annual loss from rinderpest during the same period was approximately 18,000 animals. Thus, the average annual death rate from rinderpest during the years 1917 to 1926, inclusive, was more than 18 per cent of the average annual increase in carabaos and cattle.

The seriousness of rinderpest in the Philippine Islands is thus very apparent. The problem has been recognized by all students of economic conditions in the Islands; and, as the late Governor-General Wood stated, in certain sections of the Philippines it destroys so many animals as to interfere seriously with the economic development of the people.

In countries where rinderpest has been a problem a vast amount of work has been done with a view to finding a cure for the disease or a satisfactory means of immunizing susceptible animals against it.

Following reports that the Boers had, for a long time, obtained good results with bile in immunizing animals in the Transvaal against rinderpest, Koch,(1) in 1897, investigated their claims. He found that when bile from cattle dead of rinderpest was administered in rather large amounts to susceptible animals it afforded them considerable protection against subsequent infection. Koch's observations were soon confirmed by Kohlstock,(2) Kolle,(3) Theiler,(4) Turner,(5) and a number of others.

Edington(6) recommended the addition of 1 part of glycerin to 2 parts of bile when using the latter for immunization purposes. Then, in order to produce a more substantial immunity, Kohlstock(7) recommended giving animals that had received the bile treatment 0.20 cubic centimeter of virulent blood about two weeks subsequent to the injection of bile.

The bile, and bile and virulent blood method of immunization against rinderpest have been used on a rather large scale and up to the time better methods were developed they served a useful purpose.

In 1893 Semmer(8) reported that the blood of animals that had recovered from rinderpest possessed considerable merit as an immunizing agent. This finding was not taken advantage of on any appreciable scale until some years afterwards. However, the observation was later confirmed by several investigators. Further, it was demonstrated that a more-potent serum could be produced by administering increasing amounts of virulent blood to immune animals used for serum production. Thus, the use of antirinderpest serum became an important factor in the treatment and prevention of the disease.

In the treatment of rinderpest it was soon found that in order to obtain favorable results with serum it must be administered very early in the disease and be given in relatively large amounts.

As an immunizing agent it was found that, as with most serums, the immunity conferred is of short duration. This led Kolle and Turner(9) and several others to introduce the simultaneous method of immunization. In this method susceptible animals are given an injection of antirinderpest serum, the administration of the serum being immediately followed by an injection of 1 or 2 cubic centimeters of virulent blood.

The simultaneous method of immunization against rinderpest has, without question, been of great value in controlling the disease. It has, however, several distinct shortcomings. In the first place, a certain percentage of animals receiving this treatment develop severe reactions and some losses from rinderpest occur as a direct result of vaccination. Then, reacting animals are readily capable of spreading rinderpest to susceptible animals if contact is afforded, hence this feature must always be given due consideration when the simultaneous method of immunization is contemplated.

In 1916 and 1917 Boynton,(10) working with rinderpest in the Philippines, carried out a series of experiments to determine the infectiousness of various tissues from animals dead of rinderpest. Among the experimental animals used in connection with this work he had several head of cattle which had been injected with tissue preparations in which the virus had either died out or had become reduced in virulence to the point where it would not produce disease. On subsequently inoculating these animals with virulent blood, Boynton found that they resisted the infection with little or no reaction. This finding immediately suggested the possibility of a vaccine, prepared from the various tissues, as a satisfactory means of immunizing cattle and carabaos against rinderpest.

For some years following this observation Boynton devoted his time to the development of such an immunizing agent and finally succeeded in producing a vaccine of considerable merit. In 1920 the Government of the Philippine Islands put this vaccine into use on a large scale, and it has proved of great value in rinderpest control work in the Islands.

As prepared by the Philippine Bureau of Agriculture, Boynton's vaccine consisted of a heated, glycerinized and phenolized mixture of blood and finely ground tissues (spleen, liver, kidneys, lymph glands, heart, and testicles) taken from animals destroyed in the acute stages of rinderpest. The blood content made up from one-third to one-fourth of the bulk, and the proportion of phenolized glycerin added was equal to one-third the weight of the blood and tissue. The reaction of the glycerin used was about p_H 7.8. The mixture was heated for three hours in a water bath maintained at 42° C. For use this concentrated vaccine was diluted with a fluid consisting of $33\frac{1}{3}$ per cent glycerin in physiological saline solution.

Kakizaki(11) and his associates Nakanishi, Oizumi, and Nakamura, of the Institute for Veterinary Research of Chosen, Japan, have done a large amount of work with rinderpest vaccine and report excellent results in the control of the disease with vaccines prepared from various tissues of animals affected with rinderpest.

In his early work Kakizaki employed an emulsion of spleen tissue in which the virus had been killed by prolonged contact with glycerin. The handicap with this vaccine was the long period of time required for its preparation. Later this investigator and his associates used heat and such chemicals as phenol, toluol, alcohol, ether, iodine, and eucalyptol in their vaccine experiments. Of these agents eucalyptol and toluol gave encouraging results.

In the last report received, it is indicated that Kakizaki and his coworkers are destroying the rinderpest virus in their vaccine through the combined action of heat, glycerin, and toluol. Two to three parts of glycerin and 8 to 10 per cent toluol are added to the tissue mixture which is then incubated at 37.5° C. for seven to ten days.

While toluol is undoubtedly of value in preparing rinderpest vaccine, we have found that its use results in a very viscid preparation which offers considerable difficulty in administration. Further, absorption of toluolized vaccine is very slow.

In the Philippines the vaccine prepared according to Boynton's method has, without question, been of very definite value. However, there are several factors in connection with its production that have proved to be very serious. In the first place, after preparation the vaccine must be allowed to age at refrigerator temperature for a period varying from one to as much as six or seven months before it can be used without danger of producing rinderpest. Then after it has reached the point where it can be safely injected it must be used within a relatively short period of time as it loses its potency as an immunizing agent rather rapidly, in some instances in five or six weeks. Further, in a few instances, it has happened that after a lot of vaccine was held for a long period in order to be able to inject it with safety, it was found worthless for immunizing purposes.

The seriousness of these shortcomings is obvious. First, no appreciable surplus of vaccine, ready for use, can be maintained on hand because of its poor keeping qualities. Then, in the face of a serious outbreak of rinderpest it is impossible to quickly increase the vaccine output because of the long period of time required to properly age the product. Thus, it is obvious that before the effects of an increase in production can be realized an outbreak of the disease can have spent itself.

In February, 1926, the United States Army Medical Department Research Board, at the request of the late Governor-General Wood and the Bureau of Agriculture, undertook a study of the rinderpest vaccine prepared by the Bureau of Agriculture with a view to improving it. As a result of this investigation, the board, working in coöperation with the Bureau of Agriculture, has been able to produce a highly potent rinderpest vaccine which can be safely used within a few hours after preparation. Immunization experiments carried out with a large number of cattle and carabaos have fully established the value of this vaccine. While more time will be required to determine the maximum period of time this vaccine will keep, we have thus far demonstrated that it retains its potency for at least a year. Several preliminary reports (12) on this work have already been published.

VACCINE PREPARED BY THE MEDICAL DEPARTMENT RESEARCH BOARD

During the first few months of our investigations various attempts were made to develop a means by which we could promptly destroy the rinderpest virus in tissue and blood mixtures without injuring the material as an immunizing agent. This work involved the use of varying degrees of heat, and the use of such chemicals as glycerin, toluol, phenol, and finally chloroform. In our early endeavors, in addition to work with mixtures of tissues and blood, we tried to develop filtrates of tissue extracts and also precipitates that could be used as immunizing agents. The result of such efforts were all more or less unsatisfactory until we developed our chloroform-treated vaccine. We found that when chloroform was added, in proper proportion, to a mixture of blood and finely ground tissues from an animal killed in the acute stages of rinderpest, the virus was promptly destroyed. It was further ascertained that such mixture could then be safely used as an immunizing agent with excellent results.

Our next step was to determine whether or not all of the tissue constituents entering into the preparation of the vaccine were of value. Work along this line definitely demonstrated that the blood constituent was of no value as an immunizing agent. It was thus obvious that vaccines containing blood were diluted with an inert agent which, because of its nature, detracted very materially from the keeping qualities of the vaccine. In so far as the various tissues are concerned, it was found that vaccines prepared from the lymph glands, spleen, liver, and from a mixture of kidney and testicular tissues, respectively, were all effective as immunizing agents. As a result of these findings the blood was omitted in the preparation of our vaccine.

We found that the mesenteric glands frequently contained pathogenic, spore-bearing organisms (*Clostridium oedematis-*

maligni, C. tetani, etc.). In order to eliminate possible trouble from such source the mesenteric glands were omitted in the preparation of our vaccine.

After discarding the blood as a constituent of the vaccine its consistency was changed to such an extent as to offer difficulty when it came to injection. This condition was overcome by adding sterile physiological saline solution to the ground tissues. Our method of preparing the vaccine is as follows:

Susceptible cattle are inoculated subcutaneously with 2 to 10 cubic centimeters of fresh, citrated blood from an animal in the acute stages of rinderpest. The infected animals usually develop temperature evidence of rinderpest on the third day following inoculation. A day or two later the characteristic diarrhœa sets in together with other manifestations of acute rinderpest. With the onset of diarrhœa the temperature starts to drop. At this point the animals are bled to death and with aseptic precautions the spleen, liver, and various glands (submaxillary, prescapular, inguinals, etc.) are removed and placed in sterile, covered containers. The mesenteric glands are, for reasons previously stated, omitted.

In the beginning we included the kidneys and testicles in the preparation of the vaccine. As now prepared these organs are omitted. The kidneys have been found frequently to contain bacteria, and the testicles are of low potency for vaccine production.

The collected tissues are then conveyed to the laboratory and as much of the fat and fasciæ as possible carefully trimmed from them. The organs are next placed in a 5 per cent solution of phenol for fifteen minutes and then carefully rinsed in two changes of sterile water. The tissues are then cut in pieces of convenient size to put through a large, sterilized food chopper, the ground material being collected in a sterile container as it comes through the machine. This ground tissue is then carefully covered to prevent contamination and placed in the refrigerator at a low temparture (2° C.) and allowed to remain until the following day. After thus standing the tissue grinds better.

The next step is to put the ground material through a specially constructed grinder which will grind the tissue so fine that most of the mass can be readily worked through a forty-mesh sieve. In using this grinding machine it is sterilized and the tissues put through it five or six times, grinding a little finer each time. With the aid of a sterile pestle this finely divided tissue is immediately worked through a sterile, forty-mesh sieve into a sterile, tared container. The weight of the tissue is ascertained and for each gram of tissue 1 cubic centimeter of sterile physiological saline solution is added and a thorough mixture made. This is then placed in sterile stock bottles and sufficient chloroform added to give a concentration of 0.75 per cent. The bottles are then tightly stoppered, well shaken, dipped in a 10 per cent solution of liquor cresolis compositus, and stored in the refrigerator. The chloroform destroys the rinderpest virus within several hours and is not detrimental to the immunizing constituent of the vaccine. In most of our experiments the vaccine has been used within forty-eight hours after preparation.

The grinding of the tissue is an important part of the process. First the tissue must be finely divided to permit the chloroform to quickly destroy the rinderpest virus. Then a finely divided state is essential in order that the finished product may be readily injected without clogging the syringe needle.

While not absolutely essential, it has also been our practice to shake the bottles of vaccine several times during the period they are in the refrigerator, for the purpose of distributing the chloroform, which settles to the bottom.

We are also careful not to contaminate the necks of our stock bottles when filling them with the virulent tissue mixture. Then as an added precaution, after adding the chloroform and just before inserting the stopper, we swab the inside of the necks of the bottles with chloroform. Obviously, the purpose of this is to eliminate the possibility of trouble from virulent material that might get between the neck of the bottle and the stopper and escape the action of the chloroform.

While we have fully demonstrated that this vaccine can be safely injected within two or three hours following its preparation, we have observed that it is better to allow it to stand forty-eight hours or more before use. If injected within two or three hours after preparation a slight irritating effect results from the chloroform. While this is in no way serious it can be avoided by allowing the vaccine to stand a day or two.

TEST OF VACCINE PREPARED BY THE MEDICAL DEPARTMENT RESEARCH BOARD

The first test of our chloroform-treated vaccine was carried out with four head of cattle. In this and in all of our subsequent work with cattle the animals used were imported direct from Fuga Island by the Bureau of Agriculture. Rinderpest does not occur on Fuga, so consequently cattle from there are all susceptible to the disease.

In this test three of the four animals were each given three subcutaneous injections of 10, 15, and 15 cubic centimeters, respectively, of vaccine, an interval of one week elapsing between the injections. The fourth animal served as a control and thus received no vaccine. Ten days subsequent to the administration of the last dose of vaccine each of the four animals was given 2 cubic centimeters of virulent rinderpest blood subcutaneously. Table 1 indicates the results.

TABLE 1.—*Test of chloroform-treated vaccine on cattle from Fuga Island.*

[Three of the four head of cattle included in this table each received three injections of vaccine prepared from a mixture of tissue and blood. The doses were 10, 15, and 15 cubic centimeters, respectively, administered at weekly intervals. One animal control.]

Animal No.	Vaccination completed.	Infected.	Amount of virus.	Results.
			cc.	
6214	Aug. 28, 1926	Sept. 7, 1926	2	Slight reaction. Survived.
6215	do	do	2	No reaction. Survived.
6222	do	do	2	Do.
6219	Control	do	2	Developed severe case acute rinderpest. Would have died but killed to conserve tissues.

Thus, in this test all three of the vaccinated animals survived the infection, two with no reaction whatever, the third with a slight temperature reaction. The control promptly developed an acute case of rinderpest and would have died from the same, but in order to utilize the tissues for the preparation of more vaccine it was destroyed when in the proper stage of the disease for vaccine production.

TEST TO DETERMINE THE RELATIVE VALUE OF BLOOD AND OTHER TISSUES FOR THE PRODUCTION OF VACCINE

The first step toward determining the value of the various ingredients entering into the preparation of this vaccine was to make three separate lots of vaccine from a given group of animals infected for the purpose. One lot was prepared from blood alone, a second lot from a mixture of the various organs, while the third lot was made in the usual way and represented a combination of the blood and organs.

Twenty head of cattle were used to test these three lots of vaccine. They were divided into two groups of ten each. In one group four animals were each given three doses of the vaccine prepared from the blood alone; four were treated in a similar manner with vaccine prepared from the combination of various organs and the remaining two served as controls. In the other group eight of the ten head of cattle were each given three doses of the vaccine prepared from the mixture of blood and organs, the remaining two animals serving as controls for this group.

The dates of vaccination were the same for both groups of animals. However, the group that received the vaccine prepared from the mixture of blood and organs was infected two days after the other group. As it was our intention to utilize for vaccine production all animals that developed rinderpest, we infected the two groups on different dates in order that we would not have more animals than we could handle in a given time should a large percentage of them develop the disease.

Table 2 shows the results obtained with the four animals that received vaccine prepared from the blood alone and the four that received vaccine made from the organ tissue.

TABLE 2.—*Test of the relative value of blood and other tissues for the production of vaccine.*

[Four of the ten head of cattle included in this table each received three doses of vaccine prepared from blood alone; four received three doses of vaccine prepared from tissue alone, and the remaining two served as controls. Doses of vaccine given were 10, 15, and 15 cubic centimeters, respectively, administered at weekly intervals.]

Animal No.	Type of vaccine.	Vaccination completed.	Infected.	Amount of virus.	Results.
				cc.	
6307	Blood	Oct. 14, 1926	Oct. 29, 1926	2	Developed acute rinderpest. Would have died but killed to conserve tissues.
6308	do	do	do	2	Do.
6340	do	do	do	2	Do.
6354	do	do	do	2	Do.
6338	Tissue	do	do	2	Slight temperature reaction. Survived.
6341	do	do	do	2	No reaction whatever. Survived.
6346	do	do	do	2	This animal developed a septic condition of the foot and died before test was completed.
6349	do	do	do	2	No reaction. Survived.
6294		Control	do	2	Developed acute rinderpest. Would have died but killed to conserve tissues.
6305		do	do	2	Do.

As indicated in Table 2 the four head of cattle receiving the vaccine prepared from the blood were not protected. As a matter of fact, they showed no evidence of the slightest degree of immunity. They developed rinderpest at the same time and in as severe a form as the controls. On the other hand, the animals that were vaccinated with vaccine prepared from the mixture of organs (lymph glands, spleen, liver, kidneys, and testicles) survived the rinderpest infection. One of the latter four animals, however, had, at the time the test was started, a septic condition of the foot which later proved fatal. It was thought in the beginning that the condition would not seriously interfere with the experiment and because the supply of susceptible cattle happened to be low at the time this animal was used. It died, however, of septicæmia before the test was completed.

The results obtained with the group of cattle vaccinated with the vaccine prepared from the mixture of blood and organs are shown in Table 3.

TABLE 3.—*Test of vaccine prepared from the mixture of blood and organs.*

[Eight of the ten head of cattle included in this table each received three injections of vaccine prepared from a mixture of tissue and blood. The doses were 10, 15, and 15 cubic centimeters, respectively, administered at weekly intervals. The last two animals were controls.]

Animal No.	Vaccination completed.	Infected.	Amount of virus.	Results.
			cc.	
6296	Oct. 14, 1926	Oct. 27, 1926	2	No reaction whatever. Survived.
6319	do	do	2	Slight reaction. Survived.
6342	do	do	2	Do.
6359	do	do	2	Do.
6361	do	do	2	Developed rinderpest in chronic form. Died from same 24 days subsequent to administration of virus.
6310	do	do	2	Survived rinderpest infection but died later of unknown cause. In poor condition from start.
6362	do	do	2	Slight reaction. Survived.
6377	do	do	2	Survived infection without reaction.
6293	Control	do	2	Developed acute rinderpest. Would have died but was killed to conserve tissues.
6385	do	do	2	Do.

It is thus seen that seven of the eight vaccinated animals survived the infection with rinderpest virus. One of the eight was not sufficiently protected and developed the disease. This animal had the disease in a mild form in the beginning, but it subsequently became chronic and finally resulted in death. A second animal in this group survived the rinderpest infection but died later of an undetermined cause. The two control animals promptly developed acute rinderpest in a severe form and were utilized for the production of vaccine.

Following these results it was decided to discontinue the use of blood in the vaccine prepared by the research board.

TESTS TO DETERMINE THE VALUE OF THE VARIOUS ORGANS FOR VACCINE PRODUCTION

We prepared four lots of vaccine representing different tissues from a given group of animals infected for vaccine production. One lot was made from the lymph glands, another lot from the liver, one from a mixture of kidneys and testicles, and the fourth lot from spleen tissue.

Ten head of cattle were employed for a test of these preparations. Two animals were used for each type of vaccine, and the remaining two served as controls. The vaccinated animals received three 10-cubic-centimeter doses of vaccine, a period of one week elapsing between doses. The results of this test are given in Table 4.

TABLE 4.—*Tests to determine the value of the various organs for vaccine production.*

[Eight of the ten head of cattle included in this table each received three doses of vaccine prepared from the various tissues indicated. Each dose consisted of 10 cubic centimeters of vaccine administered at weekly intervals.]

Animal No.	Tissues in vaccine.	Vaccination completed.	Infected.	Amount of virus.	Results.
				cc.	
6301	Lymph glands.	Nov. 26, 1926.	Dec. 11, 1926.	2	No reaction whatever. Survived.
6320	do	do	do	2	Do.
6343	Liver	do	do	2	Do.
6344	do	do	do	2	Do.
6348	Kidneys and testicles.	do	do	2	Do.
6365	do	do	do	2	Do.
6371	Spleen	do	do	2	Do.
6376	do	do	do	2	Do.
6298	Control		do	2	Developed acute rinderpest. Would have died but was killed to conserve tissues.
6336	do		do	2	Do.

All of the eight vaccinated animals survived the rinderpest infection without manifesting the slightest evidence of reaction. The two animals used as controls promptly developed acute rinderpest and were destroyed for vaccine production.

From this experiment it was evident that the tissues used were all of value for the production of vaccine. Of these tissues, it has been subsequently shown that the lymph glands and spleen, from a comparative standpoint, rank highest in potency for vaccine production. Vaccine prepared from these tissues alone will protect when administered in very small doses.

TEST OF VACCINE CONTAINING FIFTY PER CENT PHYSIOLOGICAL SALINE SOLUTION

As previously indicated, after omitting the blood in the preparation of our vaccine the consistency of the mixture was such as to render injection difficult. To overcome this we added an equal part of sterile, physiological saline solution to the tissue mixture. In order to prove that this addition of salt solution was not detrimental to the vaccine we subjected a lot of vaccine prepared in this manner to a test in which four head of cattle were employed. Three animals each received three injections of vaccine at weekly intervals. As the vaccine was diluted 50 per cent, the dose was increased to 20 cubic centimeters. The fourth animal served as a control. The results of this test are given in Table 5.

TABLE 5.—*Test of vaccine containing 50 per cent physiological saline solution.*

[Three of the four head of cattle included in this table each received three injections of vaccine prepared from a mixture of tissue and physiological saline solution. The doses were 20 cubic centimeters each. One animal control.]

Animal No.	Vaccination completed.	Infected.	Amount of virus.	Results.
			cc.	
6486	Mar. 1, 1927	Mar. 15, 1927	2	No reaction whatever. Survived.
6497	do	do	2	Do.
6499	do	do	2	Do.
6512	Control	do	2	Developed acute rinderpest. Would have died but was killed to conserve tissues.

All three of the vaccinated animals survived the infection with virulent blood without reaction. The control animal promptly developed acute rinderpest. Since this test all of our vaccine has been prepared with physiological saline solution to facilitate injection.

DOSAGE AND NUMBER OF INJECTIONS OF VACCINE NECESSARY TO IMMUNIZE

Vaccine prepared according to our method has now been experimentally tested on several hundred head of cattle and carabaos. It has been found that three doses of 15 to 20 cubic centimeters each, administered at weekly intervals, afford a very solid immunity against a heavy artificial infection.

Early in our work we conducted a test to determine whether or not a single injection of vaccine would effectively immunize. In this test two animals were each given a single injection of vaccine which was about $1\frac{1}{2}$ months old. The dose given one animal was 25 cubic centimeters, whereas the other received only 15 cubic centimeters. Two weeks later these two animals, together with a third used as a control, were each infected with 2 cubic centimeters of virulent rinderpest blood. The results are shown in Table 6.

TABLE 6.—*Test to determine if one injection of vaccine will immunize.*

[Two of the three head of cattle included in this table received 15 and 25 cubic centimeters, respectively, of a vaccine prepared from a mixture of tissue and blood. Such amounts were administered in one dose. The third animal served as a control.]

Animal No.	Vaccinated.	Amount of vaccine.	Infected.	Amount of virus.	Results.
		cc.		*cc.*	
6353	Oct. 1, 1926	25	Oct. 14, 1926	2	Slight reaction. Survived.
6357	do	15	do	2	Developed acute rinderpest. Would have died but was killed to conserve tissues.
6363	Control		do	2	Do.

A single injection of 25 cubic centimeters of this vaccine protected cattle against the artificial injection. The animal receiving 15 cubic centimeters developed the disease and died as a result thereof.

It should be pointed out that this test was conducted before we had demonstrated that blood was of no value for vaccine production. Thus, this lot of vaccine contained approximately 25 per cent blood which we later proved to be inert. Had the vaccine been prepared according to our final method a single dose of an amount smaller than 25 cubic centimeters would have sufficed to immunize cattle.

As carabaos are exceedingly susceptible to rinderpest a similar test was conducted with such animals. This test indicated that if it was desired to limit the immunization of carabaos to a single injection of vaccine, a relatively large dose would be required. On the other hand, if in the preparation of the vaccine we limit ourselves to the use of only those tissues of the very highest potency for vaccine production (lymph glands and spleen), a single injection will undoubtedly suffice to immunize carabaos against infection. As a matter of fact, since the adoption of our method of preparing rinderpest vaccine, Dr. E. A. Rodier, of the Philippine Bureau of Agriculture, has obtained some very convincing evidence on this phase of the subject. These data are given in another article, by Doctor Rodier, appearing in this issue.

KEEPING QUALITIES OF THE VACCINE

In January, 1927, we tested a lot of vaccine which was three months old, on two head of cattle. Each animal received three 10-cubic-centimeter doses of vaccine, the injections being made at weekly intervals. Two weeks subsequent to the last injection the two vaccinated animals, together with two controls, were each infected with 2 cubic centimeters of virulent rinderpest blood. The results are recorded in Table 7.

TABLE 7.—*Test of the keeping qualities of vaccine that was 3 months old.*

[Two of the four head of cattle included in this table each received three injections of vaccine prepared from tissue alone. The doses were 10 cubic centimeters. Two controls included.]

Animal No.	Vaccination completed.	Infected.	Amount of virus.	Results.
			cc.	
6446	Jan. 24, 1927	Feb. 8, 1927	2	Slight temperature reaction. Survived.
6452	do	do	2	No reaction whatever. Survived.
6468	Control	do	2	Developed acute rinderpest. Would have died but was killed to conserve tissues.
6483	do	do	2	Do.

The two vaccinated animals were fully protected by this vaccine. The two controls developed acute rinderpest and were destroyed for vaccine production.

On December 4, 1927, we initiated a test with a lot of vaccine that was exactly 1 year old. Three bulls were each given three doses of this vaccine, the injections being made at weekly intervals. Seventeen days subsequent to the injection of the last dose of vaccine, these three animals, together with a fourth used as a control, were each infected with 2 cubic centimeters of virulent rinderpest blood. The results obtained are recorded in Table 8.

TABLE 8.—*Test of the keeping qualities of vaccine that was 1 year old.*

[Three of the four head of cattle included in this table each received three injections of vaccine that was 1 year old at the time of administration. The fourth animal served as a control.]

Animal No.	Vaccination completed.	Infected.	Amount of virus.	Results.
			cc.	
7025	Dec. 18, 1927	Jan. 4, 1928	2	No reaction whatever.
7026	do	do	2	Do.
7028	do	do	2	Do.
7039	Control	do	2	Developed acute rinderpest. Would have died but was killed to conserve tissues.

The results clearly indicate that this vaccine will retain its potency for a period of at least one year. It will undoubtedly keep for a still longer period. Further tests will be conducted to determine this point.

One of the out-standing features of all of this work has been the very solid type of immunity conferred by this vaccine. We have now tested the product on several hundred animals, and in most instances subsequent artificial infection of vaccinated animals has failed to cause even a temperature rise. This is illustrated by the temperature charts (figs. 1 to 4) of the four animals employed for the test of the lot of 1-year-old vaccine.

SUMMARY AND CONCLUSIONS

A highly efficacious vaccine against rinderpest can be prepared from a suspension of finely ground tissues (lymph glands, spleen, and liver) from animals killed in the acute stages of rinderpest.

We have demonstrated that the rinderpest virus in such vaccine can be promptly killed, without injuring the product, by the addition of 0.75 per cent chloroform. Such vaccine can be used immediately after preparation and possesses excellent keeping qualities, remaining potent for at least one year.

Vaccine prepared from blood alone possesses no value whatever as an immunizing agent. Thus, as the rinderpest virus is present in the blood in large amounts during the acute stages of the disease, it is apparent that the active principle of the tissue vaccine is not merely virus killed by chloroform. Whatever it is, it is not present in demonstrable amounts in the circulating blood but only in certain of the other tissues. This suggests the possibility that the immunizing principle is either some biproduct of the reaction between tissue and virus or the

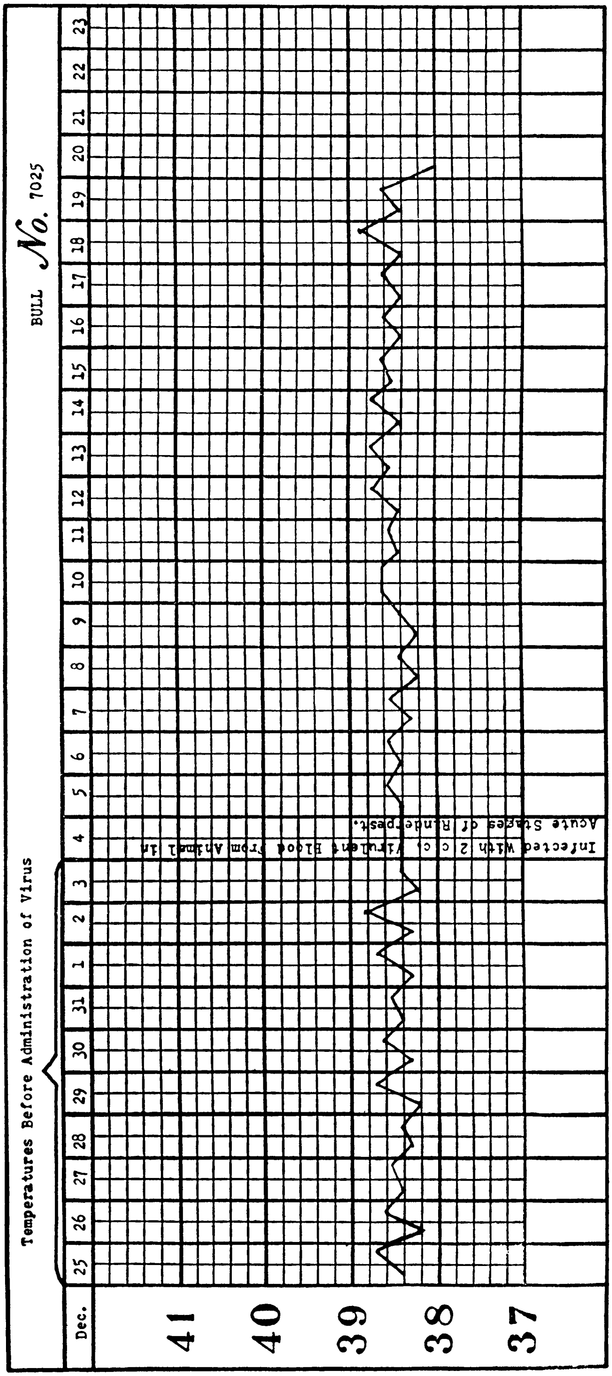


FIG. 1. Temperature chart of test animal 1. Previous to infection this animal received three injections of rinderpest vaccine that was 1 year old.

