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35

BRITISH TYROGLYPHIDÆ.

BY

ALBERT D. MICHAEL,

F.L.S., F.Z S, F.R.M.S., ETC.

VOLUME I.

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PREFACE.

THIS work must be considered as a companion to my 'British Oribatidæ,' published by the Ray Society as their volumes for 1883 and 1887, but it must not be concluded from this that I am going to continue the series so as to include the other families of Acarina. Life is short and science is long; the few years which I may have before me would be utterly insufficient for such a task.

With the Tyroglyphidæ, as with the Oribatidæ, I have been forced to rely almost entirely upon my own collecting for the British species; for there practically are not any records to help me; a few scattered notices of individual species, and that is all. Therefore I cannot rely upon this book containing every species which exists in Britain; still, as the number of known species from anywhere is small, and as this book will be found to contain a large proportion of them, I think that I may fairly hope that the omissions from it are not numerous. Perhaps I have the better ground for this hope, as the absence of records of new British Oribatidæ since the date of my work on that group would appear as if the collecting for it had been fairly exhaustive.

The Tyroglyphidæ make up for the paucity of their species by the enormous number of individuals and their wide distribution. Feeding chiefly upon the very articles which man requires to supply his commonest wants, they are carried with their food practically all over the civilised world; only a comparatively small number of species have modes of life unsuited to wide distribution.

Once more my principal thanks for assistance in the investigations recorded in this work are due to my wife, who has shared in all of them; and whose skilful hand in minute dissection and in microscopical preparation, and in the rearing of minute living Acari, has more or less defied the years which have passed over our heads; and has often attained success when I should probably have failed without her help. I have also to record my thanks to my late cousin, Mr. M. J. Michael, of the Davos Platz, for unwearied assistance in cutting serial sections of these minute creatures, in which he was remarkably accomplished. I have to record my indebtedness to Mr. E. Bostock, of Tixall, Mr. C. F. George, of Kirton Lindsey, and Mr. F. Enock, for aid in collecting specimens; to Mr. H. Waddington, of Bournemouth, for assistance in obtaining those chemicals upon which some of the Tyroglyphidæ like to feed; to Mr. Sherborne, of the British Museum, for help as to the exact dates of the various parts of some of the more difficult foreign publications which I required for the purposes of completing bibliography or settling priorities; and to almost all the foreign acarologists for the kindness with which they have kept me supplied with reprints of their writings.

The abbreviations of the names of periodical publications and other literature used in the notes and synonymy of this book are, as far as possible, those of the Zoological Record; but there are a few books and papers which are so constantly referred to that I have thought it best to adopt extremely short abbreviations for them; a list of these with the full title of each paper and where it may be found follows this Preface. A bibliography, together with a list of known foreign species and a full index, will be given at the end of Vol. II.

ALBERT D. MICHAEL.

CADOGAN MANSIONS,
SLOANE SQUARE, LONDON.
November 1*st*, 1901.

ABBREVIATIONS

Used in this work of the names of books and papers frequently quoted.

Berlese, A. M. S.

Berlese, Antonio. 'Acari Myriapoda et Scorpiones hujusque in Italia reperta (Acari Miriapodi e Scorpioni italiani).' Being published in fasciculi. First part issued in 1882, not yet complete. First parts published at Padua, later parts at Florence, last parts at Portici near Naples.

Berlese, A. M. S. Crypt.

The same work. "Ordo Cryptostigmata," Portici, 1897, being a separate introduction to the part of the work referring to the Sarcoptidæ, Tyroglyphidæ, etc.

Can., I Tiro.

Canestrini, G. 'I Tiroglifidi: Studio critico,' Padua, 1888.

Can., Pros.

Canestrini, G. 'Prospetto dell' Acarofauna italiana,' Padua, 1885—99. 'Tyroglyphidæ,' vol. iii, 1888.

Fumouze and Robin, Mem. Acar.

Fumouze, A., et Robin, C. "Sur les Acariens des genres *Cheyletus*, *Glyciphagus*, et *Tyroglyphus*," in 'J. Anat. Physiol.,' 1867, An. 4me, pp. 505—528, 561—601, pls. xxii—xxv.

Fumouze and Robin, Recherches.

Foumouze, A., et Robin, C. "Recherches Zoologiques et Anatomiques sur les Glyciphages a poils palmés ou plumeux," in 'J. Anat. Physiol.,' 1868, An. 5me, pp. 66—92, pls. vii—xi.

Haller, Zur Kenntniss.

Haller, G. "Zur Kenntniss der Tyroglyphen und Verwandten," in 'Z. wiss. Zool.,' Bd. xxxiv (1880), pp. 255—295.

Hering, die Kratzmilben.

Hering. "Die Kräzmilben der Thiere und einige verwandte Arten." 1838, in 'N. Acta Ac. Leop.,' Bd. xviii, ii, p. 618.

Koch, D. C.

Koch, C. L. "Deutschlands Crustaceen Miriapoden und Arachniden," Regensburg, 1835—1844; also forming 40 Hefte of Herrich-Schäfer's edition of Dr. G. W. F. Panzer's 'Deutschlands Insecten.'

Koch, Uebersi.

Koch, C. L. 'Uebersicht der Arachniden systems,' Nürnberg, 1837—1850, Heft 3.

Kramer, Thierreich.

Canestrini, G., and Kramer, P. "Demodicidæ und Sarcoptidæ," forming Lieferung 7 of 'Das Thierreich,' Berlin, 1899. 'Tyroglyphinæ,' pp. 132—150, by Kramer.

Monier, Notes.

Monier, R. "Notes sur quelques espèces de Tyroglyphides qui vivent aux dépens des matières alimentaires et des produits pharmaceutiques," in 'Rev. Biol. Nord, France,' 1894, t. vi, No. 12, pp. 442—460.

Nalepa.

Nalepa, A. "Die Anatomie der Tyroglyphen," in 'Sitzb. Akad. Wiss. Wien,' Abtheilung 1, 1884; in Bd. xc, Abtheil. 1, pp. 197—225; Abtheilung 2, 1885; in Bd. xcii, Abtheil. 1, pp. 116—167.

Oudemans' List.

Oudemans, A. C. "List of Dutch Acari," 7th part, 'Acaridiæ,' in 'Tijdschr. Ent.,' 1897, Deel xl, pp. 250—260.

μ in this book means "Micron," often called "micro-millimetre," which is the one thousandth part of a millimetre. μ is now ordinarily used in this sense in microscopy, zoology, and botany.

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BRITISH TYROGLYPHIDÆ.

CHAPTER I.

INTRODUCTORY.

The family of Acari, which forms the subject of this book, is a small one as regards number of species. The late Dr. Kramer in the great German work 'Das Tierreich,' only credits it with forty-seven well-established and seven doubtful known species in the whole world; he divides these into fifteen genera, and although this book will slightly add to the number, it will not do so materially. But, on the other hand, probably no other family of Arachnida contains such an immense number of individuals; many of the species swarm in such countless myriads where they do occur that the mind shrinks from any attempt to estimate their numbers even in a small space. In considering the number of species it must be borne in mind that the greater part of the world has not been searched for Acari at all, and particularly for such small and inconspicuous Acari as the Tyroglyphidæ; for although by no means the smallest creatures amongst the Acarina, they are unquestionably extremely small. One thirtieth of an inch in maximum length is a very large species, and only one species is known ever to exceed one twentieth of an inch; other measurements are proportionate, for they are not usually wide in comparison to their length.

Notwithstanding this small size they are not without importance and interest to man, for they are great destroyers of his property; their enormous numbers make up for their minuteness, and enable them to do an amount of damage not generally realised, and which would probably work out to rather surprising figures were it possible to collect statistics on the subject. The destruction which the ordinary cheese-mites, *Tyroglyphus siro* and *T. longior*, effect in cheese is a matter of common knowledge; but it is not so generally known that the same species, and many allied Acari, are almost equally abundant in, and injurious to, flour, hay, and numerous other dried vegetable products. Samples cut from hay-ricks have been sent me which, weight for weight, must have contained as large a quantity of the Acarus as of the hay; and the whole of the rick was in each case stated to be in the same condition, the pieces sent being fair samples; they came from first-class farms. The stores of dried vegetable and even animal drugs at wholesale druggists are very apt to get into a similar condition unless great care and watchfulness is exercised. Cantharides often swarms with Tyroglyphidæ to an extraordinary degree, and is liable to be destroyed by them; so is ergot of rye, and, indeed, most other drugs which consist of dried vegetable or animal matter. Some species, of which *Glycyphagus domesticus* is probably the principal, seem often to establish themselves in such articles as rush-covered chairs and tables, and to spread thence over the whole house in immense numbers; under these circumstances they are sometimes wonderfully difficult to extirpate, scarcely any amount of cleaning, white-washing, or fumigation seems to be effectual. They probably in these cases do not seriously damage the premises or the hard wood of the furniture; but their mere presence in such large quantities, and being found running over all domestic things, is a great annoyance to many, indeed to most people. A fair example of what frequently occurs in this respect is to be found in a communication to 'Science Gossip,' 1880, p. 262, which is as follows: "Would some reader kindly give me some information regarding the best means of eradicating from household furniture a mite which made its appearance a few months ago in myriads in a bedroom, and has now spread over the whole house? The furniture has been exposed to sulphurous acid fumes, saturated with solution of carbolic acid, corrosive sublimate, turpentine, acetic acid, etc., but although much reduced in numbers the family is still in a flourishing condition." The Tyroglyphidæ are probably often credited with injuries for which they are not really responsible; on the other hand *Aleurobius farinæ* is a considerable destroyer of grain and of stacked roots, such as turnips, mangels, etc., in the winter store, and probably does much more harm than it is credited with. *Rhizoglyphus echinopus* is a true root-eating creature, and is a great destroyer of bulbs and tubers, especially the former. It swarms on hyacinth and tulip bulbs, and has been supposed to specially favour Eucharis bulbs, but probably this is partly because that bulb is specially valued, and more notice is taken when it is destroyed than would be the case with a more abundant and cheaper bulb, and partly because the Eucharis bulb when it is injured seems to be specially liable to attacks of fungi on the cut surface, which turns orange and attracts attention; Rhizoglyphus prefers sound healthy bulbs to those in a state of decay. Dried fruits are often much injured by *Carpoglyphus anonymus* and other Tyroglyphidæ; the species named will follow the fruit into compounds which might be thought likely to be distasteful; thus it will thrive well upon confection of senna. Another strange habitat of this species, where it is said to do considerable damage, is inside the bottles which contain some of the southern French sweet wines; the Acari float on the top of the wine upon minute fragments which have become detached from the bottle cork.

The Tyroglyphidæ do not usually attack the foliage or green parts of living plants. Some species of the exceptional and singular genus *Histiostoma* do so to some extent, but they, in my opinion, are rather followers than causers of decay; although Méguin, their discoverer, did not take that view of the matter; they wade half immersed in the thin film of liquid which covers the surface of mushrooms and many other fleshy vegetable substances when in a state of incipient decay; which they probably hasten considerably by cutting the cells as they advance with alternate strokes of their serrated mandibles; which are different from those of any other genus in the family, and driving the stream of cell-contents into their mouths by regular beats of the flagella borne by their exceptional palpi; some of their species live in the exuded sap of forest trees, such as the elm, etc., in places where the bark has split. The members of the small genus *Hericia* have a similar habitat, but not by any means similar mouth organs; there is not any reason to suppose that either the one or the other does any substantial damage to the trees. *Histiogaster corticalis* is also found on succulent stems, but here, again, it is when they are dying that the acarus attacks them.

There are but few species of Tyroglyphidæ which are parasitic in the adult condition. *Glycyphagus* (*Dermacarus*) *sciurinus* may be looked upon as one; it is found adult in considerable numbers on the squirrel; but, as far as my own experience goes, in greater numbers in its nest. *Glycyphagus crameri*, *G. platygaster*, and *G. dispar* are all found in moles' nests, but I have not ever been able to find either of them in the adult condition on the mole itself; there is probably also a species associated with the nests of field mice, but little is known about it. The larvæ and ordinary nymphs are not any more parasitic than the adults; it is only in the hypopial stage, where there is one, that a sort of parasitism exists, but even there the Hypopus only seeks conveyance and transfer to fresh localities from its host; it does not seek nourishment from it nor live upon it permanently. If a Hypopus be parasitic upon its host, then a horseman is almost equally so upon his horse.

There is at least one species of Tyroglyphidæ which must be looked upon as a commensualist or mutualist; this is *Tyroglyphus Wasmanni;* which, up to the present time, has only been found in ants' nests.

If the species of Tyroglyphidæ be few they make up for it not only by the number of individuals, as before stated, but also by the immensely wide distribution of the principal species. Acari generally are apt to have but few local species compared to the number which extend over a very wide range, but the Tyroglyphidæ probably carry this further than almost any other family. It is difficult to say whether this is an original character or to what extent it is due to the fact that their chief habitat is in substances which are carried far and wide by man; wherever such products of civilisation as cheese, flour, grain, dried fruits, or drugs go, there the Tyroglyphidæ go with them, and spread from the centres which they thus reach. To such an extent is this wideness of range carried that a species which is abundant all over Central Europe was brought home by the Jackson-Harmsworth expedition from the Franz Joseph Archipelago, and the collector assured me that he obtained it from the talus far from camp; the same species is found far south. Probably if ever we know more of the Acari of tropical and southern countries the distribution will be found to be even wider than it is now known to be. The minute size of the creatures, and the difficulty of destroying their eggs and Hypopi doubtless greatly favour this extended range.

The Tyroglyphidæ are almost all soft-bodied creatures, the very few which have hardish, chitinised cuticle, such as *Chortoglyphus arcuatus*, being quite exceptional; they must be considered as amongst the simplest, and probably amongst the most primitive, of Acarine families as regards organization; they are without special breathing organs, they have not any heart such as is found in some Gamasidæ and Ixodidæ; they have not any eyes such as are found in Trombidiidæ, Hydrachnidæ, Ixodidæ, etc.; nor have they any other known organs of special sense except the palpi, which are far less highly developed than they are in many other families; the trophi are simple, the mandibles alone being highly developed; these are usually chelæ working perpendicularly, which is the commonest type among Acarina; the maxillary lip still shows its maxillary origin, although the maxillæ are probably not functional as such; the lingua is but slightly developed, and there is not usually any epipharynx, which is an important organ in Bdella and many other Acari; still most of the species are active creatures, which do not seem to suffer at all from the want of special sense organs or other deficiencies.

Probably to the biologist the most interesting point connected with the Tyroglyphidæ will be found to be the hypopial stage, which so greatly assists in the distribution and preservation of many of the species. This stage, as far as we know, has not any exact parallel in nature outside the Acarina; even amongst them, with one or two very doubtful exceptions, it is confined to the Tyroglyphidæ. A full account of this stage in the life-history, and of the opinions which acarologists have held concerning it from time to time, will be found in the chapter of this book on development and the immature stages.

The popular idea of the Tyroglyphidæ is based upon the common cheese-mites, *Tyroglyphus siro* and *T. longior*, of which the latter is found in even greater profusion than the former; they may properly be considered as fairly typical, and *T. siro* is most commonly received as the type by acarologists as well as others. It was one of Linnæus' very few species of Acari; but that eminent naturalist evidently confused it with the itch-mite; as, indeed, the name *siro* shows; but the itch-mites are really very different creatures, not Tyroglyphidæ at all, and considerable confusion has thus arisen. The species which we now call *T. siro*, whether it be Linnæus' original species or not, is well defined; probably the great Swedish author included many species under the one title. *T. siro* and *T. longior* are not usually regarded as particularly handsome or attractive species, nor are they entitled to be, although the latter is not without its beauty if prejudice be excluded; but such species as *Glycyphagus Canestrinii*, *G. plumiger*, *G. palmifer*, and many others, are amongst the most beautiful of Acari, and it is a very great mistake to imagine that Acari are not ever beautiful. A female *Glycyphagus Canestrinii*, well seen with dark-ground illumination and a sufficient amplification; its whole body surrounded by its peripheral row of great ostrich plume-like hairs, all shining like frosted silver, is a sight which will not readily be forgotten by any one possessed of any appreciation of beauty.

The popular name of "cheese-mites" is generally applied to the whole family; but is only really applicable to quite a few species, and even these are mostly found quite as often on other substances as on cheese.

The Tyroglyphidæ, like the Sarcoptidæ and Oribatidæ, have legs of five free joints; but unlike those families the tarsus is always terminated by a single claw, varying greatly in size in different species, either with or without a caroncle.

It may be mentioned that the Tyroglyphidæ, being minute creatures, mostly either white or without conspicuous colouring, and some of them being very active and constantly moving about and getting into unexpected places with great rapidity, and being carried by wind, water, and other agencies, are apt to be described by persons not well acquainted with this character of the family, and of some other groups of Acarina, as coming from places and in modes which are not correct, although supposed to be so. Thus Mr. Cross believed that he had created one species in his galvanic batteries, and Turpin and others agreed with him; not knowing that the species swarmed in houses generally: they have been described as brought up living from the depths of the sea, when in reality the dredge had picked them off the surface of the water where they were floating, or they had got on to the material brought in while it was being examined. Numerous other instances might be quoted; therefore, when extremely unlikely localities are quoted by persons who have not much knowledge of the habits and characteristics of the creatures, a certain amount of caution should be exercised before trusting in them implicitly.

CHAPTER II.

THE HISTORY OF LITERATURE RELATIVE TO THE TYROGLYPHIDÆ.

The literature relating to this family is rather voluminous, yet I believe it only contains five works which can be considered as in any way attempts to monograph the Tyroglyphidæ of any one or more countries. These, with one exception, are general works on the Acarina, or on still larger groups of animal life; three, viz. the under-mentioned works of Canestrini and Berlese, are in Italian and refer to the Italian species; the other two are in German. One of these, that by C. L. Koch, refers to the German species; the other, that by Kramer, in 'Das Tierreich,' refers to the Tyroglyphidæ of the world so far as they are known.

At the end of this book I propose to give a list of the bibliography which I trust will be found to include all, or most, of the books and papers published relative to the family which are likely to be useful to the student; but there are a good many which seem to me to call for a somewhat fuller notice than their mere names.

The system on which the literature is arranged in this chapter is that the authors are arranged in the chronological order of their respective earliest works on the subject; but when an author has been commenced with, the whole of his writings which are mentioned in this chapter are dealt with, although some of them may be later in date than the earliest work by the next author. Works which simply introduce one or two new species are not mentioned in this chapter, unless those species have become of special interest as having given rise to new genera, or otherwise.

The work of Dugès,* which was practically the commencement of the modern classification of Acarina, was a general classificatory paper, and has from that point of view already been dealt with at page 35 of my 'British Oribatidæ,' published by the Ray Society; as this is a continuation of the same series, I do not propose to repeat what I there said, but Dugès also devotes a short space to remarks upon each family. The Tyroglyphidæ occupy only four pages. He includes them and the Sarcoptidæ, in the restricted sense of that word (used as not including the Tyroglyphidæ), in one family under the name of Acarés, which he defines as Acari with caronculated feet, chelate mandibles, and palpi very difficult to see and adherent to the lip. He makes two genera only of Tyroglyphidæ, viz. (1) *Hypopus*, which is now known to be only a stage in the life-history, not a genus of adults; † and (2) *Acarus*, which therefore practically includes the whole of the Tyroglyphidæ. He does not describe any new species, only mentioning a few already described by de Geer, Hermann, and Lyonet; he, however, describes from personal observation what he considers to be the *Acarus domesticus* of de Geer, but it is very doubtful whether he really had that species under observation. He makes it the type of the genus (which equalled the family), perhaps overlooking the fact that a different type already existed. There are a few figures and a short description of the external anatomy; which however are not quite reliable, and there are a few observations on habits.

C. L. Koch was the next author whose works need be mentioned. His two works,‡ commenced in 1835,

* "Recherches sur l'ordre des Acariens," Troisieme mémoire, in 'Ann. Sci. Nat.,' ser. 2, t. ii (1834), pp. 37—42.

† See this book, Chapter VI, on Development and the Immature Stages.

‡ "Deutschlands Crustaceen Miriapoden und Arachniden, ein

must be treated as one; the 'Deutschlands Crustaceen,' etc., being wholly descriptions and figures of species; the 'Uebersicht,' although a separate work, is really the classificatory part of the other work, which was published in fasciculi of small loose leaves without any arrangement whatever. In 'British Oribatidæ,' page 21, I have already treated fully of the nature of Koch's works, therefore I shall do so very shortly here; they were general treatises, from a systematist's point of view, upon the whole of the Acarina. Each creature that Koch considered a species was described and figured in colour. Koch was an admirable collector, and a perfectly honest naturalist; he doubtless saw everything he figured, but the task was too vast for accuracy. The smallest difference of sex, age, or colour, even though given by the food last consumed, was sufficient to found a species upon. When it comes to classification most of his genera have stood by virtue of what later writers have selected as type species; but Koch had not a genius for classification, and his definitions of genera usually fail to convey any distinct ideas to the reader's mind. Except in unusually well-marked species identification by Koch's book is very difficult. Koch apparently paid less attention to the Tyroglyphidæ than to any other family of Acari which he knew of. He included all in the genus *Acarus* except two, which were hypopial nymphs. One of these he at first erroneously called a *Dermaleichus*, but in the 'Uebersicht' he included both in *Homopus*. It is now known that a *Homopus* is only one sort of hypopial nymph. Curiously enough Koch placed the so-called genera *Hypopus* and *Homopus* rather far apart; he placed his genus *Acarus* among the Sarcoptidæ, but said he thought it could not remain there permanently. Of the ten species remaining in Koch's work after removing the

Beitrag zur deutschen fauna," in 40 Hefts, Regensburg, 1835–44. Each heft was published simultaneously as one heft of Herrich-Schäffer's edition of Dr. G. W. F. Panzer's 'Deutschland's Insecten. Uebersicht der Arachnidensystems,' Nürnberg, 1837—1850 (in Hefte).

two hypopial nymphs, some species are not, I think, identifiable.

E. Hering was the next author. His paper* was lodged at the Academy on September 30th, 1835, but does not appear to have been published until 1838. It chiefly treats of the parasitic Sarcoptidæ, as its name implies, but it is interesting and necessary to the student of the Tyroglyphidæ as being that which originated the important genus Glycyphagus; it also contains a new species called *Acarus passularum*, which is somewhat similar to *anonymus*, upon which the genus Carpoglyphus was subsequently founded. In my opinion, however, the two species are not identical.

F. Dujardin, in 1849, is the next author who need be noticed. His paper † referred solely to the hypopial stage of the creatures. Dujardin saw that the creatures were immature, but he was entirely in error as to his principal contention; this, however, is fully discussed in the chapter of this book on development, and therefore need not occupy space here. Dujardin also described various Hypopi which he had found, and illustrated them with drawings as beautifully executed as those of that keen-eyed observer generally were; one of his creatures is evidently a homopial Hypopus.

A. Laboulbène, in 1852, published a short paper,‡ which was subsequently supplemented by a more elaborate one § written in conjunction with C. Robin. These papers are interesting, as the earlier is the first notice of any of the creatures forming the present genus Histiogaster,|| and also because *H. entomophagus* has

* "Die Kräzmilben von Thiere und einige verwandte Arten," in 'N. Acta Ac. Leop.,' vol. xviii, pt. ii, pp. 575—624.

† "Mémoire sur quelques Acariens sans bouche dont on a'fait le genre *Hypopus* et qui sont le premier age des Gamases," in 'Ann. Sci. Nat.,' 1849, ser. 3, t. xii, pp. 244—250. "Additions au memoire sur les *Hypopus*," ibid., pp. 259—265.

‡ "Description de l'*Acarus entomophagus*," in 'Ann. Soc. ent. France,' 1852, Bull., p. 54.

§ "Description de l'*Acarus* (*Tyroglyphus*) *entomophagus*, Laboulbène et Observations anatomiques sur le genre *Tyroglyphus*," in 'Ann. Soc. ent. France,' 1862, ser. 4, t. ii, pp. 317—338, pl. x.

|| Berlese (A. M. S. Crypt.) wishes to confine the genus *Histiogaster*

been supposed to be the great destroyer of dried insects in collections. I have reason to doubt the correctness of this view; that it will eat them if it has not any other suitable food is certain, but that it practically does much damage I am not by any means convinced of. I believe that a largish proportion of the sins laid to its charge are committed by other Acari or by insects. The joint paper contains considerable information upon the external but not any on the internal anatomy. It contains other interesting observations on Tyroglyphus, and is well illustrated.

H. A. Pagenstecher, in 1861, published a very short paper * on the anatomy of what he called *Tyroglyphus siro;* it really is not *T. siro*, but is *T. farinæ*—a very different species, now considered to form a distinct genus, *Aleurobius.* The paper will be dealt with in the chapter of this book on anatomy. It does not appear that Pagenstecher dissected the species (it was before the date of sections of Acari); he seems to have been satisfied with what he could see from the exterior by clearing the creature; consequently his internal anatomy appears to include a good many errors, but it is, as far as I know, all we have upon that of *Aleurobius.*

Dr. Gudden also, in 1861, wrote a paper † which, in 1863, he republished in an enlarged form. This remarkable paper was issued in a Würzburg medical journal, and its title did not indicate zoological studies; consequently it was missed by acarologists until a few years ago. This paper will be found fully referred to in the chapter on anatomy. Gudden wished to commence his medical paper on Scabies by an account of the external and internal anatomy of the Sarcoptes

to the single species *H. carpio*, Kramer, and to create another genus, *Monieziella*, for the remainder. I do not think that this is necessary.

* "Einiges zur Anatomie von *Tyroglyphus siro*," in 'Z. wiss. Zool.,' Bd. xi, pp. 12—14, pl. xiii.

† "Beitrag zur Lehre von der Scabies," 'Würzburger medicinische Zeitsch.,' 1861, p. 301; and 'Zweite vermehrte Auflage,' Würzburg, 1863.

which causes it, but before attacking such a very minute creature he thought he had better practise on something rather larger. He selected *Tyroglyphus siro*, and considering the means at his disposal, and the process he employed, his success is simply marvellous, his descriptions and drawings are admirable and extremely correct, and reflect the highest credit upon their author. A good portion of the anatomy consisted of entirely new discoveries, which others, myself included, have subsequently rediscovered, as we imagined, for the first time, having missed Gudden's paper. It is only the anatomy that affects the Tyroglyphidæ.

A. Fumouze and **C. Robin,** in 1867 and 1868, issued a series of papers * upon, *inter alia*, the genera *Glycyphagus* and *Tyroglyphus*, including what is now considered a separate genus, *Rhizoglyphus*. These papers probably have not ever been equalled by any writings on any group of the Acarina, either for the detail and accuracy of the description of external characters, or the beauty of the illustrations by Lackerbaüer which accompany them. They are constantly referred to in the systematic portion of this book. They contain much valuable information on points beyond mere descriptions, but not any internal anatomy.

C. Robin alone in the same year, 1868, published a paper † of the same character upon a new species of special interest, considered by the author to be a *Glycyphagus*, but now the type of the genus *Hericia*, and up to the publication of this book the sole representative of this genus.

E. Claparède, also in 1868, published his well-

* " Mémoire anatomique et Zoologique sur les Acariens des genres *Cheyletus Glyciphagus* et *Tyroglyphus*," in 'J. Anat. Physiol.,' 1867, pp. 568—599; 1868, pp. 66—92, and p. 287.

† 'Recherches sur une espèce nouvelle de sarcoptides du genre Glyciphage," 'Journ. Anat. Physiol.,' 1868, An. v, pp. 603—625, pls. 22—24.

known studies,* which are still one of the principal authorities, probably the most important one, upon the embryology of the Acarina. This paper contains (pp. 490—493) a short chapter upon the embryology of *Tyroglyphus siro*; it is far from being as exhaustive and careful as the author's studies of the embryology of the genus *Atax* (Hydrachnidæ) and some other Acari in the same paper, but it is almost the only observation we have upon the embryology of the Tyroglyphidæ; the essential parts of this study will be found abstracted in Chapter VI of this book. Claparède's study 4 in the same paper, occupying pp. 493—507, is headed " Die Gattung Hypopus Dugès als Mannchenform mancher Tyroglyphen." In this Claparède was entirely mistaken; this also will be referred to in the same chapter of this book under the head of " Hypopial Nymph." This portion of the paper originates the genus *Rhizoglyphus*, of which Claparède, and Fumouze and Robin were almost synchronous discoverers, and it deals somewhat with the embryology of this creature.

Donnadieu, also in 1868, published a paper on the genus *Trichodactylus* (Dufour). That genus was wholly founded upon hypopial nymphs, and has only hypopial characters. Donnadieu, and all other writers at that time, supposed them to be adults. Curiously enough Donnadieu carefully describes the coition of these creatures, which are immature and devoid of functional sexual organs. Nevertheless Donnadieu's is a useful and interesting paper, and well illustrated; it will be dealt with in this book in treating of the genus now known as *Trichotarsus*.

P. Mégnin, in 1873, published his first paper strictly upon the Tyroglyphidæ; he has been the author of a long series of admirable memoirs on the Acarina, only the more important ones which refer to the family treated of in this book are referred to here. The

* " Studien an Acariden," in 'Zeit. wiss. Zool.,' Bd. xviii, pp. 445—546, pls. xxx—xl.

first paper * was valuable, interesting, and beautifully illustrated. It introduced the creatures forming the present genus *Histiostoma*, and gave an exhaustive account of the external anatomy and singular habits of this exceptional genus (or sub-family); it also was the first paper which indicated (correctly) that *Hypopus* was a nymphal stage of some of the Tyroglyphidæ. It will be found frequently referred to in this work.

In the same year (1873) and the following year Mégnin published the three papers which contain the views he derived from his investigations into the life-history of Hypopus,† which were rewarded with special honours by the French Academy; they were papers of high importance, and greatly added to our knowledge of Hypopus. They were excellently illustrated, and introduced a new species of *Tyroglyphus*, which was admirably observed; still they were erroneous as to their principal contention relative to Hypopus. The whole of this question, with a summary of Mégnin's views, will be found in Chapter VI of this book, and therefore may be omitted here.

Some years afterward Mégnin returned to a somewhat kindred subject with regard to the genus *Glycyphagus*, although the relation between the result of his investigations and *Hypopus* does not appear to have struck him at the time. He published a short preliminary note in 1886,‡ and a rather fuller illustrated paper in 1888.§ These investigations overlapped my own simultaneous researches into the rudimentary

* "Mémoire anatomique et zoologique sur un nouvel Acarien de la famille des Sarcoptides, le *Tyroglyphus rostro-serratus* et sur son Hypopus," in 'Journ. Anat. Physiol.,' t. ix (1873), pp. 369—378, pls. x—xii.

† "Sur la position zoologique et la role des Acariens parasites connus sous les noms d'*Hypopus, Homopus*, et *Trichodactylus*," 'C. R. Ac. Sci.,' Paris, 1873, t. lxxvii, pp. 129—132, 2me note, ibid., pp. 492, 493; "Mémoire sur les Hypopes, Dugès," 'Journ. Anat. Physiol.,' 1874, t. x, pp. 225—244, pls. vii—x.

‡ "Nouvelle étude anatomique et physiologique sur les Glyciphages," in 'C. R. Ac. Sci.,' t. ciii (1886), pp. 1276-8.

§ "Observations anatomiques et physiologiques sur les *Glyciphagus cursor* et *spinipes*," in 'Journ. Anat. Physiol.,' 1888, pp. 106—110.

hypopial stage in the genus *Glycyphagus*. This subject also is fully dealt with in the chapter on development, so that only the names of Mégnin's highly interesting papers are given here.

Dr. P. Kramer, of Magdeburg, who has contributed so largely to our knowledge of the Acarina, wrote his first paper which need be mentioned here in 1876;* it was a collection of various short studies, many of them very interesting, upon the Acarina. It contained the first attempt to form a separate genus to receive the creatures now known as *Histiostoma*. Kramer, however, in this paper called the genus *Phyllostoma*, a name which was pre-occupied, and which he subsequently altered to *Histiostoma*. Kramer apparently at the time supposed himself to be not only the founder of the new genus, but also the discoverer of the creature, having overlooked Mégnin's prior paper above referred to. Kramer in this paper also makes a useful comparison of the mouth-parts of his new genus with those of *Cheyletus*, *Tyroglyphus*, and other Acarina; he also criticises Claparède's contention that *Hypopus* was the male of *Tyroglyphus*, and correctly concludes that the contention was erroneous.

In 1880 Kramer published a paper† the name of which implied that it was upon the immature stages of *Glycyphagus*. The paper contains useful information relative to the coition and larval and nymphal development of the creature which the author was observing; but that creature was not really a *Glycyphagus*, and was not ever considered to be one by any other writer known to me; it was the Acarus now known as *Carpoglyphus anonymus*. Kramer was not quite right as to the mode of coition, and had apparently not seen my own paper of the previous year, in which the mode of coition in *Glycyphagus* is correctly given.

* "Zur Naturgeschichte der Milben" in 'Arch. Naturg.,' Heft 1, p. 36.

† "Ueber die post-embryonale Entwicklung bei der Milbengattung Glyciphagus," in 'Arch. Naturg.,' 1880, pp. 102—110.

In 1882 Kramer wrote a paper * upon an Acarus which he had discovered, and which he called *Tyroglyphus carpio.* This creature is of interest as being the type upon which the genus *Histiogaster* was subsequently founded; although that genus, as ordinarily defined, includes Laboulbène's long previously described species, *H. entomophagus.* Berlese, however, considers *H. carpio* as the only species of the genus *Histiogaster*, and forms a new genus, Monieziella, to receive the other species. I agree with Kramer in his latest work, where he considers Berlese's genus unnecessary.

In 1899 Lieferung 7 of the great German work 'Das Tierreich' was published; the part was devoted to the Demodicidæ and Sarcoptidæ. The Tyroglyphidæ are included, being treated as a sub-family of the Sarcoptidæ. This portion was the work of Dr. Kramer, although the whole part bears the joint names of Professor Canestrini and Dr. Kramer. According to the scheme of 'Das Tierreich' the Tyroglyphidæ of the world are dealt with, and a short description is given of every recorded species believed by the author to be a good one. It does not contain any illustrations of species. It is unnecessary to say that this is an extremely useful and valuable work, although it contains several things which I am not able to agree with, as will be seen in the course of this work, some of which possibly Dr. Kramer might have reconsidered had not the work been written so shortly before his death. It does not contain anything relative to the internal anatomy, habits, etc., the scope of the book being purely systematic.

P. Troupeau, in 1878, published a paper † on the Acari found in flour, which contained an account of some new species and some observations of general interest.

* "Ueber *Tyroglyphus carpio* eine neue art der Gattung *Tyroglyphus*, Latr.," in 'Arch. Naturg.,' 1882, pp. 183—186.

† "Les Acariens de la farine," in 'Bull. Soc. Angers,' t. vi and vii, p. 105.

A. D. Michael.—In 1879 the first of my own papers containing matter relative to the Tyroglyphidæ appeared.* This was a short and somewhat popular paper dealing chiefly with facts already known, but it is of some importance as being the first time when it was pointed out that the posterior projection of the female *Glycyphagus* was a bursa copulatrix, a fact which I had discovered from actual observation.

In 1884 a paper of my own appeared,† dealing with the vexed question of what a Hypopus really is, and the circumstances and conditions which favoured or discouraged its production. The paper was the result of a long series of observations of Tyroglyphidæ, both in confinement and in their natural habitats. I believe that it is now generally admitted that the conclusions arrived at are correct. The hypopial stage is probably the most interesting thing connected with the Tyroglyphidæ, being quite exceptional in nature; therefore it is necessary that the facts recorded in this paper should be fully stated in the chapter of this work relative to the immature stages, for which reason it is not necessary to occupy space here by abstracting it.

In 1885 appeared another paper of my own ‡ upon *Histiogaster corticalis*. In it the life-history of the species which had not been known previously is worked out, and a certain confusion of species I had hoped made clear; but some subsequent writers have continued the old errors, which will be again explained in this book when treating of the species. The paper also contains a further contribution to the literature of Hypopus, being chiefly further proofs of the correctness of the last-mentioned paper; also a description of the Hypopus of *Rhizoglyphus echinopus* (*Robini*).

* "On some Peculiarities in the Reproductive System of certain of the Acarina," in 'J. Quekett Club,' 1879, vol. v, pp. 223—230.

† "The Hypopus Question, or the Life-history of certain Acarina," in 'J. Linn. Soc., Zool.,' vol. xvii, pp. 371—394.

‡ "Notes on the Life-history of some little-known Tyroglyphidæ," in 'J. R. Micr. Soc.,' ser. 2, vol. v, pp. 19—32.

In 1886 two papers appeared * relative to three very remarkable species of *Glycyphagus*, viz. *G. platygaster* and *G. dispar*, which were previously unknown, and *G. Crameri*, of which only the hypopial nymph was previously known. These three species were all inhabitants of moles' nests; without, apparently, being parasitic upon the mole; except that *G. Crameri* in the hypopial stage utilises the mole as a means of conveyance, in the same way as other Hypopi do other creatures. The principal contents of these papers will be found incorporated with this book under the heads of the respective species.

In January, 1889, was published a paper (read in May, 1888) † in which for the first time the rudimentary hypopial stages of the ordinary species of Glycyphagus, such as *G. spinipes* and *G. domesticus*, were recorded as the result of somewhat lengthy investigations into the life-histories. The subject is interesting, these being the only rudimentary hypopial stages known.

In 1893 the last of my papers on any of the Tyroglyphidæ appeared.‡ This paper instituted the genus *Lentungula*, now the sole genus of a sub-family. The few creatures composing it are the only known marine or brackish-water species of the Tyroglyphidæ, and are quite exceptional in the formation of the ambulacra of the anterior legs.

Dr. G. Haller, in 1880, published his only paper which need be noticed here,§ although others from his pen will be found in the bibliography, and although

* "On some Undescribed Acari of the genus Glyciphagus found in Moles' Nests," in 'Journ. Linn. Soc., Zool.,' vol. xix, pp. 269—284. "Upon the Life-history of an Acarus, one stage whereof is known as *Labidophorus talpæ*, Kramer," 'J. R. Micr. Soc.,' ser. 2, vol. vi, pp. 377—390.

† "Researches into the Life-histories of *Glyciphagus domesticus* and *G. spinipes*," in 'Journ. Linn. Soc., Zool.,' vol. xx, pp. 285—298.

‡ "On a New Genus and Species of Acari found in Cornwall," in 'P. Zool. Soc. London,' March, 1893, pp. 262—267.

§ "Zur Kenntniss der Tyroglyphen und Verwandten," 'Z. wiss. Zool.,' Bd. xxxiv, pp. 255.

he was a frequent and valuable contributor to our knowledge of various families of the Acarina. This paper contains descriptions of *Glycyphagus* (*Dermacarus*) *sciurinus* in all its stages, only the hypopial nymph having been known previously, and gives its life-history; it also founds the genus *Dermacarus* for the reception of this species and others having homopial hypopi. It will be seen that I have not retained this genus in this work, although I point out that it may possibly be desirable to revive it some day if further investigation should reveal certain facts at present unknown. Haller in this paper also devotes some space to what he considered a new species, and called *Tyroglyphus Megninii;* this, however, was in reality only *Rhizoglyphus echinopus*, a very variable species. He also describes as new a species which he calls *Tyroglyphus setiferus*. Berlese is of opinion that this is really *T. longior*. Haller also deals more or less with homopial Hypopi in general, and with the eggs of Acari, particularly Tyroglyphus and Dermacarus; furthermore, he devotes considerable space to the internal anatomy of these two genera. This portion of the paper is far from complete, and in some respects is not as correct as Gudden's much earlier paper, which is referred to above; still it is very useful, and is an honest attempt to deal with the anatomy. Haller, doubtless, was not aware of Gudden's paper.

Prof. A. Berlese, in 1883, commenced his great work on the Italian Acari, etc.,* which has been in course of publication in parts ever since; it is still unfinished, but the portion relative to the Tyroglyphidæ is complete. This publication is almost entirely classificatory, and contains coloured illustrations of the species; each order (as it is called) has a summary and indexing part. That on the Sarcoptidæ,† including the Tyro-

* "Acari Miriapodi e Scorpioni Italiani," Florence and Portici, 1883—1897.

† "Ditto, Ordo cryptostigmata," Portici, 1897.

glyphidæ, gives some very short remarks on the external anatomy and biology, but not any internal anatomy. The work is unquestionably one of the most important existing upon the Acari, and is indispensable to every acarologist.

Dr. A. Nalepa, in 1884, 1885, wrote a paper,* which is far the most important that we possess on the anatomy of the Tyroglyphidæ; it will be found constantly referred to in Chapter V of this book on the anatomy of the family. The first part of Nalepa's paper is almost entirely upon the anatomy of *Tyroglyphus longior*, the second part upon that of *Carpoglyphus anonymus*. Modern methods of section cutting, etc., were employed in the investigation, and the whole paper is excellent and sufficiently illustrated.

Prof. G. Canestrini, in 1888, published two important treatises on the Italian Tyroglyphidæ.† The first was a separate work, the second a portion of the author's general work on the Italian Acari. To say that these are by Prof. Canestrini is equivalent to saying that they are highly valuable; no student of the family could safely dispense with them. The volume of the general work appeared after the special work, and is necessarily greatly a repetition of it, but not entirely so. Both are chiefly classificatory, but some highly interesting biological observations are added; there practically is not any internal anatomy.

The two last-named authors, **Canestrini** and **Berlese,** in 1885 wrote a joint paper,‡ in which they made known the adult form of *Trichotarsus xylocopæ*. Only the hypopial nymphs of this genus had been known previously, and in consequence of the very considerable differences between them and other hypopi it had been

* "Die Anatomie der Tyroglyphen," Abtheilung i, in 'S. B. Ak. Wien,' Bd. xc, Abth. i (1884), pp. 1—32; Abth. ii (1885); ibid., Bd. xcii, Abth. i, pp. 116—167.

† "I Tiroglifidi Studio critico," Padova, 1888, 'Prospetto dell' acarofauna italiana," vol. iii, Padova, 1888.

‡ "Nota intorno a due Acari poco conosciuti," in 'Atti. Soc. Veneto-Trent,' vol. ix, fasc. 2, pp. 206—208.

doubtful whether they were Hypopi or adults. This interesting point was entirely cleared up by the observations of the two Italian acarologists.

Prof. R. Monier, in 1892, published a paper upon the results of Wasmann's collection of Acari and Thysanuridæ in ants' nests.* It is interesting for the purposes of the present work as being the first announcement of *Tyroglyphus Wasmanni*, the only species of the family at present known which appears to be a true inhabitant of ants' nests, where it increases to an amazing extent, the hypopial nymphs almost smothering the ants. There is an error in the paper as to the Hypopus, which was attributed to a different species; this error was subsequently cleared up.

In the same year Monier published another paper,† which was upon the life history of Mégnin's *Tyroglyphus mycophagus*, which was carefully worked out; the paper also states the author's observations upon the nature and development of Hypopus, in which he practically repeated my own investigations on the subject, but employing a different species for observation, and arrived at a similar conclusion.

In 1894 Monier contributed another important paper to the literature of the Tyroglyphidæ; ‡ it was a general paper upon those species found on food and drugs. The paper contains much interesting information as to habitats, habits, etc., and will be found frequently quoted in this book.

J. Ligniere, in 1893, published a paper upon what he called *Tyroglyphus malus.*§ This paper contains a considerable amount of useful biological observations,

* "Mèmoire sur quelques Acariens et Thysanoures parasites ou commenseaux des fourmis," in 'Rev. biol. Nord. France,' t. iv, No. 10, pp. 387–9.

† "Contribution à l'histoire naturelle du *Tyroglyphus mycophagus*," 'Mèm. Soc. Zool. France.,' t. v, pp. 584—601.

‡ "Notes sur quelques espèces de Tyroglyphides qui vivent aux dépens des matières alimentaires et des produits pharmaceutiques," in 'Rev. Biol. Nord. France, vol. vi, No. 12, pp. 442—460.

§ "Etude zoologique et anatomique du *Tyroglyphus malus* et de sa nymphe hypopial," in 'Mèm. Soc. Zool. France,' t. vi, pp. 5—15.

and some slightish details of the external anatomy; it is sufficiently illustrated by outline drawings. It gives a rather full description of what is said to be the hypopial nymph, which the author correctly treats as unknown up to that time. Unfortunately the paper is seriously injured by the author's almost complete neglect of the previous literature on the subject, and by great confusion in nomenclature and identification; he appears to have relied solely upon Riley's very slight notice,* and to have adopted without question a name and identification which Riley himself expressed great doubt about, and which is entirely incorrect.

The creature described by Lignière is not a *Tyroglyphus* at all, it is a *Histiogaster*. Moreover it is not the *Acarus malus* of Shimer, nor anything like it; it is the well-known *Histiogaster entomophagus* of Laboulbène. The real *Acarus malus* of Shimer is a totally different creature, which, oddly enough, Lignière describes as new in a paper † immediately following the paper now being spoken of, and calls *Hemisarcoptes coccisugus*. Lignières' paper must be considered as one upon *Histiogaster entomophagus*, adding some biological facts and a description of the hypopial nymph to the already somewhat full description of the species in the paper by Laboulbène and Robin above referred to. Lignière is right in saying that his is the first description of the hypopial nymph of the species, but he omits all reference to the previous descriptions and drawings of the almost undistinguishable hypopial nymph of the allied species *Histiogaster corticalis* by Prof. Canestrini and myself; he apparently has overlooked these memoirs. The whole question of the identification and correct naming of these species will be found fully dealt with in this book under the head of *Histiogaster entomophagus* in vol. ii.

* 'Fifth Annual Report on Noxious, etc., Insects of Missouri' (1873), p. 87.

† "Etude zoologique et anatomique de l'*Hemisarcoptes coccisugus*," in 'Mém. Soc. zool. France,' t. vi (1893), pp. 16—25.

S. J. Wasmann, in 1897, published a short, but highly interesting paper,* chiefly upon *Tyroglyphus Wasmanni* and the behaviour of its hypopial nymph in ants' nests, where the species multiplies to an extraordinary extent. The contents of this paper will be dealt with under the head of the species, and under that of "the hypopial nymph" in the chapter on development.

* "Ueber einige myrmecophile Acariden," in 'Zool. Anz.,' 1897, No. 531, pp. 170—173, No. 541, pp. 347—350.

CHAPTER III.

UPON THE CLASSIFICATION OF ACARINA IN GENERAL AND THE POSITION OF THE TYROGLYPHIDÆ THEREIN.

In Chapter IV of the first volume of my work on British Oribatidæ * I gave a history and summary of the principal classifications of the Acarina which had been published up to that time by specialists in the study of the group, and in the second volume of the same book (p. 583) I continued this history down to the year 1888, in which that volume was issued. As the present volume is one of the same series, it appears desirable that this should be continued down to the present date. The history was given with a view to show the position of the Oribatidæ in those classifications, but that of the Tyroglyphidæ is equally well shown; it would, therefore, be waste of expense and labour to repeat here what is to be found on this subject in the 1884 publication. I therefore only propose to notice here such classifications as have been published during the thirteen years which have elapsed since that date, and are of sufficient scientific value to make it advisable to refer to them; they are but few.

In 1891 Professor Geovanni Canestrini, of Padua, published a careful and well-considered classification of the Acarina.† Unfortunately the table at the end of this does not explain the reasons or basis for the various divisions, nor how each group is defined. This want is fully and ably supplied in what may be called

* London: Ray Society, 1884.

† "Abbozzo del sistema acarologico," in 'Atti. Ist. Veneto.,' ser. 7, t. ii, pp. 699—725. Reprinted by the author in his 'Prospetto dell' Acarofauna italiana,' pt. v (1892), Padua, pp. 563–587.

the text of the classification; there the descriptions of the various orders, sub-orders, and families are set out in ample detail, but this makes it so long that I should hardly be justified in translating the whole of it here; and it is, I think, scarcely fair to summarise another author's classification. I therefore confine myself to giving the tabular review at the end, and fully translating the portion of the paper which defines the groups leading up to the Tyroglyphidæ which are the immediate subject of this work, viz.:

ORDER I—**Astigmata.**—Without tracheæ, and therefore without stigmata, not only in the immature but also in the adult stage. Palpi of three or four joints, simple, having the first joint fixed. Mandibles chelate or styliform. Without eyes. Cuticle slightly chitinized. Legs of three to five joints. Organization usually very imperfect.

SUB-ORDER I—**Vermiformia.**—Body elongated, vermiform. Abdomen with superficial circular striæ. Adults with two or four pairs of legs. Mandibles styliform. Without genital or copulative suckers. Parasitic creatures; either animal or vegetable feeders.

SUB-ORDER II—**Sarcoptina.**—Body rounded, not vermiform. Abdomen not striated. Adults with four pairs of legs. Palpi of three joints usually simple and filiform. Mandibles chelate. Legs of five joints. Larva hexapod. Metamorphoses, at least in some species, binymphal, sometimes complicated by the appearance of a Hypopial form.

The definition of the family Tyroglyphidæ will come more properly into the next chapter.

The table is as follows:

General Review of the Acarine System.

Orders.	Sub-orders.	Families.	No. of Genera.
I. **Astigmata**	I. Vermiformia	1. Demodicidæ	1
		2. Phytoptidæ	4
	II. Sarcoptina	3. Cytoleichidæ	2
		4. Psoroptidæ	3
		5. Linocoptidæ	3
		6. Listrophoridæ	3
		7. Dermoglyphidæ	3
		8. Analgesidæ	17
		9. Tyroglyphidæ	12
II. **Hydracarina**		1. Halacaridæ	7
		2. Limnocaridæ	2
		3. Hydrachnidæ	23
III. **Prostigmata**	I. Trombidina	1. Tarsonemidæ	4
		2. Cheyletidæ	8
		3. Erythræidæ	2
		4. Tetranychidæ	7
		5. Raphignathidæ	6
		6. Eupodidæ	9
		7. Bdellidæ	5
		8. Alychidæ	2
		9. Rhyncholophidæ	4
		10. Trombididæ	3
	II. Hoplopina	11. Hoplopidæ	1
IV. **Cryptostigmata**		1. Oribatidæ	2
		2. Nothridæ	12
		3. Hoplophoridæ	2
V. **Metastigmata**		1. Ixodidæ	6
		2. Argasidæ	2
VI. **Mesostigmata**		1. Nicoletiellidæ	1
		2. Uropodidæ	8
		3. Zerconidæ	4
		4. Lelaptidæ	9
		5. Gamasidæ	5
		6. Dermanyssidæ	7

Genera of doubtful position are not included in the number of genera.

There is no doubt that this is an excellent classification in most respects. There are, however, certain points in which I should not be altogether inclined to follow it. The Acarina are treated as a class; this follows the opinion of Haller * and Oudemans.† It matters but little, perhaps, what a group is called, whether a class, an order, or a family; because our

* "Die Mundtheile und systematische Stellung der Milben," in 'Zool. Anz.,' 1881, No. 88, pp. 380—336.

† "Die gegenseitige verwandschaft Abstammung und Classification der sogenannten Arthropoden," in 'Tijdschr. Nederland. Dierk. Ver.,' ser. 2, Deal 1 (1886).

divisions are wholly artificial, although convenient and even necessary, but the important matter is to keep the groups of the same degree of fairly equal value in fact as well as in name, and to have a classification which gives as correct an idea as possible of the relationships or resemblances which we actually find in nature. Raising the Acarina into a class would, it seems to me, separate them from such closely allied creatures as the Phalangidæ in a way which is not desirable. Another point which does not strike me as quite happy is the establishment of the order Hydracarina. The only bond which unites the families of which this group is composed to one another, and separates them from the Prostigmata, is the aquatic habitat, and this does not seem sufficient to found an order upon. The Hydrachnidæ appear to me by their anatomy, and everything except their habitat, to be as or more closely allied to the Trombididæ as to the Halicaridæ, and to be nearer to the Trombididæ than the Tarsonemidæ are. The close relationship between the internal anatomy of the Hydrachnidæ and the Trombididæ was long since proved by Croneberg.*

My views as to the division of the Oribatidæ (Canestrini's Cryptostigmata) into sub-families (Families Canestrini) I have lately set out elsewhere.†

In 1891 Dr. Trouessart, of Paris, published a classification of the Acarina,‡ which, although I cannot entirely agree with every part of it, is, I am inclined to think, on the whole the best hitherto published. The following is a translation of the explanatory table of the paper :

* "On the Anatomy of *Eylais extendens*, Müller, with Observations on Allied Forms;" in Russian, in 'Nachr. ges. d. Freunde d. Naturkunde,' Moscow, 1878. A short summary in German called "Ueber den Bau der Hydrachniden," in 'Zool. Anz.,' 1878, No. 14, p. 316; "Ueber den bau von Trombidium," in 'Bull. Soc. Moscou,' 1879, pt. 2, p. 234.

† "Oribatidæ," in 'Das Tierreich,' Lief. 3, 1898, Berlin.

‡ "Considérations Générales sur la classification des Acariens suivies d'un essai de classification nouvelle," 'Rev. Sci. Nat. Ouest.,' 1891, pp. 289—308 (1892), pp. 20—55.

Attempt at a New Classification of the Sub-class Acaroidea.

Orders.	Sub-orders.		Families.		Sub-families.
I. Abdomen anchylosed to and confounded with the cephalothorax ACARINA.	A. Tracheæ opening in the anterior part of the body, rostrum or thorax, but atrophied in the aquatic types. Foundation of the skeleton epimeral. Rostrum with **Prostigmata**.	Palpi free, armed (raptorial). Mandibles falcate or styliform.	Terrestrial.	1. Trombididæ.	Erythræinæ. Trombidinæ. Cheyletinæ. Scirinæ. Tetranycinæ. Cœculinæ. Limnocarinæ.
			Fresh water.	2. Hydrachnidæ.	
			Marine.	3. Halacaridæ.	
		Palpi free, unarmed (tactile), Mandibles chelate.		4. Bdellidæ.	Bdellinæ. Eupodinæ.
	B. Tracheæ opening in the posterior part of the body at the base of the legs. Foundation of the skeleton a sternum or ventral plate. Rostrum with **Metastigmata**.		Palpi free, unarmed tactile; mandibles chelate.	5. Gamasidæ.	Nicoletiellinæ. Uropodinæ. Gamasinæ. Dermanyssinæ.
			Palpi tactile, mandibles falcate, a maxillo-labialspear armed with rasp-like teeth.	6. Ixodidæ.	Argasinæ. Ixodinæ.
			Palpi free, tactile, fusiform; mandibles chelate.	7. Oribatidæ.	Oribatinæ. Nothrinæ. Hoplophorinæ.
	C. Without tracheæ, skeleton epimeral. Palpi adherent at the base, tactile; mandibles chelate, **Astigmata**.			8. Sarcoptidæ.	Tyroglyphinæ. Canestrininæ. Listrophorinæ. Analgesinæ. Sarcoptinæ. Chirodiscinæ.
II. Abdomen distinct from the cephalothorax, ringed, tail-like. Tracheæ absent. **Vermiformia**.	A. Four pairs of legs; palpi falcate or armed with holding apparatus (crampons); mandibles styliform, fixed. **Octopoda**.			9. Demodicidæ.	
	B. Two pairs of legs; palpi unarmed, tactile, mandibles styliform, moveable. **Tetrapoda**.			10. Phytoptidæ.	

The main reason why I am inclined to prefer this to Canestrini's classification are: (1) that it does not rely so entirely upon a single system of organs (the respiratory) for its principal divisions, but endeavours to take a wider basis; (2) that the mites are treated as a sub-class, not a class; (3) that the question of terrestrial or aquatic habitat is not insisted on as differentiating so high a group.

Among the points upon which I am not able to agree with Dr. Trouessart are the following:

It does not appear to me to be correct to say that in the great majority of his Order I the abdomen is confounded with the cephalothorax; it undoubtedly is so in most of the Hydrachnidæ and Sarcoptinæ (I am using these expressions in Trouessart's sense); but if we are to understand the word abdomen in the sense in which it is usually employed in reference to the mites, and that sense seems to me correct, then there is a very decided and well-marked division between cephalothorax and abdomen in such groups as the Trombidinæ, Cheyletidæ, Scirinæ, Tetranycinæ, Bdellidæ, Gamasinæ, Oribatidæ, Tyroglyphinæ, and, indeed, the great majority of the Acari. Trouessart evidently felt this difficulty himself, because when he came to the fuller definition of his order Acarina he says, "abdomen *generally* anchylosed to the cephalothorax and *more or less* confounded with it" (the italics are mine), and in the fuller definition of the Trombidieæ, which form Section *b* of his Trombidinæ, and therefore an important division of his group Acarina, he says, "Cephalothorax very distinct from the abdomen." Trouessart also correctly defines his Hoplophorinæ, another subfamily of his Acarina, as "Cephalothorax moveable upon the abdomen." Of course, in the views of those biologists who consider that in the Arachnida nothing can be considered an abdomen which is provided with legs, the vast majority of the Acari cannot be considered to have any abdomen at all; amongst these is Dr. A. C.

Oudemanns,* who proposes the terms "prosoma" and "metasoma," instead of cephalothorax and abdomen † in the case of the Acari. It is not, however, apparent to me why the legless condition should be considered essential. It will not be denied that in many Arthropoda the abdominal segments, or some of them, bear appendages of some sort, *e.g.* the swimmerets of the Macrura, the pleopods of the Isopoda, etc. It does not appear to require any great stretch of imagination to suppose that some of these may become functional as locomotive limbs in some Arachnida, but it is said that the Spiders, Scorpions, etc., are without such legs. This is true, but it must be remembered that the Acari probably form the great bulk of the Arachnida, being, as far as we can judge at present, much more numerous, both in number of species and in number of individuals, than all the remainder put together; and although some biologists are inclined to regard them as degraded forms, yet there are many indications pointing rather to their being a primitive group. At all events, what is called the abdomen in the Acarina functions as such, and contains the internal organs which we find in the legless abdomina of allied creatures; and in many cases (*e.g.* Oribatidæ) it is divided from the cephalothorax by a phragma, through which the alimentary and nervous systems pass.

I do not like the expression "Acarina" for a portion of the Mites, because it has always been considered to include the whole.

I do not see that the trachea of the Prostigmata can be said to be "atrophied in the aquatic types;" it should rather be said in *some* of the aquatic types; in the Hydrachnidæ the trachea are very fully and well developed. I, however, quite approve of retaining the Halacaridæ among the Prostigmata, in spite of the

* "List of Dutch Acari," in 'Tijdschr. Ent.,' Deel xxxix (1896), p. 64.
† "Notes on Acari," in 'Tijdschr. Ent.,' Deel xxxix (1896), pp. 175—187.

absence of the tracheal system; but it does not appear to result necessarily from an aquatic life.

It seems somewhat dubious whether the Limnocarinæ can properly be called terrestrial. Trouessart's own description of their habitat is "Acari living in the mud or walking at the bottom of the water; larvæ commensal on aquatic insects." The Hydrachnidæ are not invariably inhabitants of fresh water,* but these exceptional cases may possibly be neglected.

I scarcely like the expression "falcate" (en crochets) as opposed to "chelate" for the mandibles of the Ixodidæ. Trouessart, however, describes these organs much more exactly in his fuller definition of the family, where he calls them "mandibles with two branches, pseudo-cheliceræ, not forming a didactile forceps but a harpoon with a double dart." Even this does not quite give me the idea of the organ, which does not consist of a rigid spear of one joint with a double distal end; it is a piece of apparatus which would be a chela if it were not that the teeth of the moveable arm are on its outward edge, and are turned in the same direction as the teeth, or curved point, of the fixed arm. Neumann † calls them "Cheliceræ." Supino ‡ adopts the same expression as Trouessart in the latter's fuller definition, viz. "Pseudo-cheliceræ." I should be inclined to regard them as consisting of a fixed spear and a moveable cutter.

I do not quite like the name "Octopoda," as applied to the Demodicidæ, because it would seem to be indicative of the whole of the Acari except the Phytoptidæ (*Eriophyidæ*), or even of a larger group. Trouessart adopts Canestrini's subdivision of the Oribatidæ, which I have already spoken of (page 28).

* Philippi, "Zoologische Betrachtungen VI," "*Pontarachna*, eine Hydrachnide des Meeres," in 'Arch. Naturg.,' Bd. i (1840), p. 181, von Schaub. "Ueber marine Hydrachniden nebst einigen Bermerkungen über *Midea*. Bruz." S. B. Ak. Wien, 1889, Bd. xcviii, Abth. 1, pp. 163—179.

† "Revision de la famille des Ixodidés," in 'Mém. Soc. Zool. France,' t. ix (1896), p. 2.

‡ 'Nuovi Ixodides della Birmania,' Padova, 1897.

In 1894 Nathan Banks published a classification * of the Acarina, which is as follows :

1. Body vermiform, often with but four legs, living in galls or in flesh. Very minute forms . . DESMODECOIDEA.†
   Not living in galls or flesh, adults with eight legs . . 2
2. Water-mites, soft-bodied, mostly parasitic . HYDRACHNOIDEA.
   Land-mites 3
3. No stigmata (atracheate); body soft; legs supported by chitinous rods ; no eyes ; mostly parasitic forms PSOROPTOIDEA.
   Stigmata present (tracheate), no chitinous rods visible . 4
4. Last joint of palpus forming a thumb or appendage; body soft, stigmata at base of mandibles, mostly free TROMBIDOIDEA.
   Last joint of palpus simple 5
5. Stigmata above on the cephalothorax each with a seta ; body coriaceous ; cephalothorax very distinct from abdomen ; no eyes ; non-parasitic . . . ORIBATOIDEA.
   Stigmata not above and without setæ. Body usually partly soft 6
6. Mandibles forming a serrate proboscis. Body hard ; no sucker at tip of tarsus ; eyes sometimes present ; large parasitic species . . . . . . IXODOIDEA.
   Mandibles not forming a serrate proboscis ; smaller species . 7
7. Stigmata between legs two and three, often with hard plates ; legs with a sucker at tip, no eyes . GAMASOIDEA.
   Stigmata at base of mandibles ; body wholly soft ; no sucker at tip of legs ; eyes often present . . EUPODOIDEA.

Banks calls these divisions "Super-families." The classification is only intended to apply to the Acarina of the United States of America, but a division of the super-families Trombidoidea and Eupodoidea into families and genera is given, and that of the Oribatoidea is published in a subsequent paper.‡

This classification, although later in date and possessing some good points, cannot be considered as an advance upon those of Canestrini and Trouessart; indeed, it is far behind them. It does not present much in the way of novelty except the question of size, which it is scarcely desirable to import into a classification, and the extent to which habitat is relied on ; another element which seems to me to have an

* "Some new American Acarina," in 'Tr. Amer. Ent. Soc.,' vol. xxi (June, 1894), pp. 209—222.

† The "s" in this word must probably be a printer's error.

‡ "On the Oribatoidea of the United States," in 'Tr. Amer. Ent. Soc.,' vol. xxii (January, 1895), pp. 1—16.

undue importance assigned to it. It may also be remarked that a large portion of the Phytopti do not live in galls; that water-mites are not all soft-bodied; that the definition and classification of the Oribatoidea is wholly based upon old, erroneous, exploded anatomy, and therefore fails; and that the maxillary lip of the Ixodoidea is mistaken for the mandibles.

CHAPTER IV.

UPON THE CLASSIFICATION OF THE TYROGLYPHIDÆ.

Probably the earliest thing which can be in any way considered as an attempt to classify the Tyroglyphidæ was that of **C. L. Koch** in 1842;* although in this place Koch does not call the creatures Tyroglyphidæ, and does not treat them as a family; he calls them the two genera *Acarus* and *Homopus*, and includes them in the Sarcoptidæ; but he says "the species of the genus *Acarus* are rendered somewhat remote from the other genera by their mode of life; they are not found on living creatures; they cannot remain in the present family."

The genus *Homopus* is bad in two ways; firstly, because it is founded on an immature (Hypopial-nymphal) type, and depends entirely upon the immature condition; and secondly, because the name *Homopus* was preoccupied, having been used by Duméril and Bibron † for a genus of reptiles in 1835.

Koch divides his genus *Acarus* into sections, as follows:

A. Cephalothorax and abdomen melting into one another. The tarsi thin, needle-shaped; the other joints with thick setiform or spine-like appendages. The body-hairs simple.

B. The cephalothorax plainly marked off, the body-hairs simple, the legs finely haired, the tarsi a somewhat thicker needle-shape than in A.

C. Cephalothorax and abdomen not divided from each other; body-hairs feathered.

* 'Uebersi,' Heft 3, pp. 118—121.
† Erpétologie.

D. Cephalothorax and abdomen plainly divided; the legs thick, especially the four anterior; the hinder part of the body furnished with a few fine hairs.

E. Doubtful Sarcoptidæ, the cephalothorax plainly divided off, the abdomen longish, the legs diminishing rapidly below the knees.

Koch remarks that Section E can hardly remain in the genus.

Sections A and C of this classification unquestionably constitute the present genus *Glycyphagus*, A being the species with finely-feathered body-hairs, and C those with strongly-feathered body-hairs, such as *G. plumiger*. It is true that Koch says that Section A has simple body-hairs, but he evidently had not instruments capable of detecting the pectinations when they were fine, for he includes in this section *Acarus spinipes*, and what he calls *Acarus siro*, but his *siro* is really *Glycyphagus domesticus*. There cannot be any doubt that his two species are *Glycyphagi*, because Koch draws the projecting bursa copulatrix of the female, which is so characteristic of that genus. The third species, *Setosus*, is more doubtful, and may probably have been a *Carpoglyphus*.

Section B must probably be considered as equal to the present genus *Tyroglyphus*, although apparently containing some things which would not now be included therein.

Section D is the present genus *Aleurobius*.

I doubt if it be possible to say what the two creatures forming Section E really are.

Professors **Giovanni Canestrini** and **F. Fanzago** in 1877 published what may be considered a first effort at classification of the Tyroglyphidæ.* It was entirely abandoned by Professor Canestrini in his later classification given below; still it is well to mention it. The following is a translation:

* "Intorno Agli Acari italiani," in 'Atti Ist. Veneto,' Ser. v, vol. iv, p. 196.

Family—Acarini.

Tracheæ, and consequently stigmata, absent.

1. *Acarus*, Lin. Legs terminated by a lobed sucker; cephalothorax without clubs.
2. *Claviceps*, n. gen. Cephalothorax bearing clubs; legs terminated by a claw.
3. *Trichodactylus*, Dug. Legs of the first, second, and third pairs terminated by a strong claw, fourth leg terminated by a long filament. Cephalothorax without clubs.

In this classification the genus *Acarus* includes the whole of the Tyroglyphidæ then known to the authors, except the single species which constituted No. 3. *Claviceps* was composed entirely of immature (nymphal) Oribatidæ. *Trichodactylus* was Dugés' genus founded on *Trichodactylus xylocopæ*, an hypopial nymph.

Professor **Paul Mégnin** in 1880 published a classification of the Tyroglyphidæ, which he calls *Sarcoptides détriticoles*,* thus:

Hairs feathered or palmate	.	.	. *Glyciphagus*.
Hairs simple	Tarsi with caroncles.	Male without copulative suckers.	*Carpoglyphus*.
		Male with copulative suckers.	*Tyroglyphus*.
	Tarsi without caroncles.	Rostrum with chelate mandibles.	*Cæpophagus*.
		Rostrum with mandibles transformed into small saws.	*Serrator*.

Cæpophagus = *Rhizoglyphus*; *Serrator* = *Histiostoma*.—This classification, of course, does not include all the creatures now known and belonging to the family, and the first division is not absolutely correct, because although all known species of *Glycyphagus* have the body-hairs feathered, pectinate, palmate, or forming great spines, yet feathered hairs are not absolutely unknown in the genus *Tyroglyphus*, although to a much slighter degree than in *Glycyphagus*. The body-hairs of *T. longior* are so, although the secondary

* 'Les Parasites et les Maladies parasitaires,' Paris, 1880, p. 138.

hairs, which feather the main ones, are extremely minute and fine. Still there are excellent points in this simple classification, as might be expected in Mégnin's work, and it is the foundation of much of our present arrangement.

Professor **Giovani Canestrini** in 1888 published two works on the Tyroglyphidæ, viz. 'I Tiroglifidi, studio critico,' and vol. iii (containing the Tyroglyphidæ) of his 'Prospetto dell' Acarofauna italiana.' The same classification of the family is contained in each of these; the following is a translation of it:

Analytical Key for the Classification of Genera.

1. Anal suckers exist in the male 7
   Such suckers are absent 2
2. Aberrant suckers exist in both sexes; palpi furnished with a chitinous membrane and therefore dilated 1° *Histiostoma*, Kr.
   Without such suckers; palpi normal . . . 3
3. Migratory nymph homopial; living on mammals 2° *Homopus*, K.
   Migratory nymph not homopial or not existing . . 4
4. Tarsal claw rudimentary . . 3° *Glycyphagus*, Her.
   Tarsal claw distinct 5
5. Genital suckers absent in both sexes; vulva situated behind the epimera of the second pair of legs . 4° *Hericia*, Cn.
   Genital suckers exist in at least one of the sexes . . 6
6. Both sexes possess genital suckers . 5° *Phycobius*, Cn.
   Genital suckers exist only in the female . 6° *Trichotarsus*, Cn.
7. Male provided with foliaceous appendages at the posterior extremity of the body . . 7° *Histiogaster*, Berl.
   No such foliaceous appendages 8
8. No furrow between cephalothorax and abdomen 8° *Chortoglyphus*, Berl.
   Such a furrow exists 9
9. First pair of legs of the male thickened and spurred 9° *Aleurobius*, Cn.
   First pair of legs normal 10
10. Tarsi long, without suckers; no dimorphism of the male 10° *Tyroglyphus*, Lat.
    Tarsi short, without suckers, male dimorphic *Rhizoglyphus*, Clap.

To say that this classification is by Professor Canestrini is equivalent to saying that it is a valuable one; but yet I cannot quite agree with all of it. It seems to me rather technical, and hardly to bring the main structural differences into sufficient prominence. It appears also that an importance is attached to the suckers greater than what I should consider the classificatory value of those organs; and that the distinguishing of *Glycyphagus* by the rudimentary claw is hardly satisfactory, because it is a question of degree, and the claw in *Glycyphagus*, although very small, is usually distinct, and it is very small also in some species of *Tyroglyphus*. I do not quite like the distinction of long and short tarsi as partly differentiating *Tyroglyphus* from *Rhizoglyphus;* it seems to me that the tarsi of *R. echinopus* are as long as those of *T. ovatus*.

Professor **Antonio Berlese** in 1897 published his 'Ordo Cryptostigmata' (part I, published after part II). This is the introductory and classificatory portion, as to the Sarcoptidæ and Tyroglyphidæ, of his great work on the Italian Acari.* It contains (pp. 99—101) a classification of the Tyroglyphidæ, which is certainly one of the most elaborate and careful yet issued, and contains the recently added genera up to date. The following is a translation:

Sub-families of the Tyroglyphidæ.

This family may be divided into sub-families thus:

Ambulacra borne on lengthy peduncles		.	Lentungulina.
Ambulacra sessile.	Conspicuous copulatory discs present in the males.	Ambulacrum consisting of a large claw and an almost obsolete membrane.	Tyroglyphina.
		Ambulacrum a broad triangular membrane and a minute median claw.	Chortoglyphina.
	No copulatory discs in the males.	Mandibles chelate, chela short, arms thereof subequal.	Glycyphagina.
		Mandibles terminating in a saw; not chelate.	Histiostomina.

Sub-family **Histiostomina.**

Contains only the genus . . . *Histiostoma.*

* 'Acari Miriapoda et Scorpiones hujusque in Italia Reperta,' Fierenze and Portici, 1882—1898, still publishing.

Sub-family **Lentungulina.**

Divided thus into two genera:

- Ambulacrum terminated only by a claw . . *Lentungula.*
- Ambulacrum terminated only by a membrane . *Hemisarcoptes.*

Sub-family **Glycyphagina.**

- Ambulacra with large claws.
  - Sexual dimorphism shown in the thickness of the legs — *Hericia.*
  - No sexual dimorphism (in the legs).
    - Furrow dividing cephalothorax and abdomen very conspicuous. — *Saproglyphus.*
    - No furrow between cephalothorax and abdomen.
      - Genital discs of the male inconspicuous. — *Trichotarsus.*
      - Genital discs of the male conspicuous. — *Carpoglyphus.*
- Ambulacra with very small, almost obsolete, claws and small ampulliform membranes. — *Glycyphagus.*

Sub-family **Tyroglyphina.**

- Abdomen of the male with a posterior triangular appendage bearing four leaf-like processes. — *Histiogaster.*
- Abdomen of the male rounded posteriorly and without any appendage.
  - Heteromorphic males with the third pair of legs thickened. — *Rhyzoglyphus.*
  - Third legs of the males similar to the fourth and second pairs, and to those of the female.
    - Males with the first pair of legs thicker than the others, and spurred. — *Aleurobius.*
    - Legs of the male similar to those of the female.
      - Abdomen of the male protected posteriorly by a hard shield. — *Monieziella.*
      - Abdomen of the male entirely bare. — *Tyroglyphus.*

Sub-family **Chortoglyphina.**

- Vulva arcuate, transverse. Tarsus of the fourth leg of the male bearing two copulatory tubercles — *Chortoglyphus.*
- Vulva angular, sublongitudinal. Tarsus of the fourth leg of the male without copulatory tubercles — *Mealia.*

The late Professor **P. Kramer,** of Magdeburg, in April, 1899, published in the great German work 'Das

Tierreich' what must be considered the latest classification of the Tyroglyphidæ in order of date.* The Tyroglyphidæ are treated as being a sub-family of the Sarcoptidæ, and are consequently called Tyroglyphinæ. The following is a translation.

