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# MONOGRAPH

OF THE

# BRITISH APHIDES.

## VOL. IV.

BY

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*Ψύλλαι μὲν μικραὶ μάλα μυρίαι, αὐτὰρ ἑκάστην*
*δάκνει ψυλλιδίων μικροτέρων ἀγέλη·*
*ψυλλιδίων γενεὰν ἕτερ' αὖ πολὺ μείονα δάκνει*
*Ψυλλίδι·· οὐ λήγει πρᾶγμ' ές ἄπειρον ἰόν.—*
*Μελεάγρου, ὡς δέ τινες, Στρεψιάδου·*

LONDON:
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MDCCCLXXXIII.

TO war with falsehood to the knife,
And not to lose the good of life.

*   *   *   *

As far as might be to carve out
Free space for every human doubt,
That the whole mind might orb about.

*   *   *   *

To search thro' all I felt or saw,
The springs of Life, the depths of awe,
And reach the law within the law.

TENNYSON—*The Two Voices.*



PRINTED BY J. E. ADLARD, BARTHOLOMEW CLOSE.

# PREFACE.

On introducing this concluding volume to the reader, I tender my sincere thanks to the Members of the Council of the Ray Society for undertaking the publication of my Monograph, and for the courtesy which they have shown me in fulfilling my wishes as to the form it should assume.

Prof. Helmholtz well remarks that "The materials of a monograph must be united by a logical process; and the first step is to connect like with like, and to elaborate a general conception embracing them all." Again, elsewhere, "A digest or catalogue may be likened to a good lexicon; with which almost a tyro of the present day can achieve results in the interpretation of the classics, which an Erasmus, with the erudition of a lifetime, could hardly attain."

Some may perchance think that this Monograph has attained proportions unnecessarily large. The general reader, on the one hand, may take exception to its detail. The competent biologist, with more truth perhaps, may complain of omissions as well as commissions. The first may call to remembrance and apply the causticity of Montaigne when he says, "The trade of the rhetorician is to make things appear and seem great, just as a shoemaker can make great shoes for little feet."

An attempt has been made so to blend the life-history of Aphides with their morphology, as to render the subject not wholly uninteresting to the general reader, and yet to furnish details necessary for the systematist: but the latter may reasonably ask that the facts shall not be put before him in a form unnecessarily dry.

The depths of Biology are as unfathomable as those of any other science. The long list of authors I furnish at the end of this volume, though far from exhaustive, will show how much attention has been already paid to this group of insects; and yet I am sensible of many omissions, and that much has yet to be discovered with reference to my subject. It would almost seem that more may be written on this one single insect family than on the life-history of a family of the carnivorous Vertebrata;—we may instance the Felidæ. Indeed, several years' study is required to produce a complete life-history of some insects, and they may require special treatises to exhaust the subject.

Through the kindness of M. J. Lichtenstein, I am enabled to give a short but compendious history of the grape-vine pest, *Phylloxera vastatrix*. His researches and familiarity with the whole tribe will make his observations acceptable to all.

Although not strictly within the province of a treatise on British Aphides, a chapter has been devoted to the question of the general existence of Aphides in early geological times. The author has freely consulted several important memoirs of Prof. Oswald Heer, and also his valuable treatise on the 'Primæval World of Switzerland.' Much help has likewise been obtained from Mr. Samuel Scudder's numerous published papers on Fossil Insects; particularly from those sections bearing on the fossil Aphides found in the beds of the Florissant basin of Colorado. This gentleman has most liberally allowed me to draw from some of his plates which have not yet been published. Although these forms are American, they have characters almost identical with our recent European genera.

To these sections I have also added a short account of some of the Aphides which have been included in masses of amber.

The author trusts that the preliminary remarks of this and the preceding volumes will be a sufficient acknowledgment of the sources from which much of his information has been drawn.

Towards the close of this volume I have thrown together some of the principal known facts relating to the reproduction and embryology of Aphis; and by way of introducing this subject, I have attempted a sketch bearing on the general growth of the ovum of insects. I wish here to acknowledge my indebtedness to the works of Dr. Allen Thomson, Professors Huxley, Forster, and Balfour, Ray Lankester, Ernst Haeckel, Dr. A. Brandt, E. Balbiani, and others. The late Prof. Balfour's recent treatise on 'Comparative Embryology' is a mine of wealth to all biologists.

In my former volumes I expressed, as strongly as I was able, my obligations to many friends; and I will not here repeat my thanks. One gratification in the study and illustration of natural phenomena is a continual growth of genial correspondence with those of kindred thoughts and tastes.

I must here, specially offer my thanks to Prof.

Huxley, who kindly made some valuable criticisms on reading my proofs on the 'Morphology and Reproduction of Aphis;' and also to Prof. Thomas Wiltshire and Prof. Rupert Jones, both of whom have suggestively helped me to get all my four volumes through the press.

The subscripture to the Greek verse on my title page is very obscure: and it will invite and test the ingenuity of many, as to whether the author be ancient or modern.

Recently I have received from an anonymous writer, who shrouds himself in euphonious but somewhat "stiff" Greek, a witty suggestion as to the vexed derivation of Linneus' word Aphis. It may be fairly *inferred* that both these effusions are the product of the same, or of kindred spirits.

*Ὁ δοκιμώτατος τῆς βασιλικῆς ἑταιρείας σύνεδρος Βύκτων πολλὰ καὶ μνήμης ἄξια περὶ τῶν ἀφίδων εἴρηκεν, ἃ μέντοι περὶ τοῦ ὀνόματος στοχάζεται οὐ παντάπασι πιθανά, τὴν δὲ ἀληθῆ ἐτυμολογίαν παρὰ τῶν παλαιῶν τινὶ ἔστιν εὑρεῖν, ὃς ἐν τοῖς θηριακοῖς οὕτω γράφει·*

*Πραξινόης ὁμόλεκτρος ἀνὴρ τρισκαιδεκάπηχυς*
*νηπιάχου παρεόντος ἐφημίσθη καλὸς ἀπφύς·*
*ἀλλ'ἐμὲ τόνδε σέβεσθε φίλοι πολύ καλλίον' ἀπφύν,*
*ἧ γὰρ ἐγὼ ψυλλῶν αὐτοσπόρος ἐιμὶ πρόπαππος,*
*πρώταρχος δὲ πέφυκα προάνθρωπος προσέληνος,*
*παρθένος ἠίθεός τ', οὐδὲν χατέων 'Αφροδίτης,*
*ψυλλίδι' ἐκ ψυλλῶν ἐκ ψυλλιδίων τε φυτεύων*
*μυρία μυριάκις τίκτω, τὰ δὲ τέκν' ἐπιτίκτει*
*μυριάκις πολλαπλάσιον γένος, ὧνπερ ἕκαστον*
*θρέπτρα τοκεῦσι φίλοις λαμυρούς ἐνέπηξεν ὀδόντας*
*ὀψίγονον προγόνοισι, τὰ μείονα δ' ὁπλότερ' ἀλκὴν*
*μείζοσι πρεσβυτέροις ἰσάζεται, ὥστ' ἐς ἄπειρον*
*δάκνον δακνόμενον δακέων δάκος οὔποτε λήγει.*

*φῦλον δ' ὠμοβόρον καὶ παμφάγον, ὡς Ἐρυσίχθων,*
*οὐ μόνον ἀλλήλων ἀλλ' ἀνδρόμεον χρόα δάπτει*
*αἱμοβαφῆ, καὶ καρπὸν ἀπείρονα γῆς ἐριβώλου·*
*τοσσῆς δ' ἀκαμάτου προπάτωρ ἀμάχοιο γενέθλης*
*ἆρ' οὐ πᾶσι σεβαστὸς ἐγὼ μάλα πάγκαλος ἀπφύς;*
*ἐξ ἐμέθεν δ' ἀφίδες πορθήτορες οὔνομ' ἔχουσι*
*νῦν ἔτι, πῆμ' ἀλίαστον ὀϊζυροῖσι βροτοῖσιν.*

The identity and unity of phenomena connecting the higher with the lower forms of living animals, is now too well acknowledged to want urging; yet the words of Léon Dufour may be quoted in conclusion as apposite.

"Ce n'est pas seulement à rechercher et à connaître les productions naturelles qui par leur grandeur sont à la portée facile de ces sens, que l'homme avide d'instruction doit consacrer ses soins et ses loisirs; il trouvera des sujets tout aussi dignes de son culte, dans les êtres qui par leur petitesse occupent les derniers degrés de l'échelle organique et semblent défier son attention. . . . . L'éléphant massif, l'orgueilleux *Vir sapiens*, n'ont pas plus couter au Créateur, que l'impalpable byssus . . . . et la punaise."

WEYCOMBE, HASLEMERE;
*March 7th*, 1883.

# BRITISH APHIDES.

## VOL. IV.

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## GENERAL SYNOPSIS.

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## Genus XXVIII.—THELAXES, *Westwood.**

Plattlaus.

Rostrum long, reaching to the third coxæ. Second joint very long and thin, third joint thickened, the last pointed.

Antennæ rather short, five-articulate, if the nail-like terminal process be not counted. The third joint equal to the two following, taken together. Cornicles wart-like and very short. Wings carried horizontally, and folded one over the other when at rest. Upper wing with a single furcated cubital vein, the other veins as in Pemphigus. Lower wing has only one single oblique vein, springing from the cubitus.

The eyes in the apterous forms are rudimentary. Kaltenbach points out that they are very small, and that they want the tubercle.

Von Heyden's genus Vacuna has been so generally received by Continental authors that some may feel regret that any change should be made in the name. However, it now seems granted, as a general rule, and in fairness, that priority in descriptions of genera shall decide between rival names.

Prof. Westwood by some years has precedence over Von Heyden, and therefore I adopt his nomenclature as above.

* From θηλάζειν, to bear mammæ, alluding to the papilliform nectaries.

THELAXES DRYOPHILA, *West.* Plate CXV, figs. 1—7.

*Vacuna dryophila*, Heyd., Kalt., Koch, Pass., Licht.
*Aphis dryophila*, Ratz., Schr.
*Vacuda*, Amyot.
*Cinara quercûs*, Sir O. Moseley.

*Apterous viviparous female.*

*Queen Aphis.*

| | Inch. | Millimètres. |
|---|---|---|
| Size of body | 0·090 × 0·055 | 2·28 × 1·39 |
| Length of antennæ | 0·035 | 0·88 |
| Cornicles | 0·005 | 0·12 |

Oval, flat; olive-brown, greenish, or chestnut-brown. Rings of the body well marked; a pale yellowish streak, commencing at the head with diminishing distinctness, passes down the dorsum to the apex; five dark pore-marks, each surrounded by a pale ring, occur on both sides. Nectaries wart-like, pale, and inconspicuous. Legs and antennæ brown. Eyes very small, and divested of the usual tubercle; the optical facets, which number only five or six, are set far back on the head. Antennæ about one-third the length of the body; five-jointed, the third joint much the largest. Body slightly pilose. Rostrum rather short, but this organ is longer in the younger forms.

The queen Aphis or fundatrix is, as usual, much larger than her offspring.

*Pupa.*

| | Inch. | Millimètre. |
|---|---|---|
| Size | 0·060 × 0·030 | 1·52 × 0·76 |

Small, green or yellowish, with a pinkish hue towards the head; slightly mealy, with two pale streaks down the sides; sometimes these streaks are broad and dark.

Wing-cases, antennæ, and legs pale. Eyes distinct.

*Winged viviparous female.*

| | Inch. | Millimètres. |
|---|---|---|
| Expanse of wings | 0·150 | 3·80 |
| Size of body | 0·055 × 0·020 | 1·39 × 0·50 |
| Antennæ | 0·025 | 0·63 |
| Nectaries | 0·005 | 0·12 |

Head and thorax pitchy brown or shining black. Prothorax paler. Abdomen oval, shining green, more or less mottled. Cornicles brown and very small. Legs green, and of moderate length. Wings moderate, and folded horizontally; bronzed and highly iridescent. Their apices rounded. Eyes and ocelli reddish and fully developed.

The colours of this insect are very inconstant. Koch describes and figures two marked varieties, one brown, with yellowish legs, the other with a vermilion-red prothorax and abdomen. The rostrum is long and reaches beyond the first body-ring.

The sexes of this species are minute. They occur late in the year, and are most plentiful during November and December. The male is apterous, and about two-thirds the size of the female. Doubtless from its smallness it was long overlooked or disregarded.

Both sexes are distinctly rostrated at their *early stages*, but possibly they lose these organs at a subsequent moult, since the Continental specimens are described as mouthless. All the males under my observation have been apterous, like the oviparous females.

*Male.*

| | Inch. | Millimètre. |
|---|---|---|
| Size of body | 0·020 × 0·010 | 0·50 × 0·25 |
| Antennæ | 0·015 | 0·38 |

Oval. Colour lemon-yellow. Antennæ sooty grey.

Abdomen greenish, with a double row of dorsal spots. Antennæ and legs rather long.

Taken in copulâ with the following.

*Oviparous female.*

Oval, wholly dingy green, with brownish stains and streaks passing behind the eyes and over the thorax. Abdomen with four rows of brown spots, and seven smaller dots on each side, marking the sites of certain pores other than the stomata, which last are placed on the inferior surface of the body. Legs and antennæ short. The abdominal cavity of the specimen described was almost entirely occupied by *two* large yellow eggs, the safe delivery of which is a mechanical marvel.

| | Inch. | Millimètre. |
|---|---|---|
| Length of body | 0·035 × 0·020 | 0·88 × 0·50. |
| Antennæ | 0·020 | 0·50 |
| Cornicles | None. | |

The prevalence of Thelaxes in England is variable both as to quantity and locality. Some years it is very abundant, whilst in other years it is difficult to find. In the late spring of 1871 many twigs and young shoots of *Quercus sessiliflora* growing round Haslemere were infested by many thousands of larvæ crowded round the queen-mother. For several years afterwards I failed to discover any trace of the species on these oaks. In June, 1881, Mr. Foran kindly furnished me with examples taken on *Quercus robur* near Eastbourne. They were sparsely scattered over the flowers of this oak. The winged form, he told me, was infrequent, but the large queen-Aphides continued throughout July adding to the population of their respective colonies. The species is not uncommon in Epping Forest, and at Southgate.