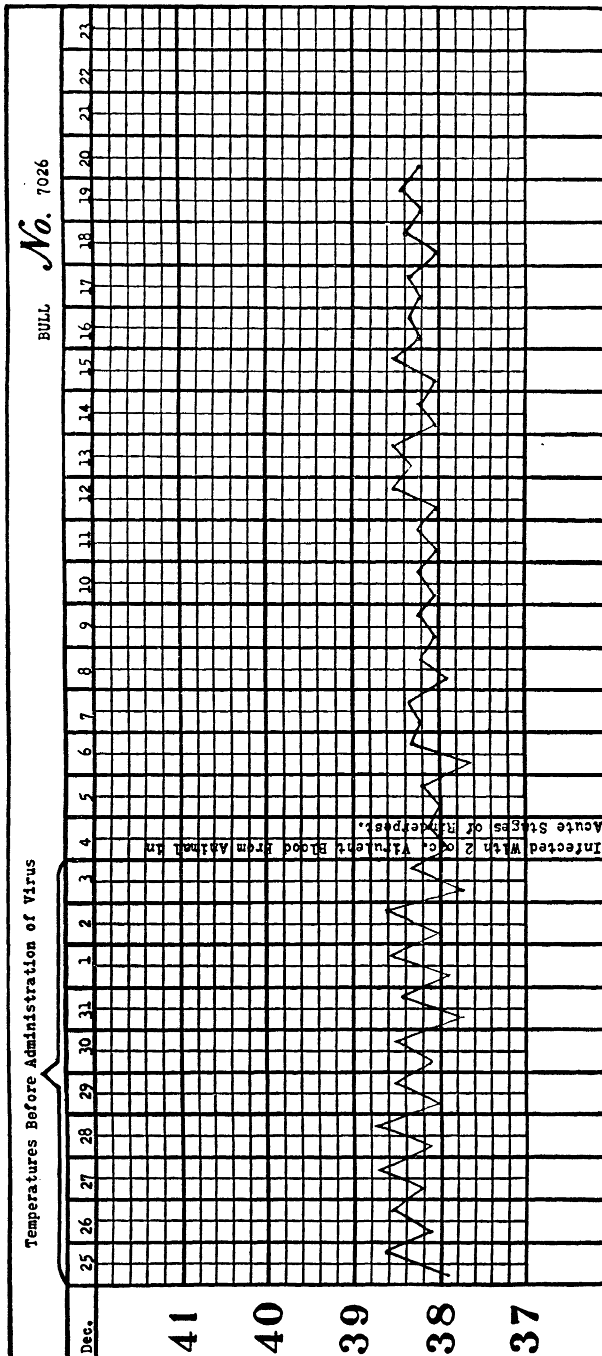


FIG. 2. Temperature chart of test animal 2. Previous to infection this animal received three injections of rinderpest vaccine that was 1 year old.

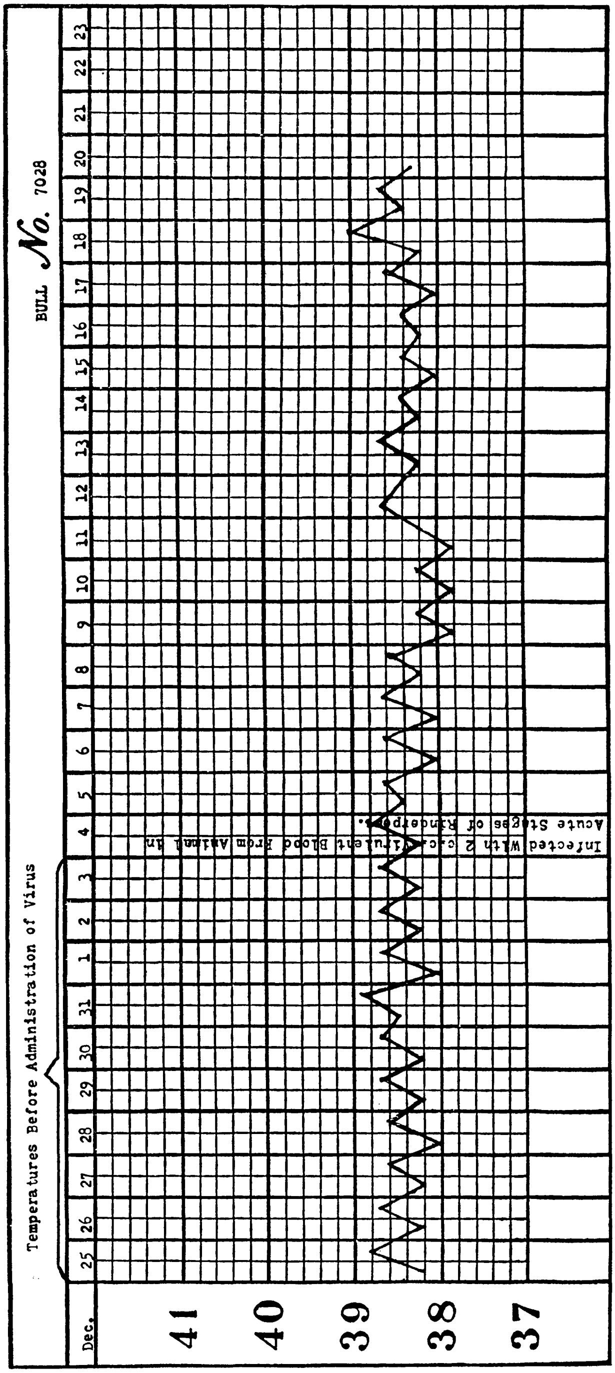


FIG. 3. Temperature chart of test animal 3. Previous to infection this animal received three injections of rinderpest vaccine that was 1 year old.

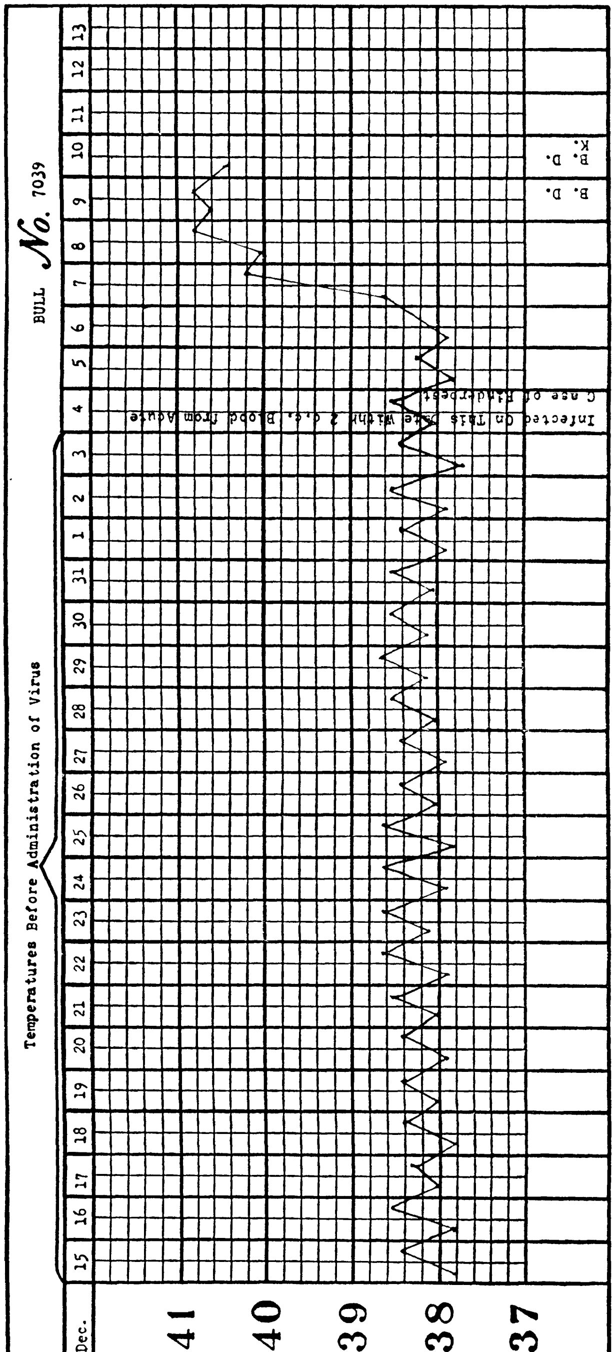


FIG. 4. Temperature chart of control animal. B. D., bloody diarrhœa; K., animal would have died but was killed in the acute stage of the disease in order that tissues could be used for vaccine.

rinderpest virus which has been changed in some particular way by the activity of the solid tissues.

Tests of this vaccine on a large number of cattle and carabaos, used in the various experiments, have fully established its worth.

Three 20-cubic-centimeter doses of vaccine, with an interval of one week between doses, afford both cattle and carabaos a very solid immunity against severe infection.

Experimentally we have obtained evidence that the number of injections of vaccine can probably be reduced from three to one, at least in cattle. However, as carabaos are extremely susceptible to rinderpest, if a single injection of vaccine is to be employed for immunization, it appears desirable, in the preparation of vaccine for such animals, to use only the tissues of very highest potency (lymph glands and spleen). Further and more-extensive tests on this phase of the subject, by Dr. E. A. Rodier, of the Philippine Bureau of Agriculture, substantiate this view.

REFERENCES

1. KOCH. Centralbl. f. Bakt., Parasit. und Infekionskrant. **21** (1897) 526.
2. KOHLSTOCK. Arbeiten aus dem Kaiserlich. Gesundheit. 22 (1897) 787.
3. KOLLE. Zeit. f. Hyg. und Infekionskrant. **26** (1898) 45.
4. THEILER. Deutsche tierärzt. Wochensch. (1898) 205.
5. TURNER. Zeit. f. Hyg. und Infekionskrant. **29** (1898) 309.
6. EDINGTON. Quoted from Huytra and Marek, "Special Pathology & Therapeutics of the Diseases of Domestic Animals," Eng. trans. 3d ed., Alexander Eger Co., Chicago, Ill. (1926).
7. KOHLSTOCK. Deutsche tierärzt. Wochensch. 22 (1897) 787.
8. SEMMER. Berliner tierärzt. Wochensch. (1893) 590.
9. KOLLE and TURNER. Quoted from Huytra and Marek, "Special Pathology & Therapeutics of the Diseases of Domestic Animals," Eng. trans. 3d ed., Alexander Eger Co., Chicago, Ill. (1926).
10. BOYNTON. Official records of Bureau of Agriculture, Manila, P. I. Philip. Journ. Sci. **36** (1928) 1.
11. KAKIZAKI et al. Third & Fourth Report of the Government Institute for Veterinary Research; Fusan, Chosen, Japan (December, 1925, and June, 1927).
12. KELSER. Military Surgeon **61**, No. 1 (July, 1927). Proceedings of the Seventh Congress of the Far Eastern Association of Tropical Medicine, Calcutta, India (December 5, 1927).

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Temperature chart of test animal 1. Previous to infection this animal received three injections of rinderpest vaccine that was 1 year old.

2. Temperature chart of test animal 2. Previous to infection this animal received three injections of rinderpest vaccine that was 1 year old.

3. Temperature chart of test animal 3. Previous to infection this animal received three injections of rinderpest vaccine that was 1 year old.

4. Temperature chart of control animal. B. D., bloody diarrhœa; K., animal would have died but was killed in the acute stage of the disease in order that tissues could be used for vaccine.

A SINGLE-INJECTION METHOD OF IMMUNIZATION AGAINST RINDERPEST

By E. A. Rodier

Pathologist, Bureau of Agriculture, Manila

Rinderpest, since its introduction into the Philippine Islands, has been by far the most important disease problem with which veterinarians have had to cope. Since its introduction in 1886 or 1887, it has caused heavy losses annually, especially in 1900 when it killed more than 90 per cent of the cattle and carabaos in some provinces, thereby reducing former livestock men to poverty and preventing agriculturists from tilling the soil.

In the last years of the past century virtually no control measures were enforced. The first serious efforts to control rinderpest in the Philippine Islands began in 1901, when the Board of Health in its inadequately equipped laboratory did some work with bile as an immunizing agent, which was tried out on a small scale with indifferent success. The problem became more acute, and in 1902 an act passed by the Philippine Commission provided for the establishment of a "Serum Institute" for the manufacture of rinderpest serum and virus and for research. At that time the method used was to give 1 cubic centimeter of virus and 30 cubic centimeters of serum. Immunization then proceeded on a much larger scale than heretofore. Efforts to check the spread of rinderpest among native cattle and carabaos by the simultaneous method were fairly successful, but the veterinarians faced grave difficulties because the people expected them to bring medicine to cure their sick animals. When it was observed that they took blood from the sick animals and injected it into well ones, livestock men at once feared that the veterinarians were trying to spread the disease rather than check it. In more than one instance the hostility aroused was so great that it was deemed expedient to abandon immunization entirely, especially in view of the fact that in many cases operations were rendered ineffective by cattle owners driving their animals into the mountains instead of presenting them for treatment.

In addition to this difficulty, as pointed out by Kelser,[1] the simultaneous method of immunization against rinderpest has several distinct shortcomings. He says:

> In the first place, a certain percentage of animals receiving this treatment develop severe reactions and some losses from rinderpest occur as a direct result of vaccination. Then again, reacting animals are readily capable of spreading rinderpest to susceptible animals if contact is afforded; hence this feature must always be given due consideration when the simultaneous method of immunization is contemplated.

Because of the strong prejudice against the simultaneous method it was abandoned and serum alone was employed as an aid to quarantine to stop the general spread of the disease. This method was effective in checking an outbreak but conferred immunity of only short duration. By 1909 the output of rinderpest serum was quadrupled and all veterinarians that could be secured were engaged in the control of rinderpest.

In 1911 a well-organized campaign for the eradication of rinderpest was started in central Luzon. Strict quarantine, enforced with the aid of the Philippine Scouts, was begun at this time. As a result of these quarantine campaigns, the incidence of rinderpest in the Islands was greatly reduced. As the work went on, however, many farmers came to believe that the Bureau of Agriculture was too stringent in the enforcement of quarantine measures. This idea gradually gained ground and unfortunately finally resulted in the passage of an act which provided that while the Director of Agriculture should prescribe the necessary measures, under the provisions of this act the enforcement of these measures was delegated to the governor of the province concerned.

The control of rinderpest has since been a still more difficult problem. This is due to several factors peculiar to the Philippines. First, the nature of the country itself makes the enforcement of rigid quarantine a very difficult task. There are practically no fences for livestock in the Islands, and it has been the custom since time immemorial to allow animals to intermix freely. These factors aid in the rapid spread of this disease. Second, much of the animal population is to be found in mountainous country. These animals are in a semiwild state, and it requires a large force of men to prevent them from passing established quarantine lines. Third, there was much difficulty experienced in persuading the people themselves to observe quarantine rules and coöperate with the field veteri-

[1] This issue.

narians in doing their part to stamp out the disease. Some of this opposition was due to the fact that quarantine measures, by restricting the movement of cattle and carabaos, necessarily imposed hardships upon a few for the benefit of all; and the result was that livestock men in many instances presented every obstacle possible to prevent quarantine being established. These facts showed the urgent necessity for a method of preventing rinderpest that would make such quarantine measures unnecessary.

The details of Boynton's original work and subsequent experimentation on the development of better vaccine for immunization against rinderpest are given by Kelser.[2] This investigator, in collaboration with Stanton Youngberg and Teodulo Topacio, has shown that that work has resulted in the production of a vaccine that can be quickly prepared, retains its potency for a long time in storage, and when given in three injections at intervals of one week, will confer a very solid immunity against a heavy artificial infection. This method of preparing vaccine has been adopted by the Bureau of Agriculture.

On account of the difficulties experienced in carrying on vaccination work in the field, it became apparent that if the number of injections could be reduced, the work would be greatly facilitated. That many animals in an infected district can be quickly immunized and that two-thirds of the field expenses can be saved, partly indicate the desirability of a single-injection method.

Early in his work, Kelser obtained evidence that tended to indicate that animals could be satisfactorily immunized against rinderpest by a single injection of vaccine. With a view to obtaining more data along this line, this phase of the work was extended by the Veterinary Research Laboratory of the Bureau of Agriculture and the results are reported in this paper.

As a result of all this work on tissue vaccine, it has become evident that the tissues of very high potency are the lymph glands, tonsils, and spleen. While the ordinary vaccine given in a single dose would undoubtedly immunize cattle against a field infection, because of the high susceptibility of carabaos to rinderpest, it was deemed advisable to test a vaccine prepared from the tissues of the highest potency, which were found to be the lymph glands, tonsils, and spleen. This does not mean that any of the tissues formerly employed are of no value. In an effort to limit the size of the dose for a single injection, we prepared

[2] Loc. cit.

several lots from the lymph glands and from lypmh glands, tonsils, and spleen, and subjected them to tests on cattle and carabaos.

Experiment 1.—To determine the potency of a vaccine made from mesenteric lymph glands when given in two injections. The carabaos used in this experiment each received two injections of a vaccine prepared from mesenteric lymph glands. The doses were 4 and 6 cubic centimeters, respectively, administered at one week interval. All animals received 2 cubic centimeters of virulent virus. The results are shown in Table 1.

TABLE 1.—*Showing the results of experiment 1.*

Animal No.	First injection.	Second injection.	Infected.	Results.
726	Aug. 22, 1927.	Aug. 29, 1927.	Sept. 6, 1927.	Slight temperature reaction.
728	do.	do.	do.	No reaction.
729	do.	do.	do.	Developed rinderpest but recovered.
730	do.	do.	do.	Do.
727	Control		do.	Developed acute rinderpest. Killed to conserve tissue. Good lesions.

Early in 1927 we discontinued the use of mesenteric lymph glands from our regular vaccine because it was found that these glands frequently contained pathogenic, spore-bearing organisms (*Clostridium oedematis-maligni, C. tetani,* etc.) This was done in order to avoid the possibility of infection by these organisms when the vaccine was put to field use. These mesenteric lymph glands were not discarded however. The glands obtained from each animal were tested to determine the presence of pathogens. Aërobic and anaërobic cultures were made and a special test for tetanus toxin consisting of inoculation into guinea pigs of the filtrate from Berkefeld-filtered glucose bouillon covered with mineral oil which had been inoculated with finely ground glands and incubated for six days at 37° C. All mesenteric lymph-gland tissue passing this test was made into a vaccine in the usual way.

The result of this test showed that a vaccine made according to the chloroform method from mesenteric lymph glands would protect carabaos when given in small dosage in two injections. It also showed that a 4- and a 6-cubic-centimeter dose administered at an interval of one week was the minimum protective dosage for this vaccine.

The first practical use of the single-injection method, using a chloroform-treated vaccine made from mesenteric lymph glands, was on September 20 when forty-six carabaos belonging to the Philippine Trust Company were brought to the Pandacan quarantine station for isolation. When they arrived at the station, four carabaos were showing evidence of being in an advanced stage of rinderpest infection. These animals were placed in a hospital isolation shed. Three of them subsequently died. The forty-two remaining animals received a single injection of 15 cubic centimeters of this vaccine without delay, despite the fact that they had all been exposed. Of this number, there were only six that did not subsequently show fever temperature. In order to prove that these animals were protected, six of them were given virulent blood with a control. When the control was killed for vaccine, it showed typical rinderpest temperature, clinical symptoms, and post-mortem lesions. None of the vaccinated animals showed any evidence of rinderpest.

Objection can be made that as the forty-two carabaos above referred to were exposed they may have become immune as the result of possible infection, the vaccine merely acting as an aid. In order to settle this question, another experiment will be cited. On December 20 nine susceptible carabaos, whose history and preinjection temperatures were known, were brought from Alabang and placed in a noninfected shed at Pandacan. Seven of these animals were given a single injection of 15 cubic centimeters of this same vaccine. Ten days later the vaccinated animals and two that were reserved for control were given 2 cubic centimeters each of virulent virus. The two controls were killed on the fifth and sixth days, respectively, showing typical rinderpest temperature, clinical symptoms, and post-mortem lesions. None of the seven receiving vaccine showed any clinical symptom of rinderpest. Four of them, however, showed slight temperature reaction.

Experiment 2.—To determine the minimum dosage that would immunize highly susceptible cattle with two injections. The cattle included in this experiment were injected with a vaccine prepared from mesenteric lymph glands. The doses were 2 and 4 cubic centimeters, respectively, administered at one week interval. Two cubic centimeters of a known virulent virus were used to test immunity. The results are shown in Table 2.

TABLE 2.—*Showing the results of experiment 2.*

Animal No.	First injection.	Second injection.	Infected.	Results.
6798	June 27, 1927	July 4, 1927	July 23, 1927	No reaction.
6840	-----do-------	-----do-------	-----do-------	Do.

The two animals used in this test showed not even a temperature reaction following the injection of virulent blood nineteen days after the second injection. This test was carried out on Fuga animals, which long experience has proven to be the most susceptible cattle in the Philippine Islands. This result was very encouraging, especially in view of the fact that the dosages employed were but 2 and 4 cubic centimeters.

Experiment 3.—To determine the minimum dosage of a vaccine prepared from glandular tissues alone that would protect cattle with but one injection. Three of the four Fuga cattle included in this experiment were injected with varying dosages of a vaccine prepared from mesenteric lymph glands and tonsils. The fourth served as a control. Amount of virus given, 2 cubic centimeters each. The results are shown in Table 3.

TABLE 3.—*Showing the results of experiment 3.*

Animal No.	Vaccinated.	Amount.	Infected.	Results.
		cc.		
7012	Nov. 28, 1927	3	Dec. 8, 1927	Developed acute rinderpest. Killed to conserve tissue. Good lesions.
7011	do	4	do	Very slight temperature reaction.
7009	do	5	do	Do.
7044	Control		do	Developed acute rinderpest. Killed to conserve tissue. Good lesions.

From inspection of these tables it will be noted that the test animals receiving 4 and 5 cubic centimeters of vaccine showed no clinical symptoms although there was a very slight temperature reaction in each case, which indicated that these animals received the minimum protective dose, especially as the test animal that received 3 cubic centimeters developed acute rinderpest and was killed for vaccine.

Experiment 4.—To determine the minimum protective dose of a vaccine prepared from glandular tissue that would protect carabaos with but one injection. Two of the carabaos included in this experiment received each 10 cubic centimeters single injection of a vaccine prepared from mesenteric lymph glands, while the other two received 15 cubic centimeters each, followed by 2 cubic centimeters each of virulent virus in fifteen days. The results are shown in Table 4.

TABLE 4.—*Showing the results of experiment 4.*

Animal No.	Vaccinated.	Amount.	Infected.	Results.
		cc.		
731	Aug. 22, 1927	10	Sept. 6, 1927	No reaction.
732	-----do-------	10	-----do-------	Do.
734	-----do-------	15	-----do-------	Do.
735	-----do-------	15	-----do-------	Temperature reaction.

This test demonstrated that susceptible carabaos could be protected against an artificial infection with one injection of 10 cubic centimeters of a vaccine prepared from lymph glands only. Considering the difference of susceptibility of individual animals, it may also be noted that it requires about twice as much vaccine to protect carabaos as is necessary to confer immunity upon cattle.

Experiment 5.—To determine the minimum protective dosage in single injection of a vaccine prepared from lymph glands and tonsils, for carabaos of known susceptibility. Seven of the carabaos included in this experiment received 15 cubic centimeters each of a vaccine prepared from lymph glands and tonsils. The last two were used as controls. Amount of virus given, 2 cubic centimeters each. The results are shown in Table 5.

TABLE 5.—*Showing the results of experiment 5.*

Animal No.	Vaccinated.	Infected.	Results.
642	Dec. 20, 1927	Dec. 30, 1927	No reaction.
686	-----do-------	-----do-------	Slight temperature reaction only.
689	-----do-------	-----do-------	Do.
687	-----do-------	-----do-------	No reaction.
738	-----do-------	-----do-------	Do.
739	-----do-------	-----do-------	Slight temperature reaction only.
740	-----do-------	-----do-------	No reaction.
685	Control-------	-----do-------	Developed acute rinderpest. Killed to conserve tissue. Good lesions.
563	-----do-------	-----do-------	Do.

The carabaos used in this test were obtained from the Alabang stock farm and brought to the veterinary research laboratory for that purpose. Seven of these animals were injected with 15 cubic centimeters each of a vaccine prepared from lymph glands only, two animals being left unvaccinated as controls. Ten days following the single injection of vaccine, all nine animals received the same lot of a virus which was proven to be virulent because the controls manifested typical rinderpest temperature and clinical symptoms. When they were killed to conserve tissue for vaccine production, they showed good post-mortem lesions of rinderpest.

Three of the seven carabaos protected by this vaccine showed slight temperature reaction only. None of them showed clinical evidence of disease at any time throughout the test.

The results of tests conducted thus far showed conclusively that a solid immunity could be conferred upon highly susceptible carabaos against a heavy artificial infection with a single injection of 15 cubic centimeters of a vaccine prepared according to the method described by Kelser, but limiting the tissues employed to lymph glands and tonsils, and that our most susceptible cattle could be protected with as little as half that amount. The writer therefore negotiated with the Calamba Sugar Estate for a field test. One hundred animals were given a single injection of a vaccine made in the usual way from lymph glands only, using a dosage of 20 cubic centimeters. Two weeks following the test, six of these vaccinated animals picked at random were isolated and with one young susceptible carabao for control, each was inoculated with 2 cubic centimeters of virulent virus. Dr. Leon Sanchez, of the veterinary research staff, made his residence on the premises for two weeks following the injection of virus and closely observed the animals at all times. At no time did any of the vaccinated animals give evidence of disease or indisposition either by temperature reaction or clinical symptoms. The control died of rinderpest fourteen days after inoculation. It is thus apparent that probably the smaller dose employed in experiment 5 would very likely have sufficed.

Having established the efficacy of the vaccine when its preparation was limited to the use of glandular tissues alone, it was decided to make another lot using spleen, lymph glands, and tonsils. The spleen and the tonsils were added because other experiments not given in this paper had shown that these tissues were also very high in potency.

Experiment 6.—To determine the minimum protective dosage for cattle of a vaccine made from spleen, lymph glands, and tonsils. Four animals were used for testing this lot of vaccine.

Three of the four cattle included in this experiment received varying dosages of a vaccine prepared from spleen, lymph glands, and tonsils. The fourth was used as control. Amount of virus given, 2 cubic centimeters each. The results are shown in Table 6.

TABLE 6.—*Showing the results of experiment 6.*

Animal No.	Vaccinated.	Amount.	Infected.	Results.
		cc.		
7017	Nov. 28, 1927	3	Dec. 8, 1927	Slight temperature reaction.
7018	do	4	do	No reaction.
7020	do	5	do	Do.
7044	Control		do	Developed acute rinderpest. Killed to conserve tissue. Good lesions.

It will be noted that in 3-cubic-centimeter dosage, there was but a slight temperature reaction following the inoculation of virulent virus given ten days following the vaccine. In 4- and 5-cubic-centimeter dosages, there was no reaction whatever. Although the control was killed on the sixth day for conservation of tissue, it showed every evidence of rinderpest infection. This test established the fact that no increase in dosage is necessary with a vaccine prepared from spleen, lymph glands, and tonsils.

Previous to the perfection of the single-injection method, it was the custom to immunize these animals by the simultaneous method. The animals were given 500 cubic centimeters of anti-rinderpest serum to protect them for a week or ten days until they would recover from the effects of the long trip. Then they were simultaneously immunized with 1,000 cubic centimeters of serum and 5 cubic centimeters of virus. Subsequent reactions were then controlled with serum. With the last three bulls from Australia immunized in this manner, 4.5 liters of serum were used on each animal and even then each of the three animals manifested temperature reaction reaching a peak on the fifth day of 41.2° C. followed by clinical symptoms of rinderpest. While all three animals eventually recovered, it was with the greatest difficulty that they were saved.

The most severe and final test that has been made with vaccine prepared with spleen, lymph glands, and tonsils administered in single doses was in the immunization at this station of twelve bulls imported from Australia. These animals were given 20 cubic centimeters of vaccine prepared from spleen, lymph glands, and tonsils, one injection only. At the same time two of our known susceptible animals were vaccinated as a control on the potency of the vaccine. Eight days after vaccination, the virus was given to the two vaccine controls, together with two controls on the virus used. As the vaccine-control animals gave no evidence of a reaction sixteen days after the Australian animals were vaccinated, they received 2 cubic centimeters of virulent virus together with two controls. None of the Australians developed the slightest evidence of disease throughout the test, while the two virus controls developed rinderpest and were killed for vaccine production.

CONCLUSIONS

1. Tests by the Bureau of Agriculture of a vaccine prepared according to the method described in the paper by Kelser with the collaboration of Youngberg and Topacio has fully established the value of the vaccine.