Sub-family **Tyroglyphinæ.**

1	Mandibles chelate 2.		
	Mandibles not chelate . .	1 Gen.	Histiostoma.
2	Maxillary palpus clavate at the distal end	2 Gen.	Nodipalpus.
	Maxillary palpus not clavate at the distal end 3.		
3	Claws of the two front pairs of legs mounted on long peduncles which are attached at the side of the end joint (Tarsus) .	3 Gen.	Lentungula.
	Claws never mounted on long peduncles, 4.		
4	♂ With anal suckers 5.		
	♂ Without anal suckers 10		
5	Cephalothorax divided from the abdomen by a furrow (constriction) 6		
	Cephalothorax not divided from the abdomen	4 Gen.	Chortoglyphus.
6	First leg of the ♂ greatly thickened and armed	5 Gen.	Aleurobius.
	First leg of ♂ not thickened or armed, 7.		
7	Anal opening and anal suckers surrounded by a common chitinous annular sclerite .	6 Gen.	Mealia.
	No such sclerite, 8.		
8	Fourth leg of ♂ with suckers . .	7 Gen.	Tyroglyphus.
	Fourth leg of ♂ without suckers, 9.		
9	Abdomen of ♂ with a chitinised terminal plate	8 Gen.	Histiogaster.
	Abdomen of ♂ without such a plate .	9 Gen.	Rhizoglyphus.
10	♀ with genital suckers, 11.		
	♀ without genital suckers . .	10 Gen.	Hericia.
11	♀ with a projecting *Bursa copulatrix* at the posterior end of the abdomen . .	11 Gen.	Glycyphagus.
	♀ without such a bursa copulatrix, 12.		
12	Cephalothorax divided from the abdomen by a furrow (constriction) . .	12 Gen.	Saproglyphus.
	Cephalothorax not divided from the abdomen, 13.		
13	Epimera of the first and second legs fused, forming a continuous structure . .	13 Gen.	Carpoglyphus.
	Epimera of the second leg fully isolated, 14.		

* "Demodicidæ und Sarcoptidæ," by Prof. G. Canestrini and Prof. P. Kramer, forming Lieferung 7 of "Das Tierreich," Berlin, April, 1899. Although the work bears the joint names of the two professors, yet the part relative to the *Tyroglyphidæ* was written by Prof. Kramer, and was completed by him before his death, but was carried through the press by Prof. Canestrini and the Editor for the Acarina, Dr. H. Lohmann.

14	At the cephalic end a chitinised fillet with a sucker at each end . .	14 Gen. TRICHOTARSUS.
	No such fillet at the cephalic end .	15 Gen. DERMACARUS.

This classification is, as might be expected from its author, one of the best; there are, however, naturally a few points in which I cannot quite agree with it. In the first place there appears to be some error about the genus *Rhizoglyphus*, due possibly to the author's death before the publication of the work. In the eighth dichotomous division of the classification Dr. Kramer defines his ninth similar division as "fourth leg of ♂ without suckers." This ninth division includes only the two genera *Histiogaster* and *Rhizoglyphus*, but the author seems to have overlooked the fact that the *Tyroglyphus crassipes* of Haller,* an American species, has the suckers on the fourth leg of the ♂, and therefore this mode of differentiation cannot be used for a group which includes the genus. It cannot be that Dr. Kramer considered Haller's species as being a *Tyroglyphus*, because when he comes to deal with the genus *Rhizoglyphus* † he includes Haller's *T. crassipes* in it, and specifies these very suckers on the fourth leg of the ♂ as a reason why he thinks the species must be different from *R. echinopus*. Moreover, no acarologist with our present knowledge could doubt that Haller's species is a *Rhizoglyphus*. There seems to be a confusion about the subject in Dr. Kramer's paper, because in his definition of the genus *Rhizoglyphus* he states that the anal suckers and those of the legs are present in the ♂; the anal suckers are present, but the sexual suckers on the fourth leg of the ♂ are absent from all known species of the genus except *R. crassipes;* and, although the point is not very clearly expressed, yet evidently Dr. Kramer refers to these suckers, because there never are any on any other leg of the Tyroglyphidæ except the fourth; he cannot refer to the

* "Beschreibung einiger neuen Milben," in 'Arch. Naturg. L. Jahrg. (1884), p. 218, Taf. xv, fig. 1.
† Page 143.

ambulacral suckers found at the distal end of the tarsus in many genera, because these suckers do not exist in *Rhizoglyphus*, and that was the very distinction upon which Claparede founded the genus; moreover, these suckers, where they exist, are not confined to one sex.

I cannot say that I like the wide separation of *Hericia* from *Carpoglyphus* in this classification, nor that of *Glycyphagus* from *Dermacarus*; in each of these cases the two genera respectively seem to me to be closely allied.

CHAPTER V.

ANATOMY.

External Anatomy.

The Cuticle.—The integument of the Tyroglyphidæ is usually soft and but slightly chitinised. There are, however, exceptions to this rule; thus the cuticle of *Chortoglyphus* is much harder and more highly chitinised than that of most other genera. In *Hericia* numerous chitinous plates are sunk in the dorsal cuticle, and often serve for the attachment of dorso-ventral and levator coxæ muscles. The skin is often highly polished, as in most species of *Tyroglyphus*, *Rhizoglyphus*, etc. In other genera, such as *Glycyphagus*, it is dull, even rough, and in some cases like shagreen; in *Hericia* and some species of *Glycyphagus*, such as *G. platygaster*, the dorsal cuticle is covered with small stout points. It very rarely presents the regularly spaced pores which are so commonly found in families of Acarina, which have a denser and more highly chitinised cuticle, such as the Oribatidæ.

Probably in most, if not all, Acarina the integument may be considered to consist of three layers or tunics; I have usually called these the epiostracum, the ectostracum, and the endostracum, following the names which Huxley adopted in 'The Crayfish.' Some writers consider that the cuticle consists of two layers only, but that in many cases one of these is divided into two; it is not very important which view is taken, and it probably depends chiefly upon what group of Acari the particular writer has paid most attention to. In the

Oribatidæ the three layers are usually perfectly distinct, and the epiostracum often rubs off leaving the other two layers intact; an almost similar thing often occurs in the Hydrachnidæ, or in such of them as have chitinous plates embedded in the cuticle, *e. g. Thyas*, *Hydrodroma*, etc.; the epiostracum often persists above the plates when it has rubbed off elsewhere. In *Bdella* and *Trombidium* it is usually difficult, if not impossible, to detect more than two layers. I have discussed the question of the two or three layers and their nomenclature in 'British Oribatidæ' (p. 111), and do not think it necessary to repeat it here. Nalepa considers that the integument of the Tyroglyphidæ consists of two layers, which he calls the "chitindecke" and the "matrix;" he says that the former is usually a thin, structureless, and tolerably stretchable tunic; but that in some cases it becomes greatly thickened by the deposition of lime-salts, usually accompanied by pigment, and then becomes hard and brittle and generally loses its character of a layer. There is no doubt that the commonest character of the two other layers of the cuticle in adult Tyroglyphidæ is what Nalepa describes; namely, that the distinction between epiostracum and endostracum is lost, and that the two form a single flexible and stretchable tunic in which little, if any, structure can be detected; but there are species in parts at least of whose bodies the three layers of the integument may be quite plainly seen. Thus in *Glycyphagus platygaster* (Pl. C, fig. 4) the epiostracum of the lateral and dorsal portions of the abdomen is a thin, structureless tunic, but is roughened on its exterior surface by thickly-set almost triangular points; the ectostracum is a much thicker tunic, and is easily distinguishable from the other layers.

The endostracum, matrix, or hypoderm is the living tunic. Nalepa says that in *Carpoglyphus* it does not consist of a distinct cellular layer, but is a loose network of anastomosing cells whose nuclei are rare and are surrounded with scanty plasma; he remarks that the secretion of the chitinous layer by this network would be scarcely comprehensible if we did not know that before the ecdysis the cells of the matrix become much more numerous and form a regular close layer. It will be seen from Pl. C, fig. 4, that this condition of forming a close layer of cells exists in some of the Tyroglyphidæ at other times besides those immediately before ecdysis; but Nalepa's network condition also often occurs, and in old specimens, when the abdomen is distended by the great development of the genital organs and products, the endostracum seems to be almost entirely lost and is difficult to distinguish at all. When the endostracum is in the network condition there is not any well-defined demarcation between it and the subcuticular connective tissue which is found in most Acari, and is often abundantly supplied with fat-cells.

The dermal appendages of the Tyroglyphidæ are numerous; they consist of hairs, scales, spines, etc. The epimera and sternum must also be considered dermal structures, but it is more convenient to treat of these in connection with the legs. The expulsory vesicles (or oil-glands) appear also to be of dermal origin, but it is more convenient to deal with them separately when speaking of the internal anatomy.

The hairs may be classified into three groups, viz. 1st, simple, flexible, setiform hairs; 2nd, pectinated, bipectinated, or plumose hairs; 3rd, stiff rods which are not pointed. Of these the very minute hairs are apparently solid, the larger ones and most of the spines are hollow.

The simple setiform hairs vary from closely-set hairs of such extreme minuteness that it is difficult to see them, as in the case of those which are found so abundantly on the tarsi of *Glycyphagus spinipes* (Pl. VII, figs. 3—7), to hairs as long as the whole body, of which the notogastral hairs of *Tyroglyphus longior* and the four great hairs on the hind margin of *Carpoglyphus anonymus* are good examples; they may even be twice as long as the body, as is the case with the long hair which terminates each fourth leg of the hypopial nymph of *Trichotarsus xylocopæ*.

The pectinated hairs, *i. e.* those having pectinations on one side only, are rare; probably the best examples are the hairs on the tibiæ of the two anterior pairs of legs of *Glycyphagus ornatus* Kramer, a foreign species; but it is rather doubtful whether they should not be regarded rather as scales than as hairs. Other good instances are a hair on the first leg of the female and one on the third leg of the male of *Glycyphagus Crameri* (Pl. XVI, fig. 12, and Pl. XVII, fig. 10).

The bipectinated hairs, *i. e.* those with pectinations on two opposite sides of the main rachis, are on the contrary extremely common and may assume great size and importance. Those on the notogaster of *Glycyphagus plumiger* (Plate IX) and *G. Canestrinii* (Pl. X) are the best examples. Those of the latter species are particularly beautiful, the main rachis and the pectinations being curved, and each pectination bending suddenly forward near its distal end so that the whole hair assumes an ostrich-plume appearance which is very striking. In the species which have the pectinations, or barbs, on more than two sides of the rachis those barbs are usually extremely short and fine; although the whole hair may be nearly twice as long as the body of the Acarus, as is the case in the notogastral hairs of *Glycyphagus spinipes* (Pl. VII); but a few cases exist where the barbs are long and very flexible, and sometimes provided with secondary barbules giving the whole hair somewhat the appearance of down; such hairs are generally very small; a very good example is a minute hair on the side of the body of the male of *Glycyphagus platygaster* (Pl. XVII, fig. 4).

Of the rod-like hairs some of the best examples are those on the notogaster of *Tyroglyphus Wasmanni*, these slightly increase in thickness toward the distal end; a short rod of a similar character is also found in the median line of the dorsal surface of the tarsus, near the proximal end, in most species of the genus *Tyroglyphus*, and in some other species.

The scales, which are of course only strangely developed hairs, are practically of two sorts; one of these may be called the leaf-like scale, in which a number of branches start from the main rachis, and these are often, but not always, joined by a bordering rib, or nervure, at the periphery of the leaf; the rachis and nervures often bear short spines extended between the rachis and nervures, and attached to both is a thin, colourless, transparent membrane; the whole structure is leaf-like in form. The best examples of this kind of scale are those of *Glycyphagus palmifer* (Pl. XIII, figs. 3, 4, 5, 7); but good instances are also found on the foreign species *G. pterophorus* and *Histiostoma phyllothricum;* in the last-named species the scales have not any nervures, but only rachis and membrane. The other sort of scale is a thick opaque membrane, without rachis or nervures but closely set on one surface with short fine hairs; an excellent specimen of this is the scale on the outer side of the femur of the third leg of the female *Glycyphagus spinipes* (Pl. VII, figs. 5, 6).

The spines are of course chiefly of the ordinary thorn-like character, but attention may be drawn to the great, hollow, ensiform spines of the male of *Histiostoma pulchrum* (Pl. III, figs. 15, 16), the immensely long spines of *Histiostoma spiniferum* (Pl. IV, figs. 1—3), and the remarkable spines of *Glycyphagus platygaster* (Pl. XIV) and *G. dispar* (Pl. XV).

The Divisions of the Body.—In most text-books of comparative anatomy the Acarina are defined as being Arachnida which have the cephalothorax and abdomen fused into one common mass without any demarcation between them; if the word abdomen be used in the sense in which acarologists almost universally employ it this definition is entirely misleading; it is doubtless founded upon such creatures as the members of the genus *Sarcoptes* and its allies (the itch-mites), and the greater part of the Hydrachnidæ; with regard to these Acari the definition is perfectly correct; a similar, or almost similar, condition is found amongst the Tyroglyphidæ in the genera *Chortoglyphus*, *Trichotarsus*, *Hericia* and *Carpoglyphus*, and many, but not all, members of the genus *Glycyphagus;* but in almost the whole of the remainder of the Tyroglyphidæ, the whole of the Oribatidæ, and by far the greater number of the Gamasidæ the Trombididæ and the Phytoptidæ, constituting much the larger portion of the Acarina, there is a sharp constriction of the body between the second pair of legs and the third if present; the portion of the creature anterior to this constriction is called the cephalothorax by acarologists, and the portion posterior to it is called the abdomen. Considerable difference of opinion has existed, and indeed still exists, as to the propriety of calling this portion of the body the abdomen. Some comparative anatomists consider that in the Tracheata nothing should be called the abdomen which is not legless, and they quote the instance of the spiders in the Arachnida; undoubtedly in the great bulk of the Acarina, what are known by the name of the two posterior pairs of legs are behind the constriction. This does not appear to me to be decisive because in other great groups of Arthropoda the abdomen does bear appendages which are used for walking or swimming, and I do not see any reason why it should not do so in the Acarina; although it might raise a question whether the third and fourth pairs of legs in the Acarina can be considered homologous with those of the spiders, etc. In the Phytoptidæ and Demodicidæ the abdomen is legless, and is vermiform in character; but in the former of those families only two pairs of legs are present, the two hind pairs being probably lost, either from the mode of life or otherwise. Again it is said that the constriction is merely external and does not indicate the arrangement of the internal organs into two entirely separate groups; but it seems to me that the arrangement of the internal organs is on the whole what might be expected if the hind division of the body be considered to be an abdomen; the genital organs always lie there, although in some few instances their products are discharged through apertures far forward in the cephalothorax; this is the case with the male sexual aperture of most Gamasidæ; which is just behind the rostrum, but is not provided with any intromittent organ. A similar position is found in the genital aperture for oviposition of many female Ixodidæ; which is so far forward as to have given rise to the idea that in that family the ova were laid through the mouth-opening. The ventriculus and hind gut are also found in what is usually called the abdomen. The sense-organs are all in the cephalothorax. In most soft-bodied Acari the anterior division, or cephalothorax, is capable of considerable movement upon the abdomen as a basis or fulcrum; special muscles are provided for the purpose. This capability of motion is specially noticeable in *Cheyletus* and *Bdella*. In the Oribatidæ the two portions of the body are divided by a distinct but small chitinous partition, which no doubt does not extend entirely through the body but leaves a large aperture through which the œsophagus and other organs pass. The cephalothorax and abdomen are often very different in character; the Phytoptidæ are an extreme instance of this. On the whole I am inclined to think that the expression abdomen is fairly used for the portion of the body posterior to the constriction between the second and third legs in the Acarina, where that constriction exists; in accordance with the general practice of acarologists I have used the term in that sense in this book.

In order to avoid the question and to adopt neutral names Oudemans proposed calling the two divisions of the body in Acarina the "Prosoma" and the "Metasoma;" one or two acarologists are inclined to follow him.

Kramer and some other acarologists following him have proposed dividing the cephalothorax into two divisions, the anterior of which they call the "Capitulum;" I cannot say that I like this term; it is too similar to "caput," and seems to identify the part spoken of with the caput of the Insecta; but they are not homologous; in such Acari as are possessed of eyes these organs are not upon the so-called capitulum but on the cephalothorax behind it, and I confess that I do not recognise as correct a caput or capitulum which does not include the eyes, or any part of the great nerve ganglia. The fact is that the term is practically used for the maxillary lip or hypostome and whatever organs happen to lie above it; that is to say on the dorsal side of it; in those numerous cases where this portion of the cephalothorax is divided from the posterior portion by a constriction or flexible band or suture; this is not the case in any of the Tyroglyphidæ which I am acquainted with, unless the genera *Histiostoma* or *Lentungula* can be considered instances, which I hardly think they can be. The old term is the "rostrum," and on the whole I think it should be preserved although I admit that it is a vague term which has been used in different senses by different authors; and which can only be taken to mean the anterior part of the cephalothorax; because although in some cases, such as the Ixodidæ, a perfectly clear demarcation exists between the rostrum (which term in this family is usually used for the maxillary lip only) and the remainder of the cephalothorax; yet in the larger number of the Acari the demarcation is lost and it is impossible to say where one ends and the other begins: this difficulty is not cured by calling the rostrum a capitulum in the cases where the demarcation is evident; for these instances fade into those where it is entirely absent by insensible degrees.

The Mouth and Trophi.

The **Mouth** is usually a moderate-sized opening in the underside of the anterior part of the cephalothorax. Occasionally, as in the exceptional genus *Lentungula*, it may be practically at the actual anterior end. It is very simple compared with that of some other families of Acarina. Its trophi consist of the mandibles, the maxillary lip and maxillæ, the maxillary palpi; and finally, in some cases, a more or less rudimentary lingua. I have not detected any epipharynx, an organ highly developed in some Acari, *e. g. Bdella*.

The **Mandibles** are always chelate, except in the one genus, *Histiostoma;* they are usually short and thick in form, and are always set so that the fixed arm of the chela is the dorsal one, and the moveable arm works perpendicularly, not sideways as in most non-acarine Arachnida, such as scorpions, etc. They closely resemble the mandibles of the Oribatidæ and of the Sarcoptidæ; they most commonly have three or four teeth on each arm of the chela. They are moderately retractile, but not nearly so much so as those of some predatory Acari such as the Gamasidæ; they are manifestly tearing and crushing organs. A short indication of the muscles by which the mandibles are worked will be found in the section of this chapter on musculation (p. 120). Illustrations of the mandibles will be found in the plates of almost every species, and their musculation is shown in Pl. C, fig. 1; and the part that is contained within the mandible itself in Pl. I, fig. 7 (*Lentungula*), and in the mandible of *Chortoglyphus arcuatus* (vol. ii).

In most species the rostrum is usually held sloping downward, or even perpendicularly downward in some cases. Thus the dorsal, or upper, edge of the mandible becomes the anterior in ordinary position, but this may be altered at any moment in most cases. In such a species as *C. arcuatus*, where the mouth and trophi are almost enclosed in a stiff chitinous hood; which is anchylosed to, and continuous with, the dorsal cuticle, the position is scarcely capable of alteration.

The mandibles in the genus *Histiostoma* are totally different from those of the remainder of the family; they are not chelate; they are saw-like, or in one instance knife-like. A tolerably full description of the variation of these mandibles in the known species will be found in the description of the genus and in the accounts of the various species, therefore I will not duplicate it here. It is probable that the *Histiostoma* mandible may be considered as derived from the ordinary chelate mandible by the suppression of the distal joint, which forms the moveable arm of the chela; but if so a considerable amount of correlated modification must be admitted to have taken place in the organ, and the mode of action has become very different from that of the original form. Instead of the slow and irregular tearing movement of the chelate mandibles of the ordinary Tyroglyphidæ, those of *Histiostoma* have a rapid, alternate, regular, forward and backward motion, forming a sawing action. The creature wades forward in the film of liquid in which Acari of this genus are usually half immersed, and the mandibles cut the vegetable cells as it advances, releasing the cell contents which are passed into the mouth by means of the palpi.

Exceptional genera with saw-like or knife-like mandibles of one joint are found in other families of Acarina, which usually have those organs chelate, as in the Oribatidæ, the Gamasidæ, etc.

The Maxillary Lip and Maxillæ.—In all Acarina the maxillæ are united together so as to form a broad lip below the mouth, known as the maxillary lip or hypostome. In many families, such as the Gamasidæ, the Trombididæ, the true Sarcoptidæ, etc., the blending is so complete that all trace of the maxillæ as separate, free, paired organs is lost. In the Oribatidæ, however, it is only the basal portions of the maxillæ which are fused; the distal parts form broad, almost free blades, truncated at the distal end, and with the truncated end toothed, and more or less chitinized. These are usually called the maxillæ, and are highly developed in the genus *Hoploderma* (formerly called *Hoplophora*, which name is, however, preoccupied); there the maxillæ have every appearance of being functional. In the Tyroglyphidæ the maxillary lip and maxillæ are of the Oribatidæ type; but the fusion is greater than in that family, and these organs are not nearly so highly chitinized; indeed they are usually so soft and transparent that it is difficult to believe that they have much, if any, biting or crushing functions; still the form of the Oribata maxilla is, as a rule, clearly traceable. Good examples of this formation are *Glycyphagus Canestrinii* (Pl. XI, fig. 10), *Glycyphagus platygaster* (Pl. XIV, fig. 6), and *Tyroglyphus siro* (vol. ii).

The **Maxillary Palpi**, which are the only palpi, spring from small shoulders, or notches, one on each side of the maxillary lip; they are not active, constantly moving organs like the corresponding parts in Gamasidæ and Oribatidæ, nor are they the strong raptorial palpi of *Cheyletus* or *Trombidium;* they lie along the lateral edges of the maxillary lip, the distal joint only being frequently turned downward: they usually consist of three free joints only; the proximal being the longest and thickest; except in *Histiostoma;* in some species this joint also shows more or less tendency toward fusion with the Hypostome. I am inclined to think that these appendages may probably be regarded as derived from a five-jointed palpus, such as that of the Oribatidæ, the trophi of which have so strong a resemblance to those of the Tyroglyphidæ in most other respects; the basal joints having become fused, either with the proximal free joint or the maxillary lip; indeed, in *Lentungula* the five joints may be traced. The principal other appendages, *i. e.* the legs, have five free joints in both of the families. The joints are usually cylindrical, or some approach to that form, often narrowing a little toward their ends;

the distal joint however is often truncated, sometimes even enlarged at the end; it often bears a sensory papilla and a few small hairs, probably tactile. There are seldom above one or two hairs on the other joints, but these may be larger.

As is the case with the mandible, so also with the palpus. That of *Histiostoma* differs almost entirely from that of all other genera of the family, although, of course, really modified from the type form; but the palpus of *Histiostoma* is as actively functional an organ as that of any Acarus. Mégnin considers that there are only two free joints, and that the third, usually found in the family, is wholly anchylosed to the hypostome; it appears to me, however, that there is a third free joint, but small, and of far less importance than is usual in the family. The two distal joints of the palpus bear a thin, broad, and transparent membrane; sometimes running their whole length, sometimes a part only (Pl. III, fig. 1, *p. m.* fig. 20; Pl. IV, fig. 7); it may surround both sides of the distal joint. In *H. rostro-serratum* this membrane runs along the hypostome also, and the membranes from the two palpi meet in the middle of the hypostome and join; thus forming one continuous, broad, undulating margin; which turns over somewhat on the hypostome, and forms a funnel leading into the mouth; or rather a half-funnel; for it is not closed above; even in those species where the membrane does not run on to the hypostome it directs the nutritive fluids towards the mouth. On the distal joints of the palpus are two flagella; the anterior is usually the larger where there is a difference; they are turned almost at right angles; the anterior is constantly in motion when the creature is feeding, beating regularly and rapidly; these flagella cause the current which carries the food-material into the mouth.

The **Lingua** is an organ not much developed in the Tyroglyphidæ; where present it is a simple, rather narrow, triangular membrane arising from the floor of the mouth and directed forward; which indeed is the usual type in the Acarina. It may be seen well in the drawing of *Tyroglyphus siro* (vol. ii), in *Lentungula algivorans* (Pl. I, fig. 8), *Glycyphagus platygaster* (Pl. XIV, fig. 6), *etc., li.*

The Legs.

These organs in the Tyroglyphidæ are ordinarily more chitinized than the body, often forming a striking contrast which reminds the observer of the nymphs of many Oribatidæ; a good example of this is *Histiogaster corticalis* (vol. ii).

The leg consists of five free joints; which is the typical number all through the Oribatidæ, the Sarcoptidæ and some of the smaller groups of Acarina. The primitive form of each joint, or rather of the integument which covers it, may be considered to be cylindrical; or that of a truncated cone as it usually slightly diminishes in diameter toward the distal end. The form is greatly modified in various ways in different joints and in numerous species; in the Coxa the cylindrical shape is usually almost lost; in the Tarsus the distal end is almost closed, and sometimes nearly pointed. Apophyses for holding purposes may arise, as in the male *Aleurobius farinæ*, but these instances are uncommon. Respecting the holding leg of the male *Rhizoglyphus*, which is the third leg, a question might possibly be raised as to whether it really is a leg of five joints or only of four. The answer to this question depends upon whether the great fixed claw-like process which terminates this joint, and is almost the whole of the joint, is to be considered as the homologue of the true claw, or unguis, of the other legs; or as the homologue of the whole tarsus, the claw being absent. Had the solution of this problem depended upon *Rhizoglyphus* alone it might probably have been a difficult one, but the existence of *Lentungula* seems to me to simplify it, as in that genus the distal or fifth joint has a form very similar to that of the third leg of the male *Rhizoglyphus*, and is used for climbing purposes; but it is evidently the whole tarsus because it bears a distinct separate claw, although of an exceptional character.

Some authors do not use any names for the joints of the legs in Acarina, but simply number them from the proximal to the distal end. I have, however, in this book preserved the same nomenclature which I used for those of the Oribatidæ. I think that on the whole it is better, as the names convey an idea of the function, and the special joint referred to is usually more easily identified by the name than by a number. These names, beginning at the proximal end, are—firstly, the coxa; secondly, the femur; thirdly, the genual; fourthly, the tibia; and fifthly, the tarsus.

The **Coxa** is usually a more or less hemispherical or shield-shaped joint, having almost universal motion; it is usually supported by an epimeron embedded in the cuticle from whence *inter alia* various muscles arise to communicate the motion.

The **Femur** varies greatly in importance in different species, but on the average it is not such a powerfully developed joint as it is in the Oribatidæ, where it is almost always the principal joint of the leg. In the Tyroglyphidæ it is frequently less thick and strong than the genual. In *Aleurobius farinæ* it is the joint which bears the holding apophysis in the first leg of the male, and is far the most powerful joint: in most legs of the genera *Tyroglyphus* and *Rhizoglyphus* it is either of the first importance, or only second to the genual; in *Glycyphagus spinipes*, *G. domesticus*, *G. dispar*, and many other species it is not by any means a principal joint.

The **Genual**, which is almost always a small joint in the Oribatidæ, is frequently one of the largest, and sometimes actually the largest, in the Tyroglyphidæ. Not that it is as long as the tarsus, or indeed often as some of the other joints, but it is often very much thicker; it is the joint which usually gives the change in position from the proximal to the distal joints. It is common that Acari, particularly swift species, hold the tibia and tarsus almost perpendicular, while the coxa and femur are nearly horizontal; the genual, which is the central joint, naturally is the one that gives this change of direction. In the Oribatidæ this is almost universal and very distinct. In some of the Tyroglyphidæ however although the same thing exists it is not quite so evident; because from the much greater relative size of the genual it pushes back, so to speak, occupying a part of the space which would be devoted to the larger femur in the Oribatidæ; and also because the length of the tarsus in some Tyroglyphidæ is so great that the tibia is not required to be perpendicular, and partly shares with the genual in producing the change of direction.

In the large families of Acarina, which have six or more joints to the leg, such as the Trombididæ, Gamasidæ, Hydrachnidæ, Halicaridæ, etc., this change of position by the genual is of course more or less lost; but the leg of five joints may probably be looked upon as the primitive arrangement in the Acarina; the legs of more numerous joints being derived from it by division of the tibia, or other joints; if this be borne in mind the genual and its action as a changer of direction may often be traced.

The **Tibia** is not usually a very important joint as regards size; it is however of interest in most active Acarina because it is the joint which bears the great tactile hair near its distal end in the median line of its dorsal surface; this hair, which is most developed on the anterior legs, practically to a great extent serves eyeless Acarina such as the Tyroglyphidæ and Oribatidæ as a substitute for the sense of sight.

The **Tarsus** is most commonly the longest and thinnest joint in the leg; it often diminishes rapidly near its proximal end and is drawn out gradually almost to a point at the distal; in the hind legs of

Glycyphagus domesticus and *G. spinipes* it is as long as all the other joints of the legs taken together. In the third, or holding, leg of the heteromorphic male *Rhizoglyphus* the tarsus is very short, and comes to a point at its distal end; the whole joint being transformed into a great clasping claw, which does not bear any true claw like the other tarsi do. In *Lentungula* the tarsi of the two anterior pairs of legs are similar to that of the heteromorphic male of *Rhizoglyphus*, and are used in climbing over rock, etc., but they bear a distinct but small claw mounted upon a long flexible peduncle which is capable of independent motion. The tarsus of the fourth leg of the male *Glycyphagus sciurinus*, which must also be regarded as a clasping leg, has a large blade along its dorsal surface, which increases in width toward its distal end, and projects beyond the body of the joint, and even larger blades are to be found on the tarsi of the male *G. Crameri*. Blades however are not common upon the legs of Tyroglyphidæ, although they are upon those of the Oribatidæ.

In the genera *Tyroglyphus*, *Rhizoglyphus*, *Carpoglyphus*, and some other genera of Tyroglyphidæ the tarsi of the first or first and second pairs of legs bear near their proximal ends, in the median line of the dorsal surface, a curved rod of clear chitin sometimes increasing a little in diameter just at the distal end, which is always rounded or truncated, never pointed: the function, if any, of this rod is not known; but it is very persistent, appearing in a large number of species and genera. The tarsi on the average bear more spines and hairs than the other joints of the leg. In *Rhizoglyphus* the spines are mostly very short and strong, and the same thing may be seen on the tarsus of *Histiostoma rostro-serratum*. The spines are longer, but not so strong on the tarsus of *Hericia Robini*. Sometimes one or more very long hairs are found on the tarsus near the distal end, as in *Carpoglyphus*, *Histiostoma rostro-serratum*, and the hypopus of *Glycy-*

phagus sciurinus, and usually there are rather more hairs on the tarsus than on the other joints of the leg; but hairs are not, as a rule, very numerous on the legs of the Tyroglyphidæ; an exception, however, is found in the tarsi of *Glycyphagus spinipes*, which are densely clothed with minute, extremely fine hairs.

The males of the genera *Tyroglyphus*, *Aleurobius*, *Chortoglyphus*, etc., usually have a pair of suckers on the inner side of the tarsus of each fourth leg, doubtless for the purpose of holding the female.

The **Ambulacra** of the Tyroglyphidæ consist almost invariably of a single claw, either with or without a caroncle or sucker. In the foreign genus *Hemisarcoptes*, Ligniere, the claw is entirely absent, and is replaced by a sucker on a long pedicle. Kramer, however, considers that the single species of which this genus consists does not belong to the Tyroglyphidæ at all, but to the Sarcoptidæ, sub-family Canestrininæ. Personally I have not ever seen the species, but from the published literature I should be inclined to suppose that Kramer's view is likely to be correct. The claw is usually largest in such genera as *Rhizoglyphus*, where the caroncle is entirely absent. In that genus it is very strong and much curved; in the two hind pairs of legs of *Histiostoma*, which also is without caroncles, the claw is almost straight. In some genera, such as *Glycyphagus*, or perhaps I should rather say the typical portion of that genus, composed of such creatures as *G. spinipes* and *G. domesticus*, the claw is almost rudimentary and has the effect of arising from the centre of the caroncle without any other direct communication with the tarsus; but in reality very minute tendons pass from the tarsal muscles to the base of the claw, which is generally enlarged or provided with projections at right angles to the length of the claw. In the genus *Lentungula* the claws of the first and second pairs of legs, which are very minute, are mounted upon long, flexible peduncles, which can be bent in all directions at the will of the creature; the peduncle springs from the side, not the end, of the tarsus (Pl. I, figs. 4—6). In this case the action of the claw appears to be rather that of a feeling and searching organ than of a holding or walking one; the climbing organ is the tarsus itself, the whole of which is transformed into a great claw-like piece, with a bluntly pointed distal end.

The caroncle, or sucker, is entirely absent in *Rhizoglyphus* and *Histiostoma*, and almost absent in *Tyroglyphus*, *Hericia*, etc. On the other hand, it is the principal ambulacrum in *Glycyphagus*, *Chortoglyphus*, *Carpoglyphus*, etc. It is a thin membrane, varying in form in different species, and which usually collapses when the tarsus is lifted, its true shape being only visible when it is pressed to the substance the creature is walking on. Almost the only way to see it properly is to put the creature alive into a glass cell and get it to walk on the under-side of the thin glass cover, and examine the caroncle with a microscope while it is doing so. Probably the finest caroncle known to me in the Tyroglyphidæ is that of *Glycyphagus sciurinus* (Pl. XVIII, fig. 8).

In the hypopial stage some species, *e. g. Histiostoma rostro-serratum* and *H. pulcrum*, have the fourth leg terminated by a hair or hairs only, without either claw or caroncle; this may be the condition of the third leg also, as in *Glycyphagus Crameri.*

The **Sternum** and **Epimera,** which are such a well-marked feature of the Tyroglyphidæ, Sarcoptidæ, etc., are chitinized in-pushings of the ventral cuticle, which have formed blades usually exposing their lower edges only on the ventral surface; the rest of the blade being sunk in the body, and forming a series of rigid skeletal pieces, the sides of which afford surfaces for the attachment of the numerous muscles which arise therefrom. The sternum is a straight blade in the median line of the cephalothorax; it usually bifurcates at its anterior end like the letter Y, only that the arms are curved, convex on the inner side; they generally run to or near to the inner sides of the coxæ of the first legs. The sternum is sometimes not a mere blade, but is spread out on the side where it is most deeply embedded in the body, and forms a bayonet-shaped sclerite, one edge of which comes to the ventral surface (Pl. C, fig. 6). In some cases the central shaft of the sternum may be very short, or even entirely absent, only the arms remaining; or the arms may be absent, leaving the shaft only. In rare cases the sternum is continued sufficiently far back to be joined to a chitinous ring surrounding the genital aperture; in the female of *Glycyphagus dispar*, where there is not any shaft to the sternum, the ends of the two arms are joined to such a ring.

The epimera are blades which are frequently more or less expanded at the end nearest to the median line of the body; that end is usually rounded, while the outer end, next the coxæ, is more commonly thickened, but not so much expanded. The edge which reaches the ventral surface is often also somewhat thickened, being thus stronger than the edge within the body. The epimera are seldom straight, they are mostly curved, and sometimes have a complicated shape; they also generally have the blade slightly turned or twisted within the body, giving a certain resemblance to one blade of a steamer's screw in shape. This turning within the body in semi-transparent species causes the epimeron, when seen from the ventral surface, to look spatulate. This appearance is generally much more noticeable in the epimera of the two anterior pairs of legs than in those of the two posterior pairs; indeed, the former are usually the largest and best developed in most respects (see Pl. XIX, figs. 4, 7, 12). The first or second epimera may be joined to the sternum, or may be free at their inner ends; they may be joined to a ring surrounding the genital aperture, as in the female of *Glycyphagus dispar*, or may be joined by cross pieces at their inner ends or otherwise, as in the male of *Lentungula algivorans* (Pl. I, fig. 3).

The **Anus** in the Tyroglyphidæ is usually a mere slit at or near the posterior end of the abdomen; it is ordinarily upon the under-side. It may, however, be partly terminal, as in *Histiogaster* and *Hericia;* it may have more or less chitinized labia, which are sometimes thin plates lying against one another; their posterior ends may project beyond the hind margin of the abdomen, as in *Glycyphagus sciurinus.* There are often a few short hairs round the anus, and in the males of *Tyroglyphus*, *Histiogaster*, etc., there is a pair of conspicuous copulative suckers, one on each side of the anus, which is generally large and capable of passing solid dejecta.

The external genital organs are described in the portion of this chapter relative to the reproductive system.

Internal Anatomy.

The **Alimentary Canal**, Pl. A, figs. 1—5, and Pl. C, figs. 1—3 and 8, 10.

Dujardin was of opinion that the Acari did not possess an alimentary canal at all, but that the food passed into the general body cavity. The erroneousness of this view, notwithstanding that author's keen powers of observation, has long been known; the alimentary canal in the Acari is a thoroughly closed system, quite cut off from the body cavity, except so far as fluids, and possibly even crystals, may pass through the walls of the canal itself to some limited extent as a physiological process, in the manner indicated in the portion of this chapter where the ventriculus is more especially dealt with. Some, by no means inconsiderable, anomalies occur in the system in such families as the Trombididæ, Bdellidæ, Hydrachnidæ, etc., which present more or less one type of canal; which although naturally having a resemblance to the canal of the Tyroglyphidæ in its broad general character, yet differs widely from it in many important features. The canal of the Tyroglyphidæ is far more closely allied to that of the Sarcoptidæ and the Oribatidæ, and is even more or less similar to that of the Gamasidæ; notwithstanding the far higher organisation of that family in almost all points of its anatomy; it is, however, decidedly simpler than that of the Gamasidæ or Oribatidæ, as might reasonably be expected.

The alimentary canal of the Tyroglyphidæ, like that of the Oribatidæ, lies somewhat loosely in the body cavity; being firmly attached at the oral and anal ends, but having very little attachment between those points; although it is slightly supported by a certain amount of connective and fatty tissues. If the oral and anal attachments and the pharyngeal and rectal muscles be cut, the canal may be removed on a hair quite entire; it was doubtless this slightness of attachment which enabled Gudden to obtain the organs successfully by the curious method which he employed.

The post-oral alimentary canal in the family which I am dealing with consists of the pharynx; the œsophagus; the ventriculus, with two large cæcal appendages; the colon; the rectum, terminating in the anus; and finally of two Malpighian vessels; which, however, do not appear to be invariably present.

The **Pharynx** (Pl. A, fig. 5 and figs. 1 and 2, *ph*) is the great swallowing, or sucking, organ in all Acarina of which we know the anatomy; it commences at the posterior end of the oral chamber. Haller * says that in Tyroglyphus it is encircled by a chitinous ring where it joins the mouth-cavity, but I have not been able to detect this nor have I found it drawn or described by any other author; its presence would be somewhat unexpected, as it would apparently be likely to interfere with the great function of the pharynx; as the pharynx does not join the mouth in a direct perpendicular plane, but rather in a curved and diagonal loop.

* "Zur Kenntniss der Tyroglyphen und Verwandten," in 'Zeit. wiss. Zool.,' Bd. xxxiv, p. 276, Taf. ix, fig. 16, *b*.

Nalepa, in the paper so constantly referred to in this chapter, is probably the only author who has described and figured the pharynx of any of the Tyroglyphidæ correctly,* but reliable information as to the form and construction of the organ in many other families of Acarina is to be found in works by MacLeod † for *Trombidium*, *Hydrachna* and *Erythræus*, by Croneberg ‡ for *Eylais*, Henkin § for *Trombidium fuliginosum*, etc., Winkler || for Gamasidæ, and by myself for *Thyas*,¶ *Bdella*,** and *Gamasus*.†† The description and figure given by Schaub for *Hydrodroma* are in my opinion incorrect; unless, indeed, the pharynx of that creature be wholly different both in position and structure from that of every other Acarus that has been investigated; which scarcely appears to be what might be anticipated having regard to the very close relationship between *Hydrodroma* and some of the creatures whose anatomy has been studied by Croneberg and myself.

What may be considered the typical form of the pharynx in the Acarina consists of two more or less chitinized half-tubes, like the gutter-pipes which run under the eaves of houses, laid one inside the other; both having the convexity downward, and running longitudinally in the median line of the anterior portion of the cephalothorax; these two half-tubes are joined, more or less flexibly, all along their lateral edges. The lower half-tube is really a continuation of the floor of

* Nalepa, Abtheil. i, pp. 198, 199, Taf. i, fig. 2.

† "La Structure de l'Intestin antérieur des Arachnides," in 'Bull. Ac. Belgique,' 1884, Nos. 9, 10.

‡ "On the Anatomy of *Eylais extendens* (Müller), with observations on allied forms," in Russian, in 'Trs. (Nachrichten) Soc. Nat. Moscou,' 1878.

§ "Beiträge zur Anatomie Entwicklungsgeschichte und Biologie von *Trombidium fuliginosum*, Herm.," in 'Zeit. wiss. Zool.,' Bd. xxxvii (1882), p. 569, Taf. xxxiv, figs. 5, 7.

|| "Anatomie der Gamasiden" in 'Arb. Inst. Wien,' 1888, Bd. vii, Hft. 3, p. 339, Taf. xx, fig. 15.

¶ In 'P. Zool. Soc.,' London, 1895, p. 180, pl. ix, fig. 27.

** In 'Tr. Linn. Soc.,' London, 1896, vol. vi, pt. 7, p. 485, pl. xli, figs. 1, 2; pl. xliii, figs. 3, 4.

†† Ibid., vol. v (1892), pt. ix, pl. xxxv, fig. 73.

the mouth and the maxillary lip; it forms the floor of the pharynx; it is usually more chitinized than the upper half-tube, and is either permanently fixed or else attached to very short muscles, as in the Oribatidæ. The upper half-tube is more or less flexible, and forms the roof of the pharynx; it is by the movements of this roof that suction and swallowing are effected; into its dorsal surface a number of paired muscles are inserted, generally by a tendinous attachment, which is often long and single, as in *Bdella*, or may be a line of several very short tendons, as in *Thyas*: these muscles are conspicuous, and may, in good sections, be easily traced upward or upward and backward; and it will then be found that they arise from the lower surface of the roof of the rostrum (Pl. A, fig. 5, *rr*), upon the upper surface of which the mandibles rest; this roof is called "Chitin Boden" by Schaub, who treats it as a floor which the mandibles repose on, and its hinder part, which is sometimes thickened, is called "Chitin Brucke" by Henkin. These muscles (fig. 5, *m l p*) I have called the *levator tecti pharyngis* or *dilatores pharyngis* muscles; when they contract they draw the roof of the pharynx upward, leaving a partial vacuum between it and the floor of the organ; into this vacuum the food contained in the mouth rushes; it is prevented from returning by some sort of valve or constrictor muscles; the *dilatores pharyngis* are then relaxed, the upper half-tube is allowed to descend upon the lower one, partly often by its own elasticity, but more by the action of *occlusor pharyngis* muscles (*m o p*). The food is thus forced backward into the œsophagus, and finally into the ventriculus. There is considerable variety in the occlusor muscles, but probably the commonest form, particularly in such genera as *Trombidium* and *Bdella*, is that between each *distensor* muscle and the one before it, a short, transverse, horizontal muscle passes across and above the pharynx; it is attached at each end to one edge of the two half-tubes where they join; when these muscles contract the edges of the half-tubes are brought nearer together; consequently the upper and inner half-tube is driven down upon the lower and outer one. This alternate action is the sucking process.

This type is a good deal departed from in *Gamasus*, where the lumen of the pharynx when very slightly distended is triradiate in the species which I have cut sections of, and the *distensor* muscles are inserted into the lateral as well as the superior walls of the organ; but the principle is similar.

The pharynx in the Tyroglyphidæ, or at least in those species of that family whose pharyngeal anatomy has been investigated, does not depart greatly from the type above described; but it is probably the simplest form of that type known, as might naturally be anticipated. In *Glycyphagus platygaster* the *distensor pharyngis* muscles consist of, I think, five pairs of muscles (Pl. A, fig. 5, *m l p*) placed in two longitudinal rows, one on each side of the median line. The second and anterior muscles are the longest, the length diminishing gradually in the third to fifth pairs. This arises chiefly from the strong upward turn which the pharynx takes as it passes backward. The central pair of muscles are almost perpendicular; those in front and behind radiate slightly, so as to raise the whole roof of the pharynx (*p r*), which is somewhat longer than the roof of the rostrum (*r r*), being the outer of the two more or less concentric curves. The *levator tecti pharyngis* (*distensor*) muscles of *Hericia Robini* are similar (Pl. C, fig. 1), but Nalepa, treating of those of *Tyroglyphus longior*, although he does not say how many pairs there are, says that they are numerous; but then he seems to me to draw four or five pairs wholly contained within the same transverse perpendicular plane,* an arrangement which I have not seen. But Nalepa's drawing is very small, and in

* Nalepa, 'Abth. i,' Taf. 1, fig. i.

the absence of any description on the point, I am not certain that this is his intention.

There is not any approach to the extremely diagonal *levator tecti pharyngis* muscles found, *e. g.*, in *Bdella;* this doubtless is a consequence of the far shorter rostrum of the Tyroglyphidæ.

The *levator tecti pharyngis* muscles in the Tyroglyphidæ whose anatomy I have studied are not attached to the roof of the pharynx by tendons which I could detect, as is the case in other families which I have investigated, and Nalepa does not draw or mention any such tendons; therefore we must at present conclude that they do not usually occur in the family. It may possibly be that as there are not transverse *occlusor* muscles passing between each *levator* muscle and its anterior neighbour, as in the other families spoken of, open space between the *levatores* is not so important.

It is probably in the *occlusor* muscles of the pharynx (*m o p*) that the greatest departure from the type given above exists. Instead of these consisting wholly of straight transverse muscles passing from one lateral edge of the half-tubes to the opposite edge (Pl. C, fig. 9, *m o p*), the Tyroglyphidæ known to me have only a few such muscles at the hind part of the pharynx, which is constricted principally by ring muscles passing round it; this may be seen clearly in dissections (Pl. A, fig. 2), and is similar to the arrangement in the Oribatidæ. The reason for this would appear to be that the members of both these families live upon solid food, not upon fluids like *Bdella* and *Trombidium*, and therefore the pharynx requires to be capable of much greater expansion and contraction.

The **Œsophagus** (Pl. A, figs. 1, 10, *æ*) where it joins the pharynx turns suddenly backward and slightly downward, forming almost an angle with that organ; at this point the lumen is very narrow when not distended. The effect of this is that in sagittal (longitudinal) section the two organs when at rest hardly look continuous; the œsophagus appearing to commence at a slightly lower level than that at which the pharynx terminates; although the continuity of the lumen is seen immediately these passages are at all distended. The œsophagus passes right through the centre of the so-called brain, as is usually the case in the Acarina. There is only a very short portion of the organ anterior to the cerebral mass in the Tyroglyphidæ whose anatomy is known to me, far shorter than is the case in *Trombidium*, *Bdella*, *Thyas*, etc., but the lumen is much larger. In the genera named the opening in the brain for the passage of the œsophagus is very small, scarcely larger than the diameter of the thin tube of the œsophagus when not occupied by food; in the Tyroglyphidæ it is greatly wider (Pl. A, figs. 9, 12; Pl. C, fig. 1), and the œsophagus when empty does not nearly fill it. This also is similar to what occurs in the Oribatidæ; doubtless for the same reason as the similarity of the occlusor muscles, viz. that solid food is swallowed by both families.

A short portion of the œsophagus usually lies behind the brain (Pl. A, figs. 1, 10); at its posterior end this often widens out somewhat, and sometimes is slightly invaginated, and protrudes a little into the ventriculus; this was noticed by Nalepa in *Tyroglyphus longior*, and I have seen a similar arrangement in some Oribatidæ; it serves to prevent the regurgitation of food from the ventriculus into the œsophagus, which is also hindered in some cases by a ring muscle.

The **Ventriculus** (Pl. A, figs. 1, 2; Pl. C, fig. 1, *v*) is the largest viscus in the alimentary canal; it is doubtless the great seat of digestion. In *Glycyphagus platygaster* it is a large sack with thick walls, and having a somewhat triangular form with the base of the triangle at the posterior end and the œsophagus entering at the anterior point; the posterior corners are strongly rounded; a somewhat similar form is described by Nalepa for *Tyroglyphus longior*. Gudden does not draw it so for *T. siro*, but Gudden's process of obtaining it had evidently so washed and softened the organ that its form was destroyed, for he does not draw, and apparently did not suspect, any distinction between the ventriculus and colon, but treats the two as one long sack (see Pl. A, fig. 4). Haller,* speaking of what he calls *Tyroglyphus setiferus*, a species which Berlese † considers to be only a synonym of *T. longior*, also omits to observe that the ventriculus and colon are different divisions of the canal; but he says that the ventriculus is deeply constricted in the middle and forms two retort-shaped halves; of course the anterior of these only is the true ventriculus.

Seen from the side the ventriculus in all species of Tyroglyphidæ with known anatomy widens towards the posterior end, so that it is both broader and thicker there than anteriorly; to such an extent is this carried that in *Hericia Robini* (Pl. A, fig. 1; Pl. C, fig. 1, *v*) it is nearly as triangular in lateral aspect as in dorsal. Nalepa draws the organ in *Carpoglyphus anonymus* ‡ as of similar shape, and Haller gives the same form for that of what he calls *Tyroglyphus setiferus*.

The ventriculus in all investigated species of the family has two cæca, and two only, but these are large (Pl. A, figs. 1, 2, *cæ*). They arise from the lateral edges of the ventriculus, one on each side, as paired organs; sometimes they have a slight tendency to be placed a little toward the ventral surface; they are so in *Glycyphagus platygaster*, and Gudden draws them so in *Tyroglyphus siro* (Pl. A, fig. 4). On the other hand, Nalepa figures those of *T. longior* as nearer the dorsal than the ventral surface (Pl. C, fig. 3). The cæca vary in form, and in the precise position on the edge of the ventriculus, according to the species; in *Hericia Robini* they are

* 'Zur Kenntniss der Tyroglyphen und Verwandten," in 'Zeit. wiss. Zool.,' Bd. xxxiv (1880), p. 276, pl. x, fig. 2.

† 'A. M. S. Crypt.,' p. 109.

‡ Nalepa, Abth. ii, Taf. iii, fig. 16.

narrowish, slightly constricted where they join the ventriculus about in the middle of its edge, are directed almost perpendicularly downward (Pl. A, fig. 1, *cæ*). In *Glycyphagus platygaster* they are broad, and widest at the proximal ends where they join the ventriculus, the whole lateral edges of which they occupy except the anterior third; they are directed nearly straight backward, only a little downward (Pl. A, fig. 2, *cæ*). Gudden draws them as springing from near the centre in *T. siro*, but directed backward and outward, and as narrower than those of *G. platygaster* (fig. 4). Nalepa draws those of *T. longior* as springing almost from the posterior end of the ventriculus (Pl. A, fig. 3), and as directed straight backward. They are sacks the form of which probably varies a little from time to time from peristaltic and other movements. The food contents of the stomach pass to some extent into the cæca, but these organs apparently also have some secretory function, particularly toward their distal ends, as in the *Oribatidæ*. They are generally about as long as the ventriculus.

The **Colon,** or proximal division of the hind gut, is sometimes an almost globular organ, as in *Glycyphagus platygaster* (Pl. A, fig. 2, *co*), *Tyroglyphus longior* (Pl. A, fig. 3, *co*), and *Carpoglyphus anonymus;* or it may be more elongated and funnel-shaped, as in *Hericia Robini;* it is entered by a large circular opening in the upper part of the posterior wall of the ventriculus (Pl. A, fig. 1, *co*); this opening is doubtless capable of considerable constriction, and is probably usually so constricted during life; but I generally find it open in sections, even when the creature is killed instantaneously by boiling water. The colon usually contains a digested, or partly digested, food-ball.

The **Rectum** varies in shape temporarily, according to the amount of dejecta which it contains; but when empty, a condition which is not usual, it is an elongated, more or less funnel-shaped viscus, the narrow end whereof adjoins the colon; there it is sharply constricted, forming a valve; it varies somewhat in different species; its direction is more or less downward, sometimes it is almost perpendicular; its distal end of course surrounds the anal opening, which is usually a longitudinal slit in the ventral surface, but may, in some species, be almost terminal; although even then it is more on the ventral than the dorsal surface. The posterior portion of the rectum is attached to the cuticle of the posterior end of the abdomen by a number of fine muscles, and threads of connective tissue which form almost a circle round the anus, but are not close together (Pl. A, fig. 2).

The Malpighian Vessels.—These are a pair of cæcal tubes which arise one on each side of the narrow constriction between the colon and the rectum. They may be of even diameter throughout, or may enlarge at the distal ends, as in *H. Robini* (Pl. A, fig. 1, *m v*); in that species they are considerably longer than the rectum. Nalepa draws those of *Tyroglyphus longior* and *Carpoglyphus anonymus* as shorter than the rectum; he also shows them as turning sharply toward the anterior end of the body (Pl. A, fig. 3, *m v*), and thus lying one on each side of the colon about the middle (perpendicularly) of its lateral wall. I have not seen them in that position in any species which I have investigated. Gudden depicts and describes them as very small in *T. siro;* he says he once found them filled with a yellow fluid. Berlese figures them as equally small in *Aleurobius farinæ.** I have not been able to detect them at all in *G. platygaster.*

Two precisely similarly situated Malpighian vessels exist in *Gamasus*, or at least in every species which I have investigated; although Winkler, in his admirable paper,† makes them discharge almost into the centre of the rectum, which I think must be one of the very

* "Ricerche sugli organi e sulla funzione della digestione degli Acari," Portici, 1896; also in 'Rivist. patolog. vegetale,' 1896–7, vol. v, pp. 130—195, Pls. viii, ix, fig. 36.

† "Anatomie der Gamasiden," in 'Arb. Inst. Wien,' T. vii, Heft 3 (1888), pp. 317—354.

few errors which his paper contains. In *Gamasus*, however, the organs are large, conspicuous, and abundantly functional; discharging quantities of the white, opaque, excrementary (? urinary) matter so well known in the Acari. In the Tyroglyphidæ they appear to be far smaller, more delicate, less evidently functional, and altogether strike the observer as more rudimentary, or, perhaps, nascent would be a more appropriate word.

The **Histology** and **Physiology** of the Alimentary Canal.

The outer wall of the canal, as correctly stated by Nalepa, consists of a structureless or almost structureless tunica propria, which looks like a fine line in section. Nalepa says that the wall of the œsophagus alone has a firm tunica propria projecting in three or four folds into the lumen.* I have not noticed this to any but a very slight extent in my sections of Tyroglyphidæ, but in *Bdella* I have found the lumen of the œsophagus between the pharynx and the brain almost filled up by projections inward from the wall.† These, however, appeared to me rather of an epithelial nature than plications of the *tunica propria ;* but in Bdella, with its œsophagus of small diameter and its solely fluid nourishment, the necessity for great expansion does not arise ; nor would the minute passage through the brain allow of it. Nalepa, however, says that there is not any epithelial lining to the œsophagus in *Tyroglyphus longior*, and he says in general terms that the canal of *Carpoglyphus anonymus* resembles that of *T. longior*. I have not observed any in the Tyroglyphidæ. Leydig did not find any in *Ixodes;*‡ Henkin does not mention any in *Trombidium*, but he deals rather shortly with the his-

* 'Abtheil,' i, p. 202, pl. i, fig. 8.

† "The Internal Anatomy of Bdella," in 'Tr. Linn. Soc. London,' vol. vi, pt. 7, p. 487, pl. xlii, fig. 28.

‡ "Lehrb. d. Histologie," Frankfurt-a.-M., 1875, p. 230, § 299.

tology of the fore-gut. Pagenstecher on the other hand considered that he had found one in *Argas reflexus*,* but Nalepa thinks that Pagenstecher must have been mistaken. Berlese draws an intima as the inner tunic of the œsophagus in the Oribatidæ. The inner tunic of the ventriculus consists of rather large clearly nucleated cells, forming at first a tolerably even layer; they are apt to remain so for a considerable period in the anterior portion of the viscus; when in this condition I have found these cells in *Glycyphagus platygaster* to measure from about 16 μ to about 30 μ in length and width, by about 12 μ to 16 μ in thickness; and to be furnished with large and clear round nuclei of about 10 μ to 13 μ in diameter by about 5 μ in thickness. Nalepa says that those of *T. longior* are as thick as wide. A process takes place with these cells which is not peculiar to the Tyroglyphidæ amongst Acarina; nor apparently to the Acarina amongst Arachnida,† although, of course, there is considerable variation in different orders, which it would be out of place to enter into fully here, but which may be shortly summarised as follows:—The individual cells gradually elongate inward into the lumen, not regularly or all together, but irregularly in groups or single cells; this elongation continues until the cells present almost a columnar appearance. Nalepa says that in *Tyroglyphus longior* they are then 20 μ to 28 μ in length, with an extreme width of 9 μ; in many Acari, however, they are much longer in proportion. The food which has been taken into the ventriculus has been acted upon, partly probably by the secretion of the salivary glands, and partly probably by the secretion of the glandular cells or

* "Zur Anatomie von *Argas reflexus*," in 'Zeit. wiss. Zool.,' 1862, Bd. xi, p. 145.

† See Bernard, "Notes on some of the Digestive Processes in Arachnida," 'J. R. Micro. Soc.,' London, Aug., 1893, vol. xiii, p. 427, pl. vi. Berlese, "Ricerche sugli organi e sulla funzione della digestione negli Acari," 'Riv. di Patologia,' 1896, vol. v, p. 129. Reprinted, Portici, 1896. "Circa il Mesointestino di alcuni Aracnidi," ibid., 1899, vol. vii, Nos. 5—8. Michael, "Anatomy of Bdella," loc. cit., p. 489. Henkin, op. cit., p. 571.

portions of the cæca of the ventriculus itself, and has thus been prepared for absorption; the fluid portions of the prepared food are absorbed into these elongated cells by endosmosis. The cell becomes crowded with droplets of fluid prepared food, the digestion and elaboration of which takes place within the cell itself; the cell now swells at its distal (inner) end and becomes clavate; they either continue to project straight into the lumen or the clavate portions bend over the unelongated cells next to them, if there be any. The clavate portions also become filled with food droplets, and the whole of the finally elaborated nourishment passes by exosmosis through the outer walls of the cells and the tunica propria into the general body cavity, where it mixes with the blood. When the nourishment has passed out of the clavate portion of the cell a constriction arises at the proximal end of the clavate portion, that portion becomes more or less globular, the constriction increases; until finally the inner globular portion of the cell, which has become large, breaks off and falls into the lumen of the ventriculus. These cells are empty, or nearly so, except that a certain amount of excretory matter is left in the cell; this crystallises or forms small concretions, many of which have existed before the food droplets have entirely left the cell; these are a portion of the white opaque excretory matter so abundantly present in the Acarina, and usually looked upon as being of a urinary nature. The cells lie quite loosely in the ventriculus and in the cæca, which are often full of them (Pl. C, fig. 10), but they gradually crumple up, and in such Acari as the Tyroglyphidæ, Oribatidæ, etc., where the passage from the ventriculus to the anus is by a hind gut fitted to pass solid dejecta, they form a part of the balls of excremental matter found in the colon and rectum. Nalepa says that in *T. longior* these balls can be shown by micro-chemistry to contain uric acid abundantly, but not in a concretionary or crystalline condition.

The above, however, is not the only manner in which the urinary white matter, if it be urinary, finds its way out of the cells of the ventriculus; it probably passes out in solution in considerable quantities into the body cavity. Bernard also thinks that crystals and concretions pierce the wall of the canal and pass out; he thinks that minute cells not distinguishable from blood-corpuscles are formed in the ventricular cells, and that they really are blood-corpuscles, which finally pass through the walls of the canal, carrying the excretory crystals with them; this, however, seems a somewhat bold suggestion. It appears, however, certain that in some manner or other the urinary matter, either in a fluid or solid form, gets into the body cavity in large quantities. In Acari, such as Gamasidæ, Trombididæ, Hydrachnidæ, etc., which have large and actively functional Malpighian vessels,* these organs eliminate the urinary matter, and from them it is discharged, either directly or indirectly, by the anus. In creatures like the Tyroglyphidæ, however, in which the Malpighian vessels are comparatively small and sometimes apparently absent altogether, the urinary matter (or some part of it) forms crystals or concretions which seem to remain permanently in the body cavity, which in old specimens of such species as *Histiostoma rostro-serratum* and *Hericia Robini* is absolutely crowded with these objects; it is perhaps worthy of remark that these two species which show the accumulation of the concretions in such remarkable quantities are both waders, which practically pass their whole existence almost immersed in the fluids upon which they subsist.

* It must not be understood that the Malpighian vessels of these three families are homologous; their functions are analogous, but while the organs in the Gamasidæ are clearly homologous with those of the Tyroglyphidæ, the great single so-called Malpighian vessel found in the Trombididæ and Hydrachnidæ appears probably to be a modification of the principal line of the hind gut. See Michael, "A Study of the Internal Anatomy of *Thyas petrophilus*," 1895, in 'P. Zool. Soc.,' London, pp. 185—188.

When the Acari are mounted in Canada balsam these concretions do not depolarize light.

The cells near the distal ends of the cæca in *Glycyphagus platygaster* are usually thicker than those of the ventriculus itself; they have clear nuclei and nucleoli. The exhausted cells found in the lumen of the cæca before they collapse have an average diameter of about 20 μ. Berlese has figured the cells of the cæca of *Histiostoma rostro-serratum* practically similarly.*

The cells of the colon in *Glycyphagus platygaster* differ somewhat at the two ends of the viscus; those at the anterior end are flattish cells, somewhat of the nature of pavement epithelium; they average about 19 μ in diameter by a thickness of about 6 μ; those at the posterior end are smaller but thicker. They have an average diameter of about 13 μ, and are about as thick as their diameter; all have round nuclei of about 4 μ to 5 μ diameter, and are distinctly nucleated. Nalepa says that the cells of the colon of *Tyroglyphus longior* are flat and small. The colon does not contain clavate cells.

The cells of the extreme anterior part of the Rectum of *Glycyphagus platygaster* are clavate; those of the remainder have a length of about 24 μ, and a thickness of about 10 μ. Nalepa says that in *Tyroglyphus longior* the upper part of the rectum is lined with columnar cells whose secretory functions are unmistakable, and that they gradually fade into a small-celled epithelium which clothes the lower portion of the rectum and is covered by a soft cuticula; he also says that the clavate cells have small nuclei surrounded by a space (*Secretraum?*), and that they are not like fat-cells.

Nalepa states that the Malpighian vessels of *T. longior* have a wall of a soft structureless membrane and a lining of large round secretory cells with spaces between, that they project into the lumen, and are usually filled with finely-granular colourless matter, and that the nuclei cannot usually be seen: when

* "Ricerche sulli Organi, etc.," loc. cit., fig. 22.

seen they are round, about 7 μ in diameter, and frequently present several nucleoli.

The Salivary Glands (Pl. A, figs. 6, 7).—These glands are always known by this name in the Acari; it probably expresses their principal function, but I have elsewhere expressed a doubt whether it is absolutely a correct name. Gudden * calls them the salivary or poison-glands. There is not, however, any reason to suppose that the Tyroglyphidæ, which are vegetable feeders, require or possess poison-glands, although such a suggestion might readily be entertained with regard to the predatory families such as the Trombididæ. In *Trombidium* and *Bdella*, and also in the Hydrachnidæ, these glands assume great variety and importance. I have treated elsewhere of them fully with regard to these forms, and with regard to the views taken by different authors concerning them.† In such few Tyroglyphidæ as have been studied in this respect these glands are far smaller and simpler than in the great group of which *Trombidium* may be considered to be a type; in *Glycyphagus platygaster* the glands consist of two on each side of the body, lying close together at the side of the anterior part of the cephalothorax. Each of these glands is paired with its fellow on the other side of the body, but the two on the same side, although histologically similar, are very different in size. No one who is well acquainted with the salivary glands of the Trombididæ, etc., can doubt that the two pairs of glands above spoken of in *G. platygaster* are analogous. The larger of the two (Pl. A, fig. 6) is a flattened, slightly kidney-shaped gland consisting of very large, almost triangular, secreting cells almost radiating from a centre; they have an average length, in the radial direction, of about 40 μ to 50 μ, and an extreme width of about 30 μ; they have conspicuous round or elliptical nuclei of about 10 μ in diameter, which

* Loc. cit., p. 12, pl. ii, fig. 8.

† "The Internal Anatomy of *Thyas petrophilus*," loc. cit., p. 188. "The Internal Anatomy of *Bdella*," loc. cit., p. 492.

are distinctly nucleolated. At the point from which the cells radiate is a minute chamber, which is really the commencement of the duct, which is extremely fine. This gland has considerable similarity to the "reniform" salivary gland in *Thyas* and *Bdella*, and is probably the homologue of that organ; the cells are usually filled with a fine and slightly granular secretion, which stains very slightly with hæmatoxylin or carmine. Gudden evidently saw this gland in *Tyroglyphus siro*, and figures it fairly correctly (Pl. A, fig. 7); he does not say much about it, and it rather seems as if he took the large individual cells for lobes, but it is an extraordinary thing that he should have seen it at all by the process he adopted; that process would probably make the cells look lobe-like from endosmosis.

The other gland consists of two or three similar large cells, and is probably the homologue of the anterior salivary gland in *Bdella*.

The duct from these glands is extremely fine and difficult to follow to its point of discharge; but I am almost certain that its course is practically similar to that of the "main common duct" in *Thyas* and *Bdella*, viz. the ducts from the two glands from the same side of the body join not very far from the glands; the joint duct then runs along the side of the body, near the cuticle, until it reaches a point almost opposite the proximal end of the mandibles; it then turns inward and joins its fellow from the opposite side of the body upon the roof of the rostrum between the mandibles; the two having joined form a short common duct, which passes a short distance along the underside of the roof of the rostrum, and discharges into the rear of the mouth.

Haller * appears to recognise the existence of two salivary glands on each side of the body in the larva of *Glycyphagus* (*Dermacarus*) *sciurinus;* he apparently saw them, by transparency, through the skin.

* "Zur Kenntniss der Tyroglyphen und Verwandten," loc. cit., p. 277, Taf. ix, fig. 14.

The Reproductive Organs. Pl. B and Pl. C, figs. 1, 11.

Nalepa* is strongly impressed with the similarity of the reproductive system in the two sexes of the Tyroglyphidæ; this, however, does not appear quite as great to my mind as it does to that of the eminent Austrian acarologist; I should have thought that in some other families of Acari, *e. g.* the Oribatidæ, the resemblance was stronger. It is quite true, as Nalepa says, that in both sexes the true reproductive, or germinal, glands are two paired organs whose ducts do not coalesce until near the external sexual organ; but the intermediate course of those ducts and their development is very different in the two sexes. In the female the ring-form, so common in these organs in the Acari, is carried to its fullest extent; in the male it can scarcely be traced. It is also true, as Nalepa says, that in both cases each of the above-named reproductive glands is at first a nucleus-bearing plasma-mass not distinctly defined into cells; it is by a slowish process that a portion of the plasma surrounding each nucleus gradually defines itself as an independent cell containing the nucleus, and becomes a germ-cell or a spermatoblast, as the case may be. The Tyroglyphidæ doubtless vary considerably from the higher Acari in the structure of the genitalia and the development of the sexual products; yet in the higher Acari a similar plasmodic mass containing nuclei is often found, and Bertkau describes it in some spiders, *e. g.* the Agelenidæ.† When the Imago, of either sex, emerges from the nymphal skin the internal sexual organs are comparatively small; although even then they are of substantial size; but when the sexual products are fully developed and the oviducts are occupied by eggs or

* 'Abth. I,' p. 206.

† "Ueber den Generationsapparat der Araneiden," in 'Arch. Naturg.,' 41 Jahrg. (1875), p. 244.

the accessory glands of the male are stored with secretion, the reproductive organs become some of the largest, if not the largest, in the body: indeed they seem often to force almost all the other organs out of position, and even produce considerable distension of the external cuticle.

The Male Reproductive Organs. Pl. B, figs. 1—7; Pl. C, fig. 5.

These consist of the testes, two in number in all species whose anatomy is known;* the vasa deferentia; the ductus ejaculatorius; the accessory glands; and the penis with its surrounding sclerites and its and their muscles; and finally the genital suckers (so called), and the copulative suckers; they all usually lie in the hinder part of the abdomen.

The Testes.—In *Glycyphagus platygaster*, and in all other Tyroglyphidæ the anatomy of which is known, the testes consist, as above stated, of two paired organs; in *G. platygaster* they are pyriform, the broader end being the posterior; they lie far back in the body (Pl. B, figs. 1, 2, *t*); they are, as before stated, at first plasmodic masses with very numerous scattered nuclei, round each of which the plasma gradually collects and forms a cell; the formation being of course by individual nuclei at different times, not all at once. Nalepa figures the testes of *Tyroglyphus longior* similar in form, but one of them placed rather further forward in the body, involving a shortening of its vas deferens; he says that they are globular or oval, but later on become irregular in form; the testes of *Hericia Robini* I also found to be of the same shape,

* Haller describes and figures four in *Aleurobius farinæ*, and six in *Glycyphagus sciurinus*, but it is extremely doubtful whether this is reliable; he apparently did not dissect or cut sections, and probably mistook the accessory glands for a second pair of testes, and possibly even the cæca of the ventriculus for a third. Pagenstecher, treating of the same species, which he in error calls *T. siro*, only gives two; his paper, however, is very slight and cannot be considered an authority.

and Gudden's figure of those of *T. siro* is similar; but Nalepa figures those of *Carpoglyphus anonymus* as being more elliptical, the ellipse having its long axis transversely across the body, the vas deferens in the centre of the anterior side, and the spermatogenous layer chiefly on the posterior side. The testes have a soft tunica propria, but not any muscular or epithelial layer.

Nalepa gives the following account of the development of the sperm elements in *T. longior*. The central part of the testis is a finely granular protoplasmic mass in which numerous long nuclei are imbedded; near the centre they are crowded and small; near the periphery less numerous and larger. These nuclei are the starting-point for the formation of spermatoblasts; they grow greatly, become roundish; while the protoplasm surrounding them separates itself from the adjacent plasma; finally they become formed cells, united by protoplasmic threads. The spermatoblasts scarcely increase in size; they have a diameter of about ·0036 mm. They are difficult to stain with ammonia-carmine; the nuclei are round and uni-nucleolar. Their number causes an expansion of the wall of the testis; through mutual pressure they lose their round form and become hexagonal, so that the testis looks as if covered with pavement epithelium. In each portion of the testis near the vas deferens the zoosperm is developed by unknown division of the spermatoblasts. They are round, large-nucleated cells, with a diameter of scarcely ·0036 mm. They colour deeply with carmine. In the vas deferens they become long-shaped from pressure.

The Vasa Deferentia.—In *Glycyphagus platygaster* a long, flexible vas deferens (Pl. B, fig. 2, *v d*) starts from the smaller, anterior end of each testis; and continues separate from its fellow of the opposite side of the body until near the penis: it is much the widest where it leaves the testis, and is not sharply differentiated from that organ, which fades gradually into it; the diameter of the vas deferens diminishes gradually as it approaches its distal end. The tunica propria of this duct is stronger than that of the testis, but there is not any muscular tunic. The two vasa deferentia are of equal length, but in *Tyroglyphus longior* Nalepa found that in consequence of the more forward position of one testis than of the other the vasa deferentia were of unequal length. I am not aware that any other author has traced the course of these organs, for Haller's Pl. X, fig. 9, at^3, although called the duct from the third testis, is evidently the duct from the accessory gland.

The Ductus Ejaculatorius.—This in *Glycyphagus platygaster* is a short duct (Pl. B, figs. 5, 6, *d e*) formed by the joining of the two vasa deferentia (fig. 5, *v d*); it passes through a hole in the chitinous supporting-piece of the penis, and on its distal side widens out to form a distensible chamber (*dec*); which collapses when not in action (fig. 6, *dec*), forming a wide fold, and is only distended and functional at the time of ejection of the genital products. This enlarged chamber, or something of a similar nature, was seen by Nalepa in *Tyroglyphus longior*. At first he took it for a separate vesicula seminis, but in the second part of his paper he corrects this and says he has ascertained that it is merely an enlargement of the ductus ejaculatorius. He found a muscular tunic to this portion of the ductus.

The **Accessory Glands** are far the largest organs in the male genitalia; this is quite usual in the Acarina, but the variation of them in different families and genera, and even in different species, is very great. The opportunities of variation are not so numerous in the Tyroglyphidæ, whose genital organs so far as they are known are comparatively simple, as they are in the far more complicated organs of the higher Acari, such as *Bdella*, etc.

In *Glycyphagus platygaster* there are two great accessory glands, which, however, cannot be considered as paired; they differ in form, size, and structure. One, which for want of a better name I will call the chambered accessory gland (Pl. B, figs. 1, 2, *gac*), is a large pyriform gland with the hinder end the larger; it discharges by a very short wide duct, not sharply differentiated from the gland, into the ductus ejaculatorius. It lies above the testes and above the other accessory gland, and consequently near to the dorsal surface; but further forward than the testes. This gland has a stoutish tunica propria, but its whole mass, except a small part round the duct, is divided into very large cells varying from about 25 μ to about 50 μ in length and from about 20 μ to 30 μ in breadth and thickness, having nuclei of about 9 μ to 12 μ in diameter; these cells are crowded against one another so that all rounded surfaces are lost, and they are bounded by flat surfaces meeting at angles but very irregular in form. The walls of these cells are thick, almost like formed material, and they are filled with a rather coarsely granular secretion which stains but little either with carmine or hæmatoxylin. The secretion is usually discharged by the breaking up of the inner end of the cell; the walls of the remainder of the cell being left quite perfect and persisting; so that after the cells have been emptied, which seems to occur one cell at a time, not all together, the gland is left like an empty honeycomb only not so regular in form. The histology of this gland, the persistency of the cell-walls after the contents have been discharged, and the nature of these contents, closely resemble those of the great mucous glands of the male genital system of *Bdella*; and there is every reason to suppose that the functions are analogous; but the two glands cannot be considered to be homologous, because the mucous glands of *Bdella* are really the vasa deferentia, which in that genus have become enormously developed, and have assumed a glandular function in addition to their primary purpose.

The second accessory gland in the ♂ reproductive organs of *Glycyphagus platygaster* I propose to call "the receptacular accessory gland" (Pl. B, figs. 1, 2, *gar*); it is considerably larger than the chambered accessory gland, and is probably the largest organ in the body except the ventriculus: its form is inversely pyriform; the broader end being the anterior, next to the penis, and the smaller posterior end being greatly truncated. Both the broad anterior end and the narrower posterior end are nearly straight; in the centre of the anterior end the short wide duct emerges and discharges into the ductus ejaculatorius. The sides of the gland are curved and somewhat irregular in form. This gland has a thin tunica propria, and the walls of the cells are fine and difficult to see, and never persist if the cell be empty. These cells are large flat cells of about 30 μ to 40 μ in diameter, but of slight thickness; they are almost like pavement epithelium, except that they are not sufficiently pressed against each other to have assumed angular forms, and that the demarcation between one cell and its neighbours is indistinct. They stain deeply with carmine or hæmatoxylin, have round clear nuclei of about 15 μ to 20 μ diameter, and distinct nucleoli. Within this outer layer of cells the whole interior of the gland appears to be hollow and undivided, but is always full of a homogeneous or extremely finely granular mass of secretory matter, which stains only slightly (see Pl. B, fig. 2). The arrangement reminds me somewhat of that of the true testis in *Bdella*, where half the interior of the organ consists of a chamber in which the sperm produced is received and stored. In specimens which have been subjected to the action of reagents for the purpose of making preparations or otherwise, this mass of secretory matter often breaks up into laminæ, or hexagonal or other forms which have a very deceptive appearance; but these phenomena do not exist during the life of the creature.