The wings of the parthenogenetic females are often of a rich violet, with a metallic sheen.

The venation is subject to remarkable variations, the nervures increasing in number and complication so as almost to suggest a dimorphic character. Representation of these anomalous forms may be seen in Plate CXVII *bis*, figs. 7, 8.

At Montpellier, Thelaxes would *seem* to show migratory habits, like Phylloxera. In summer the parthenogenetic forms give rise to the agamous generations on *Quercus ilex*; and in December these winged individuals give birth to the sexed insects on *Quercus pubescens*. In the month of November M. Lichtenstein sent me living examples of the oviparous female; each was burdened with a large egg ready for laying. In no case amongst these could I find that the female had more than one egg, yet there appeared to be no difference between the French and English insects.

In my description of the Genus Callipterus,* notice was taken of Prof. Huxley's memoir on the 'Reproduction of Aphis.'† In the former an opinion was stated that the anatomical details ascribed, in that memoir, to *Vacuna dryophila* should be applied to *Callipterus quercûs*. In so expressing myself, it seems to be incumbent on me to give reasons, and here I offer the following in substantiation of my views.

As the true males and females of *Siphonophora pelargonii*, the kind previously used for dissection, could not be detected at that time feeding on the ivy-leaved geranium, Prof. Huxley selected a different species of Aphis for his study, and he found an oak in the Zoological Gardens "infested with multitudes of females, full of ova, and also similar ova adhering to the plant in the axils of the leaves, and more particularly between the outer bracts of the buds." In a note Prof. Huxley says that he does not think that his Aphis is identical with that described by Réaumur as feeding on the oak, or that of Bonnet. "None of the specimens attained the size of theirs, neither do they mention the peculiar dorsal marking

* 'Mon. Brit. Aphides,' Ray Society, vol. iii, p. 23, 1881.
† 'Trans. Linn. Soc.,' xxii, 1858.

of the newer insects. Also the proboscis of both Réaumur's and Bonnet's Aphides was very long, whilst the others (those under examination) had very short rostra."

Probably Réaumur's insect here alluded to is either *Stomaphis quercûs* or *Lachnus longipes*; but their great size, &c., compared with "$\frac{1}{12}$ of an inch," would exclude them altogether from identity.

The reader is referred to Prof. Huxley's memoir* for a full description, but the same abstracted appears thus:

Size $\frac{1}{12}$ of inch. Pale green, with four rows of blackish rounded spots; the spots in the medial line larger than the rest, each spot raised above the integument, and furnished with tufts of long, knobbed, glandular hairs. Eyes red, with small tubercles. Antennæ about equal to the body, annulated, and seven-jointed; the proximal half setose. Promuscis† [proboscis] short, extending only to the prothoracic sternum. Abdomen terminated by two rounded anal valves.

The small size, the four rows of rounded spots tufted with capitate setæ, the eyes (not "small") furnished with tubercles, the short rostrum, the long seven-jointed antennæ, the anal valves, and the numerous true ova, leave no doubt on my mind that these descriptive details belong to *Callipterus* rather than to *Vacuna*.

If the winged female had been described in the Memoir, no doubt could have arisen as to the genus and species under dissection. It may be also noted that the minute size of the oviparous female of Thelaxes is not so convenient for examination of the internal organs as the larger female of *Callipterus quercûs*. I believe that, if *Callipterus quercûs* be substituted for *Vacuna dryophila* in the Memoir referred to, the

* Prof. Huxley, "The Agamic Reproduction of Aphis," 'Linn. Trans., 1858, pl. iii. p. 202 *et seq*.

† Unless this word is derived from the unlikely word promo, it would appear to have arisen from a printer's error for proboscis. As "promuscis" has been copied by others, I make no alteration, but only a suggestion.

value of the observations will remain intact; and this substitution I would suggest to the author of the paper.

Kaltenbach, in describing the genus Vacuna, states that the winged females seldom make their appearance, and then only late in summer, and that *these lay eggs:* further he remarks that in this respect Vacuna resembles the genus Phylloxera.*

Again, he says the winged forms appear at the end of August in insignificant numbers, and that then they may be found sitting under the leaves, surrounded by eggs in concentric circles. This is true of *Phylloxera quercûs*, but the fact may be doubted as to Thelaxes (Vacuna); at least no winged female Aphis has yet been shown to be truly oviparous.

The galls on the leaves of the oak are occasionally tenanted, not only by Cynipidæ, but also by the larvæ of *Thelaxes dryophila.* These Aphides take no part in forming such "*oak-apples*"; but they seek shelter and hide in their recesses, chiefly for the large quantity of sap collected in the masses. In Italy Passerini† has noticed the same habit. "Occurrit in quâdam gallâ turbinato-calyciformi quercûs," &c.

Aphides have also been observed to nest within certain galls on the evergreen oak, *Quercus ilex*, near Florence.

Some of the Hemerobiidæ prey on the larvæ, and the eggs are greedily devoured by a species of Scymnus. Mr. J. Walker counted upwards of one thousand larvæ of Thelaxes under one oak-leaf in the Isle of Man. This large number was reduced to ten individuals within the space of two days through the voracity of one single Scymnus caterpillar.

I here add a few remarks on the general anatomy of *Thelaxes dryophila.* The alimentary canal is short and

* "In der Fortpflanzungsweise scheinen sie der Gattung Phylloxera nahe zu stehen, mit der sie auch die eigenthumliche Flügelläge gemein haben." Kalt., 'Mon. der Pflanzenläuse,' p. 177.

† Pass., 'Aphid. Italicæ,' p. 83.

but little convoluted in the apterous larva, but in the winged female it is bent into a loop at the lower part of the abdominal cavity before it descends into the rectum.

The viviparous females develop twenty or more embryos, which, at the breeding time, differ greatly in size, according to their maturity. These embryos show red eyes, each compounded of three or four simple lenses. These fœtal eyes are quite as large as those borne by the full-grown insects; thus showing that an arrest of growth as to the eyes occurs during the larval states. It is only after the insect has assumed wings that the complex eye with its ocellus and the stemmata are fully developed.

Behind the three lenses of the apterous female I have more than once discovered a mass of red rods and cones radiating from a centre. These bodies constitute the sensitive terminations of the fibres in communication with the optic nerve.

The nectaries of the winged female, although very short, have large expanded mouths and long internal tubes, which decrease in diameter, and finally end in transparent ducts. These apparently do not anastomose with any viscus, but seem lost in the general fluids of the body. The ducts are directed towards the anal ring; but whether they have any function analogous to ureters it is not easy at all to decide. Similar ducts may be noted in other genera as well as in Thelaxes.

The reproductive organs of the oviparous female are well suited for dissection. They will be described in the anatomical chapters at the conclusion of this volume.

## Genus XXIX.—GLYPHINA, *Koch.**

### Kerblaus.

Rostrum shorter than in Thelaxes.

Antennæ ~~five~~-jointed, nail-like process somewhat long. Cornicles wart-like. Legs moderate, but very short in the larvæ.

Wings longer, narrower, and more pointed than in Thelaxes. Upper wing with an unforked cubital vein, which does not anastomose with the cubitus. Hind wing with an oblique vein. Stigma long and knife-shaped.†

N.B.—The wing-veining, as in Thelaxes, is liable to variation. In some specimens a very faint tendency to show a forked cubitus may be traced. Koch describes but one species, viz. *G. betulæ*, which, though like the following insect, cannot be identical with it. His figure of Glyphina shows, as above, three simple oblique veins, without any furcation; but Passerini regards this character as abnormal, and not generic.

"Alata præbit cubitum haud furcatum, quod interdum exceptione observatur."‡ I would suggest that the "exception" is rather the rule. Such a character of venation will also better accord with all other Chermesinæ. Under this tribe he places Vacuna, which he considers identical with Thelaxes.

Mr. Monell's new American genus Colopha has much in common with Koch's Glyphina, but nevertheless the insects must be distinct. The cubital vein only once forked, allies the insect (which some have thought to be identical with *Schizoneura compressa* of Koch) to Thelaxes; but the strongly-ringed antennæ,

* From γλύφανον, a surgeon's knife, a scalpel.
† "Messer-formig," Koch, p. 259.
‡ Passerini, 'Aphididæ Italicæ,' p. 83.

the form of the wings, and the clouded inner margin of the stigmata, show some accord with Glyphina.

Glyphina pilosa, *Buckton*. Plate CXVI, figs. 1—4.

*Apterous female.*

| | Inch. | Millimètre. |
|---|---|---|
| Size of body | 0·070 × 0·040 | 1·77 × 1·01. |
| Length of antennæ | 0·040 | 1·01. |

Body oval, globose. Dark olive-green or blackish, pilose, and flecked with white down, which is most plentiful on the apical rings. Eyes dark brown. Cornicles black, and inconspicuous. Legs stout, pale olive-green, tarsi long, rostrum rather short. The down on this insect is pale greenish.

Numerous during some seasons at Haslemere, on the Scotch fir, throughout the months of July and September. Mr. Walker sent me specimens feeding on *Pinus sylvestris* at Southgate, all of which in the alate forms showed the non-furcated cubitus. He supposed the insect to be *Lachnus pineti*, Kalt., which, however, has distinctly a double furcation in the upper wing.

*Winged viviparous female.*

| | Inch. | Millimètres. |
|---|---|---|
| Expanse of wings | 0·229 | 5·74. |
| Size of body | 0·070 × 0·035 | 1·77 × 0·88. |
| Length of antennæ | 0·030 | 0·76. |

Body rather linear. Head and thorax dark brown and shining. Abdomen smooth, carinated, oval, greyish drab. Hind legs long. Wings long and narrow, fuscous, and somewhat wrinkled, dull. Insertions, cubitus, and stigma pale greenish. The other veins are pale ochreous and usually very indistinct. The third or cubital vein unforked, and often it does not anastomose to the cubitus. Stigmatic vein straight, and leaves the stigma at about an angle of 45°. Stigma long and pointed.

Koch has described an insect under a new genus, Mindaurus or Mindarus, which has some characters in common with *Glyphina pilosa*, but this last Aphis, nevertheless, does not agree with his *Mindarus abietinus*, notwithstanding their similar habitats.

GLYPHINA BETULÆ, *Heyd.* Plate CXVII, figs. 1—5.

*Vacuna betulæ* Heyd., Kalt., Ratz.
,, *alni*, Pass. (?)
*Thelaxes betulæ*, Walk.
*Glyphina betulæ*, Koch.
*Tremulinax*, Amyot.

*Apterous viviparous female.*

| | Inch. | Millimètres. |
|---|---|---|
| Size of body | 0·090 × 0·040 | 2·28 × 1·01 |
| Length of antennæ | 0·015 | 0·38 |

Oval, flat, dark green, with a pale dorsal streak, and a row of disjointed white spots down the sides. Antennæ very short and partially developed. Rostrum and legs short.

Pupa smaller than larva, with rounded head, large eyes, and longer legs.

*Winged viviparous female.*

| | Inch. | Millimètres. |
|---|---|---|
| Expanse of wings | 0·240 | 6·09 |
| Size of body | 0·090 × 0·030 | 2·28 × 0·76 |
| Length of antennæ | 0·030 | 0·76 |

Body long-oval; head round; antennæ short, third joint the longest. The fourth, fifth, and sixth joints about equal. All joints are deeply ringed. Thorax brownish. Abdomen olive-green. Legs moderately long, yellow-green. Wings long, very hyaline, with pale-yellow veins and greenish stigmata. These have darker inner margins. Cubital vein without any fork. It does not anastomose with the cubitus, but is cut short as in Schizoneura. Third and fourth veins proceed almost from the same point of the cubitus. Lower wing with a single faint oblique vein.

The ringed antennal joints are not noted by Koch, but Kaltenbach describes Vacuna as always annulated in these organs, "alle zärt geringelt," and gives a rough figure in accordance with this character.

Passerini considers *Vacuna betulæ* to be identical with *V. alni*, which, in Italy, infests the ends of the branches of *Alnus incanus*.

*Thelaxes betulæ* is noted by Walker in his 'Cat. of Hemipt.,' vol. iv, p. 1052. Elsewhere he says, "it is sometimes common in the Isle of Man."

# IV.

## CHERMESINÆ, Pass.

UPPER WING WITH THREE OBLIQUE NON-FURCATED VEINS.

UNDER WING WITH A SINGLE OBLIQUE VEIN.

## CHERMESINÆ.

This tribe is limited as to species, but it contains several insects of interest. The simple character of their wings separates them from the foregoing Aphides, and brings them nearer to the Coccidæ, to which also the larvæ approximate in form, and somewhat also in habit.

Some kinds are bark-feeders, some are gall-makers, some inhabit tufts of woolly matter spun from their bodies for concealment, and others, like Phylloxera, have aerial and subterranean habits combined in the same individual.

## Genus XXX.—CHERMES, *Linn.**

### Tannenlaus.

Rostrum very short and stout. The setæ prolonged sometimes twice or thrice the length of the whole insect.

Antennæ short, stout, five-jointed, and terminated by a minute button usually furnished with bristles. The third, fourth, and fifth joints nearly equal. The first and second shorter.

Cornicles wanting.

Head and prothorax disproportionately developed. Fore wings broad. Costa rounded. Cubitus stout and terminated by a broad stigma, which by encroachment on the cubital cell shows some approximation to the semi-coriacous texture of the Hemiptera Heteroptera. The fore wing has one stigmatic and two simple non-furcated oblique veins. The hind wings have a single oblique vein. The oblique veins of the upper wing sometimes do not anastomose with the cubitus, but spring from a continuation of the stigmatic vein, which runs for a certain distance parallel to and below the cubitus.

This characteristic led Koch to divide Chermes, and to describe the insects having this last peculiarity under a new genus Anisophleba; but I have hesitated thus to split up the genus, for I am not clear that this conformation is constant in any species.

The males of Chermes have been slightly noted by Kaltenbach, Ratzeburg, and Koch, and described as

* Chermes or Kermes, probably from the Arabic or Hebrew קִרְמִז.

winged; but anatomical evidence that the insects in question were of this sex is desirable.