2. Under conditions existing in the Philippine Islands, rinderpest control work will be facilitated if the number of injections of vaccine can be reduced.

3. Early test of the vaccine prepared according to the method of Maj. R. A. Kelser indicated possibilities along this line. Further and more extensive tests on this phase by the writer have indicated the following:

(*a*) That for ordinary purposes with cattle under field conditions, a single injection of chloroform-treated vaccine prepared with spleen, lymph glands, and liver will undoubtedly protect against natural infection. However, as carabaos are highly susceptible to rinderpest, if the preparation of the vaccine is limited to the use of spleen, lymph glands, and tonsils the objections arising from the use of a dose too large to be practical for field use can be overcome by eliminating the less-potent liver when preparing a vaccine for use on carabaos.

(*b*) That several tests in which twenty of the cattle and twenty-seven of the carabaos were inoculated with virulent virus, definitely show that a satisfactory immunization can be produced against a heavy artificial infection with a single dose of a vaccine prepared from spleen, lymph glands, and tonsils.

(*c*) That a dosage of 20 cubic centimeters for carabaos and 10 cubic centimeters for cattle is in every way entirely satisfactory for field use.

4. Research is also necessary to determine the length of immunity conferred by the single-injection method as compared with the three-injection method. Investigation on this phase of the problem will be continued.

ACKNOWLEDGMENT

The writer is indebted to Dr. Stanton Youngberg, director of the Bureau of Agriculture, and Maj. R. A. Kelser, of the United States Army Medical Department Research Board, for the many valuable suggestions given by them during the pursuance of this work.

ISNEG TEXTS WITH NOTES [1]

By OTTO SCHEERER

Of the University of the Philippines, Manila

ONE TEXT FIGURE

INTRODUCTION

When discussing in his "The non-Christian tribes of northern Luzon" [2] the question of the division of these peoples into tribes and dialect groups, the late Dean C. Worcester, after recognizing for northern Luzon the seven non-Christian tribes of "Negritos, Ilongots, Kalingas, Ifugaos, Bontoc Igorots, Lepanto-Benguet Igorots, and Tinguians," remarks (p. 861) that—

> A considerable amount of new work must be done before a satisfactory conclusion can be reached as to the dialect groups into which the seven tribes of northern Luzon should be divided.

The foregoing remark holds good as much to-day as when it was made some twenty years ago, the reason for our backwardness in the task of dividing those peoples linguistically being due not only to the absence, or rarity, of trained investigators, but also to the fact that the interior of northern Luzon is broken up dialectically quite as much as topographically. Where almost every valley, often each small group of settlements, has developed its own little unit of speech it requires indeed a considerable amount of new work to record such units in the first place individually, to compare and group these afterwards, and finally to arrive, through further study and comparison, at the ultimate establishment of the dialect groups had in mind by Worcester in saying:

> Where different dialects prevail among the members of a single tribe it should be subdivided into dialect groups. The differences in language

[1] "The inclosed paper on Isneg Texts by Professor Scheerer is, to my knowledge, the first contribution on the dialects spoken in the Subprovince of Apayao. Professor Scheerer is to be congratulated for having produced a paper which is valuable, both from the linguistic and historical point of view. I consider it would be highly desirable to have it published in the Philippine Journal of Science."—From letter of Dean Maximo M. Kalaw, of the University of the Philippines, in transmitting this manuscript.—EDITORS.

[2] Philip. Journ. Sci. 1 (1906) 791–875, 67 pls.

between the people of different dialect groups of a tribe are of course far less radical than are those between the people of different tribes.

In the present paper an attempt will be made to clear up, as far as possible, the linguistic relations of that part of the Mountain Province in northern Luzon which is officially designated as the Subprovince of Apayao. This attempt will be made by presenting, in the first place, direct evidence from the mouth of the inhabitants themselves in the form of some of their

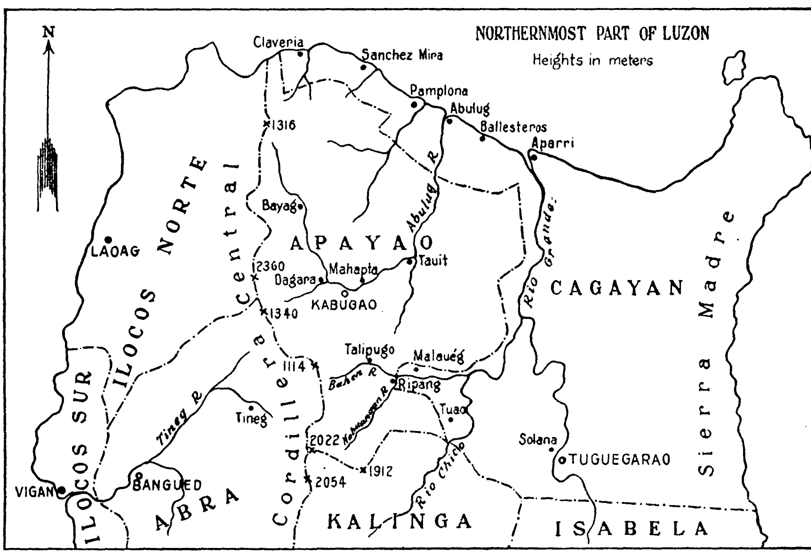


FIG. 1. Northernmost part of Luzon, showing the location of Apayao.

popular stories, next by analyzing and annotating these texts, and by discussing the results thus obtained.

The subprovince mentioned was characterized by Worcester as "a hitherto almost unknown region." It owed this character, aside from the head-hunting proclivities of its inhabitants, to its peculiar geographic situation (see fig. 1). It is covered for the greater part with dense forests, and is hemmed in, on the west, by the high range of the Cordillera Central; on the east, by an extensive swamp region between the Abulug River and the Cagayan River; and on the south, by a spur of the Cordillera separating it from the equally inhospitable land of the warlike Kalinga. With a scantily inhabited coastal strip as its northern boundary the country in question has at all times been difficult of access, and has remained in almost primitive conditions until quite recent times. This should be born in mind in forming a judgment of the people from the texts here given.

Including a small number of immigrants from the neighboring Christian provinces Ilocos and Cagayan, the population of the Subprovince of Apayao amounted in the last census, of 1918, to about 11,000 souls, being composed of two racially quite different elements: a minority of Negritos, locally known as Agta, who occupy chiefly the already mentioned swamp region, and a majority of brown people commonly designated by outsiders as "Apayao," but who, according to my inquiries, admit for themselves more readily the tribal name of "Isneg" or "Itneg." Among themselves these Isneg use to allude to each other by prefixing *i*, the common particle of northern Luzon for forming tribal or community names, to that of their home place, be this simply a rancheria, that is a native settlement consisting often enough of only a few houses, or a somewhat wider locality. A person from a rancheria called Mahapta, for instance, would thus go in Apayao under the name of an "Imahapta." Having gone to another province, however, he would say of himself: "Isnaggà," "I am an Isneg."

It may now be stated that among these Isneg of Apayao I was enabled, by casual intercourse with several individuals from different localities, to distinguish two distinct dialect groups. I found a group located near the southern extremity of the subprovince and consisting of the rancherias Talipūgo, Tawīni, Pudtul, Katablan͠gan, Bedtun͠g, Ili, and a few minor ones, which group, situated as it is along the Bāhen (or Bāhan) River (the Baren River of some maps) can be given the same name by which its members call themselves, and are called by their northern neighbors; namely, Ibāhen (or Ibāhan). To tell one of them to speak in his own dialect a companion would say to him: "Magibahen ka;" that is, "Speak as an (or 'in') Ibāhen." A special designation given this group by their neighbors on the Nabuan͠gan River in the southeast is Ià-bab.

A second dialect group, to the north of the Ibahen, and thus more centrally located, is made up by a number of rancherias surrounding the present subprovincial capital officially known as Kabugao.[3] These rancherias are Kà-bun͠gaw, Bulu, Nagbabálayan, Palītaw, Latwakan, Alumani, Nagsì-banán (Nagsim-

[3] Being specially concerned with popular pronunciation I adhere to a phonetic transcription of native words and thus shall write for Kabugao "Kabuhaw." A similar remark applies to other divergencies of spelling that may be found.

banán), Kolilímtaw, Hinà-buñg̃, and Mahápta, with some others. Kabuhaw proper is nowadays predominantly inhabited by Christian natives from Ilocos and Cagayan.

The first mentioned southern dialect group is represented in the following by the texts numbered I and II; the second central one, by texts III and IV.

The acquisition of these texts was made by me in a casual manner during vacation time in Baguio, in the mountains of Benguet. It was rendered possible through the courtesy of Prof. J. A. Wright, director of the Trinidad Farm School, who, as on previous similar occasions, afforded me every facility for prosecuting my studies among his students recruited from practically every part of the Mountain Province and some of whom hailed from the Subprovince of Apayao. The manner of recording the stories told me by the latter and here reproduced was very much the same as stated in my "Kalinga texts from the Balbalásang-Ginâang Group." [4]

The orthography followed for the vernacular in the present paper is in general the same as in my previous publications except that I have now adopted also for falling diphthongs the use of *y* and *w* and thus write, for example, *balay* and *algaw* in place of the former *balai* and *algao*. For the velar nasal I employ the symbol *ñg̃* instead of the former *ng*, putting myself thus in accord with the best Filipino usage. Since in pronouncing a word of two or three syllables the weight of the voice appears to fall, through duration or stress, most often on the penult I give this as understood and have reserved the use of the acutus, with the exception of uncommonly long words, for those cases where the stress falls on the ultima. As a further guide for the reader I have marked a more or less lengthened penultima by a dash above the vowel. The glottal stop (or "hamzah"), which manifests itself by an abruptly checked pronunciation of a vowel, followed by a slight hiatus, has been marked with a grave accent and the encounter of this with an acutus leads naturally to the formation of a circumflex. In the dialects here newly recorded the glottal check very often indicates the elision of some consonant. In Ibanág it regularly replaces *p, t,* and *k* in final position, and is there represented in conventional orthography by writing such a quasi-mute letter separated by a hyphen from the body of the word. For instance, words written in my texts as *anà*, child, *manû,* chicken,

[4] Philip. Journ. Sci. 19 (1921) 184.

appear in the Ibanág dictionaries as *ana-c, manu-c,* a spelling modified by Conant in his contributions to Philippine phonology to *ana*^{k}, *manú*^{k}. In my quotations from Ibanág I follow the latter method.

The strange English used in translating the texts finds its excuse, of course, only in that it is designed to follow as closely as possible the peculiar diction of the vernacular.

TEXT I. FROM TALIPUGO

KALIÑGA SALDÀ TALIPUGO EY DUMADAGA

1. Mapūlu dagún timmalíb Talipugo ey Dumadaga magkokópun da. Ñgem issa algaw Galī ñga Italipugo napén nañgalyug ko Duy-un. Ked nu nagawíh ñgimmīna asu.

FEUD BETWEEN TALIFUGO AND DUMADAGA [5]

1. Ten years had passed that Talifugo and Dumadaga were living as friends. But one day Gali, a man from Talifugo, went to trade to Duy-un. Then, when he returned he bought a dog.

Title. *Kaliñga:* feud, enemy (Ibg. *Kaliñga,* Ilk. *kabusor,* enemy). *saldà:* between; *saldà iddí ey ituni:* between here and there.

1. *dagún,* year; *piga dinagún na?* How many years has he? (Ibg. *dagún,* Ilk. *tawén.*)

timmalíb, perfect of *tumalíb:* who or what passes; *taliban:* place to be passed, perfect *tinaliban; italíb:* what is carried in passing.

magkokōpun, who are friends; *kōpun:* friend (Ibg. *kofun,* Ilk. *gayyem*).

issa algaw: one day; better: *issa ñga algaw;* the ligature *ñga* is here as elsewhere often omitted (Ibg. *aggaw,* Ilk. *aldaw,* day).

napén, perfect of *mapén:* who goes; *papanen:* who is made to go; perfect *pinapen; Ipén mu liblu kagina:* Go and take the book (Sp. *libro*) to him. *Awâ kapannam?* Where are you going? (Ilk. *mapán,* who goes somewhere.)

nañgalyug, perfect of *mañgalyug:* who trades; *ialyug:* object of selling, perfect *nealyug; alyugan:* object of buying. *Inalyūgà* or *inalyūgan ku:* I bought it.

nagawíh, perfect of *magawíh:* who returns; *iyawíh:* what is taken along in returning (as something unsold on the market), perfect *neyawíh; nagawihán:* object bought on returning. In careful pronunciation the final *h* was heard as an unvoiced palatal fricative.

ñgimmina asu, better: *ñgimmina ko asu:* was buyer respecting a dog; *ñgumina,* who buys (Ibg., Ilk. *ñgina,* price). I had no means to determine whether the frequently careless diction of the texts was peculiar of the story-tellers or is typical of the dialects.

[5] This is an account of the last head-hunting raid which occurred in Apayao about the year 1911.

2. N̄gem ya dālan saldà Talipugo ey Duy-un adú tōlay. N̄gem Galī madī na nasiñ̄gen agīda ta nagsūhù da kia aséñ̄g dālan.

2. But (on) the road between Talifugo and Duy-un (there were) many people. But Gali did not see them for they were hiding near the road.

2. *ya dālan:* the road; one expects *kia dālan,* that is the article *ya* in the demonstrative relation, similarly as in *kia aséñ̄g dālan* at the end of the paragraph; however, names of places, especially proper names of such, are not infrequently used without a proper demonstrative particle, in Apayao as well as in other parts of northern Luzon.

adú, many, much (Ilk. *adú,* Ibg. *arú*).

tōlay: person, people (Ibg. *tōlay,* Ilk. *táo*).

madí: what is denied or disliked (Ilk. *madí,* Ibg. *marí*). Monosyllabic pronominal postpositives attach themselves in speaking to the preceding word and produce phonetic changes of different kinds; to facilitate analysis I have, as a rule, written such postpositives detached from the preceding word. Lists of Talipugo and Mahapta personal pronouns will be found in "Summary and comparative notes," following the texts.

nasiñ̄gen, perfect of *masiñ̄gen:* what is visible, what can be seen. "I see it" is *Masiñ̄gen ku* or, more usually, *Masiñ̄gô.* (Ibg. *masiñ̄gan,* Ilk. *makita.*)

nagsūhù, perfect of *magsūhù:* who hides; *susuhūkan:* hiding place; *Isūhù ku* or *Isūhuk ku:* I shall hide it; *Isūhuk mu di:* Hide this.

aséñ̄g: near; *kaséñ̄g ku:* person at my side.

3. Ked nu Galī timmalíb aséñ̄g da kayát da ñ̄ga sayáñ̄gen, ñ̄gem neppay kia asu na. Napia ta madí neppay key Galī.

3. Then when Gali passed near them they wanted to spear him, but hit his dog. (It was) well that they did not hit Gali.

3. *kayát:* desire, liking, volition; *Kayát ku mañ̄gan:* I want to eat (Ilk. *kayát,* Ibg. *ayá'*).

say-áñ̄gen: object of spearing, perfect *sinay-áñ̄g; nagsasay-áñ̄gan:* place of fighting with spears in the past; radical *say-áñ̄g:* a special kind of spear.

neppay, perfect of *ippay:* what is thrown, placed, lodged; *neppayan:* wound caused by spear or other cutting weapon (Ibg. *pay,* idea of placing or throwing anything somewhere, Ilk. *kabil*).

napia: good (of character, taste, etc.); *Napia agīna:* He is good.

4. Ey Galī nagtalaw, madī na ináx-ā-puhán asu na ta nansíñ̄g. Daya tōlay pinatáy da asu. Galī inumbét ko baláy da ey nebagā na key daya kabulún na ñ̄ga adú tōlay nañ̄gilpañ̄g kagīna.

4. Gali ran away, not minding his dog for he was afraid. The people killed the dog. Gali arrived at his family's house and told his companions that many people had ambushed him.

4. *nagtalaw,* perfect of *magtalaw:* who escapes; *makitalaw:* who joins others in running away.

ináx-ā-puhàn (phonetics not quite clear; the sound represented by *x* vacillated between a velar and a laryngeal fricative), stated to be the perfect of *apūhan:* object to be cared for; *Apūham apuy*: Look after the fire.

nansin͠g, perfect of *mansin͠g:* who is afraid (Ibg. *massin͠g,* Ilk. *mabutén͠g*).

pinatáy, perfect of *patáyen:* object of killing; *ipatáy:* instrument of killing; *mamatáy:* who kills; *papatáyan:* any part of the human body the wounding of which by spear or head ax is apt to cause death (also *kapatáyan* is thus used); *agmatmatáy:* who is dying; *natáy:* dead.

inumbét or *linumbét,* perfect of *umbét* or *lumbét:* who arrives, comes; *linumbétan:* place where arrival was made; *Alalbét Huán:* John has just arrived (Ibg. *labbé*ᵗ, Ilk. *daténg*).

ko baláy da: to or at or in their house; also *kia baláy* might be said; the possessive pronoun *da,* their, characterizes the house as being that of Gali and his family.

nebagá, perfect of *ibagá:* what is told; the following *na* changes the stressed final *á* to long *ā*.

kabulún: companion (Ibg. *kavulún,* Ilk. *kakuyog, kabbaláy*).

nan͠gilpan͠g: who has been in ambush; *nan͠glappan͠gan:* place where an ambush was made.

5. Daya kaílian ne Galī kayát da n͠ga umén͠g da bumāles. Madī da ammo awâ kapannān da, n͠gem Baydan yan na n͠ga: "Mapén tadá ko Dumadāga ta ammò n͠ga kabdén͠g me agīda. Gabbáen tadá lāman͠g ya beddén͠g."

5. The town mates of Gali wanted to go to take revenge. They did not know where to go, but Baydan said: "Let us go to Dumadaga although I know they are our partners in a peace treaty. Just let us break the treaty."

5. *umén͠g:* who goes, perfect *immén͠g*.

bumāles: who takes revenge, perfect *bimmāles. Nebāles ku amá:* I have revenged father. *Makibāles kayú:* Join in our revenge.

ammo: knowledge; *ammò:* my knowledge; *ammom:* thy knowledge; *ammō na:* his knowledge.

awâ: where; *Awâ baláy mu?* Where is thy house?

kabdén͠g: party to a *beddén͠g,* or peace treaty, marked in the rancherias concerned by a big festival called *paspû*. Compare Ilk. *boddón͠g:* exchange of one thing for another without any premium on either.

6. Talipūgo tōlay napén da nan͠gn͠gayaw ko Dumadāga. Adú agīda mapén non-onna íssa algaw sekūha daya dadūma naggannūkat. Inumbét da ko Dumadāga pasun͠gānay tahaút anû.

6. The Talifugo people went on a head-hunting raid to Dumadaga. Many of them went in advance one day before the others started. They arrived in Dumadaga at the time of the first cock's crow.

6. *nan͠gn͠gayaw*, perfect of *man͠gn͠gayaw:* who goes on a head-hunting raid; *n͠gayawan:* place to be raided, perfect *n͠ginayawan.*
sekūha: before.
naggannūkat, perfect of *maggannukat:* who departs; *naggannukātan:* place where start was made.
pasun͠gānay tahaút anû: the first crowing of cocks; *pasun͠gānay:* the first time. *Awâ in͠gn͠gem nagpasun͠gānay?* Where did you pass the first time? *anû:* chicken.

7. Nasin͠gen da apuy allam naya baláy. Ked nu nasin͠gen da apuy naghohón͠gos inumnà kia baláy. Odaw n͠ga uliteg ko non-onna inumnà kia baláy. Odaw nasin͠gen na ya lalāki matūdug. Ked nu nagì-nā na daya tōlay nilumnà nalukág.

7. They saw fire inside a house. Then, when they saw the fire, they rushed to enter the house. Odaw, my uncle, was the first to enter the house. Odaw saw a man sleeping. Then, when he heard the people entering, he awoke.

7. *allam naya baláy; allam:* inside; *naya baláy:* of the house; further on *kia baláy:* to the house; *ya baláy* may mean "the house" or "a house;" for the plural compare: *daya tōlay, naya tōlay, ki daya tōlay;* for a form like *bábalay:* houses, the article was stated to take the forms: *daya, naya,* and *kia bábalay* (*bábbalay?*), there being, however, some uncertainty about the latter statement.
naghohón͠gos, perfect of *maghohón͠gos:* who rush; *naghohon͠gōsan:* place invaded with a rush.
inumnà, stated to be an alternative of *nilumnà*, perfect of *lumnà:* who enters. *Ilnà mu di:* Take this inside with you. *Nelnà ku:* I have taken it inside.
ya lalāki matūdug or *ya lalāki n͠ga matūdug:* a man who sleeps.
nagì-nā na: his audible thing in the past; *magì-ná:* what is audible; *maggì-ná:* who listens; *Gì-nan mu:* Listen to it. *Ginì-nà:* I have heard it (Ibg. *magginna:* who hears, Ilk. *makan͠gn͠gég*).
nalukág, perfect of *malukág:* who awakes (Ibg. *lukág*, idea of awaking).

8. N͠gem Odaw ni-nā na sin͠gal na, neppay kia sináy na. Odaw madī na nasin͠gen ya babáy asén͠g naya dapúg. Odaw immūlug, yan na: "Pinatáy ku! Pinatáy ku!" Daya dadduma tōlay inúmsil da.

8. But Odaw threw his spear; he lodged it in his belly. Odaw did not see a woman near the fireplace. Odaw came down from the house, saying: "I have killed one! I have killed one!" The other men were filled with envy.

8. *nì-nā na:* object thrown by him. *ì-nam ko sináy na:* Throw at his belly. *Awâ pañgì-na-à?* Where shall I throw at? *Sináy na pañgì-naám:* Throw at his belly (lit. "His belly be the place of your throwing").
siñgal, general term for spear of any kind.
immūlug, perfect of *umūlug:* who descends from a house (usually by the stair. As a matter of fact in this case the sides of the house had been cut open by the raiders. Ibg. *ulúg,* Ilk. *úlug,* idea of descending.)
inúmsil, perfect of *úmsil:* who envies; *asīlen:* object of envy, perfect *ínsil* (Ibg. *passíl,* envy).

9. Napén da allam baláy; Aliñgóg pinatáy na ya babáy aséñg dapúg. Maggay ey Bulawat magwagi da. Maggay pinatéd na ya bù-law naya lalāki. Bulawat pinatéd na pe bù-law naya babáy. Dadduma nagsamsam da ko gūsi, lembubú ey adú nadumdumma ñga buñgot.

9. They went inside the house; Aliñgog killed the woman near the fireplace. Maggay and Bulawat were brothers. Maggay cut the neck of the man; Bulawat likewise severed the head of the woman. The others plundered jars, switches, and many different kinds of beads.

9. *magwagi:* who are brothers or sisters (Ibg. *wagí,* brother, relative).
pinated, perfect of *putdén* or *patdén:* what is cut across, beheaded; *mamatéd:* who beheads, perfect *namatéd* (Ibg. *futúl,* idea of beheading; Ilk. *púted,* idea of cutting across).
bù-law: neck (Ibg. *vulláw:* neck, throat, Ilk. *bukláw: glutton,* Inib. *bukdow,* neck).
gūsi: glazed earthenware jars of Chinese origin and great age, the family treasure of the wealthy among the mountain peoples.
lembubú: switches worn by both men and women, generally made of the owners own dead or cut-off hair, and wound into the living hair as an adornment.
buñgot: beads (another family treasure among the mountain dwellers of northern Luzon).

10. Ked nu nagawíh da nagañgwā da ko patūñg. Dūa būlan timmalíb gubérnador inumbét ko Talipūgo ta imméñg da pinanutnūtan. Ked nu inumbet da ko Talipūgo diñgkat da ñgammin daya tōlay.

10. Then, when they returned they made a day of general rejoicing and feasting. Two months having passed, the governor came to Talifugo and they proceeded to make an investigation. Then, when they arrived in Talifugo they called together all the people.

10. *nagañgwa*, perfect of *magañgwa*, stated to be an alternative form of *mañgwa:* who makes; *kwaen:* object of making, perfect *kiñgwa:* what has been made (Ibg. *kwa*, idea of doing, making).
patūñg (*patuuñg?*)*:* festival in celebration of a successful head-hunting raid; after this festival no work is done for five days, a spell called *kanyaw*, the violation of which exposes a person to sickness.
gubérnador, there being no *r* in this dialect an Isneg less civilized than my informant would pronounce *gubélnadol;* so also, further on, *pelesidente* for *presidente*.
pinanutnūtan, perfect of *panutnūtan:* investigation; *nutnūten:* what is to be followed, as, for instance, footprints on the ground.
diñgkat, perfect of *dakāten:* who is called or invited to a gathering; *magdakkát:* who calls together by going from house to house.

11. Ked nu daya tōlay nabunbunuñg gubérnador nebagā na ki daya tōlay kantam ta nañgñgáyaw da. Daya tōlay timbag da ñga ya presidente da madī na nebagá kagida ñga gubérnador masadút kia mañgñgáyaw.

11. Then, when the people were assembled in files, the governor asked of the people why they had gone out head hunting. The people replied that their presidente had not told them that the governor was opposed to head hunting.

11. *nabunbunuñg*, perfect of *mabunbunuñg:* who are assembled in files; *nagbunbunuñg:* who have been placing themselves in file; *gabunbunuñg da:* they are placing themselves in file; *nagbunbunuñgan:* place where an assembly was made.
timbag, perfect of *tabagen:* what is given as answer (Ibg. *itabbag*, what is answered).

12. Ne gubérnador nebagā na ñga: "Nagan namatáy kia tōlay?" Odaw yan na: "Īyô namatáy kia lalāki." Aliñgóg yan na pe agīna namatáy kia babáy.

12. The governor asked: "Who killed the people?" Odaw said: "I killed the man." Aliñgog said also that he was the killer of the woman.

12. *nagan* or *ñgagan:* name; *nagan* is also interrogative: who? what? *namatáy kia tōlay*, note the construction of the "nomen agentis" *namatày*, killer, with *kia*, and compare *hummatañg ka abuy* in notes to Text III, section 3. Instances of the same construction occur in other parts of these texts.

13. Maggay ey Bulawat yan da: "Ikamí magwāgi namatéd kia bù-law da." Ne gubérnador: "Nagan nañgipañgūlo

13. Maggay and Bulawat said: "We brothers cut their necks." The governor: "Who acted as leader to you?" Bay-

kikayú?" Baydan yan na n͠ga: "Īyô." Ne gubérnador kagīen na n͠ga: "Mabālud kayú n͠gammin."

dan said: "I." The governor said: "You are all prisoners."

13. *nan͠gipan͠gūlo*, perfect of *man͠gipan͠gulo:* who acts as *pan͠gulo* or headman, leader.
kagīen: what is said, perfect *kināgí; makagí:* who speaks. *Nagan kagī na?* What language does he speak? (Ibg. *kagí*, Ilk. *saó* word.)
mabālud: who is bound, a prisoner.

14. Daya tōlay yan da n͠ga: "Awán liwat da ta ya presidentē da madī na nebagá kagīda," n͠gem gubérnador: "Ya presidentē nu mabālud pe, uméñg kikayú ko Tawit." Ked nu masahu napén da n͠gammin ko Tawit.

14. The people said: "They are not guilty for their president did not tell them," but the governor: "Your president is also arrested, he will go with you to Tauit." Then, next morning, they all went to Tauit.

14. *awán:* there is not (Ilk., Ibg, *awán*).
liwat: guilt, fault (Ilk. *liwat*, Ibg. *liwa'*).
Tawit, on the Abulug River, was up to about 1915 seat of the subprovincial government which was then transferred to the more centrally located Kabuhaw (Cabugao). The word *Tawit* is found also in the name of a large group of people occupying mainly the rural parts of southern Cagayán and calling themselves *Itawit*, which name, according to a certain phonetic law of Ibanág, becomes in this dialect *Itáwì*.

15. Dūa būlan dan ko Tawit yan da n͠ga: "Magtalaw tadá!" N͠Gem natkém da manín ey nipapén da Buntô. Natágtagissá da n͠ga natáy, issá Odaw nagawíh ko Talipūgo.

15. Two months they were already in Tauit (when) they said: "Let us run away!" But they were caught again and made to go to Bontoc. One by one they died; alone Odaw returned to Talifugo.

15. *dūa būlan da:* literally: "two months their" to which is added in the text *n* = already.
natkém, perfect of *matkém:* who or what is caught; *tà-men:* object of catching; Catch him : *Tà-mem* or *Tà-men mu.*
nipapén, compare note to *napén* in section 1.
natágtagissá, perfect of *matágtagissá:* one by one; *magdudūa:* two by two.

16. Issa n̄ga būlan na ko Talipūgo, gubérnador yan na n̄ga: "Ikáw, magpresidénte ka." Timbag ne Odaw: "Madì kayát ta nabāludà ey daya kabulún madī da nad kúxkuhugén."

16. One month he (Odaw) had been in Talifugo when the governor said: "You, you take the office of president." Odaw's answer was: "I do not want to because I have been a prisoner and the townmates might not obey me."

16. *nabāludà:* was-prisoner-I.
nad expresses possibility; *natáy nad:* he is perhaps dead.
kúxkuhugén, reduplicated form of *kuhugén:* who or what is obeyed; perfect *kinuhúg; x* represents the velar fricative (Ibg. *kurúg:* idea of believing, assenting).

17. Yan ne gubérnador: "Uhay laman̄g, nu madī da ka kúxkuhugén ibagám kīyô." Odaw: "Panda uhay mu, n̄gem nu awád magì-nà dakê kagí kīyô, patayô."