The male accessory glands of *Hericia Robini* appear to be very similar to those of *Glycyphagus platygaster*.

In *Tyroglyphus longior* Nalepa only describes one male accessory gland;* he draws it as a large ram's-horn shaped organ, with the thicker end nearer the ductus ejaculatorius and curling round the posterior end of the abdomen, and as composed of an exterior layer of large, loose, rounded cells and an interior mass of homogeneous material with numerous vacuoles therein. Nalepa describes it as having a soft structureless exterior tunic, not any true epithelial layer; but the lumen of the gland is surrounded with a plasmodic layer containing large nuclei. This plasmodic layer is said to send honeycomb-like depressions, which give the gland a lattice-work-like exterior appearance, and to send numerous projections into the lumen, which are often united by strings of connective material. Instead of the nuclei there are often a number of small granules; the secretion seems like white of egg, and becomes finely granular under the action of reagents. I find it rather difficult to reconcile this description with the drawings illustrating it; I also find a difficulty in determining which, if either, of the two accessory glands of *Glycyphagus platygaster* this azygous gland of *T. longior* should be identified with; it seems to combine some of the qualities of each.

Gudden draws a somewhat similar azygous accessory gland in the ♂ of *T. siro*, but the gland is shorter and the duct longer; it emerges at the corner of the broad anterior end.

In *Carpoglyphus anonymus* Nalepa describes and figures two accessory glands,† one globular and lying directly over the penis and filling the space between the rectum, the colon, and the cæca of the ventriculus; the other a large crescent-shaped gland lying anterior to the ductus ejaculatorius and below the ventriculus. Nalepa does not draw any distinction between the histology of these two glands; he says that the secretory epithelium consists of cells of about 9 μ in diameter, which stain deeply with ammonia-carmine;

* 'Abth. I,' pp. 209—210, pl. ii, figs. 2, 4, 6, *g*.
† 'Abtheil. II,' p. 135, pl. 1, fig. 1, g^1, g^2.

their small nuclei are central surrounded by a small space for secretion. The secretion of the globular gland is rich in small, dust-like, highly refractive particles; that of the crescent-shaped gland is homogeneous and like white of egg.

I am not aware that any other author has described the ♂ accessory glands of the Tyroglyphidæ.

The **Penis** and its associated sclerites vary so greatly in different species that Nalepa suggested that they would form a good means of distinguishing species; this as to the penis itself will be seen not only from Pl. B, figs. 3—5, but also from the various figures of the organ on the plates depicting the respective species. In the penis however the great diversity of form and position is united to a correspondence with a general scheme or type which runs through the whole; the associated sclerites however vary not only as to matters of form and detail, but also as to the entire principle upon which they are constructed.

The penis when at rest lies in the external genital aperture of the male (Pl. B, fig. 3), or it may be withdrawn within the body. In *Glycyphagus platygaster* it has a spoon-shaped bulb at its proximal end; I call it spoon-shaped for want of a better name, but it is too deep in proportion to its breadth to agree in form with any ordinary spoon; the convex side of the spoon is downward, and the bulb looks like a closed vessel when it is viewed from the ventral aspect; the upper side of the bulb is however quite open without anything to cover it in, and it is into this that the sperm and the secretions of the accessory glands are discharged by the ductus ejaculatorius. At the distal end of the bulb the organ suddenly narrows and becomes a closed tube, and continues to be so to its distal termination. This tube tapers more gradually when seen from the side than when seen from the ventral surface; it is also strongly curved, the curve being upward when the organ is at rest, more forward when it is erected (Pl. B, fig. 5, *pe*). On the external cuticle near the edge of the genital aperture are two spines which are probably protective, and may possibly serve as guides (see fig. 4, which is *Hericia Robini*). At the proximal end of the organ are a pair of short apophyses which afford a place of attachment for the erector muscles (fig. 6). In *Hericia Robini* the penis is of a very similar form, but the bulb is less sharply defined and the tube less curved (fig. 4).

The penis of *Tyroglyphus longior* was found by Nalepa to be S-shaped.* Berlese figures a similar form for the organ of *Tyroglyphus infestans*.† The penis of *Aleurobius farinæ* is well figured by Robin, who however in the explanation of the plate calls the species *T. siro*, and calls the end of the ductus ejaculatorius the penis; both being errors.‡ He does not describe it, but Nalepa § says that the penis of *T. siro* is composed of a three-edged, only slightly curved gutter, and has the form of the beaks of some birds. In spite of Robin's mistake of species his figure must closely resemble the penis of *T. siro*, for Nalepa, who probably had overlooked Robin's pl. v, fig. 5, says that Robin's figure is very exact. In *Carpoglyphus anonymus* Nalepa says that the penis is clavate and has a comb-like ridge on the dorsal side; it is wide and open proximally, closed and narrower distally.|| Berlese figures the penis of *Trichotarsus xylocopæ* as sickle-shaped,¶ that of *Histiostoma fimentarium* as simply conical. That of *Chortoglyphus arcuatus* is large, slightly curved, triangular in section, and diminishes regularly from the proximal to the distal end.**

The penial supporting sclerites of the Tyroglyphidæ

* 'Abtheil. I,' p. 214, pl. 1, figs. 3, 4.

† Berlese, 'A. M. S.,' Fasc. 14, No. 6. This species is however now admitted to be identical with *T. longior*.

‡ "Mémoire zoologique et anatomique sur divers espèces d'Acariens de la Famille des Sarcoptides," 1860, 'Mém. Soc. Nat. Moscou,' pp. 1—110, pl. viii, fig. 4. Pl. v, fig. 5, proves Robin's mistake in the species.

§ 'Abtheil. I,' p. 215, and 'Abth. II,' pl. iii, fig. 5.

|| 'Abtheil. II,' p. 134, pl. iii, fig. 4.

¶ Berlese, 'A. M. S.,' Fasc. XVIII, No. 1.

** Ibid., Fasc. IX, No. 7.

appear to vary far more in different species than even the penis itself does; but very little is known of them, the only figures and descriptions being those of Nalepa; which include three species, and my own now published for the first time; this is doubtless due to the fact that no other investigator has, so far as I know, really dissected or cut sections of the Tyroglyphidæ; and without these processes the sclerites cannot be properly seen.

In *Glycyphagus platygaster* the supporting sclerite of the penis (Pl. B, fig. 6) is in form a little like a capital letter A standing upright in the body, *i. e.* in a perpendicular plane; only the arms of the A are not quite straight, but are bent toward one another a little in the lower part; they increase in thickness from top to base, and the lower end of each arm is rounded. The top of the A is truncated and the cross-bar is nearer the top than it would be in the letter, and is somewhat curved, being convex below. Between this bar and the top of the A an open space is of course left, and through this the ductus ejaculatorius passes; the expansible chamber (*dec*) formed by its distal portion lying below the bar and falling into the open part of the penis. A small chitinous bar with enlarged ends (Pl. B, fig. 7, and fig. 5, *cb*) lies transversely below the ductus ejaculatorius a little further into the body than the principal sclerite (fig. 6 and fig. 5, *sp*), and this gives further support to the ductus ejaculatorius.

In *Hericia Robini* the whole design of the supporting sclerites is different (Pl. B, fig. 4). There are two paired pieces in this species; each is a triagular framework of chitinous rods with a posterior prolongation of the ventral rod, which is the base of the triangle; to this prolongation the erector muscles are attached, the retractors being inserted into the upper point of the triangle.

Nalepa * says that the supporting sclerites are paired in *T. longior*, but that they join at the anterior ends;

* 'Abth. I,' p. 214.

forming a pointed bow, the free ends of which are connected with the ventral surface and turn backward during the coitus.

Nalepa says that the supporting sclerite of *T. siro* is boat-shaped, and that the bulbous proximal end of the penis fills its hollow.* He also says that in *Carpoglyphus anonymus* the supporting sclerite is azygous,† and is not fixed to the external cuticle; it is a half-oval plate the strong chitinized edge of which bends inward and projects forward in a hook to which the retractor muscles of the penis are attached.

The Genital Suckers.—The organs which are known by this name; and which are usually, but not invariably, present in both sexes when they are present in either; have been the subject of much difference of opinion amongst acarologists as to whether they are really suckers. They are certainly in some way connected with the external genital organs, *i. e.* the penis and the vulva, but not with the bursa copulatrix; they have a sucker-like appearance, and in the male are undoubtedly exerted at the time of coition; this is however the result partly, if not entirely, of the protrusion and exertion of the penis; on the other hand, there is not any reason to suppose that those of the female are exerted at that time. The organs are found in most families of the Acarina, but the extent of their development and the complication of structure varies greatly in different families. In the Tyroglyphidæ the so-called genital suckers usually exist in both sexes; but in *Hericia* they are absent from both sexes, and in *Trichotarsus* they exist only in the female. In the Tyroglyphidæ and Sarcoptidæ the organs, although usually present, are in the simplest form; there are two on each side of the genital aperture lying in a pocket formed by a fold, or double fold, of the cuticle. Nalepa, who investigated them in *Tyroglyphus longior*, considered

* 'Abth. I,' p. 215.
† 'Abth. II,' p. 134.

them to be dermal processes; he says* that they are raised on small elevations on the floor of the pocket, and that they are conical. He says also that the large base, by which expression he apparently means the distal end, serves as a sucking-disc; and that the wall of the cone is a chitinized membrane, while the disc is thinner and flexible; if the sucker be much projected the disc becomes domed; but this form is opposed by the retractor muscle, which makes it plate-like. The projection of the sucker is said to be effected by the flow of blood into it, and its action as a sucker by a simple but powerful retractor muscle within the sucker, and inserted into the proximal side of the disc and which passes transversely across the body to the epimeron of the fourth leg. The withdrawal of the whole sucker is said to be due to a muscle-bundle attached to the edge of the disc. Nalepa is convinced that it is a true sucker and functions as such. I do not however gather from his paper that he has seen the sucker in action; indeed, it would be hardly possible to do so in consequence of the position; he apparently judges from the anatomical structure which he describes.

Claparede † and Nicolet,‡ both writing of the Oribatidæ, and Fumouze and Robin,§ writing of the Tyroglyphidæ, also considered that the organs were true suckers. On the other hand, Mégnin,|| also speaking of the Tyroglyphidæ, entirely denies that the organs are suckers; he says that in the male they serve to separate the male from the female after the coitus; and that in the female they have not any function connected with coition, but serve to guide the egg during oviposi-

* 'Abtheil. I,' pp. 211—213.

† "Studien an Acariden," in 'Zeit. wiss. Zool.,' 1868, Bd. xviii, p. 511.

‡ "Histoire naturelle des Acariens qui se trouvent aux environs de Paris," in 'Arch. Mus. Paris,' 1855, t. vii, p. 415.

§ 'Mém. Acar.,' pp. 591, 592.

|| "Mémoire sur les Hypopes," in 'J. Anat. physiol.,' 1874, pp. 239, 240.

tion. He says that he has watched them in action and is convinced of the function.

Haller,* writing of the Hydrachnidæ, although he calls the organs "Haftnapfe," puts that word between inverted commas as if he did not wish to be responsible for it, and expresses an opinion that the organs are too highly organised for suckers and seem more like sense-organs; he points out that externally they have strong convex chitinous coverings which he does not consider to be suitable for sucking purposes. Von Schaub † talks of the two pairs referred to by Haller as so-called suckers; and is of opinion that they are not suckers, although he draws an internal muscle to each much the same as Nalepa's; but Schaub considers that a third pair lying between the other two, and which he calls chitinous rings, are true suckers; he apparently only figures these in the ♂.

With regard to my own observations on structure I confess that in all my sections of the Tyroglyphidæ so very little is disclosed as to that of these so-called suckers, and that little is so unsatisfactory, that I should hesitate to come to any definite conclusion regarding the function (Nalepa says that it is very difficult); but in *Thyas petrophilus* (one of the Hydrachnidæ) the case was quite different; there the organs were large and highly developed, and I got beautiful sections which I figured; certainly the impression left on my mind was that Haller was correct in saying that the organs (in that family) appeared much more like sense-organs than suckers.

The principal difficulties in the way of considering these organs to be suckers appear to me to be as follows:

Firstly, that although the mode of coition of the Oribatidæ is still unknown, that of the Tyroglyphidæ

* "Die Hydrachniden der Schweiz," in 'Mt. Ges. Bern.' for 1881, published 1882, Heft 2, p. 48.

† "Ueber die Anatomie von *Hydrodroma* (C. L. Koch): ein Beitrag zur Kenntniss der Hydrachniden," 'S. B. Ak. Wien,' 1888, Bd. xcvii, Abth. i, p. 143.

and Sarcoptidæ is perfectly well known; both of these families possess the genital suckers, but in them coition does not take place by the vulva of the ♀, but by a special bursa copulatrix at the posterior end of the female; the male during the act is above, not below the ♀, and the ventral surface of the ♂ is turned to the dorsal surface of the ♀; the ventral surface of the ♀ is next the ground, so that it is quite impossible that the so-called genital suckers of the female can ever touch the ♂ during the coitus, yet they are as well developed as those of the ♂, and are evidently functional.

Secondly, that the males only of the Tyroglyphidæ and the Sarcoptidæ usually possess a pair of organs on the ventral surface, one on each side of the anus, which all acarologists agree are manifestly copulatory suckers, and which ordinarily bear that name; it is perfectly easy to see during the coitus that the ♂ is attached by these organs, and in many species, particularly of the Sarcoptidæ, the coitus continues for a long time; then in most Sarcoptidæ the two sexes, after the first adhesion, have their anterior ends turned in opposite directions and the genital suckers of each sex are far from the body of the other sex, so that they could not act as holding-suckers. In these cases it is easy to see that the attachment is maintained by the copulative (anal) suckers of the male, aided sometimes by the interlocking of the posterior legs. In the genus *Tyroglyphus* and one or two other genera, the males only have a pair of tubercles on the inner side of the tarsus of each fourth leg, which no doubt serve as holding-suckers to maintain a grasp.

The principal difficulties in adopting Mégnin's view appear to be—

Firstly, the apparent improbability that precisely similar organs in the two sexes of the same species, should have such very different functions as he suggests.

Secondly, that the Oribatidæ have these so-called genital suckers highly developed; but in this family the egg does not simply emerge from the vulval opening; it passes through a very long, protrusible, membranous ovipositor with three lobes at the end to guide it during oviposition, so that the genital suckers could not possibly touch the egg when it is passing from the body and being deposited.

May it not be possible that these organs have some general tactile function, and serve to some extent as feelers to guide the action of the parts during the various processes connected with reproduction?; feelers connected with the genital organs are not unknown in the Arthropoda.

The Copulative Suckers.—These have already been referred to at page 94, and but little more need be said about them; they are present in the males only of the genera *Mælia*, *Histiogaster*, *Aleurobius*, *Rhizoglyphus*, *Tyroglyphus*, and *Chortoglyphus*; they are also very common, indeed usual, in the males of the Sarcoptidæ. They consist of a single pair of large suckers one on each side of the anal aperture, and almost close to it; these organs are typical suckers, and are considerably exerted at the time of coition and then only. The organ is protruded by fluid driven into it from the body cavity, and is retracted for sucking action by a muscle inserted into the centre of the inner side of the disc.

In many species, especially of the genus Tyroglyphus, the male only has a pair of small sucker-like tubercles on the inner side of each fourth leg. These doubtless assist in holding the female, probably at the first moment of seizure.

The Female Reproductive Organs. Pl. B, figs. 8—10; Pl. C, figs. 1, 11.

These must be considered to have been first correctly described by Gudden in 1861; they have since been investigated and described in much greater detail by Nalepa. Several less correct attempts had been made in the meantime; it must not be forgotten that Gudden's paper, in consequence probably of the unusual periodical in which it was published, was missed by all acarologists until after Nalepa's papers appeared.

The female reproductive organs consist of the external bursa copulatrix, the passage between the bursa and the receptaculum seminis, the last-named organ itself, the ovaries, the oviducts, the vagina, the external vulva with its sclerites, and the so-called genital suckers.

The **Bursa Copulatrix** (Pl. C, figs. 1, 11; Pl. B, fig. 8, *bc*), which was first discovered by Gudden, and has subsequently been frequently rediscovered by other acarologists who have somehow missed the works of previous writers; is, in the genus *Tyroglyphus*, and in most other Tyroglyphidæ, a small round hole; retro-anal in position, opening at or near the posterior end of the body in the median line: it is very inconspicuous, and not always easy to find; but it is there. Gudden's paper having been overlooked, both by myself and other acarologists, I believe that I was the next to point out the retro-anal position of the bursa in 1879.* This I did from actual observation of the ♂ and ♀ of *Glycyphagus spinipes in coitu*. I then saw that the curious projection in the median line of the posterior end of the abdomen of the ♀ in the genus *Glycyphagus* was a bursa copulatrix; this fact had been overlooked by previous authors. Koch had figured the projection in several species forty years before; Fumouze and Robin had observed that it was tubular; † but it does not seem to have struck anyone that it was a bursa copulatrix or indeed that it was functional at all.

My paper was also overlooked, and Kramer ‡ and

* "On some Peculiarities in the Reproductive System of Certain of the Acarina," 'J. Quekett Club,' 1879, vol. v, pp. 227, 228, pl. xiii, figs. 5, 6.

† 'Mém. Acar.,' pp. 572, 574, and elsewhere.

‡ "Ueber die post-embryonale Entwicklung bei der Milbengattung *Glyciphagus*," in 'Arch. Naturg.,' 1880, Jahrg. 40, p. 103.

other acarologists still continued to imagine that coition in the Tyroglyphidæ took place by the vulva.

Mégnin * saw that this was not correct; he recognised the posterior position of the male organ during the coitus, and in practically all his numerous and valuable works he asserts that coition takes place in all Acarina by the anus, which he calls "la fente vulvo-anale, ou l'ouverture ano-vulvaire," and which he considers to be a cloaca. No one can always avoid error; and even Mégnin, who has contributed so largely and so correctly to our knowledge of the Mites, made a double mistake in this; firstly, coition in the Tyroglyphidæ and Sarcoptidæ and other Acari where the female is fertilised at the posterior end of the body, is not by the anal opening, but by a special bursa copulatrix near to it; secondly, no general rule can be laid down for all Acarina; the method and the position of the organs vary even within the limits of the same family; thus in a large number, but not all, of the Gamasidæ there is not any real coitus; the female being fertilised by means of spermatophores or spermatocysts applied by the mandibles of the male; † and in the Ixodidæ the position, where it is known, is totally different from what it is in the Tyroglyphidæ; and Koenike ‡ has pointed out some very curious arrangements in the Hydrachnidæ. Kramer, subsequent to his opinions above recorded, discovered the retro-anal position of the bursa copulatrix in *Dermaleichus stilifer* Buchholtz, one of the Sarcoptidæ; § he imagined this to be a first discovery. The correct position of the bursa was of course fully recognised by Nalepa; it was also stated by Haller.||

* 'Les Parasites, etc.,' pp. 219, 220, and numerous other works.

† Michael, "On the Variations in Internal Anatomy of the Gamasidæ, especially in that of the Genital Organs, and on their Mode of Coition," 1892, in 'Trans. Linn. Soc. Zool.,' vol. v, pt. 9, pp. 281—324.

‡ "Seltsame Begattung unter den Hydrachniden," in 'Zool. Anz.,' 1891, No. 369.

§ "Ueber Milben," 1881, in 'Z. ges. Naturw.,' Bd. liv, pp. 1—5.

|| 'Zur Kenntniss,' etc., p. 287.

The **Passage between the Bursa Copulatrix and the Receptaculum Seminis.** Pl. B, fig. 8; Pl. C, figs. 1, 11, *bd.*

This, in all species which have been investigated on the point, is a simple tube of a diameter somewhat less than that of the bursa copulatrix, but doubtless elastic; it passes in a course which is not quite straight, the tube being longer than the space it has to traverse; it enters the receptaculum seminis in the median line. Nalepa says that the tube is chitinized, but this is very slightly so, if at all, in the species which I have examined.

The **Receptaculum Seminis.** Pl. B, fig. 8; Pl. C, fig. 1, *rs.*

This, in all species which have been investigated, is a bladder-like organ, of a globular or elliptical form, lying in the median line of the hind part of the abdomen; its size varies greatly at different ages; being quite small in the virgin female, while it may become very large in the fertilised creature; it then has a transparent structureless wall; its contents always appear as if contained in an inner sack; this appearance may however possibly arise from a hardening of the periphery of the contained mass: this mass consists of spermatozoa, almost round and closely packed near to the entrance of the tube from the bursa; and of a finely granular substance, doubtless the secretion of the male accessory glands, further in the sack; if there be an inner sack it must be ruptured at some time or have a passage out of it which I did not detect; as the short tubes (*ro*), one on each side of the receptaculum, which connect that organ with the ovaries spring from the outer sack.

Furstenburg * denied that the ♀ had any receptaculum seminis. Robin saw the sack, and he probably

* 'Die Krätzmilben der Menschen und Thiere,' Leipzig, 1861, p. 195.

was the first to do so, but he apparently only saw it through the cuticle of the abdomen ; he says * that it is " une vésicule très pale incoloré de la partie postérieure et dorsale du ventre." He does not appear to have suspected that it was a receptaculum seminis. It seems strange that an anatomist of Robin's excellence having seen the receptaculum seminis and observed that the posterior projection of *Glycyphagus* was tubular, should not have gone a step further and discovered the connection of the two and their function. Of course Nalepa fully recognised the nature of these organs, and it is now, I believe, admitted by all acarologists.

The **Ovaries**. Pl. B, fig. 8, *ov*.

These vary but little in the species which have been investigated; in *Glycyphagus platygaster* they consist of two paired organs, roughly pyriform in shape, lying one on each side of the receptaculum seminis; and each joined to that organ by a short tube (*ro*). The ovarian ova in various stages of development may be seen in these ovaries, the largest and most developed being usually found in the peripheral portions. The impregnation of the egg takes place within the ovary.

Nalepa gives the following account of the ovaries of *Tyroglyphus longior ;* he says that the ovaries lie one on each side of the rectum near to the abdominal wall, and that they are roundish but flattened on the side next the rectum; the oviducts commencing at the anterior poles. He says that a section of the ovary shows that it is formed like the testis; the exterior tunic of eggs in various stages surrounds a central nucleus-holding plasmodic mass, the germ layer, the inner nuclei are the smallest. The protoplasm surrounding a nucleus separates itself off with the nucleus, forming an ovarian egg without any yolk-membrane. The plasma is homogeneous, and scarcely stains with ammonia-carmine.

* "Mémoire zool. et anatom. sur divers espèces d'Acariens de la famille des Sarcoptides," 1860, 'Mem. Soc. Nat. Moscou,' p. 292, pl. viii, fig. 2, *k*.

The nucleus is comparatively large and cyst-like; rarely there are two nuclei to one cell. The plasma soon changes and a fine-grained yolk-material is formed which stains rapidly and deeply. A nucleolus appears, and a few dark-staining particles in the cell-wall. The eggs push outward in all directions, each surrounds itself with a soft egg-membrane, and at this stage it enters the oviduct.

With regard to *Carpoglyphus anonymus* Nalepa gives a somewhat different account of the structure of the ovaries; he says that they are at first globular, afterwards oval; and that they are placed as in *T. longior*, but not so near together. Nalepa further says that the plasma-mass of the ovaries contains not distinct nuclei, but a highly-refractive, finely-granular, nuclear substance arranged in clusters or radial strings; the formation of the cell he describes as taking place near the mouth of the tube from the receptaculum seminis; the eggs are thus impregnated immediately they are formed. They draw toward the exterior and assume a semilunar form. The other contents of the ovary are finely granular, and do not colour. The egg, Nalepa states, now becomes oval; the plasma-mass divides and lies at the two poles in half-moon-shaped nuclear masses, separated by a clear, finely-granular zone; the contents increase, and in the scarcely coloured part four or more deeply-stained nuclei, round or hemispherical, may be detected. In this stage Nalepa saw in the cell-wall numerous small, dark-staining bodies whose origin and purpose he could not trace.

The **Oviducts**. Pl. B, fig. 8; Pl. C, fig. 1, *od.*

These in all species which have been properly investigated are very similar in character; they consist of a long tube starting from the anterior end of each ovary, which is opposite to that where the passage from the receptaculum seminis enters; these tubes join together to form the vagina, and thus with the ovaries, the receptaculum seminis, and the small tubes joining the two last-named organs, they form a complete ring; which does not, however, retain a circular form, or indeed any definite form; but being highly flexible is, as far as I have been able to judge from the species I have investigated, bent and doubled in any direction so as to pack in between the other organs; and is not necessarily similarly arranged on the two sides of the body. Nalepa, however, as stated below, was of opinion that he traced a definite plan in the convolutions of the organ in *T. longior.* The tubes are of very small diameter in the virgin female, and at that period the cellulation of the walls may be distinctly seen; but they are highly elastic, and when the eggs enter them they stretch to five or six times their original diameter, or even more; forming chambers in which the eggs lie; or rather each egg forms a separate chamber for itself by stretching the portion of the oviduct in which it lies for the moment; this chamber in fact travels with the egg; the oviduct expanding as the egg is pushed on, and closing behind it; but it does not return to quite the small diameter which it possessed in the virgin female; in the process it seems to lose all trace of cellulation, and becomes a membrane in which little if any structure can be traced. The chambers are not numerous because there are not many eggs in an oviduct at one time, from two to six being about the usual number in each oviduct when the reproductive organs are in full action. The eggs become longer and more elliptical in the oviduct; their sides being straightish the form is often almost that of a cylinder with hemispherical ends. The eggs increase in size in the oviducts from yolk-division, etc., and in its distal part they receive their final exterior coat; which is secreted by the epithelium of the oviduct. This exterior coating is not a hard chitinized shell, as in the Oribatidæ, but usually a white and more or less soft coat; the oviducts themselves however greatly resemble those of the Oribatidæ, but they do not terminate in the long, extensible ovipositor found in that family.

Nalepa says that the oviducts in *Tyroglyphus longior* start from the anterior poles of the ovaries and run forward close to the ventral wall and near to each other until they approach the vulva; that they then bend sharply backward, but remain ventral, until they reach the ovaries once more, when they turn upward, forward, and outward; pass outside the cæca of the ventriculus; then turn inward, and join below the colon; their walls, he says, are a soft tunica propria; the epithelium is homogeneous in the virgin female, and consists of small, almost cubical cells, with large round nuclei, granular contents, and distinct walls; all which become almost or quite invisible after the eggs have distended the oviduct.

In *Carpoglyphus anonymus* Nalepa says that the oviducts are S-shaped, and that in the virgin female they are only about 12 μ in diameter, but must stretch to six times that to pass the eggs. Their walls are then so thin and transparent that the eggs appear to be free in the body cavity.

Haller,* dealing with *T. longior*, the same species that Nalepa worked upon, said that the eggs stretch forward in a simple chain from each ovary; from this chain he says that the eggs are constricted off sideways and fall into the body cavity. The constriction-off extends to the surrounding envelope, which becomes an external coating to the egg. The oviduct, according to this author, is a simple egg-tube, blind posteriorly, into which the eggs entered from the body cavity by means of an opening in its wall which is usually closed by a door; the ovary he says is provided with numerous stalked pockets, into one of which the egg enters, the stalked passage being closed behind it by a door; what becomes of the egg subsequently Haller omitted to state. How Haller came to describe this very curious and complicated arrangement I am

* 'Zur Kenntniss,' p. 286.

not able to suggest; it is probably due to his imperfect methods of examination; in the absence of dissection and section-cutting, and to the great transparency of the oviduct when distended by eggs. Whatever be the explanation, I can only agree with Nalepa that Haller's account is purely imaginary.

The **Vagina.** Pl. B, fig. 8, *va.*

The two oviducts join, as before mentioned, at their anterior ends, almost immediately above the vulva: they coalesce, forming one broad short tube which turns downward from the oviduct; it is perpendicular in the body, and at right angles to the genital ring, which nevertheless it completes. It is more than the diameter of the two oviducts together. It has thick, muscular walls in its proximal part, and is the organ by which the egg is extruded from the body; the lower, distal portion in such species as *Glycyphagus platygaster* however is far thinner and more flexible; and has a large transverse fold which, when it contains an egg, expands and forms almost a chamber; but when empty collapses, forming the fold (Pl. B, fig. 10, *odc*), which greatly resembles the distensible chamber in the ductus ejaculatorius of the male (Pl. B, fig. 6, *dec*).

The **Vulva.**

This is the aperture by which the egg escapes from the body; it must be remembered that it is an egg-laying aperture only, not one through which the female is fertilised. When seen from the exterior, *i. e.* from the ventral surface of the body, it most frequently presents at first sight somewhat the appearance of an inverted letter Y, but it must be one where the two arms are somewhat curved (Pl. VII, fig. 2, etc.); this Y generally seems to be formed of dark-coloured chitin. The appearance is due to the fact that the external opening of the vagina is closed, except at the moment of oviposition, by two lateral labia, which are pressed against each other in the central line, particularly at their anterior ends; they thus cause the external opening to be almost a longitudinal slit. These labia are almost perpendicular to the ventral surface; that is to say, the breadth of each labium is perpendicular, while its length lies along the ventral surface. In each labium is sunk a chitinous plate or blade, which sometimes fills the entire labium; the two plates lie against each other at their anterior ends, and continue to do so for a distance which varies with the species; toward the posterior end, however, the edges of the plates usually curve away from one another, forming the arms of the Y; between these arms there is ordinarily a slight depression, which is in fact a portion of the opening of the vulva. A section through the vulva showing the labia (*le*) pressed nearly against each other is shown at Pl. B, fig. 10. The plates in the labia are often connected with, or surrounded by, other sclerites of which no general description can properly be attempted because they appear to vary in every species; although they probably do not vary so widely in principle as those surrounding the external genital organ of the male.

The vulva is often also protected by an external chitinous bar, or sclerite, usually more or less horseshoe-shaped, with the convexity forward; it is generally placed a little anterior to the vulva itself; it is much more general and better developed in the Sarcoptidæ among the bird's-feather parasites than in the Tyroglyphidæ; in the former family Robin called it the "sternite:" in the latter it may be seen more or less developed in *Hericia Robini*, *Carpoglyphus anonymus*, and in some species of the genus *Glycyphagus*. It may become a continuous ring entirely surrounding the vulva (*Glycyphagus Crameri*, Pl. XVII, fig. 6), and the epimera of some of the legs may be joined to it (*Glycyphagus dispar*, Pl. XV, fig. 2). Where it forms a ring the stalk of the Y is apt to be much shortened or entirely abolished, and then the space within the ring becomes divided into three more or less equal triangles, with curved exterior sides; two of these are lateral, and are the ordinary labia. The third is posterior, and is a third labium closing the posterior part of the vulva, which would otherwise be widely open. *Glycyphagus dispar* is a good example of this arrangement. *Chortoglyphus nudus* has the third posterior labium, although the vulva is not surrounded by an annular sclerite; the third labium is really only a development of what is one of the commonest of the additional sclerites round the vulva, besides the lateral labia, viz. a posterior central supporting piece.

In the genus *Histiostoma* the vulva is usually a mere longitudinal slit without any sclerites whatever.

Nalepa gives the following account of the vulva of *Tyroglyphus longior*. The outer form of the genital field is an elevated isosceles triangle, the sides marked by the lateral, the base by the posterior supporting pieces (sclerites). The lateral are distorted D-shaped plates tonching at their anterior, wide apart at their posterior ends; and presenting their edges to the exterior. They bend inward and are more strongly chitinized at their posterior ends; they close the anterior part of the genital opening. The posterior supporting sclerite is an almost quadrangular plate, whose right and left edges are joined to the lateral sclerites by a hinge-like joint; when the vagina is protruded all three plates become perpendicular. In *Carpoglyphus anonymus* Nalepa says that the lateral plates would not close the genital opening, and that they are less chitinized than in *T. longior*, but the posterior plate is largely developed and closes the vulva; it is boat-shaped, convex externally, and is split into two by a median flexible seam. There is an apophysis on each side near the lower corner to which the occlusor muscles are attached; the hinges and flexible plates allow the soft egg to pass without injury.

Haller supposed that the external vulva in *Tyro-*

glyphus was closed by a membrane stretched across, which was ruptured by the first egg that passed; this, however, is an error.

The Genital Suckers.—These, when present, exactly resemble those of the male, therefore nothing need be said about them beyond what has already been written above respecting those of the male (page 91). In the genus *Hericia* the ♀ is without genital suckers.

THE NERVOUS SYSTEM. Pls. A, figs. 8—12; C, figs. 1, 3.

This is extremely difficult to investigate in the Tyroglyphidæ, and very little is known about it; the only writings touching the subject in any serious manner are the paper by Nalepa, so often quoted in this chapter, and my own paper on the brain in Acarina,* of which paper, however, only a small portion refers to the Tyroglyphidæ. I have also made some researches for the purpose of this book, but I have not met with the success which I was able to attain in some other families.

The so-called brain may be fairly well observed in really good sections; and the four pairs of great nerves to the legs are comparatively easily traced in all Acarina; but having dealt with these it is most difficult to get further with the nervous system of the Tyroglyphidæ with any certainty; although something may be learned with care and patience by a person well accustomed to the same organs in other families of Acarina where they are better developed; and something may perhaps fairly be guessed from homology and analogy to those families.

The great nerve-centre in all Acarina, the so-called brain, consists primitively, no doubt, of a large sub-œsophageal ganglion; a supra-œsophageal ganglion, usually somewhat smaller; and a pair of short broad

* "On the Form and Proportions of the Brain in the Oribatidæ and in some other Acarina," 'J. R. Micr. Soc., 1895, pp. 274—282.

commissures, standing perpendicularly one on each side of the œsophagus, and joining the two ganglia. In most of the Acarina, however, the commissures have lost all distinctive character; it is impossible to say where they commence or finish; the supra-œsophageal ganglion and the sub-œsophageal ganglion appearing to be joined to one another and forming a continuous substance. In some families of Acarina, of which the Hydrachnidæ are the best example, the extreme fusing of cephalothorax and abdomen into one undivided mass, which is stated in so many text-books to be characteristic of the Acarina generally, but which is really only found in a few families,* is accompanied by an entire fusing of the supra- and sub-œsophageal ganglia; so that the whole brain, ganglia, and commissures form a single, almost globular mass; which is pierced centrally, but rather obliquely, by the œsophagus.† In some other Acarina, as, for instance, *Bdella Basteri*, the supra- and sub-œsophageal ganglia quite retain their character of separate ganglia, although they are joined together, and no line of demarcation can be seen in transverse sections through the two.‡ In such Tyroglyphidæ as have been investigated the brain may be fairly said to be in a condition intermediate between these two formations. In *Glycyphagus platygaster* (Pl. A, fig. 10), seen in sagittal median section, the whole brain is almost wedge-shaped, except that the sub-œsophageal ganglion bears a distinct rounded swelling on its dorsal surface immediately adjoining the aperture for the passage of the œsophagus; the supra- and sub-œsophageal ganglia being about equal in length. In *Hericia Robini* (Pl. C, fig. 1, *gso*, *gsu*) the shape re-

* See p. 49 of this book.

† R. von Schaub, "Ueber die Anatomie von *Hydrodroma*," in 'S. B. Ak. Wien,' 1888, Bd. xcvii, Abth. i, p. 98; Michael, "A Study of the Internal Anatomy of *Thyas petrophilus*," in 'P. Zool. Soc. London,' 1895, p. 199.

‡ Michael, "The Internal Anatomy of *Bdella*," in 'Tr. Linn. Soc. London,' 1896, vol. vi, pt. 7, p. 497, pl. xli, fig. 13.

sembles that of *G. platygaster*, but without the rounded swelling, and the sub-œsophageal ganglion is much the longer, although the supra-œsophageal is considerably the thicker. In *Tyroglyphus longior* Nalepa* draws the brain somewhat of the same shape as in *G. platygaster*, but without the rounded swelling, and with the sub-œsophageal ganglion much the longer of the two, and somewhat concave on its dorsal surface: in reading the expressions dorsal and ventral in connection with the brain, it must be remembered that in the Tyroglyphidæ the two ganglia do not lie in a perpendicular, but in a diagonal line; the sub-œsophageal being below and behind the supra-œsophageal, and extending almost horizontally backward. If seen from below, or in horizontal section through the sub-œsophageal ganglion, the brain of *Hericia Robini* shows an irregularly octagonal form, the boundary-lines of the octagon being concave, not straight (Pl. A, fig. 8). It is to be observed that, in some species at all events, the form of the brain is not identical in the two sexes; this may be noticed in transverse sections of that of *G. platygaster* (Pl. A, figs. 11, 12).

The brain in all Acari which I am acquainted with has an external layer of small, round, cortical cells which stain very deeply; and an inner, more fibrous mass; which does not stain nearly so readily. In the Tyroglyphidæ that I am acquainted with the cortical layer is very thin, usually only one cell thick.

At the end of my paper on the "Brain in Acarina" above quoted will be found a table giving the approximate proportionate volume of the brain as compared to that of the whole creature in selected species from various families of Acarina; the proportion which the bulk of brain bore to that of the whole creature in *Glycyphagus platygaster*, which was the species selected from the Tyroglyphidæ, was ·19 per cent.; this is far the lowest of any family that was tested; the highest proportion was 1·61 per cent. in *Gamasus terribilis*, and

* Pl. A, fig. 3.

the lowest, except the Tyroglyphidæ, ·24 in *Thyas petrophilus*, one of the Hydrachnidæ.

Nalepa says that the brain in *T. siro* is about 70 μ long, and its greatest breadth is about 50 μ. The sub-œsophageal ganglion he says is an elongated, star-shaped plate; whose ventral surface is slightly arched. He says that the ganglion-cells are apparently about $1\frac{1}{2}$ μ in diameter, but are very difficult to measure.

The nerves, except the four great pairs running to the legs, are, as before stated, extremely difficult to trace; these four pairs are very easily seen; they do not arise merely from the surface of the sub-œsophageal ganglion, but may be traced far into its substance (Pl. A, fig. 8, *n* 1, *n* 2, *n* 3, *n* 4); they do not appear, so far as I can see, to be accompanied by the smaller accessory nerves, one of which is usually found with each principal leg-nerve in *Trombidium*, *Bdella*, *Thyas*, *Hydrodroma*, etc.

Behind the pair of nerves serving the fourth pair of legs is another pair of large nerves, the starting of which it is quite easy to see (Pl. A, fig. 8, *ng*), but I could not trace them quite to my satisfaction in the Tyroglyphidæ, although they undoubtedly ran into the abdomen; Nalepa agrees in this, but he does not enter into further detail of their course. In *Bdella Basteri* and *Thyas petrophilus*, however, where the nerves are much larger and more easily seen, I was able to dissect out the brain with most of the principal nerves and many of the lesser ones attached; and to follow these nerves by dissection, as well as by sections, for a considerable distance; in most cases to the organs they innervated; where we find in the Tyroglyphidæ a nerve apparently homologous to a nerve which was traced in *Bdella* and *Thyas* I think it is not going too far to suggest that they probably serve the same purpose, although the Acari belong to different families. Now both in *Thyas* and *Bdella* there is a pair of nerves apparently homologous with this pair of abdominal nerves in the Tyroglyphidæ; it is the posterior pair of paired nerves springing from the sub-œsophageal ganglion (in *Thyas* there is an azygous recurrent nerve between the two). This pair of nerves certainly served the genitalia, and possibly also some of the other organs of the abdomen; they had several branches: I called them the genital nerves, and I have preserved that name in the present family.

Anterior to the pair of nerves serving the first pair of legs is another pair of nerves springing from the sub-œsophageal ganglion, making six pairs in all; they arise from the two anterior projections shown in Pl. A, fig. 8. Nalepa says they serve the mouth organs; but he does not mean the mandibles, for he expressly says that these are innervated from the supra-œsophageal ganglion; apparently he does not mean the palpi, for he says that these also are innervated from the supra-œsophageal ganglion; although I doubt the correctness of this; there therefore only remain the maxillæ and the lingua; but the former are soldered together to form the maxillary lip or hypostome, and the lingua is very slightly developed in the Tyroglyphidæ. I cannot say that I could trace the course of these nerves in the Tyroglyphidæ, but I have little doubt that Nalepa is right in saying that they innervate the maxillæ, because in *Bdella* the homologous pair of nerves certainly does so; but it also in that genus innervates the palpi; as the palpal branch is much larger than that to the maxillary lip I called the nerve the palpal nerve. It must be remembered that the palpi in the Acari are maxillary palpi, and spring from the maxillary lip; they are not labial palpi; it would therefore seem to be improbable that the maxillæ should be innervated from the sub-œsophageal and the maxillary palpi from the supra-œsophageal ganglion, and it certainly is not the case in *Bdella*. In *Thyas* the same nerve sends branches to both organs; but that nerve arises from just where the two ganglia may be supposed to join, and the fusing of the two is so complete that it would not be possible to say which ganglion the nerve arises from. Croneberg, speaking of *Eylais extendens*, one of the Hydrachnidæ, says that the palpal nerves arise from the sub-œsophageal ganglion.*

Schaub, speaking of *Hydrodroma*, also one of the Hydrachnidæ, considered that the palpi were innervated from the supra-œsophageal ganglion.†

With regard to the nerves proceeding from the supra-œsophageal ganglion, I was able in one happy median sagittal section of *Hericia Robini* to trace clearly the azygous pharyngeal nerve (Pl. C, fig. 1, *nph*); although possibly I might not have detected it had I not been so well acquainted with it in some other Acari, and looked for it. It is a very fine nerve arising from the median point of the anterior end of the supra-œsophageal ganglion almost close down upon the œsophagus; it follows a straight line along the dorsal surface of the anterior end of the œsophagus, and sends out fine nerve-threads which innervate the dilator and occlusor muscles of the pharynx. I cannot say that I was able to trace to my own satisfaction the course or destination of any of the other two or three pairs of nerves which may just be seen arising from the supra-œsophageal ganglion. Nalepa considered that he had traced two pairs, the first he says innervate the mandibles (*Cheliceræ*) and the second the palpi. With regard to the first I have no doubt that Nalepa is right; because in all Acari, where I have been able to trace the nerves with certainty, the mandibular nerves have arisen from the supra-œsophageal ganglion, and this is usual in adult Arachnoidea. It may be said that the mandibular nerves of insects arise from the sub-œsophageal ganglion; this, however, is subject to three remarks, viz. (1) that many writers,

* "On the Anatomy of *Eylais extendens*, Müller, with Observations on Allied Forms," in Russian in 'Mem. Soc. Moscou,' 1878. A short summary in German called "Ueber den Bau der Hydrachniden," in 'Zool. Anz.,' 1878, No. 14, p. 316.

† "Ueber die Anatomie von *Hydrodroma* (C. L. Koch): ein Beitrag zur Kenntniss der Hydrachniden," in 'S. B. Ak. Wien,' Bd. xcvii, Abth. i (1888), p. 98.

such as Lang and others, consider that this very fact prevents the mandibles of insects and Arachnids being considered homologous; (2) that Winckler* stated that in *Gamasus* he had found the roots of the mandibular nerves in the sub-œsophageal ganglion, and that they passed right through the substance of the supra-œsophageal ganglion before emerging from its dorsal surface. I have a very high opinion of Winckler's general accuracy in this paper, but I have not ever been able to confirm this statement, although I have great numbers of successful serial sections through the brains of Gamasids of various species cut in all directions; (3) that although the mandibular (cheliceral) nerves arise from the supra-œsophageal ganglion in adult Arachnoidea, yet that in some at least of the creatures belonging to that class, the ganglia from which these nerves spring in the embryo are not supra-œsophageal, but work upward in the course of development.

As above stated, I can hardly think that Nalepa is correct in saying that the palpal nerves arise from the supra-œsophageal ganglion.

As so little is really known of the course of the nerves in the Tyroglyphidæ it may possibly be useful just to state what nerves I found arising from the brain in *Bdella*. They were from the supra-œsophageal ganglion, the azygous pharyngeal nerve, and three pairs of paired nerves, viz. (1) the mandibular nerves; (2) a thin pair innervating the dorso-ventral muscles near the rostrum; (3) the optic nerves: from the sub-œsophageal ganglion seven pairs of nerves, viz. 1, the palpal nerves; 2 to 5, the leg-nerves; 6, the genital nerves; 7, a thin pair, innervating the dorso-ventral muscles in the centre of the body.

Organs of Special Sense.

This must necessarily be a very short section of the anatomy, for the known organs of special sense in the

* "Anatomie der Gamasiden," in 'Arb. Inst. Wien,' T. vii, Heft 3, pp. 317—354.

Tyroglyphidæ are very few, and little is known about them except that they are extremely simple. Probably the great leading sense in all Acari is touch; this no doubt is widely distributed over the body; but, as far as can be judged, it is located principally in certain long setiform hairs one of which is placed on the median point of the dorsal (or anterior) side of each tibia of the first pair of legs, near the distal end of the joint. A similar hair, similarly placed, but usually not quite so long as that on the first leg, is found on each tibia of the second pair of legs; and very often on each tibia of the third and fourth pairs; but these hairs are usually shorter than those of the second pair. In treating of other families of Acari I have always called these particular hairs "the tactile hairs," not as intending to indicate that they are the only hairs on the creature which have a tactile sense; but as a name which drew attention to the fact that it is in them that the highest tactile sense is resident. These hairs are found practically in all non-parasitic Acari, and in many parasitic ones; but the extent to which they are developed in different families and species varies considerably. The sense of touch, and probably the sensitiveness to minute disturbances of the air which these hairs possess, must be very high; for it is apparently by their means that the creatures avoid collisions, etc., when they are in rapid movement; and it is apparently by their assistance that such blind, predatory Acari as *Gamasus* are enabled to catch and devour such active insects as the Thysanuridæ. It must be remembered that in consequence of the perpendicular position of the tibiæ during life these hairs stand out horizontally from the tibia and point forward.

The sense of touch also probably exists in a lesser degree in many of the other hairs upon the creature; there is also every reason for believing that it is rather efficient in the palpi. In such highly-developed families as the Gamasidæ these organs are constantly trembling, and touch the ground lightly and rapidly at every step the creature takes; they certainly, in some species, possess sensory papillæ on the distal end of the organ. There is some reason to suppose that the sense of taste does to some extent reside in the palpi, which are particularly active when food is being sought or consumed; but nothing is definitely known on the subject.

As regards the sense of sight the Tyroglyphidæ are usually without eyes or any organs which can be looked upon as optic; but there is one known species, and one only, where the eyes exist in all stages from larva to imago, and may be plainly seen; this species is *Carpoglyphus anonymus*, which possesses a pair of simple eyes on the anterior margin of the cephalothorax; which are more conspicuous in the larvæ and nymphs than in the adults, but are plainly visible in all; they resemble the ocelli of insects. These organs were first pointed out by Kramer,* but appear to have been overlooked by all subsequent writers except Nalepa, who says that they consist of a moderately arched cornea and a refractive lens beneath it; he was not able to trace the optic nerve.

No other organs of special sense are at present known in the Tyroglyphidæ.

The Expulsory Vesicles or Oil-glands.

On each side of the hinder part of the abdomen, in most if not all of the Tyroglyphidæ, is a vesicle often of considerable size, usually containing highly refractive fluid; which is sometimes colourless, sometimes yellow or brown; it is generally placed on the actual side of the body where the abdomen is thick in a dorso-ventral direction; often more dorsal in position where the abdomen is very flat, or comes to a sharp edge laterally, as in some Hypopi. It must be considered a dermal organ; it immediately underlies the skin, and its chitinous layer is cast with that of the

* "Ueber die postembryonale Entwicklung bei der Milbengattung *Glycyphagus*," in 'Arch. Naturg.,' 1880, Jahrg. xl, Bd. i, pp. 102—110.

rest of the skin at each ecdysis. This vesicle is very conspicuous in some species where the cuticle of the abdomen is smooth and transparent, such as *Rhizoglyphus echinopus*, *Aleurobius farinæ*, *Tyroglyphus mycophagus*, *T. Wasmanni*, etc. It may be seen in all stages subsequent to the egg, and indeed is often seen in the hypopus when it cannot be seen from the exterior in the living adult, as in *Glycyphagus Crameri*. The form of the organ is usually hemispherical, or lenticular, but in the adult it generally presents its edge, or nearly its edge, to the observer looking from the dorsal aspect; it is practically a membranous sack filled with a highly refractive oily liquid. This vesicle communicates with the exterior surface of the abdomen by a short narrow canal which ends in a small round hole or mouth in the cuticle, often surrounded by a chitinized ring or ridge. A precisely similar organ exists in the larvæ and nymphs of many Oribatidæ, such as *Oribata lapidaria*, *O. setosa*, and *O. orbicularis*. It persists in many of the adult Oribatidæ, such as *Hermannia convexa* (*picea*), *H. bistriata*, *Nothrus palustris*, *N. spinifer*, and *N. sylvestris*; in *Hermannia arrecta* the mouth is surrounded by a chitinous tubular projection instead of a mere ring, which makes it a conspicuous object. The organ probably exists in many other Oribatidæ where it has not been seen.

Considerable difference of opinion has arisen from time to time among acarologists as to the function of this organ; probably Robin was the first who saw and described the vesicle;* his species was *Tyroglyphus siro*. He called it a "vesicula pleine de liquide incoloré," but he did not discover its passage to the exterior, nor did he suggest a function. Pagenstecher† saw the external opening of the passage in *Aleurobius farinæ* (which he calls *T. siro*), but he took it for a

* "Mémoire zool. et anatom. sur diverses espèces d'Acariens de la Famille des Sarcoptides," in 'Bull. Soc. Moscou,' 1860, t. xxxiii, p. 292, pl. viii, fig. 2, *i*.

† "Einiges zur Anatomie von *Tyroglyphus siro*," in 'Z. wiss. Zool.,' 1862, Bd. xi, p. 122, Taf. xiii, fig. 3.

stigma; although he says that there are not any tracheæ. Turpin apparently saw the vesicle in what probably was *Glycyphagus domesticus*,* and Fürstenberg saw it in some Sarcoptidæ;† but these authors took the organ for an air-sack, which is strange considering that it is almost always full of liquid unless the contents have been artificially expelled. Fürstenberg even describes a regular motion of expansion and contraction in the vesicle, which no one else has ever been able to see. Claparède ‡ considered the organ to be an excretory gland; and practically to represent the Malpighian vessels of the Gamasidæ, Trombidiidæ, Ixodidæ, Hydrachnidæ, etc., although not homologous to them, and he says that the two organs never exist in the same species, which he gives as an important argument in favour of his view; but in this the eminent Swiss naturalist made a mistake, for both exist in the very species he was writing about, viz. *Tyroglyphus siro* and *T. longior;* and probably in most if not all other Tyroglyphidæ. The Malpighian vessels are clearly homologous with those of the Gamasidæ (see p. 73), but there still is this point in favour of Claparède's argument, viz. that in the Tyroglyphidæ the Malpighian vessels are very small, sometimes almost rudimentary, instead of being large and important organs, as they are in the Gamasidæ. Nalepa § entirely repudiates all previous suggestions about their function, and declares them to be oil-glands which serve to keep the skin lubricated; he suggests that they would thereby, *inter alia*, prevent the creatures sticking to the various sugary and other adhesive substances upon which they are so often found; he calls the organs the oil-glands. Claparède had mentioned the contents as thick and oily. In my own work on the Oribatidæ,||

* 'C. R. Ac. Sci.,' 1837, t. v, p. 672.

† 'Die Kratzmilben von Menschen und Thiere,' Leipzig, 1861, p. 192.

‡ "Studien an Acariden," in 'Z. wiss. Zool.,' 1868, Bd. xviii, pp. 498, 499.

§ 'Abth. i,' pp. 204—206.

|| 'British Oribatidæ,' London, Ray Society, 1884, p. 180.

published about the same time as Nalepa's paper, I described the liquid contents of the sacks as highly refractive and oily, floating on the surface of water without mixing; but I was not sufficiently satisfied as to the function to use any name implying any particular office for the organs; I therefore called them the "expulsory vesicles" as a neutral name. The sacks hardly look glandular in structure, but Nalepa says that the inner side of the sack is clothed with low and small epithelial cells filled with a granular substance.

Respiration.

I do not call this section "Organs of respiration" because, as far as is known, the Tyroglyphidæ do not possess any special organs by which this process is effected. The family belongs to the atracheate group of the Acarina, in which the blood appears to be aërated simply through the cuticle of the general body-surface without special appliances for the purpose. The blood lies in the general body cavity, and is only kept in some degree of movement by the action of the legs and the muscles of the abdomen and cephalothorax; in active species, however, these are probably sufficient to keep the fluids in almost constant motion; but not in any definite course: no closed system of organs of circulation is known. The only families of the Acarina in which a heart or any circulatory vessels are known are the Gamasidæ and the Ixodidæ; in these an extremely simple one-chambered heart with a single pair of ostia and a forward and also a smaller backward aorta exist.*

It might not have been necessary to mention the

* Winckler, "Das Herz der Acarinen," in 'Arb. Inst. Wien,' 1886, T. vii, Hft. 1, pp. 111—117. In *Gamasus* they had been previously discovered by Kramer, but only very slightly described. No discoveries of similar organs in other families have been made up to the present time, although they have been searched for.

subject of respiration were it not that Pagenstecher mistook the opening of the expulsory vesicle for a stigma, and Turpin and Fürstenberg mistook the vesicle itself for an air-sack.* Mégnin, however, says † that in *Glycyphagus spinipes* and *G. domesticus* he found the stigmata at the base of the first pair of legs, and that they were long-shaped slits each protected by a plumose hair and bordered by thick lips. I do not know what the organs were that Mégnin saw; I am not aware that any subsequent acarologist has observed them, and it appears to be certain that neither these creatures nor any other known members of the family possess any tracheæ or air-sacks.

Musculation.

Pl. C, figs. 1, 2, 3, 6, 7, 9.

This would not be the proper place for entering into an exhaustive account of the musculation of the Tyroglyphidæ; which would necessarily be lengthy, and would probably be of comparatively little interest to most readers. Certain groups of muscles have necessarily been described in the foregoing parts of this chapter, *e. g.* those of the pharynx; but something may fairly be said to indicate the nature of some of the principal groups of muscles which have not been dealt with in the earlier pages of this work.

Very little has been published upon the musculation of the Tyroglyphidæ; Nalepa's paper, so often referred to in this chapter, is practically the only study of any importance on the subject; it is excellent, but is confined to a single species, *Carpoglyphus anonymus*, as the musculation is not treated of in the first part of the paper, which refers to *Tyroglyphus longior;* but something exists as to the musculation of some other Acari, as, for instance, Kramer's paper on *Halarachne*

* See this book, p. 116.
† In 'C. R. Ac. Sci.,' 1886, t. ciii, pp. 1276—1278.

(an exceptional Gamasid),* Winckler's paper, also on Gamasidæ,† von Schaub's on *Hydrodroma* (*Hydrophantes*), one of the Hydrachnidæ,‡ and a certain amount in Henkin's paper on *Trombidium*.§

The muscles of the Acarina are usually most distinctly striped; this, however, is not, perhaps, quite as conspicuous in the Tyroglyphidæ as in most of the higher groups; still it is almost always striped muscle that is found. Nalepa remarks that the striping is not equally conspicuous in all the muscles, and is difficult to see in some of those which shorten the body longitudinally, while it is very striking in others, *e. g.* the genital muscles of the ♂. The sarcolemma may usually be traced without special difficulty; but the nuclei on the muscles are usually few and not very easily seen. Nalepa says that the section of the muscles in the Tyroglyphidæ is generally round or prismatic, seldom flat; he is doubtless right on the whole; although it seems to me that flattish muscle-bands are not by any means rare. As in most families of Acarina, a large proportion of the muscles of the Tyroglyphidæ are inserted into the parts they move by means of tendons, which are sometimes short but often very long and occasionally assume considerable importance. The muscles usually diminish gradually in thickness from their point of origin to that of insertion.

The principal groups of muscles in the Tyroglyphidæ may be considered to be—

1. The muscles of the rostrum and mandibles.
2. The dorso-ventral muscles.
3. The muscles which shorten the body.

* "Ueber *Halarachne Halichoeri*, Allm.," in 'Zeit. Naturw.,' Bd. lviii (1885).

† "Anatomie der Gamasiden," in 'Arb. Inst. Wien,' 1888, Bd. vii, Heft 3, pp. 317—354.

‡ "Ueber die Anatomie von *Hydrodroma*," in 'Sitzb. Ak. Wien,' Bd. xcvii (1888), pp. 98—151.

§ "Beiträge zur Anatomie, Entwicklungsgeschichte und Biologie von *Trombidium fuliginosum*," in 'Zeit. wiss. Zool.,' Bd. xxxvii (1883), pp. 555, 663.

4. The muscles of the alimentary canal.
5. The muscles of the genital system.
6. The muscles of the legs.

The Muscles of the Rostrum and Mandibles.

The greater portion of the open space lying above the brain and the anterior part of the ventriculus and below the dorsal integuments of the anterior part of the body, is occupied by two great systems of longitudinal muscles, which seem at first sight to constitute one system only; they are both spread out in an almost parallel but slightly converging manner. These muscles all arise from the under (inner) side of the dorsal cuticle, and run forward and downward. Each system consists of numerous bundles which terminate in short tendons; all, or many, of these tendons unite and form a single large tendon by which they are inserted into the part they move; such of these muscles as fall in or very near the median line are shown in Pl. C, fig. 1, which is *Hericia Robini;* they of course vary in different species, but the general arrangement is very similar in the species the anatomy of which I am acquainted with. The anterior of these systems is that of the retractor muscles of the mandibles (*mdr*); the furthest forward of which arises from a little behind the rostrum, and the most backward from above about the centre of the supra-œsophageal ganglion. Nalepa says that in *Carpoglyphus anonymus* they arise from about over the coxæ of the second pair of legs. Their tendons are inserted into the hind edges of the mandibles, usually nearer to their dorsal than to their ventral surface: they are large and vigorous muscles, and serve to withdraw the mandibles when they have been protruded: the action is powerful, but the distance that the mandible can be withdrawn is short; very different from the long distance which these organs can be retracted in many Gamasidæ, where the retractors of the mandibles arise almost from the posterior end of the abdomen. Among the Tyroglyphidæ by far the most mobile mandibles are those of the genus *Histiostoma;* where these organs are in constant and rapid, alternate, saw-like action, and the muscles are naturally modified to suit this.

The posterior of the two systems is that of the retractor muscles of the rostrum (*mrr*); these in *Hericia* are probably the longest muscles in the body, and mostly arise about over the posterior end of the supra-œsophageal ganglion; but some of the lateral bundles arise further back. The tendons of the more central of these muscles are inserted into the hinder edge of the rostrum, but Nalepa says that in *Carpoglyphus* some, probably the lateral bundles, are inserted into the corners of the maxillary lip. All these muscles serve to withdraw the rostrum into the camerostrum.

There are other muscles attached to the rostrum; which has almost universal, although rather slight, motion. The muscles which serve as flexors of the rostrum arise, according to Nalepa, from below the pharynx; and are inserted into the hind margin of the lip. There are also some small muscles which serve to give a slight revolving movement to the rostrum, and which arise partly from the sternum and partly from the anterior epimera and sclerites.

The muscles which work the moveable arm of the chela of the mandible are contained within the mandible itself; the powerful occlusor muscles (*mdo*) arise from the inner side of the upper surface and the upper part of the posterior surface of the chitinous exterior of the mandible, and are inserted into the upper proximal angle of the moveable arm of the chela. The weaker divaricator muscles (*mdd*) arise from the lower part of the posterior surface, and are inserted into the lower proximal corners of the moveable arm.

There is but little special musculation accompanying the maxillæ. Nalepa says that in *Carpoglyphus anonymus* each of what he calls the "Kaulade," which is a moveable piece at the bottom of each maxilla, and which Laboulbène and Robin had considered to be the homologues of labial palpi, is served by a single muscle; but it must be remembered that the maxillæ are fused to form the maxillary lip, and are probably scarcely, if at all, functional.

The musculation of the palpi is practically of the same nature as that of the legs, but in miniature, and of course as there is not any free joint corresponding to the coxa, the muscles special to that joint are not reproduced.

The Dorso-ventral Muscles.

These muscles (Pl. C, figs. 1, 2, 3, *mdv*) are often some of the largest in the body; they are always paired muscles, and serve, of course, to approximate the dorsal and ventral surfaces of the body; they usually lie wholly in the abdomen, arise from the interior surface of the dorsal cuticle, and are inserted into the ventral cuticle by means of tendons; which are usually short but strong. Sometimes the spot where these muscles arise from the dorsal cuticle is strengthened by a chitinous plate embedded in the skin, as in some of those of *Hericia Robini* (Pl. C, fig. 2).

Nalepa says that in *Carpoglyphus* numerous bundles of dorso-ventral muscles pass between the depressor muscles of the second and third legs, and converge on each side of the body to a point above the epimeron of the third leg. In *Hericia Robini* I find, on each side of the body, a strong fasciculus of dorso-ventral muscles passing between the anterior portion of the ventriculus and the lateral wall of the abdomen, and converging to a single powerful tendon which is inserted into the ventral cuticle just anterior to the genital opening of the female (Pl. C, fig. 1); another, of less numerous muscle strands, lies between the colon and the lateral body-wall (Pl. C, fig. 2).

In *Glycyphagus platygaster* a dorso-ventral muscle passes on each side of the supra-œsophageal ganglion (Pl. C, fig. 3).

The Muscles which Shorten the Body.

Nalepa says that in *Carpoglyphus* four longitudinal muscle-bands arise from what he calls the shoulder-notch on each side of the body; pass close to the outer wall of the abdomen, and are inserted by broad tendons into the side of the body, about over the third coxa. He says that the contraction of these eight muscles must shorten the long axis of the body.

The Muscles of the Alimentary Canal.

The principal of these muscles are the pharyngeal, which have already been fully treated of in connection with that organ. The next in importance are the divaricator muscles of the anus (Pl. C, fig. 2, *mda*), of which several bundles are inserted into the edge of the anal opening; they arise from the cuticle of the body, and pass on both sides of the rectum.

The Muscles of the Genital System.

Some of the more interesting of these muscles will be found referred to in the description of the reproductive organs (pages 90—95, etc.).

The Muscles of the Legs (Pl. C, figs. 3, 6, 7).

These may be conveniently classed in two divisions, viz. (1) those which arise in the body, and almost all serve to move the entire leg; (2) those which arise within the leg itself, and serve to move the respective joints, or the claw. The first of these groups contains some of the largest muscles of the body; they are naturally powerful, as they have the whole leg to move, and many of the creatures are rapid; they are mostly inserted into the proximal edge of the coxa, although

Nalepa found that in *Carpoglyphus* some few pass on and are inserted into the proximal edge of the femur. Four pairs of large muscle-bundles arise from the lateral dorsal cuticle, and pass diagonally downward between the body-wall and the alimentary canal; they are inserted into the proximal edge of the coxa. These are the levator (or retractor) muscles of the coxæ; they are attached by strong tendons; a portion of a pair of these muscles, cut short by the section, is shown in fig. 3, *mlc*.

The depressor muscles of the coxæ (fig. 3, *mdc*) are very differently arranged and require a little more explanation. In the higher Acarina, such as the Gamasidæ, Bdellidæ, etc., the organ which is known in many other Arachnida, and even in some other Arthropoda, and which is called the endosternite (or episternite), is highly developed. In the above-named families of Acarina it consists of a largish, tendinous, horizontal plate lying below the ventriculus and above the brain; it is suspended from the dorsal integument by bands of muscle and of connective tissue. In *Bdella* it is a thick plate, which in *B. vulgaris* seems to show signs of being formed by the compression of a sack; at all events it has stout upper and under walls which, in transverse sections of the creature, show a narrow but distinct lumen between them. It forms practically an internal skeletal piece for the attachment of numerous muscles, principally the great muscles of the legs. In such Tyroglyphidæ as have been investigated this organ exists, but it is reduced to its smallest possible dimensions; so small that it seems to be little if anything more than a point where the tendons at the inner ends of the depressor muscles of the coxæ are joined to one another. Nalepa considers that this is what the organ in *Carpoglyphus* really is; he calls it a "*Knotenpunkte*," and says it lies below the ventriculus and above the posterior end of the sub-œsophageal ganglion. In *Glycyphagus platygaster* it is not a point, but more a small longitudinal blade, the anterior end of which reaches beyond the sub-œsophageal ganglion, and lies under the posterior part of the œsophagus; whatever its form or size it serves as a skeletal piece whence arise, *inter alia*, the depressor muscles of the coxæ (Pl. C, fig. 3, *mdc*).

The levators and depressors are not the only muscles inserted into the coxæ; these joints are capable of considerable lateral and rotatory motion, which is effected by short muscles arising from the sternum and from the epimera; in *Rhizoglyphus echinopus* the first pair of coxæ, which are the most moveable, have some of these muscles arising from each of those sclerites.

The flexor muscles which move the respective joints of the leg arise, as is the case in most but not in quite all Acari, from the cuticle; principally from the dorsal part of the cuticle; not of the joint next to the one raised, but of the second joint more proximal than that moved; thus the muscles moving the tarsus arise from the genual, not from the tibia; they are almost always inserted into the proximal edge of the joint moved.

One result of these arrangements is that each joint of the legs, except the terminal ones, contains parts of at least two sets of muscles. Nalepa states that in *Carpoglyphus* the same remark is applicable to the coxa; he says that as there is not any joint more proximal than the coxa, the muscles which move the femur arise in the body from the epimera.

The extensor muscles, which are much smaller than the flexors, arise chiefly from the immediately previous joint.

The extensor muscle of the claw arises from the proximal edge of the tarsus; its tendon is long and is inserted into the dorsal side of the claw (Pl. C, fig. 7). Nalepa says that in *Carpoglyphus* the flexor of the claw arises from the tibia, passes through the tarsus, and is inserted by a short tendon into the under side of the claw.

Nalepa also states that in *Carpoglyphus* there is an auxiliary tarsal-flexor arising from the tibia.

CHAPTER VI.

DEVELOPMENT AND IMMATURE STAGES.

The life-history of one of the Tyroglyphidæ, and of almost all other Acari, may be divided into four principal stages; namely, the egg, the larva, the nymph, and the imago. A few exceptional cases occur in the Acarina, where one or more of these stages are practically suppressed, or are passed within the body of the creature when in a different stage. As far as is at present known these cases occur more frequently among the Tarsonemidæ than in any other family. Thus in *Disparipes bombi* and *D. exhamulatus* the nymphal stage is entirely suppressed, at all events in the male; although Prof. Canestrini treated the adult male as a hypopial form,* which was an error. The most extreme instance, however, is that of *Pediculoides ventricosus*, where the whole of the immature stages, if existing at all, are passed within the body of the adult female, the imago being produced viviparously, as was observed by Laboulbène and Mégnin; † I can confirm the fact from personal observation. In the Tyroglyphidæ, however, the nymphal stage is complicated, in some genera, by the curious hypopial stage, which is fully treated of in the latter part of this chapter, and which one would be at first inclined to treat as a separate stage; although that view can scarcely be maintained; but the hypopial condition is wholly exceptional.

* 'Can. Pros.,' t. iii (1888), pp. 328, 330.
† In 'J. Anat. Physiol.,' t. xxi (1885), p. 16

In a former work * I have explained the sense in which I use the expressions "larva" and "nymph," as applied to the Acarina; but it may be convenient to repeat it here, because the other volume is not always at hand, and authors have not by any means been agreed as to the meaning of the terms in this connection.

The expression larva is used in this book to signify the creature after it has emerged from the egg, and while it is still hexapod, or has a smaller number of legs than six; as occurs in *Phytoptus*, where even the adult only has two pairs of legs, the others being abortive; or while it is without legs, as occurs in the larvæ of some Demodicidæ, where the legs are sometimes entirely absent in this stage and sometimes represented by three pairs of small tubercles which can hardly be termed legs. It has been stated that the larvæ of *Pteroptus* are octopod at birth; the assertion, however, requires confirmation. Even if it be true that when *Pteroptus* leaves the egg it has already acquired its full number of legs, it would doubtless mean only that the larval stage, such as it is now usually recognised to be in Acari, is suppressed or passed within the egg. What is here called the "larva" Nicolet called the "young larva," reserving the term "larva" without the adjective for what in accordance with the present practice of acarologists I call the "nymph." Henkin, and one or two others following him, call the larva while still within the egg-membrane the "Schadonophan;" this was with reference to *Trombidium*, the egg of which has a dentoval stage.†

The expression "nymph" is used in this book to signify the creature after it has become octopod (or has attained its full ultimate number of legs in the

* 'British Oribatidæ,' London (Ray Society), 1884, p. 66.

† "Beiträge zur Anatomie, Entwicklungsgeschichte und Biologie von *Trombidium fuliginosum*," in 'Zeit. wiss. Zool.,' Bd. xxxvii (1883), p. 596.

case of exceptional genera such as those above mentioned), and prior to the last ecdysis; in giving this definition, however, it may be necessary to except the case of the Analgesinæ (a large group of Sarcoptidæ which are found on the feathers of birds, and are called by Robin and Mégnin "Sarcoptides plumicoles"); the female in many species of this sub-family, and probably in all, does change its skin once after coition with the adult male, and after this final ecdysis the female is in many species extremely different in appearance from what it is before it. Mégnin apparently regards this as a case in which there are two successive forms of adult female, viz. the nubile female and the reproductive female; but it will probably be considered that it is rather to be looked upon as a case of pedogenesis. It would be extremely interesting to trace the life-history of one of these species, and ascertain for certain whether the female passes through the same number of ecdyses as the male or more, which would afford a substantial indication as to whether the nubile female is a nymph or an adult; but minute creatures like the Analgesinæ, which are parasitic upon such things as birds, and will not live away from the host, and are usually present in numbers if at all, are anything but easy to watch the life-histories of in such a manner as to be reliable upon such points as the number of ecdyses; to ascertain which a single specimen must be observed throughout the period between its emerging from the egg and its becoming an imago.

Mégnin's definition of the expression nymph was the creature after it had become octopod, and before it had any external sexual organs; further investigations, however, have shown that this cannot be maintained, because in a great proportion of the Acarina the nymph in the stage between the penultimate change of skin and that which brings it to the adult condition does possess external sexual organs, although they may be of small size, and, with the exception of the bird parasites above mentioned, not functional as far as is known at present. Kramer stated that in what he called *Glycyphagus* the external sexual organs appeared after the first ecdysis, and were therefore present during the whole of the nymphal period (although not functional). This would not be quite correct if it really referred to *Glycyphagus*, but Kramer's observations, which were carefully carried out, were actually made upon *Carpoglyphus anonymus*.

It may be broadly stated that great changes such as exist in the life-histories of the Oribatidæ, wherein the whole appearance of the creature entirely alters, so that there is but little resemblance between nymph and imago, are not found in the Tyroglyphidæ; smaller alterations of detail commonly exist, but as a rule the one stage would be easily recognised by anyone acquainted with the other. To this rule, however, there is one notable exception, namely, the hypopial nymph, when there is one; during this portion of its life-history the creature is entirely different from what it is at any other time.

The Ovum.

The eggs of the Tyroglyphidæ are usually large in proportion to the adult Acarus which deposited them, but this is common in the Acarina; they do not vary greatly; they are usually elliptical or oval and smooth, without projections or any conspicuous decoration. They are mostly white or light yellowish or greyish in colour, and have a more or less soft outer covering, not a rigid shell. This is probably the reason why the deutovum stage, which is found in so many Acari which lay eggs with a rigid, chitinised, external shell, does not exist in the Tyroglyphidæ; the cuticle of the eggs of these creatures appears to be capable of stretching sufficiently for the needs of the egg.

Embryology.—There have been several valuable contributions of late years to our knowledge of the embryonic development of different families of Acarina, principal amongst which may be mentioned that of Henkin on *Trombidium*,* that of Winkler upon *Gamasus*,† and that of Wagner upon *Ixodes*;‡ but the leading work on the subject still continues to be that of Claparède.§ This is practically the only existing work which treats of the embryology of the Tyroglyphidæ; unfortunately it is more shortly dealt with than that of any other family which Claparède undertook. The species he studied were *Tyroglyphus siro*, the so-called common cheese-mite, and *T. longior*, the far commoner cheese-mite found associated with it and on cheese in general, and on numerous substances. Finding that the embryology was similar in the two species, Claparède only describes that of *T. siro;* he states that the egg is ellipsoidal, and covered by the yolk-membrane (Dotterhaut). He says that the first formation of the germ-layer (Keimhaut) escaped him, and that he first detected it when it was several cells thick and enveloped the whole yolk. Claparède states that this germ-layer thickens rapidly on the ventral side and at the cephalic end; so that the yolk in the posterior half of the egg is pressed backward. The appendages appear as rounded knobs on the ventral side of the anterior half of the embryo; there are five pairs of them; the anterior pair are to be looked on as mandibles, the second as maxillæ, and the three remaining pairs as legs. As the embryo develops further the maxillæ gradually work forward, while the mandibles remain quiescent; thus the maxillæ soon come to be at the sides of the mandibles. At this time the anterior part of the embryo becomes divided by three transverse furrows; each segment thus formed

* See note, p. 127.

† "Anatomie der Gamasiden," in 'Arb. Inst. Wien,' t. vii (1886), Heft 3, pp. 317—354.

‡ "Zur Entwicklungsgeschichte der Milben.," in 'Zool. Anz.,' No. 399 (August 29th, 1892), pp. 316—320.

§ "Studien an Acariden," in 'Z. wiss. Zool.,' Bd. xviii (1868), pp. 445—546.

represents a leg; Claparède thought that they all represented thoracic segments; but remarks that they are worth investigation because in the fully-formed creature only one furrow remained, and that was between the second and third pairs of legs (this furrow modern acarologists usually consider to be the demarcation between cephalothorax and abdomen).