The apterous male I have discovered in *Chermes abietis*, and this sex I have clearly proved by dissection.

Passerini's* remarks on the propriety of retaining the genus Chermes amongst the Aphididæ appear to be judicious. It is true that the tribe as now restricted does not fully accord with the characters originally set forth by Linnæus, nevertheless some confusion would now arise by a transfer of the name to Coccus, as has been proposed by Geoffrey, and afterwards carried out by Vallot in his genus Adelges. As regard should be paid to priority, I follow Kaltenbach, Koch, and many other authors in retaining the name of Chermes amongst the Aphididæ.

The ancient Persians seem first to have given this name, Kermes, to the red dye obtained from the insect, called afterwards by Linnæus *Kermes ilicis* (now *Coccus ilicis*). The red produced from Kermes is not of such a vivid scarlet as that yielded by *Coccus cacti*, the cochineal scale-bug.

The name, Kermes mineral, given by the old chemists to one of the ores of antimony, a substance used in the East to dye the eyelids, probably has the same etymological source. The Moors have left a similar word, Kermez, in Spanish, for a dye.

Though the galls commonly found on the English oaks are not the work of an Aphis, we may conceive that this insect was called upon to act a part in the adjuration so playfully set forth by Mr. Tennyson in the soliloquy of the talking oak of Sumner Chase :—

> "I swear! and else may insects prick
> Each leaf into a gall."

* Passerini, 'Flora degli Afidæ Italiani,' p. 3.

Chermes corticalis, *Kalt.* Plates CXVII, figs. 6—10; CXVII, bis, figs. 1—3.

*Chermes strobi*, Hartig (?).
„ *piceæ* (?), Ratz.

*Apterous female.*

| | Inch. | Millimètre. |
|---|---|---|
| Size of body | 0·035×0·025 | 0·88×0·62 |
| Length of antennæ | 0·005 | 0·12 |

Small, ovate, ochreous brown. Head dark umber-brown. Abdomen covered with minute tubercles, from which is extruded a quantity of flocculent silky fibre, within which, mixed with mealy matter, the Chermes conceals itself. When denuded of this covering the insect shows numerous dots of deep brown, disposed in rows down the dorsum. Legs very short. Eyes exceedingly small. Antennæ brown, and mostly hidden. The rostrum short, with long flexible setæ.

*Pupa.*

Oblong. Head and prothorax rich brown, as also are the wing-cases, antennæ, and legs. The abdomen is transversely barred with brown.

*Winged viviparous female.*

| | Inch. | Millimètres. |
|---|---|---|
| Expanse of wings | 0·150 | 3·80 |
| Size of body | 0·040×0·025 | 1·01×0·63 |
| Length of antennæ | 0·013 | 0·33 |

Larger than the larva. Black; head broad; eyes conspicuous; antennæ black and five-jointed, each articulation furnished with a strong bristle. Thorax capacious, black and shining. Abdomen ringed and furnished with flocks of white silky thread. Legs black. Tarsi furnished with sucking discs as well as claws. Wings fuscous, punctured, dull, and parchment-like. Veins brown and coarse. Stigma broad. Rostrum short. In my figure, the veining of one fore-wing is drawn as abnormal; a circumstance not infrequently seen amongst these low types.

Sometimes this Chermes is very numerous on the twigs of the Scotch fir, *Pinus sylvestris*. In early June they form numerous tufts of white cotton round about the bases of the green needle-like leaves. If these tufts are searched, the apterous mother may be seen surrounded by thirty or more yellow eggs, which become browner as they attain maturity. The ova are much preyed upon by larvæ of *Scymnus discoideus*, *Anthocoris fusca* (Kalt.), *Agromyza chermivora* (Kalt.), and other ravenous insects.

Kaltenbach originally took this insect plentifully on the Weymouth pine (Weikmuthskiefer), *Pinus strobus*. He gives a figure of the wing showing the peculiarity of veining which belongs to Koch's genus Anisophleba.

CHERMES ABIETIS, *Linn.* Plates CXVI, fig. 5; Plates CXVIII and CXIX, figs. 1—2.

*Chermes abietis*, Linn., Fab., Schr., Kirby and Spence, Kalt., Koch, Pass., Ratz., Leuckart.
*Adelges gallarum abietis*, Haliday.
,, *abietis*, Walk.
*Aphis gallarum abietis*, De Geer, Burm.
*Sacchiphantes abietis*, "Ruricola."
*Elatiptus*, Amyot.

*Apterous viviparous female.*

QUEEN-APHIS?

| | Inch. | Millimètre. |
|---|---|---|
| Size of body | 0·035 × 0·022 | 0·88 × 0·55 |
| Length of antennæ | 0·009 | 0·22 |

Very small. Blind. Ochreous yellow. Mealy. Oval; mite-like in form; dorsal portion domed.

Legs short and greenish. Rostrum short, but furnished with long setæ.

Early in April; as soon, indeed, as the shoots of the spruce begin to push forth, the foundress commences her operations at the axils of the young leaves. A small swelling here makes its appearance, within which she encircles herself. This swelling occasionally attains the size of a hazel-nut; and sometimes it grows very much larger.

In the month of May she may be found surrounded with numerous larvæ, larger than herself, all of which develop rudiments of wing-cases. It would appear that, with the exception of the above queen-Aphis, all individuals become alate.

The cautious and indefatigable naturalist De Geer was the first to give a full history of *Chermes abietis.* Observers who came after him have only amplified and very generally confirmed his discoveries. "In early summer the shoots of the spruce-fir may often be seen covered with excrescences, which are so similar to true fir-cones that they readily deceive the casual observer as to their true nature." De Geer proved that these are produced by the punctures of an insect, exactly as we have seen the galls produced by Tetraneura and the like.

The queen Chermes or Altmütter certainly hybernates; and it is clear that she only wakes upon the return of spring, just as the sap begins to rise into the buds. By absorption she soon passes out of her shrivelled dry condition into plumpness, and then she lays one or more heaps of eggs in the neighbourhood of a bud, which she selects at the axils of two or more succulent branches.

The punctures she continues to make at the base of this bud cause an arrest of its usual growth, and by a diversion of the sap a thickening and swelling at the bases of the needle-like leaves are produced, which eventually take the form of numerous cells, the apertures of which gradually approximate to each other.

It is not yet quite clear if the queen-mother dies outside of the developing gall; leaving thus the young which hatch from her eggs to enter these chambers alone; or whether she accompanies them into their retreat. De Geer says that while the formation of the gall proceeds, the old pine-louse dies (he does not say where) of her infirmity, "die alte Tannenlaus aus Entkräftung stirbt."

On the other hand, I have commonly found a wingless Chermes surrounded with young pupæ, and quite enclosed by the walls of the chambered cone.

This insect I consider to be the original queen-Aphis; and if she be such, the encystment would be in perfect accordance with the nidification of the females of Pemphigus, Tetraneura, and the like. On the other hand, this hatching *outside* the gall is in accordance with Miss Ormerod's observations,* who remarks, in her useful Manual, "with regard to the larvæ that were hatched outside presently becoming *tenants* of the inside of the gall there is no doubt, . . . but I believe that a minute slit opens along the upper part of the sutures that mark the division of the swollen leaves, and that through these openings the larvæ creep into the chambers within."

By the irritation of the larvæ the cells increase in size, and finally become large enough to contain from twenty to fifty insects in each chamber; their rostra being plunged into the substance of the cell, and all their heads being turned outwards and towards the opening; that is, the larvæ all radiate from the centre of the cone. As before noted, the queen Chermes may be found within, surrounded by her progeny, which, after undergoing several moultings of skin, develop their wing-cases. Eventually all, without exception, become pupæ.

A quantity of mealy matter lines these chambers;

* E. A. Ormerod, 'Manual of Injurious Insects,' p. 242. I think further observation is desirable as to this question of encystment.—G. B. B.

and numerous pellucid globules may be found interspersed, which I regard as fæcal matter.*

Although these insects are too closely packed together to allow of any locomotion, they walk readily after removal from their nidus. Fine black bristles protrude from the points of their rostra, by which they hold firmly to the inside of the chamber.

As a cone may have fifty or more inhabitants in each separate chamber, a single structure, even at a moderate computation, may contain two thousand inhabitants. A section of one of these pseudo-galls often shows the spruce shoot as an axis around which the various cells are symmetrically placed.

Shortly after the middle of June the scales contract and open, so as to form clear exits for the pupæ. These on a sunny day will emerge by hundreds and mount on the spines to dry their expanding wings. A gleam of bright sunshine will call them forth in clouds; each insect taking wing with a whirling motion, and a "buzz" very loud for a body so small. After the escape of the Chermes the cones dry up and form hard masses of open cells, which remain long afterwards on the trees.

I have in vain searched for winged males amongst the thousand forms I have bred under bell-glasses during different seasons. Leuckart, indeed, some years ago denied the existence of any male; but after the recent interesting discoveries on the dissimilar genera of *Neuroterus* and *Spathegaster* by Dr. Adler, and the remarks by M. Lichtenstein upon the *Cynipidæ*, it will be hazardous now to commit oneself to such an opinion.

Ratzeburg believed that he had discovered the

* This mealy matter is insoluble in alcohol, but it dissolves in benzole. It is composed of an abundance of broken and flattened threads, which polarise light. Doubtless these are minute portions of the corkscrew-like, silky masses, which are secreted by certain glands, and which are pressed through certain apertures to be seen on the body-rings, by employing a microscope with a suitable amplifying power. This mealy matter, and the corresponding secreting glands, are figured in Plate C, vol. i, figs. 6, 7, 8, and 9.

winged male, and he figures this insect in his 'Först-Ins.,' iii, 200. He says that he repeatedly saw the male organs, which can be made to protrude by a gentle pressure of the fingers. I doubt much as to the fact of this insect being a male; and the more so, as a similar pressure will cause the protrusion of a short and blunt ovipositor from the winged females produced from the pseudo-galls. The same may be stated with reference to the winged female of *Chermes laricis*, the allied species, the male of which is at present quite unknown.

The winged females, after finding suitable localities, permanently attach themselves to the spruce leaves, lay their eggs, and die; their dead bodies becoming protective covers for their young broods, which hatch under them and emerge in early autumn. These young spread themselves over the twigs, but have not been observed to make fresh cones. Apparently they hide themselves under the stipules of the leaves in a manner similar to that of the larch Chermes. Do they there hybernate? or, if not, what is their economy? and what is the part they play in the cycle of life during the remainder of the autumn? These questions yet call for an answer; but at present conjecture only can be advanced.

*Pupa.*

| | Inch. | Millimètres. |
|---|---|---|
| This measures | 0·090 × 0·050 | 2·28 × 1·26. |

Colour warm reddish-brown, with a delicate bloom upon it. Head broad, eyes brown; thorax and prothorax remarkably broad and massive. Abdomen deeply ringed. Apical ring furnished with a small cauda and two minute spines. Legs very short. Wing-cases and thoracic lobes greenish. The whole underside of the pupa has a rich ferruginous, but dull and milky tint. Some specimens are more slaty-grey than others.

The pseudovarian sacs are very numerous in the pupæ of *Ch. abietis.* The small anterior chambers of the pseudovaria are filled with a green granular matter; whilst the larger posterior chambers show well-marked indications of the ova, which nevertheless cannot get their full development until the imago has emerged from the pupa. The exuviæ of the pupa are quite white, and perfect as an investing shell, just as we see in Aphis proper.

The cavities of the bodies of these Chermesinæ are filled with minute, green, nutritive granules, which pass into their hollow legs, and these globules show their freedom by their change of position at each moment that a contraction is made by the insect. The pulsation of the dorsal vessel also may be readily seen, if the winged insect be immersed alive in weak glycerine, under which solution it will survive with a diminished activity for some hours.

*Winged female.*

| | Inch. | Millimètres. |
|---|---|---|
| Expanse of wings | 0·270 | 6·85. |
| Size of body | 0·090×0·045 | 2·28×1·13. |
| Antennæ | 0·020 | 0·507. |
| Cornicles | None. | |

Vertex flat. Head broad; eyes brown. Antennæ short, 5-jointed; last three joints imbricated. Prothorax dilated to the full width of the body and marked, by a somewhat triangular lobe. Mesothorax with two large and two smaller lobes. Post-thorax long and narrow. Abdomen oval, very shining, and sparsely clothed with waxy filaments. Cauda not visible; but two prehensile hooks and a short ovipositor can be extended at the will of the insect. The whole insect is of a fine golden-brown colour, which deepens by age. Legs green and very short.

Wings broad and somewhat pointed; when first disclosed they are of a milky white, but they speedily become hyaline, with a delicate greenish glance. Cubitus green and stout, the apex expanding into a large green stigma. The three oblique veins usually stop short of the cubitus. Lower wings with a single vein proceeding at right angles from the post-cubital. The membranes are finely punctured. The wings are folded horizontally; that is to say, not pentwise.

This insect is numerous in many English counties. It also has a wide Continental distribution, reaching as far south as Parma, in Italy.

The winged Chermes begins plentifully to issue from the cones in early June, and if the season be late, they continue their flight even to August.

They may be found, later in the year, sitting at the apices of the leaves in the process of oviposition; the eggs being afterwards covered by flocks of woolly matter. Still later in the year the young may be discovered creeping from the dead body of the mother; her body having answered, for the time, for their temporary concealment.

The later-born winged females are only half the size of the ordinary insect, they are browner or greener than those of the early summer, and their abdomens are less developed. These probably are the supposed winged males, described by Koch. It is more possible that they develop the real sexes; and the mothers thus would be styled *pupiferæ* by Lichtenstein. I think this the more likely, since their abdomens are largely charged by green germinal matter, and when they are crushed a multitude of minute spore-like bodies are liberated, which simulate spermatozoa.

In the family of Aphides the organs destined for reproduction commence their growth at a very early stage. The rudiments may be sometimes traced in the young of *Chermes abietis* soon after their exclusion from the egg. It is well known that the sexual apparatus is in formation some time before the construction of the principal external parts of the Aphis. The occurrence of germinal matter in these imagos, therefore, need cause no particular surprise.