17. The governor said: "Never mind, if they will not obey you, tell it to me." Odaw: "According to your will, but if there are heard by me bad words against me, I shall kill the person."

17. *uhay lāman̄g,* an idiomatic expression deprecating direct action and insinuating that things be left to work themselves out at their will. Compare *uhay* in the next sentence meaning "will and pleasure" (Ibg. and Ilk. *uray*).
panda, in Ilk. "consecutively without leaving over anything."
awád: there is, there are (Ilk. *addá,* Ibg. *uwád, egga*).
magì-nà: audible-thing-mine; second person *magì-nam;* third person *magì-nā na.*
dakê: bad; *kadakēkan:* badness; also *dakes* is in use (Ibg. *dàkay,* Ilk. *dàkes*).
kagí: word, language; *kagkagí:* words of many persons; compare *kagien* under notes to section 13.
patayô: killing-object-mine; also *patayen ku* is in use, but the former was stated to be preferable. This answer was but calculated to avoid being made president ("burgomaster").

18. Ne gubérnador: "Madím patayen, n̄gem ibagám kīyô." Daya tōlay kayát da pà-nen̄g Odaw n̄ga presidente ey namiddua n̄ga nagpresidente.

18. The governor: "Do not kill anybody but tell it to me." The people liked very much having Odaw as president and he twice officiated as such.[6]

[6] The governor repeatedly cited in this text and upon whom devolved the task of correcting the appalling views held in regard to the taking of human life by those mountaineers, was the Hon. Blas Villamor, member of a prominent Ilocano family of Abra.

18. *madím patayen* or *dim patayen:* "Let there be none killed by you." *pà-neñg:* very much; *Naphāñg pà-neñg:* It is very hot.

TEXT II. FROM TALIFUGO

GAWEN

1. Íssa algaw Gawen nebagā na kia inā na ñga kayát na mañgasawa. Bohâ ñga inā ne Gawen yan na: "Bo, ñgem nagan kayát mo?" "Kayát ko Ābaw," yan ne Gawen.

GAWEN [7]

1. One day Gawen told his mother that he wished to marry. Boha, the mother of Gawen, said: "Yes, but whom do you like?" "I like Abaw," said Gawen.

1. *íssa algaw,* more correctly: *íssa ñga algaw:* one day.
inā ne Gawen: mother of Gawen; for the remaining forms expressive of the relation in which a personal name may stand to other parts of the sentence compare: "Gawen is dead:" *Ne Gawen ey natáy* or *Natáy ñge Gawen;* "They said to Gawen:" *Nebagā da key Gawen.*

2. Íssa ñga gidgidám Bohâ napén ko Agiñgan ta nebagá ki daya ap-apō ne Ābaw ta Gawen kayát na asawáen Ābaw. Daya ap-apō ne Ābaw yan da ñga: "Napía nu magasawa da."

2. One afternoon Boha went to Agiñgan and told the parents of Abaw that Gawen wished to marry Abaw. The parents of Abaw said: "It is good that they be man and wife."

2. *asawáen:* the female party as object of marrying; *mañgasawa:* the male who marries; *magasawa:* the two persons marrying each other.

3. Ked nu Bohâ napén nanādug binālin da agīna. Ked nu nagawíh Bohâ nebagā na key Gawen ñga mapén ko Agiñgan. Ne Gawen madī na kayát megyán ko baláy de Ābaw ta madī na ammo magobhá.

3. Then, when Boha had gone to treat with the parents about the marriage of the girl she was accommodated by them. So, when she returned, Boha told Gawen to go to Agiñgan. Gawen did not wish to stay in the house of Abaw and her people because he did not know to work.

[7] This story is an "idōdit" (Mahapta: "idaudit"), or legend, handed down from the old people. For some reason the scene is laid in the "untû," or sky-world, at a place called Duduñgan. The persons are Gawen and his mother Bohâ of Duduñgan, and Ābaw, a girl of the wealthy class of people called "bà-nañg," of the neighboring Agiñgan. Story-tellers sometimes change the name of Gawen to Dēmuñgan, that of Abaw to Damōliñgan.

3. *nanādug*, perfect of *manādug:* who makes or arranges those gifts (called *béllay*) to the parents of a girl which are meant as a *tādug* or gift "propter nuptias."
binālin, perfect of *balinén:* who is accommodated, what is agreed to, concluded (Ibg. *balín:* idea of finishing something by perfecting it; Ilk. *balín:* idea of being able, of what is possible).
megyán (stated to be an alternative form of *magyán*): who stays in a place; *megyánan:* the place where one stays (Ibg. *gyán:* place where one finds himself, *magyán* or *maggyán*, who dwells; Ilk. *yan, agyán:* same meanings).
baláy de Ābaw: house of Ābaw and her people; "house of Ābaw" would be: *baláy ne Ābaw.*
magobhà: who works, worker; perhaps from Sp. *obra:* work. Compare Inib. *ubdà:* work.

4. N̄gem Ābaw madī na pe kayát n̄ga megyán ko baláy de Gawen. Gawen nakagumán n̄ga mapén ko baláy de Ābaw. Ked nu inumbét ko baláy da madī na ammo kūwaén na.

4. But Abaw too did not like to stay in the house of Gawen and his family. Gawen was obliged to go to the house of the family of Abaw. Then, when he arrived in their house, he did not know his work.

4. *nakagumán:* was obliged; radical *kagumán*, which in Ibg. denotes obligation, force, effort. Compare under section 10: *kinagumán*, perfect of *kagumanen:* who is forced.
kūwaén na: his work. The position of the husband and the wife depends, among the Isneg as elsewhere, upon the respective wealth of the contracting parties; compare Text I, section 10, notes: *nagan̄gwa.*

5. Íssa n̄ga algaw awán da n̄ga danúm. Ābaw nebagā na key Gawen n̄ga umén̄g magsàdú. Gawen madī na ammo kūwaén na, n̄gem napén lāman̄g ta mal-alyaw. Ked nu inumbét ko wan̄gag awán na n̄ga pagipayan kia danúm.

5. One day they had no water. Abaw told Gawen to go and fetch water. Gawen did not know what he was to do, but went anyhow for he felt ashamed. Then, when he arrived at the river, he had nothing to use as a container for the water.

5. *magsàdū;* prefix *mag-* forms both "nomina agentis" and "nomina actionis:" Who fetches water? *Nagan ya magsà-dū?* It is difficult to fetch water: *Nasulít ya magsà-dū.* For the radical *sà-dū* compare Ilk. *sakdú:* idea of fetching water, especially for drinking.
mal-alyaw: who is ashamed; *Nagan kal-alyaw mo?* Why are you ashamed?

pagipayan: place or container into which something is put; *Nagan ippay mo?* What are you going to put? *Payam pikám:* Put some more.

6. Mal-alyaw n͠ga lumbét ko baláy da nu awán ālà na n͠ga danúm. Napén kia íssa n͠ga tendáan n͠gimmina ko lūbid; ked nu nagawíh napén ko wan͠gag manín, pinutputéd na ya lūbid ta kayát na n͠ga galūtan ya danúm, n͠gem madī na magalūtan.

6. He was ashamed to arrive at their house if he could get no water. He went to a certain shop to buy string and when he went back again to the river, he cut up the string into many pieces as he wanted to tie up the water, but it could not be tied by him.

6. *āla na:* his object of taking; one would expect a form **alaen* (thus in Ilk.) with a perfect **ināla* (as in Kabuhaw); the perfect of *ālà* is, however, *nālà.* Compare farther on *makaāla:* who is able to fetch.

tendáan: shop; probably from Sp. *tienda,* shop, Tag. *tindahan.*

pinutputéd, perfect of *putputdén:* frequentative form of *putdén:* what is cut up (also *patdén* is said). Compare *pinatéd* in notes to Text I, section 9.

magalūtan (radical *galut*)*:* what can be tied, what is "tiable;" with prefix *ma-* expressing possibility are similarly formed: *masin͠gen:* what can be seen, is visible; *makán:* what can be eaten, is eatable; *makagtú:* what can be carried, and many others.

7. Dakes pà-nen͠g an͠ges na nu madí makaālà ko danúm. Podpodnúen na nagan kuwaen na. Gawen napén nammét ko bulu ked nu inumbét ko wan͠gag sinisì-lat na ya bulu ey inahipán na.

7. His mind was very much disturbed when he could not get water. He reflected what he should do. Gawen went to get some bamboo and when he arrived at the river, he split the bamboo into sticks and cut these into sharp points.

7. *dakes pà-nen͠g an͠ges na:* literally: "bad very much mind his" meaning: he was very sad; the original sense of *an͠ges* is "respiration," which is also that of Ibg. *an͠go'*, Ilk. *an͠ges.*

podpodnúen: object of trying to hit the right solution; perfect *pinodpodnú;* compare Ilk. *pudnó:* truth.

nammet, perfect of *mammet:* who fetches.

sinisì-lat perfect of *sisì-laten,* object of splitting repeatedly.

inahīpan, perfect of *ahīpan,* object of cutting to a point.

8. Kayát na n͠ga dawisen ya danúm n͠gem madī makaālà.

8. He wanted to pick up the water with the pointed sticks

Madī na kayát magawíh ko baláy da ta mal-alyaw. Ābaw tontōnan na pēyen͠g agīna. N͠gem nu gabí, Gawen madí pikám inumbét.

but he could not get it. He did not like to return home as he was ashamed. As for Abaw, the object of her waiting all the time was he. But by night Gawen had not yet arrived.

8. *dawisen:* object of picking up with something pointed.
tontōnan: who is awaited; *magtón:* who awaits.
peyen͠g: continuously, all the time.

9. Ābaw naglidug, kin͠ggaán na n͠gammin daya lalaki ko asen͠g baláy da ta umén͠g da sapūlen Gawen. Ābaw nebagā na ki daya lalaki n͠ga Gawen napén ko wan͠gag kittu sassahu. Daya lalaki napén da n͠gammin ko wan͠gag ay simmà da ne Gawen.

9. Abaw was filled with fear; she called all the men near their house to go and search for Gawen. Abaw told the men that Gawen had gone to the river that morning. The men went all to the river and they saw Gawen.

9. *naglidug*, perfect of *maglidug:* who fears.
kin͠ggaán, perfect of *kaggaán:* who is called to come.

10. Nebagā da key Gawen: "Kantam madī ka magawíh?" "Mal-alyaw-à ta madī makaālà ko danúm," yan na Gawen. Yan da n͠ga: "Mapén tadán ta gabíyin." Gawen madī na kayát umén͠g kagīda, n͠gem kinagumán da. Ked nu inumbét ko baláy da, Ābaw inelaln͠gán na Gawet; yan na: "Ikáw, awán am-ámmom! Madì kayát ikáw n͠ga asawà; napía nu magadī ta."

10. They said to Gawen: "Why do you not come back?" "I am ashamed for I am not able to fetch water," said Gawen. Said they: "Let us go then for it is already night." Gawen did not want to go but they forced him. Then, when they arrived at their house, Abaw scolded Gawen; she said: "You, you do not know anything! I do not want you as my husband; it is better that we separate."

10. *kinagumán*, see *nakagumán* under section 4.
ineláln͠gan, perfect of *aláln͠gan:* who is scolded; *magàlan͠g:* who scolds.
magadī: who separate, or withdraw from an agreement (Ilk. *agadí*, retract).
am-àmmom from *ámmo:* knowledge and *mu:* thy, the reduplication of the first syllable of *ámmo* giving a frequentative sense and thus lending force to the reproach expressed by *awán:* there is not. Compare *ámmo* under notes to Text I, section 5.

11. Tuya Gawen magawíh ko baláy naya ap-apō na ko Duduñgan. Mebagā na ki daya ap-apō na: "Ābaw madī na kayát iyô.—

11. Therefore Gawen went back to the house of his parents in Duduñgan. He announced to his parents: "Ābaw does not want me."—

TEXT III. FROM MAHAPTA

RAÑGÁT SE KADÁW

RAÑGAT AND KADAW

1. Rañgát, Ikumaw, mapán péyañg ka Kà-buñgaw. No mahúlli, Rañgat mapán ka balay ni Kadáw ka Palītaw. Ya atawa ni Kadáw mahisīsam da. Si Kadáw kaskasisinnā na da; madī na malù-sáw.

1. Rañgat, a man from Kumaw, used to go to Kà-bungaw. When he returned, he went to the house of Kadaw in Palitaw. The wife of Kadaw (and he), they smiled (at each other). Kadaw looked at them; he was not yet angry.

1. *péyañg:* always, frequently.
mahúlli: who returns; perfect *nahúlli; Iúlli mo kiddí:* Bring it back here. *Ullíam:* Go back the way you came. (Ibg. *tóli;* Ilk. *sublí.*)
atawa: spouse (Ibg. *atawa,* Ilk *asawa*).
mahisīsam: who smiles; *Pañgisīsam na;* He says (or does) that to make others smile.
kaskasisínnan: who or what is being looked at. Compare *sinnan* under section 7.
malù-sáw: who is angry; *kalù-sáwan ko:* object of my dislike, I do not like it; perfect *kinalù-sáw ko.*

2. Kani pagmākat pinagkilóson da Rañgát. Kani mabālin nañgan, napán nin. Isa algaw Rañgát inumbét manín. Napán ka balay ni Kadáw makim-umōman kia atawa ni Kadáw. Kani mabālin da mahúm-umōman Rañgát napán nin.

2. The next morning they gave Rañgat breakfast. When he had finished eating he just went away. One day Rañgat came again. He went to Kadaw's house to converse with Kadaw's wife. When they had finished talking Rañgat went away.

2. *pinagkilóson,* radical *kilóson:* breakfast. *Magkilóson ka:* Take your breakfast.
makim-umōman (possibly from * *maki-umumōman*): who converse. *Nahan pahum-umōmanan nu?* What are you conversing about? *Pahum-umōmanan* and the following *mahum-umōman* indicate the change of prefixes *pag-* and *mag-* to *pah-* and *mah-* before a vowel.

3. Si Kadáw madī na pikám malù-sáw. Kani isa būlan nagtāpus Rañgát napán huma-

3. Kadaw was not yet angry. When one month had passed, Rañgat went to buy pigs in Kà-

tañg ka abuy ka Kà-buñgaw. Ni Kadáw ammō na manín ñga magsībal ka balay da.

buñgaw. Kadaw knew that he would stop again at their house.

3. *nagtāpus*, perfect of *magtāpus:* what finishes.
humatañg: who buys, buyer; perfect *himmatañg; ihatañg:* money as instrument of buying; *hatañgan:* what is to be bought, perfect *hinatañg.* Note here, as in other instances, the use of demonstrative *ka* after a nomen agentis (*humatañg ka abuy*) as against the associative relation used in such cases elsewhere; for example, in the equivalent Tagalog *bumili nañg babuy.*
ammo: knowledge; compare notes to Text I, section 5.
magsībal: who stops on his way at a house; one who intends to leave an object at a certain house, and recover it upon his return, would say: *Sibālan ko yaní:* Object of my stopping will be this. One who is to take along an object for leaving it at a place where he is to stop, would be told: *Isībal mo yaní:* Motive of your stopping be this.

4. Binō na ya an-anâ na si Sekel se katayug na ni Mù-log ñga mamtát kaleggi ni Rañgát beñga umbét. Datu dūa ñga napán namtát. Kani mahúlli da neppay da ya uwáy kia linuñg naya balay. Rañgát di na pikám inumbét.

4. He ordered his son Sekel and his brother-in-law Mu-log to cut and bundle rattan before Rañgat arrived. Those two went to cut rattan. When they returned they placed the rattan into the space under the house. Rañgat had not yet arrived.

4. *binō*, probably from *binón*, perfect of *bōnan:* who or what is ordered; *bōnan ni gobierno:* order of the government.
mamtát: who cuts and bundles rattan; perfect *namtát. Tattatán mo:* Cut that (said of something fastened, as with a string).
neppay, see this under notes to Text I, section 3.
linuñg: space under the house; compare Ilk. *linoñg:* shelter, shade, dusky place.

5. Agpapaso isa tōlay ummáñg ñga mañgibahá ki Kadáw ta Rañgát adanní kia balay. Kadáw rinù-rut na ya dūa ñgoyon uwáy; napán kia tatà-patán maniwsiw .

5. At the midday meal a man came who told Kadáw that Rañgat was near the house. Kadáw pulled out the two bundles of rattan; he went to the *tatà-patán* to shave the rattan.

5. *mañgibahá:* who tells something. *Makibahá ka agīna:* Communicate it to him.
adanní: near (Ibg. *aranní*, Ilk. *adaní*).
rinù-rut, perfect of *rù-rutan:* what is pulled out.
ñgoyon: bundle; compare Ilk. *uyon:* a certain amount of bundles of rice.

tatà-patán, may refer to a path near the house, or to the river bank which for these riparians is a place of frequent passage, of work, play, and other community life.

maniwsiw: who shaves rattan (which may include splitting it). *Nanniwsiwan:* shaving place for rattan. *Iddí paniwsiwan nu:* This is to be the place for your shaving rattan.

6. Ran͠gát inumbét kia hayān ni Kadáw. Kadáw ibahā na n͠ga mahāpog. Ran͠gát nā na: "Awán būa ko." Kadáw umūnè kia būa man͠gnamát ka dūa bukál. Niddē na kia Ran͠gát. Ran͠gát nagtuháw.

6. Ran͠gat came to where Kadáw found himself. Kadaw asked him for (or: proposed to him?) a chew of betel. Ran͠gat said: "I have no areca nut." Kadaw climbed an areca palm to get two nuts. He gave them to Ran͠gat. Ran͠gat sat down.

6. *hayān* (Talifugo *giyān*): place where somebody or something finds himself or itself (Ibg. *gián*, Ilk. *yan*).

mahāpog: who prepares, for chewing, a leaf of *Piper betle* (*háwad*) by coating it with lime (*āpog*) and coiling it, folded up, round a piece of areca nut (*būa*), the plug thus obtained being called *inapūhan*.

awán: there is not; compare notes to Text I, section 14.

nā na: lit. 'say his;' *nan ko:* my say; *nā mo:* thy say; *nā nu:* your say; *nan da:* their say.

umūnè: who climbs, perfect *immūnè*. *Paunékam* (from **paunékan mo*): Cause him to climb (Ibg. *umuné* [k], Ilk. *umúli*).

man͠gnamát: who gets or takes; perfect *nan͠gnamát*. *Innaya namát kia lapis ko?* Who has taken my pencil?

bukál, a general term for round things.

niddē: see *iddē* under section 10.

7. Kani sinnan dadāya nasin͠gan ni Kadáw n͠ga awád kōman nasid-dug. Ibahā na key Ran͠gát n͠ga sinnan na. Ran͠gát di na kurkurúhan. Kadáw nalù-sáw. Lummipút ka likúd na, sinapgūtan na adág ni Ran͠gát kia aliwa na. Ran͠gát nitayag na ya īma na, sinan͠gpát manín ni kadáw.

7. When looking up river Kadaw saw that there was a field that was burning. He told Ran͠gat to look at it. Ran͠gat did not pay attention. Kadaw was angry. He went round to his back and cut through Ran͠gat's back with his head ax. Ran͠gat raised his hand, it was severed also by Kadaw.

7. *Sinnan* and *sin͠gan* (radical of following *nasin͠gan*) appear to refer the first, to "looking," and, the second, to "seeing." *Pian ko no masin͠gan ko Manila:* I should like to see Manila; *Kaskasínnan ko ya bantáy:* I am looking at the mountain. (Ibg. *sinnan* and *sin͠gan*, Ilk. *kíta*.)

dadãya may mean "up river" or "up country;" in southern Apayao *dãya* generally means "west," in Ilocos "east," while *ziraya* in Itawit means "south" or "up river;" people to whom the southern Apayao are western neighbors call these *Dadaya;* people living in the west are for the southern Apayao *Namindaya,* although they have hardly any neighbors in that direction until the Itíneg on the other side of the Cordillera are reached.

koman: field cleared by burning underbrush and wood (Ibg. *koman, umá,* Ilk. *umá*).

nasiddug, perfect of *masiddug:* what is on fire.

kurkurũhan: who or what is obeyed; *Kinũrug ko ya kinahĩ mo:* I have obeyed what you said. *Dim kurũhan:* Do not obey him. (Compare *kúxkuhugén* of Text I, section 16.)

lummipút, stated to be perfect of *lumipút:* who goes round. *Lipũtan ko kadanan ko ka abút:* I shall surround my field with a fence; perfect *linipũtan.*

sinapgũtan: what has been cut through. *Sapgũtan mo ya adĩhi:* Cut through the post (giving full swing to the ax).

aliwa: general term for head ax; in this instance the special kind called *badáñg* was used as shown in Worcester, "The non-Christian tribes etc.," Plate 60 fig. 1, *f.*

sinañgpát, perfect of *tañgpãtan:* what is severed.

8. Kani mabãlin na kintáb Rañgát mapán kia hayan naya atawa na se nanã na: "Bãsul mo yan, bãsul mo." Ya atawa na madĩ na mahũni. No mahũni, Kadáw itáñgaramrám na.

8. When he had finished cutting up Rañgat, he went to where his wife was and said: "That is your fault, your fault." His wife did not speak. If she had spoken, Kadaw would have killed her also.

8. *kintáb,* perfect of *kà-bán* (from *katbán?*): what is cut up; *mañgtáb:* who cuts; *magkat-katáb:* who cut each other.

mahũni: who speaks; the people call their language *ũni me:* our speech.

itañgaramram, the exact meaning of the evident stem *tañgaram* could not be ascertained; the latter is perhaps related to Talipugo *itahám:* what is included or joined.

9. Kani mabãlin na kokõni, Kadáw nagsapúg ka taggád; nisabát na katayug na ni Apũlog. Ibahã na ñga bãsul ni Apũlog. Ni Apũlog nã na ñga: "Akkán bãsul ko." Kani daddán inumbét manín ni Mahanat, kadubdub ne Kadáw.

9. When he had finished speaking, Kadaw went out into the yard; he accidentally met his brother-in-law Apulog. He said that it was the fault of Apulog. Apulog said: "It is not my fault." By and by there arrived also Mahanat, Kadaw's neighbor.

9. *kokōni; kokonīan:* object of speaking, of conversation; perfect *kinokōni.*

nagsapúg, perfect of *magsapúg:* who goes outside: *Isapúg mo:* Take the object outside. *Nisapúg kon:* I have already taken it out.

nisabát, stated to be perfect of *misabát:* who is party to an accidental encounter.

akkán: no, not (Ibg. *akkən,* Ilk. *saán*).

10. Kadáw nā na manín n͠ga bāsul ni Mahanat. Mahanat nalùsáw, nā na n͠ga: "Dim iddē kiyâ ya bāsul mo." Ran͠gát awád pikám bittí biag na. Ni Mahanat inagtû na ka balay da.

10. Kadaw said again that Mahanat was to blame. Mahanat became angry, he said: "Do not put on me your fault." Ran͠gat had yet a little life left. Mahanat carried him to their house.

10. *dim* (from *di mo*) *iddē:* "Not thy object of giving" (to me be fault thine); perfect of *iddē* is *niddē; man͠giddē:* who gives; compare in following section 12 *niddaan,* perfect of *iddaan* or *iddān:* to whom something is given.

awád, predicates existence; compare Text I, section 17, notes.

inagtù, perfect of *agtù-an:* what is carried.

11. Kani daddán niutog da Ran͠gát ka Kumaw. Adū tōlay umunod kagīda. Kani dumatán͠g da ka Kumaw nibahā da n͠ga pinatáy da Ran͠gát. Di Ikumaw di da pikám nalù-sáw. N͠gem isa n͠ga algaw inumbét da n͠ga makiawat.

11. Afterwards they took Ran͠gat down the river to Kumaw. Many people followed them. When they arrived in Kumaw they told of their having killed Ran͠gat. The people of Kumaw were not yet angry. But one day they came to exact a fine.

11. *niutog,* perfect of *iutog:* what is taken down river (most often on a raft, *hākit,* and impelled by the current); *utōhan:* course taken down the current.

umūnod: who follows; perfect *immūnod. Unōdan mo:* Let that person (or thing) be followed by you. *Inunód ko dan:* I have followed them already.

dumatán͠g: who arrives, reaches a place; perfect *dimmatán͠g; idatán͠g:* what is taken along for somebody; for instance, provisions being brought to workmen on the road.

di Ikumaw, equivalent to *daya Ikumaw.*

pinatay, perfect of *patayan,* object of killing.

makiawat: who asks for payment, perfect *nakiawat; awatán:* what or who is to be paid. *Awatám:* Pay that. Compare Ibg. *awa*ʼ*:* fine; also*:* giving.

12. Daya tōlay ka Palītaw niddaan da ka hupōhop hūsi. Datu Ikumaw inalā da ya hūsi se da la napán. Kani dua n͠ga būlan nagtapus di Ikumaw inumbét da manin nituhot da ya panà-manán da.

12. The people of Palitaw gave them a jar with a broken rim. Those Kumaw people took the jar and just went away. When two months had passed the Ikumaw came again bringing along their leader.

12. *hupōhop hūsi: hūsi* denotes one of the ancient glazed earthenware jars of Chinese origin mentioned in Text I under the (general) name *gusi; hupōhop* expresses some damage to the vessel which need not necessarily have reduced its value very much.

inalā da: taken-object their; *ināla* stated to be perfect of *alà,* which may be supposed to be an indolent pronunciation of *alaan* or *alān* in which the elided sounds are replaced by a glottal check. *Alà ko:* I am going to take it. *Man͠gāla ka ka uwáy:* Fetch some rattan.

nituhot, perfect of *ituhot:* what or who is taken along (Ibg. *tulúd,* Ilk. *túgut*).

panà-manán: leader; compare Ilk. *manakmán:* judicious by nature or from childhood; radical *nákem:* prudence, good judgment.

13. Ibahā da manín n͠ga man͠galā da ka mahatút pirà. Daya Ipalītaw madī da n͠ga man͠giddē. Kahīan da n͠ga magpapatay da. Daya Ikumaw nān da n͠ga piān da nu isay-ám dadá. Kani mabalin say-ám nahulli di Ikumaw.

13. They said also they had come to get one hundred pesos. The Ipalitaw did not give (the money). They said they would fight. The Ikumaw said that they liked to make peace with them. When the peace was concluded the Ikumaw went back.

13. *mahatút:* hundred (Talifugo *magasút,* Ibg. *magatù'*, Ilk. *san͠gagasút*).

kahīan: what is said; *kagkahīan,* what is frequently talked about; compare *kagien* in Text 1, section 13, notes.

isay-ám: person with whom peace is made; *say-ám:* peace; *makisay-ám:* who attends a peace gathering.

14. Ran͠gát as-asissa n͠ga la ya bayad na n͠ga hūsi. Kadáw nig-sān na ya atawa na, pinataliā na. Ya atawa na maykaddua nan͠gin, ni Hundaláy, nahan-anâ ka lima lalaki; ya

14. As for Ran͠gat, he was paid for only once; namely, with a jar. Kadáw repudiated his wife and she was exchanged by him (for another one). His second wife, Hundaláy,

isá mahas-askwela ka Trinidad.

gave birth to five males; the one is going to school at Trinidad.[8]

14. *nig-san*, perfect *of ig-san:* who is to be repudiated. *Ig-san ta ka:* I shall repudiate you.
pinatalĩan: perfect of *patalĩan:* what is taken in exchange for something else; *magtāli:* who changes.
nahan-anâ, stated to be perfect of *mahanâ:* who bears children.
mahás-askwēla: who is attending school; from Sp. *escuela:* school.

TEXT IV. FROM MAHAPTA

AHAMA AY AYOÑG

1. Nabayāg na dahōn Ahāma ay Ayóñg napán da kia dappít; nituhot da bālon da. Ahāma nā na ñga: "Mañgan tadá." Kadī mañgmáñgan da Ayóñg awán isidā na; nahadañg kia biñgil ni Ahāma.

THE CRAB AND THE MONKEY

1. Many years ago the crab and the monkey went to the bank of the river; they took along their provisions. The crab said: "Let us eat." While they were eating, the monkey, having nothing to eat along with his rice, asked for some legs of the crab.

1. *nabayāg:* what has been of long duration; *dahōn:* year (Ibg. *dagún*, Ilk. *tawén*).
dappít: river bank.
mañgmáñgan, reduplication of first syllable expressive of progressive action. *Mañgānà:* I eat; *máñgan da:* they eat.
isidá: cooked food eaten with rice, thus especially meat.

2. Ahāma nibahā na ñga madī makadālen no iddē na biñgil na. Si Ayóñg kahĩan na

2. The crab said that he would not be able to walk if he gave his legs. Mr. Monkey

[8] The laconism of the preceding account suggests a few words of explanation. The repeated statement that Kadaw "was not yet angry" is to be understood evidently as meaning that he did not yet betray his anger, since his later sending away his male house-mates to cut rattan while Rañgat's visit is impending, his withdrawal at that time to a place outside the house, and his endeavors there to remain alone with and detain Rañgat clearly indicate a settled purpose. This purpose is exploded into sudden action by the rigid if not contemptuous attitude observed by his visitor, a source of irritation which is afterwards prudently avoided by Kadaw's wife. The man Mahanat was said to have stood in some relation to Rañgat.

n͠ga patalīan. Ahāma niddē na appat bin͠gil na kia Ayón͠g. Ahāma daddūa bin͠gil na nabansi.

said that he would give something in exchange. The crab gave four of his legs to the monkey. The crab had two legs left.