The mandibular and maxillary knobs now undergo a process of fusion, and form the rostrum; a longitudinal line indicates the origin of this organ from two paired halves; and a pair of projections appear at the sides, which later on become the maxillary palpi. The fusion of the mandibular and maxillary knobs becomes so complete that it is impossible to distinguish the two; it is only at a subsequent period that a division once more appears in this homogeneous rostrum, by means of which the maxillary lip and the mandibles reappear as special, although greatly altered, organs.

The leg-knobs gradually develop into sausage-shaped appendages, lying against the ventral surface and converging from behind forward. During later stages of embryonic life the two anterior pairs of legs get to bend backward; at the same time they become divided into joints, and the hairs upon them are formed. The third pair of legs, however, always remain with the tarsi pointing forward, and nearly touching the rostrum: this third pair lies nearest to the ventral surface, the two anterior pairs lie exterior to them. At this period the anal slit becomes plainly visible. Finally, when the embryo has acquired a chitinous external layer, it has become a fully-formed larva, and emerges.

In *Carpoglyphus*, which is probably the only genus of Tyroglyphidæ provided with eyes, Kramer says * that the eyes appear early in embryonic life.

* "Ueber die postembryonale Entwicklung bei der Milbengattung Glycyphagus" (1880), in 'Arch. Naturg.,' Jahrg. xl, pp. 102—110.

The Larva.

The larva of every species of the Tyroglyphidæ, the stage of which is known, is hexapod; this distinguishes it sharply from the nymph and imago, which are invariably octopod. It is the fourth pair of legs which is absent; this, as far as is known, is the rule in all Acarina. The larva usually greatly resembles the nymphs and adults, sufficiently so, in most cases, to be recognised; but there are some characters by which in many cases the larva could be known even if it were not for the hexapod condition. One of the principal of these is the absence of external genital organs, but this it shares with the first nymph, and often with the older nymphs; as will be seen, however, from the latter part of this chapter, the development of the internal genital organs has commenced even as early as the larva.

One character which, when present, is specially characteristic of the larva, is what Claparède calls the provisionary "Bruststiele." These are a pair of round rods of clear chitin, placed one on each side of the body just anterior to the epimeron of the second leg; the proximal end of the rod is attached to the ventral surface of the larva by a flexible joint, so that it is capable of motion. The distal end is generally a little knobbed, or clavate, never pointed as far as has been observed hitherto. The function of this organ is entirely unknown; it has not ever been seen on any nymph or imago: it appears to be always present in larvæ of the genus *Tyroglyphus*, as far as the larvæ of that genus have been recorded, and in those of some allied genera, but it is not found in those of *Carpoglyphus* and some other genera.

The larvæ of the Tyroglyphidæ frequently have only the epimera of the first pair of legs joined to the sternum or to each other; although in the adults the second pair may also be joined. In some cases the epimera of the first and second pairs may be joined together. *Carpoglyphus* is a good example of this; illustrations of the undersides of both larva and adult are given to show it.

In those members of the genus *Glycyphagus* which have strongly plumose or palmate hairs on the notogaster, such as *G. Canestrinii*, *G. plumiger*, and *G. palmifer*, these hairs in the larva are scarcely plumose or palmate at all. A careful examination with a microscope will disclose a tendency to be slightly villous, but that is all; this fact produces a much more striking difference in the general appearance of the larva and the imago than is usual in the family.

The larvæ of the Tyroglyphidæ are generally almost colourless and semi-transparent; exceptions to this rule exist, however, in the case of *Hericia Robini* and some other species; moreover, in cases where the whole dorsal surface is hairy or spiny, such as *Glycyphagus platygaster*, the hairiness or spininess of that part is ordinarily far less marked in the larva than the adult.

The period of larval life is short, and the creature does not increase in size very greatly during this stage, although it does increase; at the termination the larva undergoes an ecdysis (its first), and that brings it to the nymphal state. The ecdysis is preceded by a short inert period, which, however, is not usually so long as in some other families of Acarina—*e. g.* the Oribatidæ.

The Nymph.

In the Tyroglyphidæ the nymph usually greatly resembles both the larva and the imago; but the younger nymph before the first ecdysis is generally most like the larva, while toward the end of nymphal life the creature is more similar to the adult; where the sexes of the imago are very dissimilar it is most frequently the adult female that the nymph resembles most closely.

The nymphal stage is the great period of growth in the Tyroglyphidæ and in most other Acarina: in the Tyroglyphidæ it is strictly the period between the acquisition of the fourth pair of legs and that of the genital organs becoming functional; it also corresponds to the interval between the first and the last ecdysis.

With regard to the number of nymphal ecdyses there are, as far as I know, only two existing authorities, namely, Kramer and Nalepa; for although Canestrini joined with Kramer, in "Das Thierreich,"* in stating that all the Sarcoptidæ, of which the Tyroglyphidæ are there treated as a sub-family although Canestrini considered them a family,† are binymphal; yet the portion of the joint work which dealt with the Tyroglyphidæ was by Kramer alone. Both he and Nalepa had previously stated, as the result of their observations, that the Tyroglyphidæ underwent two nymphal ecdyses only. Both these authors used the same species for their investigations, viz. *Carpoglyphus anonymus*,‡ and I am not aware that either stated exactly how the facts had been ascertained. Unfortunately Dr. Kramer's observations in this matter were manifestly unreliable, because he stated that there was not any inert period before the change of skin; this is an entire mistake, and no observer who had conducted his research with sufficient care to make his results reliable could possibly have missed it. The inert period occurs before every ecdysis, and usually lasts some days; during it the creature is perfectly motionless and remains with outstretched or curled-up legs as if dead, but it does not shrivel up. I have seen it many hundreds of times, and have watched the creatures gradually becoming inert, and, as will be seen below, counted the time that the period lasted over and over again. Nalepa pointed out Kramer's

* Lief. 7, p. 4.

† Ibid., note, p. 8.

‡ Kramer, "Ueber die postembryonale Entwicklung bei der Milbengattung *Glyciphagus*," in 'Arch. Naturg.,' Jahrg. xl, Bd. i, p. 102. Nalepa, Abth. 2.

error, and considering the general accuracy of Dr. Nalepa's work, I should probably have been justified in relying upon his statement without further observations of my own; however, as he did not state his methods of working out the life-history, I thought it would be more satisfactory to check the result and to see if it applied to other species also; moreover I hoped to obtain some information as to the period which the various stages lasted, etc., which might be of interest. I think that I was not unsuccessful in this; but I may say at once that I found Nalepa's statement of the two nymphal ecdyses to be correct, as might have been anticipated, in the species which I investigated.

My method of investigation was practically the same as what I used for the Oribatidæ, viz. I took an ordinary glass microscopic slip 3 × 1 inch, and to the middle of this I cemented with gold-size a glass ring (section of tube) of a trifle less than one inch external diameter; the height of the ring, which constituted the wall of the cell, was about one third to one half of an inch. The gold-size was allowed to dry thoroughly and all smell to go off. A piece of thick white blotting-paper, a trifle less in diameter than the inside of the cell, was then placed on the bottom of the cell and slightly moistened; upon this the Acarus, or Acari, to be reared was placed with its food; a second 3 × 1 inch glass slip, or a piece of one, was placed over the top; the edge of the glass ring having been ground quite smooth; the cover was fixed on by a clip, or a thread wound several times round cell and cover; I prefer the latter method. The food before being placed in the cell must be carefully sterilised by being baked or boiled, otherwise eggs and other Acari will get in with it and render the observations unreliable. The Acari do not usually like the baked or boiled food as well as unsterilised food, but it is necessary to use the former. Success depends greatly on maintaining the precise hygrometric condition which suits the creature. The cover should be removed, first making sure that the Acarus is not on the under-side of it, every day, or at least every second day, and the cell placed on the stage of the microscope and carefully examined.

I find it best and most reliable to have only one Acarus in a cell; for observation there should never be more than three, and if there be more than one all but the one to be most carefully observed should be taken out at any time when there is any possibility of confusion between them; this I invariably did. I am sure that in order to trace the life-histories the observer should know each individual Acarus which he is rearing; this greatly increases the difficulties, because it is easy enough to rear them in numbers in large vessels with plenty of unsterilised food; but far more difficult to do so in such a manner as to be certain that one's observations in each case are invariably of the same individual.

I had a number of these cells, always full, throughout my experiments; during what are called below the winter experiments I had 29 cells; during the summer observations 19. Whenever the Acarus or Acari in one cell died, or otherwise became useless, it or they were replaced by another or others, a fresh series in that cell being started; these series were numbered.

The species which I tried to observe were *Tyroglyphus siro*, *Carpoglyphus anonymus*, and *Histiogaster entomophagus*. I found the last-named species far the best for my purpose, and the whole of the observations which I have recorded in this connection were made on this species. I found that the habitat of *C. anonymus* was not very suitable for such close observations as I wished to make (it wades on wet preserved fruits, etc.). *T. siro* is an active species, very apt to escape when the cover is removed for examination of the cell. *H. entomophagus* is a slow creature, which did not escape readily; I had an ample supply of the species upon ergot of rye, obtained for me by the kindness of Mr. Waddington; I used the ergot as the sole food during the experiments, always carefully sterilising it.

It was early in November, 1900, when it first struck me that it was desirable to check the number of ecdyses myself, and to endeavour to obtain some information as to the length of time occupied by the various stages. I was aware that the season of the year was most unfavourable for the investigation; still, as I had the time before me, I thought that it would be best to endeavour to see if I could learn anything in winter. This involved a much greater expenditure of time and trouble than I had anticipated; but it resulted in discovering one point in the life-histories which was entirely unsuspected by me; and which, as far as I know, has not been recorded by any arachnologist. I found that a creature would become inert exactly as if it were about to pass through an ecdysis; it was perfectly motionless, and had the legs either stretched out or curled up, and would lie in any position it happened to fall in. In this condition it would remain for days or even months; then suddenly one day I would find it quite active; the natural supposition was that it had emerged, but I did not see any cast skin. I thought it might have eaten it; but in the cases where I saw the creature emerge it never did eat the cast skin; moreover in those cases where there was not any cast skin the creature never looked as if it were newly emerged. From long habit of noticing them the observer gets to know the appearance of a freshly emerged specimen; the abdomen is flatter than in one that has emerged some time, and is much more dimpled; the specimens which have been out some time look fully-fed and arched on the back, and are without dimples; moreover the freshly emerged specimens are more transparent and lighter in colour. I was greatly puzzled by this at first, and feared that I had somehow missed the ecdysis; but by long and constant watching in numerous cases I found that during winter the creatures were apt, at irregular intervals, to become torpid in a manner which exactly simulated the inert stage before ecdysis; and that they remained so for varying and uncertain periods, reviving quite suddenly. I found that this might occur once or two or three times or more to the same individual during the winter without any ecdysis occurring; but I have not ever seen a similar occurrence in summer. I was not able to trace that the becoming torpid, or the length of time that the torpidity lasted, was affected by the temperature of the room in which the cells were; all the creatures did not become torpid at one time. I could not find out any settled rule about it, but practically I did not find that any adults emerged in my cells in winter.

I have therefore come to the conclusion that in *H. entomophagus*, as in *C. anonymus*, there is one larval ecdysis and two nymphal ecdyses; the second nymphal ecdysis bringing the creature to the adult or imago stage in both sexes. As will be seen below, this rule does not hold good where a hypopial stage intervenes; but during the whole time that I have kept *H. entomophagus* in confinement (considerably over a year) I have not ever seen a hypopus of that species either in my cells or in my store.

I have given, in the following tables, some abstracts of my notes made from day to day of what took place in my breeding-cells during the above investigation; I have selected a few of what seem to me to be the most instructive records out of a great number. The summer records are distinguished by the letter S before the number of the cell. Of course I cannot say how far the length of time that different stages lasted may have been affected by the artificial conditions of life which the creatures were under.

Although I think it most convenient to place these tables here at the end of the ordinary nymphal stage, yet such records as S. 8, S. 18, embrace the whole life circle.

Records of Rearing Histiogaster entomophagus.

Cell 5.

1900.
Nov. 22.—Put three inert first nymphs into this cell.
23.—Two have emerged and are now second nymphs.
30.—The two are active; the third, which did not emerge, is dead.
Dec. 2.—The two are feeding, half buried in the food.
3.—One appears inert, but is not quite so.
4.—Both are quite lively.
5.—One appears inert, the other lively.
6.—Both are quite lively.
7.—Lost one of them, the other is sluggish.
8.—The remaining one is inert (torpid). (It remained so until the 13th December inclusive.)
14.—Has suddenly become quite lively, it does not look newly emerged, there is not any cast skin. I have examined it, it is not adult. (It continued active until the 22nd inclusive.)
23.—It is very still, not quite inert.
25.—Is inert (torpid). (It continued so until 15th January, 1901.)

1901.
Jan. 15.—It has shifted its position, but still seems torpid. (It continued so until 24th January, when the position in the cell was again altered, but it still seemed inert and continued so until April 12th.)
April 12.—Has become active, have examined it; it is not adult, there is not any cast skin, it does not look newly emerged. (It continued active until April 17th inclusive.)
18.—Is nearly inert, not quite.
20.—Is inert. (It continued so until 26th.)
26.—Has emerged. It is an adult ♂.

Cell 8.

1900.
Nov. 23.—Put one inert first nymph into this cell.
25.—It has undergone ecdysis, and is a second nymph. Cast skin there. (It continued active until 28th, when it buried itself in the food, where it remained until December 3rd inclusive.)
Dec. 4.—It has emerged from the food and is grown and active. (It continued so until 10th.)
10.—Looks sluggish. (It continued becoming more sluggish until 12th.)
12.—Less sluggish, feeding. (Continued active until 15th.)
16.—Very sluggish, not inert.
17.—Apparently inert. (It continued so until 20th inclusive.)
21.—Is moving, not lively, does not look newly emerged, no cast skin. (It continued lively until 24th.)

1900.
Dec. 25.—Is getting sluggish. (It became more and more so until 30th inclusive.)
31.—It appears quite inert (torpid). It continued so until April 9th, 1901.

1901.
April 10.—It is lively. It is not adult; no cast skin. (It continued lively until 13th inclusive.)
14.—Is inert. (It continued so until 23rd inclusive.)
24.—It has undergone ecdysis, and is an adult ♀. The cast skin is there.
26.—I put a ♂ into the cell.
30.—Saw the two *in copo.*

Cell 19.

1900.
Dec. 7.—Put three inert first nymphs into this cell.
8.—One has emerged and is a second nymph.
11.—The two others have emerged, all are second nymphs. (They remained active until 30th December, then gradually became sluggish.)

1901.
Jan. 8.—All appear inert. (They remained so until the 23rd January inclusive.)
24.—One has suddenly become quite lively. I have examined it, it is not mature.
27.—Another has become lively; there are not any cast skins.
29.—They have become extremely sluggish but not quite inert. (They remained in this condition until early in April.)
April 7.—All three are quite lively. I have examined them, they are not adult. I have lost one. (They remained active until April 27th inclusive.)
28.—They are sluggish but not inert.
May 4.—One is now inert. Have accidentally killed the other.
12.—The remaining one has undergone ecdysis. It is now an adult ♂.

Cell S. 7.

This cell was kept entirely for larvæ, most of which were put into the cell in an inert condition; as soon as nymphs emerged they were removed out of this cell and placed in other cells. In this manner it was possible to be certain that the nymphs placed in those cells were really first nymphs.

Cell S. 5.

1901.
May 20.—Put three active first nymphs, bred from larvæ in cell S. 7, into this cell. (They remained active until 6th June inclusive, but on 29th May I lost one, leaving two only.)
June 7.—Both apparently inert.
11.—One has emerged and is second nymph: the cast skin is there.

1901.
June 16.—The second has emerged, both are now second nymphs; there is considerable difference in size.
24.—The larger one is nearly inert.
28.—The larger one is quite inert.
30.—The larger one has emerged and is an adult ♀.
July 6.—The smaller has emerged, is an adult ♂; the two are *in copo.*
8.—There is an egg in the cell.
10.—There are five eggs in the cell.
13.—There are nine eggs in the cell.
17.—Some of the eggs have hatched.

Cell S. 8.

1901.
April 28.—Put an inert first nymph into this cell.
May 4.—It has emerged and is a second nymph. (It continued lively until May 26th inclusive.)
27.—It is inert.
30.—It has emerged, is an adult ♀, cast skin is there.
June 1.—Put an adult lately emerged ♂ into the cell.
5.—Saw the two *in copo.*
6.—Took out the ♂.
7.—There are three eggs in the cell.
9.—There are four eggs in the cell.
11.—There are nine eggs in the cell.
13.—There are eleven eggs in the cell.
16.—There are thirteen eggs in the cell.
18.—There are fourteen eggs in the cell.
20.—Two larvæ have emerged.
26.—Several larvæ have emerged.
30.—Two larvæ are inert, put them in cell S. 19.
July 2.—Several other larvæ have emerged.
4.—Two nymphs have emerged; put them in cell S. 16.
6.—There are more nymphs.
13.—One nymph in cell S. 16 is nearly inert.
15.—Is inert. One of the nymphs in cell S. 19 is also inert.
17.—The inert nymph in cell S. 16 has emerged, and is now a second nymph. Eggs still continue to be laid in cell S. 8.
19.—The inert nymph in cell 19 has emerged and is now a second nymph; the cast skin is there.

Cell S. 9.

1901.
April 30.—Put three first nymphs, bred from larvæ in cell S. 7, into this cell. (They remained lively until May 21st inclusive.)
May 22.—One has become inert.
26.—It has emerged and is a second nymph. Have removed the remaining first nymph into another cell. The second nymph remained lively until June 4th inclusive.
June 5.—Is sluggish.

1901.
June 7.—Is inert.
11.—Has emerged, it is an adult ♂.

Cell S. 12.

1901.
May 16.—Put one first nymph, nearly inert, bred from a larva in cell S. 7, into this cell.
24.—Is inert.
26.—Has emerged, is a second nymph.
30.—Is sluggish.
June 1.—Is inert.
3.—Has emerged, is an adult ♂.

Cell S. 14.

1901.
May 12.—Put an active first nymph, bred from a larva in cell S. 7, into this cell. (It remained active until May 29th inclusive.)
30.—Is inert.
June 3.—Has emerged, and is a second nymph. (It remained active until June 25th inclusive.)
26.—Is sluggish.
30.—Has emerged, is an adult ♀.

Cell S. 15.

1901.
May 24.—Put a first nymph, bred from a larva in cell 7, into this cell.
26.—It has become inert. (It remained so until 29th inclusive.)
30.—Has emerged, is now a second nymph. (It remained active until June 23rd inclusive.)
June 24.—Is sluggish, not inert.
July 2.—Is inert.
6.—Has emerged, is an adult ♀.

Cell S. 18.

1901.
May 2.—Put into this cell one active first nymph, bred from a larva in cell S. 7. (It remained active until June 1st inclusive.)
June 2.—It is now inert. (It remained so until June 5th inclusive.)
6.—It has emerged and is now a second nymph. (It remained active until July 1st inclusive.)
July 2.—Is sluggish.
8.—Is inert.
10.—Has emerged. It is an adult ♀. Put in an old ♂ which had emerged some time.
25.—Saw the first egg in the cell.

The Hypopial Nymph.

The hypopial stage is biologically far the most interesting portion of the life-history of the Tyroglyphidæ; it is also of considerable commercial importance, because it is the existence of this remarkable provision that enables many of the most destructive species to spread themselves almost all over the world as they do. As far as I know there is not anything really similar existing in any group of living creatures outside the Acarina; even amongst them the stage is entirely, or almost entirely, confined to the Tyroglyphidæ. It is true that Prof. Berlese suggests that the creature described by me as an adult female under the name of *Disparipes bombi*, which is one of the Tarsonemidæ, is a hypopus, and that the adult female differs slightly from it in having smaller claws on the first leg, etc. This observation of Berlese's I think certainly requires confirmation, because the learned Italian professor does not appear to have based his statement upon specimens bred in confinement and carefully observed, but upon captured specimens supposed to be identical, which is not in my opinion a reliable method; whereas I have carefully bred the creature in confinement through several generations without detecting any such form as Berlese describes; although such forms may easily be captured in the open, and certainly some of them belong to different species, for the males are different. I hope some day to find time to repeat my experiments specially with a view to this point; in the meantime I do not think that it can be assumed that this is a hypopial form. The only other case which I am aware of where it has been suggested that a hypopial stage exists outside the Tyroglyphidæ is in certain of the Sarcoptidæ which in the mature stage are found on the feathers and exterior of birds, but which in the immature stages live inside the shafts of the quills, or in the interior of the birds.

Mégnin considered that these immature forms were hypopial;* they, however, appear to me to be very different from what are usually considered to be hypopi. It is true that the Acarus which Mégnin considers to be the hypopial nymph of *Pterolichus falciger* is stated to be without mouth-organs; but it lives in the subcutaneous cellular tissue of birds; and it is a very different thing for an animal in a parasitic stage to be without mouth-organs when it lives almost always bathed in liquid food-material which it can absorb, from what it is to be similarly deficient when it lives as a free temporary external parasite of hard chitinous creatures from which it cannot obtain any nourishment whatever, or as a free non-parasitic creature. At any rate, whether these exceptional and doubtful cases are really to be considered as hypopial or not they will not be treated of here, and I shall deal only with the hypopial stage in the Tyroglyphidæ.

The history of the literature relative to Hypopus, and the errors and gradual steps through which our present knowledge of the stage has been acquired, are interesting.

In August, 1735, de Geer† noticed, for the first time, on the house-fly (*Musca domestica*) some small reddish Acari, which were in such numbers that the neck and back of the fly were entirely covered by them. The mites were usually quite still, but ran about actively when touched; the body was oval, entirely chitinised, polished, convex on the dorsal, flat on the ventral surface; instead of an ordinary mouth it had a minute membranous tube, or what de Geer calls a trumpet, articulated to the ventral surface about where the mouth would be; this organ was closed distally, and ended in two hairs, often longish. Looked upon in the light of later knowledge this "trumpet"

* 'Les Parasites et les Maladies parasitaires,' Paris, 1880, p. 151, and some others of Mégnin's writings.

† 'Mémoires pour servir a l'histoire des Insectes,' Stockholm, 1752–78, vol. viii, p. 115, pl. vii, figs. 1—3.

may probably be regarded as a rudimentary maxillary lip or hypostome; or possibly as a tactile organ of the nature of the so-called "Bauchtäster" of the Gamasidæ: the earlier writers supposed that there was actually no mouth-opening, but it is now known that below this articulated lip, and covered by it, there is a minute round hole which may probably be considered to be a mouth in some, probably in all Hypopi; but there are not any trophi connected with it, and we have not any reason to suppose that it is functional for the purpose of taking in food. The two anterior pairs of legs of de Geer's Acarus were thick and well developed; but the fourth pair terminated in long setæ without claw or sucker, resembling in this respect those of the itch-mite (*Sarcoptes scabiei*). De Geer considered it an adult creature.

Linnæus in 1758 * adopted de Geer's description, and called the supposed species *Acarus muscarum*. Attempts have been made to identify this with the Hypopus of some particular species, but I do not think that any reliance can be placed upon these efforts; neither the Linnæan description nor de Geer's affording sufficient detail for identification.

E. L. Geoffroy † found what was probably either the same or some allied form, and called it the "Brown Fly-mite."

Hermann ‡ in 1757 found upon the ventral surface and legs of a *Scarabæus* larva and of the larva of *Osmoderma erimita* a large number of small red-brown mites with short legs and spines to the tarsi; these he called *Acarus spinitarsus;* his figure leaves little, if any, doubt that the creature was a Hypopus, and to that extent at all events allied to de Geer's Acarus. Mégnin § and Oudemans || identify Hermann's Acarus

* 'Syst. Nat.,' ed. 10, 1758–9, p. 617.

† 'Histoire abrégée des Insectes,' 1764, t. ii, p. 624, No. 6.

‡ 'Mémoire aptérologique,' Strasbourg, 1804, p. 87, pl. vi, fig. 5.

§ "Mémoire sur les Hypopus," in 'J. Anat. Physiol.,' 1874, t. x, p. 241.

|| "List of Dutch Acari," part 7, in 'Tijdschr. Ent.,' d. xl (1897), p. 251.

with the Hypopus of *Tyroglyphus mycophagus*, Mégnin, but I cannot see that either Hermann's figure or description affords any possibility of identifying it with this or any other species.

Schrank * in 1781 gave a description of a small mite which he found upon a male Gamasus (his *Acarus crassipes*), and which he called *Acarus acarorum;* this again is evidently a Hypopus.

Dugès in 1834 † found upon a *Hister* a minute mite which he regarded as being identical with Hermann's *Acarus spinitarsus.* He created the genus *Hypopus* to receive it, and he included de Geer's *Acarus muscarum* and also Lyonnet's "*pou de limacon*" in the same genus; he noticed the singular supposed mouth or lip with its two setæ, but mistook the ventral suckers for stigmata. In his abstract of the genera ‡ he puts a ? as to whether the creature is a larva; it is perhaps singular that Dugès should have done this in the very paper in which he created the genus, but such is the fact; I believe that it is the first occasion on which any hint was given by anyone that the Acarus in question might be immature: all previous writers had confidently described it as adult. Dugès states that he had only a single specimen.

Dufour in 1839 § added two supposed species to Dugès' genus; one he found living in closely packed groups on the head and thorax of Coleoptera of the genus *Feronia*, and called *Hypopus feroniarum;* the other he found upon Diptera of the genus *Sapromysa*, and called *Hypopus sapromysarum.* Dufour evidently regarded them as adult creatures specially parasitic upon the particular insect upon which he found them. Mégnin and Canestrini identify Dufour's *H. feroni-*

* "Enumeratio insectorum Austriæ indigenorum," 'Augustæ Vindelicorum,' p. 524.

† "Recherches sur l'ordre des Acariens," 3me mémoire in 'Ann. Sci. Nat.,' 2 sér., t. ii, p. 37.

‡ Op. cit., 1re mémoire, ibid., t. i, p. 20.

§ "Description et figures de quelques parasites de l'ordre des Acariens," in 'Ann. Sci. Nat.,' 2 sér., t. xi, p. 278.

arum and also Claparède's *H. Dugesii* * with the Hypopus of *Histiostoma rostro-serratum ;* in the case of Claparède's form this is probably right, but in that of Dufour's it must I think be considered doubtful. Dufour in the same paper instituted a new genus, *Trichodactylus*,† for an apparently somewhat allied Acarus which he found upon bees of the genus *Osmia.*

C. L. Koch ‡ in his great but faulty work admits the genus *Hypopus*, but gives only one species which he found in numbers on *Julius unilineatus*, and calls *Hypopus julorum ;* it is curious that Koch says that he frequently saw the ♂ and ♀ *in copo.* We know now that there are not any males or females capable of coition, all being immature ; what Koch doubtless saw was two individuals adhering to each other by their ventral suckers, as they will readily do to any polished surface. In his later work § Koch transfers *A. spinitarsus*, which he treats as one of his own species, *A. muscarum*, and three other species, or supposed species, to the genus; none of these are really Hypopi at all, but are probably all *Uropoda*, some adult, some immature. Koch in the same work founded a new genus *Homopus* for two somewhat similar creatures, but with certain structural differences which will be hereafter described ; these he called *Homopus sciurinus* and *H. hypudæi* after the animals he had found them upon; || he had at first called the former species *Dermaleichus sciurinus.*¶

Dujardin ** in 1843 found on the wing of a bee a small mite for which he originated a new genus *Anætus*,

* "Studien an Acariden," 1868, in 'Z. wiss. Zool.,' Bd. xviii, p. 506, T. xxxvii, fig. 6.

† This name failed, being preoccupied by Latreille for a genus of Crustacea in 1824.

‡ Koch, D. C., 1844, Heft 38, fig. 20.

§ Koch, 'Uebersi,' Heft 3, 1842, p. 129.

|| Ibid., p. 120.

¶ Koch, D. C., Heft 33, fig. 7.

** 'Ann. Sci. Nat.,' 3e sér., 'Zool.,' t. ii, p. 245; 'L'Institut,' No. 454 p. 316.

which however he subsequently suppressed, finding it to be only a Hypopus.

Gervais * next described a supposed new species of *Hypopus*, which genus oddly enough he associated with *Tyroglyphus*, although without having any idea of the real connection subsequently ascertained to exist between them; it must be admitted that he also joined certain other genera to *Tyroglyphus* which were not in any way related to it.

So far, except for the remark of Dugès above quoted, every one had treated Hypopus as a mature Acarus.

Dujardin returned to the subject in 1847 or before, but his next paper was not published until 1849.† This memoir was far the most careful study of Hypopus made up to that time, and probably no better drawings of Hypopi have ever been published. Dujardin recognised that at the posterior end of the ventral surface each Hypopus of the ordinary class was provided with a plate of thicker chitin than the remainder of the ventral surface, and that this plate was situated between the anus and the hind margin; he also observed that the plate was pierced to allow the passage of suckers, which were mostly within the area of the plate but sometimes a few just outside it, and that these suckers varied greatly in number, arrangement, size, and other details; so that one Hypopus might be distinguished from another by them; and that in the case of creatures similar to Koch's *Homopus* the suckers and sucker-plates were replaced by two clasping plates; he saw that the Hypopi readily and rapidly attached themselves to polished surfaces by their ventral suckers, and held so tenaciously that they were difficult to detach. Dujardin found great

* In "Histoire naturelle des Insectes aptères," Walckenaer, t. 3 (1844), p. 265, in 'Suites à Buffon.'

† "Mémoire sur des Acariens sans bouche dont on a fait le genre Hypopus, et qui sont le premier âge des Gamases," in 'Ann. Sci. Nat.' (1849), 3e sér., t. xii, pp. 243—250. "Additions au Mémoire sur les Hypopes," ibid., pp. 259—266, pl. ii.

quantities of Hypopi on *Musca stabulans*, on beetles, on bees, on *Ceterach officinarum*, etc.; he watched them carefully and intelligently; he observed the absence of mouth-organs, and as he considered of any mouth at all, and of any reproductive organs. He also noticed that some Hypopi immediately before the ecdysis contained within their skin, and completely filling it, an Acarus entirely different from themselves; this inner creature possessed chelate mandibles and palpi; he stated Gamasids were Acari; they had chelate mandibles and palpi similar to those seen within the Hypopus; they were to be found on flies, on beetles, on bees, and in other places where he found Hypopi; Dujardin usually found the two together; the inference to be drawn from these facts appeared obvious; Dujardin announced that *Hypopus* was the young of *Gamasus*; it never struck him that *Gamasus* might be a predatory creature which devoured the soft-bodied Acari which emerged from the hypopial skin. We know now that Dujardin was in error, and that there is not any connection between *Gamasus* and *Hypopus*; but with the exception of Dugès' query above referred to, Dujardin was the first person who suspected, and quite the first person who proved, that Hypopus was an immature form of some Acarus totally different in appearance from itself.

Fürstenberg in 1861 * in his great work on the Sarcoptidæ of mammals figured and described an Acarus which he considered as belonging to Koch's genus *Homopus*, and which Gwilt had found in immense numbers on the skin of a recently stuffed elephant; for which, not very sufficient, reason he called it *Homopus elephantis*. It is not quite clear why Fürstenberg included it in his book at all, as he expressly says that although a parasite it is not an itch-mite; possibly it was because Gerlach held a different opinion, and called it *Symbiotes elephantis*, but having included it Fürstenberg gave a very

* 'Der Krätzmilben der Menschen und Thiere,' Leipzig, 1861, p. 222.

different account of its mouth-organs from what other writers had described in Hypopus; he stated that it had maxillæ divided into two equal parts and placed between three-jointed palpi. Fürstenberg's figures clearly show that he was dealing with an ordinary hypopial nymph, not a homopial one. As to the supposed mouth-organs, it can only be said that Fürstenberg had a talent for imaginary mouth-organs; for in his most laborious and magnificently illustrated work every species is drawn and described as having two pairs of chelate mandibles, a thing never yet found in any known Acarus. Fürstenberg carried his measurements to the fourth place of decimals of a millimetre (in 1861); he however recognised that the creatures were probably immature.

Claparède in 1868 was the next contributor to the literature of *Hypopus;** he is entitled to the credit of being the first person to connect *Hypopus* in an intelligent manner with *Tyroglyphus*, although Gervais had classed them together without assigning any reason. Claparède found upon potatoes, dahlia tubers, and cabbage-stalks, near Geneva, what he considered to be a new species of *Tyroglyphus*. He had it in great profusion, and kept up his observations upon it for three years. He bred it upon hyacinth bulbs in his study in large numbers; he said it belonged to the genus *Tyroglyphus* and called it *T. Dujardinii* or *Hypopus Dujardinii*, usually the latter; but, as he imagined, he never found a male; all his specimens were females according to his view. Claparède never found any Gamasids amongst them, but he did constantly find large numbers of Hypopi all of one kind; moreover he actually saw some nymphs of the supposed *Tyroglyphus*, which greatly resemble the adult female, cast their skins and produce a Hypopus, not an adult female *Tyroglyphus* as other nymphs of the same species did. He never could see any eggs in a *Hypopus* nor any vulva. Claparède's observations were absolutely correct; but he drew from

* "Studien an Acariden," in 'Z. wiss. Zool.,' Bd. xviii, pp. 493—507.

them the very natural, but utterly erroneous deduction that *Hypopus* was the male of *Tyroglyphus*. Had he only known it Clarapède had disproved his own theory in his own paper, for he really had found the male over and over again but he did not recognise it as belonging to the same species; he made a new genus for it and called it *Rhizoglyphus Robini*. *Rhizoglyphus* is one of those exceptional creatures which have two forms of male; one with the third leg greatly enlarged and the tarsus coming to a point, the whole joint being claw-like but not provided with any real claw, this leg being a clasping leg only; the other with the third leg an ordinary ambulacral leg, not differing from the other legs and furnished with a claw. Both forms copulate equally freely with the female, as I have ascertained from personal observation, but they were at first supposed to be different species until Canestrini established their identity and the existence of intermediate forms. Claparède recognised the form with the small third leg as a male, but oddly enough mistook that with the enlarged third leg for its female; it never struck him that either was the male of his *Tyroglyphus Dujardinii*.

Claparède's suggestion that *Hypopus* was the male of *Tyroglyphus* was, however, not only disproved by his own researches, but it was disproved before he published it had he known it; but he was not aware that while he was studying his species Professor C. Robin and Dr. Fumouze were doing the same thing; they published their paper* shortly before Claparède issued his. They called the species *Tyroglyphus echinopus*, and their specific name must stand, although Claparède's generic one does; therefore the species is now called *Rhizoglyphus echinopus*. Robin and Fumouze did not trace the Hypopus, or apparently know anything about it; they did not breed it apparently, but they did recognise and describe the male correctly.

P. Mégnin took up the subject of Hypopus in 1873,

* "Observations sur une nouvelle espèce d'Acarien du genre Tyroglyphe," in 'J. Anat. Physiol.,' 1868, t. v, p. 287, t. xx, xxi.

and became the principal authority upon it. He first attacked it in his memoir upon *Histiostoma rostro-serratum*, called by him at that time *Tyroglyphus rostro-serratus*,* and afterwards in that upon *Hypopus*;† his labours were rewarded by the French Académie des Sciences with the Thoré prize of 1873. Mégnin experimented upon *Histiostoma rostro-serratum* and *Tyroglyphus mycophagus*, both species found by him in immense quantities upon mushrooms (*Agaricus campestris*). He bred his creatures in large cases, supplying them with pieces of fresh mushroom from time to time; he saw the *Hypopus* inside the inert nymph of *Tyroglyphus* just as Claparède had done; he also found that *Hypopus* turned into a nymph of *Tyroglyphus*. Mégnin also noticed that when the mushrooms and cages got dry his *Tyroglyphi* disappeared and were apparently replaced by swarms of *Hypopi*; when moisture, or fresh moist mushroom was added the *Hypopi* disappeared and the *Tyroglyphi* were again in great quantities. Specimens kept in separate cells appeared to be almost inert, and adhered motionless to the side of the cell; but when moisture was added these *Hypopi* turned into nymphs of *Tyroglyphus*. The construction which Mégnin put upon these facts was the very natural one that *Hypopus* was a form into which the nymphs of *Tyroglyphus* changed when, through dryness of the atmosphere or other causes, there was a difficulty in their continuing to live as *Tyroglyphi*, and that it was a provision of nature to insure the preservation of the species by carrying it over periods of drought, etc. Mégnin declared that Fürstenberg's mouth-organs of *Hypopi* were pure fancy, and condemned such exercises of imagination. He judged correctly that *Hypopus*, *Homopus*, and *Trichodactylus* were all forms of similar nature, and he asserted that they had the power of living without any

* "Mémoire anatomique et zoologique sur un nouvel Acarien, etc.," in 'J. Anat. Physiol.' (1873), t. ix, pp. 369—378, pls. x—xii.

† "Mémoire sur les *Hypopus*, etc.," ibid. (1874), t. x, pp. 225—254.

nourishment during the whole period of their existence in this stage; this view, which as far as is at present known is a correct one, he supported in a special paper on the subject.* Mégnin stated that the nymph which changed into a *Hypopus* showed rudiments of the sexual organs, but that the nymph which emerged from the hypopial skin did not, and was one third smaller than the other; he concluded therefore that the change into a *Hypopus* was a retrogression. Mégnin summarises his conclusion by saying that *Hypopus* is the "cuirassed heteromorphous, adventitious nymph of *Tyroglyphus* entrusted with the preservation and distribution of the species (under adverse circumstances)." In one of his later works Mégnin stated that *Homopus elephantis*, Fürstenberg, was the same as *Acarus spinitarsus*, Hermann, and was the hypopial nymph of the common cheese-mite (*Tyroglyphus siro*). Mégnin did not say how the last-named fact, or supposed fact, was ascertained; moreover in his memoir upon *Hypopus* above quoted he stated that Hermann's *A. spinitarsus* was the hypopial nymph of his *Tyroglyphus mycophagus*. I am not aware that anyone, up to the present time, has succeeded in tracing the hypopial nymph of *T. siro* in any manner upon which any reliance can be placed.

In 1872 J. G. Tatem† figured and described under the names of *Acarellus muscæ* and *A. pulicis* two creatures which are *Hypopi*, and the latter of which he thought he took from the abdominal cavity of a dead flea. I have seen one of Tatem's specimens of the flea, but the *Hypopi*, which are numerous, are not within the abdominal cavity, although they look as if they were; they are between two segments of the abdomen in the place where the anterior end of the more distal segment passes within the posterior end of the more

* "Note sur la faculté qu'ont certains Acariens avec ou sans bouche de vivre sans nourriture pendant des phases entières de leur existence et même pendant toute leur vie," in 'J. Anat. Physiol.,' t. xii (1876), pp. 603—606.

† In 'Monthly Micros. J.,' 1872, p. 263, pl. xl.

proximal in a telescopic manner; they are thus securely sheltered in the bag formed by the fold of the membrane between the two segments.

Andrew Murray,* in November, 1876, wrote at some length on the subject of what a *Hypopus* was; he does not appear to have made any personal observations, but he discusses almost all the above-named literature respecting it. Finally he came to the conclusion that Hypopus was a parasite, internal in the earlier part of its life-history, external in the latter part; and he quoted the instance of *Rhipiphorus paradoxus* to show that such a thing might exist. Presumably Murray considered that the *Hypopus* ate its way into the body of the host, and entirely devoured it, leaving only the skin, but this is not very clear in his statement.

Notwithstanding Mégnin's researches, Dr. P. Kramer, in 1877,† described a homopial Hypopus found on the mole as an adult creature under the name of *Labidophorus talpæ.* This creature I have subsequently found and bred, and find it to be the hypopial nymph of *Glycyphagus Crameri.* This is now universally admitted to be correct; it was admitted as such by Kramer in 'Das Thierreich.' In the same paper Kramer described another parasite of the mole, and called it *Pygmephorus spinosus.* In 1881 Berlese published a paper‡ in the main agreeing with Mégnin, stating, apparently correctly, that *Hypopus* does not take any nourishment; also that it was entirely devoid of buccal and anal openings, which is not quite accurate, and that its lip with the two hairs is a tactile organ, which is probable, but it ordinarily serves also to cover up the mouth-opening. Berlese also said that Kramer's *Pygmephorus* was a *Hypopus.* This was an error.

G. Haller, in 1880, published a pamphlet upon Acari

* "Economic Entomology, Aptera," London, 1877, 'South Kensington Museum Handbooks,' pp. 231—251.

† "Zwei parasitische Milben des Maulwurfs," in 'Arch. Naturg.,' xliii Jahrg., p. 248.

‡ "Indagine sulle Metamorfosi di alcuni acari insetticoli," in 'Atti Ist. Veneto,' ser. 5, vol. viii.

parasitic upon Invertebrata.* It contains a summary of existing writings on the subject, but does not record any observations of his own. Still he makes a suggestion in it that the hypopial form is a "travelling dress" for *Tyroglyphus*, to enable it to endure the journey from one fungus, etc., to another, which would sooner or later become necessary from the drying or destruction of the first fungus. This really is the nearest to the truth that anyone had attained to.

The above are the principal records, but Mr. J. S. Macintyre informed me that he also had seen *Tyroglyphi* turn into *Hypopi*. I am not aware that he published his observations.

Thus it will be seen that in 1884, when I published the results of my own observations,† there were eight different theories before the world as to what a Hypopus really was, viz.:

1. *Hypopus* is a separate family of adult Acarina	All writers before Dugès, also Koch, Dufour, and some later authors.
2. *Hypopus* is an immature stage of *Gamasus*	Dujardin.
3. *Hypopus* is an itch-mite . . .	Gerlach.
4. *Hypopus* is the adult of both sexes of some species of *Tyroglyphus* . .	Gervais.
5. *Hypopus* is the male of *Tyroglyphus* .	Claparède.
6. *Hypopus* is the cuirassed, heteromorphous, adventitious nymph of *Tyroglyphus*, etc., appearing only for the preservation and distribution of the species under adverse circumstances .	Mégnin, Berlese, etc.
7. *Hypopus* is a parasite, at first internal, afterwards external, which devours its host from within, leaving only the skin	Andrew Murray.
8. *Hypopus* is a travelling dress . .	Haller.

Of these Mégnin's was the generally received theory, and was evidently an approach to the truth. I, however, could scarcely think that it was altogether correct; and finding the subject interesting I endeavoured to investigate it.

* 'Die Milben als Parasiten der Wirbellosen, insbesondere der Arthropoden,' Halle, 1880, p. 17.

† Michael, "The Hypopus Question, or the Life-history of certain Acarina," in 'J. Linn. Soc.,' vol. xvii (1884), pp. 371—394, pl. xv.

For two or three years I carefully watched *Tyroglyphi* in confinement in small glass cages under favourable and unfavourable conditions; but my efforts were chiefly directed to *Tyroglyphus siro* and *T. longior*, and I did not succeed in getting any hypopial forms from them, nor in seeing anything that would elucidate the question. I have lately succeeded in breeding the hypopial nymph of *T. longior*, which will be figured in this book in its proper place, but it is very difficult to obtain. In 1881, however, I found a quantity of Mégnin's *Tyroglyphus mycophagus.* I soon found that with this species there was not any difficulty in obtaining and rearing the Hypopus, or in repeating Mégnin's experiments. The nymphs readily turned into Hypopi, and the Hypopi returned to the condition of nymphs of the *Tyroglyphus;* in each case by an ecdysis. I was able to procure and retain microscopical preparations made during the progress of the change, and showing the Hypopus forming or formed inside the *Tyroglyphus* nymph. This appeared to me a sufficient answer to Andrew Murray's view that Hypopus was an internal parasite; because, firstly, the Hypopus is very nearly as large as the *Tyroglyphus* from which it emerges, filling up the whole interior; which seemed highly improbable in a creature which cannot grow inside, for no one has ever seen a young Hypopus either within the *Tyroglyphus* or living free; all Hypopi of the same species being about the same size and obviously in the same stage of growth. Secondly, a Hypopus is not ever seen within a larva or within an imago, only within the nymph; although all three stages in *Tyroglyphus* are soft-bodied and very similar. Thirdly, we never see two Hypopi within the same nymph, although when the Hypopus has emerged many specimens, sometimes immense numbers, may be found, ecto-parasitic upon the same Gamasid or insect. Fourthly, the emerging of the Hypopus is preceded by an inert period, just as the ordinary ecdysis is in most Acarina, including *Tyroglyphus.* Fifthly, the Hypopus, when it emerges after the ecdysis, leaves behind it the cast skin of the ordinary nymph, quite clean, like any other cast skin, and without any torn particles of internal organs adhering to it. Sixthly, the Hypopus has not any mouth-organs except the external lip which closes the mouth-opening, or rudimentary mouth-opening, and therefore apparently has not any means of destroying its host. Seventhly, the Hypopus returns to the *Tyroglyphus*-nymph form after the ecdysis. This last reason would be sufficient alone.

If the above reasons dispose of Andrew Murray's view, as I think they do, they equally dispose of the idea that Hypopus is a separate adult creature; for that could now only be sustained if Murray's view were accepted, otherwise the evidence of Claparède, Mégnin, Berlese, Macintyre, and myself, and later on of Monier, would doubtless be considered sufficient to prove that Hypopus is a stage in a life-history.

Claparède's view that Hypopus is the adult male of *Tyroglyphus*, or rather had he known it of *Rhizoglyphus*, was as above stated practically disproved by Claparède himself, and by Fumouze and Robin. It will, I think, be found that it was even more effectually disproved by my own investigations in 1882, mentioned below, which also answered Gervais' idea; there only remained Mégnin's and Haller's explanations. My observations decidedly confirmed Mégnin's view, so far as it stated that Hypopus is a heteromorphous nymphal form of *Tyroglyphus* and some allied genera. It remained to be seen whether I could confirm his conclusions as to the cause of the transformation.

For the last-named purpose I allowed my cells with *Tyroglyphus* nymphs to get dry, but I did not obtain any increase in the number of Hypopi; although I did find a very great diminution in the number of Tyroglyphi, which died off as the moisture became insufficient, until they disappeared entirely. Upon redamping the cell, but without introducing any fresh material or allowing any communication with the exterior except when the cover was removed for the cell to be examined during which time it was watched, more larvæ and young nymphs of *Tyroglyphus* soon appeared, being bred from the eggs which previous adults had laid, and older nymphs resulting from many of the Hypopi undergoing ecdysis, were also found; but these things occurred gradually, the Hypopi did not vanish suddenly, nor were fresh adults to be found until they had grown. The experiment of allowing the cell to get dry, or partially dry, was repeated several times, but always with the same results. It appeared evident, therefore, that desiccation or other unfavourable circumstances would not cause *Tyroglyphus* nymphs to change into Hypopi more rapidly than they would otherwise have done.

In the spring of 1882 I resumed the inquiry; I stayed at a farm where an old-fashioned chaff-house adjoined the stable; this was not kept in the well-swept condition of modern stables, chaff and *débris* of fodder remained in a pile on the damp brick floor, and the conditions were extremely favourable to *Tyroglyphus* life. Warmth, moisture, and food in abundance were there, and the chaff teemed with life. Tyroglyphidæ * swarmed, numbers of Gamasidæ were preying upon them; minute Diptera and their larvæ, Myriapoda, etc., were abundant, but *Hypopi also were in immense profusion*, and continued to be so, and to attach themselves to every living insect or Gamasid which came into the chaff. The hotbed for cucumbers at the same place, which was made of stable manure, presented equally favourable conditions for *Tyroglyphi*, quantities of which throve there; it swarmed with hypopi, which covered every small dipterous insect which emerged from the hotbed. It was therefore evident that the most favourable conditions did not prevent *Tyroglyphus* turning into Hypopus.

* Principally *Tyroglyphus mycophagus*, *Histiostoma rostro-serratum*, and *Aleurobius farinæ;* but the last-named species is not known to have any hypopial stage.

I now again tried the converse experiment; I collected Tyroglyphi, and placed them in two kinds of cells: (1) small cells consisting of a glass ring (section of tube) cemented on to an ordinary microscopical slide, the upper edge of the ring being ground smooth, so that the cover, which is another microscopical slide, would lie quite closely on it, being held on by a tie or clip; in each of these I put only one or two specimens, so that I could watch and know each individual. (2) Larger similar cells (small dissecting troughs), the cover pierced by a few small holes closed with fine muslin, and so placed that they can be made to let air into the cells or not, as desired, by moving the cover; in these cells a number of specimens can be placed if desired. I now tried two of these larger cells, each with a considerable number of *Tyroglyphi*, and when they were breeding freely allowed one cell to get dry, keeping the other in proper hygrometric condition. I did not find that I got more Hypopi in the cell that dried than in the other. On the contrary, I got more Hypopi where breeding was under favourable circumstances, and consequently young nymphs more abundant, but I did find that as the cell dried the Tyroglyphi rétired into any hole which afforded moisture. I kept a small piece of blotting-paper in the cell to damp when requisite; as the cell dried the *Tyroglyphi* usually got under the blotting-paper; if fresh moisture were added they came out again, if not they died, and were not seen again. The Hypopi endured drought much better, but if it were too prolonged they died also. I repeated this experiment several times, but always with the same result. This may account for the manner in which Mégnin's *Tyroglyphi* disappeared when his cage got dry, and reappeared when fresh moist fungus was added.

At this time, April, 1882, I took two similar Hypopi from moss in the neighbourhood, where they were numerous, and placed them alone in one of the smaller cells on blotting-paper. In a few days they became inert, and one changed into a *Tyroglyphus* nymph, leaving its exuvium on the blotting-paper; the other soon afterwards did the same. Early in May one of the nymphs underwent ecdysis and became an adult *Tyroglyphus*. About 13th May the second became inert, and shortly afterward also became adult.

The fully-grown nymphs of *Tyroglyphus* never changed into Hypopi, it was always the young nymph that changed; the change occurs always about the same period of the creature's life-history. It appeared to me, in the species I was observing, that the change occurred at the second ecdysis (first nymphal), and that the form continued until the following ecdysis. By carefully watching known specimens in the small cells I found that all individuals do not become Hypopi in the course of their life-history; most progress from larva to nymph, pass the nymphal ecdyses, and become imagos without assuming a hypopial condition; but whatever be the conditions under which the *Tyroglyphidæ* are kept Hypopi will appear from time to time if the species be one where Hypopi are easy to breed, and if young nymphs be present.

I found that the Tyroglyphi which emerged from the hypopial skin, when they became adult, were of both sexes; the female predominated in number, but not more so than it always does in specimens not bred from Hypopus.

Later on, in 1884, I had ample opportunities of breeding creatures belonging to two other Hypopus-producing genera of Tyroglyphidæ,* viz. *Histiogaster corticalis* and *Rhizoglyphus echinopus*, and in both cases I found that the more favourable were the conditions of life, and the more healthful the breeding, the more Hypopi I got.

What, then, is the reason of the hypopial stage? It appeared to me to be simply to facilitate the distribution of the species, by enabling the Acarus to lay hold of

* "Notes on the Life-histories of some Little-known Tyroglyphidæ," 'J. R. Micros. Soc.,' ser. 2, vol. v (1885), pp. 19—32, pl. iii.

any small living object that came within its reach, and thus be carried to fresh places suitable for it. Were the adult, the larva, or the ordinary nymph carried by such creatures as flies, bees, etc., which delight in hot sunshine, they would be killed; the hypopus, however, can endure heat and absence of moisture very much better. Hypopi sometimes remain a long time in that condition; I have had them over three months.

I therefore came to the following conclusions, viz.—

1. That Hypopi are not adult, but are an immature stage in a life-history.

2. That they are heteromorphous nymphs of *Tyroglyphus* and some allied genera, such as *Histiostoma*, *Rhizoglyphus*, *Histiogaster*, etc.

3. That it is not all individuals that become Hypopi, usually only a comparatively small number, and that these are of both sexes.

4. That the hypopial period occupies the time between two ecdyses in those species which I had examined.

5. That the change to Hypopus is not caused by unfavourable circumstances, and is not any extraordinary or exceptional occurrence, but is a provision of nature for the distribution of the species occurring quite irrespective of adverse conditions.

6. That in the present state of our knowledge we can no more say why one nymph becomes a Hypopus and another does not than why one ovum produces a male and another a female.

7. That Hypopi are not true parasites, that they do not prey upon the host or obtain any nourishment from it, but only attach themselves to insects and other creatures for the sake of conveyance, and that they do not confine themselves to one species of insect, etc., but adhere to any suitable moving creature.

8. That the outward form of *Hypopus* is a protective provision to enable the creatures when *in transitu* to endure the heat and drought to which they are exposed, which would otherwise kill them.

In 1892 Prof. R. Monier made a careful study of the life-history, etc., of *Tyroglyphus mycophagus* (Mégnin's species *), with the result that he entirely agreed with and confirmed my conclusions in the matter which are stated above.

There may fairly be said to be three distinct types of Hypopus now known; or perhaps it would be more correct to say two which are certainly known to be hypopial and one which is supposed to be so. The two which are known to be hypopial may conveniently be called "the ordinary Hypopus type" and "the Homopus type:" the uncertain one can be designated "the Trichodactylus (or Trichotarsus) type.'

The ordinary hypopial type has already been roughly, but for the present purpose sufficiently described on pages 144 and 148; but it must be understood that the fourth pair of legs do not invariably end in setæ without claws in all species, they may be provided with claws; and of course there are other considerable differences between species; but the general character is the same. Hypopi of this type are eminently fitted by nature to cling tightly by the suckers on their ventral surface to smooth chitinous insects and other polished surfaces, they are difficult to detach, are not easily injured, and are proof against a great amount of sun and drought; so that they are almost ideal travelling forms to be carried about by insects and larger chitinous Acari, etc. Illustrations of this type of Hypopus will be found at Pl. II, figs. 6—10, *Histiostoma rostro-serratum*, Pl. IV, fig. 3, *H. spinifer*, and fig. 6, *H. pulchrum*, and on the plates of *Histiogaster corticalis*, *Tyroglyphus longior*, *T. mycophagus*, and *T. Wasmanni* in Vol. II.

Under favourable circumstances Hypopi of this class often adhere to insects, or other creatures, in astonishing numbers; perhaps the most remarkable instance of this is that recorded by Father Wasmann,

* "Contribution à l'histoire naturelle du *Tyroglyphus mycophagus*," in 'Mém. Soc. Zool. France,' t. v (1892), pp. 584—601.

the well-known authority upon ants and the creatures found in their nests.* For more than thirteen years Wasmann had observed the presence of Hypopi in the various nests of ants which he kept for observation; he found numerous other Acari, etc., in ants' nests, and these formed the subject of a paper by Monier † to whom Wasmann submitted his collection. Amongst the Acari was a *Tyroglyphus* which was new to science, and which Monier named *T. Wasmanni;* this appears to be a true myrmecophilous species, never having hitherto been found except in ants' nests as far as we know; while there it is in great numbers when the Gamasidæ which are found there, often in abundance, do not eat it up. It was found in artificial nests of *Camponotus ligniperdus* and *Formica sanguinea* at Prague in 1891 and in those of *F. sanguinea-fusca* and in natural nests of *Lasius fuliginosus* at Exacten (Holland). By some accident Monier described the hypopial nymph of this species as that of *T. Krameri*, which it greatly resembles, and described that of *Histiostoma rostro-serratum* as that of *T. Wasmanni;* but Monier had only spirit specimens to judge by and it was hardly possible to do so correctly from them. Later Wasmann sent me living specimens and I was able to rear the Hypopi to the adult condition and ascertain that what was supposed to be the Hypopus of *T. Krameri* was really that of *T. Wasmanni.*

With regard to the number of Hypopi, Wasmann says that fifty upon one ant was a small number, and that in badly infected nests hundreds, or even thousands, might be found upon one ant. Wasmann agrees that the Hypopi do not derive any nourishment from the ant; nevertheless they generally eventually kill it simply by adhering to it in such immense numbers. The essentially cleanly ants are unable to

* "Ueber einige myrmecophile Acariden," in 'Zool. Anz.,' 1897, Nos. 531, 541, pp. 347—350.

† "Mémoire sur quelques Acariens et Thysanoures parasites ou commensaux des fourmis," in 'Rev. biol. Nord France,' t. iv, 1892, pp. 376—389.

clean themselves, and become coated with a dirty crust which on the head, palpi, and limbs is especially repugnant to them. The immense numbers of Hypopi clinging to the front legs prevent the ants from using the comb, which these organs are provided with, to clean the body. The mouth and its organs become so covered with Hypopi that the ant can scarcely take food. The Hypopi clinging to the antennæ and palpi render these important organs useless; is it wonderful, Wasmann asks, that the ant should fall into a lethargy and die?

Wasmann also found great numbers of the Hypopi of *Histiostoma rostro-serratum* in his ants' nests; the ant sometimes is covered with them; as many as 150 to 200 would sit in a heap upon the head of one ant and all the actions of life were arrested or interfered with; this species is not however confined to ants' nests as *T. Wasmanni* is; it swarms in enormous numbers in most places where there is vegetable matter in the early stages of decay, and the Hypopi cling to passing creatures; the ants searching for food, etc., would doubtless bring them in in large quantities, and the oftener and longer they searched the more Hypopi would adhere to them; they would attach themselves to other suitable insects, etc., equally readily, but the ants are there and do not fly and are in every way convenient to ride upon.

Wasmann found that the Hypopi of *T. Wasmanni* were in greatest numbers on the head, abdomen, and legs; comparatively few being on the thorax; and that they almost always arranged themselves in the direction of the long axis of the joint or segment they were upon; their anterior ends being directed toward the point of the joint, or segment. The Hypopi of *H. rostro-serratum* however did not exhibit any such regularity of position but were in crowded masses, principally upon the head.

Wasmann's observations are not the only ones which tend to show that Acari which attach themselves to the bodies of ants are apt to do so in very definite positions. A still stranger instance is recorded by Janet with reference to a widely different group of Acarina, viz. the Gamasidæ;* he found that *Antennophorus Uhlmanni* and *Cilliba* (*Discopoma*) *comata* when found upon *Lasius mixtus* arranged themselves either bi-symmetrically or in the median line; so as not to upset the balance of the host that carried them. The *Antennophorus* have their anterior ends directed forward when they are on, or rather under, the head of the ant, and backward when on its abdomen.

The Homopus type of Hypopi are adapted to clinging tenaciously to the hairs of hairy mammals, on which alone they are found. The apparatus by which this is effected is curious; it varies in detail in different species, but the principle is always the same; it is as follows:—There is not any sucker-plate on the ventral surface as in the ordinary type of Hypopus, so that those of the Homopial type cannot adhere to polished surfaces; but instead of the sucker-plate, and in about the same position, there is a short longitudinal furrow in the ventral plate commencing at the posterior end of the abdomen and running forward; in this furrow a hair of the host can lie. Below the furrow are one or two minute chitinous plates, the lower (outer) surface of which is slightly rough, generally made so by more or less regular, parallel, or radiating ridges. From each lower lateral edge of the furrow, and thus on the level of the ventral plate, arises a broad, chitinous lip or wing-like piece, so broad that the two usually slightly overlap in the median line of the body when at rest; they are slightly flexible, and can be raised or depressed to a limited extent; probably not by special muscles of their own, but by those which serve to contract or expand the abdomen in a transverse direction. Each lip bears on its upper (inner) surface a rough band which presses upon the hair to be held, and forces it

* 'Études sur les Fourmis, les Guêpes, et les Abeilles;' Note 13, sur le *Lasius mixtus*, *l'Antennophorus Uhlmanni*, etc., Limoges, 1897.

against the rough plate at the upper side of the furrow; thus the hair is firmly held between the two.

There are but few species known to have homopial Hypopi; for these it may possibly, some day, be desirable to revive Haller's genus *Dermacarus;* but the propriety of this cannot be judged of until it is ascertained with certainty whether some closely allied species possess a hypopial stage or not, and if they do whether it is homopial. The Hypopus of the first of these species was described by C. L. Koch in 1841 under the name of *Dermaleichus sciurinus*,* and in 1842 under that of *Homopus sciurinus;* † it is figured in this book (Pl. XVIII, figs. 5, 6; Pl. XIX, figs. 15—18). In 1844 Koch ‡ described what was probably the homopial Hypopus of another species under the name of *Homopus hypudæi;* it was found on the field-mouse *Hypudæus arvalis*. It is not possible to be quite certain of its hypopial nature from Koch's figure and description. In 1849 Dujardin described under the name of *Hypopus arvicolæ* § a creature which was probably identical with Koch's *Homopus hypudæi*. In 1877 Kramer found upon the mole, and described ‖ under the name of *Labidophorus talpæ*, a creature which is the homopial hypopus of *Glycyphagus Crameri*, and is figured in this book (Pl. XVI, fig. 5). Dr. Oudemans ¶ considers that he has obtained the homopial Hypopi of several other species on rats and mice, but he does not name, figure, or describe them.

Of the Trichotarsus type of Hypopi only a very few species (four, I believe) are known. It is not quite certain that they are Hypopi at all; they are certainly immature. This was proved by Prof. Berlese, and I have subsequently been able to verify his correctness in this respect; although at one time, before he called

* Koch, D. C., fasc. 33, No, 7.
† Koch, Uebersi, Heft 3, p. 121.
‡ Koch, D. C., fasc. 39, No. 24.
§ In 'Ann. Sci. Nat.,' 3e sér., t. xii, p. 264, pl. ii, figs. 15, 16.
‖ In 'Arch. Naturg.,' vol. xliii, Heft 1, pp. 249—259.
¶ Oudemans' list, pp. 252, 253.

attention to it, I was inclined to regard them as adult. But we know so little of their life-histories that it is doubtful whether there is any other nymphal stage than that supposed to be hypopial; no other nymph is known; if there be not any then the creature which is known may be the ordinary nymph, not the hypopial. Undoubtedly its habits seem more consonant with the hypopial hypothesis, as the known species are parasitic, when in this condition, upon wild bees of the genera *Osmia*, *Xylocopa*, etc., and can endure the exposure to heat and drought which this involves. Moreover they are provided with suckers on the ventral surface for adhesion to the host, as Hypopi of the ordinary type are; but, on the other hand, they are not enclosed in a smooth chitinous carapace like other Hypopi; but have a softer, although tough, cuticle; usually wrinkled, and they have immense single claws on the first three pairs of legs; apparently for adhesion, which are not usually found on other Hypopi. Moreover, they have more indications of mouth-organs than other Hypopi have; although these parts must still be regarded as rudimentary. Personally I am inclined to look upon these nymphs as hypopial, but I do not think that it can be said to be finally proved.

Dufour first described one of this form of Hypopus in 1839.* He found it upon *Osmia bicornis* and *O. fronticornis;* he looked upon it as adult, and called it *Trichodactylus osmiæ.* Donnadieu subsequently found another upon *Xylocopa violacea*, and called it *Trichodactylus xylocopæ.*† Berlese ‡ subsequently traced the adult of the latter form. Canestrini has added two other forms from New Guinea.§ Donnadieu regarded the creatures as adult, and describes mouth-organs, including maxillæ; which he admits are anchylosed and fixed, and only

* In 'Ann. Sci. Nat.,' 2e sér., t. ii, p. 267.

† "Recherches anatomiques et zoologiques sur le genre Trichodactyle," in 'Ann. Sci. Nat.,' sér. 5, t. 10, pp. 69—85.

‡ 1885, Berlese, 'A. M. S.,' fasc. 18, No. 1.

§ In 'Term. Füzetek,' v. 20, 1897, p. 474, v. 21, 1898, p. 176.

serve as supports to organs of suction; he also describes mandibles and a lingua, but then he describes genital organs and the mode of coition; in which, of course, he was mistaken; as the creatures are immature. His paper is beautifully illustrated.

This part of the present chapter may properly conclude by an account of the rudimentary, probably rather expiring than nascent, condition of the hypopial stage in some of the common species of *Glycyphagus*. This is not one of the genera in which functional Hypopi usually occur; in some of those species which are associated with mammals the homopial Hypopi occur; indeed, they are confined to this genus, but they are only found in that small section of it for which Haller sought to create the genus *Dermacarus*. These Hypopi are active creatures, and the stage is thoroughly functional, but no active hypopial nymph is known in any of the other species, nor was any rudimentary hypopial stage known amongst them until the investigations by Mégnin * and by myself,† which will now be related.

I have before given an account of the inert stage which precedes each ecdysis. In May, 1885, when examining some material swarming with *Glycyphagus domesticus* in various stages, I observed that there were some that could only be classed as inert nymphs, but had not quite the ordinary appearance of the creature in that stage: the cuticle was more opaque, and seemed thicker and whiter, the back was more arched, the empty skin of the legs was more apt to be rubbed off, as if the inert stage had lasted longer than usual, giving a case-like appearance; I speak of them as "cases;" each "case" is only a nymphal skin, but it is a skin under special conditions: one is drawn (Pl. VIII, fig. 12). The fine marking of the cuticle was resolved under a highish amplification into the labyrin-

* In 'C. R. Acad. Paris,' t. ciii (1886), pp. 1276–8.

† "Researches into the Life-histories of *Glycyphagus domesticus* and *G. spinipes*," in 'J. Linn. Soc.,' London, vol. xx (1888), pp. 285—298.

thine wrinkling shown at Pl. VIII, fig. 16. The contents of each case were more drawn to the anterior end than is usual in the nymph before ecdysis. The first step was to ascertain that they were not simply dead creatures. Towards the end of May I placed three in one of my small glass breeding-cells, making the conditions as favourable as I could; on June 10th three immature *G. domesticus* emerged from the cases; which did not split irregularly like ordinary nymphal skins, but usually opened by the posterior end of the case, which had been concave, being pushed out so as to become convex; and separating from the lateral and ventral parts of the case but remaining attached to the dorsal (Pl. VIII, fig. 14). The cases, although open, were not entirely empty; I found that each contained a cast skin. After some unsuccessful attempts I again isolated several cases in a cell on July 30th, 1885; in a week two nymphs had emerged, more subsequently followed. I placed three of these nymphs in a separate cell; in about a week they became inert; a few days later an adult ♀ emerged from the cuticle of one, the others soon followed. The cast skin from which the adult emerged was thin and fine; very different from that of the cases. It was thus ascertained that the cases were a penultimate-nymphal stage, *i. e.* the nymph which emerged from the case became adult at the first ecdysis.

I was unable to resume the enquiry until January, 1888; on the 25th of that month I placed four cases in a cell, but in spite of the best conditions I could give them, they did not emerge until July 15th. On April 9th I placed a number of cases in three separate cells; on April 21st I found an inert nymph of *G. domesticus*, which had emerged from a case and become inert. I had not examined the cell for two days. On April 26th the adult emerged, and a second nymph had emerged and become inert; on May 1st the adult emerged from this.

I dissected a large number of the full cases; in each instance inside the case, and almost filling its anterior part, but not the legs which were empty, was a protoplasmic mass; which had a transparent, colourless, and almost structureless cuticle. This mass had a rounded posterior and a bluntly pointed anterior end; it was compressed dorso-ventrally, particularly at the posterior margin, and had a more or less plain sulcation round it, as though dividing cephalothorax from abdomen. The mass had the general form of a Hypopus, but there was not any trace of legs, mouth, or other external organs. The mass was always motionless, but in one instance I did find a living nymph of *G. domesticus* within the case instead of the inert mass; this nymph was ready to emerge. Almost every case from which the occupant had emerged contained the cast skin of the protoplasmic mass, not showing any trace of legs, mouth, or other external organs.

In the latter part of 1885 I found in the chaff-house of a farm, both in the dust and chaff and attached to the walls and beams, a number of cases which were more opaque than those of *G. domesticus*, and were coarsely reticulated instead of having fine labyrinthine markings; the cases opened differently, the posterior cuticle breaking away from the dorsal and lateral, and remaining attached to the ventral; so that the posterior end opened downward instead of upward, and was more torn; the hinder part of the dorsal cuticle was usually split along the median line, and the two parts somewhat separated; one of these cases is drawn (Pl. VIII, fig. 11); they were afterwards ascertained to be those of *Glycyphagus spinipes*. I placed some of these cases in a breeding-cell and dissected others; many contained, not the inert legless mass found in the cases of *G. domesticus*, but a distinctly formed living Hypopus; which had not assumed the usual brown chitinous colour and could not be called active; but still was fully formed, and was provided with legs, although they were short and stumpy; it could move these limbs freely but could not walk about (Hypopi are usually active). It was evidently not fitted for existence as a free creature, but was undoubtedly alive and fully formed (Pl. VIII, fig. 17). Most of the Hypopi dissected out were incapable of motion; only a few were able to move their legs. I searched the chaff dust, walls, and beams of the chaff-house many times in hopes of finding active Hypopi, but never succeeded in doing so. I found one or two inactive, which seemed as if from some accident the cases had been broken from them. On January 2nd, 1886, I took one of these and one dissected out of a case, and put them in a separate cell; on January 15th one emerged, leaving the cast hypopial skin behind; the creature that emerged was a nymph of *G. spinipes*. On January 16th I dissected four more Hypopi out of cases and put them in another cell; three eventually died, but one remained unchanged for nearly four months; I watched it every day, and on May 24th it underwent ecdysis and a healthy nymph of *G. spinipes* emerged. While this experiment was progressing I also watched the cell in which I had placed the cases. One nymph only had appeared, but on May 26th two more cases were open and two Hypopi had apparently crawled out of them; when touched they appeared inert and incapable of motion, but a few days after nymphs of *G. spinipes* emerged from them.

In January, 1888, I resumed the enquiry. I put seven full cases in a separate cell: I could see the Hypopus moving its legs in one; on February 7th one nymph emerged, on February 8th a second; I put these in a fresh cell. On February 9th the first of these became adult; on February 26th the other. I tried numerous other cells with confirmatory results.

I came to the following conclusions:

1. There is a Hypopial stage in the life-history of *Glycyphagus*, but in the species experimented on it is far less developed than in *Tyroglyphus*, and is not an active stage.

2. That we did not know whether it occurs in all

species, but it did not occur in the life-history of every individual of a species.

3. That the stage is not the result of desiccation or other unfavourable circumstances, but occurs as often under favourable conditions.

4. That the stage in the species investigated occupies the period between the penultimate ecdysis and that immediately previous.

5. That in *G. spinipes* the Hypopus is fully formed and capable of moving its legs, but not of walking or other active movement; and that it never becomes hard or of the dark colour of ordinary Hypopi. That as a rule it does not ever leave the skin of the young nymph in which it is formed, but that the more adult nymph is formed within the Hypopus, and emerges from it while the Hypopus is still within the young nymphal skin; so that the Hypopus is not ever seen except that in a few instances it may crawl just outside the young nymphal skin, when the more advanced nymph is likely soon to emerge.

6. That in *G. domesticus* the hypopial stage is even more rudimentary; what represents the Hypopus retaining only the general form, but being without legs or other external organs, and that it never emerges from the young nymphal skin.

7. That in both species the young nymphal skin within which the Hypopus is developed thickens, and forms a "case" different in appearance from the skin during an ordinary ecdysis.

While I was engaged on the above-detailed investigations Mégnin was also observing *Glycyphagus*, and endeavouring to find a hypopial stage; he tells us that he failed to find one, but that he discovered something equally curious. He believed that the change of a nymph of *Tyroglyphus* into a Hypopus was caused by unfavourable circumstances. He says that under similar conditions those of *Glycyphagus* become inert; that a liquefaction of all the organs takes place, "as in a change of skin," and that the gelatinous substance collects in the cavity of the "thorax" in the form of a spherical mass surrounded by a chitinous envelope; and thus forms a cyst very similar to those formed by some infusoria previous to the drying up of the water in which they are contained. Mégnin suggests that in this condition the nymphal skins containing the cysts would be blown about by the wind, and would thus finally arrive at some place where the conditions would be favourable and would then emerge, and that thus the species would be distributed.

Mégnin says that his species were *G. spinipes* and *G. cursor*, which latter is considered a synonym of *G. domesticus*, but he does not distinguish between the life-histories of the two, nor identify any particular observations with either species.

I have mentioned below (p. 181) that Mégnin's theory of the entire liquefication of the internal organs of Acari before each ecdysis is not now generally considered correct. The difference of the form which he describes from what I found may possibly arise from his examining his creatures more shortly after the change commenced than I did, or from his *G. cursor* not really being *G. domesticus.*

It is not improbable that Mégnin's idea that the nymphal skin containing his cyst would be blown about by the wind may be correct. I do not see that it would be more liable to be so during this than during any other ecdysis, except that this might last longer; but undoubtedly the creature protected by the case would bear more exposure than the species during other ecdyses.

I am not aware that any hypopial stage, either rudimentary or otherwise, has yet been traced in such species as *Glycyphagus palmifer*, *G. plumiger*, *G. Canestrinii*, etc.

Development of the Reproductive Organs.

Nalepa investigated this with his usual care in *Carpoglyphus anonymus*, and wrote an excellent account of it, which I will give an abstract of here.* He says that the idea is widely spread that the larvæ and nymphs of Acari do not show any signs which would enable anyone to distinguish sex, but this is based only upon the external characters. A study of the internal organs shows that only the larvæ and first nymph (*i. e.* the nymph after the larval, but before the first nymphal ecdysis) are sexually indifferent; the second nymph shows differences (in *C. anonymus*). The whole of the following account is Nalepa's, not mine.

The first indication of the generative gland is between the proctodeum and the posterior end of the ventral plate; it consists of two rounded cell-masses, the formation of which from the blastoderm Nalepa was not able to trace, but which he suggests were probably of epiblastic origin. These two cell-masses are again met with in the larva, only slightly altered in form; they lie near together, a little above the anus; they are composed of very small cells with clear nuclei; they stain more deeply than the surrounding tissues. There is not any distinction between the peripheral and central cells.

During the larval stage the cell-masses increase in size by addition to the number of cells. Their diameter immediately before the first ecdysis is about 9 μ. At the same time that the imaginal discs of the fourth pair of legs appear these generative glands become coated with a soft membrane, which ends in a short tube; by these tubes, which must be regarded as the commencement of ducts, the generative glands are attached to the anterior end of the anal slit, so that they have the appearance of being produced by invagination of the wall of the rectum.

* Nalepa, 'Anat.,' p. 137.

At the first ecdysis the generative glands separate from the anal opening, and move somewhat forward; at the points where they had been attached to the anus the cells multiply rapidly, and give origin to short, solid, cellular cylinders, from which the ducts are formed; the commencements of the right and left generative glands join, and appear as if united by a bridge.