Here it may be mentioned that a splendid magenta-coloured dye is produced by the action of dilute potash. The reaction is marked under the microscope. An excess of potash injures the colour. The ovoid masses in the abdomen become, under the same reagent, differently tinted; one half changes to a deep purple, whilst the other half remains yellow or green.

Circumstances unfortunately prevented a minute examination as to the sexes of the insects bred from under the bodies of these winged females. As before hinted, they might have proved to be males and true females; but, assuming this, their birth would seem to occur both externally and internally, as to the pseudo-cones. But there is yet another supposition, founded on analogy with *Chermes laricis,* in which the commencers of the next year's colonies undoubtedly hybernate. Here, under the idea that the progeny of the winged Chermes is non-sexual, the male influence would be deferred until the end of the cycle, and the true ova might not be produced at every autumn.

I have depicted at fig. 6, Plate CXVIII, one of these small winged insects, with her progeny.

I cannot certainly say that they always and exclusively breed outside of the cones. I am in the greater doubt, since my discovery, within the cones, of the wingless male, as if it had been bred there.

### *Apterous Male.*

Through the kindness of Miss Ormerod, late in July I had the opportunity of searching the contents of a number of pseudo-cones, and, after a long trial, I detected, just under a scale, a single minute apterous insect, which proved to be the sex long missing. This specimen measured only 0·030 × 0·015 of a millimètre.

Exceedingly minute, yellow, blind, apterous. Antennæ rudimentary and composed of three joints only. Rostrum very short. Head broad, and joined to the body without the intervention of any well-marked thorax. Abdomen large and deeply ringed. The posterior end is occupied by a remarkably developed male apparatus, which by compression under weak glycerine gives rise to a plentiful stream of spermatozoa. The alimentary canal is very short, and the nutritive organs are very simple. The cavity of the abdomen is taken up almost entirely by the sperm-capsules; but I am unable to satisfy myself as to the correct number of these last united into a single duct.

Several other small, wingless Chermes were dispersed within the cells of the pseudo-galls, but I could not be sure of their sex. Inasmuch as they contained no visible ova, they might have been immature males. It is likely that one male visits many cells in succession, and thus the smaller sexed females, if bred within the cones, would be fitted for their subsequent ovipositorial duties.

The above description affords yet another example of the apparent rule that a recurrence to a fecundated ovum is the ultimate step taken before the phenomenon of a true fresh birth. Thus, as the males have at last been found in Coccus and in Cynips, so now Chermes offers no exception. The degraded characters and minuteness of this sex have been the chief causes of their being overlooked hitherto.

It will be noted that in all the true Aphides hitherto described the oviparous females are wingless, and probably will always be found to be such.

There is, however, a departure in Chermes from Aphis proper. The queen Aphis in Pemphigus, Schizoneura, Tetraneura, &c., is the constructor of the gall she inhabits. She surrounds herself with vegetable growth, and in the cavity which she produces she stores her young, and their pricking increases the size of the gall already formed.

In *Chermes abietis* we see, according to the observers above quoted, that the excrescence develops itself solely by the punctation or boring into the swelling bud by the mother Aphis, long before the eggs she lays are hatched. After this has taken place the mother louse "dies of infirmity," but in the meantime the little insects slip out of the eggs, and immediately betake themselves to the juicy galls which have been caused by the mother. They crawl into the corners of the closely compressed and scale-formed needles, and try to penetrate between them.*

Miss Ormerod, in her useful 'Manual of Injurious Insects,' gives much the same account, and would seem to have witnessed the entry of these young Chermes into the chambers from without. She says the larvæ spread themselves along the lines which divide the galls, "apparently . . . disappearing into the chambers within."†

Through the kindness of friends I have received pseudo-cones from Norwich, Bishopstoke, Isleworth, Bramshot, Arlesford, and other places.

I believe that *Chermes viridis*, Ratz., is only a variety of *C. abietis*.

## Chermes laricis, *Hartig*. Plate CXIX, figs. 3—9; Plate CXX, figs. 1—4.

*Eriosoma laricis*, Sir Oswald Mosley.
*Chermes laricis*, Kalt., Ratz., Koch.
,, *geniculatus*, Ratz.
*Anisophleba hamadryas*, Koch (?).
*Adelges laricis*, Vallot.

*Queen Aphis.*

| | Inch. | Millimètres. |
|---|---|---|
| Size of body | 0·070×0·045 | 1·77×1·14 |
| Length of antennæ | 0·015 | 0·38 |

* Kaltenbach, 'Monographie der Pflanzenläuse,' p. 202.
† E. A. Ormerod, 'Manual,' p. 242.

Body broad and scutiform. Head, thorax, and abdomen obscurely divided. Colour blackish-brown. Six rows of tubercles disposed down the back and carina. Dusted with mealy or flocculent matter, which is most abundant towards the tail. Antennæ very small and partly hidden, composed of three to four joints. Legs very short, hardly protruded beyond the circumference of the body. Tarsi with two claws. Tail furnished with two hooks. Rostrum rises between the first pair of coxæ.

Habit very inactive; the insect probably never leaving the spot at which oviposition has commenced.

This insect is plentiful on the larch (*Pinus larix*), and sometimes occurs in sufficient numbers to materially injure the trees. In the year 1871, from May to October, the woods in some parts of Surrey were so covered with the myriads of white tufts spun from these insects that they appeared as if starch had been dusted over them. Many boughs died back, and in the autumn the trees looked as if they had been scorched.

For a long time I was unable to satisfy myself as to whether it were a fact that the queen Aphis hybernated, or was born from eggs surviving the winter. In 1872 I watched continually for the first appearance of this Chermes. It was not till the 27th of February, when a slight increase commenced in the tree buds, that I was able to detect, under a high magnifying power, several batches of from eight to ten individuals secreted under the leaf-scales, which were commencing to rise. These insects were so shrivelled and dry that no one would suppose them capable of waking into activity. They were very small, and entirely of the colour of the larch bark. As the sun warmed the air and the sap rose, the Aphides began to swell from inbibition of moisture, and then threw off their skins by a peculiar vermicular motion, the rejected slough passing slowly towards the tail.

For several days the fresh moulted Chermes retains this skin, which is attached by three long, spirallycoiled hairs, which may be traced from the tip of the rostrum of the living insect to the tip of the inverted and discarded sheath. These, in fact, are the three setæ found in the oral sheaths of all Aphides.

The growth of these setæ, which uncoiled may be three times the length of the insect itself, is not at all obvious. It is well known that the legs and antennæ of Aphides are extricated from their old coverings, even to the last joints, without fracture of the "casts," but in the above case the skin of the rostrum must be turned inside out like the horn of a snail to permit of the continued attachment of the insect to its exuviæ.

The extreme tenuity of these setæ would make it seem almost impossible that there could be an eversion; but Prof. Allman has shown that the still finer urticating filaments of some Hydroids are similarly exserted, and so rapidly, that the eye quite fails to follow the action.

I look upon these curious coiled hairs as *spring cables* to secure the insect from being dislocated from the branches by the rough winds of March. The slough fixed in the bark-crevice acts thus as an anchor. The insects can hardly be removed by friction with a hair pencil.

By the 4th of March, the queen Aphides, having considerably grown, again shed their skins; and then they appear of a silvery white spotted with pale brown tubercles. They soon change to a green colour. Two days after another moult is effected, and then I saw six eggs laid whilst under the microscope. By the 9th of March twenty-four eggs were laid, the mother not having moved from her first position on a young twig.

At the moment of oviposition a short and cleft ovipositor is exserted, but I failed in discovering how the eggs are attached to their long pedicles. But the process very likely is similar to that performed by Hemerobius.

These egg-tufts contain from thirty to sixty ova, and are of all shades of colour, according to their ages; from yellow to dark brown, ferruginous, and black. Subsequently the ova are covered by a peculiar silky substance, the packing and disposal of which are effected by means of the cleft ovipositor before noted.

The Altmütter, or queen, broods upon these eggs, which hatch about the end of May, about which time the green tufts of larch become dotted with small black grains like gunpowder. These are the produce of the queen Aphis's eggs.

The larvæ measure about $0{\cdot}020 \times 0{\cdot}010$ of an inch, or $0{\cdot}50 \times 0{\cdot}25$ millimètre. They are green, slaty-grey, or black; and are very unlike their parent. They are longer, with head and thorax more separated from the abdomen. The body-rings are more marked, and the six rows of tubercles are more apparent.

A resinous-looking fluid is secreted, which exudes like small yellow drops from their tail ends. This juice is an object of interest to ants and to wasps. The latter insects, in June and July, keep up a continual hum during their visits to the larch trees. The young Chermes soon double their size, and puncture the needle-like leaves so as to produce a sort of weeping of turpentine, and to cause the leaves to bend at a sharp angle where the injury has taken place.

The Chermes also shroud themselves in the silky matter which, from the odour it gives when burnt, seems to be of a nitrogenous nature; and appears to be capable of flattening by pressure, and even unravelling into smaller fibres or filamentous threads. It is insoluble in alcohol, and it does not seem to be of a waxy nature.

The tarsi of the insect are furnished with two stiff hairs, ending with discs, which probably act like pulvilli. These black tuberculated larvæ, after undergoing certain moults, develop their wing-cases, become pupæ, and finally emerge as imagos.

*Pupa.*

Dark-grey or slate-colour. Body covered with warty tubercles, which form orifices from which the silky matter is spun. Head and thorax much produced forward. Wing-cases placed far down in the meso-thorax. Antennæ relatively rather long.

The pupæ are pretty plentiful at the end of May, and the imagos appear in early June up to August. I have never, however, observed the winged Chermes in anything like the abundance of the pupæ; but this may be easily accounted for by their easy destruction through rain, and also by the power of the wind to remove them far from their birthplaces. Aphides have no power to breast a strong wind; their wings act only as organs of suspension, and thus they have but little directive force.

*Winged female.*

| | Inch. | Millimétres. |
|---|---|---|
| Expanse of wings | 0·180 | 4·57 |
| Size of body | 0·055 × 0·020 | 1·39 × 0·50 |
| Antennæ | 0·010 | 0·25 |

Head and thorax dark-brown; eyes red and large. Antennæ about equal to the width of the head, the third, fourth, and fifth joints irregularly ringed and imbricated; terminal button bristly. Prothorax very large and unweildy; meso- and post-thorax supporting the wings, less developed. Abdomen orange or brown, much ringed, and plentifully furnished with wavy silk fibres. Legs brown, and moderate in length. Wings large, broad, greenish, and finely punctured. Cubitus and stigma pale olive-green. Upper wings with three simple unforked veins, the last of which usually is the only one which springs from the cubitus.

It may be a question whether the apparently parallel course of the stigmatic vein below the cubitus is due to more than the abnormal expansion of the cubitus itself. As before noted, however, Koch thought this a character sufficiently marked to justify his genus Anisophleba. The under wings have but one oblique vein.

A gentle pressure on the abdomen causes the insect to exsert the prehensile hooks, which I believe Ratzeburg mistook for a penis, and thus he looked on certain slightly different alate insects as the males of *Chermes laricis*.

These winged females, after finding a suitable spot for oviposition, exclude their eggs in considerable numbers, clothe them with the down from their bodies, and then die. Their dry skins, with the wings attached, form, as in the last species, a certain protection over the eggs. Throughout all the summer apterous and winged females may be seen ovipositing side by side until the succulency of the sap is too much reduced to give nourishment.

The males and true females of *Chermes laricis* are yet to be discovered, and inquiry is yet desirable as to the fact whether the last be apterous or winged; but I believe that the true egg is laid by an apterous insect and hatched in autumn. Without such a habit we cannot explain the hybernation of the queen mother.

I hesitate to adopt Koch's observation that the smaller winged insects which appear simultaneously with the apterous are real males and females. The former, under his view, might have been males; but it has not yet been demonstrated that any real females among the Aphidinæ are otherwise than apterous.*

The hybernation of Chermes is a fact. I have discovered the insect secreted in the bark-fissures, near the incipient leaf-buds, as late as December 12th and as early as February 27th. At the former date I could find no evidence of enclosed eggs, or rather they were limited to mere rudiments.

The alimentary canal was easily traced, and there were several blind sacs visible within the posterior rings, which in all probability were the colleterial glands.

* Koch, 'Die Pflanzenläuse,' p. 317.

Kaltenbach infers that the eggs are laid in the autumn, and protected by the silky matter.* I have made unavailing search for such eggs in February. But few traces of cotton-like tufts can then be found, and I have uniformly found them empty.

Ratzeburg at one time thought that two species of Chermes infested the larch; one of which he named *Chermes geniculatus*, from the stoutness of the knee-joints. Subsequently he believed this to be only a variety, and he discarded the supposed species accordingly.

Passerini has not included *C. laricis* amongst the Aphides of Italy. The insect is confined to *Pinus larix*, and probably it is only to be met with where that tree is indigenous, or where it has been introduced artificially.

CHERMES ATRATUS, *Buckton*. Plate CXX, figs. 5, 6.

*Winged female.*

| | Inch. | Millimètres. |
|---|---|---|
| Expanse | 0·180 | 4·57 |
| Size of body | 0·045 × 0·025 | 1·14 × 0·63 |
| Length of antennæ | 0·010 | 0·25 |

Whole body sooty grey. Head broad; eyes black and prominent; prothorax largely developed, with broad lateral swellings; mesothorax large, with prominent lobes, from which the voluminous, greyish, and finely punctured wings spring; post-thorax moderate in size. Abdomen blunt, fusiform, marked with three or more dark crescentic bands. The head and thorax occupy more than half the length of the whole body. Abdomen sparsely clothed with long white filaments. Wings grey and dull. Cubitus and insertions dull yellow. Stigma long and dark sooty grey. Antennæ with two large basal joints, followed by three other joints, all much imbricated, and

* Kalt., 'Monogr.,' p. 195.

dilated at their inner aspects into three drum-like tubercles (auditory ?). Legs short and black.

This somewhat singular-looking insect was taken on an oak at Haslemere early in June. I could find no apterous females in the vicinity; and therefore very probably the fly was not bred on that tree, but had strayed from its birthplace.

As it answers to no published description of a Chermes, and yet has some marked characters, I add it to the list of British insects, with the anticipation that the immature forms and the life-history will at no long time hence come under notice.