2. *makadālen:* who is able to walk; *manālen:* who walks.

3. Parpáramanā na manalen; Ayón͠g kaskasinnā na Ahāma ta ammo na n͠ga makadālen pikám. Ayón͠g nibahā na n͠ga alà na manin. Ahāma simbág na n͠ga madī makadālen. Ayón͠g nibahā na n͠ga patalīan na ka bulāwan.

3. He is trying to walk; the monkey is looking at the crab and perceives that he is still able to walk. The monkey said he would take again (of the legs). The answer of the crab was that he would not be able to walk. The monkey said he would exchange them for gold.

3. *parpáramānan:* what is being tried; compare Ilk. *ramánan:* what is tasted; *parmán:* trial, experiment.

simbág, perfect of *tabbāhan:* what is answered (Ibg. *tabbagán,* perfect *sibbág*).

bulàwan: gold (Ibg. *vuláwan,* Ilk. *balitók*).

4. Ni Ahāma niddē na bin͠gil na ta piā na di bulāwan. Kani nabālin da nan͠gan Ayóng napán ka balay na. Adī na pinatalīan ya bin͠gil ni Ahāma, ta ni Ahāma natáy kia ayan ni dappít.

4. The crab gave his legs for he desired the gold. When they had finished eating the monkey went home. He did not give anything in exchange for the legs of the crab, for the crab was dead near the river bank.

4. *piā,* probably from *pian* before *na.*

SUMMARY AND COMPARATIVE NOTES

The data contained in the foregoing analytical notes to the texts, together with some supplementary information obtained by me on the two dialects concerned, may now be summed up and be accompanied by a comparison with the corresponding forms of the two principal lowland languages of northern Luzon: Iloko in the west, and Ibanág in the east. Although these two languages are chosen for comparison partly for lack of material from the more immediate neighbors of the two Isneg dialect groups concerned, their cultural influence in the past and present upon the mountaineers of northern Luzon, which was felt by the inhabitants of Apayao to some degree also from the north, is not to be overlooked and the comparison will certainly be found helpful for gaining an insight into the linguistic composition of this part of Luzon.

PHONOLOGY

The Talipugo dialect, hereafter referred to by the sign "Tal.," is characterized by an indistinct vowel—the "pepet" of Indonesian linguistics—that was heard by me—often for the same word—as one or the other of the sounds *i, e, ə, a, œ*. The unstable pronunciation proved so puzzling that I was induced to abandon, in recording this elusive sound, the principle of writing down only what I heard, and to avoid a considerable confusion by representing that sound uniformly by *e* which, while standing for an average of pronunciation, is to be taken as a symbol for the variety of sounds just enumerated. Thus words written in the texts *n͠gem* and *beddén͠g* (I, 5) were heard also as *n͠gœm* and *bœddœn͠g; nasin͠gen* (I, 7) as *nasin͠gin; mapén* (I, 5) occasionally as *mapán*, etc. The Mahapta dialect, hereafter designated by "Mah.," although not quite free from a similar vacillation, appears to have decided for the same vowel generally on the articulation of an obscure *a*. The corresponding difference between the two dialects was most clearly observed in derivatives in *-en*, a suffix containing that indistinct sound and denoting the object directly affected by the action. Thus the object of killing is in Tal. *patayen* (I, 18), in Mah. *patayan* (III, 11, notes). The relation existing in regard to the sound in question between the two Isneg dialects, Iloko, and Ibanág is seen in the following examples:

	Ilk.	Tal.	Mah.	Ibg.
Sour	naalsem	nalsem	nalsam	attam
Navel	púseg	puseg	pusag	futad
Pole	tekkén	takkén	takkán	takkán
Burial	taném	temén	tamán	tanám

This table, from which examples of certain special changes of the sound in question have been excluded, shows the Iloko standard *e* to agree approximately with the Tal. average *e*, while the Ibanág representative of the same sound finds its counterpart in the obscure Mah. *a*.

Another phonetic peculiarity to be found in the texts and this time shared by both dialects, is the elision of *k* when final or when closing a syllable before a consonant, the elided *k* being replaced by the glottal check; for example, Tal. and Mah. *anà,* child, against general Fil. *anak;* Tal. and Mah. *an-anû,* chicken, against Fil. *manúk;* Mah. *malù-sáw,* angry, agaisnt Ilk. *maluksáw;* Mah. *panà-manan,* leader, against Ilk *nanakmán,* judicious person; Tal. *bù-law,* neck, against Inb. *bukdów,* Pang. *bekléw.*[9]

The elision of certain sounds by the two dialects will require a special study in detail. It appears that the encounter also of other stops with a following consonant is avoided in Mah., while Tal. shows itself less averse to consonantal combinations of this kind; compare: Mah. *ì-log,* egg, with Tal. *eplug;* Mah. *dù-dut,* feathery down, with Tal. *dutdut;* Mah. *nà-nag,* thick, with Tal. *nagnig.* Through the elision of final *k* in conjunction with the unstableness of the indistinct vowel above first mentioned a noteworthy phenomenon is observed in Tal. in cases where a derivative in *-en* is followed by the possessive pronoun *ku,* my. Thus, for the sentence, "That person will be killed by me" or "will be the object of my killing," which in Mah. is *patayan ku,* Tal. has two forms of expression which, as my informant repeatedly assured me, are in use side by side; namely, *Patayén ku* and *Patayô* (cf. I, 17). Similarly for *masiñ̃gen ku* is said *masiñ̃gô.* A comparison of these forms shows the sound-group *-en ku* in the one to be represented by *ô* in the other. To take the first-cited *patayén ku* for demonstration, the suffix *ô* in *patayô* may be explained by assuming, in the first place, a contraction of *patayén ku* to *patayék,* a contraction quite regularly made in Iloko and other dialects for all derivatives in *-en* when followed by *ko.* This *patayék* would thereupon have suffered the elision of final *k,* this being replaced by the glottal check which latter in its turn would have produced the conversion of the preceding stressed indistinct vowel into *ô.* To support this last sound-change reference can be made to Ibanág, though, it is true, not precisely for the example just used. In Ibanág the indistinct vowel is represented generally by a dull *a* as shown above, and to a Tal. *patayen ku* corresponds an Ibanág *patayakku.* The regular change, however, of the Ibanág pepet *a* to *ô* before a glottal check has clearly been shown by Conant, who, when commenting in his "The pepet law in Philippine

[9] In connnection with these examples it is recalled that the grave accent followed by a dash after the vowel denotes an abruptly checked pronunciation of the latter with subsequent slight hiatus; were the vowel is stressed the encounter of the gravis with the acutus leads to the use of the circumflex.

languages"[10] on such Ibanág radical words as *atô,* roof; *dakô,* grasp; *alimatô,* leech; gives the corresponding rule in the following words:

The *o* of Ibg. *atō* ^{p}, *dakó* ^{p}, *alimató* ^{k}[11] is no exception [to the phonetic law by which the pepet becomes *a* in Ibg.] as it regularly stands for an Ibg. *a* representing Phil. *ĕ* [the pepet] when followed by a final glottal stop (hamza) which represents one of the surd stops *k, t,* or *p. . .* When a suffix is added to the root, the surd stop is restored and the Ibg. *a* reappears, e. g. *ató* ^{p}, with the locative suffix *-an,* becomes *attappán,* place of roof(-ing) with Ibg. doubling of original *p.*

I would point out in this connection that in Tal. as well as in Ibanág the influence exercised by the glottal check upon the nature of the preceding vowel, changing this to *o,* is not limited to cases in which such preceding vowel is the pepet as found in Tal. *patayô,* and in the Ibanág radical words just quoted from Conant. In comparing

	Ilk.	Tal.	Mah.	Ibg.
Milk	gátas	gattô or gattâ	hattâ	gattô (gattó^{k})
I (ego)	siák	iyô	iyâ	sò (so^{k}), and: sákən.

it is seen that in Tal. as in Ibg. also an original *a* is changed to *ô* by the following glottal check, and that in the first of these examples this glottal check goes back to an original *s.* True that Ibanág conventional writing testifies also in this first example to a final *k,* and that the Itawit dialect of southern Cagayán actually pronounces this final *k* in saying *gatták* (occasionally also *gattát*), the vast majority, however, of Philippine languages has *gátas,* with a secondary form *gatá* for coconut milk. (For the change from final *s* in Fil. *gátas* to *k* in Itawit *gatták* a correspondency was discovered in Text 1, 17, notes, in Tal. *dakê,* at the side of *dakes,* bad, giving the derivative *kadakēkan,* badness, which, after separating the affixes *ka-* and *-an,* leaves a stem * *dakék.*)

Of a number of other phonetic changes to be found in the texts through a comparison of the two Isneg dialects either with each other or with other Philippine languages, only a few more can be demonstrated with a sufficient number of parallel forms as supporting evidence.

The first is the change from Tal. *g* to Mah. *h* which will have been observed in the texts in those derivatives which Tal. forms

[10] Anthropos 7 (1912) 925.

[11] By representing the glottal check by means of a small *k, t,* or *p* placed against the word but raised above the line Conant imitates in a way the conventional Ibanág orthography which writes *ató-p, dakó-p, alimató-k,* etc.

with prefix *mag-* uniformly before stems beginning with consonants as well as with vowels (I, 1, *magkokopun;* II, 10, *magadí*), while Mah. changes this prefix before vocalic stems to *mah-* (III, 3, *magsibal;* III, 14, note, *mahanà*). Compare also the place-name *Mahapta* with the "*Magapta*" of outsiders. The following examples show the same change in radical words with *g* in initial and medial position:

	Ilk.	Tal.	Mah.	Ibg.
Root (and related meanings)	gamút	gamút	hamót	gamû (gamú[t])
Night	rabií	gabī	hābi	gabí
Stomach	rosok	gūsù (breast)	hūtù (breast)	gutû (gutú[k])
Blood	dara	daga	daha	daga
Nose	agóng̃	igúng̃	ihuñg	igúñg
Name	nagan	nagan or: ñgagan	nahan	ñgagan
Betel leaf	gawéd	gawed	hawad	god

The preceding examples are chosen so as to conform with those used by Conant in his "The RGH law in Philippine languages." [12] While setting forth the sound-change alreeady indicated they show that this change comprises as well the *g* of the RGH series, to which the first four examples belong, as also the *g* of the RLD series represented by the next two examples. The phonetics of Mah., which so often resemble those of Ibanág, are seen in this table in marked contrast to this language. As regards *g* in final position, it remains unchanged in Mah.; compare Tal. *apug,* lime; *iyug,* coconut; *bibig,* lip, with *apog, iyog,* and *bibig* for the same meanings in Mah. The law of the change in question comes into force, however, as soon as this final *g* is made intervocalic through affixation: Mah. *apog,* lime, but *inapūhan,* what is coated with lime (compare Text III, 6, notes).

Another important phonetic difference between the two dialects under review is the frequent passing of Tal. *s* into Mah. *t* as already to be noted in Tal. *gūsù,* breast, Mah. *hūtù,* above quoted. Other examples are:

	Ilk.	Tal.	Mah.	Ibg.
Flesh		sabbit	tabbit	tabbî (tabbí[t]), skin
Deer	ugsá	ugsa	ugta	uttá
Dog	áso	asu	a-tù	itu
Sugar cane	unas	unas	unat	unâ (uná[t])
Maggot	igges	agges	aggat	aggô (aggó[t])

Mah. shows here for the sound in question a similar conformity with Ibanág as Tal. does respecting Iloko. The sound

[12] Jaos 31 (1910) 1.

change here illustrated appears, however, to be subject to exceptions that require further elucidation. For one thing, the change does not take place in Mah. before the vowel *i;* thus Tal. *masiñgen,* what is seen; *sinag,* sun; *siñgal,* spear, remain also in Mah. *masiñgan, sinag,* and *siñgal.* In repudiating *t* before *i* Mah. is indeed but consistent with its habit of converting original *t* into *s* whenever brought into contact with infix *-in* as seen, for instance, in III, 7, notes: *tañgpātan: sinañgpat;* and in IV, 3, notes: *tabbāhan: simbág.* A like avoidance of the combination *ti* is characteristic also of Ibanág while Tal. has no difficulty in forming of *tumalib* a perfect *timmalib* (I, 1), and of *tabagen* a perfect *timbag* (I, 11).

There may finally be mentioned the absence in Tal. of the sound *r* which occurs in Mah. as a dental in such words as *barañgay,* boat; *pirà,* silver; further in III, 7, in *kurūhan,* who is believed (Ibg. *kurugán*), for which Tal. has the equivalents *bahañgay, pihà,* and *kuhugén,* showing a substitution of *r* by *h.* In the reduplicated form *kuxkuhugén* (I, 17) of the last example this *h,* finding itself closing a syllable before *k,* is condensed to the velar fricative *x.* A similar explanation might be found for the dubious *h* of *magawih* (I, 1, notes) which may go back to some hypothetical * *magawir* (compare Ilk. *agáwid,* who returns or withdraws from the place where he went), although in this case the final *h* does not tend to become *x* but the *ç* of the International Phonetic Association, the friction being shifted to the palate by the preceding *i.*

GRAMMAR

The nouns (substantive, verbal, adjective) of both dialects bear the unmistakable stamp of the Philippine languages in general. They are either radical words of mostly two syllables (compare, for instance, the preceding tables) or are built up from such stems into polysyllabic words often of considerable length with the help of the two typical means of reduplication and affixation.

Reduplication, consisting most frequently in the anticipative doubling of the first syllable of the stem plus the consonant following, generally expresses some sort of augmentation of the sense of the stem; the action is represented as repetitive or frequentative: Tal. *putputden,* what is cut up repeatedly (II, 6); Mah. *kagkahian,* what is frequently talked about (III, 13, notes); as progressing or lasting: Tal. *tontonan,* who is awaited

(II, 8); Mah. *mañgmañgan,* who is eating (IV, 1); as participated in by many: Tal. *mabunbunuñg,* who are assembling in files (I, 11). Other ramifications of such generally augmentative significance of reduplication exist but may be left to be determined by more-detailed study.

Affixation may be illustrated by a few of the commonest instances which I select so as to exemplify what in other Philippine languages is generally considered the characteristic significance of each affix:

Prefix *mag-*, indicating one who holds a position in the sense of the stem or who is active in such sense generally, without reference to a precise object (intransitive action): Tal. *magkopun,* who are friends; *magwagi,* who are brothers; *magasawa,* who are spouses; *magpresidente,* who officiates as president; *magsuhù,* who hides; Mah. *mahuni,* who speaks; *magtuhaw,* who sits down.

Prefix *mañg-*, indicating one who executes an action habitually, professionally, or is bent upon getting something: Tal. *mañgalyug,* who trades; *mañgñgayaw,* who goes headhunting; *mañganúp,* who goes hunting with dogs; Mah. *mañgala,* who goes to fetch something; *mañgayu,* who goes for wood.

Prefix (infix) *um-*, indicating who or what is gradually moving towards an aim, is becoming something, or is moved interiorly: Tal. *umulug,* who descends a stair; *umsil,* who feels envy; Mah. *umunè,* who climbs; *umunod,* who follows; *dumatáñg,* who reaches.

Prefix *ka-* forms designations for associates in the manner of English co- in "co-worker, co-heir;" Tal. *kabdéñg,* partner to a *beddéñg,* or peace-treaty; *kabulún,* companion, from *bulún,* idea of accompanying; Mah. *katayug,* brother-in-law, *kadubdub,* neighbor are equally formed.

Pronouns.—The languages of northern Luzon are distinguished from those of the rest of the Archipelago by certain characteristics, conspicuous among which is the possession of two forms for the personal pronoun as subject of a sentence. To establish this feature for the two Isneg dialects under review, and to ascertain at the same time whether by a corresponding comparison with the two lowland languages already used above something can be gained that would lead to the recognition of a specific Isneg speech, I present in the following a full list of the personal pronouns from both dialects (compare Tables A, B, and C) together with a view of their most developed (emphatic) forms compared with Iloko and Ibanág (Table D). Table A shows that both dialects possess the double series of nominatival forms characteristic of the northern group of Philippine languages. It will be observed in the same table that, while in the postpositive nominative these dialects fully agree, they use a different prefix in forming the first four plural forms of the emphatic prepositive nominative, the remaining forms of the latter being, however, with some slight phonetic variation, identical. A like uniformity is found in the possessive forms given in Table B. The relational forms listed in Table C show themselves likewise built upon one and the same plan with the sole exception of the same first four plural forms which differed already in the nominative, although they appear here more or less reconciled by the employment of one and the same (demonstrative) element *k* as prefix to the nominative stems. Table D, finally, which shows, of course, the common general Filipino basis, makes the Isneg pronouns stand out, in spite of their internal difference already mentioned, in pronounced common contrast to the Iloko and Ibanág equivalents. This contrast betrays a specific Isneg character especially in four out of the eight forms listed; namely, in the first and third person singular, in the inclusive first person plural, and in the third person plural. This idiomatic feature remains distinct also if, for the only further comparison available, we turn to the table given at the end of my paper on "Kalinga texts from the Balbalasañ̃g-Ginaañ̃g group"[13] containing the personal pronouns from a western Tiñ̃gyan and from some Kalinga dialects.

A list of the personal pronouns used in the two speech groups corresponding to the preceding texts.

A. PARADIGM SHOWING THE PERSONAL PRONOUN IN ITS EMPHATIC FORM (USED TO SET UP THE PERSON AS SUBJECT OF THE SENTENCE), AND IN ITS SHORT POSTPOSITIVE FORM.

	Talipugo.	Mahapta.
I, I am Isneg.	īyô, isnégà	īyâ, isnéggà [a]
Thou, thou art Isneg.	ikáw, isnég ka	ikáw, isnég ka
He (or she) is Isneg.	agīna, isnég	agīna, isnég
We, we are Isneg (exclusive)	ikamí, isnég kamí	dakamé, isnég kamé
We, we are Isneg (inclusive)	itadá, isnég tadá	datadá, isnég tadá
We two, we are Isneg.	itá, isnég ta	datá, isnég ta
You (plural), you are Isneg	ikayú, isnég kayú	dakayó, isnég kayó
They, they are Isneg.	agīda, isnég da	agīda, isnég da

[a] Also pronounced "*Isnággà*" which would indicate the *e* of "Isnég" to be the indistinct vowel which as a rule becomes *a* in Mahapta.

[13] Philip. Journ. Sci. 19 (1921) 175.

B. PARADIGM SHOWING THE PRONOUN IN ASSOCIATIVE RELATION, AS "POSSESSIVE" POSTPOSITIVE. [b]

My name	n͠gagan ku	nahan ko
Thy name	n͠gagan mu	nahan mo
His (her) name	n͠gagan na	nahan na
Our name (exclusive)	n͠gagan mi	nahan me
Our name (inclusive)	n͠gagan tadá	nahan tadá
Our name (dual)	n͠gagan ta	nahan ta
Your name	n͠gagan nu	nahan nu
Their name	n͠gagan da	nahan da

[b] When the noun ends in a vowel Tal. *ku* and Mah. *ko* disappear leaving that final vowel with an abruptly stopped pronunciation followed by a slight hiatus; thus 'my father' is in both dialects *amà*. In the second person *mu* and *mo*, respectively, lose their final vowel in the same case, and the remaining *m* attaches itself to the preceding vowel, giving for "thy father" in both dialects *amám:* Talipugo uses besides this also the form *ama mu*, and others similarly. For *n͠gagan* Talipugo was said to have in use also the alternative *nagan*.

C. PARADIGM SHOWING THE PRONOUN IN DEMONSTRATIVE RELATION.

He told it	to me	Nebagā na	kīyô	Nibahā na	kiyà
	to thee		kikáw		kikáw
	to him (her)		kagīna		kagīna
	to us (exclusive)		kikamí		kadakame
	to us (inclusive)		kitadá		kadá-tadá
	to us (dual)		kittá		kadá-ta
	to you		kikayú		kadakayó
	to them		kagīda		kagīda

D. COMPARISON OF FORMS FOR THE EMPHATIC NOMINATIVE IN ILOKO, TALIPUGO, MAHAPTA, AND IBANAG.

	Ilk.	Tal.	Mah.	Ibg.
I	siák	íyô	īyâ	sò (so[k]) sakən
Thou	sika	ikáw	ikáw	sikaw
He, she	(isú)	agina	agina	yaya
We (exclusive)	dakami	ikamí	dakamé	sikamí
We (inclusive)	datayo	itadá	datadá	sīttəm
We two	data	itá	datá	sittá
You	dakayó	ikayú	dakayó	sikamú
They	ida (isuda)	agida	agida	ira

Article.—The existence of an aggregate of dialects coinciding more or less with the confines of the Subprovince of Apayao, and constituting through common grammatical and other charactertistics a nucleus of idiomatic Isneg speech, is further made probable by an examination of the article used before common nouns in the two dialects under review. This article is in both the same; namely, *ya*, and is given an employment not always congruent with that of the definite article in English:

Mah. *ya atawa ni Kadáw*, the spouse of Kadaw (III, 1);
Tal. *ya lalaki matudug*, a man sleeping (I, 7);

in the last of which examples *ya* stands for the English indefinite article.

In associative relation the Isneg article takes the form *naya:*

Tal. *allam naya baláy*, inside of the house (I, 7, notes);
Mah. *Neppay da ya uwáy kia linuñg naya balay*, They put the rattan into the ground-floor of the house (III, 4);

while in demonstrative relation the form *kia* is found, probably a combination of *ki* with *ya:*

Tal. *Odaw inumnà kia baláy*, Odaw entered into the house (I, 7);
Mah. *adanní kia balay*, near to the house (III, 5).

Comparing these regularly built forms of the Isneg article with their Iloko and Ibanág equivalents, we find:

	Ilk.	Tal. and Mah.	Ibg.
The house	ti (or: ití) baláy	ya balay	ib baláy
Of the house	ti baláy	naya balay	nab baláy
To the house	ití baláy [a]	kia balay	tab baláy

[a] Compare, The use of *ti* and *ití* in Iloko, The Archive, No. 4, Manila (1925-26).

Demonstrative particle.—The element *k* which was observed entering into the formation of the relational forms both of the article and the personal pronoun characterizes likewise the demonstrative particle in both dialects, although followed in each by a different vowel:

Tal. *Inumbét ko baláy da*, He arrived at their house (I, 4).
Mapén tadá ko Dumadaga, Let us go to Dumadaga (I, 5).
Mah. *Napán ka baláy ni Kadáw*, He went to Kadaw's house (III, 2).
Dumatáñg da ka Kumaw, They arrived in Kumaw (III, 11).

The same particles characterize in these dialects the relation between the "nomen agentis" and the object upon which the activity of the agent is directed:

Tal. *Nagsamsám da ko gusi*, etc., They plundered jars, etc. (I, 9).
Madí makaala ko danúm, He was not able to fetch water (II, 7).
Mah. *Mañgnamát ka dua bukál*, He picked two nuts (III, 6).
Nahan-anâ ka lima lalaki, She bore five males (III, 14).

Ligature.—The explanatory particle *ñga* which links an attribute to the preceding noun, and is known from both Iloko and Ibanág, is common also to both Isneg dialects:

Tal. *Kayát da Odaw ñga presidente*, They liked Odaw as president (I, 18).
Mah. *Inumbét da ñga makiawat*, They came as exactors of a fine (III, 11).

In what the two dialects distinguish themselves—and certainly not very favorably—in respect to this ligature, is the frequency of its omission, to be noted at least in the texts; it contrasts with the regular use made of the same ligature in other dialects:

Tal. *issa algaw*, one day (I, 1), against Mah. *isa n̄ga algaw* (III, 1).
Mah. *Ran̄gát Ikumaw*, Ran̄gát, a man from Kumaw (III, 1), against Tal. *Galī n̄ga Italipugo*, Gali, a man from Talipugo (I, 1).

LEXICON

Since the whole stock of words in use by the two dialects under review finds in the preceding texts a comparatively very much scantier representation than their systems of sounds and grammatical categories it must necessarily be a hazardous undertaking to characterize their lexicon on such insufficient basis. Any attempt, moreover, to set down certain words definitely as Isneg idioms is precluded by our complete ignorance of the speech of the peoples immediately surrounding the two dialect groups in question. An examination, nevertheless, of that part of the vocabulary which is contained in the texts justifies a few comments.

In the first place we find a stratum of words which through their occurrence—in like or slightly varied form—all over the Archipelago would proclaim these dialects as unmistakably Filipino. Choosing some such words at random from my records I quote:

algaw	day	*asu*	dog	*ina*	mother
danúm	water	*asawa*	spouse	*apuy*	fire
inúm	drink	*patáy*	dead	*lalaki*	male
dalan	road	*balay*	house	*babay*	female
bulan	month	*man̄gan*	eat	*isa, dua*	one, two

A noteworthy feature is the strikingly frequent lexical agreement between the Isneg dialects recorded and the two lowland languages which, for lack of material from more immediate neighbors, have been used for comparison. This agreement is readily gathered from the parenthetical references to Iloko and Ibanág added to the notes under the texts. It is especially remarkable in regard to Ibanág although Iloko, too, often enough shares in this agreement. A more systematic comparison would show such correspondencies to be still more numerous so that it might be asked if we have to do here with the outcome of a gradual advance of lowland culture into the mountains whereby a once more-idiomatic Isneg speech is slowly being assimilated by stronger dialects. At present there exists not only a great number of vocables that are typical for northern Filipino speech and are practically identical in Isneg and one or the other of the two lowland languages, but a phraseology belonging to every-day life comes thus into existence which belongs almost as much to the one as to the other language. Expressions like *Kayát ko mapán Manila,* I wish to go to Manila; *Awán danúm,* There is no water; *Adú balay,* Many houses; *Madí,* He does not like, and others are either entirely or very nearly as much Isneg as Iloko, while they are at the same time easily intelligible also to the Ibanág.

As regards specifically Isneg idioms they probably make up the greater part of the more-specialized terms of the texts. They may have to be looked for precisely in that part of the general lexicon which describes peculiarities of Isneg architecture, dress, implements, social and religious life, etc., since along these lines terms have been evolved that distinguish even one small group of Isneg speech from the other. Thus to a Mah. *kiloson,* breakfast, was said to correspond the Tal. localism *udma;* "at the time of the midday meal" is in the former *agpapaso,* in the latter *agnanabawan.*

CONCLUSION

As far as an opinion may be expressed upon the evidence of the preceding texts and notes, there appears to be ground for reckoning with the possibility that future more comprehensive research on the spot will establish a more or less concrete Isneg form of speech distinct from what is so far known of the surrounding dialects. Until such more complete investigation will have been made, and until the two dialect groups found by me can either be coördinated with, or be distinguished from, their linguistically still unexplored neighbors, the present contribution to our knowledge of the dialects of northern Luzon must necessarily remain in a certain sense an isolated nucleus of information. But even so, it affords an opportunity to examine briefly the place assigned by Worcester to the inhabitants of Apayao in the ethnography of northern Luzon, and to compare his findings with some general information gathered by me along linguistic lines from my Isneg informants.

In his already quoted work on the non-Christian tribes of northern Luzon, in which he laid a new fundament for the ethnography of that part of the Philippines, Worcester (p. 852) says, under the heading Tribe VII. The Tingians, the following:

> The people of the district of Apayao have long been known under the name of *Apayaos*, although their immediate neighbors call them *Kalingas*. On a recent trip through this hitherto almost unknown region I was greatly surprised to discover that they were *Tingians*, but *Tingians* with a degree of civilization comparable to that possessed by those of Abra a century and a half or two centuries ago. They themselves trace their ancestry without hesitation to the *Tingians* of Ilocos Sur, for whom they still entertain friendship and whom they often visit. They call themselves *Itneg*.

That the Isneg should have been given the name of "kalinga" by their immediate neighbors, a designation the fitness of which Worcester himself denies in a later work, is not to be wondered at since this term, with the Isneg as well as with the Ibanág and other neighboring peoples, means simply "enemy." In former times also Talipugo and Mahapta as other rancherias within Apayao were "kalinga" to each other. "In the head-hunting countries [of northern Luzon]," says Worcester (p. 798), "*rancherias* of people of the same tribe were constantly at war with each other, and the blood feuds between them were handed down from generation to generation." It has been thus evidently only through a mistaken notion of the Spaniards that the term Kalinga first came to be used as a tribal designation. As such it was given by Worcester a fixed value on the basis of common physical and cultural—but not necessarily linguistic—characteristics to a people inhabiting "broadly speaking, the eastern slopes, river valleys and foothills of the Cordillera Central from the Saltan River north to Dagara and to the vicinity of the valley of the Ablug [sic] River. * * * They are constantly at war with those of Dagara and the Apayaos district." Worcester here (p. 819) brings up the northern boundary of the Kalinga as far as Dagara and the Abulug River; he thus excludes my Talipugo or Ibahen group from the Isneg and incorporates them with the Kalinga.

How the same author came to adopt for people who, according to him, call themselves Itneg, the name Tingian or, more specifically, "wild Tingian" is explained by him (p. 852) as follows:

> The name *Tingians* or *Tinguianes* has long been applied to the non-Christian inhabitants of Abra and to certain of those of the western slopes of the eastern mountain ranges of Ilokos Norte and Ilokos Sur. These people call themselves *Itneg*, and this appellation would be a fitting

tribal designation for them, but the name [Tingian] which I have adopted has been so long and so generally in use that it seems undesirable to change it.