At the point of junction of the two future ducts the outer nascent genital organ of the nymph is formed from the hypodermal tissue; it consists of the two sucker-pockets, each containing one sucker. The pockets are formed by invaginations of the hypodermis. The suckers originate at the end of the newly-formed retractor muscles, which receive a dome-like coating from the hypodermis.

The further development of the sexual organs during the first nymphal stage is almost confined to the increase in size of the generative gland and ducts; the latter especially lengthen greatly. This involves an alteration in the position of the gland; which, however, occurs differently in the two sexes, and even thus early indicates the sexual nature of the creature. In the adult male the vasa deferentia run directly from the testes to the genital opening. We must therefore look upon those nymphs where the duct proceeds directly backward as males; in them the testes arrive thus early at their final position on each side of the rectum. In the female the growing oviduct makes a strong bend to the side, by which the ovaries are pushed laterally; they only shift to the side of the rectum after the formation of the loop. The ducts of the generative glands are still solid cylinders; in transverse sections of them the radial arrangement of the cells may be seen. Above each sucker-pocket a comb-like cellular growth appears; from which, at a later stage, the accessory glands of the male and the vagina of the female develop. At the end of the first nymphal stage the testes have assumed an oval form; their long diameter is about ·018 mm. The ovaries maintain their original round form, and are about ·02 mm. in diameter.

In the first nymphal ecdysis, as in the larval, the sucker-pockets are formed, but each contains two suckers; they lie between the epimera of the fourth pair of legs, and are only slightly directed upward. Kramer speaks of an external opening; this must not be taken literally; the external opening only appears at the last ecdysis.

It is during the second nymphal period that the development of the genital organs makes most progress; the difference between the sexes becomes evident, inasmuch as the characteristic accessory organs are formed. Hitherto the progress of the male organs has been almost parallel to that of the female, but a sharp distinction between the two now commences, and renders separate descriptions necessary.

In the **male** the comb-like cell-mass which lies over the median chitinous piece of the external genital organs at the juncture of the vasa deferentia increases continuously in size. At its anterior end two solid cellular papillæ bud out and lengthen rapidly; the right one is almost exactly in a line with the left vas deferens, and the left one with the right vas deferens; so that the vasa deferentia appear to cross above the outer sexual organs. At the same time a globular cell-mass arises from the median mass at the junction of the vasa deferentia. A growth of cell-tissue may now be seen between the two vasa deferentia; it forks, and becomes two strings of cells; finally its base thickens, and forms a horse-shoe from which the supporting sclerites of the penis are formed. If the organs be now compared with those of the adult there is not any difficulty in identifying them. The semicircular gland is formed from the anterior cellular papillæ by the two increasing in size, and uniting at their bases. A lumen is now formed in the central cellular body which has hitherto been solid. At first it is a narrow central canal, but widens surprisingly from the pushing outward caused by the division of the cells of the wall; the two lumina soon communicate. The cells of which the mass is formed before the lumen commences are large and pyriform, having the smaller end turned toward the axis of the cylinder; their larger rounded ends protrude beyond the cell-mass; their nuclei are large, round, central, and stain deeply; their contents are clear, transparent, and non-absorbative. Later on, when the lumen has enlarged greatly, the cells flatten; and their contents become finely granular and stain easily.

A similar process of development is found in the more dorsally situated cellular papilla whence the large globular gland arises; after this has attained to a certain size the pyriform cell-mass shows a vertical split, which increases continuously; the short, thin stalk by which the body of the gland is fastened to the underlying parts remains solid for a long time.

While these glands are growing the structure of the testes undergoes considerable alteration; hitherto they have consisted of small indifferent cells not distinguishable from those of the female organs; now a zone of small cells collects at the posterior pole and there forms a spermatogenetic region. The outline and the nuclei become clearly defined, and the cell-contents stain more easily. The anterior portions of the testes are already filled with spermatoblasts; the vasa deferentia acquire a lumen and are clothed with small, cubical, epithelial cells.

The changes which the testes and their accessory glands undergo between this time and the ecdysis are confined to increase in size. The development of the penis commences during the ecdysis; it grows out of the cell-mass placed above the external sexual organs, and is a globular body divided by a dorsal furrow. Even during the ecdysis abundant production of sperm-cells takes place; these push into the vasa deferentia and widen them until they are sack-like. The epithelium flattens, and finally appears as a scarcely stainable layer containing scattered nuclei; then the testes enlarge greatly, and their posterior poles become almost arched over by the pileus-like germinal portions.

In the **female**, immediately after the second (first nymphal) ecdysis, a vigorous growth of the hypodermal tissue occurs at the posterior end of the anal slit. Later on the hypodermis invaginates at this point and forms a thick-walled, clavate sack between the rectum and the ventral surface. It is easy to understand that the receptaculum seminis is formed from this invagination; the opening, during the whole second nymphal stage, lies close behind the anal slit.

Turning to the ovaries and their ducts we see that the cell-mass at the junction of the ducts has greatly increased and assumed an almond shape; soon a longitudinal split appears which gradually widens; finally the median cell-mass forms a hollow three-sided pyramid at the dorsal angle of which the two oviducts enter by a common opening. It is easy to see that the cell-mass from which the accessory glands and the penis of the male are formed becomes the vagina in the female.

The oviducts have greatly increased in length, and make a sharp turn outward; they have not as yet any lumen, this appears shortly before the ecdysis.

The ovaries still retain their globular form, but have moved somewhat backward at the side of the rectum. A change in the cells occurs in the ovaries as it does in the testes; it is different from that of the male organs, but equally results in the formation of a germ-layer. Until the second ecdysis the germ-gland consists of small indifferent cells, but after it a difference arises between the peripheral and the central cells; the first assume an epithelial character, they increase to many times their former size, but retain their distinct outline. The central cells grow but little, but gradually lose their outlines; the protoplasm becomes a homogeneous layer, in which nuclei are embedded; later on even these break up into finely granular, refractive pieces, which lie like nests in the ground-plasma; these often unite with those adjacent to them, and thus form radial strings of nuclear matter.

In the adult female small particles of the nuclear substance separate themselves and form irregular-shaped pieces which wander to the periphery of the gland; immediately under the exterior surface they separate and form distinct, almost hemispherical nuclei (germato-blasts) which are surrounded by a thin layer of protoplasm, and protrude in a dome-shaped manner from the surface, but finally separate themselves from it entirely.

From the above account it is evident that the distinction between germ-cells which are developed from distinct cells and those differentiated from the nucleus-holding protoplasmic layer is not of importance.

The epithelium-like cells of the periphery of the ovaries, especially those near the anterior pole, grow rapidly and assume the character of egg-cells; these cells remain unaltered during the ecdyses and may be recognised in the virgin female.

After the receptaculum seminis has attained a certain size its wall bends out in two places; at the same time the wall of each ovary buds out below the oviduct; these projections from the ovaries and the receptaculum grow in length, and finally join. The two ovaries at this time are joined by a fine string of cells. The ovaries continue to move backward, and the receptaculum to increase in size; the ovaries in like degree approach the receptaculum. The connecting string on each side increases in diameter and a lumen appears in it; so that free communication between the receptaculum and the ovaries is established.

The further changes by means of which the inner sexual organs of the female assume their complete condition, as well as the development of the external organs, are carried out during the ecdysis. The external opening is shifted forward as the oviducts increase in length; the lateral supporting-pieces arise at the margin of the vagina, which has already assumed the form of the sexual external opening.

As Nalepa's account abstracted above did not seem to me perfectly clear on the point, I have carefully observed to see whether the nymph from which the adult emerged showed any sign of *external* sexual organs; I made my observations upon *Histiogaster entomophagus*, *Carpoglyphus anonymus*, and *Tyroglyphus siro;* in each case the creature was isolated in a cell alone so as to avoid any possible mistake; numerous specimens were observed, especially of *H. entomophagus*, which I found the most favourable species; but in no instance did the nymph show external sexual organs, although the internal organs might sometimes be more or less seen through the skin. During the later stages of ecdysis the organs of the adult may possibly be seen a little through the nymphal skin.

The Ecdyses.

Numerous authors have dealt, more or less, with the changes of skin of the Acarina in general, and of that of special families; I do not, however, think that it will be necessary here to go in any way exhaustively into the literature of this subject; it will be sufficient if I refer briefly to the principal controversy which has arisen between acarologists upon the subject, and then give a condensed account of the best observation which has been made upon the ecdyses of the Tyroglyphidæ.

Gudden,* writing concerning the parasitic Sarcoptidæ, stated that at the ecdyses the whole of the inner parts of the creature return to an amorphous mass, like the egg; and that from this the new creature was formed, as from an egg.

Mégnin† fully supported this view, and extended it

* "Beitrag zu den durch Parasiten bedingten Hautkrankheiten," in 'Arch. f. phys. Heilk.,' Stuttgart, 1885, p. 28.

† 'Les parasites et les maladies parasitaires,' Paris, 1880, p. 214, and numerous other writings.

to all families of Acarina; he asserted that at each ecdysis all the internal organs liquefied and became reduced to a sarcodic plasma enveloped by a veritable blastoderm; which behaved like that of the egg, and sprouted in the same manner. By some error Mégnin attributed this supposed discovery to Claparède, who for a considerable time had the credit of it in the writings of subsequent authors; but in reality Claparède never said so, and Mégnin apparently overlooked the fact that it was Gudden who had announced it. Subsequent investigation has, however, shown that the theory is not correct; and that the return to a more or less amorphous condition is usually, and probably always, confined to the soft parts of the legs and trophi, and what may be described as appendages or external organs. Kramer* soon expressed doubts about the correctness of this theory; which was shown to be erroneous in the Trombidiidæ by Henkin,† and by others in different groups; and by Nalepa in the careful account of the ecdysis in one of the Tyroglyphidæ, of which the following is an abstract.‡

Nalepa observed the ecdyses in *Carpoglyphus anonymus*, he says correctly that the larvæ and nymphs of that species, like those of other Acaris, fall into an inert and motionless state before each ecdysis. In this condition they do not take nourishment, they lie with outstretched legs in wet parts of their habitat. The first glance shows the atrophy of the lime and fat so largely contained in the connective tissue. Later on a rapid increase in the number of cells in the hypodermal tissue may be observed : the hypodermis, which has hitherto shown a reticulated appearance, takes on an epithelial character, and thus returns as it were to an embryonic condition. In the connective tissue large, fine-grained cells appear, the origin of which

* "Ueber Milben," 'Z. ges. Naturw.,' 1881, Bd. liv, p. 12.

† "Beiträge zur Anatomie, Entwicklungsgeschichte, und Biologie von *Trombidium filiginosum*, Herm.," in 'Z. wiss. Zool.,' 1882, Bd. xxxvii, Heft 4, p. 569.

‡ Nalepa, Anat., 2, pp. 149—157.

Nalepa could not trace. The cells multiply most rapidly at the roots of the long hairs, along the anal opening, and beneath the oil-glands (expulsory vesicles). During this process the cuticula has gradually raised itself away from the underlying soft parts. In the place where the oil-glands lay there are now deep pits in the epidermis. The muscle-bundles situated in the legs and trophi are not lost; but the large space filled with connective tissue between them diminishes, and the muscles of the various joints blend so as to form an apparently homogeneous cylinder, which is coated by an easily seen epidermis. This cylinder lies in the lumen of the legs without filling it, and after the loosening of the cuticle is still attached to the tip of the tarsus by a fine string. This string soon breaks, and the soft part of each leg draws itself slowly out of the chitinous sheath. The legs then appear as short roundish projections on the surface of the body. If observed closely it will be seen that these projections do not consist of a homogeneous cell-tissue; but of wholly separate tissue bundles, which must be derived from the muscle-bundles. The muscular tissue has, however, undergone a change, inasmuch as the transverse striping has disappeared and the power of imbibition has greatly increased. This softening may also be seen in those muscles which pass directly into the creature in the next stage of its development. Similarly the muscles of the trophi draw themselves out of their chitinous sheaths, and appear as hemispherical protuberances from the mouth-opening.

A large proportion of the body-muscles remain intact; especially the retractors of the rostrum and the mandibles, the flexors of the coxæ, etc. The retractors of the genital suckers and the parts of the leg-muscles which lie within the body become renovated; and in the change from mature nymph to imago the muscles, especially those of the coxæ and the retractors of the mandibles, are strengthened and perhaps partially renovated.

I believe the above to be a correct account of the change of skin, and to be on the whole applicable to other species of the family which I have observed; such as *Tyroglyphus siro*, *Histiogaster entomophagus*, etc. I do not think that the old legs are always stretched out as Nalepa says; I frequently find them curled under the body. Some time before the new creature emerges I have often seen its legs being slowly moved within the nymphal skin, so that they do not invariably lie perfectly still close to the body the whole time.

PART II.

SYSTEMATIC.

Descriptions of Genera and Species.

PRELIMINARY OBSERVATIONS.

In this work it has been necessary to consider a question on which great differences of opinion exist, and may fairly do so, viz. whether if an author described and figured an immature form of one of the Acarina, believing it to be adult and named it; and another author subsequently described the adult under a different name the earlier name of the larval form or the later name of the imago should be retained as that of the genus or species as the case might be. I have considered it best to retain the name based upon the adult, and have done so in the few instances where such circumstances occur: my reasons are as follows.

There is not any authoritative English rule upon the subject; neither the "Rules for Zoological Nomenclature" drawn up by H. E. Strickland at the instance of the British Association in 1842, after consultation with many British and Foreign Zoologists, which has always been the principal authority for British zoological nomenclature, nor the report of the Committee appointed by the same Association in 1864 to consider whether any alteration was required in those rules, say a word upon the question; nor do the Rules for the nomenclature of organised creatures adopted by the international congress of zoologists held at Paris in August, 1889.

In the following congress held at Moscow in 1892 the question was directly considered, and the Acari are expressly named. The rule is as follows:

" *Art.* 16. *La loi de priorité doit prévaloir et, par conséquent, le nom le plus ancien doit être conservé.*

* * * * * *

" *(b) Quand la larve, considérée par erreur comme un être adulte, a été denommée avant la forme parfaite.*"

" *Exception doit être faite pour les Cestodes, les Trématodes, les Nématodes, les Acanthocephales, les Acariens, en un mot pour les animaux à métamorphoses et à migrations, dont beaucoup d'espèces devraient être soumises à une révision, d'on résulterait un boulversement profond de la nomenclature.*"

In the rules for the scientific nomenclature of animals issued by the German Zoological Society in 1894 the following is found:

17. " *Bei Arten, in deren Generationscyclus verschiedene Formen auftreten, ist als Artbezeichnung nur ein zur Bezeichnung einer entwickelten fortpflanzungsfähigen Form vorgeschlagener Name zulassig.*"

This rule was well translated by Mr. P. L. Sclater for the Zoological Society of London in March, 1896, thus:—

" 17. In the case of species with a cycle of generation of different forms the specific term must be taken from an adult form capable of reproduction."

At the third International Congress of Zoology held at Leyden in 1895 a Committee was appointed to consider the laws of Zoological nomenclature; this Committee reported to the fourth Congress held at Cambridge, in 1899, *inter alia*, thus:

" § 31. The law of priority is valid; the oldest permissible name is to be retained even—

" (*b*) If the larva has been named before the adult creature.

" An exception must be made, at least at present, for the Cestoda, Trematoda, Nematoda, Acanthocephala, Acarina; in short, for all creatures which undergo a metamorphosis and change of hosts, otherwise for many of these groups a revision of the nomenclature would have to be commenced, which would give rise to a confusion in the present nomenclature, the extent and final result of which it is not possible to foresee."

Unfortunately, in consequence of differences of opinion upon other points, this report was not confirmed by the fourth Congress; but was referred back to the Committee for further consideration, and no fifth Congress has yet been held.*

I am not aware of any other attempts to settle the question except individual opinions.

It appears to me therefore that all the existing authorities are in favour of not adopting names in the Acarina which are based upon immature forms; and this appears to me to be reasonable; although I am aware that many eminent naturalists hold an opposite view. I cannot think it desirable that a name should be adopted which is attached to a description and figure which are utterly unlike the adult creature and from which it could not possibly be recognised; moreover if the opposite rule were established, no amount of care in searching before naming a new species would ensure an author from having his name subsequently upset; in addition to these arguments there is the well-known objection of the large number of well-established names which would be cancelled.

The Tyroglyphidæ seem to me to be an extreme instance of the undesirability of adopting names founded upon immature specimens and upon characters which simply imply immaturity; because in this family such names are usually founded upon the Hypopus; a stage which is not only immature and entirely unlike the adult, but is also adventitious, not occurring in the

* Since writing the above the Berlin conference of 1901 has been held; at the time of going to press I do not know if it has dealt with the subject.

life-history of every individual, but only occurring in the development of some specimens without any known rule.

The drawings of whole creatures in this book have in every instance been made from living specimens; this is almost a necessity because the cuticle in the Tyroglyphidæ is usually only slightly chitinised, and therefore the shape is apt to alter considerably after death; I have, however, always had a second specimen, either dead and unmounted or mounted without presure, ready for constant reference as to detail; this is most conveniently kept under a second microscope. All whole figures and sections and the larger dissections have been drawn by dropping a piece of glass ruled into squares into the eye-piece and drawing on paper also ruled into squares (engineer's sectional paper), drawing square for square. This, in my opinion, gives a more correct result than the camera, which necessarily always produces a certain amount of distortion; even the squared-glass system, which I use and believe to be the best, produces a slight amount of distortion; because the ruled glass being between the field-lens and the eye-lens of the eye-piece the correction of the error of the eye-lens by the opposite error of the field-lens is not obtained; but the distortion is far less than that of the camera.

The smaller dissections, such as legs, mandibles, etc., have been drawn by the aid of a Zeiss two-prism camera. With these very minute objects the amount of distortion is a negligible quantity.

The scale of each figure, except those of larvæ and nymphs, is given in the explanation of the plates; it would be useless to give it in drawings of the immature creatures because it would depend on the exact age of the specimen drawn from. The fully-grown nymph is generally slightly smaller than the imago. The hypopial nymph is an exception from this rule; the Hypopus does not grow, and therefore its size is constant.

I have endeavoured to give figures of the adult of each species; and it has usually been necessary to draw both sexes, which was not requisite in the Oribatidæ; but, on the other hand, I have not usually thought it worth while to figure the larva or ordinary nymph, as these would be easily recognised from the adult in most cases; but I have always drawn the Hypopus, where one is known, as that is quite different.

A description of each species is given, which I trust may prove sufficient. A statement of the characters of each genus is also added, and at the end of it a table to assist in the identification of such British species as are known to me; these tables are not intended as classifications but simply as aids to identification. There is not any record of what are British species previous to this book; it is scarcely likely that I have found them all; it is possible that the discovery of further British species may render some of these tables less exhaustive; but at the end of vol. 2 a short summary of the foreign species known at present will be found.

It must be remembered that in attributing species to the earlier writers, and even to C. L. Koch, a doubt must generally exist whether the species described are really those of the authors referred to, whose descriptions and figures, as a rule, do not admit of certainty.

The figures of whole creatures are mostly to some extent diagrammatic in position; living Acari do not usually assume the "spread-eagle" posture in which it is convenient to draw them in order to display the legs; in reality the tibiæ and tarsi are usually held perpendicularly, by which means the body of the creature is usually kept off the ground; therefore, when looking on the dorsal aspect the genual is often the lowest joint seen; but if they were drawn thus the form of the leg would be lost, and it is often useful for identification.

The rostrum is often very mobile and can be raised or depressed, and to some extent exerted or retracted.

Its apparent length therefore depends somewhat on position. The extent to which the mandibles, or one of them, are or is protruded also affects the apparent form of the rostrum.

The colour of many, indeed most, of the species depends greatly upon what food they have been eating; the colour seems to be not merely in the alimentary canal but diffused almost all over the body.

Nymphs of course vary greatly in size according to age; it is scarcely possible to guess the age from the external appearance; particularly as the females are usually larger than the males, and thus a young female nymph may be as large as an older male nymph; but there are not any external genital organs to judge sex from.

In the outline drawings of parts of the creatures some of the smaller hairs are sometimes omitted when they render articulations, etc., obscure.

Where a species varies greatly in size, in different individuals, the known amount of the variation in length is usually given in the first line of the measurements; in the second line a typical length is given; this means that the typical length is a medium, and one of the commonest lengths of English specimens; and that the other measurements, viz., those of breadth, length of legs, etc., *are proportionate to* the typical length, and would correspond to a specimen of that length; this is useful, for although the actual size of the creature is often not of much value in identifying species, yet the proportions of the creature vary but little and are very useful; of course, when creatures are distended by food, eggs, etc., a certain amount of distortion takes place.

TYROGLYPHIDÆ.

Atracheate Acarina; usually with soft cuticle, which is smooth or granular; never raised into parallel undulating folds; rarely with smooth chitinised cuticle.

Cephalothorax and abdomen usually divided by a distinct sulcation between the second and third pairs of legs but sometimes undivided. Legs of five free joints; tarsi of adults terminated by a single claw usually sessile; rarely pedunculated; either with or without a caroncle which is not ever pedunculated.* No eyes. Mandibles usually chelate; chelæ working perpendicularly, rarely non-chelate and serrated. Maxillary palpi usually of three joints, rarely five; basal joint usually more or less anchylosed to the maxillary lip. Usually strong sexual dimorphism. Genital openings usually but not invariably abdominal in both sexes; those of the female consisting of an ova-depositing vulva which is rarely cephalo-thoracic, and a separate bursa copulatrix which is always abdominal. Adults usually free-living, rarely more or less parasitic. Larvæ and ordinary nymphs ordinarily resemble the adults, but Hypopial (travelling) nymphs often exist which are totally different.

Division into sub-families.

A.	Ambulacra of the first two pairs of legs borne on long peduncles	LENTUNGULINÆ.
	Ambulacra of the first pair of legs sessile .	B.
B.	Mandibles saw-like or knife-like, both in form and action	HISTIOSTOMINÆ.
	Mandibles chelate	TYROGLYPHINÆ.

Sub-family **Lentungulinæ.**

The characters of the family are necessarily those of the only genus contained in it, viz. *Lentungula.*

* Berlese includes *Hemisarcoptes* amongst the Tyroglyphidæ; it has not any claws at the ends of the tarsi, but has pediculated suckers; Canestrini and Kramer, however, I think correctly, exclude it from the Tyroglyphidæ and include it in the sub-family Canestriniinæ of the Sarcoptidæ. Lignières, who originated the genus, appears also to allot it to the Sarcoptidæ, although he does not say very distinctly which group he includes it in.

GENUS LENTUNGULA * (*Michael*).

Lentungula, 1893. "On a New Genus and Species of Acari found in Cornwall," in 'P. Zool. Soc.,' London, 1893, pp. 262—267, pl. xviii.
" 1897. Berlese, 'A. M. S. Crypt.,' p. 103.
" 1894. Lohmann, in 'Wissenschaftliche Meeresuntersuchungen von d. Biol. Anstalt auf Helgoland,' vol. i, Heft 1, pp. 86—91, pl. iv.
" 1899. Kramer, 'Thierreich,' Lief. 7, p. 136.

In 1889 Mégnin originated a genus, *Hyadesia*,† for a creature closely allied to that upon which I based *Lentungula*. Mégnin's genus was avowedly founded upon an immature form. Mégnin had not any adults. Unfortunately it was published, not in the part of the 'Mission Sci. du Cap Horn' relative to Acari, but separately, at the end of the Protozoa, without anything external on that part to indicate that the contents were other than Protozoa. Thus I missed it, and was not aware of its existence when I wrote my paper in 1893; had I known of it I certainly should have referred to it; and although, for the reasons given on page 187, I could not have recognised a generic or specific name in the Acari founded upon an immature type, I should have endeavoured to preserve Mégnin's name, either by adopting it for the adult (if that be permissible), or in any other possible manner, if I had been sure of the identity of the two genera. As to this, however, there seems to be very grave doubt, in spite of the great general resemblance; because Mégnin states as one of the principal characteristics of his genus that there is not any line of demarcation between cephalothorax and abdomen, whereas in *Lentungula* that demarcation is extremely strong. This has usually been recognised as a difference of at least generic importance in the Acarina, although there are creatures

* *Lentus*, flexible; *ungula*, a little claw.

† "Note sur un Acarien de la Terre de feu *Hyadesia uncifer*," 'Miss. Sci. Cap Horn,' vol. vi, part 3, Protozoaires, at end of part.

of both descriptions in the genus *Glycyphagus*, but that is a very specialised and varying genus, which may have to be divided some day, although it is difficult to see how it can be satisfactorily done at present, without further knowledge of some of the forms. The demarcation is quite as strong in the young of *Lentungula* as in the adults. It may, of course, be said that Mégnin had only a small number of specimens, which had been kept in some preservative liquid; but even under these disadvantages I cannot think that so careful an observer as Mégnin would have missed so important a character.

As far as I know the genus *Lentungula* has been adopted by all writers up to this time who have dealt with the subject.

Tyroglyphidæ with the ambulacrum of each of the first two pairs of legs consisting of a minute monodactile claw only, without sucker or caroncle; this claw is borne upon a long flexible peduncle arising from the side of the tarsus. It can be flexed at the will of the creature. Ambulacra of the two hind pairs of legs large, monodactile, sessile claws; without suckers or caruncles. Mandibles chelate. Cephalothorax and abdomen clearly divided from one another. Without marked sexual dimorphism.

This is a wholly exceptional genus of Tyroglyphidæ; subject to what is said above relative to Mégnin's *Hyadesia*. Firstly, it is the only genus of the family which is aquatic, or semi-aquatic; although certain others, as *Hericia*, *Histiostoma*, etc., are usually found wading in vegetable juices. Secondly, it is one of the very few genera of Acari, outside the Halicaridæ, which has any claim to be considered marine; the two species of this genus known are inhabitants of salt or brackish water. They are not, however, swimming creatures; they are strictly and solely crawlers, frequenting algæ and stones in shallow water, or even left dry between tides; or living in places where fresh water trickling over rock becomes mixed with salt spray, and the growth of green algæ takes place; but they are evidently capable of living comfortably under water. Thirdly, the ambulacra of the two anterior pairs of legs are quite exceptional. I am not aware that anything like it occurs again in any of the Acarina; perhaps the nearest thing to it is in the true Sarcoptidæ (the itch-mites such as *Sarcoptes*, *Psoroptes*, etc.), and in the above-named genus *Hemisarcoptes*. But in all these cases the long peduncles on which the ambulacra are mounted are stiff and chitinous, and can only be moved as a whole; whereas in *Lentungula* the peduncle is soft, and can be flexed in any direction at the will of the creature. Moreover in *Lentungula* it bears a claw only, and in the other cases it bears a sucker only.

The **Rostrum**, in the species yet known, is practically an oral tube, having a certain resemblance to that of the Gamasidæ. It may be exposed, as in the British species *L. algivorans*, or hidden by the hood formed by an advancing, part of the remainder of the cephalothorax, as in the Continental species *L. fusca*.

The **Maxillary Lip** is of the ordinary type in the family, but shows its dual origin somewhat more plainly than is generally the case.

The **Palpi** appear to vary in number of joints in different species. *L. algivorans* has five free joints, and *L. fusca* only two, the other or others being fused with the maxillary lip. All through the Sarcoptidæ and Tyroglyphidæ the palpi are in a very rudimentary, or debased, condition, and the extent to which they are fused with the maxillary lip varies.

Labium.—There is in *L. algivorans* a small, triangular chitinous piece below the maxillary lip, which might possibly be considered to be the homologue of a labium.

Mandibles.—These are of the ordinary chelate type; in the known species they are short and powerful, with few teeth.

Legs of moderate length in the known species; they are the principal characteristic of the genus. The two anterior differ greatly from the two posterior pairs. The former are extremely narrow from side to side, so that they look almost linear when seen on edge; but they are deep dorso-ventrally, so that they look broad when seen from the side. The whole of each tarsus of these two pairs of legs diminishes gradually, and forms a great curved, but not hooked, claw: it is with this tarsus used as a claw that the creature climbs and holds on. It is a powerful holding organ; a similar development of the tarsus into a holding claw may be found in the enlarged leg of the heteromorphic males of *Rhizoglyphus*, but there the true claw is entirely absent. In *Lentungula* a long *flexible* peduncle arises from the side of the tarsus about halfway between the proximal and distal ends; this peduncle ends distally in a small bulb, which bears a minute claw. Every part of the peduncle can be flexed in any direction at the will of the creature; the bulb with its claw can also be turned in any direction, but cannot be bent in the middle. This claw and peduncle are not used in climbing or holding as far as I could see, and I observed them carefully in life. The peduncle is usually flexed upward when the creature is climbing, so as to keep the small claw out of harm's way; it seemed to me to be used more as a tactile than a holding or climbing organ. The two posterior pairs of legs are quite different; they are thin rounded legs of the ordinary type; their tarsi are terminated by large claws without peduncles, and also without suckers or caruncles.

Ventral Surface.—The chitinous skeletal pieces are very well developed, particularly the sternum. The external genital openings are placed between the coxæ of the third and fourth pairs of legs in both sexes, and are protected by band-like sclerites. The anus is terminal; formed of two blades on edge lying close against each other; they form a small point in the centre of the posterior margin, but the opening is ventral.

Immature Stages.—These greatly resemble the adults, they would be known from them. No hypopial nymph is known.

Habitat.—The known species, as before stated, are found on marine or brackish water algæ.

It is quite probable that if more species are discovered it may be found that some of the above particulars are rather specific than generic.

There is only one known British species, *L. algivorans.* The only other species, *L. fusca*, Lohmann, from Heligoland and the North Sea, may be known from *L. algivorans* (should it be found here) by its larger size (length ·53 mm.), darker and evener colour; by having the rostrum hidden by a hood-like projection on the remainder of the cephalothorax, by a small chitinous plate on the anterior margin of the cephalothorax, and by its palpus of only two free joints.

LENTUNGULA ALGIVORANS,* Michael. Plate I.

Lentungula algivorans, 1893, Michael. "On a New Genus and Species of Acari found in Cornwall," in 'P. Zool. Soc. London,' March 14th, 1893, pp. 262—267, pl. xviii.

Length without mandible, about . . .	·38 mm.
Greatest breadth, about	·20 ,,
Length of legs, first pair, about . . .	·13 ,,
,, ,, second pair, about . .	·14 ,,
,, ,, third and fourth pairs, about .	·15 ,,

Colour.—The actual colour of the creature, if it had been fasting for a long time, would probably be almost entirely light yellow, but as ordinarily seen it is dark olive-brown with very numerous light yellowish spots and markings. The yellowish colour is chiefly in spots and spaces surrounded by the olive, but the spots are not arranged in any definite pattern; although a few spots on the cephalothorax have a tendency to be constant, yet the markings as a whole are most irregular and varying. The olive-brown colour greatly

* *Algæ*, seaweeds, etc.; *voro*, I devour.

predominates, and some specimens are almost wholly of that tint. The colour apparently arises from the diffusion of food-material or products; it is not pigment in the cuticle. This can be demonstrated by placing a dark specimen in a drop of water on a glass slip under the microscope, and placing a cover-glass over it; as the water evaporates the cover will be slowly drawn down, producing pressure upon the creature; the result of this will be that what appears like the whole contents of the body are gradually discharged through the anus, and the opaque dark creature becomes yellowish white and transparent. During life, however, the brown colour does not look as if it were caused by food-contents; it has every appearance of being the true colour of the greater part of the body. The rostrum and legs are always pale pinkish yellow.

Texture polished.

Shape.—This also depends considerably upon whether the creature is fully fed; when it is so the distinctive form is lost, and the Acarus becomes almost a roll with little shape in it; but when not quite so fully-fed the shape is rather striking. The cephalothorax is slightly broader than the abdomen, but much thinner dorso-ventrally; so that where the two join, the dorsum of the abdomen stands high above the cephalothorax. There is a sharp indentation in the lateral edge of the creature where the cephalothorax and abdomen join; behind this the abdomen of the female is almost sack-shaped; that of the male narrows a little more posteriorly. In both sexes the hind margin is indented in the middle, so that each side forms a rounded lobe.

Cephalothorax.—The rostrum is a smooth tube or collar, long for the family; the strong chelate mandibles (fig. 7) project considerably; each arm of the chela is tridentate. The five-jointed palpus (fig. 8) is otherwise of the ordinary type; and is adherent to the membranous maxillary lip, below which is a triangular chitinous sclerite which might possibly be considered to represent a labium. The central portion of the cephalothorax, behind the rostral tube, forms a large, rounded, fleshy lobe which overhangs the rostrum. The hinder part of the cephalothorax widens greatly, its edge being the double curve known as the "line of beauty." This edge is formed by a large raised roll; the median portion of the cephalothorax is also raised; but between the two, in the hinder part of the cephalothorax, is a large shallow depression, or dimple. There are a pair of hairs, close together, near the anterior edge of the rostral tube. On each side there is a very long hair near the edge of the body a little in front of the first leg, a similar hair near the posterior corner of the cephalothorax, and a shorter one about midway between them; also one pair on the dorsum of the cephalothorax; these, and all the other hairs on the creature, are simple and setiform.

Abdomen.—The anterior edge has a somewhat exceptional form; the central portion (about half the width) projects boldly into the cephalothorax, is concave anteriorly, and runs out laterally so as to form a short horn or point. From the central projection the margin, on each side of the body, runs back at an angle; but this portion also is concave anteriorly; it forms a raised roll with a large, shallow depression, or dimple, behind it; like that on the cephalothorax. When the creature is very fully fed all these depressions vanish; they also disappear after death. There are two pairs of hairs on the central projection of the anterior margin of the abdomen; the inner pair are the longer. There are also two other pairs of hairs on the notogaster (the hinder are the longer). The anus forms a short, median, projecting, posterior point when seen from above; but a long slit when seen from the ventral surface; it is formed of two thin blades on edge, lying close against each other, but capable of being separated widely posteriorly.

The **Legs** are short, the posterior pair not reaching the hind margin of the body: the two front pairs are almost blade-like; so that when seen on edge they appear almost linear, but they are rarely seen in this position; they are usually turned at an angle, so that the side is partly seen. Thus they look very broad: they are much curved. The only remarkable feature is the tarsus (fig. 5), which is a generic feature, and is described in treating of the genus (p. 195). There is a short curved spine on the under side of the tarsus, a strong spike on the under side of the tibia, and some fine hairs, as seen in the plate. The two posterior pairs of legs are quite different from the anterior; they are ordinary rounded legs, rather small, but without any special feature. The tarsi are of the ordinary nature, and are terminated by large, single, curved claws (fig. 6).

The Ventral Surface (figs. 2 and 3).—The sternum is a triangular chitinous plate sending out band-like projections on each side parallel to the edge of the rostral collar; and a similar, but straight, posterior band in the median line; which is longer in the male than in the female. The epimera of the first pair of legs are formed by the lateral projections of the sternum and a branch arising from the sternum and passing behind the legs. Those of the second pair of legs are somewhat Y-shaped sclerites, which in the male are joined at their posterior ends to the posterior end of the sternum by short cross-pieces. In the female they are wider apart, and not attached. The epimera of the third and fourth pairs of legs are short, right-angled pieces in the male; they are not apparent in the female. The vulva is situated between the two posterior pairs of legs, but advances further forward than the insertions of the legs; it is protected anteriorly by a large, semi-annular, chitinous band (the sternite of Robin), and has well-marked chitinous labia. The male organ (fig. 9) lies rather further back; it is protected by a slightly elliptical (almost circular) plate, slightly truncated posteriorly. This plate covers the longish curved penis (fig. 10) and the somewhat elaborate skeleton which supports it (fig. 9). This consists of a horseshoe-shaped sclerite, with thick, projecting, posterior ends joined by a broad band; from a central projection of which the penis arises. The anterior end of the organ, when at rest, is supported by a notch formed by two short rods attached to triangular blade-like sclerites on edge.

Habitat.—I found a large number of specimens in a patch of green alga (*Cladophora fracta*), growing where the fresh water of a small stream trickled over the face of the granite cliffs within reach of the spray of the sea, near the Land's End, Cornwall. I have not found it elsewhere, and I am not aware of anyone else having done so.

Sub-family **Histiostomidæ.**

The characters of the sub-family are necessarily those of the only genus contained in it, viz. *Histiostoma.*

Genus HISTIOSTOMA * (*Kramer*).

Histiostoma, 1876. Kramer, "Beiträge zur Naturgeschichte der Milben," in 'Arch. Naturg.,' 42 Jahrg., Heft 1, p. 105. 1889, 'Thierreich,' Lief. 7, p. 133.
„ 1888. Canestrini, 'I Tiro,' p. 5; Pros., p. 354.
„ 1895. Jensen, "En Tyroglyphide i Hesteiglens Œg Kapsel," in 'Vid. Medd.' (Copenhagen), January, 1895, pp. 72—104.
„ 1896. Berlese, 'A. M. S.,' fasc. lxxix, No. 6.
Phyllostoma,† 1876. Kramer, "Beiträge zur Naturgeschichte der Milben," in 'Arch. Naturg.,' 42 Jahrg., Hft. 1, p. 39.
Serrator, 1880. Mégnin, 'Les Parasites,' p. 145.
Hypopus,‡ 1883 to 1887. Berlese, 'A. M. S.,' fasc. ix, Nos. 7 and 8; fasc. xxix, No. 4; fasc. xxxix, No. 9; Notes, fasc. i, p. 14.

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* Ἱστίον, a sail, tissue, or web; στόμα, the mouth.

† Name preoccupied by Geoffroy and Cuvier, 1797, Chiroptera; E. Geoffroy, St.-Hilaire, 1870.

‡ Sed non *Hypopus*, Dugès, 1834, 'Ann. Sci. Nat.,' sér. 2, vol. i, p. 37, which was simply the hypopial stage of any of the Tyroglyphidæ.

Tyroglyphus (part), 1873. Mégnin, "Mém. anat. et zool. sur un nouvel Acarien de la famille des Sarcoptides, le *Tyroglyphus rostro-serratus*," in 'J. Anat. physiol.,' vol. ix, pp. 369—388.
" " 1893. Monier, 'Notes,' p. 453.
Acarus, part, 1876. Canestrini and Fanzago, "Nuovi Acari Italiani," in 'Atti Soc. Veneto-Trent,' vol. v, p. 140. 1877, "Intorno agli Acari Italiani," in 'Atti Ist. Veneto,' ser. v, vol. iv, p. 201.
Anætus, 1898. Oudemans' 'List,' p. 252.

Tyroglyphidæ with the ambulacra of all the legs sessile, not pedunculated; with the mandible not chelate, but consisting of one blade only; which is usually saw-like, but possibly rarely knife-like. With palpi the two distal joints whereof usually bear a membranous expansion, and the distal joint bears two flagella, usually of unequal length. With a strongly marked division between cephalothorax and abdomen, without anal suckers; with considerable, but not extreme sexual dimorphism, and with a well-developed hypopial stage.

This genus, which is the only one in the sub-family, is a wholly exceptional one amongst the Tyroglyphidæ; being strongly differentiated by its saw-like or knife-like mandibles, which contrast sharply with the chelate mandibles of all other genera of the family; and by the flagella-bearing palpi, the flagella being functional as such; which again is entirely unknown in any other genus of the family, and probably in any other Acari. The mode of action of these organs is interesting. Mégnin was the first author to call attention to the existence of any of these creatures; in his 1873 paper above referred to he says that he found the Acarus *H. rostro-serratum* in immense abundance, wading in the thin film of liquid which covered decaying mushrooms in the well-known mushroom-cellars of Paris. It is not, however, by any means confined to mushrooms; it is found on most decaying vegetation of a fleshy nature, particularly underground parts such as tubers, tap-roots, etc. I have very frequently watched *H. rostro-serratum*, and other species, feeding. The process has always been as follows:—The mandibles are darted out alternately and rapidly, one mandible being withdrawn while the other is being exerted; thus they are alternately plunged into the substance to be fed upon and withdrawn from it, and by a saw-like action cut the vegetable cell-walls and allow the contents to escape. While the mandibles are at work the anterior of the two palpal flagella, which is usually much the longer, beats regularly and strongly, causing a current which carries the contents of the torn cells, as it exudes, to flow steadily into the open mouth of the creature, into which it is generally guided by a short wide funnel formed by the membrane attached to the two palpi, and sometimes to the maxillary lip. The Acarus keeps slowly advancing as its mandibles empty the food material before it. Mégnin was of opinion that these Acari were the initiators of decay in fungi; he even went so far as to suggest that fungi would probably not decay without them. I am not able to agree with him on this point; it seems to me that they are followers of decay; I have not ever found them, as I have so frequently found *Rhizoglyphus*, eating into the sound portion of a root; and if placed in such a situation, or upon sound, healthy, suitable vegetation, they do not appear to me to attack it as *Rhizoglyphus* does; they do not thrive until the plant is wounded, or fungoid growth, nematoid worms, other Acari, or some cause has started decay. In the species which live in the exuded sap of trees the action of the mandibles is not so noticeable. This exceptional mouth may possibly be considered to be an adaptation to the mode of life of the genus; but it is not found in *Hericia*, which wades in the exuded sap of trees, and feeds upon it exactly as some species of *Histiostoma* do.

The **Rostrum** in most species is clearly defined, and is apt to be somewhat square or oblong; this form is given by the size and importance of the maxillary lip and its palpi; in the curious foreign species *H. flagellifer*, however, the remainer of the cephalothorax appears from the discoverer's drawings to be drawn out anteriorly so as to form a kind of hood, which hides the rostrum.

Mandibles (Pl. III, figs. 2, 13, 19).—These, as before stated, form the great characteristic of the genus; instead of the broad and robust chelate mandibles of all other Tyroglyphidæ, which are holding and tearing organs, those of *Histiostoma* are long, thin blades on edge; usually diminishing somewhat in breadth toward their distal ends, and occasionally ending there in a piercing point or small pointed hook turned downward. The lower edge of these blades is cut into a number of teeth like a saw; these may extend the whole length of the mandible, or may occupy its distal end only; they may be of even size throughout, as in *H. pyriforme* (Pl. III, fig. 19), or may be of unequal sizes, as in *H. rostro-serratum* (Pl. III, fig. 2). In the Italian species, *H. fimetarium* of Canestrini and Berlese,* the mandible is stated by those eminent acarologists to be entirely without teeth on its lower edge, which differs from all other known mandibles in the genus. I have not succeeded in finding any species with the mandibles in this condition. In *H. pyriforme* the teeth are difficult to see; in *H. pulchrum* much more difficult; but I have not found any species where the teeth cannot be demonstrated if the mandible be dissected out and examined by an amplification of about 500 diameters, with good apochromatic objectives and sub-stage condenser, and the light skilfully managed; but I do not for a moment doubt that *H. fimetarium*, which I have not seen, has the knife-like mandible, as it has been examined by such very competent observers.

It is curious that in the Oribatidæ, another family of Acari, which in some respects is rather allied to the Tyroglyphidæ, one of which is the strong chelate

* "Nuovi Acari," in 'Atti Soc. Veneto-Trent,' vol. vii, p. 150 (1881).

mandible found in both,—there is a single exceptional genus (*Serrarius*) with non-chelate saw-like mandibles, forming an instance precisely similar to the present genus.

The Maxillary Lip.—This is usually broad at the base, but often drawn out to a narrow distal end, membranous, very slightly chitinised, and forms a shelf over which the liquid or semi-liquid food passes into the mouth when driven by the palpal flagella.

The **Palpi** (Pl. III, figs. 1, 20; Pl. IV, fig. 7) form another of the distinctive features of the genus; they consist of three joints, the proximal of which is said by Mégnin to be much longer than the others, and wholly anchylosed to the maxillary lip; the central and distal joints being free. I am not quite able to agree with Mégnin; in this I think there is a small third free, or almost free, proximal joint. The distal joint is usually the smallest, but is ordinarily slightly broadened and flattened at its distal end; it bears two flagella, one at the actual distal end or antero-lateral angle, the other on the outer side a very short distance back. The anterior flagellum is always the longer when there is a difference, and is generally directed forward and outward; the posterior is often much shorter, and is usually directed backward and slightly outward. In some species, *e. g. H. rostro-serratum*, the two flagella are of about equal length. The length of the anterior flagellum, in proportion to the length of the whole Acarus, varies greatly in different species. In addition to the flagella the two distal joints of the palpus usually bear a broad, thin, flexible, membranous border to the whole or some part of their edge. The form and arrangement of this membrane varies with the species, but is not a regular even border in any species where it has been described; the two membranes sometimes run along the maxillary lip as well as the palpi, and join together in the middle, forming a funnel down which the liquid food passes into the mouth.

The **Notogaster** in some species, such as *H. rostro-*

serratum, is apt to bear mammilliform elevations, or lumps ; one of which may form the antero-lateral, and one the postero-lateral angle of the abdomen. When these mammilliform processes are present, they each usually bear a hair, which may be quite short, as in *H. rostro-serratum ;* or may be longer than the whole body, as in the Italian species *H. flagellifer*. The notogaster may also have its hairs transformed into great leaf-like scales, as in the Italian species *H. phyllotrichum*, or into long curved spines as in *H. spiniferum*, or into stiff ensiform spines as in *H. pulchrum*.

The **Legs** are usually, but not invariably, long and thin; especially the tarsus, which is sometimes as long as all the other joints added together; they often bear short, stout spines, sometimes fine hairs. The tarsus is terminated by a claw, which is generally long and very slightly curved, without sucker or caroncle.

The Ventral Surface.—The development of the chitinous epimeral skeleton varies in different species; the sternum is usually short. The external genital organs are generally placed between the coxæ of the fourth pair of legs. The vulva is a mere longitudinal slit with protecting sclerites. There are generally two pairs of discs with chitinized edges, which resemble suckers; some authors identify them with the genital suckers found in most other genera of the family: they, however, differ considerably from the ordinary genital suckers both in appearance and position; they are not even within the genital area, emerging between the genital labia, as is usually the case with the genital suckers of other genera, but are often quite distant from the genital opening. There are not any anal (copulative) suckers.

The Immature Stages.—The larvæ and nymphs usually resemble the adults, with the ordinary exceptions; but hairs, spines, and scales are apt to be less developed than in the adults. The hypopial stage is a very important one in the life-history; hypopial nymphs are extremely abundant in such species as

H. rostro-serratum, and are doubtless the chief, if not almost the only means of distribution of the species; it is sometimes astonishing after keeping material infested with *H. rostro-serratum* under observation for some time, *under favourable conditions of life*, to see the immense numbers in which the Hypopi will suddenly appear. In this genus the Hypopi are apt to have rather long thin legs for that stage, and have a mode of stretching out the two anterior pairs which is characteristic.

Habitat, etc.—As before stated, Mégnin originally found the first species of this genus immersed in the thin film of liquid which covers decaying mushrooms, but they are not in any way confined to mushrooms, almost any sort of thick fleshy vegetable matter in a state of incipient decay is acceptable. I found *H. pyriforme* in the exuded sap of beech trees. Kramer found *H. pulchrum* in a somewhat similar situation. The Italian acarologists found *H. fimetarium* and *H. phyllothrichum* in dung-heaps; and most other recorded species have been found on decaying vegetable matter. There is one known remarkable exception which was disclosed by the highly interesting investigations of Jensen, quoted in the synonymy at the head of this genus. The Danish naturalist found his species, *H. Berghi*, in the egg-capsule of the horse-leech (*Aulastoma gulo*). In 1863, Leuckart described how this creature laid its eggs in a capsule which it buried in the banks of the stream or pond which it inhabited. In 1885, Bergh investigated and described the somewhat complex metamorphoses which the leech larva undergoes within the capsule; he also stated that he found Acari within the capsule. Jensen, in 1895, carefully traced the life-history of the mite, which he found was a *Histiostoma*. It appears from his researches that from the egg of the Acarus, within the capsule, emerges the usual hexapod larva; which soon changes its skin and becomes an octapod nymph, which gradually devours the larval leech and all the albuminoid contents of the capsule. The nymph now passes into the hypopial stage, in which it can endure greater changes of temperature, etc., than in any other, and can attach itself firmly to insects and other creatures. The empty capsule breaks and frees the Hypopus, which avails itself of its power of fastening on to other creatures in order to obtain a conveyance to a fresh capsule; it then leaves the temporary host, mounts upon the new capsule, casts the hypopial skin, becoming a fully grown nymph of the ordinary sort; which penetrates through the wall of the capsule, and assumes the adult form inside. There reproduction takes place, and the life-circle commences anew. The author thinks that the nymph uses its short powerful front legs to dig through the wall of the capsule; but I do not gather that he has seen the process: it is quite probable that these legs may assist in opening the slit when it is made, but I cannot help thinking that the saw-like mandibles must be the real penetrating organs.

That the genus has not been found out of Europe is probably due to want of search.

Table for the Identification of British Species of Histiostoma.

With mammilliform elevations, or tubercles, on dorsal surface.	Spines on notogaster round in section and of the ordinary character.	Spines on notogaster short, less than one tenth of the length of the abdomen.	H. ROSTRO-SERRATUM.
		Spines on notogaster longer than abdomen.	H. SPINIFERUM.
	Principal spines on notogaster of male broad and ensiform, not quite round in section near the body.		H. PULCHRUM.
Without mammilliform elevations, or tubercles, on dorsal surface			H. PYRIFORME.

HISTIOSTOMA ROSTRO-SERRATUM,* Mégnin. Pl. II and Pl. III, figs. 1—12.

Tyroglyphus rostro-serratus, 1873. Mégnin, Mémoire anatomique et zoologique sur un nouvel Acarien, etc.,' in 'J. Anat. Physiol.,' vol. ix, pp. 369—378, pls. x, xi, xii.
" " 1874. Mégnin, "Mémoire sur les Hypopus," ibid., vol. x, pp. 225—254, pl. ix.
Phyllostoma pectineum, 1876. Kramer, "Beiträge zur Naturgeschichte der Milben," in 'Arch. Naturg.,' 42 Jahrg., Hft. 1, p. 39. (Generic name preoccupied by Geoffroy and Cuvier in 1797, Chiroptera.)
Histiostoma pectineum, 1876. Kramer, ibid., p. 105.
Acarus mammillaris, 1876. Canestrini and Fanzago, "Nuovi Acari Italiani," in 'Atti Soc. Veneto-Trent,' vol. v, p. 140. 1877, "Intorno agli Acari Italiani," in 'Atti Ist. Veneto,' ser. v, vol. iv, p. 201.
Rhizoglyphus rostro-serratus, 1877. Murray, 'Economic Entomology, Aptera,' London, p. 263.
Serrator amphibius, 1880. Mégnin, 'Les Parasites et les Maladies parasitaires,' Paris, p. 145.
? *Histiostoma rostro-serratum*, 1881. Berlese, "Indagini sulle Metamorfosi di alcuni Acari insetticoli," in 'Atti Ist. Veneto,' ser. v, vol. viii, p. 45. 1897, 'A. M. S. Crypt.,' pt. 1, p. 102.
? *Hypopus juliorum*, 1886. Berlese, 'A. M. S.,' fasc. xxix, No. 4.
Histiostoma feroniarum, 1888. 'Can. Pros.,' vol. iii, p. 375.
" " 1899. Kramer, 'Thierreich,' Lief. 7, p. 135.
Tyroglyphus feroniarum, 1893. Monier, 'Notes,' p. 453.
Anœtus feroniarum, 1898. Oudemans' 'List,' p. 252.

Hypopial nymph.

? *Hypopus feroniarum*, 1839. Dufour, "Description et figures de quelques Parasites," in 'Ann. Sci. Nat.,' ser. 2, t. xi, p. 278, pl. viii, figs. 4—6.
Hypopus Dugesii, 1868. Claparède, "Studien an Acariden," in 'Z. wiss. Zool.,' Bd. xviii, p. 506, pl. xxxvii, fig. 6.

This species is stated in error by Karpelles † to be identical with *Histiostoma fimetarium*, Can. et Berl.

It is very difficult to say whether Berlese's species is the same as Mégnin's. In his drawing of the species,

* *Rostrum*, a snout; *serratus*, toothed like a saw.
† 'Miscellan.,' p. 16.

fasc. xxix, No. 4, Berlese does not draw any tubercles on the back or the margin. For this and other reasons they would not appear to be identical; but in the illustrations of this species accompanying the description of the genus, fasc. lxxix, No. 6, the tubercles are drawn, and the whole creature is much more like Mégnin's, but Berlese identifies his two drawings as being the same creature. Berlese himself appears to have had considerable doubt upon the subject. In the paper by G. Canestrini and Berlese jointly, called "Nuovi Acari," * the authors say that *Tyroglyphus rostro-serratus*, Mégnin, and *Histiostoma pectineum*, Kramer, are the same creature; but later in the same year Berlese † corrects this, and says that they are different. This is confirmed by Canestrini, who identifies *Histiostoma pectineum*, Kramer, with *Hypopus juliorum*, Koch. Berlese follows this in 1886 (as shown in the synonymy), but in his "Ordo Cryptostigmata," forming the summary of the same work, in 1897, he again identifies *Hypopus julorum* and *Phyllostoma pectineum* with *Tyroglyphus rostro-serratus*, and calls the species *Histiostoma rostro-serratum*.

	Female.	Male.
Length	·38 to ·60 mm.	·25 to ·45 mm.
Typical length (English specimens)	·55 mm.	·40 mm.
„ breadth . . .	·30 „	·20 „
„ length of legs, first and fourth pairs . .	·20 „	·17 „
„ length of legs, second and third pairs . .	·15 „	·14 „

This was the first species of the genus discovered, and must be considered the type species.

Colour.—Light dirty yellowish, or buff; frequently, perhaps usually, showing a good deal of opaque white or yellowish white on the dorsal surface. This arises from accumulations of white excremental matter showing through the dorsal cuticle. Legs very light yellowish red.

* In 'Atti Soc. Veneto-Trent,' 1881, vol. viii.

† 'Indagini,' etc., l. c., p. 150.

Texture dull, without polish, like that of the chamois leather of commerce; usually dotted with minute irregular projections.

Shape differs in the two sexes, and will therefore be described under the respective headings.

Male (Pl. II, figs. 3, 4).—Almost diamond-shaped, flattened dorso-ventrally. Cephalothorax almost as long as the abdomen, but sharply divided from it by a transverse sulcation. Rostrum long and narrow, slightly bulbous at the proximal end; posterior portion of the cephalothorax with slightly concave lateral outlines. Mandibles (Pl. III, fig. 2) somewhat undulating in outline both above and below; the anterior part, forming about one-third of the whole length, is much narrower than the remainder of the organ. The teeth are upon the narrow portion, except the posterior pair, which are situated on the shoulder where the width suddenly increases. The teeth are curved, and are of about uniform size, except the two anterior and the two posterior, which are larger than the others; the anterior tooth is terminal. Palpi with two flagella of about equal length, which is slightly greater than that of the free portion of the palpus. These flagella are almost stiff and straight, but slightly hooked at the distal ends. Membranous expansions of the palpi bilobed, much wider than the palpi; they continue on along the anterior end of the maxillary lip, and join in the median line, forming a funnel down which the liquid nourishment passes. There are two small pointed tubercles on the dorsal surface of the distal joint of the palpus just before the insertion of the dorsal flagellum. The legs are shortish, the fourth pair set far back, and from this cause and the shortness of the abdomen the whole tarsus of the fourth leg passes the posterior margin of the abdomen. The two anterior pairs of legs are thicker than the posterior, but both are stout. They bear several short conical spines, the positions of which may be seen from Pl. III, figs. 3—6, and a few fine short hairs. The tactile hair is small. The claw is short, strong, and sharply curved. The abdomen is widest at the anterior margin, and diminishes in width rapidly toward the posterior margin, which is deeply incised in the middle, so as to be almost bifid. It bears on each lateral edge three or four large raised mammilliform tubercles; the number varies. I most commonly find three; the posterior of them forms the posterior projecting corner of the abdomen. Mégnin draws three besides the projecting corner. Mégnin also draws three similar tubercles on the central portion of the notogaster. I have seen these, but I more usually find the notogaster hollow, as in Pl. II, fig. 3. There is a short curved hair on each antero-lateral corner of the abdomen, one on the posterior tubercle, and two on each lateral margin near together and near to the posterior end. The epimera of the first pair of legs are joined to the sternum; those of the second pair are free, but are large and nearly meet. The third seem broken into two sclerites. The fourth are well marked and of the reversed Y type. The penis is placed posterior to the epimera of the fourth pair of legs. The anus is minute and near the posterior margin. There is a pair of small chitinous rings on the ventral surface just anterior to the penis, and another pair, rather larger and rather further apart, between the anterior ends of the epimera of the fourth pair. There are two or three pairs of very minute spines on the ventral surface.

Female.—This is a larger and wider creature than the male. The posterior portion of the rostrum is more bulbous, and the posterior part of the cephalothorax has a convex lateral outline. In consequence of the greater length of the abdomen the fourth pair of legs do not pass its posterior margin; the abdomen in the specimens I have seen most commonly increases slightly in width from the anterior until near the posterior end. Mégnin draws it decreasing slightly; this, however, is partly a question of age and condition. The epimera of the third pair are similar to those of the fourth. The vulva is placed just posterior to the coxæ of the fourth pair of legs like the penis of the male, but in consequence of the longer abdomen of the female the vulva is much the further from the posterior margin; it is a mere slit, without chitinized labia, and is often difficult to see. The anus, also, is further from the posterior margin than in the male. The chitinous rings or discs are further forward, and further from the median line than in the male. The posterior margin of the abdomen is much less bifid, only a slight central concavity being usually visible. The posterior tubercle does not constitute the postero-lateral angle, and there are one or two more pairs of small spines on or near the posterior margin than in the male; in other respects the two sexes are similar.

Hypopus (Pl. II, figs. 5—10).—

Length	·14 mm. to ·20 mm.
Average length about . . .	·19 „
„ breadth about . . .	·13 „
„ length of first pair of legs about	·18 „

Colour when first emerged rosy-pink or vinous, darker and browner after a time. Legs the same colour as the body.

Texture polished.

Form ovoid; the thicker end of the oval is the anterior; the posterior is narrowed. The anterior end of the cephalothorax is a blunt and slightly rounded point; the posterior is still more rounded. The cephalothorax and abdomen are divided by a well-marked line and constriction; the latter is about three times as long as the former. Notogaster arched. The lip (fig. 7) is long and narrow, and the two characteristic hairs at its distal end are long, reaching as far as the proximal ends of the tarsi of the first pair of legs when outstretched; there is a small point or spine outside each hair. There are three or four pairs of minute hairs on the lateral margins, not any on the notogaster.

The **Legs** are long, the first pair (fig. 9) nearly as long as the whole body. This length is wholly in the tarsus, which in each leg is as long as the other four joints put together; but very much thinner and of almost even thickness throughout; a trifle the thinnest about the middle, and increasing again a little at the distal end, which is truncated. All the legs, except the fourth, are terminated by a claw, the fourth by a small point and a long hair. The first pair has also a longish stalked caroncle or sucker. There is also a single hair on the end of each tarsus outside the claw; this hair is the longest on the leg, except the tactile hair on the front legs. The tactile hair, however, is short for that hair. There are a pair of large, thickened, almost spatulate hairs near the proximal end of the tibia of the first leg; a small pair of spines about the middle of the tarsi, and a pair of short hairs near the distal end of each tibia and genual of the two front pairs of legs. The first and second legs are usually stretched out and almost close together when this hypopus is adhering to insects, etc., and the two hind pairs doubled forward under the abdomen.

Ventral Surface nearly flat; epimera not joined to sternum. Sucker-plate (fig. 8) broader than long, straightish anteriorly, but with a central projection and rounded corners, curved posteriorly; just outside it anteriorly is a pair of small suckers, one on each side of the anus. The plate itself contains a pair of suckers close together, and almost touching the anterior edge of the plate; then, further back, but touching the first pair, is a transverse line of four suckers; of which the central pair is much the larger, and seems more elaborately formed than the other suckers; finally, there is another pair of small suckers almost touching the hind margin of the plate, protected by a pair of small spines. There are two or three pairs of small hairs on the ventral surface.

Mégnin identifies this hypopus with *Hypopus feroniarum*, Dufour, and *Hypopus Dugesii*, Claparède, and this identification appears to have been taken for granted by subsequent authors. In the case of Claparède's species I should say that it is certainly correct; that author's drawings and descriptions are usually sufficient for identification; but in the case of Dufour's species I think the identity extremely doubtful. It may possibly be correct, but I am not able to see in Dufour's figure and description any sufficient means of identifying a Hypopus, which is far from being an easy matter; the general shape, which is the principal thing which can be judged of from Dufour's figure, does not appear to me to agree well with Mégnin's *rostro-serratum*.

Nymph.—In this stage the creature has more the form of the adult male than of the female, which is unusual in the Acarina. The mammillary protuberances on the dorsum are less developed than in the adult; there is not any sternum, the two epimera of the first pair of legs being simply joined to each other at their inner ends. The legs are thinner in proportion than those of the adult.

Larva resembles the nymph, except in the absence of the fourth pair of legs.

Eggs elliptical, about ·16 mm. long and about ·1 mm. broad.

Habitat.—Mégnin found the species originally wading in great quantities in the thin film of liquid which covers decaying mushrooms. It is hardly an exaggeration to say that it may be found on all kinds of damp, decaying, soft vegetation which has substantial thickness; it is perhaps most abundant on fungi and roots, but it is very generally distributed; it is extremely abundant. The species has been recorded in France, Germany, Italy, and Switzerland; it is found in all parts of England. It is, I think, a follower, not an initiator of decay.

HISTIOSTOMA SPINIFERUM,* n.s. Pl. IV, figs. 1—3.

Length about	·260 mm.
Breadth about . . . , .	·075 „

I regret to say that I cannot give as perfect a description as I should desire of this remarkable undescribed species, for I only found one adult specimen and one or two immature, and I have not ever been able to find it again. It is easily known by the long narrow shape and the great length of the curved notogastral spines.

Colour transparent white or light yellowish brown; rostrum and legs pinkish.

Texture dull, slightly granular.

Form oblong, long and narrow.

Female (fig. 1).—Cephalothorax very long, rostrum rather clearly marked off from the remainder of the cephalothorax; central portion of the cephalothorax a truncated cone; posterior portion thereof with a convex lateral outline. Flagella of the maxillary lip not above half as long as the width of the abdomen. No spines on the cephalothorax. Abdomen square anteriorly, but ending in a point posteriorly; the portion which forms the hind margin has curved sides. On the notogaster, somewhat within the lateral margin, are two longitudinal rows, each of *four large mammillary elevations* with slightly chitinized tips; each of these bears a *very long curved spine*; those on the two anterior pairs, when measured along the arcs of their curves, are nearly as long as the length of the abdomen; they are directed outward and curve backward in a single curve; the third pair are about one-third shorter, are directed backward and outward, but curve inward; the fourth pair are much the longest, about half as long again as the abdomen; they are directed backward and curve outward in a double curve (line of beauty). The posterior pair of mammil-

* *Spinifer*, bearing spines.

lary elevations which bear these spines are the largest, and form the posterior corners of the abdomen. Legs long and slender; the anterior pair pass the tip of the rostrum by the whole length of the tarsus; the fourth pair pass the posterior margin by the whole length of the tibia and tarsus; the tarsi are very long. The hairs upon the legs are few and short.

I have not found the male of this species.

Nymph (fig. 2).—Nearly colourless, slightly yellowish; rostrum and legs pink, but very light; broader in proportion than the adult, the abdomen being widest at its junction with the cephalothorax and diminishing backward. There are four pairs of mammillary elevations on the dorsal surface, but one pair is on the cephalothorax and three on the abdomen; the pair on the cephalothorax is almost conical, those on the abdomen broad, almost cylindrical, but truncated at the distal end, and with a tubercle on the truncated surface; the tips are not chitinized as in the adult, and the spines borne by them are not as long as those of the adult; otherwise there is a considerable resemblance between the two.

Hypopial Nymph (fig. 3).—

Length about	·20 mm.
Breadth about	·12 ,,
Length of legs, first pair	·13 ,,
,, ,, second pair . . .	·10 ,,

Almost colourless; legs pinkish; obovate, very long in form; legs slender; fourth pair passes the hind margin. Notogaster polished, entirely without hairs. I regret to say that I could not make out the disposition of the suckers on the sucker-plate.

Habitat.—I only found this species once; that was in a mole's nest. I am not aware that anyone else has ever found it. I do not suppose it to be a parasite of the mole.

The figures were drawn from life.

HISTIOSTOMA PULCHRUM,* Kramer. Pl. IV, figs. 4—10.

Histiostoma pulchrum, 1886. Kramer, "Ueber Milben" (second paper of that name), in 'Arch. Naturg.,' 52 Jahrg., Heft 1, p. 259, T. 12, fig. 18.
„ „ 1897. Berlese, 'A. M. S. Crypt.,' p. 103.
„ „ 1899. Kramer, 'Thierreich,' Lief. 7, p. 134.

Length, both sexes	·30 to ·40 mm.
Typical length, both sexes . . .	·35 mm.
„ breadth, both sexes . . .	·17 „
„ length of legs, first pair . .	·14 „
„ „ „ second pair . .	·17 „
„ „ „ third pair . .	·13 „
„ „ „ fourth pair . .	·16 „

This well-marked and somewhat singular species was first found by Dr. P. Kramer in 1886; I am not aware of any record of its having been found again until the present one. Kramer found the adult male and the nymph and larva. The female and hypopus are, I believe, now described for the first time.

Colour yellowish white, or light buff, the opaque white given by the excremental matter showing through the dorsal cuticle is conspicuous, as in other species of the genus.

Texture dull, without polish.

Male (fig. 4) has a tendency to a diamond shape, but is truncated and rounded posteriorly; the diamond form is not nearly as well marked as in the ♂ of *H. rostro-serratum.* The cephalothorax, including mandibles, is nearly as long as the abdomen; the division between the two is very conspicuous, and the body is widest just behind it. Rostrum slightly bulbous at the proximal end. Mandibles (Pl. III, fig. 13) not mentioned by Kramer in his original description, but in 'Das Thierreich' he states that they have numerous saw-like teeth on their under edge. They certainly have something of that nature, but I should scarcely call them teeth. The whole mandible is very thin, and is flexible, bending sideways when the leg presses

* *Pulcher*, beautiful.

against it. They are rather broad blades on edge, and curve downward at the end, forming short blunt hooks. The under edge is not straight, but forms two convex lobes; the curved edge of the distal (anterior) of these bears a close series of extremely fine short ridges; these are Kramer's teeth; they scarcely project and can only be seen with a highish amplification and careful illumination. The palpi (Pl. IV, fig. 7) bear the usual two flagella; the anterior of these is nearly twice as long as the free portion of the palpus; the hinder is about half the length of the anterior one; there is also a third hair, much smaller, on the distal joint of the palpus behind the smaller flagellum. Membranous expansion of the palpus wide and running out into a lateral point. There are a pair of short setiform hairs, near together, just behind the epistome pointing forward; also a long pair a trifle further back and further apart pointing backward, and extending a short distance over the abdomen. The abdomen has a pair of mammillary processes on its lateral edge just behind its line of demarcation from the cephalothorax, bearing long curved spines standing laterally outward. Behind these are *three pairs of large spines* of clear chitin, almost horizontal and pointing backward and slightly outward; they are raised on low, somewhat chitinized, dark-coloured papillæ placed within the lateral margin.

These spines (Plate III, figs. 15, 16) are the great characteristic of the species. Kramer describes them as ensiform; this is true if the outline only be considered, which is rather doubly curved, like a sword-bayonet; it must not, however, be understood in the sense that they are flat; they are large, stiff, thick spines of clear, colourless chitin, and are quite hollow; they vary a little in form, are either sharp-pointed or round-ended, and are somewhat suddenly enlarged at their proximal ends, where they are set into the papillæ. This end of the spine is flat below and convex on its upper surface. The flat under surface runs a considerable distance down the spine, but gradually fades into a circular form like that of ordinary spines. *There are four pairs of similar but rather smaller and rounder-ended spines near the posterior margin,* and projecting considerably beyond it; the central pair is the smallest. There are also a pair of ordinary hairs a little behind the cephalothorax extending nearly half the length of the abdomen, and a much shorter, more spine-like pair, distant from the posterior margin about one-third of the length of the abdomen; also a long pair on the posterior margin. Legs of moderate length; about half the tarsus of the fourth pair passes the posterior margin of the body. The two anterior pairs are much thicker than the two posterior, and are usually turned somewhat backward.

The anterior pairs (fig. 8) bear three pairs of stout, curved spines, and a rounded chitinous knob near the distal end of the tarsus; two pairs, one of which is larger than the other, about the middle of the same joint; and one large unpaired spine near its proximal end; there is also a spine on each femur, genual, and tibia. The claws are long, strong, and only slightly curved; there is a long flexible hair just behind the claw. The posterior legs have fewer spines and a shorter hair by the claw. There are the usual two pairs of discs on the ventral surface; one pair, widely separated, about opposite the middle of the anal opening, and the other pair near together between the ends of the fourth epimera. The first pair of epimera are joined to the sternum; the second meet, or nearly meet, in the median line; the third and fourth are free. There is a pair of short hairs between the first and second epimera, another between the third and fourth, another close to the outer sides of the anterior pair of discs, a pair opposite the penial sclerites, and two pairs by the anus.

Female differs from the male in having on the notogaster ordinary stiffish curved hairs, not thick ensiform spines like those of the male; and not raised on papillæ, but only surrounded by the ring common at the base of Arthropod hairs; it also differs in having only two pairs on the hind margin instead of the four pairs near to it in the male; it is also rather less diamond-shaped.

Nymph and Larva.—Kramer found these, but has not described or figured them; they are both practically colourless, and do not show the accumulations of white excretory matter beneath the cuticle which are conspicuous in the adults. The legs are quite transparent.

The nymph more resembles the male than the female in shape; the hairs on the notogaster are raised on papillæ as in the male; the papillæ are transparent, not chitinized, and some of them are rather large; the hairs themselves, however, are more like those of the female, but are not quite so long in proportion to the body; they are flexible, but not highly so. Epimera of the first pair of legs joined to a very short sternum, the others free.

The larva is more parallel-sided than the nymph, and its notogastral and peripheral hairs are shorter; otherwise they resemble those of the nymph. The two epimera of the first pair of legs join in the median line, but there is not any sternum. There is a conspicuous chitinous disc (or ring) on each side of the body between the first and second legs.

Egg elliptical, yellowish white, with several longitudinal, undulated, brown, chitinous ridges on its outer surface.

Hypopus (fig. 6). — Light yellowish brown; polished; an unequal diamond shape. The abdomen much longer than the cephalothorax, only slightly rounded posteriorly. Above the rostrum is a curious hood of clear chitin (Pl. III, fig. 18), which projects nearly from the level of the dorsum of the cephalothorax, and is immoveably fixed to it, but is divided from it by a distinct line when seen from above; this hood has a cheek-like, rounded lamina of rather darker chitin on each side, which falls almost perpendicularly downward; thus they completely protect the rostrum from above and from the side. The cheek-like pieces are seen through the dorsal part of the hood in consequence of the transparency of the latter. When seen from above the hood looks exactly like a minute caput. Dorsal surface hairless.

Rostrum long and narrow; in life it is usually held perpendicularly. Rostral hairs very long. Legs longish, particularly the first pair; the fourth pair slightly passes the posterior margin and has a long terminal hair. The other pairs have a nearly straight claw; that of the third leg is very small. The femora and coxæ of the third and fourth legs are very much broader than the other joints when seen from the side, but not when seen from below. The tarsi of all the legs are long and thin. The suckers are three pairs almost touching and close to the posterior margin, arranged one pair anteriorly and two posteriorly, or perhaps it would be more exact to say forming a triangle on each side of the body; the anterior pair is the largest.

Habitat.—Dr. Kramer found the species on trees in Germany, in places where the sap was running from wounds in the bark. I have found it in Warwickshire in a somewhat similar situation, and also in considerable numbers at Studland in Dorsetshire on an elm tree in the same condition.

HISTIOSTOMA PYRIFORME,* n. s. Pl. V.

	Female.	Male.
Length (without rostrum) about .	·30 mm.	·25 mm.
Breadth about	·13 ,,	·12 ,,
Length of legs, first pair, about .	·15 ,,	·16 ,,
,, ,, second pair, about .	·17 ,,	·16 ,,
,, ,, third pair, about .	·20 ,,	·16 ,,
,, ,, fourth pair, about .	·22 ,,	·20 ,,

The breadth of the female is taken midway between the second and third legs; there it is tolerably

* *Pyrum*, a pear; and *forma*, form.

constant; behind the fourth pair of legs it varies widely according to the extent to which the eggs in the abdomen are developed.

This species may be known by the combination of long palpal flagella and dentate mandibles with an abdomen not bearing mammilliform elevations, or spatulate or leaf-like hairs on its dorsal surface. The nearest ally probably is the *Histiostoma fimetarium* of Canestrini and Berlese;* but it is distinguished from that species by its serrated (instead of knife-like) mandibles; its pyriform (instead of oblong) form; its strongly convex (instead of concave) hind margin; by the presence of two pairs of largish hairs on the antero-lateral corners of the abdomen, and the much greater size of the two pairs on or near the hind margin.

Colour.—The body is almost colourless, but as seen by reflected light on a dark ground it has a very decided blue tinge in those parts which are not occupied by excremental (urinary) matter; except in the middle along the course of the alimentary canal, where a yellow tinge is usually visible, and this often spreads further in the body; both the blue and the yellow are transparent. The body is, however, generally very highly charged with the excremental concretions usual in the genus; they are very abundant in this species; so that the greater part of the body is occupied by opaque white, chalky-looking masses which show clearly through the cuticle, giving their own colour to the body; the distribution of these masses is constantly varying.

Texture really smooth and even polished, but the

* "Nuovi Acari," in 'Atti Soc. Veneto-Trent,' 1881, vol. vii, p. 150. Berlese says ('A. M. S.,' fasc. ix), but with a ?, that the hypopus of this species is the *Acarus acarorum* of Linnæus ('Syst. Nat.,' p. 2934, No. 81); and he also says, without a ?, that it is the *Hypopus julorum* of Koch ('D. C.,' fasc. xxviii, pl. xx); but subsequently (fasc. xxix, No. 4) in the same work he gives *Hypopus julorum*, Koch, as a separate species, which he afterwards ('A. M. S. Crypt.,' p. 186) identifies with *Histiostoma rostro-serratum*, Mégnin. See, however, Berlese's remarks in his 'A. M. S. Notes,' fasc. iv, pp. 44, 45.

white concretions make it look granular when the creature is not in liquid.