The following short list comprises, I believe, all the species of Chermes as yet described from European localities :

*Chermes abietis*, Linn.; *Ch. laricis*, Hartig; *Ch. corticalis*, Kalt.; *Ch. strobilobius*, Kalt.; *Ch. pini*, Koch; *Ch. coccineus*, Ratz.; *Ch. atratus*, Buckton; *Anisophleba hamadrias*, Koch.

It is to be noted that the larval forms of Chermes seem to approach nearer to those of Coccus; and that in their alate forms the costæ of the wings and the dilation of their stigmata (coupled with the tendency shown by some to deposit chitine in the ordinary substance of the membrane) suggest some possible passage out of the Homoptera into the lower members of the Heteroptera.

CHERMES PINI, *Koch* (?). Plate CXVII bis, figs. 4—6.

*Anisophleba pini*, Koch.

*Apterous oviparous female.*

| | Inch. | Millimètres. |
|---|---|---|
| Size of body | 0·035 × 0·022 | 0·88 × 0·55 |
| Length of antennæ | 0·005 | 0·12 |

Coccus-like in form. Dark-brown, plentifully furnished with long silky filaments, which take a corkscrew form as they issue from the body-pores. When denuded, the insect shows the body deeply ringed, and marked with spots of varying size down the back and the sides. The antennæ are very small, and they are usually inconspicuously folded under the head. They are very rudimentary in form, and only contain from three to four joints. The queen Aphis occurs in May, and about June is surrounded with her pedunculated eggs, which are yellow or brown, and well covered from the weather by cottony flocks.

In 1874 they were taken plentifully at Haslemere on *Pinus sylvestris*, and in December of the same year, when the thermometer marked 21° Fahr., the apterous mothers were found congregated in knots of from ten to fifteen at the bases of the leaf-tufts of *Pinus insignis*. They were then very inactive, and usually attended by the grub of a Scymnus, which daily devoured some of them, leaving comparatively few to pass the winter. Like other Chermes, they were anchored to the buds by long rostral setæ, more than twice the length of the insects themselves.

Koch found, at the Botanical Gardens at Erlangen, a Chermes which, from the character of the wing-veining, he put into a new genus. He called this insect *Anisophleba pini*. They were first noticed in the greenhouses on a variety of the Scotch fir called *Pinus siberica*, but the insects spread beyond the greenhouses to other species of Pinus, amongst which he names *Pinus uliginosa*.

In a general manner his description agrees with that above given; but his specimens seem to have been brighter in colour, and the legs were ringed with yellow near the femoral joints.

I have not been able to secure the winged form of *Chermes pini;* but Koch says that his pupæ had large and smooth thoracic lobes, with olive-brown wing cases.

The winged females are, he remarks, very similar to those of *Anisophleba hamadryas* (*Chermes laricis?*), but they want the tubercles which stud the body. Again he remarks that this insect has a close affinity to *Chermes corticalis* of Kaltenbach, which insect is not, however, included in the list given by Koch.

It is to be regretted that the illustrations of Chermes in Koch's 'Pflanzenläuse' are far from satisfactory. They give but little help in identifying the species he describes.

Kaltenbach adds to his list of Chermes *Ch. strobilobius*, which has not yet been noticed in England. It forms a yellow pegtop-shaped gall (Zapfenartigen) swelling towards the ends of the twigs of *Pinus abies*.

## Genus XXXI.—PHYLLOXERA,* *Boyer de Fonsc.*,

### Kolbenlaus.

Rostrum moderately long in the winged insects, but entirely wanting in the perfect sexes.

Antennæ three-jointed, the first and second short, and nearly equal. The third joint much the longest, roughly imbricated, with a circular tubercle near its base, and a longer, somewhat inconspicuous, tubercle towards its apex.

Eyes small and almost rudimentary in the apterous females.

Legs very short; tarsi single-jointed, each furnished with two claws, two capitate bristles, and a cushion-like pad or pulvillus.

Wing-membranes delicate; upper wing with a well-marked cubitus, from which spring three faint, oblique veins without any furcation. Lower wing with a veinless cubitus.

Body globular in the queens, fusiform or ovate

* From φύλλον, a leaf, and ξηρον, withered, or from ξηραίνω.

in the later generations. In the larvæ the head is united to the body without any apparent constriction to form a proper thorax. Cornicles none.

M. Lichtenstein uses the tubercles of the antennæ as specific characters in the genus.

This genus is, in a qualified sense, exclusively oviparous, for the true ovum applies only in strictness to the produce of the perfect sexes. Prof. Passerini has included all the known forms of Phylloxera under the tribe Chermesinæ; but more recently M. Lichtenstein, who perhaps has studied this small group of insects as completely as any one, sees sufficient differences in their habits and general characters to separate them not only from the Chermesinæ, but from the Aphidinæ altogether. Prof. Targioni Tozzeti also contemplates a similar dissociation, and has proposed that the group should be capitalised under the name *Phylloxerites*.*

I feel indisposed to assert how far *Phylloxera* has or has not a natural classification under the family of Aphides. Hard and fast lines of demarcation are almost impossible to be defined for nearly allied forms, and much will depend on the relative values and importance given by systematists to any particular deviation from the type. For the present, therefore, I prefer to leave *Phylloxera* (which contains *perhaps* only a single known genus) to the family assigned to it by Passerini and other writers. Without such a grouping, indeed, the insects now to be described could have no place in this Monograph.

### *General remarks on the genus Phylloxera.*

It may be well said that of all pestiferous Aphidian genera *Phylloxera* is the most destructive. Fortunately in this country we have felt no great injury from the only known indigenous species. From the

* 'Bull. de la Soc. Ent. Ital.,' 1875, f. 281.

circumstance that viticulture in the open country is but little attended to in England, no very serious evils have yet arisen from the far more destructive insect *Phylloxera vastatrix*, whose attacks are confined to the grape vine. It may be also said that no insect, large or small, has been honoured by such a voluminous literature as this destructive pest.

The appearance of some minute insects on the leaves of a vine growing in a greenhouse at Hammersmith caused the Rev. M. J. Berkeley to bring the subject to Prof. Westwood's notice, and an article was written by that author on the same insect in the 'Gardeners' Chronicle' for 1863, p. 584. Prof. Westwood gave this insect the name of *Perytimbia vitisana.*

This small beginning has developed into the investigations of the commissions connected with the Governments of France, America, Italy, the Cape of Good Hope, and elsewhere; all of which inquiries have been conducted at the public expense. Their reports have been supplemented by valuable memoirs written by Lichtenstein, Planchon, Riley, Cornu, Signoret, Balbiani, and a host of others. A large proportion of these memoirs are to be found scattered in the 'Comptes Rendus,' and the Transactions of the Natural History Societies of Europe and America.

Here we have another illustration of the natural fact that to the world at large the interest and the importance of a subject is often measured by the effect it may have on our social economy. The loss of many millions of francs or dollars to a country, leading to the decay of an important industry, forces numerous biological and scientific questions on the public notice, which, apart from such a stimulus, would be regarded with an utter apathy, and suggest thoughts that time spent in such a subject would be lost in puerilities.

The painful industry of the man of science who at his life-hazard studies the minute Bacillus, and traces its connection with tuberculosis or the fatal splenic fever—or again, investigates the sequence of such-like microscopic organisms with cholera, has his high reward in the knowledge that he benefits his kind, and reduces the world's misery. The observation that the dry scientific fact of to-day may form part of the public riches to-morrow, is somewhat trite.

The genus *Phylloxera* was constructed by Boyer de Fonscolombe in 1834,* to receive the then unique Aphis *Phylloxera quercûs*. The members of the group are now somewhat numerous, but only two species can, with certainty, be regarded as British. That on the oak is plentiful in our southern counties during some seasons.

PHYLLOXERA PUNCTATA, *Licht.* Plates CXXI, CXXII, figs. 1—6; and Plate CXXXI.

*Phylloxera quercûs*, Walk.
,, *coccinea*, Kalt. (?)

M. Lichtenstein, in 1877, gave a short diagnosis of an oak *Phylloxera* which he first found at Biarritz, and to which he gave the name *Phylloxera punctata*.

I append the substance of his remarks, as follows :—
"I found the foundress in May at Biarritz on *Quercus fastigiata*. Her colour was white, irregularly spotted with red globules, which appeared to consist of internal granulations. She may be recognised by her long antennæ. She surrounds herself with her eggs disposed in two concentric circles. I have not been able closely to study this species; but it ought to be common in the North, for I have seen it at Genthod, up in the mountains at Geneva, and at Bagnères-de-Bigorre; and Dr. V. Signoret showed it to me at Paris as being the type of *Phyl. coccinea*, of Balbiani, Hayden, &c.

"It is the palest in colour of all the *Phylloxeræ* in all their forms, and its pupæ appear to me relatively the largest. The sexated insects are whitish."

I have repeatedly taken this *Phylloxera* on the oaks

* 'Boy. de Fonsc., Ann. Soc. Ent. Fr.,' tom. iii, 223.

in my fields at Haslemere, but until lately I always regarded it as *Ph. quercûs.* I also some years ago received specimens of this same insect from the late Mr. F. Walker, who saw them surrounded by thousands of eggs in concentric circles, on some oaks near Shanklin in the Isle of Wight. Like myself, he regarded this insect as *Ph. quercûs* of Fonsc., and as such it appears in his 'Catalogue of Homoptera.'

A few months ago, M. Lichtenstein was good enough to inspect my drawings; and he at once came to the conclusion that they do not represent the French and Italian *Ph. quercûs.* The same gentleman kindly forwarded to me living specimens of the last, and I quite concur as to the identity of the British and Montpellier insects.

I believe the following account and diagnosis is the most complete that has yet been published.

*Queen mother.*

| | Inch. | Millimètre. |
|---|---|---|
| Size of body | 0·030 × 0·012 | 0·76 × 0·30 |
| Length of antennæ | 0·010 | 0·25 |

Very small, flask-shaped, amber-yellow, occasionally spotted with red. Body smooth and not tuberculate. Head very broad; eyes very small, black, and composed of three or four facets. Thorax hardly separable from the abdomen, which is globose, and terminated by apical rings. The apex furnished with an obtuse ovipositor, which is employed in ranging the eggs (which number one hundred or more) in two or three concentric circles on the oak leaves.

Antennæ rather setaceous and tri-articulate. Rostrum short, as also are the legs; tarsi stout, each garnished with double claws and two capitate bristles.

The apterous larvæ differ much both as to size and outline. This is partly dependent on the amount of eggs stored within them. The number of eggs capable of deposition by these apterous larvæ is very large, but the number much diminishes in the following generations. The eggs are at first quite smooth and shining, but very shortly afterwards show a corrugated appearance, which is caused by the extraordinarily rapid development of their contents. In the course of a few hours indeed the young *Phylloxeræ* are disengaged from their membranes, and then they are comparatively active and stray away in search of nourishment.

*Phylloxera punctata* infests the under sides of the leaves of both varieties of the English oak. Some years at Haslemere, at Wanstead, and at Southgate, they are very numerous, but at other times I have found much difficulty in securing even a few specimens. The masses of pseudo-eggs appear as minute spots like honey; and it often happens that the larvæ of a small Scymnus or a minute Myina is employed in greedily devouring them.

*Pupa.*

Long, oval, ferruginous yellow, which becomes darker by age. Wing-cases brown; rostrum short. The pupæ change into the winged insects about early June. The larvæ undergo four moults before becoming pupæ (Licht.).

*Winged female. "Emigrante."*

| | Inch. | Millimètres. |
|---|---|---|
| Expanse of wings | 0·170 | 4·31 |
| Size of body | 0·070×0·030 | 1·77×0·76 |
| Length of antennæ | 0·010 | 0·25 |

Head and thorax broad. Abdomen tapered to a point, furnished with a blunt ovipositor.

Thorax disproportionately large, brownish. Abdomen green, variegated with lighter spots, which show the pseudova within.

Antennæ with three joints, the last imbricated and the longest, furnished with a long, tubercular indentation covered by a membrane.

Legs very short. Wings rounded at the apex; cubitus and stigma brownish; membranes with three oblique veins, the first and second oblique closely approximate at their tips. Lower wings with a costal vein only. The insect figured in my Plate contained eight "eggs" of nearly the same size. Taken in September.

Late in the autumn much smaller pupæ and alate individuals may often be traced in company with the normally-developed winged insects. These diminutive forms are a puzzle; for they occur not unfrequently in other genera of Aphis. They have been in other species often, yet incorrectly, regarded as males; but Balbiani has shown that they are partially developed females, which have somewhat an analogy with the neuter workers of bees and ants. These pupæ of *Phylloxera punctata* sometimes do not equal one quarter the size of the usual kind.

M. Lichtenstein has discovered the fact that, unlike most, if not all, other Aphides, the parent of the winged sexes is apterous instead of being furnished with wings to transport the perfect sexes to suitable situations for oviposition. The same peculiarity obtains in another species foreign to England, viz. *Phylloxera acanthochermes*, Kollar; and if *Phylloxera vastatrix* fails to produce alate forms in any country, the sexes must here also develop from apterous insects.

*The male and female.* Pl. CXXXI, figs. 1, 2, 3.

The insect which produces the perfect sexes of *Phylloxera punctata* is (unlike that of other Aphides) apterous. For this reason, amongst others, M. Lichtenstein, who has studied this insect during this present summer of 1882, is inclined to remove the species from *Phylloxera*, and to place it in another genus, *Acanthochermes*, the "pupifer" of which he states to have always this peculiarity.

The sexes of *P. punctata* are very like those of *P. quercûs* and *P. vastatrix.* They are without rostra, and therefore they can neither feed nor grow. The female contains one single impregnated egg, of large size.

Through the liberality of M. Lichtenstein I am able to add the following remarks which are the results in series of his observation on this insect.

1. The fundatrix or produce of the true egg.

2. She gives rise to the winged form (*Emigrante*), which lays her unfecundated eggs under the leaves of *Quercus pedunculata.*

3. These produce apterous insects (*Gemmans*), each of which surrounds herself with concentric circles of eggs.

4. These bodies develop apterous females (*Pupiferæ*), which carry four or five ovoid envelopes of different sizes, one of which gives birth to the male, and the other to the female sex.