Worcester thus expressly recognizes that the people living on the western slopes of the Cordillera as well as those on its eastern side in Apayao call themselves Itneg. In giving names to the two dialect groups illustrated by my texts I considered it safest to distinguish them for the present by those of the chief localities where these dialects are spoken; namely, Talipugo and Mahapta. For a designation of their common linguistic features it was but natural to use the one recognized by the speakers themselves as their common appellative: Isneg or Itneg. To employ in linguistics instead of this the term Tin͠ggyan, adopted by Worcester, would mean a subsumption in speech not justified by any existing record; compare in this regard my Tin͠ggyan text.[14]

The most intelligent of my Isneg informants, a nephew of President Odaw of Talipugo (mentioned in Text I) and who had travelled down the Abulug River and thence along the north coast to Aparri in Cagayan, stated that the Isneg of the whole Apayao district can understand each other with more or less difficulty. Having crossed also the Cordillera in going to Tineg, a town on the western slope in Abra, where his people, the Ibahen, were wont to provide themselves with pottery, he had made himself understood also by the people there. Upon my inquiry he stated that not only the inhabitants of the town called Tineg but all the neighboring people on that side of the Cordillera Central were called by his own people *Iténeg*, a designation which, although for some reason differentiated from *Itneg*, represents very probably but a fuller form of this latter. Both words embody evidently the same radical *tineg*. If this *tineg* might possibly be a variant of the old Filipino term *tin͠gge*, mountain range, I am not prepared to say. The latter is recorded from as early as 1576 when Governor General Francisco de Sande wrote in his "Carta-relación de las Islas Filipinas" of the head-hunters in the interior: "los llaman tinguianes como serranos que tingue es sierra." It should not be difficult to verify and amplify the statements of my informant on the spot.

Another of my Isneg friends, questioned by me on the names they give to all their neighbors, informed me that for the inhabitants of certain rancherias towards the east, of which he

[14] Philip. Journ. Sci. 19 (1921) 175–206.

mentioned Karakitan, Kalapog, and others, located south of Ripañg̃ between the Isneg and the Itawit of southern Cagayán, they had the popular name Kalà-ūwan, a term referring to some peculiarity of dress. The glottal check following the second *a* in this word points to the elision of a consonant, probably *g*, so that a fuller form of this name would be Kalagūwan. I suspect this to be the origin of the "tribal name" Calauas or Calaguas introduced by the Spaniards but relegated by Worcester to a synonymy with Kaliñg̃a. Buzeta and Bravo as well as Blumentritt spell Calaüas, that is, putting a stress on the *u*.

ILLUSTRATION

TEXT FIGURE

FIG. 1. Map of the northernmost part of Luzon, showing the location of Apayao; mainly based on Coast and Geodetic Survey map of Northern Luzon (1922).

SOME NEW PHILIPPINE CHALCID FLIES

By A. A. GIRAULT

Of the Department of Agriculture, Brisbane, Queensland

The types of the following species are in the Queensland Museum, Brisbane, and the whole of the material was collected by Prof. C. F. Baker. The species resemble Australian forms.

CLEONYMINÆ

THAUMASURELLOIDES SILVAE Girault.

In the original description, line 8, the last word, "large," refers to the size of the whole insect and not to that of the femora.

EUPELMINÆ

CALOSOTA SPLENDIDA Girault.

A cotype female, No. 24238, Samar. The ovipositor was slightly extruded beyond stylus, apex red. Also another female, No. 24237, Sibuyan.

EUPELMUS COOKI (Girault).

Originally described from Singapore, a female was recognized in the material, No. 24243, Mount Maquiling, Luzon.

The narrow hyaline stripe of the fore wing was not quite complete caudad. Lateral ocellus against eye, latter hairy.

EUCYRTINÆ

ANAGYRODES PUNCTATICEPS sp. nov.

This genus heretofore has been known from Australia only.

Dark aëneous, wings clear, scape, venation, and legs reddish brown except coxæ, proximal half of femora, and tibia 3 entirely except more or less below near knee.

Head umbilicately punctate, punctures less dense and smaller below antennæ, latter a bit below middle of face but above eye ends, the head thin, rounded-triangular, frons wide. Ocelli well separated, lateral somewhat closer to median than to eye.

Prothorax transverse. Scutum, scutellum, and the large axillæ with a velvety sculpture and densely pilose from faint punctures. Hind femur compressed, setose, the tibia a bit wider (distinctly dilated) and more densely setose. Stigmal curved, distinctly exceeding postmarginal. Hairless line closed about three-fourths way down, ciliation from it to base somewhat looser, almost filling the wide costal cell.

Joint 2 of labial palpus wider than long, much shorter than 1 or 3; 2 of maxillary palpus much exceeding 3 which is subequal to 1; 4 longest; palpi dark. Scrobes short.

Funicles half longer than wide, 6 quadrate, equal to pedicel in length. Club distinctly 3-jointed.

Two females, Basilan, No. 24241.

A species typical of the genus except that the jaws are more acute than usual and the teeth very unequal. Thus 1 is thornlike, 2 though acute is short and more than halfway down the side of 1, while 3 is a mere notch farther down and below the base of 2 (3 is about halfway between base and apex of the inner margin of the jaw).

MEGASTIGMINÆ

BOOTANOMYIIA GEMMA sp. nov.

Differs from most of the Australian species in having the ovipositor equal to the body.

Brilliant green, wings clear; legs except coxa 3, head except center of occiput, upper half of face and all of vertex; tegulæ, scape beneath and at base more or less, pedicel beneath; median ventral line narrowly and lateral median line widely of abdomen (the lateral line crossing dorsum just before apex), golden.

Aëneous parts of head (except occiput) and dorsal thorax, striate densely (usually crosswise), on scutellum the striation more or less anastomosed, oblique distad of the cross suture; on propodeum, the striæ are coarser and longitudinal from base for a short distance, their length limited by a ruga (or a median pair) which leaves base at meson and after a short distance curves laterad; rest of propodeum with irregular rugæ, these not dense. Cephalic margin of scutum glabrous. Scattered obscure punctures elsewhere. Median, curved carinæ of propodeum separated at base.

Ring joint much wider than long; funicle 1 over thrice longer than wide, twice the pedicel; 2 over twice longer than wide, 7 nearly twice longer than wide. Jaw 3 widely truncate.

Dorsal scape with longish, stiff setæ. Lateral ocellus closer to median than to eye.

Scutum with scattered, loose pilosity, still sparser on scutellum where the marginal setæ number at least 6 for each side and are elongate.

A female, Baguio, Benguet, Luzon, No. 21242.

EUCHARITINÆ

PARAPSILOGASTER MONTANUS sp. nov.

Aëneous; wings obscurely stained from stigmal vein; veins, legs except coxæ, red-yellow, also tegula and scape, the abdomen with suffused brown.

Head and thorax finely striate in the usual manner, the widely joined axillæ obliquely, the scutellum longitudinally, its apex widely emarginate. Distal end of scutum and mesocaudal angle of parapside, smoother. A median impression near apex of scutellum. Propodeum finely rugulose but on each side of median line with a glabrous central area, the spiracular sulcus obscure. Petiole twice longer than wide, smooth. Lower mesopleurum densely foveate, a central glabrous area below the tegula. Pubescence of dorsal thorax sparse. Ciliation of fore wing longish, dense.

Funicle 1 a bit exceeding scape, nearly four times longer than wide, longest, 9.5 longer than wide, shorter than the solid club, exceeding pedicel; club equal to funicle 3, ovate. Mouthpiece 7-digitate, digits long, mesal ones longer, each at apex with a stout, elongate spine.

A female, Mount Maquiling, Luzon, No. 24246.

PARAPSILOGASTER STRIATUS sp. nov.

As the preceding but the petiole with strong longitudinal carinæ, wings hyaline, propodeum entirely rugose-punctate, abdomen entirely green and smaller, triangular.

Also the antennæ are entirely reddish, the mouth plate 9-digitate and the upper face is smoother. The lateral part of scutellum also is rather coarsely foveate and there is no median impression near apex.

A female, Los Baños, Laguna, Luzon, No. 24244.

CHALCURA GLABRA sp. nov.

Purple, wing with a rectangular cloud from distal end of marginal and the stigmal vein, one-third complete, thence faintly suffused across. Legs save coxæ, scape, pedicel, pale straw yellow; abdomen at apex widely (or distad of the long segment 2) reddish yellow.

Glabrous but with foveate parapsidal furrows; a few coarse cross striæ on prothorax and cephalic scutum; minute pin punctures on head, axillæ; coarse foveæ at base of scutellum and the latter with a median carina and carinate margins (except base). Dorsal thorax with scattered, longish hairs, also the vertex. Propodeum with foveate base and spiracular and dorsolateral sulci, the petiole six times longer than wide, finely, obscurely long-lined; segment 2 over three-fourths surface, more or less minutely pitted. Lateral ocellus much closer to median than to eye. Discal cilia of the fore wing dense, to opposite base marginal vein, longish and hairlike, costal cell well ciliated.

Funicle 1 elongate, seven times longer than wide, longest, slightly toothed at apex, 2 to 7 on same side at apex with a thick thornlike prolongation, narrowest on 2; 7 over twice longer than wide. Club constricted (but not articulated) at middle, subequal to funicle 2, pedicel very short.

Jaws usual, 2- and 3-dentate. Palmate mouth plate 9-digitate, the digits elongate-spindle-shaped, armed at apex with a strong, elongate spine.

A female, Mount Maquiling, Luzon, No. 24247.

Runs to the genus in Ashmead's table but, as the club is solid, the antennæ are 10-jointed only.

KAPALA FASCIATIPENNIS sp. nov.

Blue-green, the fore wing with a brown cross stripe (not quite reaching caudal margin), more or less wavy, from stigmal vein. Tegulæ, legs save coxæ, antennæ, red-brown, scape paler, femora more or less aëneous.

Head striate, glabrous below antennæ. Scutellum with a median groove and coarsely long striate as are the axillæ; scutum, parapsides pilose, finely cross striate. Prong of scutellum normal, arms exceeding the basal part by two times, the whole process about as long as the pilose scutellum. Propodeum rugose-punctate, with a shallow, wide, rugulose (or weakly tricarinate) median path and laterad of this a large, central subglabrous area; spiracular and dorsolateral sulci, narrow, obscure, punctate. Cephalic mesopleurum glabrous.

Petiole twice longer than wide, more or less lineolated with margins carinate; segment 2 glabrous, the whole surface. Discal ciliation long, extending widely cephalad halfway to base from base marginal, the wide costal cell ciliate.

Antennæ serrate, 11-jointed. Scape over twice length funicle 1 which widens distad and is more or less twice longer than wide at apex; funicles 2 to 8 produced from apex of the same side, 2 for a short distance only, 3 to 6 for a distance greater than their width, the produced part triangular and tipped at apex; club equal to funicle 1, exceeding other funicles, oval. Funicles and club densely setose.

Mouth plate 8-digitate, the digits long, the external one of each side more divergent and originating farther down, longer, all with stout apical spines. Jaws 2- and 3-dentate, as usual.

A female, Cuernos Mountains, Negros, type, No. 24249; cotype female, Baguio, Benguet, Luzon, No. 24245.

KAPALA FOVEATELLA sp. nov.

Aëneous, wing with a transverse substigmal spot and faintly dusky from thence to apex; tegulæ, legs except coxæ, scape, pedicel (rest of antennæ but darker), rich reddish.

Head above antennæ striate, below smooth but face with scattered pin punctures. Thorax rugose-punctate, with spiracular and dorsolateral sulci on propodeum and a wider, foveate median sulcus on scutellum.

Petiole nearly five times longer than wide, scabrous, lateral margins carinate; segment 2 the whole surface glabrous, but laterad and ventrolaterad with numerous pin punctures; wide space between axillæ striate. Prong as in *Kapala fasciatipennis* but basal part a bit longer than wide; discal ciliation as in the same species. Palpi 3-jointed, 1 of maxillary elongate.

Funicle 1 half longer than wide, toothed at apex on one side (the same side that bears the rami), not half the scape, with the following joints, densely setose; 2 to 5 quadrate, following lengthening, 7 equal 1 but narrower, 9 twice 1; from apex on same side, joints 2 to 9 (funicle), a very elongate ramus is borne, that of 2 sometimes considerably shorter. Club solid, narrow, elongate twice scape, shorter than the rami of 5 to 7 which are longest. Mouth plate as in *fasciatipennis*. Pedicel very short.

Two males, Mount Maquiling, Luzon, Nos. 24,250 (type) and 24,248 (cotype).

Typical for the genus, but the antennæ are 12-jointed.

In the Eucharitinæ, the palpi might prove of much value in classification, but in most specimens they seem to be missing; nor have they been much noted in descriptions.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), III [1]

By CHARLES P. ALEXANDER
Of Amherst, Massachusetts

TWO PLATES

The crane flies discussed in the present report were taken chiefly at high altitudes in the mountains of Formosa by Prof. Syuti Issiki. Fewer were collected in Fukushimaken and Miyagiken, northeastern Honshiu, Japan, by Professor Issiki. This important series has added materially to our knowledge of the tipulid fauna of these two regions. I am including the single new species of *Paracladura* (Trichoceridæ) that was contained in this shipment. I am greatly indebted to Professor Issiki for the privilege of retaining the types of the novelties described at this time.

The venational innovations mentioned in the preceding part under this title [2] have now been discussed in detail in two recent papers.[3] Several leading students of venation in Australia and New Zealand, as Messrs. Mackerras, Nicholson, Tillyard, and Tonnoir, and the late Doctor Ferguson, have indicated (in litt.) their approval of the main principles of this modification of the radial field but have held that in certain groups (subfamilies Tipulinæ and Cylindrotominæ; tribes Limoniini and Lichriini of the Limoniinæ) these principles have been insufficiently applied. I now consider that this contention is correct, and the venation in the groups listed may be brought into conformity with the three tribes in the Limoniinæ (Pedicini, Hexatomini and Eriopterini) where it has been satisfactorily applied by making the following changes in the names of certain elements of the veins: Free tip of R_1 becomes free tip of Sc_2; r becomes R_1; R_2 becomes R_{1+2}.

[1] Contribution from the Department of Entomology, Massachusetts Agricultural College.

[2] Philip. Journ. Sci. 35 (1928) 455–489.

[3] Proc. Linn. Soc. N. S. W. 52 (1927) 42–72, fig. 92; Rec. Ind. Mus. 29 (1927) 169–172, pl. 13.

TRICHOCERIDÆ

PARACLADURA CUNEATA sp. nov.

General coloration pale brown, the mesonotal præscutum with a dark brown median stripe; rostrum and scapal segments of antennæ yellow; wings nearly hyaline, cuneiformly narrowed at base; male hypopygium with the dististyle simple; gonapophyses appearing as pale flattened blades, each prolonged into a needlelike point.

Male.—Length, about 3.2 millimeters; wing, 4.

Female.—Length, about 3.8 millimeters; wing, 5.

Rostrum yellow; palpi dark brown. Antennæ setaceous, as in the family; scapal segments light yellow; flagellum dark brown. Head light brown.

Pronotum dark brown medially, paler laterally. Mesonotum pale brown, the præscutum with a dark brown median stripe; scutellum dark brown, the postnotum more testaceous brown. Pleura yellowish testaceous, with a diffuse brown dorsal stripe. Halteres relatively elongate, yellow, the knobs infuscated. Legs with the coxæ and trochanters yellowish testaceous; remainder of legs pale brownish yellow, the terminal tarsal segments darker; basistarsus more than three times as long as thick. Wings relatively narrow, the basal third cuneiformly narrowed, nearly hyaline; veins and macrotrichiæ brown. Venation (Plate 1, fig. 1): Vein $R_1 + Sc_2$ near its outer end and the basal portion of R_{1+2} arcuated toward costa; cell M_1 about one-half longer than its petiole; cell 1st M_2 very narrow; m-cu on M_4 shortly beyond its origin.

Abdominal tergites dark brown, the sternites and outer tergites somewhat brighter brown; subterminal segments dark brown; hypopygium brownish yellow. Male hypopygium (Plate 2, fig. 1) with the basistyles, *b*, short and stout; dististyle, *a*, simple, appearing as an elongate-cylindrical lobe, the mesal face except on the basal fourth with delicate retrorse setæ. Ædeagus double. Gonapophyses appearing as pale flattened blades, each prolonged into a needlelike point.

Habitat.—Formosa.

Holotype, male, Noko, altitude 9,000 feet, June 26, 1927 (*S. Issiki*). Allotopotype, female.

In the collections from Noko, altitude 8,000 feet on June 26, 1927, Professor Issiki included a second species of *Paracladura*, unfortunately represented only by the female sex. I suspect that this will prove to be *P. nipponensis* Alexander, described from Kiushiu. There is no question that the higher mountains of Formosa support at least three species of this interesting genus.

TIPULIDÆ

TIPULINÆ

NESOPEZA TRICHOPYGA sp. nov.

General coloration of thorax dull brownish yellow; antennæ relatively long, flagellar segments elongate, the verticils relatively short; tarsi whitish; wings with a strong brownish tinge, the oval stigma darker brown; male hypopygium with the fused basistyle and sternite produced caudad into a conspicuous lobe, the caudal margin of which bears long yellow setæ.

Male.—Length, about 9 millimeters; wing, 10.5; antenna, about 3.6.

Frontal prolongation of the head short, brownish testaceous, dark brown at tip; palpi brown, elongate. Antennæ (Plate 2, fig. 3) relatively long, the flagellar segments elongate, becoming shorter and slenderer outwardly; verticils very sparse and scattered, more elongate and conspicuous outwardly; scapal segments yellowish brown, the flagellum dark brown. Head above rich fulvous brown, the vertex behind and the occiput more testaceous brown.

Pronotum yellowish brown. Mesonotum nearly uniform dull brownish yellow, the præscutum unmarked. Pleura obscure yellow, the anterior pleurites a little darker. Halteres elongate, pale brown, the base of the stem narrowly yellow, the knobs infuscated. Legs with the coxæ obscure yellow, the fore coxæ a little darker; trochanters obscure yellow; femora pale brown, the bases brighter, the tips a little darkened; tibiæ pale brown, the tips paling to dirty white; tarsi chiefly dirty white, the terminal segment darker. Wings with a strong brownish tinge, the oval stigma darker brown; veins beyond the cord vaguely and narrowly seamed with brown. Venation (Plate 1, fig. 2): Free tip of Sc_2 pale; medial cells relatively deep.

Abdominal tergites dark brown, the bases of the intermediate segments light brown; basal sternites chiefly light yellow, the outer segments brownish black. Male hypopygium viewed from the side (Plate 2, fig. 2) with the heavily blackened ninth tergite, *t*, medially provided with conspicuous erect yellow setæ, the caudal lateral angles produced into an erect black spine on either side. Outer dististyle, *d*, fleshy, dusky at tip, with conspicuous black setæ. Inner dististyle a highly compressed blade.

The fused ventral portion of the basistyle and ninth sternite, *s*, produced caudad into a conspicuous lobe, the broad, gently convex margin of which bears very long conspicuous yellow setæ.

Habitat.—Formosa.

Holotype, male, Noko, altitude 9,000 feet, June 26, 1927 (*S. Issiki*).

Nesopeza trichopyga is well distinguished by the rather remarkable hypopygium of the male. It may be distinguished from *N. taiwania* Alexander by the more elongate antennæ (Plate 2, figs. 3, 4) and the deeper medial cells of the wing (Plate 1, figs. 2, 3).

TIPULA (ACUTIPULA) LACKSCHEWITZIANA sp. nov.

Allied to *T. filicornis* Brunetti; antennæ (male) elongate, with conspicuous erect setæ and pubescence; male hypopygium very large, the ninth tergite subtruncate across the caudal margin; outer dististyle a slender complicated black structure.

Male.—Length, about 14.5 millimeters; wing, 16.5 antenna, about 15.

Frontal prolongation of the head obscure yellow, the dorsal half brighter; nasus relatively slender, with long black setæ, those at the tip yellow. Antennæ (male) very elongate, as shown by the measurements; basal segment of scape very narrow at base; scapal segments obscure yellow, the flagellar segments brown; basal enlargement of segments small and slightly darker in color; flagellar segments elongate-cylindrical, with long scattered black verticils and a shorter delicate erect white pubescence, the longest verticils fully seven or eight times the diameter of the segment at the point of attachment; terminal segment short. Head buffy brown, brighter in front and on the narrow posterior orbits.

Mesonotum pale buffy brown with four scarcely evident, slightly more-grayish stripes that are vaguely margined with a narrow line of darker brown; scutal lobes a little grayish, the median area buffy; scutellum brown, more yellowish medially; postnotum yellowish gray with yellow setæ. Pleura yellow. Halteres relatively slender, pale brown, the base of the knobs somewhat darker. Legs with the coxæ and trochanters light yellow; femora brown, the bases narrowly yellow, the tips narrowly blackened; tibiæ yellowish brown, darkened outwardly; tarsi black, terminal segments broken. Wings with a grayish suffusion; stigma brown; cells C and Sc slightly less infumed than the stigma, especially the former; prearcular region more yellowish; veins dark brown, obliterative areas extensive. Venation: Cell R_2 small, as in the subgenus, the inner end pointed; cell 1st M_2 relatively small, irregularly pentagonal; m a trifle longer than the petiole of cell M_1; cell 2d A relatively narrow.

Abdominal tergites obscure yellow, the lateral margins narrowly dark brown; sternites clearer yellow; a conspicuous black subterminal ring that includes segments 6 to 8; segment 9 brownish yellow. Male hypopygium (Plate 2, fig. 5) large. Tergal region, *t*, pale, appearing as a convex subrectangular plate, the caudal margin subtruncate, provided with long conspicuous yellow setæ. Outer dististyle, *d*, black, complicated in structure, viewed laterally appearing more or less bomerang-shaped, the long apex obtuse at tip; outer surface of apical arm dull with an appressed pubescence, the inner of mesal surface shiny; viewed caudally (Plate 2, fig. 5*a*), the mesal margin of the style is seen to be microscopically serrulate, near the base bearing a slender arm that is microscopically spiculose. Caudo-mesal margin of sternal region, *s*, bearing dense brushes of short reddish brown setæ, with an additional median brush; region of sternite ventrad of this densely filled with pale membrane.

Habitat.—Formosa.

Holotype, male, Noko, altitude 8,000 feet, June 26, 1927 (*S. Issiki*).

This interesting *Tipula* is named in honor of my friend, Dr. P. Lackschewitz, of Latvia, eminent student of the crane flies of the Baltic region. It is the first representative of the subgenus *Acutipula* to be described from Formosa. The species is allied to *T. filicornis* Brunetti[4] and *T. mitocera* Alexander;[5] it differs, especially, in the structure of the male hypopygium.

TIPULA NOKONIS sp. nov.

General coloration greenish gray, the præscutum with four dark olive-brown stripes that are narrowly margined with dark brown; antennal scape bright yellow, the flagellum black; tips of the femora black, preceded by a vague yellowish subterminal ring; wings creamy, variegated with brown and gray clouds; male hypopygium with the ninth sternite produced ventrad into a conspicuous tubercle.

Male.—Length, about 18 millimeters; wing, 19.5.

[4] Rec. Ind. Mus. 15 (1918) 267–268.

[5] Rec. Ind. Mus. 29 (1927) 181–182, fig. 3.

Frontal prolongation of head relatively long, nasus distinct, dark grayish brown, with a more-chestnut lateral stripe; palpi dark brown, the base of the elongate terminal segment paler. Antennæ of moderate length, if bent backward extending to shortly beyond the base of the abdomen; scape bright yellow, flagellum black; basal enlargement of the flagellar segments relatively small, verticils comparatively long. Head buffy, more reddish in front and laterally behind, the vertex with a conspicuous dark brown median area.

Mesonotal præscutum with a greenish gray ground color, with four dark olive-brown stripes that are narrowly margined with brownish black; scutum greenish gray medially, each lobe with two dark areas; scutellum dark, sparsely pruinose, with a median brown line; postnotal mediotergite pale greenish gray with a capillary brown median line. Pleura variegated brown and olive-gray, in ill-defined areas, the pleurotergite with a velvety area before the halteres. Halteres elongate, brownish yellow, the base of the knobs conspicuously blackened. Legs with the coxæ greenish gray; trochanters brownish yellow; femora yellowish brown, the tips conspicuously blackened, preceded by a diffuse, somewhat brighter yellow ring; tibiæ brown, passing into dark brown; tarsi brownish black. Wings with a creamy ground color, the prearcular region and cells C and Sc yellow; a conspicuous brown and grayish brown pattern, distributed over the entire wing, the darker spots being at arculus, origin of Rs, and stigma; wing tip rather uniformly darkened; of the paler clouds in the medial cell, the outer one is much the larger, the narrower inner cloud being confluent across vein M with extensive similar clouds in cell R; veins dark brown, brighter in the flavous areas. Venation: Rs long; R_{1+2} entirely preserved, without macrotrichiæ except one or two at extreme base; cell 1st M_2 relatively short and high, irregularly pentagonal; petiole of cell M_1 shorter than m.

Abdominal tergites reddish with three brownish black stripes, the sublateral stripes widening out on the outer segments, the apex of the abdomen, including segments 6 to 8 and the hypopygium black; lateral margins of the segments narrowly buffy; basal sternites more reddish brown, the outer segments dark brown, pruinose; caudal and lateral margins of the segments very narrowly margined with buffy. Male hypopygium (Plate 2, fig. 6) relatively small, the tergite, *t*, fused with the sternite basally. Ninth tergite (Plate 2, fig. 7) relatively short and wide, the caudal margin with a broad U-shaped notch, the lateral lobes thus formed being even wider, subtruncate to obtusely rounded at tips. Ninth sternite, *s*, produced ventrad into a conspicuous tubercle. Basistyle, *b*, complete. Outer dististyle, *d*, flattened, narrowed at base, more or less spade-shaped, provided with delicate yellow setæ and scattered longer black setæ. Inner dististyle a chitinized, highly compressed blade, the caudal margin with conspicuous yellow setæ. Eighth sternite with the ventral surface provided with very long yellow setæ.

Habitat.—Formosa.

Holotype, male, Noko, altitude 9,800 feet, June 27, 1927 (*S. Issiki*).

Tipula nokonis is generally similar to *T. subapterogyne* Alexander, likewise from Noko, *T. terebrata* Edwards, and several other species in eastern Asia. It differs in the details of coloration of the antennæ, wings, and thorax, but especially in the structure of the male hypopygium. The peculiar tubercle on the ninth sternite is approached in a lesser degree by *T. verecunda* Alexander, of northern Japan.

TIPULA SPARSISSIMA sp. nov.

Belongs to the *T. annulicornis* group; antennæ (male) relatively elongate, bicolorous; mesonotal præscutum golden yellow with four pale olive-brown stripes; wings creamy, vaguely tinted with brown, especially in cell R_3; basal and costal regions light yellow; cord and vein Cu seamed with brown; a small group of macrotrichiæ in the distal end of cell R_5; m-cu close to the fork of M; cell 1st M_2 small; male hypopygium with the median lobe of the tergite short, compressed.

Male.—Length, about 8.5 millimeters; wing, 9.6.

Female.—Length, about 9.5 millimeters; wing, 10.4.

Frontal prolongation of the head relatively short, the nasus reduced to a small tubercle; prolongation obscure yellow, darker laterally; palpi dark brown. Antennæ (male) relatively long, if bent backward extending to beyong the base of the abdomen; scape yellow; flagellar segments bicolorous, the basal enlargement of each segment black, the apex obscure yellow; outer segments more uniformly infuscated. In the female the antennæ are short but similarly bicolorous. Head yellowish gray to olive gray.

Mesonotal præscutum golden yellow with four pale olive brown stripes, the intermediate pair narrowed behind, scarcely attaining the suture, the capillary line separating them only a little paler than the stripes themselves; anterior ends of the intermediate stripes more or less golden pollinose; scutum greenish yellow, the lobe marked with brown; scutellum and postnotum brownish yellow. Pleura yellow, vaguely variegated with dusky on the propleura, anterior anepisternum and again near the root of the halteres. Halteres slender, testaceous, the apices of the knobs light yellow. Legs with the coxæ and trochanters yellow; femora yellow, the tips brownish black; tibiæ brown, the tips narrowly darkened; tarsi dark brown. Wings with a faint creamy ground color, vaguely tinged with brown, more especially in cell R_3; prearcular and costal regions light yellow; stigma oval, dark brown, conspicuous brown seams between the branches of Cu and along the cord; obliterative areas very extensive, appearing as creamy before and beyond the stigma, and across cell 1st M_2, covering almost all of the basal sections of M_{1+2} and M_3; veins dark brown, yellowish in the flavous areas. A small group of from about five to fifteen macrotrichiæ in the outer end of cell R_5. Venation (Plate 1, fig. 4): Rs relatively short; R_{1+2} entire; R_2 distinct, more than one-half R_1 alone; cell 1st M_2 very small; m-cu long, close to the fork of M; m in cases greatly reduced; m-cu long.

Abdominal tergites obscure brownish yellow, the caudal and lateral margins of the segments darkened; sternites obscure yellow; subterminal segments blackened; hypopygium dark brown. Male hypopygium (Plate 2, fig. 8) with the caudal margin of the ninth tergite produced caudal into a short, highly compressed, median blade. Tergite, *t*, and sternite, *s*, fused basally, the basistyle more or less rectangular in outline, cut off from the remainder of the hypopygium by incomplete sutures above and below. Outer dististyle relatively slender, pale, with scattered setæ. Inner dististyle, *d*, a greatly compressed blade that extends to a slender black point at the anterior margin.

Habitat.—Formosa.