Shape.—The male, without the rostrum, is not very far from oblong; but somewhat enlarged behind the fourth pair of legs; the posterior end is rounded; the back slightly arched. The virgin female is about the same shape as the male, but as the eggs are developed it becomes more and more suddenly and strongly enlarged behind the fourth pair of legs; the drawing is made from a specimen where the eggs are about half developed.

Male (fig. 2).—Rostrum long and chitinized. The mandible (Pl. III, fig. 19) small, blade-like, ending distally in a pointed hook; set with small teeth of even size throughout and close together.

Flagella of palpi very long, the longest of any known species except *H. fimetarium*, which has them equally long. Body smooth, *without mammillæ* or lumps of any sort on the dorsum, and without markings. There are two pairs of short hairs on the dorsum of the cephalothorax, two longer on the shoulders, and two longer pairs on or near the hind margin. Under side flat; epimera of the first pair of legs joined to the short sternum; all the other epimera free. Male organ placed between, or a trifle behind, the coxæ of the fourth legs; anus immediately behind it. There is a pair of chitinous rings (? suckers) between the ends of the epimera of the fourth legs, but near to the median line of the body; and another pair, one on each side of the male organ, but much further apart. Legs rather long, particularly the fourth pair, which *extend considerably behind the hind margin* of the body. The fourth pair are curved inward; there is a spine on the under side of each coxa, a very small spine on each genual and tibia, a whorl of stronger spines about the middle of the tarsus: there is a small spine near the claw in each tarsus, and there is a large curved spine immediately above the claw on the first leg only; this spine is almost as large as the claw, and a good deal like it.

There is also a very long flexible hair near the distal end of each tarsus. The claw is very long, and very slightly curved; it is joined to the tarsus.

The **Female** (Pl. V, figs. 1, 3) is very like the male with the above-named exceptions. The vulva is between the epimera of the third pair of legs. There is one pair of rings or suckers between the epimera of the fourth pair of legs and those of the third; and a second pair, one on each side of the vulva, but nearly as far apart as the ends of the epimera of the fourth pair. The fourth legs are not curved like those of the male, and the tarsus of the first pair is without the large spine above the claws.

The **Nymph** (Pl. V, fig. 5) is widest at the shoulder, and narrows a little toward the hind margin; *this margin bears two pairs of strongly developed mammillæ*, these carry the hairs.

The **Larva** is much the same as the nymph, with the usual exception.

I have not found the hypopus of this species.

Habitat.—I have found the creature only in the exuded sap and wet decaying débris on beech trees (*Fagus sylvatica*), where the bark has been wounded, and where the exudation, etc., has collected and kept wet.

Of the specimens which I obtained, the greater number were thickly covered on the dorsal surface, and more sparsely on the legs and ventral surface, with living Vorticellidæ (Pl. V, fig. 4).

Sub-family TYROGLYPHINÆ.

Tyroglyphidæ with the ambulacra of all the legs sessile and with chelate mandibles.

I have thought it convenient to include such foreign genera as I think should be retained in the following table, but there are not any British representatives of either of the genera *Saproglyphus* or *Mælia* known at present.

Table of the Division of the Tyroglyphinæ into Genera.

A.	Female with a projecting tubular bursa copulatrix	Glycyphagus.
	Female without projecting tubular bursa copulatrix	B.
B.	No demarcation between cephalothorax and abdomen	C.
	Cephalothorax and abdomen plainly divided by a distinct constriction or line . .	G.
C.	Dorsal cuticle wholly chitinized and forming a hood anteriorly, which hides the mouth-organs from the dorsal aspect. Penis withdrawn within the body when not in action	D.
	Dorsal cuticle soft, no anterior hood, penis not withdrawn within the body when not in action, but visible from the exterior .	E.
D.	Penis emerging close to the hypostome, in front of the epimera of the first pair of legs	Chortoglyphus.
	Penis emerging between the epimera of the third and fourth pairs of legs . .	Fusacarus, n. g.
E.	Epimera of the first two pairs of legs of the male joined to the sternum and to each other, forming a continuous skeleton	F.
	Epimera of the second pair of legs of the male not joined to the sternum . .	Trichotarsus.
F.	Strong sexual dimorphism, particularly in the form and size of the legs; dorsal cuticle, especially in the male, with numerous chitinous plates embedded in it. No genital suckers in either sex . .	Hericia.
	Scarcely any sexual dimorphism and not any in the legs; no chitinous plates in the dorsal cuticle; genital suckers present in both sexes	Carpoglyphus.
G.	Male without anal (copulative) suckers .	Saproglyphus.
	Male with conspicuous anal (copulative) suckers	H.
H.	No sternum	Mælia.
	A sternum to which the epimera of the first pair of legs are joined . .	I.
I.	Dorsal surface of the posterior margin of the abdomen of the male prolonged so as to form an overhanging shelf, which may be either split into lobes or entire .	Histiogaster.
	Dorsal surface of the posterior margin of the abdomen of the male not prolonged so as to form a shelf	J.

J.	First leg of the male much thicker than the other legs, and having the femur spurred	ALEUROBIUS.
	First leg of the male not conspicuously thicker than the other legs, and its femur not spurred	K.
K.	Males strongly dimorphic; the heteromorphic males having the third leg much thicker than the others, and its tarsus converted into a great slightly-curved claw, but without the ordinary ambulacra	RHIZOGLYPHUS.
	No dimorphism of the males . .	TYROGLYPHUS.

GENUS GLYCYPHAGUS * (*Hering*).

Glycyphagus, 1838. Hering, "Die Krätzmilben," in 'N. Acta Ac. Leop.,' vol. xviii, pt. 2, p. 619.
,, 1882. Scudder, 'Nomencl. Zool. Universal Index,' p. 132.
,, 1894. Monier, 'Notes,' p. 17.
,, 1897. Berlese, 'A. M. S. Crypt.,' p. 106.
,, 1898. Berlese, 'A. M. S.,' fasc. lxxxix, No. 1.
,, 1898. Oudemans' 'List,' p. 251.
,, 1899. Kramer, 'Thierreich,' Lief. 7, p. 144.
Glyciphagus, 1844. Gervais, in Walckenaer, 'Insectes aptères,' vol. iii, p. 263. Printed in error *Glycyphocus* in vol. iv, p. 557.
,, 1867. Fumouze and Robin, 'Mém. Acar.,' p. 568.
,, 1879. Troupeau, "Des Acariens de la Farine," in 'Bull. Soc. d'Études Sci. d'Angers,' 1876–8, fasc. ii, p. 110.
,, 1880. Mégnin, 'Les Parasites,' p. 138.
,, 1888. Canestrini, 'I Tiro,' p. 6; 'Pros.,' p. 355.
Glycophagus, 1846. Agassiz, 'Nomencl. Zool. Arachnidæ,' p. 6. This must probably be a misprint.
Glyciphalus, 1868. Donnadieu, in 'Ann. Sc. Nat. Zool.,' vol. x, p. 69.
Glyziphagus, 1880. Claus, 'Grund Zool.,' vol. i, p. 651.
Acarus, part. Of all writers prior to 1796, and probably of all prior to 1835.
,, 1842. Koch, 'Uebersi,' p. 118.
,, 1877. Canestrini and Fanzago, "Intorno agli Acari Italiani," in 'Atti Ist. Veneto,' ser. v, vol. iv, p. 196.

Special synonymy relative to the Acari included here in the genus *Glycyphagus*, but which constituted the genus DERMACARUS,† Haller, and the genus HOMOPUS, Koch.

* Γλυκύς, sweet; φαγῶ, to eat.
† Δέρμα, the skin; ἄκαρι, a mite.

Founded on Adult.

Dermacarus, 1880. Haller, "Zur Kenntniss der Tyroglyphen und Verwandten," 'Z. wiss. Zool.,' vol. xxxiv, pp. 268—273.
„ 1899. Kramer, 'Thierreich,' Lief. 7, p. 150.
Homopus,* 1888. Canestrini, 'I Tiro,' p. 6; 'Pros.,' p. 354.
Labidophorus,† 1898. Oudemans' 'List,' p. 265.
Glyciphagus (part), 1886. Michael, "Upon the Life-history of an Acarus, one stage whereof is known as *Labidophorus talpæ*, etc.," in 'J. R. Micr. Soc.,' London, ser. ii, vol. vi, pp. 377—390.
Glycyphagus (part of), sub-genus *Homopus*, 1897. Berlese, 'A. M. S. Crypt.,' p. 106.

Founded on Hypopial Nymph only.

Dermaleichus, part, 1841. Koch, D. C., fasc. xxxiii, No. 7.
„ part, 1879. Canestrini, "Intorno ad alcuni Acari parasiti," in 'Atti Soc. Veneto-Trent,' vol. vi, fasc. 1, p. 13.
Homopus, 1842. Koch, 'Uebersi,' Heft 3, p. 121.
„ 1844. Koch, D. C., fasc. xxxix, No. 24.
Labidophorus, 1877. Kramer, "Zwei parasitische Milben des Maulwurfs," in 'Arch. Naturg.,' Jahrg. 43, pp. 248—259.

It will be seen that the first notice of any stage of the creatures forming Haller's genus *Dermacarus*, but here included in *Glycyphagus*, was by C. L. Koch, who in 1841 found the hypopial nymph of *G. sciurinus* and supposed it to be an adult creature; he included it in the genus *Dermaleichus;* probably only from its parasitic habits. It must be remembered that at this time the genus *Hypopus*, as it was then called, was looked upon as being composed of adult creatures; Koch supposed them to be allied to *Uropoda;* deceived probably by a considerable resemblance in general external appearance on the dorsal surface; he evidently soon saw that the creatures did not belong to *Dermaleichus*, but were very like *Hypopus;* but he must have seen, correctly, that there was a difference between them and other Hypopi; he therefore originated the

* Name preoccupied by Duméril and Bibron in 1835 for a genus of reptiles, 'Erpétologie générale,' vol. ii.

† ? Name preoccupied, *Labidophora*, 1876, Scudder, Orthoptera (Forfic.), in 'Proc. Boston Soc. Nat. Hist.,' vol. xviii, p. 297.

genus *Homopus* to receive them; but this genus was formed entirely upon an immature (hypopial) form, and on characters which depended solely upon that stage; moreover the name was preoccupied.

The next writer, practically, who dealt with any of the creatures of this group was Kramer; he found a species upon the mole, and created a new genus for it, *Labidophorus*, having evidently overlooked the identity of his genus with Koch's *Homopus;* being next in order of date, and *Homopus* having failed, Kramer's generic name would have stood had it not been for two objections, viz. firstly, it was based on an immature (hypopial) form, and depended solely upon the characters of that stage just the same as Koch's genus; and secondly, it is very doubtful whether this name also is not preoccupied, Scudder's earlier name in Orthoptera differing from it only in having a feminine termination instead of a masculine; as to whether this is sufficient there is grave difference of opinion between zoologists.

The only authorities exactly in point which I am aware of are (1) the exception "a" to § 4 of the rules for the scientific naming of animals, issued by the German Zoological Society; and (2) Article 21 of the Rules of Nomenclature, adopted by the Zoological Congress, at Moscow, in 1892. In the former, after stating (in the rule) that names of the same origin and only differing from each other in the way they are written are to be considered identical, and giving examples, it proceeds: "(a) On the other hand, it is permissible to use both *Picus* and *Pica*, etc." The latter rules state, "Names should be avoided which only differ from one another in their masculine, feminine, or neuter terminations."

The next author who dealt with the group was Haller in 1880; he found Koch's species, but he also found and described the adult form, and his genus was based upon it. Therefore, for the reasons given at page 187 of this work, I consider that Haller's name of *Dermacarus*, which he then gave to the adult, should stand as the name of the genus, if there ever be a genus to receive the group.

The next paper was my own in 1886 (loc. cit.). I found Kramer's species, but I worked out the whole life-history, and found the adults of both sexes; at the same time I found the adults and some, at least, of the immature stages of some closely allied species. I came to the conclusion that there was not in the then state of our knowledge any sufficient means of instituting a sound generic distinction between the Acari forming this group and the genus *Glycyphagus*, and I included them all in the last-named genus.

In 1897 Berlese (loc. cit.) took the same view as I had done in 1886, and included all the species in *Glycyphagus;* but he has, as it seems to me, complicated the matter considerably by creating a sub-genus *Homopus* (overlooking the preoccupation of that name), and putting into it not only Koch's and Kramer's species noticed above, and their allies, but also what seem to me to be such very different species as *Glycyphagus plumiger*, *G. palmifer*, *G. Canestrinii*, *G. perigrinans*, and *G. intermedius.* None of these, as far as we know, have any *hypopial* nymphs having any of the characters upon which the genera *Homopus* and *Labidophorus* were intended to be founded, nor have the adults any of the characters upon which the genus *Dermacarus* was founded. Berlese only leaves three species in the sub-genus which he calls "*Glycyphagus veri;*" these are *G. ornatus*, *G. domesticus*, and *G. spinipes.* He says that these three have smooth skins, and the body-hairs very finely plumose, while the sub-genus *Homopus* have punctured or rough skins, and body-hairs thickly plumose, deeply barbed ("*alte barbatulæ*") or laminaceous, or, rarely, simple and short; but, as a matter of fact, none of the three species constituting Berlese's "*Glycyphagus veri*" have smooth skins, and their body-hairs are almost as plumose as those of *G. perigrinans* or *G. intermedius.**

* Both foreign species.

In 1899 the late Prof. P. Kramer, in the Tyroglyphidæ part of "Demodicidæ und Sarcoptidæ," constituting *Lieferung* 7 of 'Das Thierreich,' makes the classification translated at page 42 of this book; in it he preserves both the genus *Glycyphagus* and the genus *Dermacarus*, but he separates them by a long distance, and the distinction he makes between them is that the female *Glycyphagus* has the projecting bursa copulatrix, and the female *Dermacarus* has not. To satisfy this definition he includes *G. Crameri* (which he calls *G. talpæ*) in *Glycyphagus*, and places *sciurinus* and one other species, *arvicolæ* of Dujardin, in *Dermacarus*. I cannot help thinking that if Dr. Kramer had been personally acquainted with the creatures he would not, even so shortly before his death, have placed *G. Crameri* and *G. sciurinus* in two separate genera; they are extremely closely allied creatures in every stage, and must, in my opinion, certainly be in the same genus, and even in the same sub-genus if there be one. In addition to this there is another serious objection to Dr. Kramer's classification of this group, viz. that it is not correct to say that *sciurinus* has not any projecting bursa copulatrix; it is undoubtedly very small, but so it is in *G. Crameri*, although in that species it is a trifle larger than in *G. sciurinus*. It is true that if Haller's drawing were the only thing relied on, and probably Kramer had not anything else to judge from, it might well be supposed that *G. sciurinus* had not any projecting bursa copulatrix; but Haller only figures the underside of the female, and in *G. Crameri* the bursa copulatrix cannot be seen from the ventral aspect. Moreover Haller expressly says that he had only two specimens of the lately emerged female, which is the period when coition takes place, and that both these were in such extremely bad condition that he had not attempted to draw or describe from them; and that consequently his figures and description were taken entirely from the older female when the eggs were ripe. This is plainly shown in his drawing; but at this time, when the abdomen is distended by eggs and the function of the bursa is over, a small bursa is apt to be obliterated by the distension of the cuticle; particularly when it lies between two lobes, as it does in *G. sciurinus.* As to Kramer's only other species, *D. arvicolæ*, Dujardin, only the hypopial nymph is known, and that stage never shows any sign of sex in any species; and, of course, never has a bursa copulatrix; therefore it is not apparent how Kramer knew that it should be put into *Dermacarus* rather than *Glycyphagus*, according to his definition.

Since 1886 we have got to know a little more about the species included in this genus, but it is very little: the hypopial stage is only known in the three or four species known then, and in one of these, *Hypopus arvicolæ*, Dujardin, the adult is not known at all, and in another (if they be different), "*Homopus hypudæi*," Koch,* the adult is only known from Oudemans' announcement that he has found it,† but he has unfortunately omitted to describe or figure it. In the same place this author states that he has found the adults of three other species and the hypopial nymph of a fourth; but as he does not describe or figure any of these it is not possible to judge whether they properly belong to this genus at all;‡ indeed, it is not possible to be quite certain about Koch's *H. hypudæi.* Under these circumstances I am still of opinion that it is best, for the present at all events, to leave all the species in the genus *Glycyphagus* until the life-histories of all are thoroughly known.

If ever the hypopial nymphs of *G. platygaster* and *G. dispar*, if they have any, should be discovered, and should be homopial—that is to say, provided with apparatus for holding the hairs of mammals between the ventral surface of the abdomen and certain specialised overlapping chitinous plates near the posterior end,

* Koch, 1844, 'D. C.,' fasc. xxxix, No. 24.
† 'List,' p. 252, called *Labidophorus hypudæi.*
‡ Oudemans does not name them.

instead of being provided with suckers to hold on to smooth surfaces like most other Hypopi,—then the genus *Dermacarus* might well be revived; but to be at all satisfactory the definition of the genera, whatever it may be, must be such as to place (including foreign species) *palmifer*, *pteroptus*, *ornatus*, *plumiger*, *Canestrinii*, *perigrinans*, *spinipes*, *domesticus*, and *intermedius* in one genus, and *dispar*, *platygaster*, *Crameri*, *sciurinus*, and probably *arvicolæ* and *hypudæi*, if both be real species, in the other.

GLYCYPHAGUS.

Tyroglyphidæ with the ambulacra of all legs sessile; caroncle usually more developed than the claw; with chelate mandibles; with the bursa copulatrix of the female forming a tubular projection in the centre of the posterior end of the abdomen. With or without a division between cephalothorax and abdomen; with a cuticle usually more or less rough, never polished. With considerable, rarely extreme, sexual dimorphism. Dorsal hairs usually pectinated or plumose, or transformed into foliaceous scales or into spines. Without anal suckers. Hypopial stages, as far as at present known, either quite rudimentary and not functional, or else active and homopial.

This genus probably contains all the most beautiful, and many of the most interesting, species in the family; many of them are great destroyers of human stores of foodstuffs and other dried vegetable and animal matters. Few more beautiful microscopic objects can be seen than a good female specimen of *Glycyphagus Canestrinii*, properly shown with black-ground illumination. The question of sexual dimorphism in the genus is also interesting, because in all known species except *G. dispar* the male, although very different from the female, is sufficiently like her to cause any observer to suspect at once that they were the two sexes of one species; but in *G. dispar* the male is utterly unlike the female, and utterly unlike every other male in the genus. Yet the female of *G. dispar* differs but little from that of *G. platygaster*, a species in which the male does not differ from the female more than is usual in the genus, probably rather less.

The **Rostrum** is small; not usually distinctly divided from the remainder of the cephalothorax. It is sometimes truncated anteriorly to allow the mandibles to protrude, as in *G. plumiger*, *G. palmifer*, etc. Sometimes it forms a more or less chitinous hood over them, as in *G. platygaster*, *G. dispar*, etc.

The **Mandibles** are chelate, usually short and powerful; generally either tri- or quadri-dentate on each arm of the chela.

The **Maxillary Lip** is of the typical character in the family—membranous, broad in the proximal part, and inclined to separate into maxillæ and central lip at the distal end; but the maxillæ are not functional.

The **Palpi** are of three joints; the basal joint may be anchylosed to the maxillary lip.

The **Cephalothorax** is small, and greatly hidden by the anterior portion of the abdomen in such species as *G. dispar*, *G. platygaster*, etc.; much larger and not at all hidden in such as *G. plumiger* and *G. palmifer*.

The **Notogaster** is strongly arched in such species as *G. spinipes*, *G. domesticus*, etc., but has a tendency to be flat in species like *G. platygaster*, *G. dispar*, etc. It is usually provided with abundant hairs or their homologues; these may be very long flexible hairs which may be clothed with small secondary hairs, as in *G. spinipes*, *G. domesticus*, etc., or may be strongly bipectinate, as in *G. plumiger*, or biplumose, as in *G. Canestrinii*; or the hairs may be transformed into elaborate phyllomorphic stalked scales, with a central, branched rachis, sometimes bearing spinelets, and a thin transparent membrane stretched between the branches and the central stem, as in *G. palmifer* and the foreign species *G. pterophorus*. The dorsal cuticle of the notogaster is almost always more or less rough; in such species as *G. plumiger* and its allies it is very rough, or granular, and studded with little bifid or trifid points. In such species as *G. spinipes* and *G. domesticus* it is much smoother, rather more like chamois leather; but it is not ever polished or really smooth in any known species. The bursa copulatrix forms a tubular projection in the centre of the hind margin, but not usually on the actual margin; rather on the notogaster close to the margin, in the females throughout the genus. This projection may be very short, as in *G. Crameri* and *G. sciurinus;* or it may be long, as in *G. platygaster* and *G. domesticus*. It sometimes has the posterior edge cut into short labia.

The **Legs** vary so much in length and thickness in different species that no general rule can be indicated. The tarsi are ordinarily the longest joints, occasionally as long as all the other joints put together, but sometimes very little longer than the tibiæ. The ambulacrum generally consists of a medium-sized caroncle and a very minute claw, so small very often as to be difficult to see. The legs are often provided with pectinated, serrated, plumose, or villous hairs or scales; but these are not usually numerous, the legs being provided with setiform hairs as well. In *G. Crameri* and *G. sciurinus* the legs of the male also bear some thin, transparent, chitinous laminæ, which in the former species are mostly deeply serrated on their distal edges (Pl. XVII, figs. 8, 9).

The Ventral Surface.—The epimeral skeleton is usually well developed; the epimera are often joined to the sternum or to a chitinous band, which often surrounds the vulva, and sometimes forms a semicircle in front of the penis. In species like *G. domesticus* the development of the epimera is weak. The vulva is sometimes placed between the coxæ of the second and third pairs of legs, in which case it is usually large, surrounded by a stiff chitinous ring, and consists of two labia, separated rather widely at their posterior ends; where there is occasionally a third, smaller, triangular labium between them, as in *G. Crameri;* or it may be placed between the coxæ of the fourth pair of legs, when it is most frequently two flexible labia only; not separating widely when at rest, and not surrounded by any chitinous ring. The anus is on the ventral surface, not terminal. There are not any anal (copulative) suckers, but the so-called genital suckers are present in both sexes.

The Immature Stages.—The larvæ and nymphs are usually sufficiently like the adults to be guessed from them. In *G. Crameri*, however, they are very different from the adult. With regard to the hypopial stage, this is usually either very rudimentary or unknown at present, or else active and homopial. The rudimentary hypopi of *G. spinipes* and *G. domesticus* have already been fully dealt with in chap. vi, pp. 168—173. This information need not be repeated here. In the species upon which Haller's genus *Dermacarus* was founded the hypopial nymph is a stage found in full vigour and activity, but it is homopial. What a homopial nymph is has also been described at p. 165, and need not be repeated.

Habitat.—*Glycyphagi* such as *G. spinipes*, *G. domesticus*, *G. plumiger*, etc., are principally found in hay, fodder, farinaceous substances, etc.; but many of them, *e. g. G. domesticus*, are found in most dried vegetable and many dried animal stores, especially in houses and buildings. Indeed, it seems hardly possible to keep *G. domesticus* out of anything in a house. The rapidity with which it gets into unexpected places has led to many curious errors; it is certainly a destroyer of dried insects. A considerable group are only found in the nests of mammals, *i. e.* the mole, the squirrel, and the field-mice. Those found in the mole's nest, of which I have been the principal discoverer, have always been found by me abundantly in the nest; but, with the exception of the hypopial nymph of *G. Crameri*, never on the mole itself. *G. sciurinus* I have found both in the nest and on the squirrel. Haller, who discovered the adult, found it upon the squirrel itself in some numbers. The species connected with the mice have only been found in the hypopial stage, when they are naturally found upon the mouse more than elsewhere.

I have preserved the name of *Dermacarus* in connection with the species having homopial nymphs, in case the time should come when it may be desirable to revive that genus.

Genus Glycyphagus.

Table for the Identification of British Species.

Hypopial nymph rudimentary or unknown.	Abdomen not divided from cephalothorax.	Tarsi bearing only a few (4 to 6) setiform hairs of unequal length, easily seen			G. DOMESTICUS.
		Tarsi thickly clothed with extremely fine hairs of equal length			G. SPINIPES.
	Abdomen divided from cephalothorax by a distinct sulcation.	Hairs on notogaster plumose or leaf-like.	Hairs on notogaster plumose	Barbs, *i. e.* secondary hairs on main rachis or stem, straight; so that the whole plume is like a bipectinate comb	G. PLUMIGER.
				Barbs turned suddenly forward near their distal ends	G. CANESTRINII.
			Hairs (or scales) on notogaster leaf-like		G. PALMIFER.
		Hairs on notogaster transformed into strong spines.	Male and female resembling each other, both with the abdomen bordered by projections (mostly trifid) bearing large, almost straight spines		G. PLATYGASTER.
			Male and female entirely different. Male without peripheral projections to the abdomen, and with only very short straight spines; female with projections and large curved spines		G. DISPAR.
Hypopial nymph active, functional and homopial.	Hairs on notogaster transformed into very short straight spines				G. CRAMERI.
	Hairs on notogaster setiform				G. SCIURINUS.

Glycyphagus domesticus,* de Geer. Pl. VI, and Pl. VIII, figs. 3, 7, 8, 9, 10, 12, 14, 16.

Acarus domesticus, 1778. De Geer, "Mémoires pour servir à l'histoire des Insectes,' Stockholm, vol. vii, p. 88, No. 1, pl. v, figs. 1—9.
" " 1793. Gmellin, in Linnæus' 'Syst. Nat.,' Gmellin's edition, t. i, pars v, p. 2928. Contarini, 'Venezia e le sue Lagune,' vol. ii, p. 162.
" " 1877. Canestrini and Fanzago, "Intorno agli Acari Italiani," in 'Atti Ist. Veneto,' ser. v, vol. iv, p. 196.
Glycyphagus domesticus, 1884. Berlese, 'A. M. S.,' fasc. xiv, No. 3.
" " 1894. Monier, 'Notes,' p. 459.
" " 1898. Oudemans' 'List,' p. 251.
Glyciphagus domesticus, 1888. Canestrini, 'I Tiro,' p. 20; and 'Pros.,' p. 384.
" " 1888. Michael, "Researches into the Life-histories of *Glyciphagus domesticus* and *G. spinipes*, in 'J. Linn. Soc. Zool.,' vol. xx, pp. 285—298, pl. xvi, figs. 1—7.
? Troisième espèce de Mite, 1829. Lyonet, "Anat., etc.," in 'Mém. du Muséum d'Hist. Nat.,' Paris, p. 284, pl. xii (fourth of the paper), figs. 10—12.†
Glyciphagus cursor, 1841. Gervais, "Notes sur quelques espèces de l'ordre des Acariens," in 'Ann. Sci. Nat.,' ser. 2, t. xv, pp. 5—10, pl. ii, fig. 5.
" " 1844. Gervais, in Walckenaer's 'Insectes aptères,' vol. iii, p. 264.
" " 1867. Fumouze and Robin, 'Mem. Acar.,' p. 573.
" " ?1879. Troupeau, "Des Acariens de la Farine," in 'Bull. Soc. d'Études sci. d'Angers,' 1876–8, fasc. ii, p. 110, fig. 12.‡
" " ?1880. Mégnin, 'Les Parasites,' p. 139. (Mégnin's figure hardly seems to be *G. domesticus*.)

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* *Domesticus*, of the house, domestic.

† I do not think that it is possible to say for certain whether Lyonet's species was *G. domesticus* or *G. spinipes*.

‡ I have grave doubts whether the creature referred to by Troupeau was not really *G. spinipes*; he draws a band near the anus reticulated with hexagonal markings, and says it occurs in some specimens. These hexagonal markings do occur on *G. spinipes* when about to assume the inert condition of a case which contains the rudimentary hypopus; but they do not occur on *G. domesticus*.

Glyciphagus spinipes, 1884. Targioni-Tozzetti, in 'Lavori della Stazione di Entomologia agraria di Firenze,' vol. lxxxiv, p. 72, pl. ii, fig. 3. 1888. "Relazione, etc.," in 'Ann. di Agricoltura,' p. 479.
Acarus siro, 1841. Koch, D. C., fasc. xxxii, No. 24.
? *Acarus cubicularis*, 1841. Koch, D. C., ibid., No. 23.
? *Sarcoptes hippopodos*, 1835. Hering, 'Die Krätzmilben,' p. 607.
? *Glyciphagus hippopodos*, 1841. Gervais, "Notes sur quelques espèces, etc.," in 'Ann. Sc. Nat.,' ser. 2, vol. xv, p. 8, pl. ii, fig. 4.
? *Glycyphagus prunorum*, 1835. Hering, 'Die Krätzmilben,' p. 619.

Sed non—

Acarus domesticus, 1798. Latreille, "Hist. nat. des Crust. et des Insect.,' Paris, vol. vii, p. 400. 1806. 'Gen. Crust. et Insect.,' Paris, vol. i, p. 158.
Nec Acarus domesticus, 1843. Dujardin, 'Observateur au Microscope,' p. 151.
" " 1834. Dugès, "Recherches sur les Acariens," 3me mém. in 'Ann. Sci. Nat.,' ser. 2, vol. ii, p. 40.
" " Contarini, 'Cataloghi,' p. 16.

Mégnin* considers that this species is identical with *Acarus cubicularis*, Koch, which is not improbable, and with *Glycyphagus prunorum*, Hering,† and *Sarcoptes hippopodus*, Hering,‡ which is possible, although I do not think that anyone can say with certainty; and also with *Acarus destructor*, Schranck,§ *Acarus dimidiatus*, Hermann,|| *Acarus setosus*, Koch,¶ and *Acarus hyalinus*, Koch;** all of which seem to me to be quite different creatures.

Fumouze and Robin†† say that *Acarus destructor*, Schranck, is a *Glycyphagus*, but seem doubtful whether it should be identified with this species or not.

Monier (loc. cit.) says, probably correctly, that this

* 'Les Parasites et les Maladies parasitaires,' p. 139.
† "Die Krätzmilben der Thiere," 'N. acta Ac. Leop.,' vol. xviii, p. 619, pl. xlv, figs. 16, 17.
‡ Ibid., p. 607, pl. xliv, fig. 11.
§ "Enumeratio Insect. Austriæ," 'Augusta Vindelicorum,' 1781, sp. 1057.
|| 'Mémoire aptérologique,' Strasbourg, 1804, p. 85.
¶ 1841, Koch, D. C., fasc. xxxiii, No. 3.
** Ibid., fasc. xxxii, No. 19.
†† Loc. cit., p. 274.

is the species really referred to by numerous French writers on micrography, etc., when they speak of *Tyrogyphus farinæ.*

It seems to me quite uncertain what the *Acarus domesticus* of Latreille was.*

Fumouze and Robin considered Lyonet's "troisième espèce de mite" to be *G. domesticus*, but, as before stated, I think this very uncertain.

Linnæus does not mention *domesticus* in any edition of the 'Systema Naturæ' published in his lifetime; de Geer remarks that Linnæus did not distinguish between this species and *A. siro*: after the death of Linnæus, and after the publication of de Geer's work, Gmellin introduced *A. domesticus* into his edition of the 'Syst. Nat.'

There can be but little doubt that by many ancient and even some modern writers the specific name *domesticus* has been used in error when the creature really spoken of was *T. siro*, *T. longior*, or *G. spinipes*.

This creature probably was the *Acarus horridus* of Turpin,† which Mr. Cross thought that he had created by electricity; but it is not possible to be certain from Turpin's paper.

	Female.	Male.
Length . . .	·43 mm. to ·55 mm.	·36 mm. to ·50 mm.
Typical length about .	·5 „	·48 „
„ breadth about .	·27 „	·25 „
„ length of legs, first and second pairs . .	·30 „	·27 „
Typical length of tarsus of first pair . . .	·13 „	·12 „
Typical length of legs, third pair . . .	·35 „	·35 „
Typical length of legs, fourth pair . .	·37 „	·37 „
Typical length of tarsus, fourth pair . .	·18 „	·18 „

This is one of the commonest of species; it is found in great quantities, chiefly in houses and buildings,

* 'Genera Crustaceorum et Insectorum,' Paris, 1806–9, vol. i, pp. 150, 151; 'Hist. Nat. des Crustacés et des Insectes,' Paris, 1798, p. 400, pl. lxvi.

† 'C. R. Ac. Sci.,' 1837, t. v, p. 672.

and is one of the great destroyers of dried animal and vegetable stores; but it is not by any means confined to houses. It is frequently confused with *G. spinipes*, and is at first very difficult to distinguish from that species; when the observer is accustomed to the two, however, he can pick them out readily; even the novice, if he can use a microscope properly, may easily do so by the following characters: firstly, the tarsi of the present species are smooth and have on them only a very few (four to six) moderately long setiform hairs, which are easily seen; those of *G. spinipes* are densely clothed with very short fine hairs which are difficult to see and almost invisible in glycerine, or indeed in almost any liquid or in balsam; they are best seen dry with an amplification of 150 to 200 diameters; but none of these hairs are much longer than their fellows. Secondly, the tarsi of *G. domesticus* are much longer than those of *G. spinipes;* in the former species the tarsi are as long as all the other joints of the leg put together. Thirdly, the third joint of the third leg of *G. spinipes* bears on the outside a peculiar hair or scale (Pl. VII, figs. 5, 6), shaped like a husk of corn, and placed with the concavity inward; its outer surface is thickly clothed with very fine hairs like those on the tarsi; this scale is absent from *G. domesticus.* Fourthly, the bursa copulatrix of the female *G. domesticus* is twice as long as that of *G. spinipes.* Fifthly, *G. spinipes* is sharply constricted between the second and third pairs of legs, and is much narrower behind the constriction than before it; whereas *G. domesticus* can hardly be said to be constricted at all, although slightly curved inward, and its abdomen is nearly or quite as wide posteriorly as anteriorly; this difference of form can only be seen in living specimens.

Colour pearly white or very pale grey; generally bluish grey on the side next the light, but yellowish white on the side opposite the light; the creature being somewhat translucent.

Texture even, but not smooth or polished; the texture of chamois leather, but covered with very fine labyrinthine markings.

Shape.—Conical anteriorly, with slight indentations for the reception of the first and second pairs of legs; very gradually and very slightly curved inward between the second and third pairs of legs, but *becoming as wide posteriorly as anteriorly* from the continuation outward of the same slight curve; posterior margin rounded.

Female.—*Rostrum* blunt, the palpi showing plainly at the side of the mandibles. Mandibles (Pl. VIII, fig. 8) tridentate on each arm of the chela. There are a pair of hairs quite close together springing near to the median line a little anterior to the insetting of the first pair of legs, and projecting anteriorly beyond the proximal ends of the tarsi of the first pair of legs when stretched out. A second pair of about similar length further apart, but nearer the median line than the edge of the body and about opposite the insetting of the second pair of legs; these hairs curve forward and outward. A third pair spring from a little within the edge of the body a short distance behind the second legs; the length of these hairs is nearly equal to the width of the body; they stand more outward than forward. A fourth pair of hairs a little further back, and of similar length, spring from about mid-distance between the median line and edge of the body; and therefore do not project so far over the lateral edge of the body as the third pair, although parallel to them. A fifth pair, not much above half the length of the fourth, spring from slightly under the body. A sixth pair, inserted slightly within the edge of the body and about over the coxa of the third leg, is longer than any of the preceding; it is three-quarters the length of the entire creature. A seventh pair, about the middle of the lateral edge of the body, is shorter—rather more than half the length of the sixth; this is the last hair which usually points at all forward. The eighth pair is a little within the margin and as long as the sixth;

it points outward and backward. The ninth is equally long and placed on the periphery about where the hind margin may be considered to commence; then follow the tenth and eleventh pairs, much shorter. A twelfth pair crosses the margin here; it springs from the abdomen slightly anterior to the insetting of the 8th hair, but much nearer to the middle line of the body; this hair is the longest hair on the body. The 13th is nearly, but not quite, as long; it points backward, and is set within the hind margin. The 14th, a trifle shorter than the 13th, is set a little under the body. The 15th and 16th hairs are comparatively short, the former not a third of the length of the 14th; the 16th is near the bursa copulatrix. All these hairs project beyond the margin of the body; but there are two pairs on the dorsal surface which do not, the anterior of these is the longer. All these eighteen pairs of hairs are finely pectinated (or serrated); more finely than those of *G. spinipes*, and the hairs themselves are not so stout as in that species. The bursa copulatrix probably projects more than in any other known species of *Glycyphagus*. The legs are long and thin, the fourth pair passing the hind margin by almost the whole length of the tarsi; this length of the leg is almost entirely due to the length of *the tarsus, which in the two posterior pairs of legs is as long as all the other joints put together.* There are one to three curved pectinated hairs on each joint, except the coxa and tarsus, of each leg; excepting in the case of the femora of the two posterior pairs, and there are a few fine hairs besides the tactile hairs. *The tarsi are entirely without the very fine short hairs which so thickly clothe those of* G. spinipes, *but instead there are a few (four to seven) setiform hairs on each tarsus, which, although small and fine, are considerably longer than those of G. spinipes;* this forms the easiest and most certain mode of distinguishing the species. The epimera of the first pair of legs are joined to the sternum; those of the second pair are free. The coxæ of the two posterior pairs are mounted on mammillary elevations, which almost resemble a sixth joint, but are not chitinized. The vulva is placed between the coxæ of the fourth pair of legs, and has two pairs of fine hairs anterior to it. The anus nearly touches the posterior margin.

Male slightly less broad in form than the female, and smaller; the penis is placed between the coxæ of the third and fourth pairs of legs; it lies in a small depression with slightly chitinized edges, and is protected anteriorly by a short, transverse, curved, rod-like sclerite, with a pair of very fine hairs at each end. In other respects, except the absence of the bursa copulatrix, the male practically resembles the female.

The Hypopial Stage.—This only exists in an extremely rudimentary condition; in order to avoid repetition the reader is referred to page 168 for information on this point. The hypopial "case" in this species (Pl. VIII, fig. 12) is covered with extremely fine vermiform markings (fig. 16), and opens posteriorly by a sort of trap-door (fig. 14).

Habitat.—This species is probably most abundant in houses and buildings upon almost all sorts of dried vegetable and animal matter which is not too hard; it swarms on hay and fodder in stables; it is found in great quantities on many vegetable drugs; it is found on dried insects and on dried fruits. I have known it occur in such quantities in houses on rush furniture, etc., that the occupants have stripped and fumigated the walls and the furniture, and adopted numerous supposed remedies of a chemical nature without succeeding in getting rid of it. Oudemans * found the same thing on furniture at Assen, the Hague, and Utrecht; he says that the Acari literally covered the furniture of the whole house, and that they fed on the animal fat which adhered to the not thoroughly cleaned horsehair with which the furniture was stuffed; he also found it on cork and tobacco. It is also found in the open, but much less commonly.

* 'List,' p. 251.

It has been recorded from most parts of Europe where Acari have been searched for, and it probably has a much wider range. It has even been found by Mr. Fisher, the botanist of the Jackson-Harmsworth Polar Expedition, upon the talus at Northbrook Island, Franz Joseph Archipelago.

GLYCYPHAGUS SPINIPES,* Koch. Pl. VII, and Pl. VIII, figs. 1, 2, 4, 5, 6, 11, 13, 15, 17.

Acarus spinipes, 1841. Koch, D. C., fasc. xxxiii, No. 1. 1842, 'Uebersi,' Heft 3, p. 119.
„ „ 1877. Canestrini and Fanzago, "Intorno agli Acari italiani," in 'Atti Ist. Veneto,' ser. v, vol. iv, p. 197.
Glyciphagus spinipes, 1867. Fumouze and Robin, 'Mém. Acar.,' p. 577, pl. xxiii.
„ „ 1888. Can., 'I Tiro,' p. 19.
„ „ 'Pros.,' p. 381, pl. xxvii, fig. 1.
„ „ 1888. Michael, "Researches into the Life-histories of *Glyciphagus domesticus* and *G. spinipes*," in 'J. Linn. Soc. Zool.,' vol. xx, pp. 285—298, pl. xvi, figs. 8—15.
Glycyphagus spinipes, 1884. Berlese, 'A. M. S.,' fasc. xiv, No. 2.
„ „ 1894. Monier, 'Notes,' p. 460.
„ „ 1898. Oudemans' 'List,' p. 254.
„ „ 1899. Kramer, 'Thierreich,' Lief. 7, p. 147.

Sed non—

Glyciphagus spinipes, 1884. Targioni-Tozzetti, in 'Lavori della Stazione di Entomologia agraria di Firenze,' vol. lxxxiv, p. 72, t. 2, fig. 3.

Canestrini (loc. cit.) is of opinion that this species is identical with *Glycyphagus pronorum* of Hering,† and probably also with the *Sarcoptes hippopodos* of the same author;‡ if this be correct, then the species should be called by one of Hering's names, probably *hippopodos*, if the identity of that creature were certain, as that appears first in Hering's book. Canestrini says that he retains Koch's name of "*spinipes*" because it is the best name, which is quite true, and

* *Spina*, a spine; *pes*, a foot.

† "Die Krätzmilben der Thiere," in 'Acta Ac. Leop.,' vol. xviii, p. 619, pl. xlv, figs. 16, 17.

‡ Ibid., p. 607, pl. xliv, fig. 11.

because the two names were published about the same time; but Hering's was published in 1835, and Koch's not until 1841. Canestrini says that a glance at Hering's figures, particularly No. 17, which is the under side of the female, will show that it is *G. spinipes*. I confess that it does not produce this impression upon me; the vulva in Hering's drawing is placed between the coxæ of the fourth pair of legs, that of *G. spinipes* is just behind those of the second pair of legs; this is a point that Hering would hardly have been likely to be wrong in. Then the general shape is quite different; Hering's drawing is as broad posteriorly as anteriorly. *G. spinipes* is characterised by the sudden narrowing between the second and third pairs of legs, and the consequent comparative narrowness of the posterior portion of the body. Again, the numerous very long and conspicuous hairs on the notogaster and the posterior part of the dorsal surface of the cephalothorax in *G. spinipes* are absent from Hering's drawing, and are replaced by a single pair of short hairs. The great hairy scale on the third leg of *G. spinipes* is absent from Hering's drawing, and the hairs shown on the tarsi of the first and second legs in that drawing are quite inconsistent with the extremely fine and even pilosity of those parts in *G. spinipes.*

Oudemans * says that Mégnin identifies *G. spinipes* with *Acarus destructor*, Schrank, and *Acarus setosus*, Koch. Oudemans does not say where Mégnin asserts this. I do not find any reference to the subject in his 1889 paper,† but in "Les Parasites," p. 139, he treats *Acarus destructor*, Schrank, and *Acarus setosus*, Koch, as being identical with *Acarus* (*Glycyphagus*) *domesticus*, de Geer, not *A. spinipes*, Koch. He also treats *Glycyphagus prunorum*, Hering, and *Sarcoptes hippopodos*, Hering, as synonyms of *A. domesticus*. I

* 'List,' p. 252.

† "Observations anatomiques et physiologiques sur les *Glycyphagus cursor* et *spinipes*," 'J. Anat. Physiol.,' t. 25, pp. 106—110.

personally cannot see that *A. setosus*, Koch, can be either *G. spinipes* or *G. domesticus;* it seems to me to be different from both.

Lackerbäuer's drawing of this species, which illustrates Fumouze and Robin's paper, is, in my opinion, one of the finest drawings of an Acarus ever published.

	Female.	Male.
Length	·45 to ·80 mm.	·40 to ·50 mm.
Typical length of English specimens about	·70 mm.	·45 mm.
Typical breadth of English specimens about	·45 „	·24 „
Typical length of legs, first and second pairs, about . . .	·36 „	·30 „
Typical length of legs, third pair, about	·45 „	·34 „
Typical length of legs, fourth pair, about	·51 „	·36 „

As to the means of distinguishing this species from *G. domesticus*, see the description of the latter species.

This is an abundant and widely distributed creature.

Colour pearly white or pale grey. Rostrum, tarsi, and epimera reddish.

Texture nearly smooth, but not polished; almost the texture of chamois leather, but slightly granular.

Shape.—Conical anteriorly, with strong indentations for the reception of the first and second pairs of legs. These indentations are bordered by a narrow chitinous band. Body sharply constricted near the insertion of the third pair of legs; *the portion of the body behind this constriction is considerably narrower* than the part immediately before it; posterior margin rounded.

Female.—Rostrum blunt, palpi showing plainly at the side of the mandibles. Mandibles (Pl. VII, fig. 8) with the fixed arm of the chela quadridentate, the moveable arm tridentate, but with the proximal tooth slightly bifid. Berlese * makes the dentition more elaborate than I do. I have not, however, been able to see the mandible quite as he draws it in any speci-

* Loc. cit., fasc. xiv, No. 2, fig. 6.

men which I have dissected. There are a pair of hairs quite close together inserted at the base of the rostrum, and projecting anteriorly considerably beyond the proximal ends of the first pair of legs; a second pair, of about equal length, but further apart, between the coxæ of the first pair of legs; a third pair, still further apart and longer, between the coxæ of the second pair of legs; a fourth pair, not quite so long, near the edge of the body, and just behind the insertion of the second pair of legs. A fifth pair, about the same length as the fourth, still nearer the edge of the body, but considerably further back, a little anterior to the insetting of the third pair of legs. A sixth pair, longer, on the actual edge a little further back; a seventh pair, shorter, on the actual edge, just behind the constriction of the body. An eighth and a ninth pair, both about the length of the sixth, on the actual lateral margin of the narrow part of the abdomen; and four pairs on the notogaster, making fifteen pairs. All these hairs are strongly and *conspicuously pectinated;* the longest are those on or near the hind margin, and a pair near the middle of the notogaster. Some of these hairs are longer than the body, often considerably longer in lately emerged specimens where the body is small. The bursa copulatrix does not project very far; seen under a sufficient amplification it shows a slightly trilobed posterior edge, both above and below.* The legs are of moderate length, the fourth pair passing the hind margin by about half the length of the tarsus. The tarsi of the third and fourth pairs of legs are as long as all the other joints put together; but still are far shorter than the corresponding joints in *G. domesticus. The tarsi of all the legs are thickly clothed with extremely short fine hairs*, which are only visible with fairly high powers of the microscope, and cannot usually be seen when the creature is in liquid or in balsam. These

* Berlese (loc. cit.) calls this organ in this species "the oviduct," which, I suppose, is an oversight; it is not an oviduct, the egg never enters it.

hairs are entirely upon the fine outer layer, or epiostracum, of the cuticle, which forms a sheath; this layer occasionally gets detached (see Pl. VII, fig. 5), and then the tarsus appears quite smooth. There are two or three pectinated hairs on the various joints other than the tarsus of each leg, and the usual tactile hairs. The genual of the third leg bears a broad, flat, lanceolate scale on its outer side, which scale is clothed with short fine hairs, like the tarsi. The epimera of the first pair of legs are joined to the sternum, those of the second pair are free.

The vulva is long, parallel-sided, rather open, and placed between the second and third pairs of legs; it is not chitinized, but is protected anteriorly by a semilunar sclerite. It has two pairs of very short hairs at the side. The labia of the anus project slightly beyond the posterior margin of the abdomen. There are a pair of short hairs at the anterior end.

Male practically similar to the female, but somewhat smaller, and, of course, without the projecting bursa copulatrix. The penis is placed almost between, but a trifle anterior to, the coxæ of the third pair of legs; there are a pair of short hairs at the sides of it, and another posterior to it. The hairs on the body are longer in proportion to the body itself than those of the female.

The **Nymph** and **Larva** closely resemble the adults, with the ordinary exceptions.

The Hypopial Nymph (Pl. VIII, fig. 17).—Only slightly developed, and rarely emerging from the hypopial case. It is not really functional, but still is capable of individual movement when removed from the case. In order to avoid repetition the reader is referred to page 170 for information on this point. The hypopial case in this species (Pl. VIII, fig. 11) is covered with fine reticulations (Pl. VIII, fig. 15), and opens posteriorly by the splitting of that end of the case (Pl. VIII, fig. 13).

The Egg.—Regularly elliptical, about ·14 to ·18 mm. long, and about ·07 to ·1 mm. broad.

Habitat, etc.—The species is very abundant and widely distributed; it is found chiefly on dried vegetable and animal matter. It swarms on hay and fodder in stables, is found abundantly on cantharides, in flour, meal, etc. It has been recorded in England, France, Germany, Holland, Italy, etc. It probably has a much wider distribution.

The creature is very quick and active.

GLYCYPHAGUS PLUMIGER,* Koch. Pl. IX, and Pl. XI, figs. 1—7.

Acarus plumiger, ? 1835. Koch, D. C., Heft 5, No. 15.
" " ? 1844. Gervais, in Walckenaer, 'Insectes aptères,' vol. iii, p. 263.
Glyciphagus plumiger, ? 1868. Fumouze et Robin, 'Recherches,' p. 67, pl. vii.
" " 1882. Haller, "Beitrag zur Kenntniss der Milbenfauna Würtembergs," in 'Jahresb. von Würtembergs,' p. 297.
" " 1888. Canestrini, 'I Tiro,' p. 21; 'Pros.,' vol. iii, p. 388.
Glycyphagus plumiger, 1884. Berlese, 'A. M. S.,' fasc. xiv, No. 1. See, however, *G. intermedius*, fasc. xci, No. 10, and 'Notes,' fasc. i, p. 9.
" " 1896. Kramer, 'Thierreich,' Lief. 7, p. 146.

The synonymy of this species and *G. Canestrinii* presents great difficulties. I have decided, not without hesitation, to treat the present species as *Glycyphagus plumiger*, although I cannot help having grave doubts whether it really was the species to which Koch originally gave the name. My reasons for doing so are that it is quite impossible to say with certainty which was Koch's species. Until 1887 no acarologist who had written on the subject apparently suspected that there were at least two, if not three very distinct species. I had the present species and what is now

* *Pluma*, a feather; *gero*, I bear.

called *G. Canestrinii* in my cabinet long before, but being busy with other families of Acarina I had not published anything on the subject. In 1887 Armanelli described *G. Canestrinii* as a new species, and in 1888 Canestrini adopted that specific name for that species, and retained *G. plumiger* for the present one; in which he has been followed by Berlese and Kramer, so that it disturbs nomenclature less to leave the names as Canestrini used them than to treat what he called *G. Canestrinii* as Koch's original *G. plumiger*, and to give a new name to the present species. As Koch's figure and description are uncertain I do not feel bound to do so, although unfortunately Armanelli and Canestrini fell into a grave error in describing *G. Canestrinii;* this error would deceive any student. It was not until 1891 that Berlese examined Canestrini's specimens, which Canestrini had from Armanelli, and discovered the error in the description. The matter is rather complicated by the fact that Canestrini in 1888 described as new a species which he called *G. intermedius*,* and which he says is intermediate between *G. plumiger* and *G. spinipes*. Berlese, in 1898,† says that his own drawings of *G. plumiger* in 1884 above referred to, were partly taken from *G. plumiger* and partly from *G. intermedius*, and he specifies which drawings were taken from each; but Berlese, in the very short note which he gives of the latter species, seems to me to give it the characters which Canestrini allotted to *G. plumiger*, and to transfer to that species those which Canestrini gave for *G. intermedius*.

Koch's original drawing and description of his *Acarus plumiger* are very imperfect; they might easily refer either to the male of *G. Canestrinii* or the female of the present species, or, possibly, even to *G. intermedius;* they would not, I think, have been so applicable to the female of *G. Canestrinii* or the male of the present species. There are certain reasons to

* I have found this species in the Tyrol, but not in England.
† 'A. M. S.,' fasc. xci, No. 10.

suspect that Koch may have described and figured the male of *G. Canestrinii*, firstly because his figure has not got the projecting bursa copulatrix, which is very large and conspicuous in the females of this species. Koch, although he doubtless did not know what was the function of the organ, was fully alive to its existence, for he drew it in other *Glycyphagi* when he was depicting the female; presumably, therefore, he drew his figure of the present species from a male, and if so, it was most like *G. Canestrinii*. Secondly, the shape of his figure is more like a male than a female. Thirdly, the hairs are too strongly pectinated for the male of the present species. Gervais simply refers to Koch; Fumouze and Robin's admirable paper was next, and if this had contained any indication of which they considered to be Koch's *A. plumiger* I should certainly have followed them; but, unfortunately, it does not; they doubtless only knew of one species, and it is not at all easy to determine which. The magnificent drawings by Lacherbäuer, which illustrate the paper, are of the male only, and the female is the characteristic sex. Had there been such drawings of the female no doubt could have existed, but the hairs seem rather too strongly pectinated for the male of the present species, and Lacherbäuer was a most exact draughtsman. All these, however, are arguable grounds, whereas there is not any doubt about Berlese's drawing from Canestrini's specimens.

Of course it is possible that there may be even more species than above referred to.

	Female.	Male.
Average length about . . .	·30 mm.	·20 mm.
,, breadth about . . .	·20 ,,	·12 ,,
,, length of legs, first pair, about .	·13 ,,	·14 ,,
,, ,, ,, second pair, about .	·13 ,,	·14 ,,
,, ,, ,, third pair, about .	·13 ,,	·12 ,,
,, ,, ,, fourth pair, about .	·17 ,,	·16 ,,

Both Berlese and Canestrini describe this species as somewhat larger than *G. Canestrinii;* the English specimens are smaller, although not always shorter than that species. I should think I must have seen some thousands of each.

The principal distinctions, beyond size, between this species and *G. Canestrinii* are—firstly, that the secondary hairs on the main body hairs of the female are straight in this species, but are sharply bent inward at their distal end in *G. Canestrinii*, and that these secondary hairs in both sexes are much shorter in this species than in the other.

Colour yellowish grey, with a very slight shade of pink at the edges of the body. Rostrum and legs reddish.

Texture rough and dull, the male simply granular; the female covered on the dorsal surface with wart-like projections of the cuticle irregularly scattered; often bifid or trifid, but not so large as those of *G. Canestrinii.*

Shape.—Cephalothorax of female a short, wide triangle; of male rather longer in proportion. Abdomen of female approaching square, but slightly more oblong than that of *G. Canestrinii.* Abdomen of male less square and less flattened.

FEMALE.

The Pectinated Hairs.—The body is bordered by about sixteen pairs of large and elegant bilaterally pectinated hairs, the longest of which are on the lateral margins; five pairs of these are on the cephalothorax, and the remainder on the abdomen; the dorsum of the abdomen also bears five pairs of hairs. *The barbs or teeth of all these hairs are nearly straight;* those on the peripheral hairs (Pl. XI, fig. 5) are mostly much longer and further apart than those on the notogastral hairs. The notogastral hairs are arranged as follows: viz. one pair, of less than half the length of the abdomen, placed between the sixth pair (*i. e.* the first abdominal pair of peripheral hairs); a second pair, much longer and passing the hind margin of the abdomen, is placed between the ninth pair of peripheral hairs, and are much nearer together than the first notogastral pair. Further back are the remaining three pairs placed in echelon, each pair being further back and nearer to the median line of the body than the pair before it; they are also shorter, as they are inserted further back, so that although the proximal ends are retrogressive, yet the distal ends extend about equal distances behind the posterior margin.

Rostrum not usually visible from the dorsal aspect; mandible (Pl. XI, fig. 1) tridentate on the fixed, and bidentate on the moveable arm of the chela.*

Body.—Abdomen raised in the middle, depressed laterally. The wart-like projections show all along the edge. Bursa copulatrix not so long as the corresponding organ in *G. Canestrinii.* Vulva wide, placed between the epimera of the third pair of legs, slightly chitinized. Sternum well marked but short; epimera of the first pair of legs joined to it; the inner ends of the other epimera free.

Legs rather longer in proportion than those of *G. Canestrinii;* all pairs of nearly equal thickness; caroncles large and rounded. There is a slight chitinized ridge in the upper median line of the tarsi of the first and second legs.

Male.

The male is smaller and more active than the female. The number and arrangement of the pectinated hairs are much the same as in the female (there is one pair less on the notogaster), but they are not all quite so peripheral as those of the female. The hairs (Pl. XI, fig. 6), however, are mostly somewhat longer in proportion, and the barbs or pectinations are far less deep than those of the female; all the body hairs of

* Berlese draws the moveable arm rather more elaborate, with some additional minute teeth, which I have not seen, but it is probably drawn from the male.

the male resemble the notogastral hairs of the female. Penis (Pl. XI, fig. 7) slightly curved, and supported on a horseshoe-shaped sclerite, to which tendons are attached; it is placed between the epimera of the fourth pair of legs. The legs are longer and thicker in proportion than those of the female, and the two front pairs are thicker than the hind pairs.

The **Nymph** and **Larva** would readily be known from their resemblance to the adult male, but the body hairs are fewer, shorter, and far less pectinated; in fact, they are only slightly villous.

Habitat.—In hay and fodder, usually abundant when it occurs at all. I have found it in great quantities in old honeycomb. It has been recorded in Germany and Italy (subject to what is said above relative to the synonymy).

Glycyphagus Canestrinii, *Armanelli*. Pl. X, and Pl. XI, figs. 8—23.

Glycyphagus Canestrinii, 1887. Armanelli, 'Acari del Fieno della Provincia di Padova,' Cefalù, p. 7.
" " 1888. Canestrini, 'I Tiro,' p. 21, tav. i, figs. 4 and 5; 'Pros.,' p. 390, tav. xxix, fig. 1.
" " 1891. Berlese, 'A. M. S.,' fasc. lviii, No. 3.
" " 1899. Kramer, in 'Thierreich,' Lief. 7, p. 146.

I have not ever been able to obtain a copy of Armanelli's original paper. It was published separately in a small town in Sicily, and is extremely difficult to obtain, but I believe that Dr. Armanelli was a pupil of Prof. G. Canestrini's, and that practically the whole of Armanelli's paper is incorporated in Canestrini's two works above referred to; Armanelli supplied Canestrini with specimens. Relying, therefore, on Canestrini's publications as a correct representation of Armanelli's, it is necessary to point out that there is a grave error in the original description of the species, and in Canestrini's reproduction of it, and in the plates which illustrate Canestrini's papers. This error is that the secondary hairs or barbs which spring from the rachis of the principal dorsal hairs or plumes of the female, which form the characteristic of the species, are sharply turned at their ends in the real creature; so that the turned end of each barb touches, or almost touches, the barb next to it and more distal than itself. These turned ends of the barbs were mistaken for the edge of a membrane joining the barbs, and thus the hairs, which are simply plumose, were drawn and described as leaf-like membranous expansions with radiating nervures, such as are found on *Glycyphagus palmifer* and the foreign species *G. pterophorus.* This error completely changed the real appearance of the species, and it was not discovered until Berlese examined Canestrini's specimens, and pointed out the mistake in 1891. Up to that date I never suspected that the specimens in my cabinet were identical with Armanelli's species.

	Female.	Male.
Average length without rostrum about .	·31 mm.	·20 mm.
„ breadth about . . .	·24 „	·15 „
„ length of legs, first pair . .	·16 „	·16 „
„ „ „ second pair . .	·14 „	·16 „
„ „ „ third pair . .	·15 „	·17 „
„ „ „ fourth pair . .	·18 „	·18 „

This species shares with *Glycyphagus palmifer* the distinction of being the most beautiful of all the Tyroglyphidæ; probably *G. Canestrinii* will generally be considered the more elegant.

Colour yellowish grey, shading off to pink or pinkish red at the edges. Rostrum and legs reddish.

Texture rough and dull, the male simply granular; the female covered on the dorsal surface with large wart-like projections of the cuticle irregularly scattered, but averaging about ·01 mm. apart, the interspaces being twice or three times as wide as the actual raised tubercle, which projects about 7 μ, and is irregular in shape, often bifid or trifid at the apex (Pl. XI, figs. 15, 16).

Female.

Shape.—Cephalothorax a very short wide triangle, abdomen almost square; the two are distinctly divided by a transverse line.

The Plumose Hairs (Pl. XI, figs. 17 and 23).—These are by far the most striking feature of the species, and therefore I describe them first and separately. The body is bordered by thirteen bilateral pairs of large and elegant plume-like hairs; these do not vary greatly, but those at the sides of the body are rather the longest and most curved, the first pair being nearly straight, except for a downward curve, which is slight. Those on the posterior margin are rather smaller, and diminish more rapidly from base to apex than the others; they are therefore not quite so graceful. Five pairs are on the cephalothorax, and eight on the abdomen. There are also five pairs of almost similar hairs on the notogaster, arranged as follows, viz. one rather small pair near together, about in a line with the fifth pair of peripheral hairs, or between them and the fourth; one pair considerably longer, but even nearer together, about in a line with the seventh peripheral pair; one long, but much less plumose pair about in a line with the ninth peripheral pair, but further apart; and two rather smaller pairs in a transverse line a little further back; these last-named three pairs of hairs form rather a bunch. Adopting, as convenient, the nomenclature of a bird's feather, each plumose hair consists of a central shaft or rachis, generally more or less curved. This rachis has a number of very minute roughnesses or projections arranged linearly, and it also has a projection at the insertion of each barb. The vexillum of the feather consists of about fourteen to twenty parallel barbs on each side of the rachis; the barbs on the two sides of the rachis are sometimes opposite, sometimes not. The barbs are mostly of some approach to equal length until near the tip of the feather, when they diminish rapidly. The barbs are arranged in a single line on each side of the rachis, and are horizontal. Each barb makes a slight angle with the rachis, and runs outward and slightly forward in a tolerably straight line until it has attained almost the full width of the feather, *when it suddenly turns forward, and runs almost parallel to the rachis ;* at the extreme tip there is frequently a slight tendency to curl outward again. Each barb comes to a point. The barbs are simple, without barbules. Both rachis and barbs are hollow; the proximal end of each hair is embedded in the cuticle.

Rostrum not usually visible from the dorsal aspect; mandibles (Pl. XI, figs. 8, 9) rather attenuated distally, tridentate on the fixed arm, quadri- or quinquedentate on the moveable arm of the chela.

Body.—Abdomen raised in the middle, and also at the hinder part, so that the antero-lateral portions of the body are depressed and somewhat thin. The wart-like projections show all along the edge. On the abdomen, about opposite to the eighth pair of peripheral hairs, is a single pair of very long thick hairs which are closely set with fine spines on all sides, and extend much further back than any of the other hairs. The bursa copulatrix (Pl. XI, fig. 21) is a conspicuous truncated curve about ·03 mm. in length. The vulva (Pl. XI, fig. 19) is very large, extending in the median line from a little behind the epimera of the second pair of legs to quite as far back as the hind angles of the insertions of the fourth pair of legs. At the anterior end it is strengthened by a compact block of chitin, convex forward; from which the large, slightly chitinized labia run backward and outward; the whole is surrounded by an elliptical band or plate, very slightly chitinized, and bearing three pairs of small fine hairs. The sternum is well marked but very short, about 15 μ; the epimera of the first pair of legs are joined to it; the inner ends of the other epimera are free. On the under side there is a pair of hairs by the anus, another between the first and second epimera, a third between the third and fourth epimera, and a fourth near the hind edge of the vulval plate.

Legs rather short, the two hinder pairs scarcely extending beyond the plumose hairs; all the pairs are of nearly equal thickness. Caroncles (Pl. XI, fig. 14) large and rounded. Tactile hairs of first pair of legs nearly twice the length of the tarsus; those of second pair about the length of the tarsus. There are the following curved, slightly pectinated hairs on the legs, viz. one on each coxa except the fourth pair, one on each femur except the third, one on each genual except the fourth, and one on each tibia. There is also a small, curved, rod-like projection with a small globular head in the middle of the anterior edge of each tibia of the first two pairs, just under the tactile hair. There are also a few fine hairs on the legs.

Male.

The male is much smaller and more active than the female; the cephalothorax is longer in proportion to its width, and the abdomen less square and less flattened.

The Plumose Hairs (Pl. XI, fig. 18).—The number of what may be considered peripheral plumose hairs is the same as on the female; but they are not all so truly peripheral as in that sex, and their character is very different; they are somewhat longer than those of the female, but not nearly so wide; they have the rachis almost similar to that in the hairs of the female, but the barbs diminish in length much more gradually from near the base to the point; they are parallel and almost straight, standing forward and outward; they never turn forward at an angle near the tips in the manner so characteristic of the female. There are four pairs of similar hairs on the notogaster; some of these lying over some of the peripheral hairs causes quite a bunch near the hind margin. All the plumose hairs stand more upright than those of the female. A pair of long spinous hairs, similar to those of the female but not quite so long, are found on the abdomen. The penis (Pl. XI, fig. 22) is long and rod-like; it is placed between the epimera of the third pair of legs, and reaches beyond those of the second pair. The first and second epimera are similar to those of the female; but the second and third epimera are united together and to the sternum by a narrow chitinous band. There are a pair of small fine hairs by the anus, another by the penis, and two other pairs between the epimera.

The **Legs** are larger in proportion in the male than in the female, and the two front pairs are thicker than the hind pairs. The arrangement of the hairs on the legs is almost similar to that of the female, but the pectinated hairs on the two front pairs of genuals are much larger and stronger in the male.

The Nymph and Larva.—The fully grown nymphs indicate sex, but are without the bursa copulatrix or penis; the general appearance resembles that of the adults; but the plumose hairs are more like those of the adult male than those of the female, though smaller and less plumose; the epimera are like those of the female. The young nymphs resemble the larva. The larva has the hairs so slightly pectinated that they do not appear plumose; it is short in the body, and in other respects resembles the nymph.

Habitat.—The species is usually found in the hay and fodder in stables, etc.; when found it is generally abundant. It has been recorded in Italy.

GLYCYPHAGUS PALMIFER* (Fum. and Rob.). Pls. XII, XIII.

Glyciphagus palmifer, 1868. Fumouze and Robin, 'Recherches,' p. 69, pls. 8—11.
" " 1888. Can., 'I Tiro,' p. 21.
" " 1888. Can., 'Pros.,' p. 390, pl. xxvi, fig. 1.

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* *Palma*, a palm tree or leaf; *fero*, I carry.

Glyciphagus plumiger. Anfosso, 'Arachnidi,' p. 64. This author seems to have exchanged the names of *G. palmifer* and *G. plumiger*
Glycyphagus palmifer, 1888. Berlese, 'A. M. S.,' fasc. 51, No. 2.
" " 1899. Kramer, 'Thierreich,' Lief. 7, p. 145.

	Female.	Male.
Average length without rostrum about .	·26 mm.	·19 mm.
" breadth about . . .	·17 "	·12 "
" length of legs, first pair . .	·16 "	·15 "
" " " second pair . .	·12 "	·15 "
" " " third pair . .	·12 "	·11 "
" " " fourth pair . .	·17 "	·13 "

This species and *G. Canestrinii* are undoubtedly the most beautiful in the family; *G. palmifer*, if not the more beautiful, is probably the more remarkable of the two.

Colour.—Very pale buff, delicately shaded with light tints of purple and red; where the light comes through it the colour is almost yellow.

Texture.—Rough and granular, but still translucent. On the cephalothorax the markings on the skin are simply granular, but on the abdomen they are irregular wavy or vermiform ridges or corrugations, the granulation being a finer secondary marking.

Female (Pl. XII, fig. 2).

Shape.—Cephalothorax a very short wide triangle; abdomen almost square: the two are divided by a well-marked line or fold just behind the second pair of legs.

The Palmate Hairs (Pl. XIII, fig. 3).—These are by far the most striking feature of the species, therefore I describe them first and separately. The body is bordered by thirteen pairs (bilateral) of large and elegant leaf-like hairs; the corresponding hairs on the two sides of the body are alike in form, but each pair has its special shape, differing more or less from the other pairs. Three pairs are on the cephalothorax and ten pairs on the abdomen. Counting from the rostrum backward, the first pair are comparatively narrow but nearly straight; the second still narrower and more drawn out at the tips, but slightly curved; the third broader but somewhat more curved; the fourth still broader but shorter and almost straight; the fifth considerably smaller; the sixth larger and broad; the next three pairs about the largest on the body; the tenth much like the sixth; the eleventh considerably the longest and narrowest on the body and drawn out to a long fine point; the twelfth small but broad, and the thirteenth much like the sixth. There are also a pair of smaller similar hairs on the posterior part of the dorsal surface of the abdomen just where it begins to sink towards the hind edge; another larger pair, further apart and distant from the hind margin about one third of the length of the abdomen; and finally two pairs of extremely minute, scarcely palmate hairs, less widely separated; the first somewhat in front of the middle of the abdomen, and the second immediately behind the line dividing the abdomen from the cephalothorax. Each of the larger palmate hairs consists of a central stalk or midrib which is hollow, and the proximal end of which is embedded in the cuticle like a feather; and of a thickened nervure running round the periphery of the leaf-like expansion. From the mid-rib to the peripheral nervure run a number of short transverse nervures, also hollow; generally about eight to twelve. They are sometimes straight, sometimes curved or bent; often divided so as to form a Y, or two may run together forming a V; occasionally two are joined by a very fine nervure running from one to the other near their distal ends. These transverse nervures do not correspond on the two sides of the body, nor even on the opposite sides of the same hair; they are wholly irregular. Along each side of the midrib is a line of fine spines, pointing outward, and a similar line of short spines on the peripheral nervure projects beyond the edge of the leaf.

Rostrum.—Bent downward, reddish in colour; the only portions which show from the dorsal aspect are the mandibles (Pl. XIII, fig. 2) and palpi; the former are usually more or less extruded, and are stout and bulbous at their proximal ends.

Body.—Abdomen raised in the centre, particularly toward the posterior end, and with a somewhat thin and depressed lateral margin; the actual edge is usually cut into a series of more or less trifid projections, the outer lobes of each projection being the larger and rounder, and the central lobe being a small papilla bearing the palmate hair. This trifid shape is not so well marked on the hind margin. The epimera of the first pair of legs are joined to a short sternum, those of the other pairs are free. The vulva is large, extending from a little in front of the third to considerably behind the fourth epimera; it has wide open lips, and is protected by a short, strong, transverse, chitinous piece anteriorly; and by a long, fine, chitinous band of a reversed horseshoe shape, with prolonged curved ends posteriorly. The so-called anal projection (bursa copulatrix) is long and somewhat conical.

Legs short, almost entirely hidden from the dorsal aspect; tactile hairs on first pair more than twice the length of the tarsus; on second pair about as long as the tarsus; on the other pairs small and without the tactile character. Caroncles large and trifid; there is a fine short hair on each tarsus just above them, two farther back, and one or two other small fine hairs on most of the other joints except the coxæ.

Male (Pl. XII, fig. 1).

The male is much smaller and more active than the female; the body is rounder, and the vermiform wrinkles much less pronounced; it is more granular. The trifid projections are absent from the periphery, the cephalothorax is longer in shape, the rostrum usually more extruded, the abdomen less square and less flattened.

The **Palmate Hairs** on the margin are much longer and narrower than those of the female, and more pointed; the membranous portion is only a strip, but still the construction is similar to those of the female; the spines at the edge are longer than those of the female. The first pair of palmate hairs are set somewhat back on the rostrum, and are straight; the second pair are small, and are really not palmate, being without the membrane, but assume the form of a central stalk with a few large lateral spines; the fourth to ninth pairs inclusive are curved and as above described, then come four pairs of hairs which are simply finely and closely pectinated on all sides, resembling the hairs of *G. spinipes;* three of these pairs are on the periphery, and one pair set on the notogaster some way from the edge, and about a third of the length of the abdomen from the posterior edge. This last-named pair of hairs (Pl. XIII, fig. 6) are stout, and far the longest on the body, extending a long way behind the legs. Finally, there are three pairs of broader palmate hairs, more like those of the female, very near together so as to form a bunch a short distance from the posterior margin (Pl. XIII, figs. 4 and 5). All the body-hairs of the male stand much more upright than those of the female. There are a pair of remarkable, but very small, pinnatifid hairs on the underside (Pl. XIII, fig. 7), which have not, I believe, been previously recorded. Epimera of the first pair of legs as in the female; those of the second and third pairs joined by a cross-piece, and also joined to the posterior end of the sternum by another cross-piece. Penis between the third pair of legs.

Legs much larger in proportion than those of the female; in particular the two front pairs are far stouter, and the tactile hairs on the first pair are much longer and stronger. The hairs on the genuals of the first and second legs are pectinated, and the first pair of tibiæ have each a spike instead of a hair on the inner side.

The Nymph and Larva.—The older nymphs resemble the females, but the palmate hairs are smaller and narrower in proportion. The bursa is, of course, absent; the skin is even more wrinkled, and the colour is lighter. The younger nymphs and the larvæ have the hairs scarcely palmate at all, only pectinated; their disposition is rather more like those of the male, but the pair of long hairs are absent.

The **Egg** is a long ellipse about ·1 mm. long, and about ·05 mm. broad.

Habitat.—The creature is usually found in the dust of the walls and the saw-dust of cellars. I have also found it in stables in the fodder. I have found it in Warwickshire and Cornwall; it has been recorded in France, Italy, Germany, etc., and is not uncommon; where found at all it is usually abundant.

GLYCYPHAGUS PLATYGASTER,* Michael. Pl. XIV, and Pl. XVII, figs. 1—4.

Glyciphagus platygaster, 1886. Michael, "On some Undescribed Acari of the Genus *Glyciphagus* found in Moles' Nests," in 'J. Linn. Soc.,' vol. xix, p. 275, pl. xxxiv, and pl. xxxv, figs. 1—5.
" " 1898. Berlese, 'A. M. S. Crypt.,' p. 106.
" " 1899. Kramer, 'Thierreich,' Lief. 7, p. 145.

	Female.	Male.
Average length about . . .	·76 mm.	·54 mm.
" breadth about . . .	·66 "	·44 "
" length of legs, first pair, about .	·35 "	·32 "
" " " second pair, about .	·32 "	·25 "
" " " third pair, about .	·38 "	·28 "
" " " fourth pair, about .	·46 "	·41 "

A very remarkable and conspicuous species.

Colour when just emerged pure white, afterwards cream-white to parchment colour, becoming almost pink near the lateral and anterior edges. The male

* Πλάτυς, broad; γαστήρ, the abdomen.

rather darker and pinker; legs and rostrum in both sexes pinkish or pinkish brown. All the colours opaque.