5. The apterous non-rostrated males and females produce

6. The fecundated egg ready to commence the new cycle.

M. Lichtenstein calls my attention to two small lateral tubercles on each side of the females. I omitted to notice these organs when I made my drawing. They are characters to be noted, but they occur also in *Aphis papaveris*, *A. viburni*, *A. Jacobææ*, &c., though in these last insects the papillæ are more numerous. Their economical significance is unknown.

PHYLLOXERA QUERCÛS, *Boyer de Fonsc.* Pl. CXXIII. figs. 1—10, Hartig, Lichtenstein, Riley.

*Apterous pseudo-female.*

| | Inch. | Millimètre. |
|---|---|---|
| Size of body | 0·030×0·015 | 0·76×0·38 |
| ,, antennæ | 0·007 | 0·17 |

This insect hatches in early spring from the egg laid in Autumn. The egg is usually deposited in the crevices of the bark of the chermes oak, *Quercus coccifera.*

After several moults the insect assumes a flattish, flasked-shaped body, and becomes distended with pseudo-eggs, which are deposited, without any regular order, in small patches under the leaves. Wherever these insects congregate, a yellow or orange-coloured spot forms on the leaf, which penetrates through the substance and causes the upper surface also to appear brightly speckled.

The young hatched from these eggs are much more slender in shape, and become darker and redder at each skin-shedding, which occurs four times.

In about a fortnight they become pupæ, and the first winged females appear late in May or in early June.

At this stage all the winged insects are stated to migrate to the hairy oak, *Quercus pubescens*, and there they drop their pseud-ova. The resulting apterous females apparently do not give rise to winged forms until August. "Alors ces insects ailés, qui cette fois-ci ne sont plus porteurs d'œufs, mais bien pupifères retournent au chêne kermes et déposent sur les feuilles leurs pupes sexuées de dimensions différentes."* The largest of these are the true oviparous sexed females, the smaller are the males. After coupling, the result is a single fecundated egg much larger than any of the pseud-ova previously developed.

This ovum is the commencement of the new cycle, and discloses the queen-mother in the spring following.

According to Lichtenstein coupling in *Phylloxera quercûs* is effected soon after birth of the sexes. The male is very ardent and visits many females. As they are born from the second winged individuals, which occur in September or later, doubtless the egg is lodged in some crevice in the oak-bark and remains there till the early spring.

* *Vide* M. Lichtenstein's notes at the end of this section of my Monograph, p. 63.

No fewer than sixteen species of *Phylloxera* were named in America in 1875.* M. Lichtenstein thinks it safe to decide that only five well-defined species inhabit France, viz. *P. coccinea*, Heyd.; *P. corticalis*, *P. quercûs*, *P. punctata*, and *P. vastatrix*.

I have not yet been able with certainty to identify more than the two last-named species as British denizens, and of these the vine *Phylloxera* must be regarded as a late introduction into these Islands.

Although the pseud-ova of Aphides take their origin from internal organs which morphologically cannot be separated from the true ovaria, the former should not be confounded with the true egg, which is always compounded of a true yolk and a germinal vesicle. Probably this egg would be wholly sterile without the influence of the male Aphis.

A slight examination of the abdominal contents of any *viviparous female* of Aphis will show that all stages of completeness obtain, from the minute nucleated point in the ovary to the well-developed young ready for birth. These embryos are all included in an ovoid chamber, a kind of follicle; and in many species the insects are excluded, still enshrouded in glistening membranes which appear very like eggs.

In early days it was often a subject for discussion whether the product of an Aphis was not *always* an egg, and there are several species of true Aphis which deliver their young so much in the form of ova, that they well might deceive the incautious observer.

Examples of such are to be found figured in this Monograph. Thus with *Aphis petasitidis*, *Schizoneura ulmi*, and *Pemphigus bursarius*, the young do not extricate their limbs from their investments till some minutes after birth. The curious growth of these young from the pseudova which is sometimes seen, and which is very rapid, is caused by the inspiration of air

* Interesting information on the American Phylloxeras is to be found in Prof. Riley's Seventh Report on Noxious Insects in Missouri, p. 97, *et seq.*

into the tracheæ of the live insects within; I believe this expansion is never to be noticed with reference to the true ova. M. Lichtenstein has well distinguished between these separate ovoid bodies, so like each other, and yet so different in their destinations.

Notwithstanding that objections have been taken to the names proposed by Huxley for these two bodies, I think the terms of ova and pseudova (false ova), ovaria and pseudovaria, are very convenient; and quite as intelligible as buds and gemmæ.

But, after all, the phenomenon of viviparism may be looked at as a process in which the completed fœtal development is effected within the parent, whilst in oviparism that same process is deferred for some considerable time, and in part is conducted externally to the parent.

From this point of view we might regard the whole family Aphididæ (Chermes and Phylloxera included) as to their pseudova viviparous, but as to their real eggs oviparous; the difference only being that in the genera of low grade the viviparous broods do not throw off their membranes until after their birth.* These membranes of the pseudova probably have no analogy to the chorion of the true egg, but may be regarded as mere sacs which enclose the embryos.

## PHYLLOXERA VASTATRIX, *Planchon.*

So much has been written on the vine Aphis, that it will be well to offer here only a short summary of the subject. For greater detail the reader is referred to numerous memoirs found in the 'Comptes Rendus,' 'Annals Soc. Ent. de France,' and other sources, the chief of which are indicated in the bibliographical list at the end of this present volume.

*Phylloxera vastatrix* offers a good example of the

* *Vide* vol. ii, p. 70, Pl. lviii; also vol. iii, pp. 98, 118, Pl. cviii, and Pl. cxi, of this Monograph.

rapid spread of one animal, effected almost entirely through man's unwilling agency.

Thirty years ago the insect was unknown, although its existence in North America must date many thousand years back. Now it has crossed the Atlantic, spread over the greater part of Southern Europe, touched at Cape Colony in Africa, and brought its baneful influence to bear on the vineyards of Australia.

The earliest notice that I have found of the grape Aphis occurs in 1856, at page 158 of the First and Second Report on the Noxious Insects of the State of New York, by Dr. Asa Fitch. He there speaks of the "grape-leaf louse," which he names *Pemphigus vitifolii*. He describes the galls made by this insect as small and globular, about the size of peas, raised on the margins of the vine leaves in early June. These galls at that time contained only wingless females. He gives no printed diagnosis of the insects, but he refers to certain MS. notes which do not appear to have been published.

The *Aphis vitis viniferæ* of Scopoli and of Fabricius, appears to be quite a different insect.*

Although *Phylloxera vastatrix* was known in England in 1863, it does not appear to have reached California, in Western America, till 1871. Prof. E. W. Hilgard remarks on the modifying influence of climate as to the development of the aerial form, which condition may be thought to favour its rapid extension. Yet doubtless the introduction of the egg through the vine root has done infinitely more injury than any possible flight of the insect; which must be confined to districts where the vine flourishes, and cannot extend itself over barren plains and oceans.

The vine Phylloxera is not indigenous to Great Britain; but it has certainly been imported into our graperies and hothouses, where the even temperature seems favorable to its growth if permitted. The

* Scopoli, 'Ent. Carn.,' 398; Fabr., 'Ent. Syst.,' iv, 220.

comparatively rare winged forms, as well as the subterranean, have been repeatedly bred in England.

The occurrence of this pest at Hampstead has been before noted. Prof. Westwood,* who was only acquainted with the root-living state, named it in 1863 *Peritymbia vitisana.*

Mr. McLachlan has had more recently under his notice some vine leaves from Scotland, on one of which (only one inch and a half across) he counted thirty-five well-marked Phylloxera galls. If this vine had been left to itself, doubtless it would in due time have given forth those apterous forms which descend into the earth to feed on the roots.

Shortly after its appearance in England the insect invaded France, showing itself first at Tarascon in Le Gard, and then spreading through the Departments of Vaucluse, du Var, de l'Herault, and the valley of the Rhone, and thence to Girond, Cognac, &c. Its march since then has been continuous.

Thus in 1880 the Phylloxera had spread over a large portion of the wine-districts of France. The pest has in great measure followed the course of the large rivers, whose banks have been terraced for vines. All the valley of the Rhone, from its debouch into the Mediterranean up to Dijon in the Côte d'Or, is infected. A wide tract now spreads from Monaco and Nice, beyond Montpellier, even to the Pyrenees; and a broad band of devastation extends in a line from Toulon to La Rochelle in the north-west. In 1877 only twenty-eight Departments had been visited, but in 1880 these had increased to thirty-nine.

Messrs. W. and A. Gilbey stated, in September, 1882, that in some of the brandy-producing districts of les Charentes the vineyards were giving way to cornfields. Herault, which furnishes about one-fifth of all the wine produced in France, is at this present time seriously affected; and the same may be said of the Gironde, which has annually supplied Great Britain with six and

* J. W. Westwood, 'Gard. Chron.,' p. 584, 1863—1868.

a half millions of gallons of wine out of the nine millions imported into the country.

As one twenty-fifth part of the area of France is now under wine-cultivation, it will not excite surprise that the authorities still offer a prize of 300,000 francs for a real remedy and abatement of an evil, which, in 1881, is said to have inflicted on this French industry a loss of three milliards of money.

From the foregoing it will appear that notwithstanding we possess the complete life-history of the insect, no sure, certain, and unexceptionable remedy has yet been advanced. Doubtless the ravages have in some districts been checked; and in others the Phylloxera has even been stamped out. Flooding the vines in winter has been found very efficacious, but this cannot be effectual on high levels. Arseniate of copper, carbon disulphide, phenic acid, and other chemical agents as insecticides, have been applied with greater or less success; but such compounds, apart from their cost, are highly dangerous to human life.

As an insecticide, the substance known as sulpho-carbonate of potassium has been the most efficacious. M. Dumas happily suggested that the poisonous effect of carbon disulphide might be modified, by combining the liquid with potassium sulphide. The resulting solid compound is far less volatile than the liquid, and it seems also to have the advantage of acting on the vine-stocks as a manure.

From the fact that the Australian vines are less liable, and are perhaps in some sorts even indifferent to the attacks of *Phylloxera vastatrix*, it has been argued that from a too select cultivation and grafting "in and in," the French stocks are not sufficiently robust to repel this insect, and hopes accordingly are still entertained that a large gain will accrue by budding on new strains. The idea that the vine Aphis and other Aphides also, select the weaker plants, was strongly urged by the late Mr. Alfred Smee in his papers on *Aphis vastator* in connection with the potato-blight.

On the other hand, it is averred that the healthiest vines, as being those possessing the most nutritious sap, are those chiefly selected, and most open to attack. Although soil seems to have but little to do with the evil, the wettest and the most sandy loams are generally the most free from Aphis infection.

The three chief diseases of the vine arise from the growth of the cryptogamic *Oideum Tuckeri*, the injuries caused by the small pyralian moth *Œnophthira pelleriana*, and this *Phylloxera*. Besides these, in hothouses we have the grievances caused by mildew and scale. Sulphur, hot water, or tobacco, are cures for these last; but the myriads of *Phylloxera vastatrix* in great measure have survived all attempts at extermination on the large scale.

M. Lichtenstein states that cavities are sometimes found in the bark of the French vines stuffed full of small black Aphides. These insects do not puncture the vine for its sap, but they have been transported thither, and form the stores of such predatory and minute wasps as Psen, Pemphredon, Cernonus, and the like.

Prof. Florel, of Lausanne, says that the Phylloxera was introduced into his district through the importation of English vines into the graperies of Baron Rothschild in 1869.

It was once thought that this pest could not pass the tropics alive, as the insect cannot bear dessociation from its food for a single week. Its appearance, however, at the Cape of Good Hope, and in also Australia, shows that the eggs will bear considerable dessiccation without injury to their vitality.

Before giving a diagnosis of *Phylloxera vastatrix* I would make the remark that every moult which an insect undergoes has its significance, and corresponds to internal changes progressing within the body. It will thus appear how elaborate the history of any insect would become, if every phase in its metamorphosis should be fully studied and described.

In illustrating the development of the vine Aphis only a few forms can be here figured. This necessary restriction has been, indeed, applied to all the species I have attempted to set forth in this Monograph; but, as a rule, I have chosen types of most marked phases. With reference to *Ph. vastatrix* the reader can consult the engraved plate issued by M. Lichtenstein in 1876, in which twenty-one forms of the insect are represented. Some present lacunæ may be supplied from thence. Any one attempting to draw twenty individuals of the same species under the camera will remark the diversity of *proportion* of their organs at different times of their development.

*Phylloxera vastatrix* may be conveniently grouped for description into the aerial and the subterranean forms, which answer to the terms Gallæcola and Radicicola of Professor Riley.

### Aerial apterous female.

*Fundatrix.*

Phylloxera vastatrix, *Planchon.* Pl. CXXII, figs. 7, 8, and Pl. CXXIV, CXXV.

*Pemphigus vitifolii*, Asa Fitch.
*Peritymbia vitisana*, Westwood.
*Dactylosphæra vitifolii*, Shimer.
*Phylloxera vastatrix*, Lichtenstein, Riley, Signoret, Cornu, Balbiani.

| | Inch. | Millimètres. |
|---|---|---|
| Size of the body | 0·070 × 0·050 | 1·77 × 1·26 |
| Length of antennæ | 0·009 | 0·22. |

Body nearly circular, flask-shaped, drawn out at the tail, which ends in a short and truncated ovipositor. Colour amber-yellow, fuscous, or ferruginous; spotted from the numerous eggs which fill the body-cavity. Head- and tail-ends slightly browner. Eyes black and very small. Antennæ short and very fine, three-jointed, the last being much the longest. Legs very small, scarcely protruding beyond the body. Rostrum about one-fourth the length of the body.

This insect is the immediate produce of the true ovum, which was laid in the autumn by the sexed female. Her history, after exclusion from the egg, is probably somewhat different according to the climate, and, perhaps, the character of the vine on which it occurs.

The aerial forms are rare in the colder countries, but they increase in frequency as we go southwards or cross into America. Where the aerial forms occur, the foundress punctures the leaves in such a manner that the swelling masses close over and finally entomb her. The leaves become studded over the surface (and particularly near the edges) with gall-like masses, many of which are pedunculate. Each foundress appears to form a single gall, within which she lays hundreds, or even thousands, of yellow egg-like bodies. This oviposition continues through the summer, after which operation she dies.