Holotype, male, Noko, altitude 8,000 feet, June 26, 1927 (*S. Issiki*). Allotopotype, female, pinned with the male. Paratopotypes, 2 males, 8,000 to 8,500 feet.

Although generally similar to *T. sparsiseta* Alexander, *T. acifera* Alexander, and other Japanese species of the *T. annulicornis* group, the present species is abundantly distinct in the venation and wing pattern. The present form is likewise generally similar to *T. microcellula* Alexander, also from Formosa, but actually belongs to an entirely different group of species.

LIMONIINÆ

PEDICIINI

TRICYPHONA OROPHILA sp. nov.

General coloration dark gray, the præscutum with three black stripes; antennæ 16-segmented, black throughout; halteres yellow, the knobs weakly infuscated; legs black, the femoral bases yellow; wings yellowish brown, the base clearer yellow; r-m connecting with R_{4+5} just beyond origin; m at fork of M_{1+2} male hypopygium with the interbases appearing as very large, flattened, curved blades.

Male.—Length, about 8 millimeters; wing, 10.

Rostrum and palpi black. Antennæ 16-segmented, black throughout, the basal segment sparsely pruinose; flagellar segments short-oval, the outer segments more elongate oval and less crowded. Head dark gray; vertical tubercle conspicuous, simple.

Pronotum dark gray. Mesonotum dark gray, the præscutum with three black stripes, the median stripe weakly bifid behind; extreme margin of humeral region more chitinized, obscure horn yellow; scutal lobes black, the median area and remainder of the notum gray pruinose. Pleura dark gray. Halteres relatively elongate, pale yellow, the extreme base of the stem more orange, the knobs weakly infuscated. Legs with the coxæ dark gray, the lower faces more yellowish, especially of the fore coxæ; trochanters brownish yellow; femora black, the bases broadly yellow, narrowest on the fore femora where it includes only about the basal sixth, broader on the hind legs where nearly the basal half is brightened; fore and middle tibiæ black, hind tibiæ paler, the tips darkened; tarsi black. Wings with a strong yellowish brown tinge, the base more strongly yellow; narrow and vague dusky seams along the cord; veins dark brown, the subcostal and prearcular veins more yellowish. Venation (Plate 1, fig. 5): Sc long, Sc_1 extending to just beyond the base of cell R_4; Sc_2 some distance before the origin of Rs; R_2 about twice R_{1+2}; r-m connecting with R_{4+5} just beyond the end of Rs; cell R_4 deep; m present, opposite the fork of M_{1+2} m-cu connecting with M_4 just beyond its base.

Abdomen brownish black, including the hypopygium. Male hypopygium (Plate 2, fig. 9) with the ninth tergite, *t*, very large, the caudal margin subtruncate or very feebly emarginate, provided with low lobes. Basistyle, *b*, moderately slender, deeply bifid at apex, the outer lobe a little more elongate, spinose and setose at tip, the inner lobe more flattened, with very elongate setæ. Dististyle, *d*, single, in the notch of the basistyle, provided with short, black, peglike spines. Interbase, *i* (only one shown in figure), very powerful, appearing as flattened divergent blades, strongly curved, the inner margin with a few microscopic setulæ, the apex strongly recurved, obtuse, set with low spinous teeth.

Habitat.—Formosa.

Holotype, male, Noko, altitude 9,000 feet, June 26, 1927 (*S. Issiki*).

Tricyphona orophila is very different from other described members of the genus; in general appearance it is most similar to *T. optabilis* Alexander, of Japan, but is still very distinct.

RHAPHIDOLABIS (RHAPHIDOLABIS) ATRIPES sp. nov.

General coloration light gray, the præscutum with four narrow dark brown stripes; antennæ 14-segmented, black throughout; legs black, the femoral bases restrictedly paler; wings subhyaline, stigma brown, prearcular region light yellow; cell R_3 petiolate; cell M_2 open.

Male.—Length, about 5.5 millimeters; wing, 7.

Rostrum gray; palpi black. Antennæ 14-segmented, the terminal segment longer than the penultimate; antennæ black, the basal segment a little pruinose; second scapal segment long, nearly equal in length to the first flagellar; intermediate flagellar segments oval. Head light gray, the center of the vertex a little infuscated.

Pronotum light gray. Mesonotum light gray, the præscutum with four narrow dark brown stripes, the intermediate pair not reaching the suture; each scutal lobe with two dark markings. Pleura clear light gray, including the dorsopleural membrane. Halteres pale, the knobs infuscated. Legs with the coxæ gray; trochanters light brown; remainder of legs black, only the extreme bases of the femora somewhat paler. Wings subhyaline, the ill-delimited stigma brown; prearcular region light yellow; veins dark brown. Venation (Plate 1, fig. 6): $Sc_2 + R$ approximately two-thirds $Sc_2 + R_1$; R_2 gently oblique in position, much longer than R_{1+2}; Rs weakly angulated near midlength; R_{2+3+4} longer than R_2; cell M_1 short; cell M_2 open; m-cu at about one-third its length beyond the fork of M.

Abdomen dark brown, sparsely pruinose. Male hypopygium (Plate 2, fig. 10) with the lateral lobes of the ninth tergite, *t*, large, conspicuously setiferous, the median area smooth, subchitinized. Lateral lobe of the basistyle, *b*, with abundant setæ and short spines. Dististyle, *d*, parallel-sided, a little longer than the lobe of the basistyle. Interbase broad at base, gradually narrowed to the curved acute tip.

Habitat.—Formosa.

Holotype, male, Higashinoko, altitude 7,500 feet, June 27, 1927 (*S. Issiki*).

Rhaphidolabis atripes is allied to *R. flavibasis* Alexander, of Japan, differing in the smaller size, shorter antennæ, the presence of four instead of three præscutal stripes, and slight differences in the male hypopygium. This may possibly be the species recorded as *R. brunettii* Edwards [6] based on a female specimen from Arisan. Brunetti's description [7] differs in many regards from the present form in the coloration and structure of the antennæ. It is possible that the high mountains of Formosa support a rather considerable number of species of pediciine crane flies.

LIMONIINI

ORIMARGA PRUINOSA sp. nov.

General coloration of head and thorax light gray; wings grayish subhyaline, the veins pale; R_{2+3} elongate, nearly as long as R_3 alone; abdomen elongate, the tergites dark brown.

Female.—Length, about 7 millimeters; wing, 5.8.

Rostrum brown; palpi dark brown. Antennæ with the scapal segments brown; flagellum black; antennæ relatively short, if bent backward ending some distance before the wing root; flagellar segments oval. Head light gray, brighter anteriorly.

Mesonotum light gray, the præscutum with four slightly darker gray stripes; anterior lateral pretergites restrictedly orange-yellow. Pleura gray. Halteres pale orange-yellow, the knobs a trifle darker. Legs with the coxæ dark brown, sparsely pruinose; trochanters yellowish brown; remainder of legs brownish yellow, the terminal tarsal segments darker. Wings grayish subhyaline, the veins pale. Macrotrichiæ of veins relatively abundant; none on Rs, R_2, or the basal two-thirds of R_{2+3}; a series of trichiæ on the other longitudinal veins beyond the cord; no trichiæ on Cu or the anal veins. Venation (Plate 1, fig. 7): Sc long, Sc_1 ending nearly opposite the fork of Rs, Sc_2 a short distance from its tip; free tip of Sc_2 very pale and indistinct but present; R_{2+3} elongate, nearly as long

[6] Ann. & Mag. Nat. Hist. VIII 18 (1916) 254; IX 8 (1921) 101.

[7] Fauna British India, Dipt. Nematocera (1912) 492.

as R_3; R_2 a little shorter than R_{1+2}; petiole of cell M_3 shorter than M_4; m-cu shortly before midlength of Rs.

Abdomen elongate; tergites dark brown; sternites a little more yellowish brown; genital segment obscure orange. Ovipositor with the tergal valves slender, gently upcurved to the acute tips.

Habitat.—Japan (Honshiu).

Holotype, female, Mount Bantaizan, Fukushima-ken, August 4, 1927 (*S. Issiki*).

Orimarga pruinosa is most closely allied to *O. formosicola* Alexander, of Fomosa, which differs in the narrower wings with darker veins and slightly different venation. The genus *Orimarga* had not been recorded hitherto from the main islands of Japan.

DICRANOPTYCHA CAESIA sp. nov.

Antennæ brown throughout; thorax clear light gray, the præscutum with light brown stripes; tips of the femora weakly infuscated; wings strongly tinged with yellow; m greatly reduced in length; abdomen obscure yellow.

Female.—Length, about 10 millimeters; wing, 10.

Rostrum dark, sparsely pruinose; palpi dark brown. Antennæ brown throughout, the first scapal segment still darker, pruinose; flagellar segments oval, with relatively short verticils. Head light gray.

Pronotum and mesonotum clear light gray, the præscutum with two narrow submedian pale brown stripes that are obsolete anterior to the small tuberculate pits; lateral stripes less distinct; pseudosutural foveæ black. Pleura clear light gray. Halteres pale yellow. Legs with the coxæ yellow, the extreme bases of the fore and middle coxæ a little darkened and sparsely pruinose; femora yellow, the tips narrowly and weakly infuscated; tibiæ and basitarsi yellow, the tips narrowly brown; remainder of tarsi dark brown. Wings strongly tinged with yellow, iridescent; veins brown, the costal, subcostal, and radial veins yellow. Costal fringe (female) short. Venation: Rs a little longer than cell 1st M_2; m greatly reduced, the basal section of M_3 correspondingly lengthened; m-cu about one-half its length beyond the fork of M.

Abdomen obscure yellow, the segments more infuscated laterally. Ovipositor with the tergal valves conspicuously compressed, the tips obtusely rounded.

Habitat.—Japan (Honshiu).

Holotype, female, Tatusawa, near Inawasiro, Fukushimaken, altitude 2,000 feet, August 5, 1927 (*S. Issiki*).

Dicranoptycha caesia may be confused only with *D. yamata* Alexander, which is distinguished by the much larger size and different coloration, such as the pale antennal scape and uniformly darkened abdomen.

HEXATOMINI

EPIPHRAGMA NYMPHICA sp. nov.

General coloration dark brown; antennæ with the scape black, the basal flagellar segment yellow; outer flagellar segments passing into dark brown; halteres with the apices of the knobs light yellow; legs yellow, the femora with a broad black subterminal ring; wings creamy, the costal region light yellow, the disk with a broken, more or less ocelliform, dark brown pattern; radial cells extensively free from markings.

Male.—Length, about 8 to 9 millimeters; wing, 9.5 to 11.

Rostrum brownish black; palpi black. Antennæ with the scapal segments black; basal segment of flagellum enlarged, bright yellow; second segment slightly more obscure; succeeding flagellar segments testaceous, the outer segments passing into dark brown; flagellar segments cylindrical, with relatively long verticils. Head dark brown, the posterior orbits a little brighter.

Pronotum and mesonotum dark brown, the præscutum with a narrow velvety black median stripe that is narrowed to a point behind and becomes obsolete some distance before the suture; anterior half of the sclerite a little dusted with golden-yellow pollen; lateral margins of the sclerite blackened. Pleura, including the dorsopleural region, black; surface vaguely variegated with areas of yellowish pollen. Halteres dark brown, the base of the stem restrictedly pale, the apices of the knobs light yellow. Legs with the coxæ brownish yellow; trochanters obscure yellow; femora yellow with a relatively broad black ring before the tips, this ring nearly twice as extensive as the pale apex beyond; tibiæ and tarsi yellow, the terminal tarsal segment brown. Wings creamy, the costal region broadly light yellow; a handsome dark brown pattern, consisting of confluent broken circles in cells C to M, having as centers a point beyond the arculus and the origin of Rs, the latter ocellus connected with a large solid area in the cubital and anal cells, ending at vein 2d A, with a connecting area at near two-thirds the length of cell 2d A; the basal ocellus is connected with the prearcular region; base of cell 2d A darkened;

a third, very extensive, broken ocellus has the entire cord as a center; beyond the cord an irregular arcuated brown band extending from the end of cell R_5, across the outer end of cell 1st M_2 to the wing margin in cells Cu and 1st A; besides the above major areas there are scattered isolated marks at h, the supernumerary crossvein in cell C, tip of R_3, and tips of veins M_3 and M_4; the radial cells are thus conspicuously free from markings except basally and in cell R_5; veins yellow, especially bright in the outer costal region, dark brown in the infuscated areas. Venation: Supernumerary crossvein in cell C perpendicular; R_{2+3+4} longer than R_{2+3}; cell M_1 about as long as its petiole; cell 1st M_2 large, gently widened outwardly; m-cu near the inner end of cell 1st M_2, about its own length beyond the fork of M.

Abdominal tergites dark brown, the segments variegated caudally and medially with obscure yellowish gray; sternites dark, obscure yellow medially, the caudal margins narrowly gray; hypopygium yellowish brown.

Habitat.—Formosa.

Holotype, male, Kirakei, altitude 4,000 feet, June 28, 1927 (*S. Issiki*). Paratopotype, male.

Epiphragma nymphica is separated from the rather numerous species in southern and eastern Asia by the diagnostic features listed above. The species appears to be most similar to *E. vicina* Brunetti in the black femoral ring but differs in many important details of coloration.

PSEUDOLIMNOPHILA NOKONIS sp. nov.

General coloration of thorax dark brown, the præscutum dull ocherous, with a broad black median stripe; pleura with a narrow black longitudinal stripe; rostrum and palpi yellow; antennæ black; wings yellow, sparsely variegated with brown; cells beyond the cord unusually short for a member of this genus.

Female.—Length, about 7.5 millimeters; wing, 7.5.

Rostrum and palpi yellow. Antennæ black throughout; flagellar segments long-oval. Head brownish gray.

Pronotum ocherous brown, somewhat darker laterally. Mesonotal praescutum dull ocherous, with three brown stripes, the median stripe broad and conspicuous, especially behind, the lateral stripes scarcely evident; tuberculate pits lacking; pseudosutural foveæ reduced to small pale depressions close to the margin; remainder of mesonotum dark brown, sparsely pruinose. Pleura with a narrow black longitudinal stripe extending from the cervical sclerites, passing above the fore coxæ, traversing the anepisternum and middle portion of the pteropleurite to the pleurotergite, where it is more pruinose; ventral pleurites pale gray; dorsopleural region pale. Halteres relatively long, pale yellow, the knobs infuscated. Legs with the coxæ and trochanters yellow; remainder of legs yellow, the tips of the tibiæ weakly infuscated, the terminal tarsal segments passing into dark brown. Wings with a strong yellow suffusion; stigma long-oval, pale brown; very narrow and vague brown seams at origin of Rs, along the cord and the outer end of cell 1st M_2; veins dark brown, the basal veins more yellowish. Venation (Plate 1, fig. 8): Sc short, both Sc_1 and Sc_2 ending before the fork of Rs; Rs strongly arcuated at origin; R_{2+3+4} only gently arcuated; R_2 subequal to R_{1+2}; all cells beyond the cord unusually short; cell M_1 about three times its petiole; cell 1st M_2 large; m-cu about one-half its length from the outer end of the cell; anterior arculus lacking.

Abdominal tergites dark brown, the caudal margins of the individual segments obscure yellow; sternites clearer yellow. Ovipositor with the valves horn-colored, the sternal valves black at base; tergal valves very slender and only gently upcurved.

Habitat.—Formosa.

Holotype, female, Noko, altitude 8,000 feet, June 26, 1927 (*S. Issiki*).

Pseudolimnophila nokonis is somewhat similar to *P. kirishimensis* (Alexander), of southern Japan, differing from this and all other regional species by the short subcosta and the unusually short veins and cells beyond the cord, in combination with the petiolate cell M_1 and position of m-cu.

LIMNOPHILA (TRICHOLIMNOPHILA) EXCELSA sp. nov.

General coloration black, the thorax sparsely pruinose; antennæ black; halteres yellow; legs yellow, the tips of the femora broadly, of the tibiæ more narrowly, blackened; wings brownish yellow, sparsely variegated with brown; macrotrichiæ of cells restricted to outer ends of cells R_2 to M_3.

Female.—Length, about 7 millimeters; wing, 6.

Rostrum and palpi black. Antennæ black, the first scapal segment vaguely paler at base; flagellar segments with long verticils. Head black, heavily gray pruinose.

Pronotum black, gray pruinose. Mesonotum coal-black, the surface very sparsely pruinose to give a subnitidous appearance; postnotum more pruinose. Pleura black, the surface slightly pruinose. Halteres pale yellow. Legs with the fore coxæ dusky, the remaining coxæ testaceous yellow; trochanters yellow; femora yellow, the tips broadly brownish black; tibiæ yellow, the tips narrowly blackened; tarsi testaceous yellow, the tips of segments 1 and 2 and the terminal segments darker; legs with long conspicuous setæ. Wings with a strong brownish yellow suffusion, the base and costal region clearer yellow; stigma oval, dark brown; narrow brown seams along the cord and outer end of cell 1st M_2; veins brown, more yellowish near the wing base. Macrotrichiæ of veins of moderate length; of the cells restricted to the distal ends of cells R_2, R_3, R_4, R_5, 2d M_2, and M_3, more abundant in cell M_1. Venation (Plate 1, fig. 9): Sc relatively short, Sc_1 ending before the fork of Rs; cell M_1 longer than its petiole; cell 1st M_2 rectangular; m-cu about two-thirds its length beyond the fork of M.

Abdomen brownish black, including the genital segment. Ovipositor with the elongate valves yellowish horn color; tergal valves straight, the tips gently upcurved.

Habitat.—Formosa.

Holotype, female, Noko, altitude 8,000 feet, June 26, 1927 (*S. Issiki*).

Limnophila excelsa is entirely distinct from *L. platystyla* Alexander, the only other species of the subgenus *Tricholimnophila* known from Formosa. It is more closely allied to the more northern *L. pilifer* Alexander, differing especially in the smaller size, dark antennæ, more intensely black thorax, and other characters. The male, when discovered, will very probably furnish additional hypopygial differences.

LIMNOPHILA (PRIONOLABIS) ORITROPHA sp. nov.

Size relatively large (wing, male, over 10 millimeters); general coloration coal-black; halteres yellow; femora extensively blackened, especially the fore and middle femora; male hypopygium with the outer dististyle bispinous.

Male.—Length, about 9 millimeters; wing, 11.5.

Rostrum, palpi, and antennæ black; flagellar segments with the ventral face a little produced, the segments rapidly decreasing in size outwardly. Head black, very sparsely pruinose.

Pronotum black. Mesonotum polished coal-black, especially the region of the præscutal stripes. Pleura black, a little duller than the notum. Halteres yellow. Legs with the coxæ and trochanters black; fore femora black, only the extreme base pale; middle femora with about the distal half blackened; hind femora testaceous yellow, only about the distal sixth blackened; tibiæ testaceous brown, the bases and tips blackened; basitarsi brownish testaceous, the tips and remaining tarsal segments passing into black; legs with conspicuous black setæ. Wings with a strong yellow suffusion, the base and costal region even brighter in color; stigma very small, dark brown; origin of Rs, the cord and outer end of cell 1st M_2 narrowly seamed with brown; Cu and the longitudinal veins beyond the cord vaguely seamed with dusky; veins dark brown, the basal and costal veins yellow. Costal fringe and macrotrichiæ of the veins beyond the cord relatively elongate. Venation (Plate 1, fig. 10): Sc_1 ending about opposite the fork of R_{2+3+4}, Sc_2 opposite the fork of Rs; R_{2+3+4} subequal to the basal section of R_5; cell M_1 about equal to its petiole; m-cu beyond midlength of the lower face of cell 1st M_2.

Abdomen black, including the hypopygium. Male hypopygium (Plate 2, fig. 11) with the caudal margin of the ninth tergite, *t*, emarginate, thickened, and provided with microscopic spiculæ. Outer dististyle, *d*, conspicuously setiferous, terminating in a slender black spine, with a similar subterminal spine. Inner dististyle stout, terminating in a narrow, truncated, black point, before the apex with a group of small spines, the number of the latter variable, there being a group of four on one style of the type and only two on the other, as figure. Gonapophyses and ædeagus as in the subgenus.

Habitat.—Formosa.

Holotype, male Noko, altitude 8,500 feet, June 26, 1927 (*S. Issiki*).

The subgenus *Prionolabis* had not been recorded from Formosa.

ERIOCERA ISSIKII sp. nov.

Belongs to the *E. spinosa* group; antennæ (male) short; mesonotal præscutum golden-yellow with three conspicuous black stripes; legs black, the femoral bases broadly fulvous; wings brownish, the base broadly bright yellow, the apex paler yellow; abdomen black.

Male.—Length, about 18 millimeters; wing, 18; first flagellar segment of antenna, 1.4.

Rostrum dark brown, the long palpi black. Antennæ broken beyond the first flagellar segment but from this evidently short for a member of this genus; antennæ black throughout; first scapal segment tumid; first flagellar segment shorter than the second segment of the palpi, unarmed except for scattered appressed setæ. Head velvety black medially, the broad lateral margins of the vertex buffy brown; vertical tubercle weakly bifid in front.

Mesonotal præscutum golden-yellow with three conspicuous black stripes; scutal lobes black, the suture and anterior portion of the median area of the scutum black, the posterior portion more pruinose; scutellum heavily dusted with yellowish pollen; postnotum black. Pleura with the dorsopleural membrane yellowish gray pollinose; a broad stripe crossing the anepisternum and anterior portion of the pteropleurite; sternopleurite and pleurotergite densely covered with a miscroscopic yellowish gray pubescence. Halteres obscure yellow, the knobs brownish black. Legs with the coxæ black, heavily yellowish gray pruinose; trochanters obscure fulvous; remainder of legs black, the femoral bases broadly fulvous, this including about the basal third of the fore femora and about the basal half of the posterior femora. Wings with a strong brownish suffusion, the base broadly bright yellow; cells beyond the cord fading into paler yellow; stigma small, dark brown; most of the longitudinal veins further seamed with brown; veins dark brown, yellowish in the flavous costal and basal areas. Venation (Plate 1, fig. 11): R_{2+3+4} shorter than the basal section of R_5; cell M_1 present, nearly as long as its petiole; distal section of Cu_1 very short.

Abdomen, including the hypopygium, black; basal sternites a little paler.

Habitat.—Japan (Honshiu).

Holotype, male, Zyogi, near Sendai, Miyagi-ken, August 2, 1927 (*S. Issiki*).

Eriocera issikii is very distinct from all other Asiatic species of the *E. spinosa* group. I take great pleasure in naming this very distinct crane fly in honor of the collector, Prof. Syuti T. Issiki, who has added very materially to our knowledge of the Tipulidæ of Japan and Formosa.

ELEPHANTOMYIA (ELEPHANTOMYIA) LUCULENTA sp. nov.

General coloration reddish yellow; rostrum short, not exceeding one-half the length of the body in either sex; wings with a strong yellow suffusion; cell 1st M_2 large; m-cu at near midlength of the cell, longer than the distal section of Cu_1.

Male.—Length (excluding rostrum), about 6 millimeters; wing, 7.5; rostrum, about 3.

Female.—Length (excluding rostrum), about 8.5 millimeters; wing, 8.5; rostrum, about 3.2.

Rostrum dark brown, not exceeding one-half the length of the body in either sex. Antennæ with the first scapal segment ocherous; remainder of antennæ dark brown; outer flagellar segments linear with elongate verticils. Head reddish ocherous, the narrow anterior vertex and posterior orbits more whitish.

Thorax somewhat reddish yellow, the surface subnitidous. Halteres obscure yellow, the knobs a little darker. Legs with the coxæ and trochanters yellowish testaceous; remainder of legs obscure brownish yellow, the tarsi somewhat brighter in color; tibial spurs slender. Wings with a strong yellow suffusion, more intense in the costal and apical regions; veins yellowish brown. Venation (Plate 1, fig. 12): Sc_1 ending just before the fork of Rs, Sc_2 close to its tip; cell 1st M_2 very large, nearly as long as vein M_3 beyond it; m-cu at near midlength of cell 1st M_2, longer than the distal section of Cu_1.

Abdominal tergites brownish yellow, the sternites clearer yellow; hypopygium yellow; in the male with a subterminal black ring that includes segment 8. Ovipositor with the tergal valves very long and slender, nearly straight, the tip gently upcurved; sternal valves shorter and stouter.

Habitat.—Formosa.

Holotype, male, Higashinoko, altitude 7,500 feet, June 27, 1927 (*S. Issiki*).

ERIOPTERINI

GNOPHOMYIA LATEROSPINOSA sp. nov.

General coloration dark brown; antennæ relatively elongate; head dark gray; halteres yellow; wings tinged with yellow; cell 1st M_2 long, subequal to vein M_4 beyond it; male hypopygium with the outer dististyle a long slender rod that bears a conspicuous erect spine just before midlength.

Male.—Length, about 4.5 millimeters; wing, 5.2; antenna, about 1.7.

Rostrum and palpi brownish black. Antennæ (male) relatively elongate, as shown by the measurements, black throughout; flagellar segments elongate-cylindrical, clothed with a dense, erect, white pubescence. Head dark gray.

Pronotum dark brown. Anterior lateral pretergites restrictedly yellow, the posterior pretergites narrowly darkened before the suture. Mesonotal præscutum and scutum dark brown; scutellum a little more testaceous; postnotum dark brown.

Pleura dark brown, the dorsopleural region restrictedly pale. Halteres pale, the knobs light yellow. Legs with the fore coxæ dark brown, the remaining coxæ more testaceous; trochanters testaceous; femora yellowish brown with delicate dark setæ; tibiæ and tarsi passing into dark brown. Wings with a strong yellowish suffusion; stigma lacking; veins brownish yellow. Venation (Plate 1, fig. 13): Sc_1 ending about opposite R_{2+3+4}, Sc_2 some distance from its tip; Rs in alignment with R_5; r-m at the end of Rs; cell 1st M_2 relatively long, gently widened outwardly, about as long as vein M_4 beyong it; m-cu about its own length beyong the fork of M.

Abdomen brownish black, the basal sternites more yellowish. Male hypopygium (Plate 2, fig. 12) with the basistyles, *b*, short and stout, the mesal face armed with four distinct groups of stout spinous setæ, the largest of these setæ being two located on the extreme cephalic mesal portion. Outer dististyle, *d*, very long and slender, appearing as a nearly straight rod that is longer than the basistyle, a little expanded at apex, the mesal edge of which is microscopically toothed, the surface of the rod at apex with small setulæ; before midlength of the rod a conspicuous erect spine. Inner dististyle small, the apex armed with long conspicuous setæ from conspicuous raised tubercles.

Habitat.—Japan (Honshiu).

Holotype, male, Tatusawa, near Inawasiro, Fukushima-ken, altitude 2,000 feet, August 5, 1927 (*S. Issiki*).

GONOMYIA (PTILOSTENA) PALLENS sp. nov.

General coloration yellow, the præscutum and scutum marked with reddish brown; pleura striped; wings grayish yellow; petiole of cell R_3 subangularly bent near midlength and here with a distinct spur of R_2; male hypopygium with the tergal region produced caudad into two slender, feebly divergent rods.

Male.—Length, about 4.8 millimeters; wing, 5.5.

Rostrum and palpi black. Antennæ with the scapal segments light yellow, the basal flagellar segments brownish yellow, the outer flagellar segments passing into dark brown; antennæ of moderate length, if bent backward extending approximately to the wing-root; flagellar segments elongate-oval, with moderately long verticils. Head conspicuously light yellow, not at all darkened behind.

Mesonotal stripes and scutal lobes more reddish brown than in *G.* (*P.*) *sachalinensis;* scutellum somewhat obscure yellow.

Pleura and postnotal mediotergite marked as in *sachalinensis.* Legs with the tips of the femora not at all darkened, the tips of the tibiæ rather narrowly infuscated but scarcely blackened. Wings with a grayish yellow tinge, the base and costal region clearer yellow; veins brown, more luteous in the yellow areas. Venation (Plate 1, fig. 14): Sc long, Sc_1 extending about to midlength of Rs, Sc_2 opposite the origin of Rs; petiole of cell R_3 shorter than in *sachalinensis,* subangularly bent, at the point of angulation with a distinct spur of R_2; petiole of cell M_2 short.

Abdominal tergites dark brown, the caudal margins of the segments conspicuously yellow; hypopygium yellow. Male hypopygium (Plate 2, fig. 13) with two elongate, gently divergent pale rods (only one shown in the figure) arising from what appears to be the ninth tergite, these rods conspicuously setiferous near base. Basistyle, *b,* stout basally, the outer apical angle produced into a large pale setiferous lobe. Three dististyles present, the outer, *d,* a long simple acicular rod, its tip an elongate black spine; the largest dististyle appears as a glabrous flattened blade, on the outer margin with a long slender glabrous rod that bears a large black tooth at base; innermost dististyle slender, bifid, the arms appressed, the outer arm a slender, black-tipped spine, the inner arm pale, with conspicuous setæ. Ædeagus with a conspicuous blackened bispinous head, as figured.

Habitat.—Japan (Honshiu).

Holotype, male, Sakunami, near Sendai, Miyagi-ken, August 2, 1927 (*S. Issiki*).

Gonomyia (*Ptilostena*) *pallens* is closely allied to *G.* (*P.*) *sachalinensis* Alexander, of Karafuto, which differs chiefly in details of venation. The male of the last-named species is still unknown.

GONOMYIA (LIPOPHLEPS) PTILOSTENOIDES sp. nov.