Texture of the body rough and granular, like shagreen; each granulation bears a short and minute spine (Pl. XVII, fig. 1). The male is the rougher. The result of this is that all the edges of the body are covered with a thickly set irregular series of short blunt points.

Female.—Cephalothorax small, short, less than one sixth of the total length of the creature as seen from above, conical, with curved sides. Rostrum rather obtuse, forming a hood above the mandibles; which project, giving a pointed appearance. The two rostral hairs thick, stiff, and strongly curved downward. Further back on the dorso-vertex are two powerful spines or spikes directed forward; *they spring from large papillæ*, almost close to the anterior margin of the abdomen. Mandible (Pl. XIV, fig. 5, and Pl. XVII, fig. 2) large, short; each arm of the chela tridentate, the terminal tooth of the fixed arm bifid. Maxillæ (Pl. XIV, fig. 6, *mx.*) plain, not dentate; composed of thin, clear, colourless chitin. There is a well-marked chitinous skeleton supporting the maxillary lip, and projecting inward (Pl. XIV, fig. 6). Palpus (Pl. XIV, fig. 6, *p.*) blunt-ended, with a small projecting tactile point. Lingua triangular, somewhat spoon-shaped, of clear membrane. Abdomen large, gradually increasing in width from the anterior until near the hind margin; the increase, however, is most rapid in the first third of the abdomen. The anterior and posterior margins are almost straight. The notogaster is considerably raised above the cephalothorax, and is almost flat in general level; the central part, however, is slightly arched, and its lateral edges form bands which are sharply depressed at their inner, and slightly raised at their outer sides. The anterior and posterior edges of the abdomen are somewhat depressed. The extent of the arching of the notogaster varies in different specimens and at different ages; there are often vague, irregular depressions of the surface. Along the outer edge of the lateral band, on each side of the abdomen, *are ten singular projections*, often having markings of darker colour at their bases; the first of these is at the angle of the anterior, the tenth at that of the hind margin. The first, third, and tenth are single and papilliform; the second, fifth, and sixth single but less projecting, and directed backward in a somewhat hooked manner; the fourth and ninth have an approach to a bifid form; the seventh and eighth are decidedly trifid. From each projection, except the second, fifth, and sixth, springs a large pointed spine; those that spring from the first, third, fourth, and ninth projections are decidedly, *but not strongly*, curved; the *others are nearly straight, and all are directed almost radially.* Bursa copulatrix long, and directed slightly upward. On the notogaster, not very far from the median line, are two rows each composed of four fine but strong spines; the first is directed forward, and the others backward; the third of these is the longest, and the fourth the shortest. There is also a very long spine between the third and fourth, but nearer to the lateral edge of the abdomen. The legs are very thin in proportion to the size of the creature, rather short, the fourth pair passing the hind margin by about half the length of the tarsus. The two front pairs spring from large, rounded, chitinous projections at the edge of the lower part of the cephalothorax; these projections have rough, chitinous knobs at their posterior angles. The third and fourth pairs are set well under the body. The legs diminish gradually in thickness from the proximal to the distal ends. Coxæ short and rounded; tarsi nearly as long as the three immediately previous joints, which are of about uniform length. Tactile hairs long on the first three pairs of legs, short on the fourth. The other hairs on the legs are more spine-like in character; they are a pair on the third joint of each leg, those on the two anterior pairs curved strongly downward and inward, and slightly serrated. A very strong, somewhat similar, curved spine springs from the under-side of each tibia near its distal end. There are two or three short spines on the under-side of each tarsus; and one, rather larger, on the upper side of that of the second pair. Ventral surface much arched, projecting in the centre; edges thinner and flatter. Sternum short, joined to the epimera of the first pair of legs. Epimera of the second pair free. Epimera of the two hind pairs joined together at their inner ends by a cross-piece. None of the epimera quite reach the vulval sclerites. Vulva (Pl. B, figs. 8, 10) large and placed far forward, its anterior end being between the coxæ of the second pair of legs. It is protected anteriorly by a thick, pointed, chitinous band of a Gothic-arch shape, the point forward, and posteriorly by a more rounded and thinner piece fitting within the arch; these form an enclosure; the labia of the vulva extend its whole length; they bear two pairs of very minute hairs. Anal opening long, almost touching the hind margin; it has projecting labia lying together like knife-edges; and is bordered by five pairs of spines of various sizes, of which three form a triangle on each side.

The **Male** (Pl. XIV, fig. 1), as will be seen by the measurements, is much smaller than the female; the difference is almost wholly in the size of the abdomen. Cephalothorax similar to that of the female; but the papillæ from which the two spines on the dorso-vertex spring are not so large or projecting as those of the female. The sternum is longer than that of the female, but otherwise similar. A chitinous cross-piece joins the ends of the epimera of the second, third, and fourth pairs of legs instead of only the last two. There is a singular branched hair (Pl. XVII, fig. 4) on each side of the body between the coxæ of the first and second pairs of legs. It is very minute, not above 25 μ long. I could not see it on the whole creature, and only discovered it by dissections of the exo-skeleton. Abdomen rounded posteriorly, instead of having a straight hind margin like that of the female. It has ten projections on each side, the same number as the female; but they are larger and differently arranged, as there is a greater distance between the first and second; the fact being that what would correspond to the second in the female is rudimentary in the male; the second in the male corresponding to the third in the female. On the other hand, the projections extend not only along the lateral, but also along the posterior margin; the two tenth projections coming close together almost in the median line, leaving a deep narrow cut between them. This is partly due to the fact that the posterior spine of each notogastral row is borne, not on the notogaster itself as in the female, but on a large projecting papilla on the hind margin; which forms the tenth projection of the male, and almost coalesces with the ninth. Bearing these differences in mind, so as not to be confused by the numerical order of the projections (*i. e.* remembering to count the rudimentary second projection), the forms of these projections, the spines they carry, the marginal bands and arching of the notogaster and the spines upon it, correspond fairly well with the equivalent parts in the female. The penis is in the median line between the insertions of the third and fourth pairs of legs. The anus is situated further forward than that of the female, and is surrounded by a chitinous band. It is protected by two pairs of very large spikes near its posterior margin, the outer pair being the longer. Legs stouter and longer in proportion to the size of the abdomen than those of the female; the tarsal joints, however, are considerably shorter and more conical than those of the female; the tibiæ, particularly of the two hind pairs of legs, and also the genuals of the fourth pair, are very much longer in proportion. There is another singular arrangement in the two hind pairs of legs which is entirely absent in the female. These legs have a decided curve inward; the genuals and tibiæ, particularly the tibiæ of the fourth pair of legs, increase rapidly in thickness at their distal ends; the whole increase being on the inner sides, so that this projects at its distal end, forming a large curved point; from which the tarsus curves away, completing the distal side of the point. To enable this construction to work the articulation, although close on the outer side, is exceedingly loose on the inner; the two joints being there attached by a flexible membrane of considerable width, generally bowed outward; giving great play to the tarsus, probably for clasping purposes. The hairs on the legs differ very little from those of the female, but the third and fourth tarsi of the male have a singular assemblage of small, chitinous, recurved knobs or hooks at their distal ends.

The Nymph.—This is easily known from its similarity to the adult, but there are many differences. In the fully-grown nymph the sex is well marked; the bursa copulatrix and other external sexual organs of the female are easily seen; so that the male and female nymphs are somewhat different, but not so much so as the adults. The fully-grown female nymph is almost white, without the pinkish peripheral colouring of the adult. The legs are about the size of those of the adult; the abdomen is considerably smaller and more square, its edges are more raised and its central part more depressed than those of the adult. The rough projections around the periphery, instead of being separated by spaces and being absent from the hind margin, form an almost continuous line round the lateral and posterior margins. It is evident that the spikes carried by these projections will thus afford greater protection to the creature during growth at a period of life when the object of the straight hind margin of the female has not arisen.

The **Larva** has much the same characters as the nymph, except that it is smaller, more transparent, with the raised edge less strongly marked. It is, of course, hexapod.

Habitat.—I have often found this species in considerable numbers in moles' nests in England. I do not think that any record exists of its having been found by anyone else, but my friend Mr. E. Bostock has found it in similar situations. I have not ever found it upon the mole itself, nor have I found it anywhere except in the moles' nests. The nests must be fresh and inhabited by the mole at the time.

GLYCYPHAGUS DISPAR,* Michael. Pl. XV.

Glyciphagus dispar, 1886. Michael, "On some Undescribed *Acari* of the Genus *Glyciphagus* found in Moles' Nests," in 'J. Linn. Soc.,' vol. xix, p. 280, pl. xxxv, figs. 6—17.
Glycyphagus dispar, 1898. Berlese, 'A. M. S. Crypt.,' p. 106.
,, ,, 1899. Kramer, 'Thierreich,' Lief. 7, p. 145.

	Female.	Male.
Average length about	·35 mm.	·17 mm.
,, breadth about . . .	·24 ,,	·13 ,,
,, length of legs, first pair . .	·16 ,,	·10 ,,
,, ,, ,, second pair . .	·14 ,,	·08 ,,
,, ,, ,, third pair . .	·13 ,,	·09 ,,
,, ,, ,, fourth pair . .	·19 ,,	·09 ,,

The most striking character of this very singular species is the extreme dimorphism between the sexes; this is carried to an extent far beyond any sexual differences found in any other species of the Tyroglyphidæ; indeed, the two sexes would not ever have been supposed to belong to the same species, or even genus, if they had not been taken *in copo*.

Colour when just emerged white; afterwards the female is reddish brown; darker and redder than that of *G. platygaster*. The spaces on the underside, enclosed by the sclerites surrounding the genital and anal regions, remain pure white. The male is dull, light grey, considerably lighter than the female; sometimes without and sometimes with the red shade of the female.

Texture of the female very similar to that of

* *Dispar*, unlike.

G. platygaster, *i. e.* rough and granular like shagreen; the male is different, being covered with minute hemispherical bosses or dots, much larger in proportion to the size of the creature, and much rounder and more regular.

Female.—Cephalothorax small, short; about one-sixth of the total length of the creature as seen from above; conical with curved sides. Rostrum rather obtuse, forming a hood above the mandibles, which project, giving a pointed appearance. The rostral hairs rather thick, far back, stiff, and curved downward. Further back, on the dorso-vertex, are two powerful spines directed forward; *not springing from papillæ,* but almost close to the anterior margin of the abdomen. Mandible (Pl. XV, fig. 5) short; each arm of the chela tridentate; the terminal tooth of the fixed arm bifid. Abdomen large, gradually increasing in width from the anterior to the posterior margin, but with a curved lateral outline; the increase is most rapid in the first third of the abdomen. The anterior margin is almost straight. The *hind margin is entirely occupied by two great rounded lobes* directed backward; the bursa copulatrix is sunk between them. The notogaster is raised above the cephalothorax; it has a certain flatness of general appearance, but is not so flat as that of *G. platygaster;* its central part is slightly arched, and its lateral edges form bands which are sharply depressed at their inner, and slightly raised at their outer sides. The lobes, which form the posterior margin, are raised; they coalesce, and a broad raised tongue with a rounded anterior end runs from them along the median line of the notogaster for about two-thirds of its length. Along the outer edge of the lateral band on each side of the abdomen are *nine singular projections;* the first of these is at the angle of the anterior, the ninth at that of the posterior margin; they are irregular in form, but usually all more or less bifid or trifid; each one, except the second and sixth, bears a very strong *greatly curved* pointed spine, which decreases in thickness from its insertion to its point. The first of these points forward, the others are directed first outward and then backward, so that *the distal portion is nearly parallel to the side of the abdomen.* The only spines on the notogaster are a pair so close together that they generally look like a single large spine in the median line a little behind the centre, and a pair of much smaller spines further forward. There is not any true sternum. The vulva is very large, extending from the level of the insertion of the lower edge of the coxa of the first leg nearly to that of the insertion of the third coxa; it consists of two large, slightly chitinized labia, somewhat separated posteriorly; it is entirely surrounded by a chitinous band or ring at some distance from the labia laterally, but almost touching their posterior ends. This chitinous ring is thickest at the sides and thinnest posteriorly. The epimera run from above the first leg, below the second, and between these two legs; all run radially inward and join the vulval ring. The epimera of the two posterior pairs of legs are free, that of the fourth leg is very small. The anus is large, placed rather far forward, and entirely surrounded by an elliptical chitinous ring. There are two pairs of spines of moderate size near the hinder part of this ring, and a pair of larger spines on the ventral surface of the abdomen further back and more to the side. Legs thin, rather short; the fourth pair passing the hind margin by about half the length of the tarsi. They diminish gradually in thickness from the proximal to the distal ends. Coxæ short and rounded, tarsi longer than the two immediately previous joints; femora, genuals, and tibiæ of about equal lengths. Tactile hairs long on the first three pairs of legs, short on the fourth. The other hairs on the legs are more spine-like in character; they are a pair on the third joint of each leg, those on the two anterior pairs are strongly curved downward and inward and slightly serrated. A strong, somewhat similar, curved spine springs from the underside of each tibia near its distal end. There are two or three short spines on the underside of each tarsus; and one, rather larger, on the upper side of the second pair.

Male entirely unlike the female in appearance: irrespective of the extreme difference in size, and the difference of colour before referred to, the legs and abdomen are quite dissimilar. Cephalothorax very like that of the female; but without the hinder of the two pairs of spines conspicuous in that sex, and having the front pair very small and exactly at the angle of the epistome. Abdomen almost shield or spade-shaped; the anterior margin straight for the short distance where it adjoins the cephalothorax, then running outward and backward in a double curve on each side. The abdomen is widest at the anterior angle of the lateral margin, and gradually narrows backward; the hind margin is rounded. There is a low, broad, rounded elevation along the greater part of the median line, with a sulcation round it; otherwise the notogaster is flat. The abdomen is less thick in proportion from dorsal to ventral surface than that of the female. Round the edge are six or seven bilateral pairs of very small straight spines; *the bifid or trifid projections and great curved spines of the female are entirely absent.* There are three or four pairs of small spines on the notogaster similar to those round the edge. Legs short and thick, almost conical, but slightly curved; the two posterior pairs are wholly hidden beneath the abdomen. The femora are somewhat bell-shaped, particularly in the two posterior pairs of legs (the two anterior pairs having an inward curve). The tarsi of the two hind pairs of legs are very loosely articulated on the inner side, with considerable spaces between them and the tibiæ occupied by flexible membrane. Caroncles broader and shorter than those of the female. There is not any true sternum nor any epimera to the second, third, or fourth legs, but there is an epimeral piece both above and below the first leg; which two are joined at their inner ends, and the lower is also joined to the outer penial sclerites. The anus is protected by two pairs of small spines similar to those on the notogaster.

I am not acquainted with the immature stages of this creature, possibly they so closely resemble those of *G. platygaster* that I have not distinguished them.

Habitat.—I have frequently found this species in moles' nests in England; I do not think that any record exists of its having been found by anyone else. I have not ever found it upon the mole itself, although I have examined great numbers; nor have I found it anywhere else than in moles' nests. The nests must be fresh and inhabited by the mole at the time.

GLYCYPHAGUS CRAMERI,* Michael. Pl. XVI, and Pl. XVII, figs. 5—11.

Glyciphagus Crameri, 1886. Michael, "Upon the Life-history of an Acarus one stage whereof is known as *Labidophorus talpæ*, Kramer, etc.," in 'J. R. Micr. Soc.,' ser. ii, vol. vi, pp. 377—388, pl. x.
Homopus talpæ, 1888. Canestrini, 'I Tiro.,' p. 18, pl. ii, figs. 12—14; and 'Pros.,' p. 379, pl. xxxv, fig. 3.
Glycyphagus talpæ, 1897. Berlese, 'A. M. S. Crypt.,' p. 106.
,, ,, 1899. Kramer, 'Thierreich,' Lief. 7, p. 145.
Labidophorus talpæ, 1898. Oudemans' 'List,' p. 252.

Hypopial Nymph.

Labidophorus talpæ, 1877. Kramer, "Zwei parasitische Milben des Maulwurfs," in 'Arch. Naturg.,' vol. xliii, Hft. 1, pp. 249—259, t. 16, figs. 1—3.

	Female.	Male.
Average length about	·36 mm.	·25 mm.
,, breadth about . . .	·21 ,,	·13 ,,
,, length of legs, first pair . .	·15 ,,	·12 ,,
,, ,, ,, second pair . .	·13 ,,	·10 ,,
,, ,, ,, third pair . .	·17 ,,	·12 ,,
,, ,, ,, fourth pair . .	·20 ,,	·14 ,,

Colour.—Dull reddish brown of median depth of tint, the male a trifle darker than the female. When

* Named in honour of the late Dr. P. Kramer, the German acarologist.

the creature has just emerged from the nymphal skin the hinder part of the abdomen of the female is lighter than the anterior portion; at this time, in both sexes, there is a pinkish shade, and the tint, of course, is lighter.

Texture.—Dull and rough, rather granular, the female more strongly so than the male.

Female.—Cephalothorax, as seen from above, about one-fifth of the total length; narrow; lateral margin (behind the rostrum) concave; the posterior part of the cephalothorax is as wide as the anterior margin of the abdomen, or nearly so. Rostrum somewhat truncated or concave anteriorly. Rostral hairs very short. A narrow, raised, longitudinal ridge starts from near the rostral hair on each side; after following the line of the rostrum for a short distance it curves toward the median line; after the middle of the cephalothorax it curves outward again, and runs as far as the anterior margin of the abdomen. Mandibles (Pl. XVI, fig. 6) short, powerful; tridentate on each limb of the chela. The mandibles, when not in use, do not usually project beyond the rostrum. There is a strongly chitinized concavity on each side of the cephalothorax near the base, which holds air when the creature is immersed in liquid. It appears to be partly closed by a membrane, and to have a nerve running to it. Possibly it may be a sense-organ, and if so, is probably auditory. It is found in both sexes. The abdomen is a long heart-shape with the point placed anteriorly, and the two rounded lobes forming the hind margin; between them, on the dorsal level, is the small tubular projecting bursa copulatrix. The lobes are considerably raised and rounded on the dorsal surface; they occupy the whole central part of nearly half the abdomen; anterior to them is a single broad lobe, less raised, occupying the central part of the greater portion of the remainder of the abdomen; it bears two longitudinal irregular ridges on its dorsal surface near the median line, and there is a depressed trench along the lateral border of the lobe. Exterior to the lobes and trench there is a broad raised belt, sloping upward toward its outer edge; it extends all round the abdomen except the posterior margin; there is a small raised lobe in the centre of its anterior part. There are four minute chitinous spines, or points, round the posterior margin, and a pair near the anterior margin. Legs of moderate length; the fourth pair about reach the posterior margin of the abdomen. The two front pairs are the thicker. The coxa is rounded, the proximal ends of the femur small; thence the leg gradually increases in thickness until the distal end of the bell-shaped genual, whence it gradually diminishes. The tarsus is nearly as long as the three previous joints, but this varies a little in the respective legs. There is the usual tactile hair on each tibia, those on the two anterior pairs are the longest. There are two strongly serrated hairs on the femur and one on the genual of the first leg, and one on the genual of the second leg; the serration of these hairs is usually coarser at the distal than at the proximal ends (Pl. XVI, fig. 12). There are a few fine hairs on the tarsi, and one or two on some of the other joints. The tarsi are terminated by a long-shaped caroncle and fine claw. The chitinous skeletal pieces of the under surface of the cephalothorax are as follows:—some short distance behind the maxillary lip is a curved transverse band, concave anteriorly; from the centre of this band the sternum runs straight backward in the median line, just passing the posterior edges of the second coxæ; then the sternum bifurcates; the branches are much thinner than the true sternum, and join the antero-lateral part of the undermentioned vulval ring. The epimera of the first pair of legs join the branches of the sternum rather anterior to their centres; those of the second pair of legs join the vulval ring almost at the same point as the branches of the sternum. The short epimera of the third leg do not join the vulval ring; there are not any epimera to the fourth leg which show externally. The vulva is very large, placed between the coxæ of the third and fourth pairs of legs, and is surrounded by a strong, chitinous, elliptical ring, the transverse axis of which is the longer. This ring has a short, blunt, anterior, central projection. Inside the ring are the labia; the two ordinary lateral labia are widely separated posteriorly; behind them is an unpaired, posterior, almost triangular labium opening downward and backward. The anus is much smaller than the vulva; it is a long ellipse placed far backward; there are a pair of short spines behind it.

Male.—The cephalothorax is somewhat shorter and broader in proportion than that of the female; the same observation applies to the mandibles. The abdomen is almost elliptical, but is somewhat prolonged anteriorly; the hind margin is rounded, and entirely devoid of the bilobed shape of the female. The notogaster is without the lobes of the female; its centre is arched, but not strongly so; the lateral margin is slightly raised, and usually has a few wrinkles in addition to its otherwise rough texture. The legs (Pl. XVII, figs. 8—10) are remarkable, and are very different from those of the female; they are very thick and heavy, much more so than those of the female; the coxæ, tibiæ, and genuals are broader than they are long. The most remarkable feature consists in certain projections from the undersides of the first two pairs of legs. From the median line of the underside of the tibia of each of these legs there projects a flat, fan-shaped blade of clear colourless chitin edged by seven to nine deeply-cut teeth or spikes, radiating outward. On the underside of the femur of the second leg are two blades of similar texture; the proximal round, with a thickened central boss; the distal curved, but longer in shape; both these are edged with radiating spikes similar to those on the tibia. The tarsi of the two anterior pairs of legs have broad curved blades, both above and below, in the median line; and there is one on the upper side of the tibia of the second leg, but all these have plain edges, without spikes. The under side of each tarsus terminates distally in a short, stout, recurved point or hook. There is a very long tactile hair on the first leg, springing from a large papilla; a few fine hairs on the tarsi, and a short thick hair on the upper side of the tarsus of the second leg. There is a curved, strongly serrated hair on the upper side of the femur of the same leg; a curious curved hair, with a very few long pectinations, on the under side of the tibia of the third leg; and a rough, clavate hair on the under side of the genual of the same leg. There are a few other hairs of minor importance. The bands behind the maxillary lip and the sternum are nearly similar to those of the female; the sternum is rather longer than that of the female, and its posterior bifurcation forms a small close arch with free posterior ends, instead of the wide arch with attached ends formed by the corresponding parts in the female. The epimera of the first, second, *and third* legs join this arch. There are epimera to the fourth legs, but they are free. The penis is placed between the coxæ of the fourth pair of legs; it is large, somewhat conical, and points forward; its point, when at rest, lies within the sternal arch; it is divided proximally into two diverging blades, and is protected on each side by a small, curved, chitinous band. The anus is smaller than that of the female.

Nymph (Pl. XVI, fig. 4).—Colour pure white when young; rather yellowish white when fully grown. Texture dull, semi-transparent, finely but irregularly wrinkled. Cephalothorax large, fully one-third of the total length; its hinder part as wide as the abdomen. Rostrum rather concave, blunt; rostral hairs thick, almost leaf-like. Behind the rostrum there usually is a transverse ridge with returned ends. The dorsal surface of the hinder part of the cephalothorax is ornamented, or protected, by numerous small plates of clear colourless chitin of various shapes; the arrangement of these plates is usually as follows, viz. commencing from the rostral end, a comparatively large shield-shape plate in the median line; a curved, more or less triangular plate on each side of and partly behind it; then a transverse row of about five smaller round or oval plates; lastly, still further back and close to the abdomen, a second transverse row of about eight plates, of which the two outer are the largest, and are usually oval; the next pair are smaller and of the so-called pine-shape common on Indian textile fabrics; the two inner pairs are very small and round. Abdomen almost square, except that the hind margin is cut into four rounded lobes, of which the central pair are the larger, and consequently project further backward. Above these two central lobes, and a little further forward, are two large conical papillæ, or apophyses, directed upward and backward. In front of the papillæ is a transverse ridge with the ends turned forward; bearing two large, rough hairs. The notogaster is nearly, but not quite flat; the central part being slightly arched and divided by a narrow and shallow depression from the slightly raised and rounded edge; which is also rather lobed both at the anterior and posterior ends. The notogaster bears a number of plates of a similar nature to those on the cephalothorax; the forms and arrangement of these plates are usually somewhat as follows: viz. two longitudinal rows, each of about four pine-shaped plates, on the arched central portion; on each lateral border, proceeding from the anterior toward the posterior end, firstly two pine-shaped plates turned different ways, then two small roundish plates followed by two more pine-shaped plates, and finally a single large, irregular-shaped plate. There are three pairs of broad, spatulate hairs, or scales, on the hind margin; and one pair on the antero-lateral angles. Legs of moderate length, the fourth pair not reaching the hind margin, thinnish; coxæ rather large; other joints of about even thickness throughout, except the tarsi, which diminish gradually. There are the usual tactile hairs on the tibiæ of the first two pairs of legs; a short, thick, curved hair on each genual of the first pair and each tibia and genual of the second pair of legs, and a few fine hairs on the various joints. Claws and caroncles as in the adult.

The Hypopial Nymph (Pl. XVI, fig. 5, and Pl. XVII, fig. 7).—

Length about	·25 mm.
Breadth about	·15 „
Length of legs, all pairs, about . . .	·09 „

Colour yellowish white; legs and posterior end of abdomen reddish. Texture polished: slight granulation shows through the semi-transparent chitin. Hood of rostrum narrow and drawn out, much more so than in Kramer's original drawing; the two ordinary labial hairs of a hypopus short and wide apart. Behind the rostrum the cephalothorax is large and wide; it has strongly curved lateral edges, and a posterior outline slightly convex backward. The abdomen is slightly broader than its length; concave anteriorly; sharply divided from the cephalothorax; it has a strongly rounded outline both laterally and posteriorly; on the posterior margin, however, are two projecting points some short distance from the median line; the outline between them is concave; these points and concavity are produced by the apparatus on the ventral surface for holding the hairs of the host. Notogaster arched, without hairs or markings; there are, however, a pair of very short hairs, or spines, near the antero-lateral angles of the abdomen, and two similar pairs on the posterior margin near the points. The expulsory vesicles show plainly at the edge of the abdomen, about one-third of its length from posterior end. The legs are of moderate length; the fourth pair scarcely project further back than the posterior margin. The two anterior pairs are much thicker than the posterior; they have large tactile hairs, and two or three fine curved hairs near the distal ends of most joints, except the tarsi. Each tarsus of these legs bears four large hairs near its distal end, a few fine curved hairs, and a large claw. The third tarsus bears at its end four large and some smaller hairs and a minute claw. The fourth leg ends in three long and some shorter hairs. One of the latter is lanceolate; there is not any claw. The two hinder pairs of legs are set far under the body. The anus is between the femora of the fourth pair of legs. There is a short, straight sternum, but no epimera are joined to it. The apparatus for holding the hairs of the host (Pl. XVII, fig. 11) is as follows:—At the posterior end of the ventral surface is a median, concave, longitudinal channel (*b*) in which the hair lies; this is overlapped by a flexible, lip-like organ (*d*) on each side; the two lips cross slightly when there is not any hair beneath them; they are provided with powerful retractor muscles which draw them closer to the body. Each lip bears a large chitinous plate on its inner surface, and on the inner side of this plate is a strong chitinous band (*e*) with transverse ridges. On the abdomen, immediately above each band (when the creature is dorsal surface upward), is a circular chitinous plate (*f*) with radiating ridges; the hairs of the host are firmly held between the bands and the circular plates.

This hypopus was well described, and was figured by Kramer in the paper quoted in the synonymy.

Habitat.—The hypopial nymph is found upon the common mole (*Talpa europæa*). The adults and nymph were found by me in the nests of the mole, but never on the mole itself; they are not rare. The creature, in some stage, has been recorded in England, Germany, Holland, and Italy.

GLYCYPHAGUS SCIURINUS,* Haller. Pls. XVIII, XIX.

Dermacarus sciurinus, 1880. Haller, "Zur Kenntniss der Tyroglyphen und Verwandten," 'Z. wiss. Zool.,' Bd. xxxiv, pp. 268—273, pl. ix, figs. 4—16.
" " 1899. Kramer, 'Thierreich,' Lief. 7, p. 150.
Homopus sciurinus, 1888. Can., '1 Tiro.,' p. 18; 'Pros.,' p. 377.
Labidophorus sciurinus, 1898. Oudemans, 'List,' p. 252.
Glycyphagus sciurinus, 1897. Berlese, 'A. M. S. Crypt.,' p. 106.

Hypopial Nymph.

Dermaleichus sciurinus, 1841. Koch, D. C., fasc. 33, No. 7.
" " 1879. Canestrini, "Intorno ad alcuni Acari parassiti," in 'Atti Soc. Veneto-Trent,' vol. vi, fasc. 1, p. 13.
Homopus sciurinus, 1842. Koch, 'Uebersi,' Heft 3, p. 121, pl. xiii, fig. 69.

It will be seen from the above synonymy that the hypopial nymph of this species was first discovered by C. L. Koch, who took it for an adult creature. He at first placed it in the genus *Dermaleichus*, but subsequently created a new genus for it which he called *Homopus*. The adult was discovered by Haller, who founded his genus *Dermacarus* upon it. Haller fully recognised that Koch's *Homopus sciurinus* was an immature stage of his adult, but, oddly enough, he considered it to be the larva; his reason apparently being that he could not find any other larva, but this is a very insufficient reason. Of course, what was a *hypopus*, and what the position of that stage was, was not as well understood when Haller published his article as it is to-day. Haller had expressed an opinion that *Homopus* was immature some time before he found the adult.†

Haller's description and drawings are long and careful; still he missed a good many points, and some that he described and drew were not absolutely correct; he apparently missed the pectination of the body-hairs; moreover the form of caroncle which he gives is only

* *Sciurus*, a squirrel.

† "Revision der Gattung *Analges*, sive *Dermaleichus*, Koch," 1877, 'Z. wiss. Zool.,' Bd. xxx, pp. 78, 79.

correct when the foot is raised, or the creature is dead, or soaked in reagents; the form is quite different in the living creature with its foot on the ground. He apparently drew and described from preparations or specimens in spirit or glycerine; as may be judged from the shrinking of the eggs in the body of the female, which does not occur in life.

	Female.	Male.
Length	·5 to 1·0 mm.	·4 to ·7 mm.
Typical length of English specimens about	·6 mm.	·5 mm.
Typical breadth about . . .	·35 ,,	·28 ,,
,, length of legs, first pair, about .	·25 ,,	·25 ,,
,, ,, ,, second pair, about	·22 ,,	·22 ,,
,, ,, ,, third pair, about .	·25 ,,	·20 ,,
,, ,, ,, fourth pair, about	·33 ,,	·25 ,,

All the above measurements of these legs are without the caroncle and claw.

Haller makes his measurements much larger than the English specimens which I have seen; but his measurements and drawings seem to me to be made from dead specimens in fluid; these are usually somewhat distended.

Colour light lemon-yellow, sometimes with a slight greenish tinge. Legs, rostrum, and epimera red-brown or brownish red.

Texture dull, without any polish; not quite opaque; rather coarsely granular with closely packed raised dots about 250 to the millimetre; on the underside of the ♂ they are much finer, and are therefore not depicted on fig. 4, as they would not be seen by most people with the amplification employed.

Female.—Cephalothorax broadly conical; not divided from the abdomen by any sulcation or line on the dorsal surface, although the line of demarcation may usually be seen on the ventral surface. Abdomen almost parallel-sided at first; later, when the eggs are getting ripe, the abdomen is rather wider near the posterior end than at the shoulders, but narrows in somewhat towards the actual hind margin; which has a broad, shallow, curved indentation in the centre; leaving the corners as large, paired, rounded lobes; thus the whole creature is somewhat heart-shaped. Notogaster rather flat; with two irregular, longitudinal furrows about midway between the median line and the lateral margin; they are only due to the action of the dorso-ventral muscles, and alter in detail from moment to moment; in dead specimens, or preparations, they are usually entirely lost. The mandibles (Pl. XVIII, fig. 7) when seen from above seem to curve inward and be sharp-ended, so that the two look as if they formed a pair of horizontal nipping jaws; this is however only an accidental appearance, when dissected out they do not disclose any special reason for it; they are of the type usual in the family, but the chelate portion is smaller than usual and its moveable arm deep and strongly curved; it is tridentate; the fixed arm is quadridentate, or rather the terminal tooth is bifid. The palpi (Pl. XIX, fig. 2) have the first and second joints of about equal length, the third shorter; the first is much thicker than the second, is strongly curved, and increases a little toward its distal end; it bears a single hair springing from a notch near the distal end of the joint; there are two hairs about the middle of the second joint. The third joint is the thinnest; it bears two papillæ, presumably sensitive, on its actual distal end; the lower is slightly the longer. Haller says that the palpus is five-jointed; this does not seem to me to be correct. There are a pair of hairs, near together and near the median line, projecting over the rostrum and reaching a little beyond the tips of the palpi and mandibles. About as far back as the coxæ of the second pair of legs there is a transverse line of four largish hairs on the notogaster, and in a line with the inner pair of these are three other pairs further backward; the two hairs of each pair separate rather more widely as they get nearer to the posterior margin. There are five hairs on each lateral margin; two of which are between the coxæ of the second and third legs, and three behind those of the fourth pair. There are also three pairs of hairs on the hind margin. All the above-named hairs are strong and rather stiff, inclined to be spine-like; they are all clearly, but rather finely, pectinated. Haller appears to have overlooked this, but there cannot be any doubt about it. The bursa copulatrix scarcely projects at all. The legs are thin and rather long; the two distal joints of the first pair project beyond the points of the mandibles; the fourth pair, without the caroncles, just pass the posterior end of the abdomen. The tarsi are the longest joints; particularly those of the fourth pair, which are as long as the other four joints of that leg taken together. The caroncles are similar to those of the male, but longer, narrower, and less developed; they will be described with the male. There are a few fine hairs on the respective joints and the usual clavate curved spine on the anterior tarsi. The vulva is large and placed far forward; it extends from between the anterior ends of the coxæ of the second pair of legs to between the commencement of the coxæ of the fourth pair; it consists externally of two broad, slightly chitinized labia, protected anteriorly by a crescentic sternite. The so-called genital suckers are small and near together. The epimera are strong and rather elaborate; they will be best understood from the drawings (Pl. XVIII, fig. 2, and Pl. XIX, fig. 12); they have a strong thickened edge and mostly a deep blade of thin, and apparently porous chitin, and of a form varying in the respective legs, on the portion of the epimeron nearest to the leg. Those of the first and second pairs are more or less triangular, comparatively narrow, and run more than halfway along the epimera; the first pair of epimera are joined to the sternite (not the sternum); the second are free. The thickened edges of the epimera of the third and fourth legs are joined at their inner ends, and form a curious, undulated, irregular loop; the blades are short, deep, curved, swollen at their proximal ends, then suddenly narrowed and tooth-like.

The anus reaches the hind margin, but does not project: there are three pairs of small hairs near its posterior end, of which two are pectinated; there is also a pair of very small fine hairs between the rostrum and the first epimera, and a similar pair between the first and second epimera.

Male is smaller than the female, and is widest between the second and third coxæ; thence it diminishes in width to the posterior end; which is rounded, not excavated in the middle as in the female. The dorsal surface is more arched than that of the female. The hairs are practically similar to those of the female, except in being rather larger. The legs, especially the two posterior pairs, are thicker than those of the female; the two anterior pairs are about the same length, but the posterior legs shorter than those of the female, particularly in the tarsi of the fourth pair. These tarsi, and those of the third pair, are very different from those of the female. They are curved inward, and are evidently suited for holding the female; on their upper surface, in the median line, they have a blade which increases in width towards the distal end of the joint. Haller saw this, but described it as a ridge which projected like a tooth beyond the end of the joint; this is its appearance when seen from above, because it is on edge, but when the leg is dissected off and looked at from the side it is seen that the part is a blade curving over the end of the joint and then truncated (Pl. XIX, figs. 5, 6). The caroncle is described and figured by Haller as simply wedge-shaped; this is undoubtedly its appearance when it is lifted off the ground, or when it has been soaked in fluid or reagents; the sides then collapse and hang down, or fold over the median part; but if the caroncle be examined with an amplification of 300 to 500 diameters when the creature is alive, and walking or standing on the under-side of a thin cover-glass, a very different form is disclosed. It is largest, and therefore most easily seen, on the fourth leg of the male (Pl. XVIII, fig. 8); but the other caroncles are more or less of the same form. In the fourth tarsus of the male the basal part, which forms three-quarters of the length, is the shape of an oval vase; narrowing toward the proximal end, which is truncated, and narrowing toward the distal end; where, however, it curves outward again; and terminates distally in a trilobed end, almost a trefoil. Transversely across this part is a fine rod of clear chitin, to the distal side of which the small claw is attached; the tendon of the retractor muscle is inserted on the proximal side. The caroncle is flat and composed of extremely thin membrane along the sides and edges; but its median part, which contains the tendon, is thicker and stiffer. The whole edge of the proximal vase-like division of the caroncle is set with extremely fine short hairs with intervals between them.

The penis and its supporting sclerites are large, conspicuous, and dark in colour (Pl. XVIII, fig. 4; Pl. XIX, figs. 9, 10); it lies between the coxæ of the fourth pair of legs. The anal opening has a chitinous piece at its anterior, and one at its posterior end, which projects beyond the end of the remainder of the abdomen; and is therefore seen from the dorsal aspect as well as from the ventral. There is a short sternum to which the epimera of the first pair of legs are joined; the second pair are free, and there is a short epimeral piece behind the second leg. The third and fourth epimera are joined, and would form something resembling the loop of the same parts in the female were not the posterior portion broken into two pieces with an interspace between; both epimera have long, deep blades on their anterior parts (Pl. XIX, figs. 4, 7).

Nymph.—Haller remarks that the nymph resembles the male more than the female. This is unusual, nevertheless it is correct in so far as that it is widest at the shoulders, and has the projecting anal commissure; but the excavated posterior margin, flattish notogaster, and thin posterior legs more resemble the female. It is greyish white with light pink legs; the hairs on the notogaster are very similar to those of the adult, but are not so long. The marginal parts of the posterior portion of the abdomen have a tendency to be lobose.

Hypopus (Pl. XVIII, figs. 5, 6).—

Length (English specimens) about . . .	·25 mm.
Breadth (English specimens) about . . .	·17 ,,

Haller gives his specimens about twice the size.

This hypopus is homopial, *i. e.* it adheres to its temporary host not by suckers, but by holding one or more of the hairs of the host between special plates on the ventral surface of the parasite. It was the type upon which Koch's genus *Homopus* was founded.

Colour.—Light yellow with an orange shade, especially at the sides. Legs and homopial (hair-holding) plates Indian red.

Texture.—Really polished, but the effect of polish is almost entirely destroyed during life by the longitudinal sulcations mentioned below.

Form, etc.—Cephalothorax and abdomen divided by a clear line; the former about half the length of the latter. Cephalothorax conical, with curved edges; the sides convex, the base concave; it is fully twice as broad as long, is pointed anteriorly, the point being slightly drawn out; the rostrum is strengthened by a chitinous ridge on its inner surface (Pl. XVIII, fig. 9), which ridge divides and widens out posteriorly and surrounds the mouth. The anterior part of the cephalothorax is semi-transparent. Abdomen widest where it adjoins the cephalothorax, gradually narrowing as it approaches the posterior end; sides convex, posterior margin concave. Notogaster moderately arched; it is without hairs or any true markings, but during life is usually broken up by a series of irregular longitudinal sulcations, which vary in number and form, and are not constant in the individual; they are probably due to muscular strain; they are most conspicuous in lately emerged specimens, and are usually lost in dead creatures and preparations. Anterior legs short and thick; the first pair (Pl. XIX, fig. 15) pass the point of the rostrum by about the length of their two distal joints; there are a few fine hairs, principally on the tarsus. In the first three pairs of legs the claw is rather long, but only very slightly curved. The fourth leg (Pl. XIX, fig. 16) has the coxa and femur very thick, but diminishes rapidly toward its distal end; the tarsus terminates in a straight, fixed spine, probably the homologue of the claw; and two hairs, one of which is at least twice as long as the leg, the other shorter but still long. There are three or four other hairs, or spines, on the tarsus. The ventral surface is flat with a concave median channel at the posterior end to hold the hairs of the host. Mouth-opening, which is a small round hole, covered by a broad, thin, flat, pyriform, transparent lip (Pl. XVIII, fig. 9). Epimera of first pair of legs joined to the sternum; the others free. There are epimera both anterior and posterior to the second legs; those of the third pair of legs almost surround the coxæ, and have two spurs directed backward; there are not any to the fourth pair. The anus is a longitudinal slit placed between the fourth coxæ; its labia can be widely opened, and they generally assume this position after death, and indeed retain it for long periods during life. There are two pairs of minute hairs behind it. The holding (homopial) plates (Pl. XIX, fig. 17) are a pair of broad, thin, chitinous, somewhat flexible, wing-like expansions, whose form can be best understood from the figure; they are attached by the edge nearest the lateral side of the body and fold inward, most frequently crossing a little; they are semi-transparent; on the upper surface, *i. e.* that next the body, are a number of fine, curved, parallel ridges, which start from the edge next the median line of the body, and run about half across the plates. On the ventral surface of the body covered by each holding-plate is a strong, irregular, compressed, chitinous ring with a hollow centre; the outer or lateral edge of this ring is much thickened, and there is a spur on the anterior portion of the ring just where the thickened part begins. Haller considered that each homopial plate was mounted on this ring. I think that this is a mistake; it seems to me that the hair to be held lies in the hollow of the ring and passes over the ring itself, and that the homopial plate folds over it and holds it firmly against the ring. Just inside the chitinous ring is a strange spoon-shaped, moveably articulated hair or process. Haller was uncertain what their function might be, but suggested that the contents of the expulsory vesicles, which are a red liquid, might be discharged into them. This scarcely appears probable; the contents of these vesicles are of an oily nature in all Tyroglyphidæ where they are known; and this would not facilitate holding the hair. I have not been able, however, to observe what are really the functions of these spoon-like processes with any certainty.

Habitat.—This species, as far as I know, has only been found in squirrels' nests and on the squirrel; it has been recorded in England, Germany, Italy, and the Netherlands.

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EXPLANATIONS OF THE PLATES.

Lettering used.

A. Anus.
bc. Bursa copulatrix.
bd. Passage from bursa copulatrix to receptaculum seminis.
br. Brain.
c. Cuticle.
cæ. Cæca of ventriculus.
car. Caruncle.
cb. Chitinised bar below ductus ejaculatorius.
cc. Chitinised cuticle.
co. Colon.
cx. Coxa.
de. Ductus ejaculatorius.
dec. Chamber of the ductus ejaculatorius.
ec. Ectostracum.
ed. Endostracum (Hypoderm).
ep. Epiostracum (Epidermis).
epm. Epimeron.
ex. Balls of wholly, or partly, digested food.
f. Femur.
fj. Flexible joint.
fp. Flagella of the palpus (in *Histiostoma*).
g. Genual (middle joint of leg).
gac. Chambered accessory gland of ♂.
gar. Receptacular accessory gland of ♂.
ge. External genital aperture.
gel. Labia of external genital aperture.
gso. Supra-œsophageal ganglion (upper part of brain).
gsu. Subœsophageal ganglion (under part of brain).
la. Outer labia of vulva.
le. Inner labia of the vulva.
li. Lingua.
m. Mouth.
mc. Constrictor muscles.
md. Mandibles.
mda. Divaricator muscles of the labia ani.
mdc. Depressor muscles of the coxa.
mdd. Divaricator muscles of the mandibles.
mdf. Fixed arm of the chela of the mandible.
mdm. Moveable arm of the chela of the mandible.
mdo. Occlusor muscles of the mandibles.
mdr. Retractor muscles of the mandibles.
mdv. Dorso-ventral muscles.

mep. Erector muscles of the penis.
ml. Maxillary lip.
mlc. Levator muscles of the coxa.
mlp. Levator tecti pharyngis or dilatores pharyngis muscles.
mop. Occlusor (constrictor) muscles of the pharynx.
mrp. Retractor muscles of the penis.
mrr. Retractor muscles of the rostrum.
mv. Malpighian vessels.
mx. Maxillæ.
n. 1. Nerve to first leg.
n. 2. Nerve to second leg.
n. 3. Nerve to third leg.
n. 4. Nerve to fourth leg.
ng. Genital nerve.
nph. Pharyngeal nerve.
o. Ova.
od. Oviduct.
odc. Chamber of the oviduct.
œ. Œsophagus.
ov. Ovary.
P. Palpus (maxillary).
pe. Penis.
ph. Pharynx.
pm. Membranous expansion of the palpus (in *Histiostoma*).
pr. Roof of the pharynx.
r. Rectum.
ro. Passage from receptaculum seminis to ovary.
rr. Roof of rostrum.
rs. Receptaculum seminis.
sp. Chitinous support of the penis.
st. Sternum.
t. Testes.
ta. Tarsus.
ten. Tendons.
ti. Tibia.
uc. Urinary concretions.
un. Unguis.
v. Ventriculus.
va. Vagina.
vd. Vasa deferentia.

PLATE A.

ANATOMY.

The Alimentary Canal and the Brain.

Fig. 1. The alimentary canal and mandibles of *Hericia Robini*, ♂, seen from the side, × 190.

2. The alimentary canal of *Glycyphagus platygaster*, ♀, seen from the side, × 100. The anus is seen through the wall of the rectum, and a portion of the ventral cuticle surrounding it is shown. A muscular band runs from the cuticle to the rectum, also lines of connective tissue.

3. The alimentary canal of *Tyroglyphus longior* seen from the side. Reichert, Obj. 5, Oc. 1, copied from Nalepa's figure (*f*), pharynx, etc. (Schlundapparat).

4. The alimentary canal of *Tyroglyphus siro* seen from above (no amplification given). Copied from Gudden's figure.

5. Sagittal section of the pharynx and surrounding parts of *Glycyphagus platygaster*, ♀, × 350. The mandibles rest on the anterior portion of the roof (*r r*) in front of the perpendicular bend.

6. Salivary glands from one side of *Glycyphagus platygaster*, ♀, × 350.

7. Salivary gland of *Tyroglyphus siro*, copied from Gudden's figure (no amplification given).

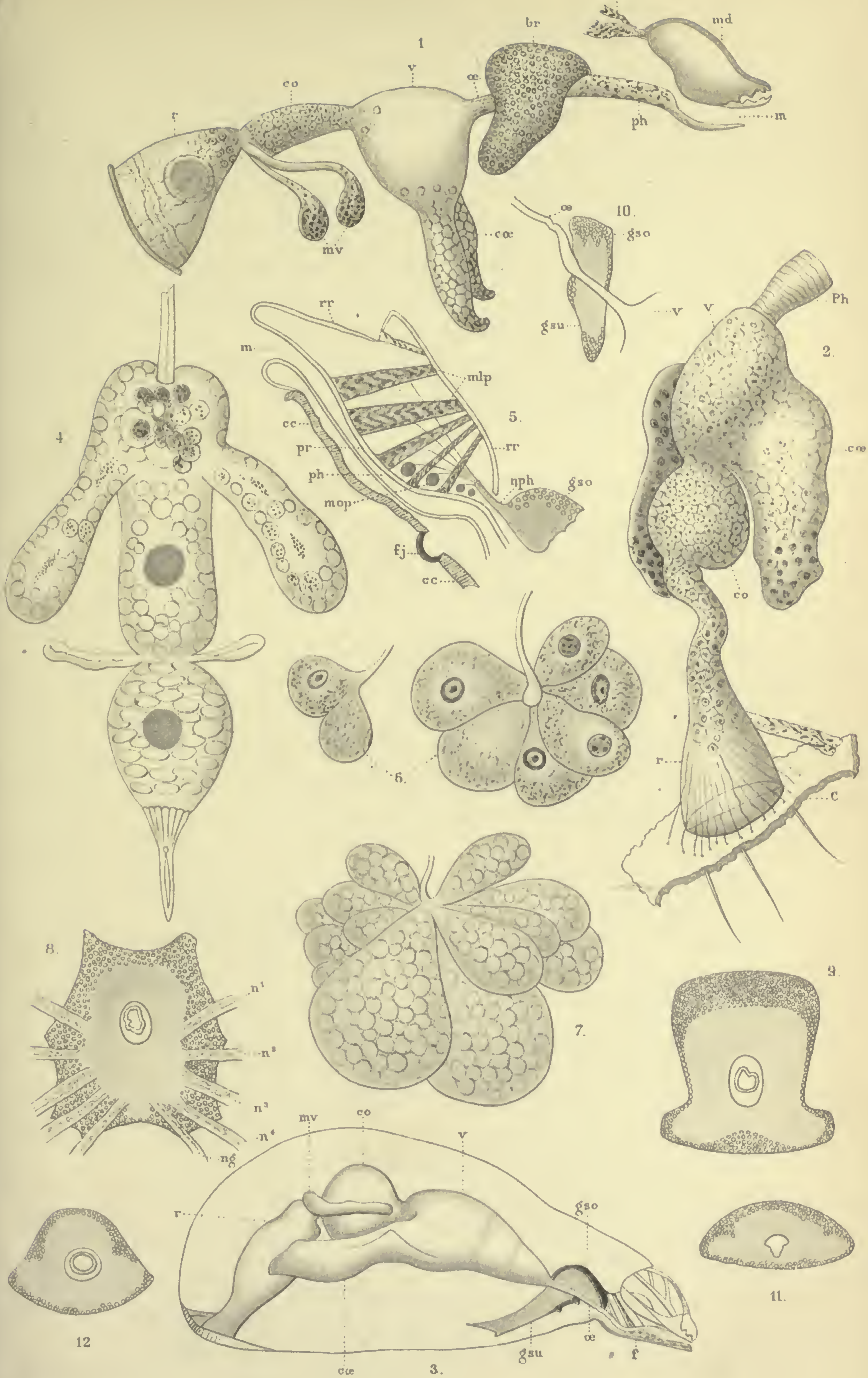
8. Horizontal section through the brain of *Hericia Robini*, × 500, showing the starting of the nerves to the legs and the genital or splanchnic nerve. The section of the œsophagus is shown in the centre of this and the two following figures.

9. Transverse section through the brain of *Hericia Robini*, ♂, cut about the middle of the supra-œsophageal ganglion, × 500.

Fig. 10. Median sagittal section through the brain of *Glycyphagus platygaster*, ♀, × 175.

11. Transverse section of the brain of the same species and sex about the centre, × 175.

12. Transverse section of the brain of the same species, ♂, about the centre, × 175.



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ALIMENTARY CANAL AND BRAIN.

PLATE B.

Anatomy.

The Reproductive Organs.

Fig. 1. Reproductive organs of *Glycyphagus platygaster*, ♂, seen from the dorsal aspect, × 170.

2. The same seen from the ventral aspect, × 170. The surface of the central portion of the receptacular accessory gland (*gar.*) is cut away to allow the mass of homogeneous secretion contained therein to be seen.

3. Penis of *Glycyphagus platygaster*, ♂, at rest in the external genital aperture, seen from the ventral aspect, × 350.

4. Penis and supporting organs of *Hericia Robini* seen from the side in partial erection, × 500. The cuticle, except the edges of the genital opening, is omitted in order to show the organs.

5. Penis and adjacent genital parts of *Glycyphagus platygaster* seen from the side, × 350.

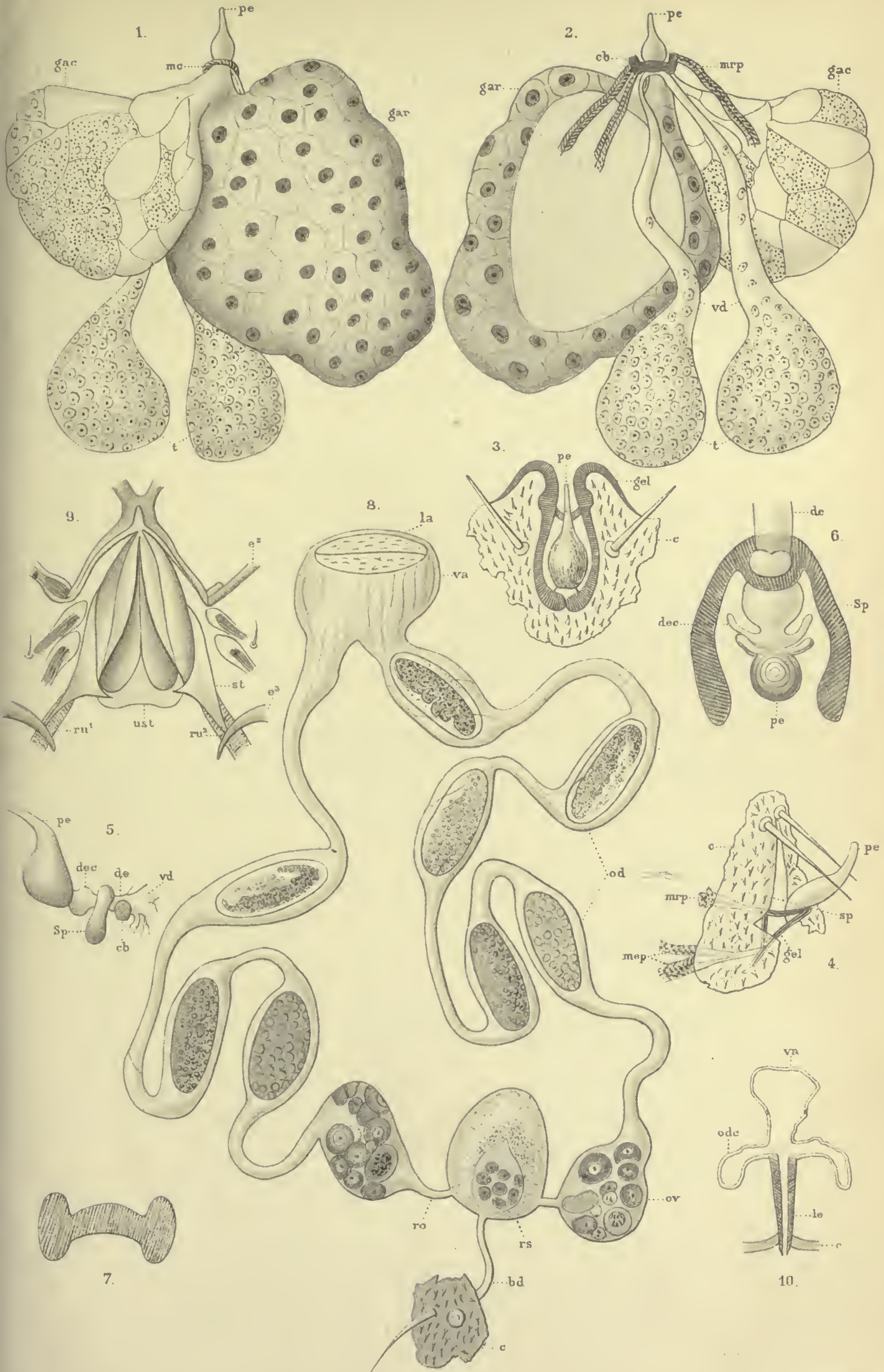
6. Supporting piece of the penis with portion of the ductus ejaculatorius, etc., of *Glycyphagus platygaster*, × 800. The chitinous supporting piece (*sp*) stands perpendicularly in the body.

7. Chitinous bar (fig. 5, *c b*) below the ductus ejaculatorius, further in the body than the supporting-piece (fig. 5, *sp*, fig. 6), of *Glycyphagus platygaster*, × 800.

8. Reproductive organs of *Glycyphagus platygaster*, ♀, × 100. The small circular opening of the bursa copulatrix is seen in the centre of the piece of cuticle at the lower end of the figure.

9. Female genital opening of *Carpoglyphus anonymus*, ♀. Reichert, Obj. 3, Oc. 9, copied from Nalepa's figure. *st*, lateral supporting-plates; *ust*, lower unpaired supporting-plate; ru^1 ru^2, retractor muscles of *ust*; e^2 e^3, epimera of the second and third pairs of legs.

10. Transverse section of the vulva of *Glycyphagus platygaster*, × 350.



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REPRODUCTIVE ORGANS.

PLATE C.

Anatomy.

Sections.

Fig. 1. Sagittal central section of *Hericia Robini*, ♀, × 285. A small portion of the passage between the receptaculum seminis and the ovary is seen; it passes behind the rectum. Part of the genital (splanchnic) nerve is seen springing from the posterior corner of the sub-œsophageal ganglion.

2. Transverse section of *Hericia Robini*, ♂; the plane passes through the posterior part of the colon, × 150.

3. Transverse section of *Glycyphagus platygaster*, ♂. The plane passes through the anterior portion of the supra-œsophageal ganglion, × 225.

4. Transverse section of a portion of the external cuticle of the side of *Glycyphagus platygaster*, ♀. The plane passes through the vulva, × 500.

5. Ventral portion of a transverse section of *Glycyphagus platygaster*, ♂, to show the histology of the accessory glands, × 150. The receptacular accessory gland is shown with the lumen empty.

6. Horizontal section close to the ventral surface through the sternum, and first and second coxæ of the left side, of *Rhizoglyphus echinopus*, ♀, to show the musculation, × 150.

7. Longitudinal section through the fourth leg of *Hericia Robini*, ♂, showing the principal muscles, × 150.

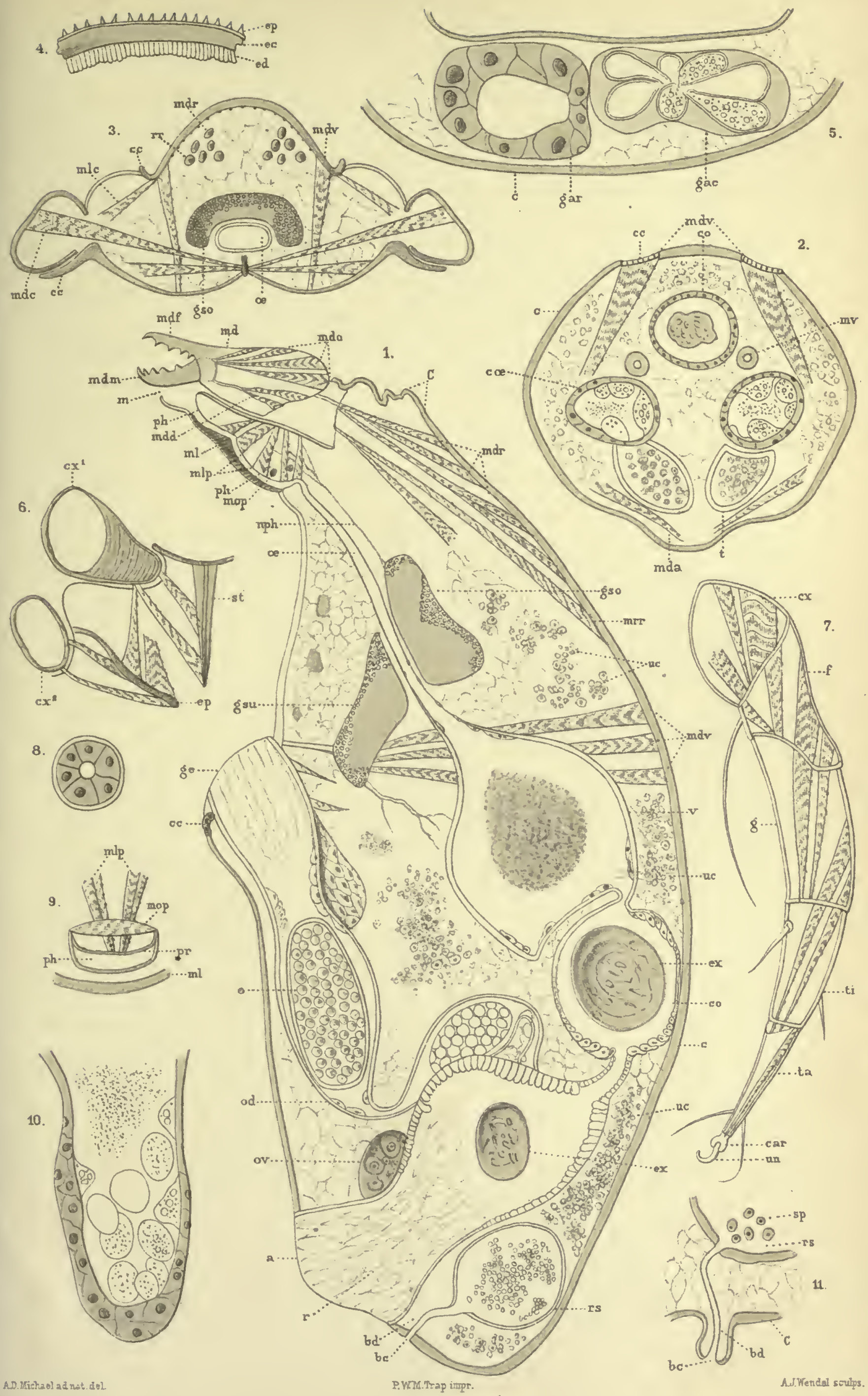
8. Transverse section through the distal (posterior) part of one of the cæca of the ventriculus of *Hericia Robini*, × 200.

Fig. 9. Transverse section of the pharynx of *Glycyphagus platygaster*, ♀, × 150. The plane of the section cuts the pharynx near its posterior end, so as to catch one of the straight occlusor muscles (*mop*).

10. Horizontal section of the distal part of the right cæca of the ventriculus of *Glycyphagus platygaster*, ♀, × 225. It contains food material at the proximal end, and at the distal end numerous loose cells which have become exhausted and detached after performing the office of absorbing and digesting food globules. Some are empty, some contain small urinary or excremental granules.

11. Sagittal section through the bursa copulatrix of *Glycyphagus platygaster*, ♀, × 150.

Plate C.



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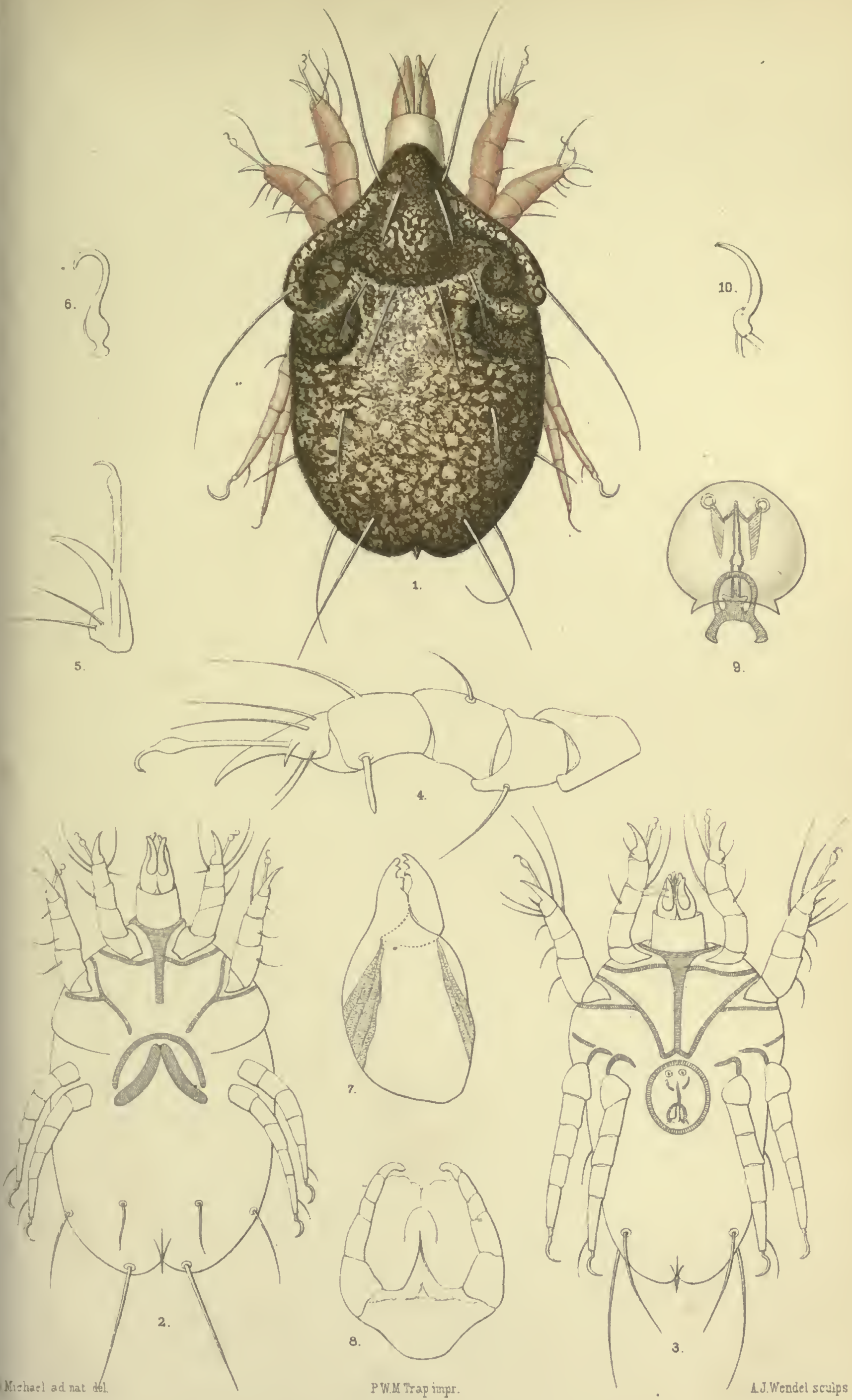
SECTIONS

PLATE I.

LENTUNGULA ALGIVORANS, page 196.

Length of both sexes about ·38 mm.

Fig. 1. Adult female seen from above, × 150.
2. Adult female seen from below, × 150.
3. Adult male seen from below, × 150.
4. Second left leg (drawn from adult male, but similar in both sexes); side view, × 320.
5. Tarsus of first left leg, × 320.
6. Claw of fourth leg (drawn from male, but sexes similar), × 320.
7. Left mandible of female seen from the inner (right) side, × 320.
8. Maxillary lip, palpi, and ? labium, seen from below, × 320.
9. Penis and penial skeleton and sclerites seen from below, × 320.
10. Penis seen from the side, × 320.



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LENTUNGULA ALGIVORANS.

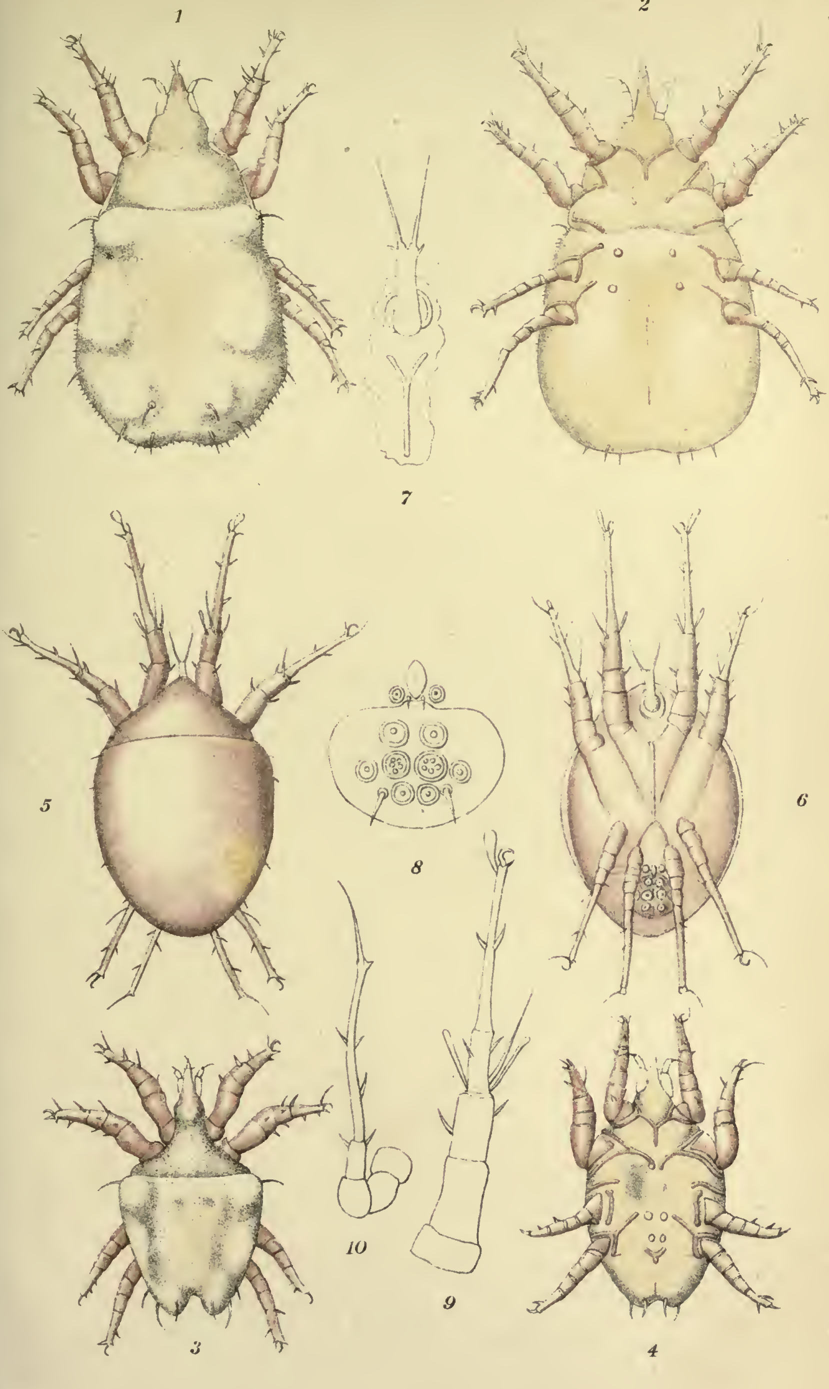
PLATE II.

HISTIOSTOMA ROSTRO-SERRATUM, page 208.

Length, ♀ about ·55 mm., ♂ about ·4 mm.

Fig. 1. Adult ♀, dorsal view, × 85.
2. Adult ♀, ventral view, × 85.
3. Adult ♂, dorsal view, × 85.
4. Adult ♂, ventral view, × 85.
5. Hypopial nymph, dorsal view, × 200.
6. Hypopial nymph, ventral view, × 200.
7. Hypopial nymph, mouth-opening, lip, and sternum from below, × 500.
8. Hypopial nymph, sucker-plate and anus, × 500.
9. Hypopial nymph, first leg from below, × 500.
10. Hypopial nymph, fourth leg turned forward at the genual, as the third and fourth legs generally are when the creature is not moving.

PLATE II.



HISTIOSTOMA ROSTRO-SERRATUM.

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PLATE III.

Genus—Histiostoma.

Fig. 1. *Histiostoma rostro-serratum.* Maxillary lip and trophi of ♀ seen from below, × 500.

2. *Histiostoma rostro-serratum.* Mandibles of ♀ seen from the side, × 500.

3. *Histiostoma rostro-serratum.* First right leg of ♂ from below and the inner side, × 275.

4. *Histiostoma rostro-serratum.* Second leg of ♂ from the side, × 275.

5. *Histiostoma rostro-serratum.* Third right leg of ♂ from below and the inner side, × 275.

6. *Histiostoma rostro-serratum.* Fourth right leg of ♂ from below and the inner side, × 275.

7. *Histiostoma rostro-serratum.* First leg of ♀ from side, × 275.

8. *Histiostoma rostro-serratum.* Second leg of ♀ from side, × 275.

9. *Histiostoma rostro-serratum.* Third leg of ♀ from below, × 275.

10. *Histiostoma rostro-serratum.* Fourth leg of ♀ from below, × 275.

11. *Histiostoma rostro-serratum.* Vulva from below, × 400.

12. *Histiostoma rostro-serratum.* One labium of vulva from the side, × 400.

13. *Histiostoma pulchrum.* Mandible, × 800.

14. *Histiostoma pulchrum.* Second claw of ♂, × 400.

15. *Histiostoma pulchrum.* Second spine from left side of abdomen of ♂, × 800.

16. *Histiostoma pulchrum.* Spine from the posterior margin of ♂, × 800.

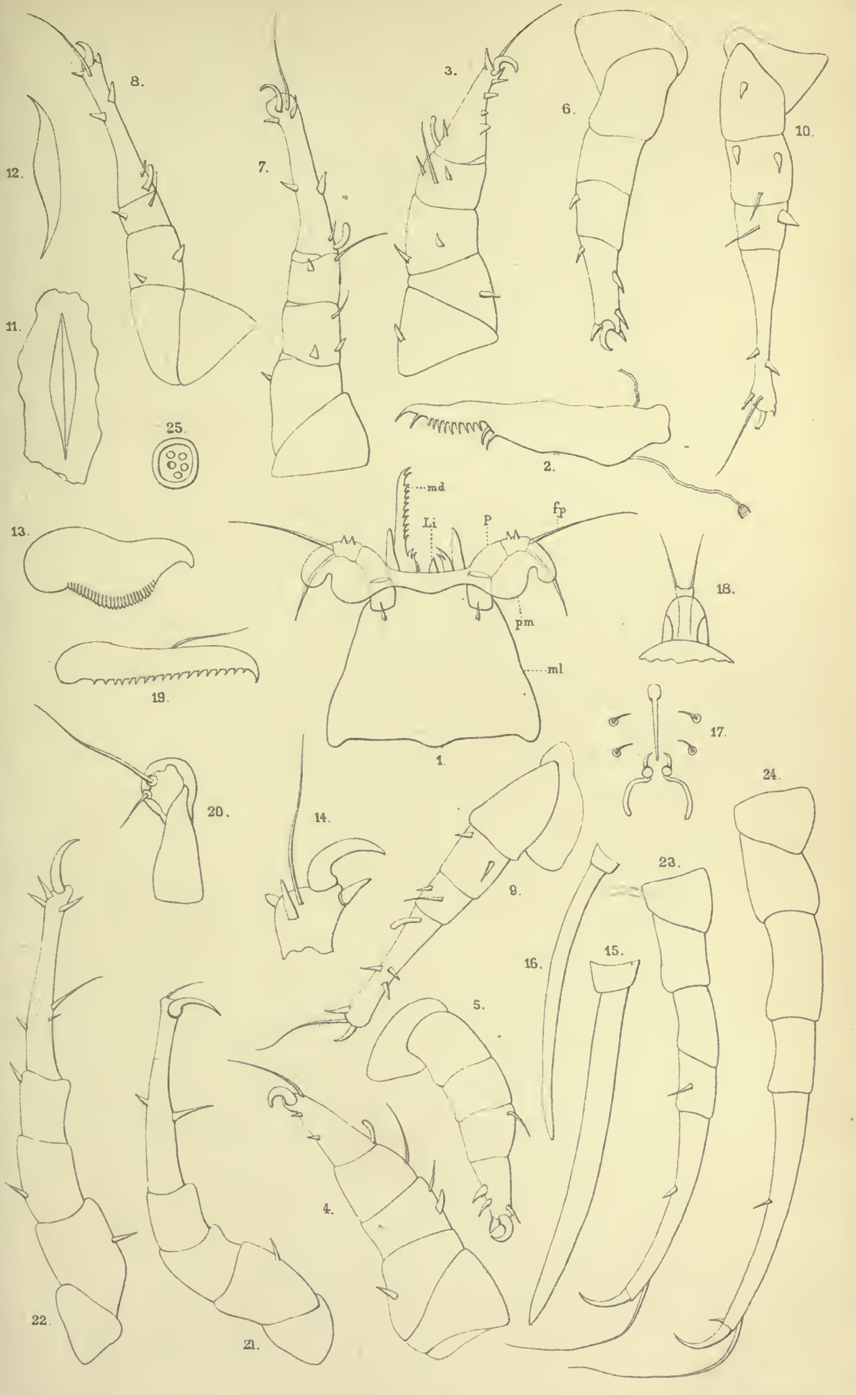
17. *Histiostoma pulchrum.* Penis from below, × 800.