These galls are round, fleshy, and corrugated. They often number a hundred or more upon a single leaf. A vine which is much infected soon becomes sickly. The leaves show distortion, turn yellow or brown, and during their decay yield a faint and unpleasant odour. The stocks become stunted, and if the roots be uncovered they will be found (especially as regards the fibrils) swelled into small blebs and tubercles. These are the result of the attacks of the young Phylloxeras, which, after their development on the leaf and escape from the gall, have descended into the ground and commenced their subterranean existence. These creatures are so numerous that the roots when turned up often appear dusted with yellow grains. In this condition they produce the greatest destruction to the European vines. In America the aerial form appears to produce the greatest evil.

### Subterranean apterous female.

These apterous larvæ are smaller than the fundatrix, and measure $0{\cdot}026 \times 0{\cdot}016$ of an inch. They are amber-yellow, with an olive stain towards the head and vent. In later generations the forms are more flask-like and colour ferruginous. During their life underground they oviposit. One specimen, however, on dissection contained only eight eggs, but this number is not constant. The egg-like bodies are of a pale yellow colour and shining. When the larger roots are attacked the cortex is loosened; it rots and scales off under the irritation of the insects, as seen in Pl. CXXIV, fig. 5. When the small fibres are affected, swellings and nodules mark the injury done, as seen in Pl. CXXV, fig. 10.

Professor Riley states that this root modification of *Phylloxera* passes through five or six generations, which fact will account for the various forms and sizes seen simultaneously crowding the roots of the plant. The American forms appear to be more tuberculate than those I have been able to examine through M. Lichtenstein's courtesy.

About the month of July many of these underground forms pass into nymphs and come to the surface, where they develop wings, and then they fly to distant vineyards to carry on the invasion. In America during August they swarm in thousands. A quart pot of earth containing infested roots will for three weeks yield a dozen of these alate forms daily, each of which contains one, two, up to eight egg-like bodies of different sizes, which are deposited sometimes under the leaf, and sometimes in the fissures of the bark. This winged insect is the "Pupifer" of Lichtenstein, and furnishes through the above pseudova the true males and females.

*Winged (pseudo-) female.*

| | Inch. | Millimètres. |
|---|---|---|
| Expanse of wings | 0·120 | 3·04 |
| Size of the body | 0·045 × 0·015 | 1·14 × 0·38 |
| Length of antennæ | 0·015 | 0·38 |

Body greenish-yellow, fusiform. Abdomen tapering towards the apex. Head broad. Eyes large and red. Antennæ rather short, third joint much the longest, strongly ringed, and apparently without any marked tubercle. Wings carried pentwise, membrane hyaline and very delicate. Cubitus broad and yellow. Stigma very faint. The three nervures pale yellow.

The only specimen I have examined contained one single large egg, measuring 0·015 of an inch. The identity of species of these aerial and subterranean insects is now too well-known to require comment; beyond the fact that Professors Riley, Balbiani, and Cornu have all proved that the two kinds may be compelled by artifice to change their habitats. The apterous larvæ taken from the roots, however, show much disinclination to feed on the leaves, and probably they never would raise the galls.

Prof. Balbiani has shown that the appearance of the winged insect is not necessary to complete the cycle of life. In this case, when a recurrence to the male becomes necessary, an apterous form must yield the eggs which give rise to the sexes, just as it occurs in the case of *Phylloxera punctata*.

The American *Phylloxera* appears to have as many as six different periods for egg-laying; but the European insect, from Lichtenstein's observation, would appear to have fewer. The root-feeding larvæ undergo a hybernation, during which time they shrivel up without losing vitality. In April they wake up, become supple and inflated from the imbibition of sap, and then it is that the chemical insecticides have the greatest activity upon them. Extreme cold does not much affect the ova of insects. M. Girard points out that the egg of the silkworm will bear a cold of 25° C. in their passage over the mountains of Japan, and that the caterpillars may be frozen, "so as to ring like metal on a marble slab," and yet after a slow thawing they will come to life and feed like others. The fond hopes that cold would destroy the hybernating egg of Phylloxera cannot therefore be realised.

Balbiani states that the winged females deposit their pseudova amidst the down on the underside of the leaf; and Riley says that this is the common habit of the American species. The insect, however, will drop them on the bark, or stem, or indeed almost anywhere.

The produce of these last egg-like bodies, which differ in size, is the true female from the larger, and the male from the smaller variety. The sexes are both mouthless, and live only for reproduction. The male is comparatively active and visits many females, from which it would appear that the last sex is in excess.

*The male and female.* Pl. CXXII, figs. 7, 8.

These perfect sexes I believe were first discovered by M. Lichtenstein, and afterwards by Prof. Riley in America. They are exceedingly small, and have no true mouth parts. A small eminence is the sole representative of the buccal organs.

*The apterous male.*

This minute insect is pale ferruginous yellow, cycloid, flat, testudinate, with a very broad head furnished with small black eyes. Thorax proper there is none. The abdomen is coarsely ringed and corrugated. Legs short, with obtuse tarsi and very minute claws. The male is so small that it may be easily overlooked.

*The sexed female*

is much of the colour of the male but is larger. The abdominal cavity contains a single egg which is the true ovum. The female delivers herself of it about the fourth day after she is hatched, and this without any real necessity of concourse with the male. Whether such eggs are barren it does not appear (see Riley, Eighth Report, p. 159). The true ovum is larger than all the preceding pseudova. It is yellow at first, but soon afterwards it becomes olive in colour with a rough exterior. Its survival through the winter in the crevices of the bark has been substantiated by Dr. Balbiani and M. Lichtenstein, and there is no doubt that the fundatrix is the produce of the same, just as with all other Aphides.

It has been stated that the *Phylloxera* keeps below the soil in dry weather, but ascends the stocks in the wet season (Villedieu).

M. Lichtenstein lays much importance on the fact that the males and females remain for several days after they have been deposited by the winged insect in certain delicate membranes, which at one time he regarded as cocoons. The reason why he now considers these egg-like bodies as pupæ (nom donné par Latreille aux chrysalides qui sont formée par la peau de la larve se durcissant autour de l'animal) will be found in the general summary of the genus Phylloxera, with which he has obliged me.

I gather from his remarks that, when two winged generations appear in Phylloxera, the first produces a rostrated progeny, and the last a non-rostrated. If the vine Phylloxera shows but one alate generation, it furnishes the non-rostrated sexes, in the autumn. He warns all investigators against the confusion likely to arise by confounding an alate insect with its later winged successor.

If there be no aerial forms in a cycle, the foundress descends at once to the roots and no galls appear on the leaves.

In concluding my diagnosis of such Phylloxeridæ as have come to my notice, I introduce to the reader the following valuable summary. M. Lichtenstein is accomplished both as a biologist and a linguist, and the reader will note not only his concentration of the subject within a small space, but also will appreciate the clear English he employs, of which language he has made himself a proficient. I here heartily thank him for the material help he has given me in the preparation of this Monograph.

Summary on the Genus Phylloxera. *A Letter addressed to the Author by M. Jules Lichtenstein*

La Lironde, Montpellier;
*September 10th*, 1882.

My dear Sir,

You ask me to give you a note on the genus Phylloxera, which I have now had under particular observation ever since 1868. I am sorry to say I am not able wholly to explain in a satisfactory way the very curious metamorphoses of these Proteus-like insects, which seem to defy the endeavours of naturalists to group them by sharp and rigid characters.

As you have already mentioned in your work on 'British Aphides' my ideas about the biological evolution of plant-lice in general, and gall-lice in particular, I can spare your readers a good deal of explanation; and begin with a short affirmation of a theory, which is now about ten years old, and which all my subsequent observations lead me to confirm.

With reference to the hypothetical frame I have fancied of Aphis evolution, I will shortly indicate what I *know* surely to be true, and what I *suppose* to be so, but cannot as yet bring to rigid proof. First of all I am of opinion that the evolution of plant-lice is entirely different from the common metamorphosis of other insects; and, as Baron von Gleichen, De Geer, and Götze said before me, I think the only way of understanding the various life-stages of a plant-louse is to compare it with the growth of a plant.

The egg, which is often single in the females of Aphides, is not destined, as in other insects, to produce a sexuated male or female; it furnishes only an *agamous* form, which by a sort of budding process (*bourgeonement* or *gemmation* in French, *Keimung* in German) reproduces a great number of individuals able to continue this budding reproduction for a more or less prolonged period, until there arrives a period in which the produce of these gemmations consist no more of agamic individuals all equal, but sexuated insects, male and female, which last lays the fecundated egg, and gives origin to a new series of beings.

As I said before, this kind of evolution calls to mind that of a vegetable, from the seed of which arises the trunk, branches, leaves, and flowers by gemmation, giving at last, once more, the fecundated seed, through a kind of copulation. I suggested for the agamous forms—thus able to reproduce by budding, the name of Pseudogynæ; and, considering them to be only transitory or larval forms, I gave the four life-stages preceding the appearance of the sexuated insects the following names:

1. *Pseudogyna fundatrix.*
2. — *migrans.*
3. — *gemmans.*
4. — *pupifera.*

I retained, of course, the names of male and female for the sexuated forms, which show the genital organs and are able to copulate. I called the first form issuing from the fecundated egg the *fundatrix* (as a translation of the German word Stammütter), thus indicating the first foundress of a colony. This is the insect which generally forms the galls in those species where galls are produced. Nevertheless, in some species the power of forming gall-like swellings is not limited to the *Pseudogyna fundatrix*, *e.g.* *Phylloxera vastatrix*.

The name of *Pseudogyna migrans* was suggested by the fact that in the greatest part of plant-lice the second form is winged and flies away from the place where it was born. Yet here, as in the preceding case, there may be exceptions, and some kinds do not leave their birthplaces. Still, I regard emigration as the rule.

I gave the name of *gemmans* to the form succeeding the emigrant, because it is the curious period in which the budding reproduction gets to such a height, that Bonnet was able to obtain without access of the male nineteen generations from *Aphis sambuci*. Kyber, of Eisenach, and later Schrader, of Bordeaux, noted four years' reproduction from *Siphonophora rosæ* and *Phylloxera vastatrix*. As to this last one, I am myself well convinced that the power of reproduction of the underground *Pseudogyna gemmans* of the root form, has occurred in a piece of vineyard of my own property ever since 1875, and the process is probably everlasting. Of course this will happen only as long as food and temperature allow it, because the two conditions of heat and nourishment have the greatest influence on the reproductive power of the agamous-gemmans form in all Aphides. Here also, as in the two preceding states, numerous exceptions to the rule find place; for if it is possible and even easy, by maintaining Aphides on fresh leaves or fresh roots in warm rooms, to obtain constant reproduction, it will occur more frequently that the want of food in the cold season will kill the gemmans-phase, or oblige it to undergo the last metamorphosis, and then become what I call the *Pseudogyna pupifera*.

This last name has been criticised more than once. I would indicate by it the form which produces the sexuated insects. I wished to establish by the word *pupifer* that it is not an egg, but a true pupa or chrysalis of two different sizes, giving birth to males and females. These last are laid by the *Pseudogynæ* of the fourth stage.

I must acknowledge that the word pupifer is not perfect; as in many species the males and females are born alive, because the fine skin by which they are surrounded bursts at the moment of laying.

However, I gave all names after a full consideration of the biology of *Phylloxera quercûs;* and as in this species the sexuated insects remained some days in their egg-shaped pupæ, I inadvertently selected a name which is not equally well adapted to all Aphides.

Of the sexuated forms, male and female, I have little to say. The females seem always to be apterous, the males occur both with or without wings in the same genus, and even in the same species.

I now hasten to describe my classification of the genus Phylloxera—or I would rather say of the family Phylloxeridæ, for I think it is not possible to retain under the same genus the numerous species already known.

## PHYLLOXERIDÆ.

These are easy to distinguish from all Aphides by their three-jointed antennæ, shown in all their life-stages. This is a good plastic character, and separates the Phylloxerians from all other insects of their class. It is a fact that each of the four life-stages of the above-mentioned family is separated from the following one by an egg-like quiescent state; so that the Pseudogynæ, which seem to be viviparous in other Aphides, here appear to be oviparous. With the Phylloxerians these may be looked upon as pseudova.*

* I have had no opportunity to study the Chermesians, which are, perhaps, also oviparous; but the genus Vacuna, which is mentioned by some authors as oviparous, I can testify is certainly viviparous.

N.B.—My own observations on *Thelaxes dryophila* (*Vacuna*) also put this fact beyond doubt. However, Vacuna has been confused with Phylloxera by some authors.—G. B. B.

The European representatives of the genus Phylloxera were limited about fifty years ago to one single species, named by Boyer de Fonscolombe *Phylloxera quercûs*. This author mentioned the insect as feeding on *Quercus pubescens* and *Q. coccifera*. His observations on the insect were correct, and I can establish the evolution of the species as follows:

1. Egg deposited in the bark crevices of *Quercus coccifera*.
2. Foundress, or *Pseudogyna fundatrix*, feeds on the same tree.
3. *Pseudogyna migrans*, as larva and nymph, feeds on the same tree, but after getting wings emigrates to *Quercus pubescens*.
4. *Pseudogyna gemmans* feeds under the leaves of *Quercus pubescens*.
5. *Pseudogyna pupifera* feeds, as larva and nymph, on the same tree; but after getting wings flies back to *Quercus coccifera* to deposit on the leaves the pupæ out of which the males and females issue.
6. These last, after union, deposit their single egg in the bark crevices, where it passes the winter.

When I first published the above observations many able entomologists doubted their correctness; but shortly after me Prof. Targioni Tozzetti, of Florence, found that the same cycle of life occurred in another species of Phylloxera, that is to say, *Phylloxera florentina*, Targioni. This insect is born on *Quercus ilex*, the evergreen oak, and passes the summer on *Quercus sessiliflora*.

Thus, two species of Phylloxera have been proved to migrate from the deciduous to the evergreen oak; but, as the ilex group is a southern species, it is probable that neither *Phylloxera quercûs* nor *P. florentina* occurs in Great Britain.