General coloration black, the thorax variegated with yellow; halteres and legs black; wings with a faint blackish suffusion; Sc_1 ending opposite the origin Rs; medial field of the wing as in the subgenus *Ptilostena;* abdomen black, the pleural membrane sulphur yellow.

Female.—Length, about 4.5 millimeters; wing, 4.8.

Rostrum and palpi black. Antennæ black, the first scapal segment pruinose; flagellar segments oval, becoming smaller outwardly; verticils relatively short. Head black, the surface sparsely pruinose; front and anterior orbits broadly buffy yellow.

Pronotum black, the anterior lateral pretergites broadly light yellow; posterior lateral pretergites very narrowly light yellow. Mesonotal præscutum chiefly plumbeous black, the lateral and humeral portions restrictedly shiny black; scutum dull black, the median area in front restrictedly pale; a small yellow spot above the wing root; scutellum broadly light yellow; postnotum black. Pleura black, the dorsopleural region yellow; a narrow, longitudinal, yellowish white stripe extending from behind the fore coxæ, crossing the dorsal portion of the sternopleurite, becoming more extensive on the metapleura and pteropleurite. Halteres black, the knobs scarcely paler. Legs black throughout. Wings with a faint blackish suffusion; veins brownish black, the basal section of M_{1+2} paler. Macrotrichiæ of veins relatively short and sparse. Venation (Plate 1, fig. 15): Sc short, Sc_1 ending opposite the origin of Rs, Sc_2 some distance from its tip; Rs gently arcuated at origin; M in alignment with M_{3+4}; cell M_2 small, much shorter than its petiole; m-cu more than its own length before the fork of M.

Abdomen black, the pleural membrane sulphur yellow. Ovipositor with the valves yellowish horn-color, the tips of the tergal valves extensively blackened; tergal valves slender, only gently upcurved.

Habitat.—Formosa.

Holotype, female, Noko, altitude 8,000 feet, June 26, 1927 (*S. Issiki*).

Gonomyia (*Lipophleps*) *ptilostenoides* is a very puzzling species. The venation of the radial field of the wing is as in the subgenus *Lipophleps*, but that of the medial field is as definitely that of the subgenus *Ptilostena*. Until more material is forthcoming, I am referring the fly to *Lipophleps*, where it would run by means of existing keys.

GONOMYIA (GONOMYIA) GILVIPENNIS sp. nov.

General coloration of mesonotum and scutum dark brown; scutellum light yellow; pleura pale reddish with a whitish longitudinal stripe; head gray; halteres yellow; wings with a strong yellowish suffusion; vein Sc relatively long; cell 1st M_2 closed; male hypopygium with a single dististyle; phallosome asymmetrical.

Male.—Length, about 4 to 4.2 millimeters; wing, 4.8 to 5.

Female.—Length, about 4.5 millimeters; wing, 5.2.

Rostrum obscure brownish yellow; palpi dark brown. Antennæ brownish black, the first scapal segment a trifle paler; flagellar segments oval, with a delicate white pubescence. Head gray, brighter anteriorly.

Pronotum yellow. Mesonotal præscutum dark brown, the humeral triangle and broad lateral margins yellow; scutal lobes dark brown, the median region broadly obscure yellow; scutellum light yellow; postnotum dark brown. Pleura pale reddish with a whitish longitudinal stripe across the dorsal portion of the sternopleurite; dorsopleural region pale yellow. Halteres relatively elongate, yellow. Legs with the coxæ and trochanters yellowish testaceous; femora obscure yellow at base, passing into dark brown; tibiæ and basitarsi pale brown, the terminal tarsal segments a little darker, with yellow setæ. Wings with a strong yellowish suffusion, the stigmal region vaguely darker; veins pale brown, the basal and subcostal veins somewhat more yellow. Venation (Plate 1, fig. 16): Sc relatively long, Sc_1 extending to from one-third to nearly opposite midlength of Rs, Sc_2 shortly beyond this origin; cell R_3 large; cell 1st M_2 closed; m-cu close to the fork of M, in cases a short distance beyond. In the allotype, the basal section of M_3 is only weakly preserved in both wings.

Abdominal tergites dark brown, the lateral margins and sternites more yellowish. Male hypopygium (Plate 2, fig. 14) with the basistyles, *b*, relatively slender, the outer apical angle produced caudad into a very long slender lobe that is approximately as long as the basal portion of the style; a smaller oval lobe at apex of basistyle, this provided with microscopic setulæ in addition to stouter setæ. A single dististyle, *d*, present, this appearing as a powerful chitinized blade that terminates in a slender curved spine; on the inner face of the style near base with a stout pale lobe that bears two stouter fasciculate setæ in addition to smaller normal setæ. Phallosome, *p*, consisting of a very long pale compressed blade that is irregularly bifid near apex, a long slender rod that is gently sinuous, the tip blackened, and a much smaller and slenderer needlelike spine. Ovipositor with the valves elongate, the tergal valves gently upcurved.

Habitat.—Japan (Honshiu).

Holotype, male, Tatusawa, near Inawasiro, Fukushimaken, altitude 2,000 feet, August 5, 1927 (*S. Issiki*). Allotopotype, female. Paratopotypes, 2 males.

DASYMOLOPHILUS NOKOENSIS sp. nov.

General coloration brown; antennæ short; wings pale grayish subhyaline, the cells virtually without macrotrichiæ.

Male.—Length, about 1.8 millimeters; wing, 2.8.

Female.—Length, about 2 millimeters; wing, 3.

Rostrum and palpi dark brown. Antennæ short, dark brown throughout, if bent backward extending nearly to the wing root. Head dark brown.

Mesonotum and pleura brown, with long conspicuous dark brown setæ. Halteres dark brown, only the base of the stem restrictedly pale. Legs with the coxæ and trochanters brownish testaceous; remainder of legs brownish testaceous, covered with long dark setæ. Wings pale grayish subhyaline, the very long abundant macrotrichiæ of the veins dark brown; veins pale brown, relatively inconspicuous. Macrotrichiæ of cells virtually lacking, there being a row of from eight to ten punctures in cell R_1 in alignment with R_3; in the male a few scattered punctures in the extreme outer end of cell R_3. Venation (Plate 1, fig. 17): R_{2+3} perpendicular to the end of Rs, subequal to and in alignment with R_2; basal section of R_5 and r-m lying just beyond the fork of Rs.

Abdomen brownish black, including the male hypopygium. Ovipositor with the tergal valves very powerfully constructed, compressed, strongly upcurved.

Habitat.—Formosa.

Holotype, female, Noko, altitude 9,800 feet, June 26, 1927 (*S. Issiki*). Allotopotype, a broken male, altitude 9,000 feet.

Dasymolophilus nokoensis is the first member of the genus to be described from Asia. It is distinguished from the known species of the genus by the virtual lack of macrotrichiæ in the cells of the wing. The nearest approach to this condition known hitherto is found in *D. subnudus* Alexander, of western North America, where the trichiæ are sparse in the distal cells of the wing although well distributed basad of the cord.

The relationships of *Dasymolophilus* with *Tasiocera* Skuse seem evident. The genus *Dasymolophilus* is based on the combination of venation, presence of macrotrichiæ in the distal cells of the wing, and presence of a single dististyle in the male hypopygium. Certain New Zealand species of *Molophilus* have macrotrichiæ in the distal cells of the wing, while other members of the same genus have but a single dististyle (*M. monostylus* Alexander, of Chile). Despite these points of contact there can be little question of the validity of the group.

MOLOPHILUS NIGRIPES Edwards.

Molophilus nigripes EDWARDS, Ann. & Mag. Nat. Hist. IX 8 (1921) 104.

A male specimen from the type locality (Noko, Formosa, altitude 9,800 feet, June 26, 1927, *S. Issiki*).

The specimen agrees entirely with Edward's description. The male hypopygium has not been adequately described. Male hypopygium (Plate 2, fig. 15) with the dorsal lobe of the basistyle, *b*, developed only as a low obtuse lobe; mesal lobe broadly flattened, the tip obtuse; ventral lobe appearing as a long cylindrical structure that is provided with large scattered setæ and microscopic setulæ. Outer dististyle, *d*, slenderer, appearing as a pale straight rod the tip a little expanded, blunt, provided with six or seven small denticles. Inner dististyle of approximately the same length, dilated at base, gradually narrowed to the acute tip, the outer margin before apex microscopically setulose. Ædeagus slender, a little longer than the dististyles.

MOLOPHILUS NOKONIS sp. nov.

Belongs to the *M. gracilis* group and subgroup; general coloration plumbeous black; antennæ short, black; halteres dirty yellow; wings with a brownish suffusion; vein 2d A short; male hypopygium with ventral lateral portion of the basistyle produced into a needlelike spine; inner dististyle a sinuous black rod, the apex with conspicuous spinous teeth.

Male.—Length, about 3.2 millimeters; wing, 4 to 4.2.

Female.—Length, about 3.6 millimeters; wing, 4.8.

Rostrum and palpi black. Antennæ black throughout, relatively short, if bent backward extending approximately to the wing root. Head dark gray.

General coloration of the thorax dull plumbeous black, in cases with the anterior lateral pretergites and humeral triangles restrictedly brightened; pseudosutural foveæ shiny black. Halteres dirty yellow. Legs with the coxæ and trochanters yellowish testaceous; femora obscure yellow basally, passing into dark brown; tibiæ and tarsi light brown, passing into darker brown outwardly. Wings with a brownish suffusion, the base and costal region more yellowish; veins pale brown; macrotrichiæ dark brown. Venation: R_{2+3} only gently arcuated; R_2 in alignment with r-m; petiole of cell M_3 more than twice m-cu; vein 2d A relatively short, ending just before m-cu.

Abdomen black, the hypopygium yellowish brown. Male hypopygium (Plate 2, fig. 16) with the basistyles, *b*, relatively short and stout, the dorsal lobe (not shown in figure) relatively small and stout, provided with setæ and delicate setulæ to the apex; ventromesal lobe very large, fleshy, conspicuously setiferous, a little constricted at base; ventrolateral region of the style produced into a long acicular spine, its base a little expanded. Outer dististyle, *d*, glabrous, very broadly dilated at base, soon narrowed into a flattened blade, in lateral aspect appearing to be a long acute spine; from what appears to be the basal portion of this style arises a smaller, nearly straight spine. Inner dististyle blackened, sinuous, the basal portion a little more enlarged, the apex provided with conspicuous spinous teeth, the apex acute. Ædeagus elongate. Ovipositor with the valves long and slender, the tergal valves blackened basally, the slender gently upcurved tips pale horn yellow; sternal valves long and straight.

Habitat.—Formosa.

Holotype, male, Noko, altitude 7,000 to 9,000 feet, June 26, 1927 (*S. Issiki*). Allotopotype, female, altitude 8,000 feet, June 26, 1927. Paratopotype, 2 males, with the allotype.

MOLOPHILUS ISSIKII sp. nov.

Belongs to the *Molophilus gracilis* group and subgroup; general coloration dark brownish gray; antennæ short, dark brown; halteres yellow; wings with a yellowish brown tinge; vein 2d A moderately elongate; abdomen, with hypopygium, black; male hypopygium with the dorsal lobe of the basistyle very much reduced, two ventral lobes, the outer a slender flattened spine; both dististyles acute at tips.

Male.—Length, about 4.2 millimeters; wing, 5.2.

Rostrum and palpi black. Antennæ dark brown throughout, relatively short, if bent backward scarcely attaining the wing root; flagellar segments oval with long conspicuous verticils. Head dark brownish gray.

Mesonotum dark brownish gray, clearer gray on the scutellum and postnotum; anterior lateral pretergites whitish; pseudosutural foveæ blackened. Pleura plumbeous black. Halteres yellow, the central portion of the stem a trifle darker, the elongate knobs brightening into citron yellow. Legs with the coxæ and trochanters testaceous yellow; femora dark brown, the bases obscure yellow; tibiæ and tarsi dark brown. Wings with a faint yellowish brown tinge, the base clearer yellow; veins pale brown, the abundant macrotrichiæ darker brown. Venation: R_{2+3} gently arcuated, longer than R_{4+5}; petiole of the deep cell M_3 a little more than twice m-cu; vein 2d A relatively long but nearly straight beyond the basal fourth, extending to about opposite one-fourth the length of the second section of M_{3+4}.

Abdomen, including the hypopygium, blackened. Male hypopygium (Plate 2, fig. 17) with the basistyle, *b*, unusually large; dorsal margin not produced into a lobe, appearing merely as a low yellow ridge, the margin crenulate (not shown in figure); ventromesal lobe relatively small, with comparatively few long setæ and numerous microscopic setulæ; ventrolateral region of the style produced caudad into a slender, gently sinuous flattened blade, the tip acute, the surface microscopically roughened; between these two ventral lobes of the basistyle a powerful, strongly curved, black rod; mesal lobe of basistyle larger than the ventromesal, with more delicate setæ. Outer dististyle a glabrous structure, strongly curved into an elongate spinous tip. Inner dististyle, *d*, approximately as long, less strongly curved, gradually narrowed into a long spine, the surface with rather numerous punctures. Ædeagus relatively small.

Habitat.—Formosa.

Holotype, male Noko, altitude 9,800 feet, June 26, 1927 (*S. Issiki*).

This very distinct species of *Monophilus* is named in honor of the collector, Prof. Syuti T. Issiki, distinguished student of the Mecoptera of eastern Asia.

MOLOPHILUS EDITUS sp. nov.

General coloration of mesonotum plumbeous brown, the anterior part of the præscutum castaneous; pleura testaceous yellow, especially the sternopleurite; antennæ black; halteres dark brown; wings with a brownish suffusion; vein 2d A short.

Female.—Length, about 4 millimeters; wing, 4.4 to 4.5.

Rostrum and palpi brownish black. Antennæ black throughout; flagellar segments truncate-oval to subcylindrical, with verticils that exceed the segments. Head dark plumbeous gray.

Mesonotum posteriorly pale brown, with plumbeous reflections, the præscutum in front brightening into castaneous, this including the broad lateral margins, the humeral triangles, and the cephalic portion of the sclerite. Pleura testaceous yellow, the posterior sclerites a little more plumbeous. Halteres dark brown. Legs with the coxæ yellowish testaceous;

trochanters yellow; remainder of legs passing into dark brown, the femoral bases a little paler. Wings with a brownish suffusion, the base and costal region more yellowish; veins brown, more yellowish in the flavous areas above described; macrotrichiæ rather bright brown. Venation: R_2 lying shortly proximad of the level of the basal section of R_5; m-cu oblique in position, a little less than one-half the petiole of cell M_3; vein 2d A short, ending about opposite the caudal end of m-cu.

Abdominal tergites dark brown, the sternites more yellowish brown. Ovipositor with the valves long and slender, the tergal valves gently upcurved to the acute tips, the sternal valves a trifle stouter, straight.

Habitat.—Formosa.

Holotype, female, Noko, altitude 8,000 feet, June 26, 1927 (*S. Issiki*). Paratopotype, female.

Molophilus editus is distinguished from the other Formosan species of the genus by the combination of thoracic coloration, dark antennæ and halteres, and uniformly unfumed wings.

ORMOSIA DIPLOTERGATA sp. nov.

General coloration of thorax light reddish brown, the præscutum unmarked; antennæ (male) short; halteres light yellow; legs obscure yellow, clothed with dark setæ, the outer segments brown; wings pale brown, the stigma dark brown; cell 1st M_2 open by the atrophy of the basal section of M_3; vein 2d A elongate, sinuous; male hypopygium with the gonapophyses hairy; ninth tergite appearing as two superimposed flattened plates.

Male.—Length, about 3.6 millimeters; wing, 4.5.

Rostrum and palpi dark brown. Antennæ short, dark brown, the scapal segments a little paler; flagellar segments oval with long conspicuous verticils. Head brownish gray, with long yellow setæ.

Pronotum and mesonotum light reddish brown, the anterior lateral pretergites more yellowish; posterior sclerites of the notum a little more plumbeous. Pleura slightly plumbeous. Halteres light yellow. Legs with the coxæ obscure yellow; trochanters yellow; remainder of legs obscure yellow, with dark setæ, the outer segments passing into brown. Wings with a faint brown tinge, the conspicuous stigma dark brown; veins brown. Venation (Plate 1, fig. 18): Cell M_2 open by the atrophy of the basal section of M_3; m-cu at the fork of M;

vein 2d A elongate, sinuous, the cell narrowed just before the outer end.

Abdomen brown, the hypopygium somewhat brighter, yellowish brown. Male hypopygium (Plate 2, fig. 18) with the ninth tergite appearing double, there being two depressed median plates, one lying immediately above the other. Dististyle two, the outer very small, appearing as a gently curved structure, the outer surface somewhat squamose. Inner dististyle, *d*, much larger, pale, shaped as in the figure. Gonapophyses, *g*, two on either side, the larger pair appearing as flattened hairy structures that terminate in a long black spine; second pair of apophyses appearing as a slender black spine on either side.

Habitat.—Formosa.

Holotype, male, Higashinoko, altitude 7,500 feet, June 27, 1927 (*S. Issiki*).

ILLUSTRATIONS

[Legend; *a*, ædeagus; *b*, basistyle; *d*, dististyle; *g*, gonapophysis; *i*, interbase; *p*, phallosome: R_{1+2}, $Radius_{1+2}$; *s*, 9th sternite; Sc_1, Sc_2, Subcosta; *t*, 9th tergite. Venational terminology used, Comstock-Needham-Tillyard, the radial field as modified by Alexander. Hypopygial terminology used, Crampton.]

PLATE 1

FIG. 1. *Paracladura cuneata* sp. nov., venation.
2. *Nesopeza trichopyga* sp. nov., venation.
3. *Nesopeza taiwania* Alexander, venation.
4. *Tipula sparsissima* sp. nov., venation.
5. *Tricyphona orophila* sp. nov., venation.
6. *Rhaphidolabis atripes* sp. nov., venation.
7. *Orimarga pruinosa* sp. nov., venation.
8. *Pseudolimnophila nokonis* sp. nov., venation.
9. *Limnophila (Tricholimnophila) excelsa* sp. nov., venation.
10. *Limnophila (Prionolabis) oritropha* sp. nov., venation.
11. *Eriocera issikii* sp. nov., venation.
12. *Elephantomyia luculenta* sp. nov., venation.
13. *Gnophomyia laterospinosa* sp. nov., venation.
14. *Gonomyia (Ptilostena) pallens* sp. nov., venation.
15. *Gonomyia (Lipophleps) ptilostenoides* sp. nov., venation.
16. *Gonomyia (Gonomyia) gilvipennis* sp. nov., venation.
17. *Dasymolophilus nokoensis* sp. nov., venation.
18. *Ormosia diplotergata* sp. nov., venation.

PLATE 2

FIG. 1. *Paracladura cuneata* sp. nov., male hypopygium.
2. *Nesopeza trichopyga* sp. nov., male hypopygium, lateral.
3. *Nesopeza trichopyga* sp. nov., base of antenna.
4. *Nesopeza taiwania* Alexander, base of antenna.
5. *Tipula lackschewitziana* sp. nov.. male hypopygium, lateral; 5*a*, outer dististyle of male hypopygium, caudal.
6. *Tipula nokonis* sp. nov., male hypopygium, lateral.
7. *Tipula nokonis* sp. nov., ninth tergite, dorsal.
8. *Tipula sparsissima* sp. nov., male hypopygium, lateral.
9. *Tricyphona orophila* sp. nov., male hypopygium.
10. *Rhaphidolabis atripes* sp. nov., male hypopygium.
11. *Limnophila (Prionolabis) oritropha* sp. nov., male hypopygium.
12. *Gnophomyia laterospinosa* sp. nov., male hypopygium.
13. *Gonomyia (Ptilostena) pallens* sp. nov., male hypopygium.
14. *Gonomyia (Gonomyia) gilvipennis* sp. nov., male hypopygium.
15. *Molophilus nigripes* Edwards, male hypopygium.
16. *Molophilus nokonis* sp. nov., male hypopygium.
17. *Molophilus issikii* sp. nov., male hypopygium.
18. *Ormosia diplotergata* sp. nov., male hypopygium.

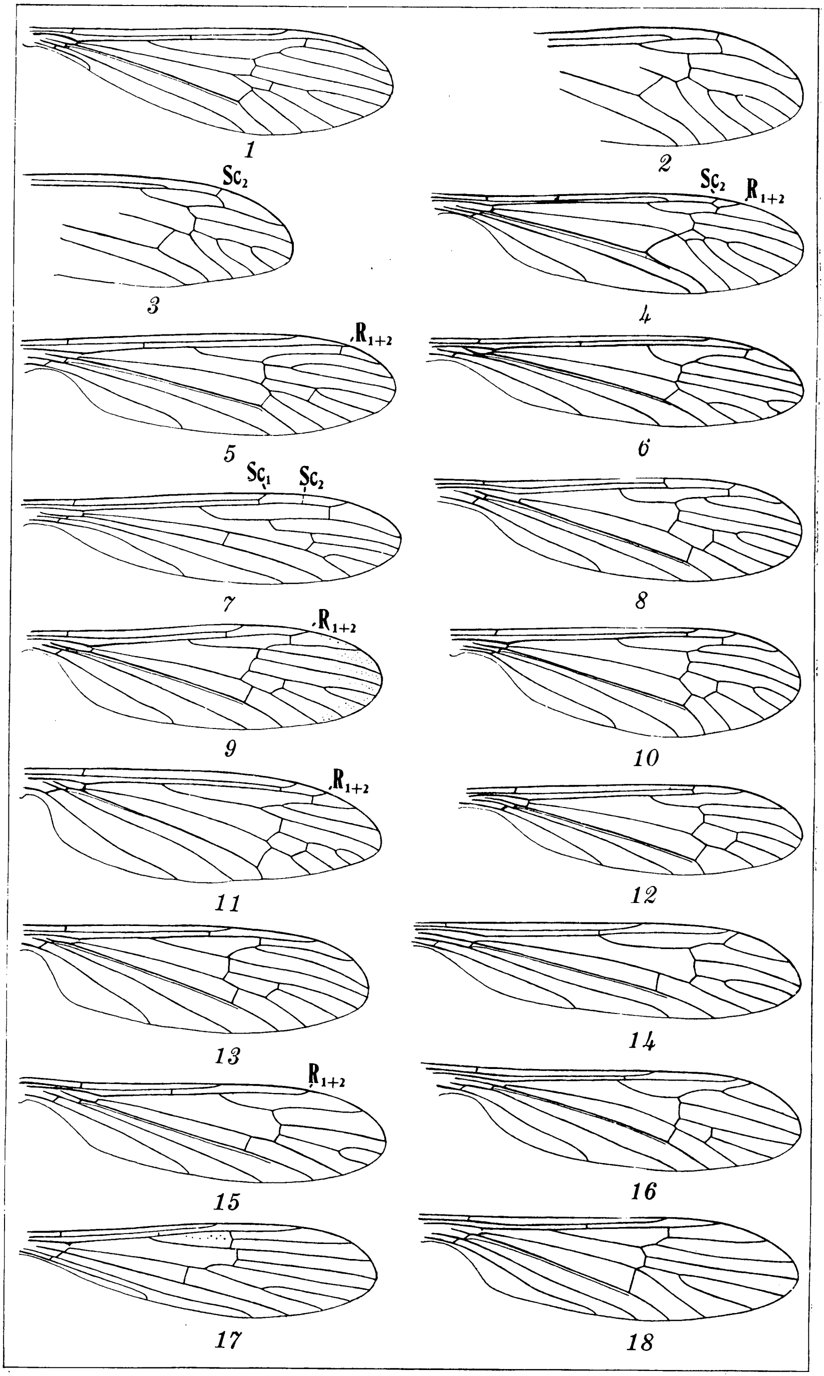

1
2
Sc_2
3
Sc_2
R_{1+2}
4
R_{1+2}
5
6
Sc_1
Sc_2
7
8
R_{1+2}
9
10
R_{1+2}
11
12
13
14
R_{1+2}
15
16
17
18

PLATE 1.

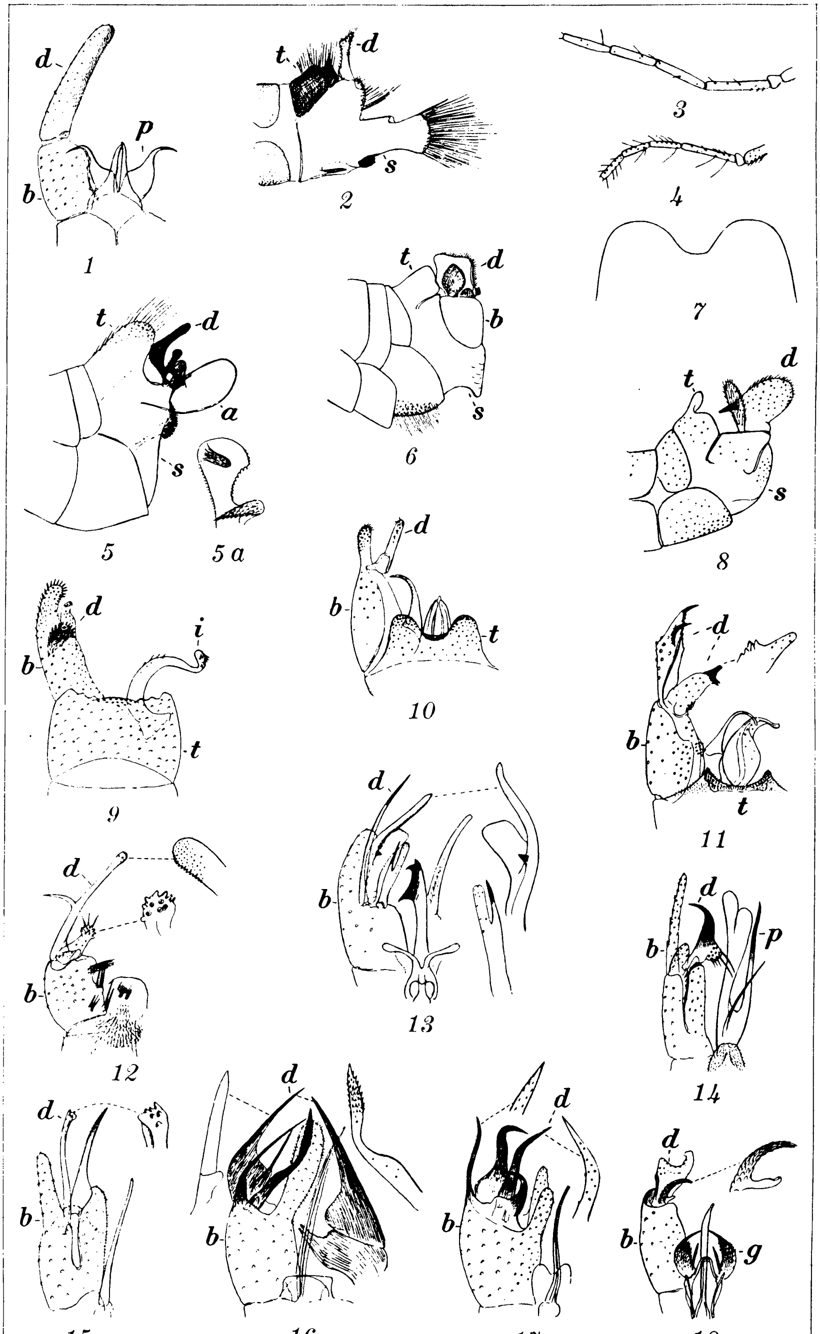

d
p
b
1
t
d
s
2
3
4
t
d
a
s
5
5a
t
d
b
s
6
7
d
t
s
8
d
i
b
t
9
d
b
t
10
d
b
t
11
d
b
12
d
b
13
d
b
p
14
d
b
15
d
b
16
d
b
17
d
b
g
18

PLATE 2.

ERRATA

Page 80, in the tenth line from the bottom, for *F. pictipes* sp. nov. read *F. picticeps* sp. nov.

Page 244, in the thirteenth and fourteenth lines from the top, for *Ehinodiscus auritus,* read *Echinodiscus auritus.*

INDEX

[New names and new combinations are printed in **boldface**.]

C

D

M

Q

R

U

VOL. 36, NO. 4 AUGUST, 1928

THE PHILIPPINE JOURNAL OF SCIENCE

MANILA
BUREAU OF PRINTING
1928

286553

THE PHILIPPINE JOURNAL OF SCIENCE

Published by the Bureau of Science of the Government of the Philippine Islands

---

Manuscript intended for publication should be sent to the editor. One hundred separates of each paper published in the Journal are furnished to the author without charge. Additional copies may be had at the author's expense if ordered when the manuscript is submitted for publication.

Publications sent in exchange for the Philippine Journal of Science should be addressed: Library, Bureau of Science, Manila, P. I.

The Journal is issued twelve times a year. The subscription price is 5 dollars, United States currency, per year. Single numbers, 50 cents each.

Subscriptions may be sent to the BUSINESS MANAGER, Philippine Journal of Science, Bureau of Science, Manila, P. I., or to any of the agents listed on the third page of this cover.

CONTENTS

The Philippine Journal of Science is issued twelve times a year. The sections were discontinued with the completion of Volume XIII (1918).

Yearly subscription, beginning with Volume XIV, 5 dollars United States currency. Single numbers, 50 cents each.

Publications sent in exchange for the Philippine Journal of Science should be addressed: Library, Bureau of Science, Manila, P. I.

Subscriptions may be sent to the BUSINESS MANAGER, Philippine Journal of Science, Bureau of Science, Manila, P. I., or to any of the agents listed on the third page of this cover.

Entered at the post office at Manila, P. I., as second-class matter.