18. *Histiostoma pulchrum.* Hood of rostrum of Hypopus, × 300.

19. *Histiostoma pyriforme.* Mandible, × 800.

Fig. 20. *Histiostoma pyriforme.* The two terminal joints of the palpus, × 250.

21. *Histiostoma pyriforme.* First leg of ♂, × 300.
22. *Histiostoma pyriforme.* Second leg of ♂, × 300.
23. *Histiostoma pyriforme.* Third leg of ♂, × 300.
24. *Histiostoma pyriforme.* Fourth leg of ♂, × 300.
25. *Histiostoma pyriforme.* One of the four discs from the ventral surface, × 500.



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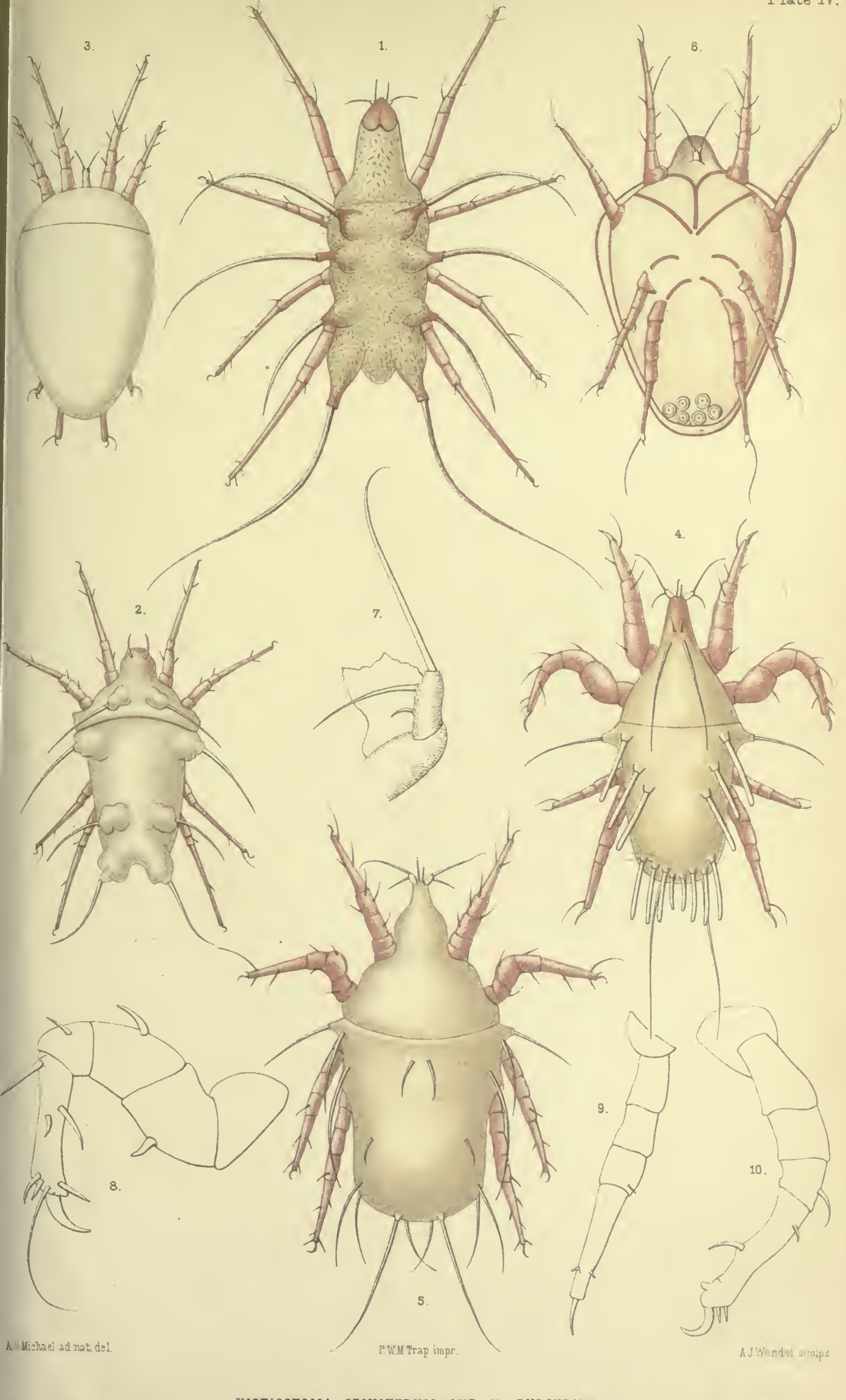
GENUS HISTIOSTOMA.

PLATE IV.

HISTIOSTOMA SPINIFERUM, page 215, length ·26 mm., and H. PULCHRUM, page 217, length ·35 mm.

Fig. 1. *Histiostoma spiniferum.* Adult ♀, dorsal aspect, × 150.

2. *Histiostoma spiniferum.* Nymph.
3. *Histiostoma spiniferum.* Hypopial nymph, dorsal aspect, × 150.
4. *Histiostoma pulchrum.* Adult ♂, dorsal aspect, × 120.
5. *Histiostoma pulchrum.* Adult ♀, dorsal aspect, × 140.
6. *Histiostoma pulchrum.* Hypopial nymph, ventral aspect, × 250.
7. *Histiostoma pulchrum.* Terminal joint and portion of the second joint of palpus, × 650. A broken portion of maxillary lip is shown below the palpus.
8. *Histiostoma pulchrum.* Second leg of adult ♂ from the side, × 320.
9. *Histiostoma pulchrum.* Third leg of adult ♀ from above, × 320.
10. *Histiostoma pulchrum.* Fourth leg of adult ♀ from the side, × 320.



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HISTIOSTOMA SPINIFERUM AND H. PULCHRUM.

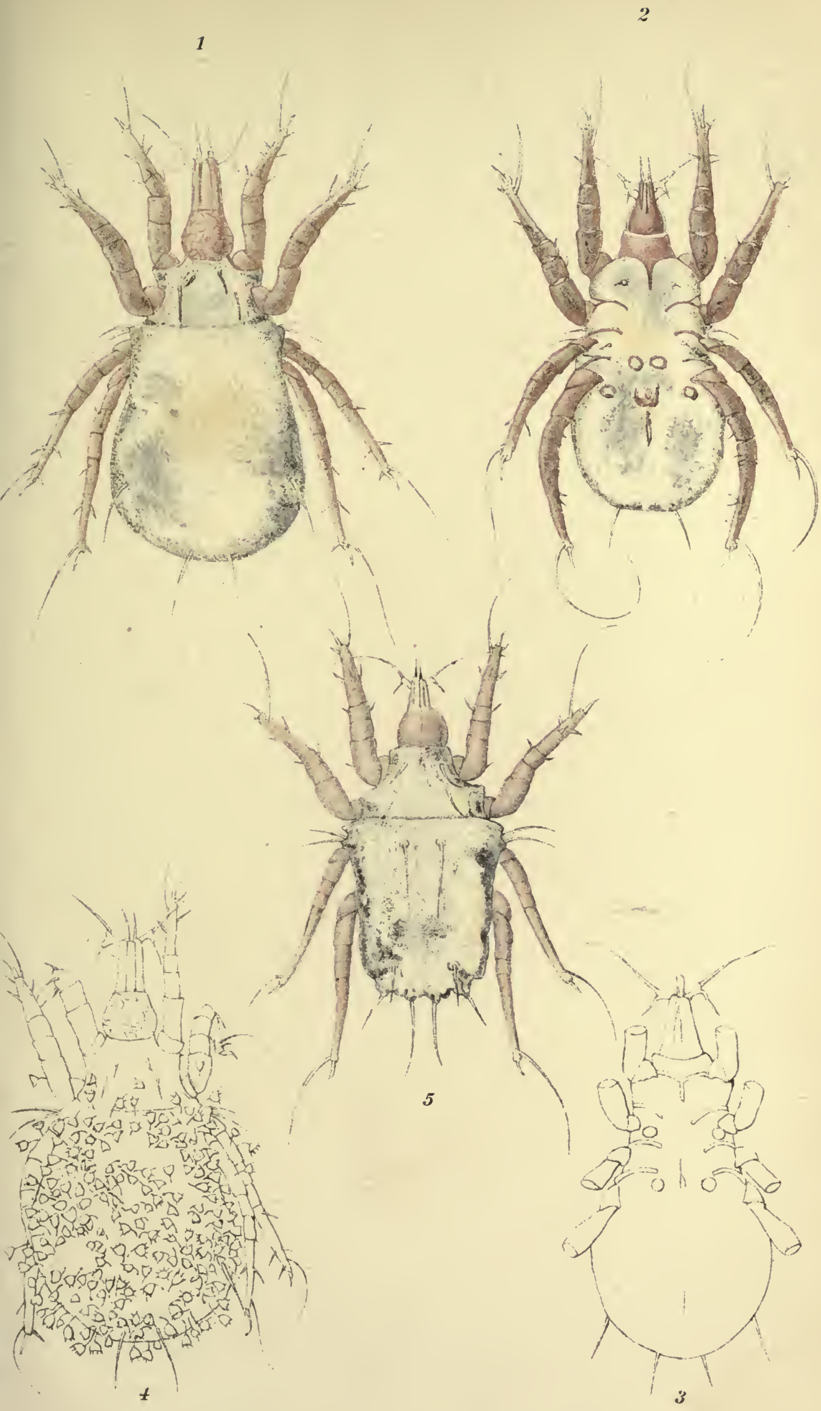
PLATE V.

HISTIOSTOMA PYRIFORME, page 221.

Length (without rostrum), ♀ about ·3 mm., ♂ about ·25 mm.

Fig. 1. Adult ♀ seen from above, × 130.
2. Adult ♂ seen from below, × 130.
3. Adult ♀ seen from below, × 130, lately emerged specimen.
4. Adult ♀ seen from above, covered with Vorticellæ, as sometimes found.
5. Nymph, about half grown, × 250.

PLATE V.



HISTIOSTOMA PYRIFORME.

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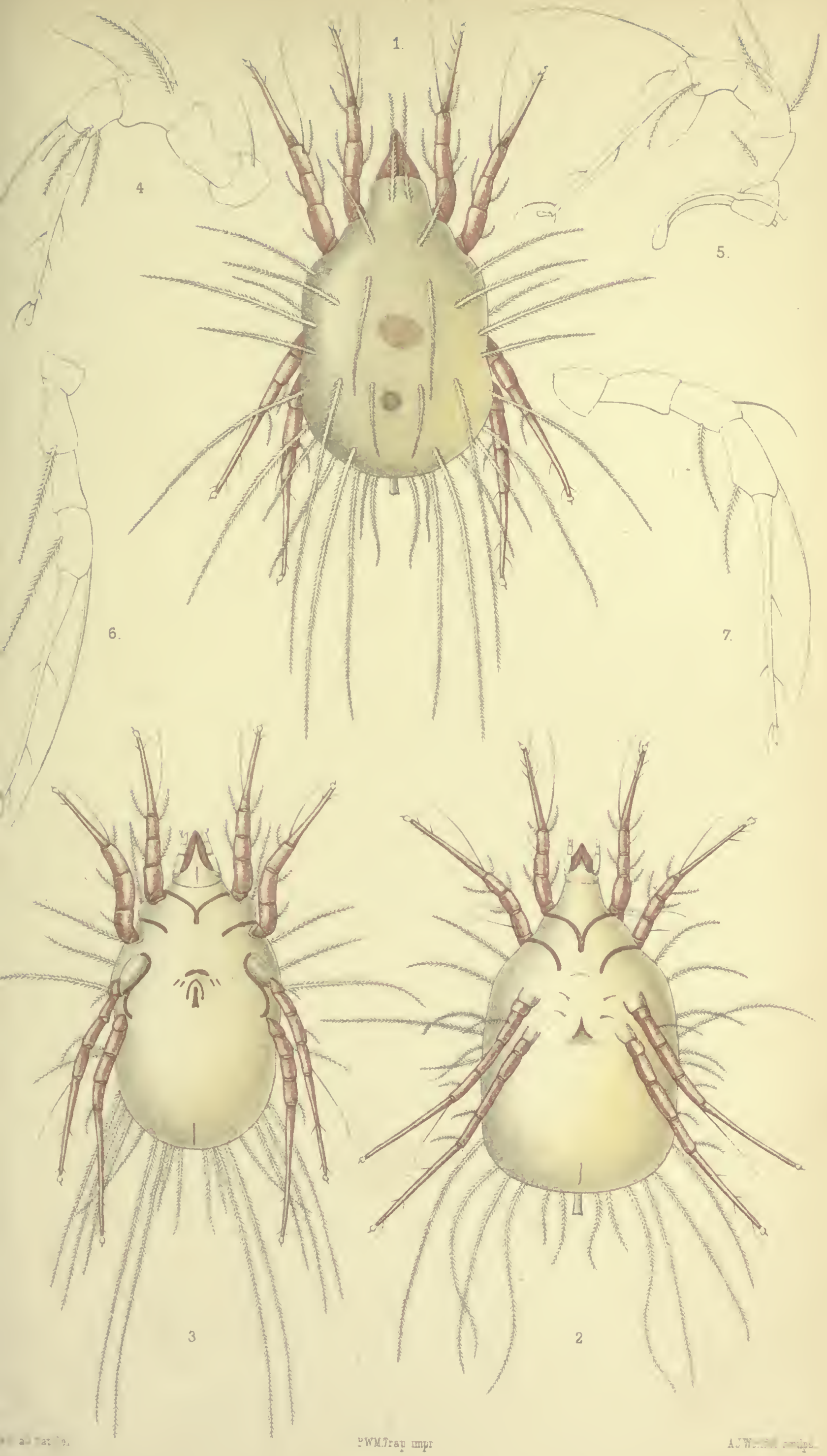
PLATE VI.

Glycyphagus domesticus, page 238.

Length of both sexes about ·5 mm.

Fig. 1. Adult ♀, dorsal aspect, × 90.
2. Adult ♀, ventral aspect, × 90.
3. Adult ♂, ventral aspect, × 90.
4. Adult ♀, first leg from side, × 180.
5. Adult ♂, second leg from side with its epimeron, × 220.
6. Adult ♀, third leg from below and slightly to the side, × 180.
7. Adult ♂, fourth leg from outer side, × 220.



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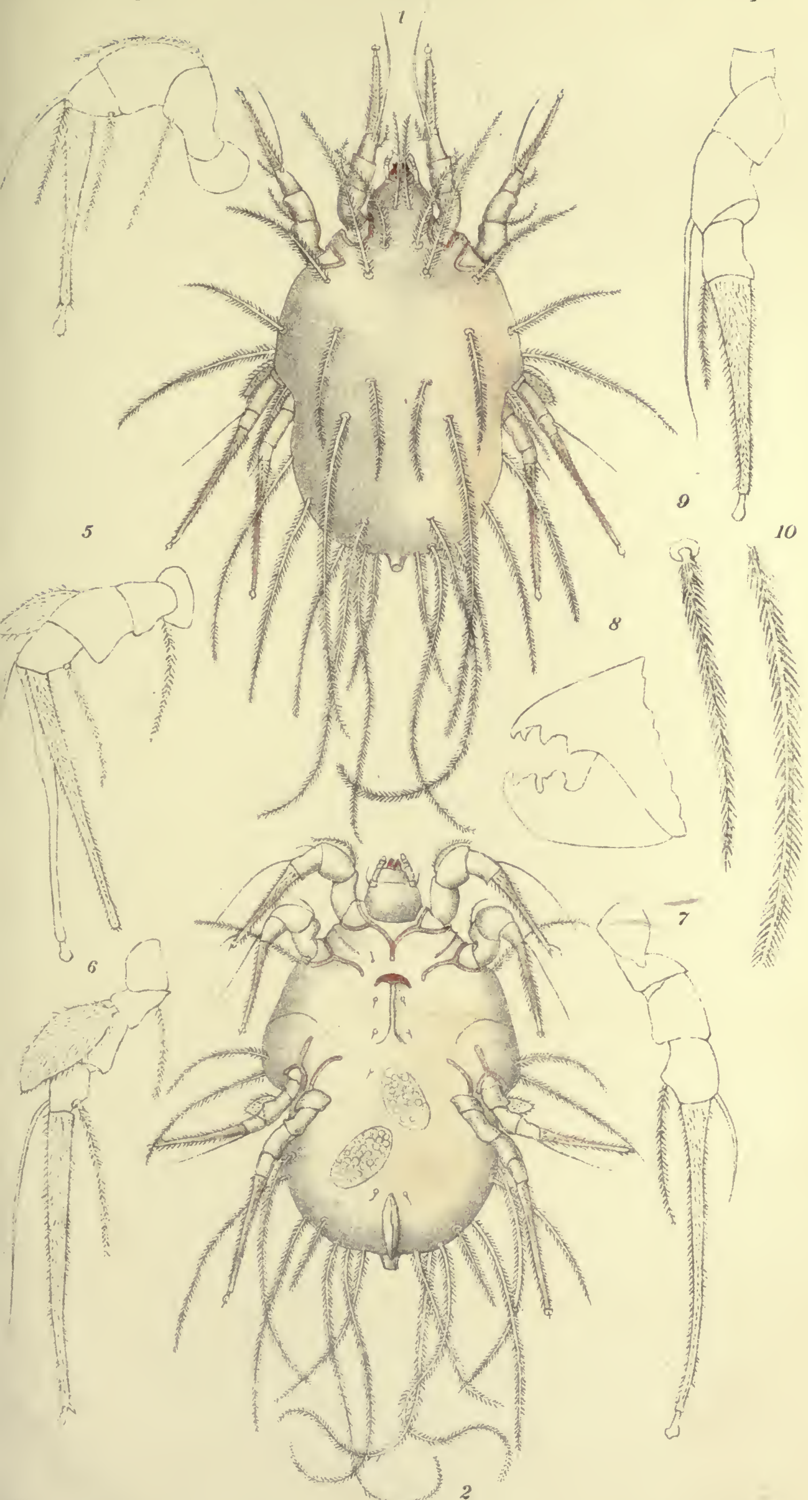
GLYCYPHAGUS DOMESTICUS.

PLATE VII.

GLYCYPHAGUS SPINIPES, page 245.

Length, ♀ about ·70 mm., ♂ about ·45 mm.

Fig. 1. Adult ♀ from above, × 65.
2. Adult ♀ from below, × 65.
3. First left leg of adult ♂ from the left side, × 175.
4. Second left leg of adult ♂ from the left side and below, × 175.
5. Third left leg of adult ♀ from the right side, × 175. The sheath of the tarsus has become detached from the tarsus itself, except at the proximal end, where it is attached by its whole width.
6. The third right leg of adult ♀, × 175. The sheath of the tarsus in the usual position (attached), × 175.
7. Fourth right leg of adult ♂ from the right side, × 175.
8. Chelate portion of the mandible of adult ♂ from without, × 500.
9. One of the hairs from the leg, × 350. The drawing was made from the hair on the third tibia of the ♀, but the spinous hairs on all the legs in both sexes are similar in character.
10. A portion of one of the hairs on the dorsum, × 350; drawn from the ♀ but similar in both sexes.



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GLYCYPHAGUS SPINIPES.

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PLATE VIII.

GLYCYPHAGUS SPINIPES, page 245; and G. DOMESTICUS, page 238.

Fig. 1. *G. spinipes.* Adult ♂, under side, × 85.

2. *G. spinipes.* Fourth left tarsus of adult ♀ from above, × 200. At the right side is a line showing the extreme width of the abdomen, same amplification.

3. *G. domesticus.* Fourth left tarsus of adult ♀ from above, × 200; at the left side is a line showing the extreme width of the abdomen, same amplification.

4. *G. spinipes.* Bursa copulatrix of adult ♀ from below, × 600.

5. *G. spinipes.* Bursa copulatrix of adult ♀ from above, × 600.

6. *G. spinipes.* Bursa copulatrix of adult ♀ from above, × 200.

7. *G. domesticus.* Bursa copulatrix of adult ♀ from above, × 200.

8. *G. domesticus.* Chelate portion of the mandible of adult ♂, × 450.

9. *G. domesticus.* Vulva of adult ♀, × 200.

10. *G. domesticus.* A small portion of the cuticle, × 1000.

11. *G. spinipes.* Hypopial case containing the Hypopus (see page 170), × 150.

12. *G. domesticus.* Hypopial case containing the inert mass (very rudimentary Hypopus), × 150.

13. *G. spinipes.* Posterior end of the hypopial case from which the nymph in its last stage has emerged; seen from above, to show the mode of opening.

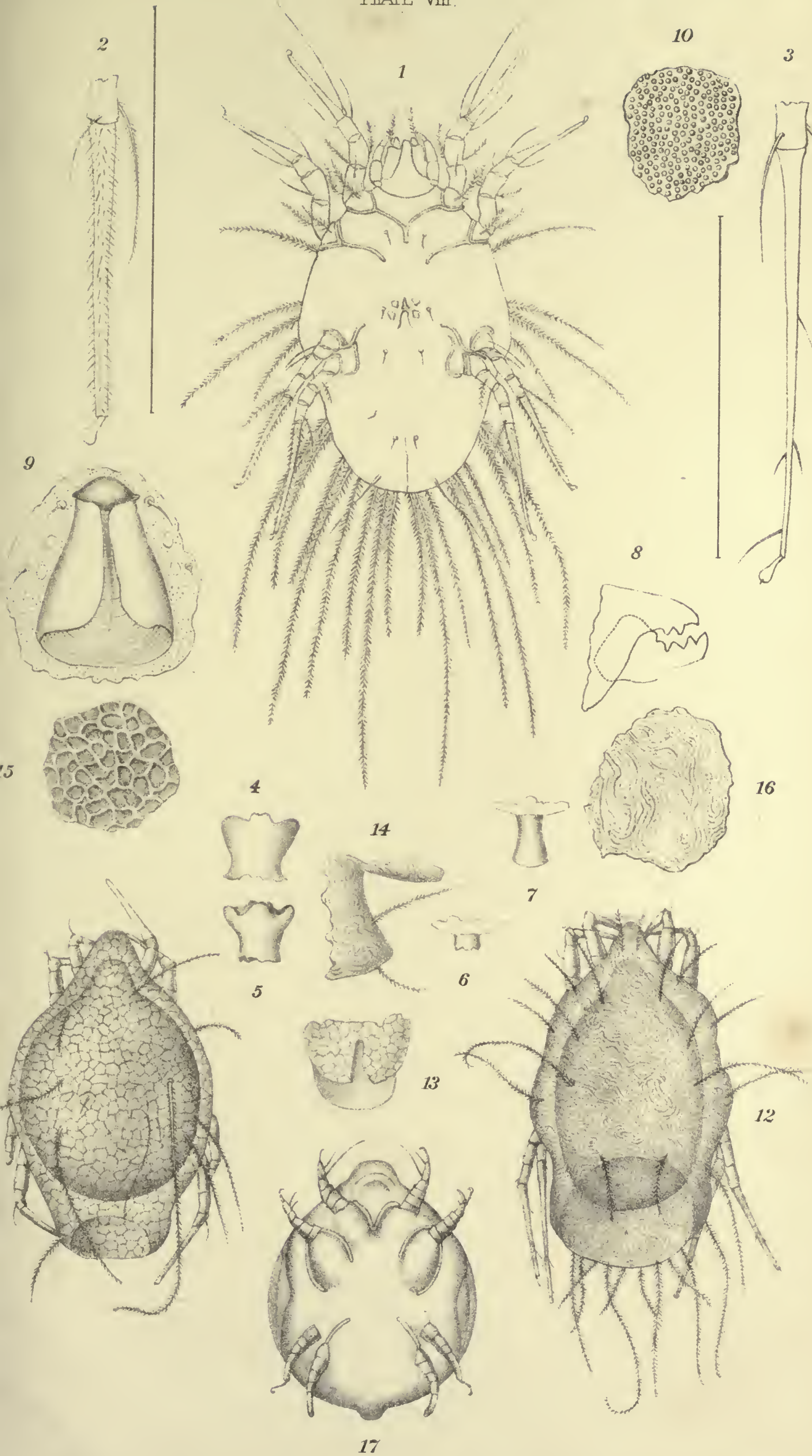
14. *G. domesticus.* Posterior end of the hypopial case from which the nymph in its last stage has emerged; seen from the side, to show the mode of opening.

Fig. 15. *G. spinipes.* A portion of the cuticle of the hypopial case to show the reticulated markings, × 250.

16. *G. domesticus.* A portion of the cuticle of the hypopial case to show the vermiform markings, × 250.

17. *G. spinipes.* Hypopus dissected out of the hypopial case, × 180.

PLATE VIII.



GLYCYPHAGUS DOMESTICUS AND G. SPINIPES.

A.D. Michael ad nat. del.

G. Freytag & Berndt, Vienna.

PLATE IX.

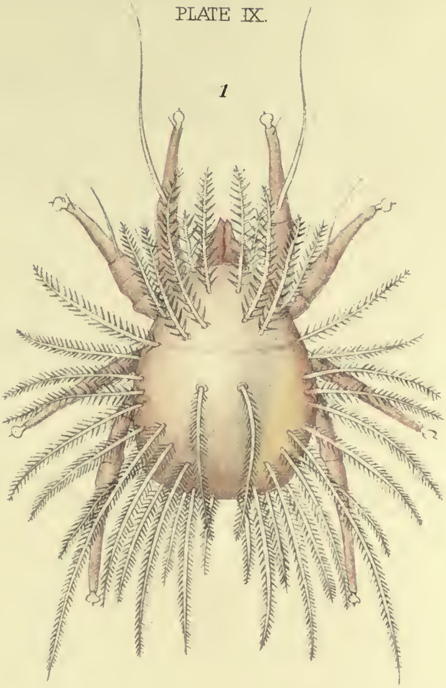
GLYCYPHAGUS PLUMIGER, page 250.

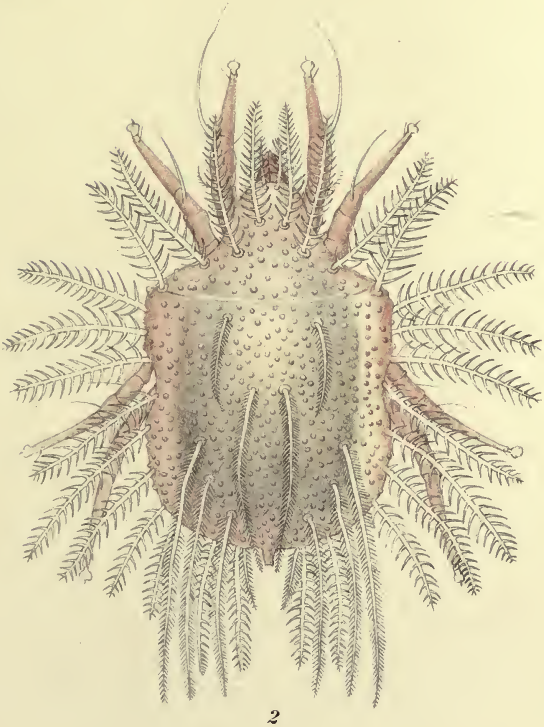
Length, ♂ about ·20 mm., ♀ about ·30 mm.

Fig. 1. Male from above, × 200.
2. Female from above, × 200.

PLATE IX.

1





2

GLYCYPHAGUS PLUMIGER.

A. D. Michael ad nat. del.

G. Freytag & Berndt, Vienna.

PLATE X.

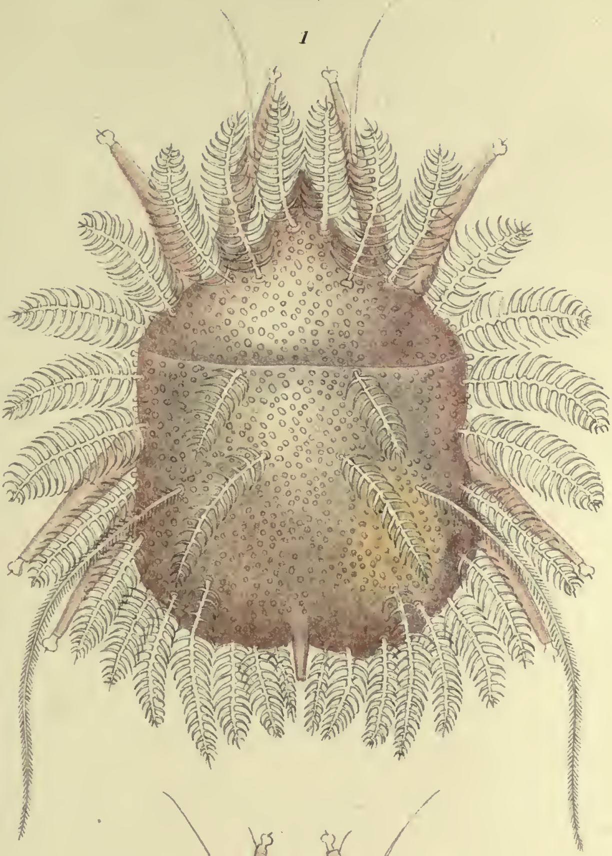
Glycyphagus Canestrinii, page 255.

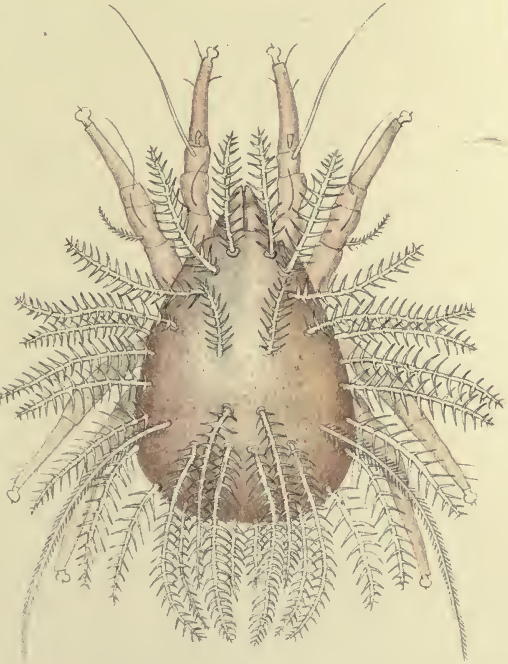
Length, ♂ about ·20 mm., ♀ about ·31 mm.

Fig. 1. Female from above, × 200.
2. Male from above, × 200.

PLATE X.

1





2

GLYCYPHAGUS CANESTRINII

A. D. Michael ad nat. del.

G. Freytag & Berndt, Vienna.

PLATE XI.

GLYCYPHAGUS PLUMIGER, page 250; and G. CANESTRINII, page 255.

Fig. 1. *Glycyphagus plumiger.* Mandible of ♀, × 350.
2. *Glycyphagus plumiger.* First leg of ♂ from the outer side, × 350.
3. *Glycyphagus plumiger.* First leg of ♀ from above, × 350.
4. *Glycyphagus plumiger.* Third and fourth legs of ♀ from above, × 350.
5. *Glycyphagus plumiger.* One of the most bipectinated hairs of the ♀, from the body near the fourth leg, × 350.
6. *Glycyphagus plumiger.* One of the most bipectinated hairs of the male, from a similar part, × 350.
7. *Glycyphagus plumiger.* Penis, × 350.
8. *G. Canestrinii.* Mandible of ♀ from the side, × 350.
9. *G. Canestrinii.* Mandible of ♂, chelate portion, × 450.
10. *G. Canestrinii.* Maxillary lip from below, × 300.
11. *G. Canestrinii.* First leg of ♂ from above and without, × 350.
12. *G. Canestrinii.* First leg of ♀ from below, × 350.
13. *G. Canestrinii.* Fourth leg of ♀ from the side, × 350.
14. *G. Canestrinii.* End of tarsus with caruncle and claw, × 600.
15. *G. Canestrinii.* A portion of the dorsal cuticle of the abdomen of the ♀ seen from above, × 500.
16. *G. Canestrinii*, ♀; a small piece of the same cuticle seen from the side to show the projection and form of the cuticular processes, × 500.

Fig. 17. *G. Canestrinii.* One of the bipectinated hairs from the edge of the body of the ♀, × 350.

18. *G. Canestrinii.* One of the most bipectinated hairs from the body of the ♂, × 350.

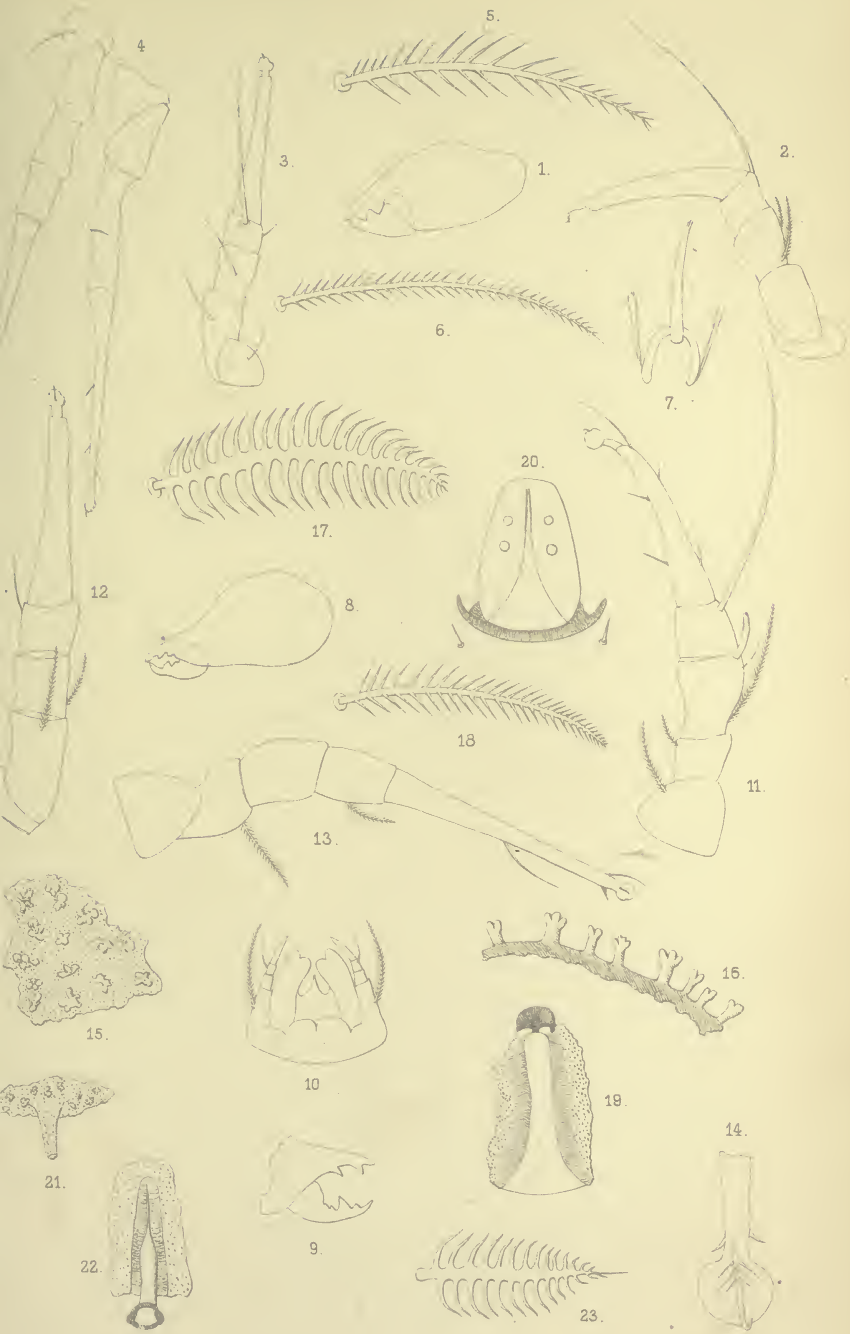
19. *G. Canestrinii.* External labia of the vulva, × 250.

20. *G. Canestrinii.* Internal labia of the vulva, × 350.

21. *G. Canestrinii.* Bursa copulatrix, × 250.

22. *G. Canestrinii.* Penis, × 400.

23. *G. Canestrinii.* One of the central (posterior) pair of hairs from the edge of the ventral surface of the abdomen of the ♀, × 350.



GLYCYPHAGUS PLUMIGER, &c.

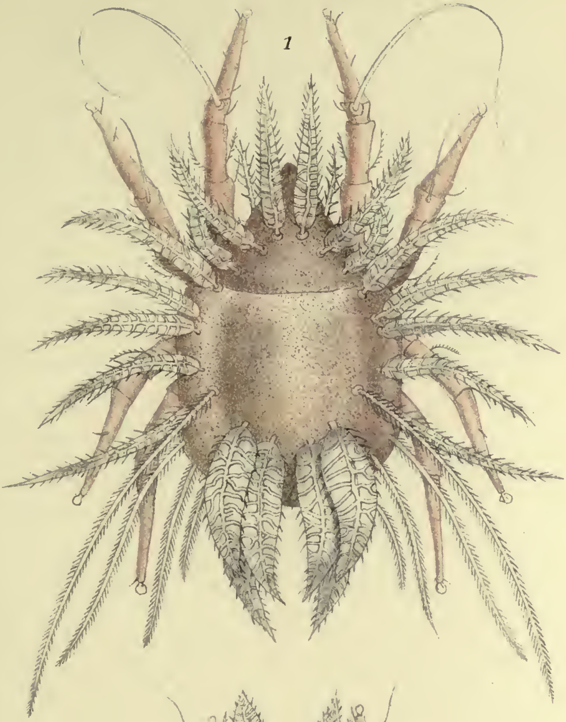
PLATE XII.

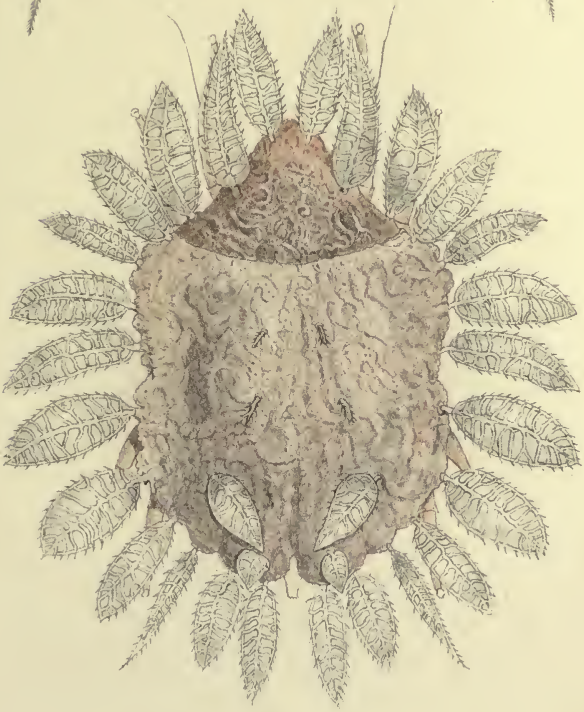
Glycyphagus palmifer, page 260.

Length, ♂ about ·19 mm., ♀ about ·26 mm.

Fig. 1. Adult male, dorsal view, × 250.
2. Adult female, dorsal view, × 250.

1





2

GLYCYPHAGUS PALMIFER.

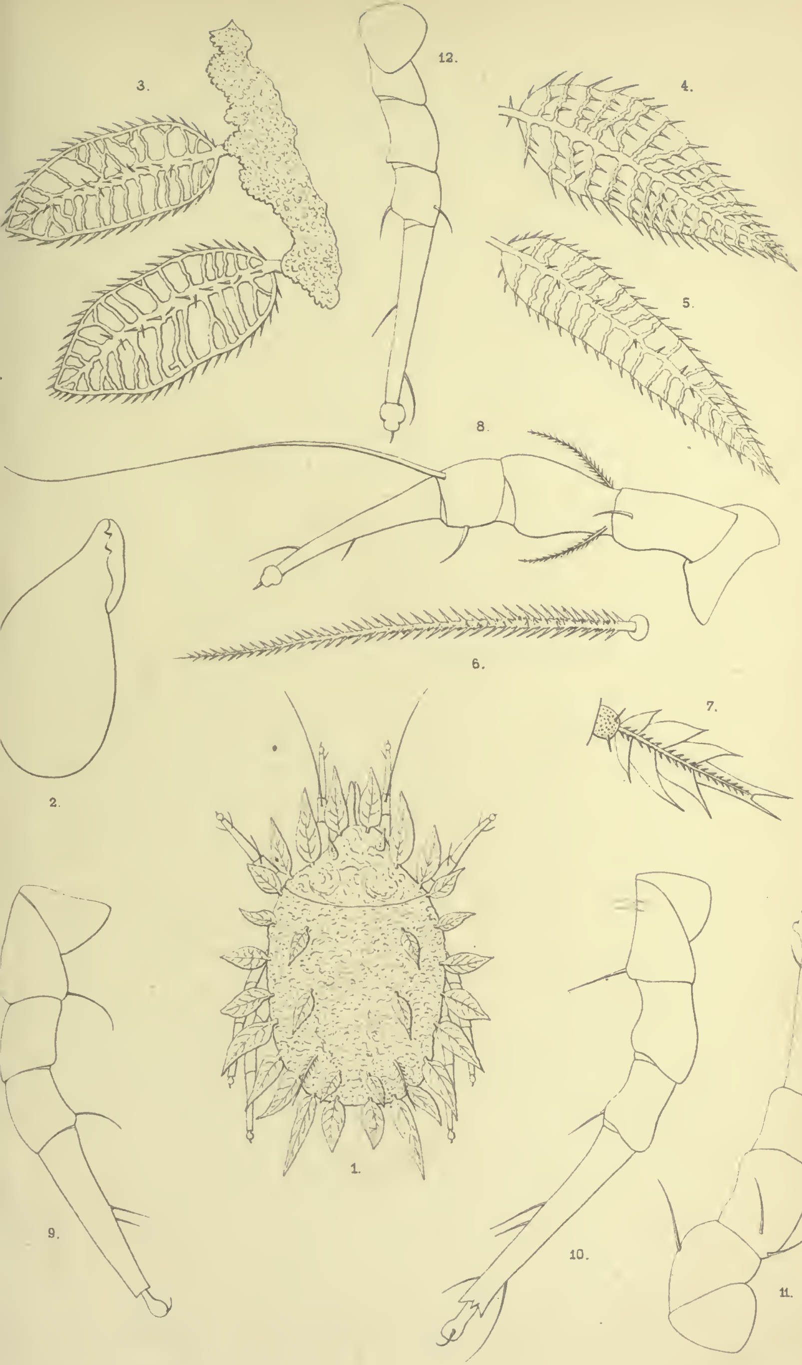
A. D. Michael ad nat. del.

G. Freytag & Berndt, Vienna.

PLATE XIII.

GLYCYPHAGUS PALMIFER, page 260.

Fig. 1. Fully-grown nymph, dorsal view, × 220.
2. Mandible of adult female, × 500.
3. Two of the palmate hairs on the edge of the abdomen of adult female, × 500.
4 and 5. Two of the palmate hairs on the notogaster of the adult male, × 500.
6. One of the pair of long non-palmate hairs on the notogaster of the adult male, × 400.
7. Pinnatifid hair from the under-side of the adult male, × 750.
8. First leg of adult male, × 400.
9. Third leg of adult male, × 400.
10. Fourth leg of adult male, × 400.
11. Second leg of adult female, × 400.
12. Fourth leg of adult female, × 400.



ichael ad nat del   P.W.M.Trap impr.   A.J.Wendel sculps

GLYCYPHAGUS PALMIFER.

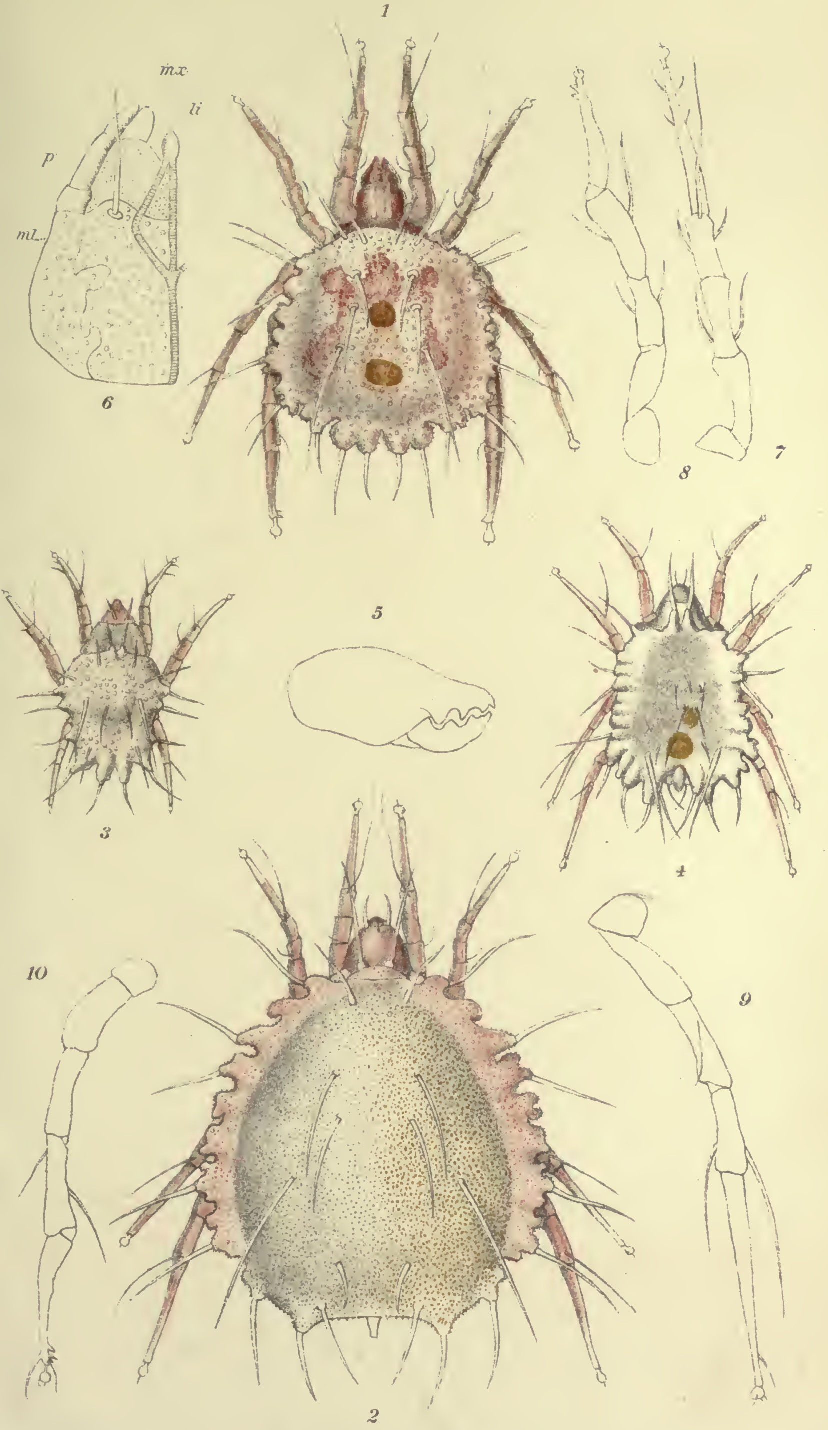
PLATE XIV.

Glycyphagus platygaster, page 265.

Length, ♀ about ·76 mm., ♂ about ·54 mm.

Fig. 1. Adult male, dorsal view, × 75.
2. Adult female, dorsal view, × 75.
3. Larva, dorsal view.
4. Nymph, dorsal view.
5. Mandible of adult male, side view, × 300.
6. Half of the maxillary lip of the adult female seen from below, × 300. The skeletal strengthening of the hypostome is seen through the integument.
7. First right leg of adult female from above, × 150.
8. Third right leg of adult male from the outer side, × 150.
9. Fourth left leg of adult female from the side, × 150.
10. Fourth right leg of adult male from the side, × 150.

PLATE XIV.



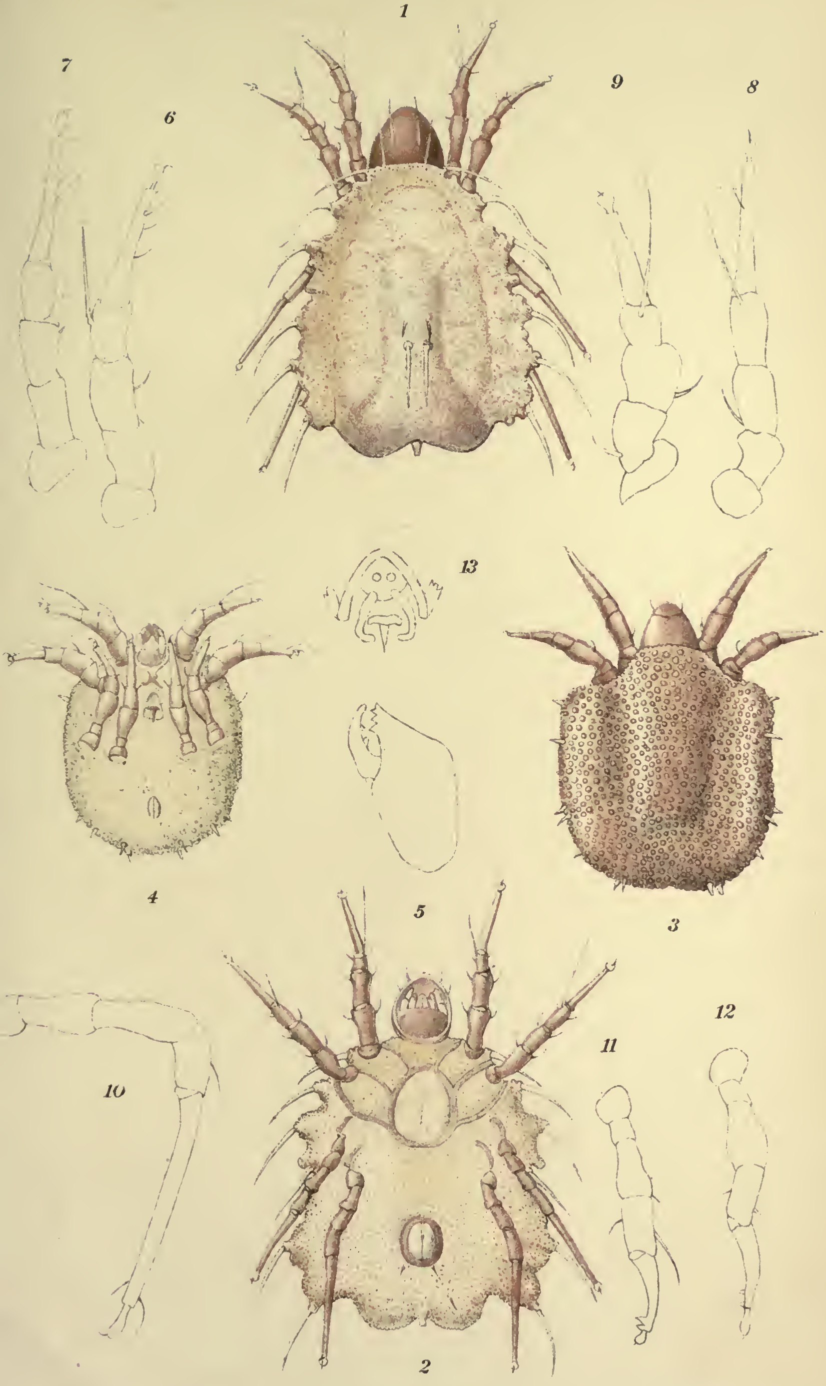
reytag & Berndt, Vienna. GLYCYPHAGUS PLATYGASTER. A D Michael ad nat del.

PLATE XV.

Glycyphagus dispar, page 271.

Length, ♀ about ·35 mm., ♂ about ·17 mm.

Fig. 1. Adult female, dorsal view, × 130.
2. Adult female, ventral view, × 130.
3. Adult male, dorsal view, × 200.
4. Adult male, ventral view, × 130.
5. Mandible of adult female, × 400.
6. First right leg of adult female from above, × 300.
7. Second right leg of adult female from above, × 300.
8. Third right leg of adult female from above, × 300.
9. First left leg of adult male from above, × 400.
10. Fourth right leg of adult female from the side, × 300.
11. Third right leg of adult male from the side, × 400.
12. Fourth right leg of adult male from the side, × 400.
13. Penis and surrounding sclerites, etc., of adult male.



GLYCYPHAGUS DISPAR.

A.D. Michael ad nat. del

G. Freytag & Berndt, Vienna.

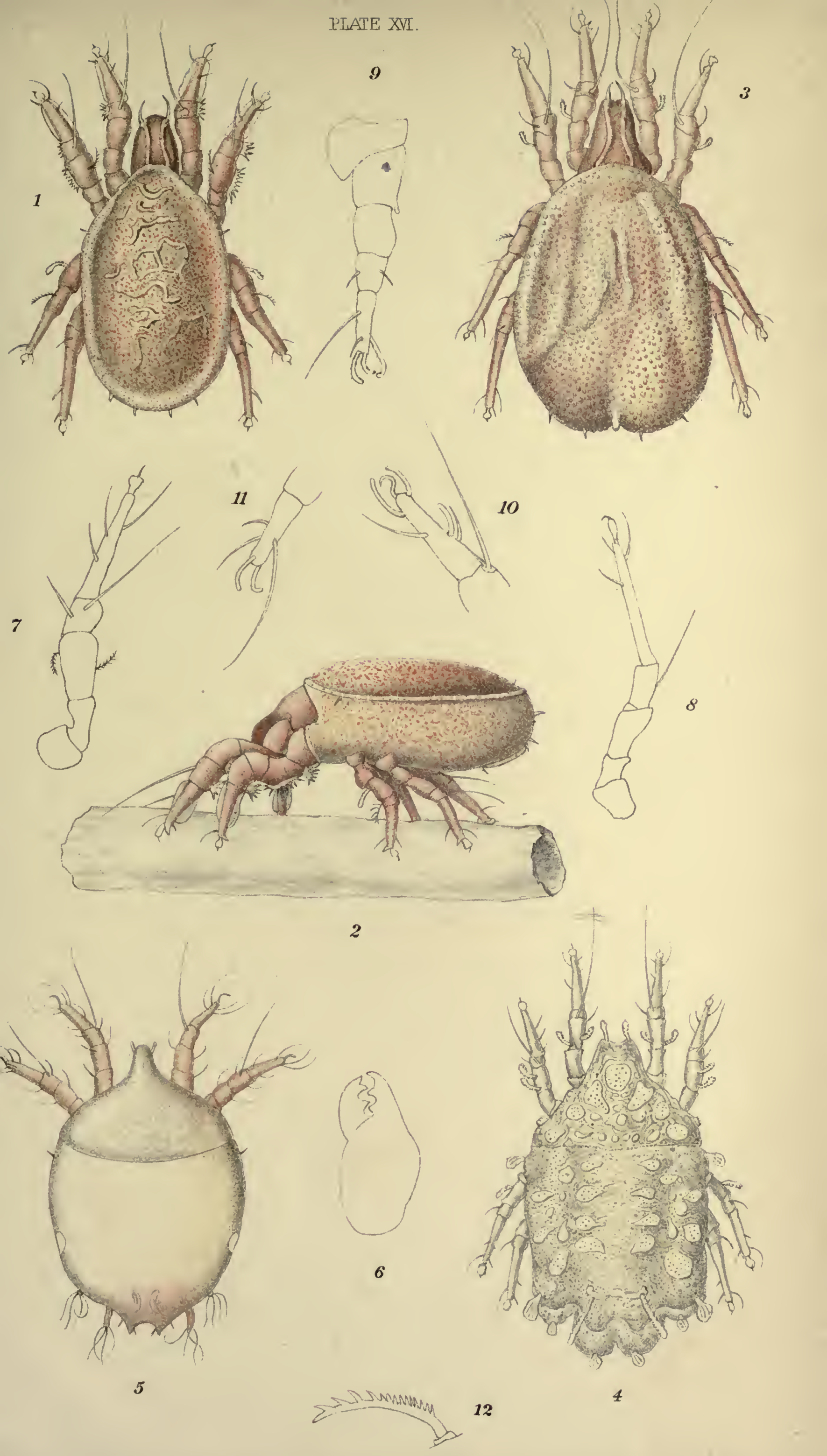
PLATE XVI.

Glycyphagus (Dermacarus) Crameri, page 275.

Length, ♀ about ·36 mm., ♂ about ·25 mm.

Fig. 1. Adult male, dorsal view, × 160.
2. Adult male, side view, × 160.
3. Adult female, dorsal view, × 130.
4. Nymph, fully grown, dorsal view, × 160.
5. Hypopial nymph, dorsal view, × 160.
6. Mandible of adult ♂, × 380.
7. First right leg of adult ♀ from above, × 200.
8. Fourth left leg of adult ♀ from the inner side, × 200.
9. Third right leg of hypopial nymph from outer side, × 320.
10. First tarsus of hypopial nymph, × 450.
11. Fourth tarsus of hypopial nymph, × 450, showing the two claw-like hairs turned upward.
12. A hair from the first leg of adult female, × 500.

PLATE XVI.



A. D. Michael ad nat. del. GLYCYPHAGUS CRAMERI. G. Freytag & Berndt Vienna.

PLATE XVII.

GLYCYPHAGUS PLATYGASTER, page 265; and G. CRAMERI, page 275.

Fig. 1. *Glycyphagus platygaster*. Part of the posterior portion of the abdomen of the ♂, × 400, to show the cuticle.

2. *Glycyphagus platygaster*. Mandible of adult ♀ seen from below, × 150.

3. *Glycyphagus platygaster*. Left palpus of adult ♀ seen from below, × 150.

4. *Glycyphagus platygaster*. Branched hair from the side of the body of the ♂ between the first and second coxæ, × 600.

5. *Glycyphagus Crameri*. Adult ♂, ventral view, × 160.

6. *Glycyphagus Crameri*. Adult ♀, ventral view, × 130.

7. *Glycyphagus Crameri*. Hypopial nymph, ventral view, × 160.

8. *Glycyphagus Crameri*. First left leg of adult ♂ from without, × 380.

9. *Glycyphagus Crameri*. Second right leg of adult ♂ from within, × 450.

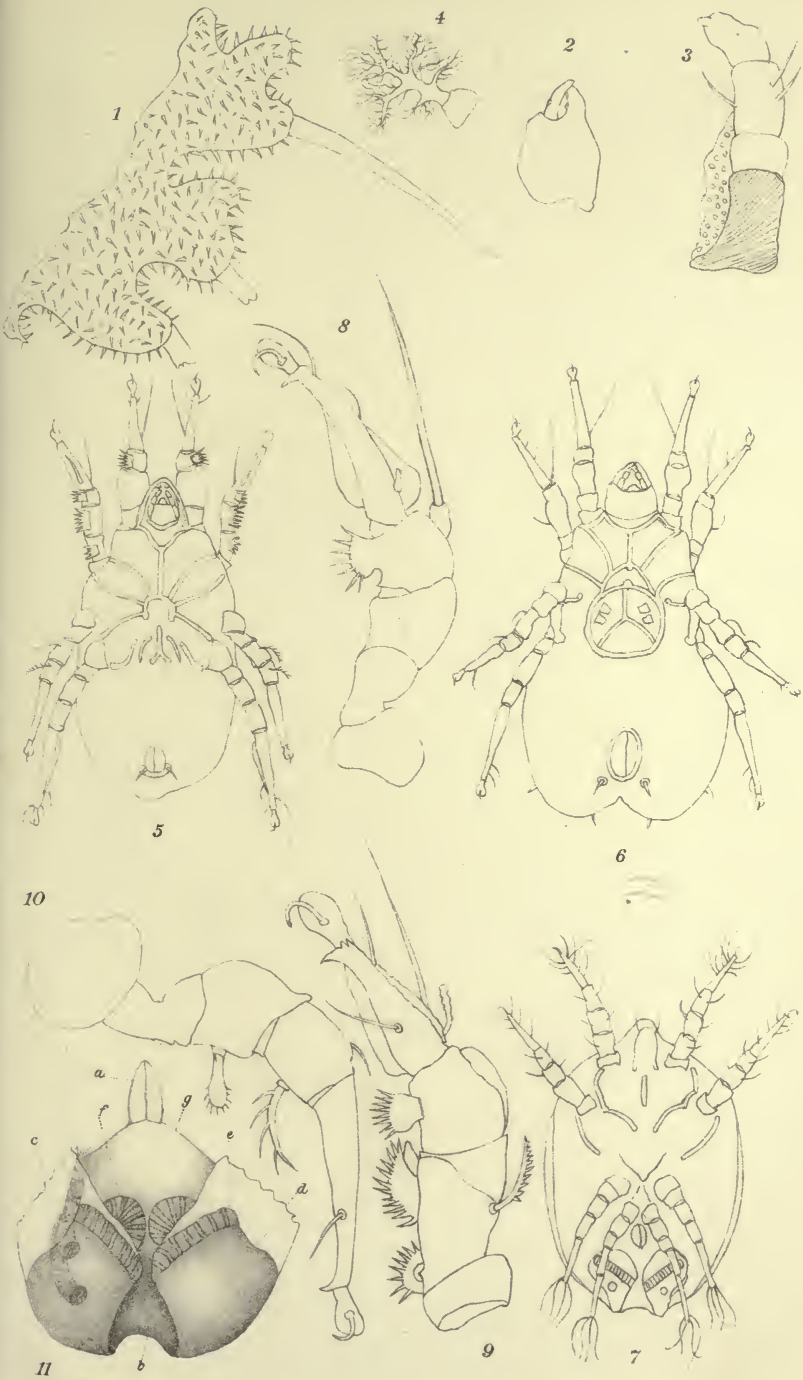
10. *Glycyphagus Crameri*. Third right leg of adult ♂ from within, × 450.

11. *Glycyphagus Crameri*. Hypopial nymph. Apparatus for holding hairs on the posterior end of the ventral surface: (*a*) anus; (*b*) channel wherein the hair lies; (*c*) large lips or wing-like processes which lie over the hair, and usually overlap each other a little when there is not any hair there (they are not drawn so for the sake of clearness); (*d*) chitinous plates on the inner side of the lips; (*e*) chitinous thickened band near the edge of the inner surface of each plate. The band has hard transverse ridges on its inner side, which in the figure are only seen in con-

sequence of the transparency of the chitin; (*f*) circular chitinous plates with radiating ridges on the underside of the abdomen; (*g*) sloping plate which serves to turn the hair, which is held, away from the anus. On the left side of the figure the retractor muscles of the lips are indicated.

Figs. 2 to 4 are copied from the author's drawings in the 'Journal of the Linnean Society;' figs. 5 to 11 from the author's drawings in the 'Journal of the Royal Microscopical Society,' by permission of those Societies.

PLATE XVII.



GLYCYPHAGUS PLATYGASTER AND G. CRAMERI.

A. D. Michael ad nat del.

G. Freytag & Berndt Vienna.

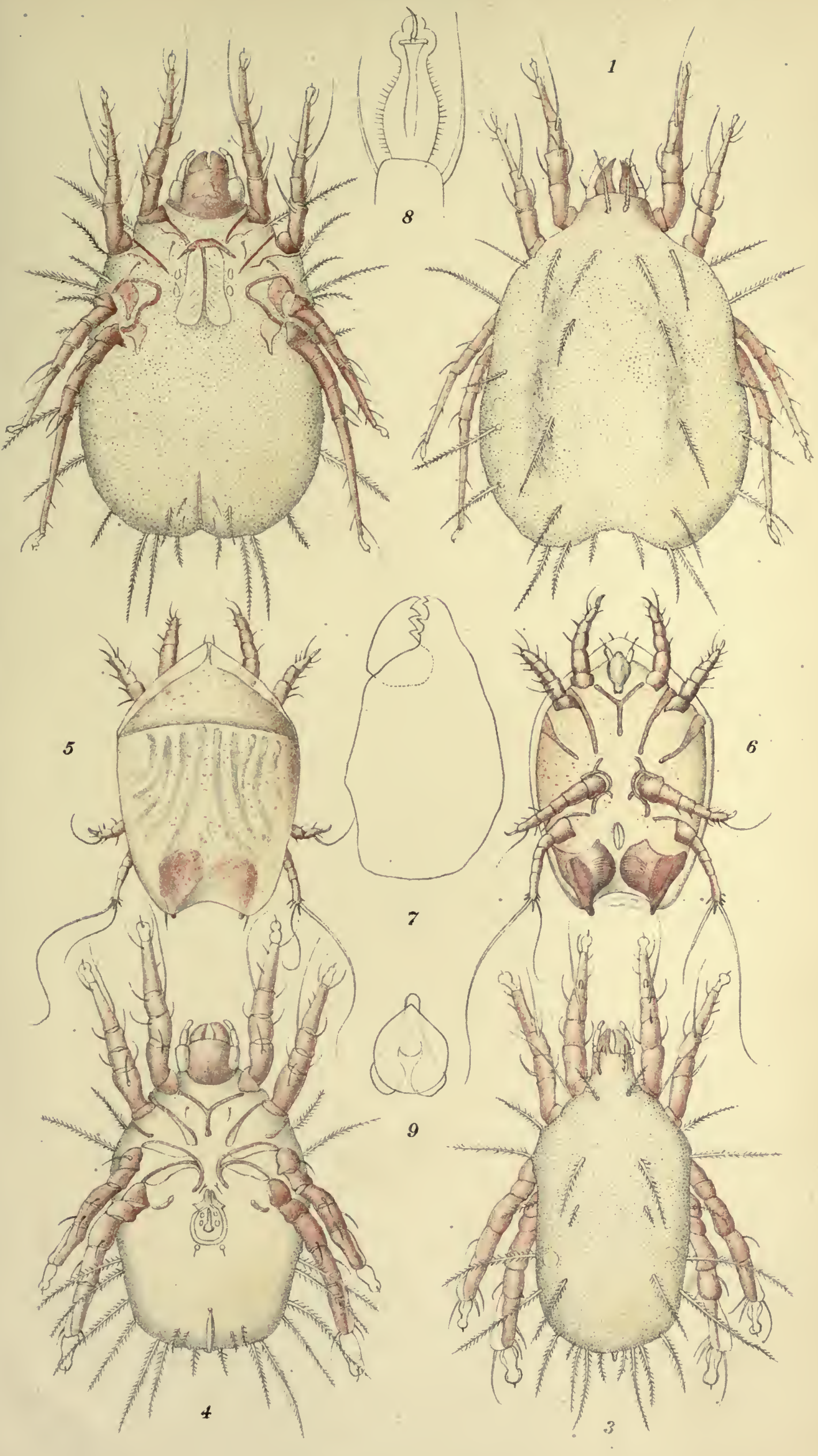
PLATE XVIII.

Glycyphagus sciurinus, page 283.

Length, ♀ about ·6 mm. to 1 mm., ♂ about ·5 mm.

Fig. 1. Adult ♀ from above, × 90.
2. Adult ♀ from below, × 90.
3. Adult ♂ from above, × 90.
4. Adult ♂ from below, × 90.
5. Hypopial nymph from above, × 120.
6. Hypopial nymph from below, × 120.
7. Mandible of adult ♂, × 380.
8. Caruncle and claw of adult ♂, × 500.
9. Lip of Hypopus, showing the mouth, a round hole, and the rostral skeleton, through; from the transparency of the lip, × 380.

PLATE XVIII.



A.D. Michael ad nat. del. GLYCYPHAGUS SCIURINUS G. Freytag & Berndt Vienna.

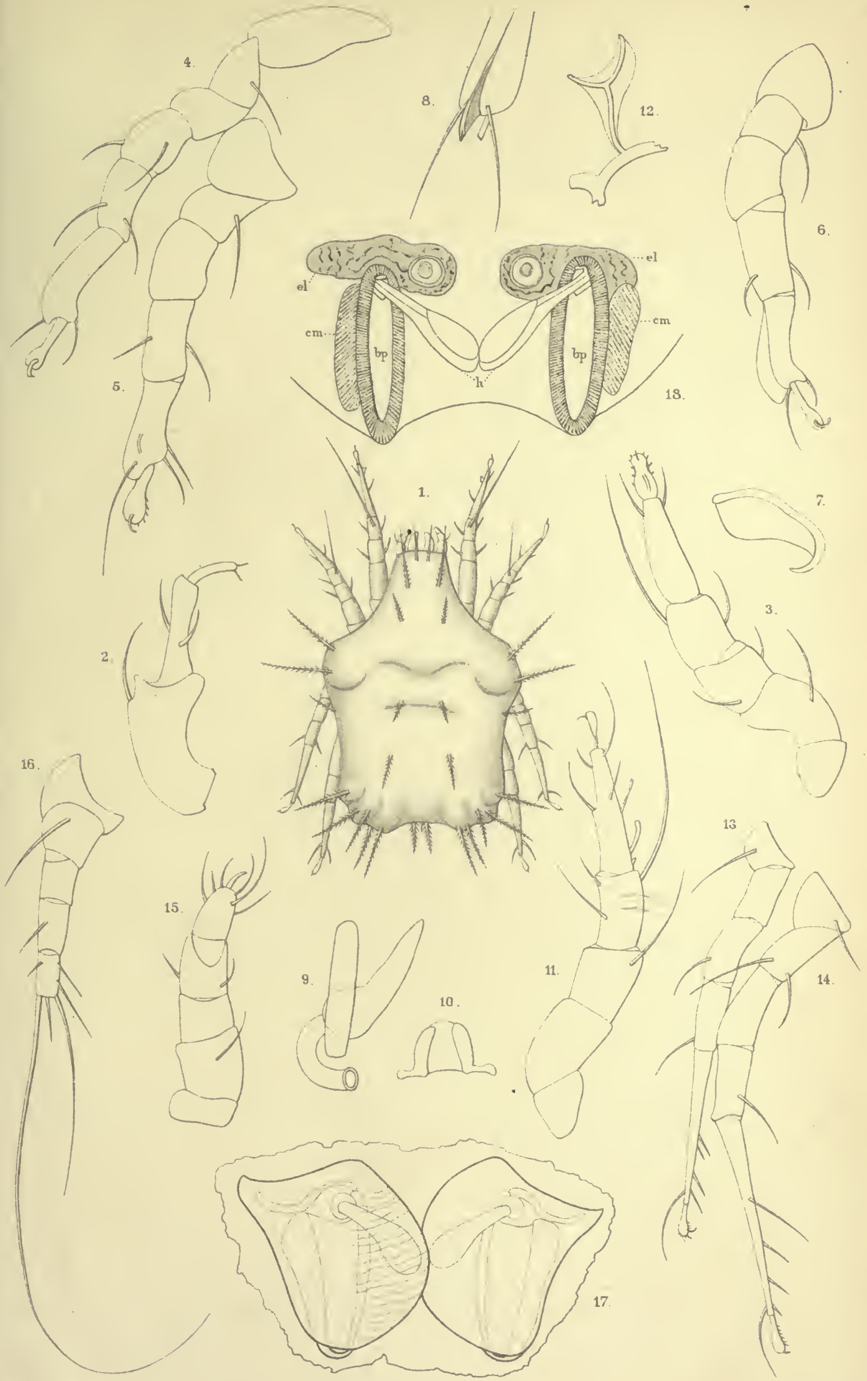
PLATE XIX.

GLYCYPHAGUS SCIURINUS, page 283.

Fig. 1. Fully grown nymph from above, × 100.
2. Palpus of adult, × 380.
3. First leg of adult ♂, × 190.
4. Third leg with epimeron of adult ♂, × 190.
5. Fourth leg of adult ♂, × 190.
6. The same leg from the inner side and below, × 190.
7. Epimeron of fourth leg of adult ♂ dissected out, × 190.
8. The so-called false claw of Haller, being the blade on the third and fourth tarsi of the adult ♂ seen from above, and therefore nearly on edge; it is attached to a portion of the tarsus; copied from Haller's drawing.
9. Penis and supporting sclerite of adult ♂, × 380.
10. Chitinous rest for distal end of penis, × 380.
11. First leg of adult ♀, × 190.
12. Epimeron of same leg dissected out, × 190. It is joined to a broken portion of the chitinous ring surrounding the genital aperture; this forms the lower part of the figure.
13. Third leg of adult ♀, × 190.
14. Fourth leg of adult ♀, × 190.
15. First leg of hypopial nymph, × 380.
16. Fourth leg of hypopial nymph, × 380.
17. The plates at the posterior end of the ventral surface of the hypopial nymph for holding the hairs of the squirrel, seen from below, × 380. The undulating lines on the plate on the left side of the drawing (true right of the creature) are ridges on the inner surface of the plate; they are omitted on the right side of the drawing for clearness; they press against other ridges on the ventral surface,

not shown in the drawing. The other apparatus is seen through the plates.

Fig. 18. Copied from Haller's drawing of the apparatus below the plates after the plates have been removed. The parts marked with diagonal or transverse lines are chitinous, and are coloured red in Haller's drawing. Haller's explanation of the figure is—(*bp*) space left by the cutting away of the plates which commenced here; (*h*) spoon-shaped hair; (*cm*) chitinised muscle; (*el*) excretionary pockets. —As to the correctness of this see page 291.



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GLYCYPHAGUS SCIURINUS.

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