The following four species appear to undergo their whole biological evolution on *Quercus robur* or its varieties:

*Phylloxera coccinea*, Heyden.
— *corticalis*, Kaltenbach.
— *punctata*, Lichtenstein.
— *acantho-chermes*, Kollar (sub. *Acantho-chermes quercûs*).

The yellow, black-spined *Phylloxera corticalis* feeds only on the trunk and twigs of *Quercus pubescens*, and was found by Kaltenbach at Aix in 1862. Its habitat does not allow one to confound it with any other species. I believe its economy is similar to that of *Phylloxera quercûs*, but without its migration. I know the *Pseudogyna migrans*, *gemmans*, and *pupifera*. I have not yet obtained the sexuated forms.*

*Phylloxera coccinea*, *P. punctata*, and *P. acantho-chermes* all feed under the leaves of *Quercus robur*. *P. coccinea* forms a gall-like folding of the leaf-edges, under which it lays the pseudova from which the emigrants issue.

I am not sure if these become winged; for about the time in which that metamorphosis ought to take place, clouds of emigrants of *Phylloxera quercûs* arrive on the same trees, and I have not been able satisfactorily to isolate one species from the other. The foundresses (*Pseudogynæ fundatrices*) of each species are very different. In *Ph. quercûs* she is active, large, and tuberculated; whilst in *Ph. coccinea* she is quite smooth, and lies in a gall. This last insect is found also at Paris, and was discovered at Frankfort by von Heyden. I received winged pupiferæ from M. Signoret, which furnished me here with pupæ, from which I obtained males and females.

I consider *Phylloxera punctata* to be an inhabitant of the mountains, having seen it only in Switzerland and in the Pyrenees. Here we meet with the unusual circumstance that, while in all the preceding species the pupiferous form is winged, it is apterous in *Phylloxera punctata*. Thus the pupæ of two different

* Since this was written I obtained in my breedings the very small sexuated forms of that species on the first of October.

sizes, enclosing males and females, are laid by an apterous individual.

The last of these species feeding on the oaks is *Phylloxera acanthochermes:* and it partakes also of the above anomaly of showing the pupiferous form wingless. I can say very little more of this curious Aphis than what Kollar has told us. It is surrounded in its gemmans period with star-shaped appendages, which remind one of the coccidous mealy-bugs (Dactylopius). I have had only one opportunity of examining it at Bordeaux, and then I chanced to obtain the apterous *Pseudogynæ pupiferæ*, which produced pupæ, out of which I obtained males and females. The first life-stages of this insect are unknown.

There yet remains for description the dreadful nuisance of our vineyards, *Phylloxera vastatrix.* It is, however, so well known that I can hardly add any new facts to the very complete information given by my excellent friend Riley in his interesting Reports from 1869 up to this day.

Introduced into Europe about twenty years ago, it has in its struggle for life destroyed the best vineyards of the Continent. Professor Westwood, the "actual prince of Entomology" (as we used to call Latreille), has described the gall-making form (fundatrix) under the name of *Peritymbia vitisana*, a name well adapted to the habits of the foundress whilst surrounding herself with the gall in which she must die. If, for the scientific world, sub-genera are to be created for the grape-louse, this species should be called *Peritymbia vastatrix.*

As I limit myself here to a biological sketch of the different species of Phylloxera, I will not enter on an examination of the plastic characters which distinguish the grape- from the oak-lice. The form of the impression on the third joint of the antennæ, which is elongated and oval in the oak-species, and circular in the grape-louse; is perhaps the most easy character to seize.

In its biology and evolution *Phylloxera vastatrix*—half aerial and half subterranean, is different from all the other species. According to my views; the cycle of life is, I believe, as follows. There is but one generation in the year, thus:

1. The egg, deposited under the bark of the vine in the winter.
2. The *Pseudogyna fundatrix*, forming galls on the leaves in May and June.
3. The *Pseudogyna migrans*, issuing from the galls and descending to the roots. July.
4. The *Pseudogyna gemmans*, feeding on the large roots. August.
5. The *Pseudogyna pupifera*, feeding on the small roots, where they form tear-shaped swellings. These insects issue from the soil as nymphs, and obtain their wings in September. They fly to the vineyards to deposit their pupæ under the leaves, out of which the sexuated forms appear. After union, the female goes under the bark, where she lays her single egg and dies. October.

But I fancy this simple cycle may be modified in the American insect. It may change under the influence of a climate and food entirely different. Two or three centuries hence may perhaps show the transformation of this species; but even now we witness some alteration of habits. In the northern parts of France wherever I have observed the grape-Aphis its evolution is a slow one. It conforms to the above general description with this difference; that the foundress goes at once to the roots because the leaves of the European vine do not seem adapted to produce galls. Evolution becomes always more rapid as we proceed southwards. Thus, whilst in Germany and Switzerland the winged form is very rare, and appears in September, I found it at Aix in Savoy in August. At Lyons it appears in July, at Montpellier in June, and Malaga in May. Again, I had roots experimented upon in the hot-houses of the Botanical Gardens of

Montpellier, and I obtained the winged Pseudogynæ in March; so it is easy to conceive that, according to the climate—and perhaps also to the difference of food and other circumstances, insects usually elsewhere having one brood in the year may have two or more.

If we consider that we have to deal with the family of insects where, besides the sexual, there is an agamic reproduction, extending perhaps to an infinite series, there is no wonder that in southern climates we find thousands of acres of vineyards destroyed in the course of a year or two. Although we see these insects so alike in form that it is not easy to find plastic characters sufficient to distinguish one from the other; yet in their biological evolution a tolerable classification may be made as follows:

On oaks.—Emigrant species.

From *Quercus coccifera* to *Quercus pubescens*. *Phylloxera quercûs*, Boyer.

From *Quercus ilex* to *Quercus sessiliflora*. *Ph. florentina*, Targioni.

Non-emigrant species.

Feeding on the bark. Pupifer winged. *Ph. corticalis*, Kalt.

Feeding on the leaves. Foundress in a gall. Pupifer winged. *Ph. coccinea*, Heyden.

Foundress (?). Pupifer wingless. *Ph. punctata*, Licht.

First stage unknown. *Pseudogyna gemmans* in a swelling of the leaf. Pupifer wingless. *Ph. acanthochermes*, Kollar.

On vines.—Evolution partly aerial and partly subterranean.

First stages all apterous. Pupifer winged. *Ph. vastatrix*, Planchon.

M. Lichtenstein closes these interesting remarks on the Phylloxeridæ with a warning that much confusion may arise by mistaking the winged emigrants for the second winged generation or pupifer. This last form alone produces the mouthless males and females.

Before dismissing this portion of my subject, I wish to make the following short comment to prevent misapprehension:

Whilst fully sensible of the value of much that M. Lichtenstein has written on the Pemphiginæ and Phylloxerinæ, I would guard myself from a committal to some of the theories he has put forward, such as the periodic migration of Aphides from one food-plant to another; and particularly as to his observations, that certain species feed on the leaves of the oak, and subsequently descend to the roots of grasses for hybernation. I find it the more necessary to make this reservation, since M. Lichtenstein in the 'Comptes rendus' for December 4th, 1882, uses my name, together with others, as an authority for these points in the economy of these insects. The utmost that I can say is, that though all analogy in other insects is against such migrations, the results of experiments, if rigidly correct, must really control preconceived notions.

M. Lichtenstein distinctly states that he and his friend M. F. Richter have bred the winged *Tetraneura ulmi* from certain larvæ feeding on the roots of *Triticum repens* (chien-dent). Of course if this be so, and no mistake has been made in identifying this species, other biologists will soon corroborate observations of such curious habits. I would say for myself, that I have not noted such an economy in the English Tetraneura, Pemphigus, and Phylloxera. I prefer, therefore, for the present, to hold my judgment in suspension.

Again, where I have used the words "emigrante" and "pupifere," I have done so, to distinguish the first alate brood, which wanders from one tree to another of the same kind; from the second alate brood, which generally produces the true sexes. I think the word "pupifere" is not a happy one, for it is likely to mislead. Still, as may be seen in a few pages back, M. Lichtenstein has given his matured reasons for retaining the term. The reader is referred to the above paper in the 'Comptes rendus,' p. 1171, for various details connected with the habits of this and other species observed by M. J. Lichtenstein.

With reference to the word pupifera as employed by M. Lichtenstein, Dr. Balbiani makes remarks to me, which accord with my own opinion on the matter.

He says : " Si l'on doit appeler des œufs de corps qui sont constitués essentiellement comme les œufs des autres insectes, qui se segmentent, et dans lesquelles, les parties de l'embryon se forment successivement et peu à peu; ces corps *sont des œuf* et *non des pupes* comme je l'ai toujours soutenu."

I may mention also the coinciding opinion of Prof. C. Riley on this subject, who speaks of the "insufficient and misleading nature of the theory regarding the evolution of the Aphididæ; whilst calling the winged females *larvæ* and their eggs *pupæ*," &c.

Vide 'American Naturalist,' xvi, May, 1882, p. 409.

I have obtained M. Balbiani's kind permission to translate and publish a portion of a letter addressed to me, which is of considerable interest; since it converts into a clear proof that which previously had only been a conjecture. The discovery here noted accounts for the total disappearance, for many months above ground, of such Aphides as feed exclusively on the leaves of annual plants. As M. Balbiani's observations have not been published they will be the more acceptable. In an economical point of view they will have interest to the hop-grower, since they will direct attention to the probable winter nidus of the egg of the Aphis which so often suddenly ruins his expectations of a fine crop of blossoms : expectations which he had a right to calculate upon from the previous healthy condition of the vines.

This letter also has some bearing on the mooted question of migration, and I quite agree with the writer that there seems to be no necessity for any theory of migration from one plant to another of a different kind in those species of Aphides which, like Pemphigus, Tetraneura, and Phylloxera, get their nourishment from ligneous trees and plants; for on the same vegetables they not only feed but secure safe harbour for their eggs during the winter. It is chiefly with reference to those Aphides which live on annual plants; the stems of which die down every year, that it would be interesting to know what becomes of them during the many months in which no food appears to be provided for them.

Dr. G. Balbiani informs me in his letter, dated January of this year, that "In the Bois de Meudon, near Paris, *Siphonophora millefolii* was exceedingly common in 1866. Colonies were very abundant upon almost all the tufts of *Achillia millefolium*, which plants were almost covered by them. In autumn the males and females appeared, and I many times witnessed the coupling of the red-winged males with the apterous females, which last were green like the agamic individuals. During nearly a whole month during which I observed them, I never saw one egg fixed to a leaf or to a stem of Achillia."

"I then examined the turf below, and to my surprise I found a large quantity of eggs which were nearly black and sticking to the leaves of several grasses and plants as *Cyperacea*, *Trifolium pratense*, &c.

"I took home with me several handfuls of these sedge plants and grasses, and at the end of February, 1867, they were covered with a number of active little 'pucerons' of *Siphonophora millefolii*."

We may conclude, therefore, from this observation; which has a bearing on the history of other Aphides living on annual plants, that when the females have coupled they quit the branches and lay their eggs in the soil on grass or on any vegetable *débris* which will remain throughout the winter. Thus these progenitors shelter their eggs even more securely than the progenitors of those which oviposit on plants. M. Balbiani further tells me that he has also made observations on

*Siphonophora solidaginis*, but the results are less complete than those of *S. millefolii*.

In September the males and females were often seen coupled together under the flower heads of Solidago, but singularly, as in the other mentioned case, the egg was never detected on the food-plant. The gravid females descended the stalks, and might be found at all heights, more than two or three inches from the ground.

M. Balbiani thinks that these Aphides abandon the plants of *Solidago vergauriæ*, which, in summer, harbour the viviparous broods, in order to lay their eggs on some of the low plants in the immediate neighbourhood; exactly as has been seen to be the habit of *Siphonophora millefolii*.

# V.

# RHIZOBIINÆ, Pass:

WINGED FORMS UNKNOWN.

## INTRODUCTION.

Classification is based on certain observed affinities and agreements with types, or divergencies therefrom. In proportion as a grouping of animals accords with their biology, morphology, and the like, will any given arrangement assume a scientific value. It is, however, obvious that all classifiers do not attach equal value to the same characters. A consensus of opinion, however, will render any schemes they may raise more likely to be in accordance with natural laws.

Genera, however, may be temporally adopted for mere convenience and a means of study, until such time as a better acquaintance with embryology and a true phyllogeny will permit a more perfect grouping. These remarks will more particularly apply to the tribe immediately following.

Perhaps of all divisions of the family Aphidinæ no group presents so great difficulties in classification as that which Passerini has marked under the sectional name of Rhizobiinæ. The fossorial habit shown by all the known species, and their attachment to the young roots of various plants, is by no means confined to Aphides of this tribe. We have noted subterranean habits in Siphonophera, Aphis, Pemphigus, Schizoneura, Paracletus, and Trama, therefore the meaning of the term is not exclusive, as a generic term should be. Linnæus's well-known words, "Nomina si nescis, perit et cognitio rerum," may go too far; but a name is a first step towards an exact knowledge of a thing. It may be a question whether the names of genera should ever express or involve an hypothesis.

Burmeister described a species which burrowed at the roots of Hieracium, to which he gave the name *Rhizobius subterraneus*. Signor Passerini, for convenience, has adapted its characters for a sectional group, and I here follow the lead of so good a naturalist.

No winged forms have yet been discovered in this group. Thus we lose the valuable help which would have been afforded by a study of the wing-veining and other characters attending a metamorphosis into the imago. Again, the simplicity of the tarsal joints, and the little light thrown on the matter by any reliable variation in the mouth parts, and the want of all fixed banding of pigment or colour on the bodies, render it very difficult authoritatively to decide what should be the points of a diagnosis.

As an illustration of the variability of a genus I cannot do better than quote Passerini's words, which, though they apply particularly to the description of a single insect, *Rhizobius menthæ*, yet equally well suit all the English species of this tribe.

With reference to the antennal joints, he says, "Secundum ætatem antennarum articuli numero variant. In junioribus articuli tres tantum extant, quorum extremus cæteris valde longior. Crescente ætate hic apice dividitur, unde antennæ quadri-articulatæ fiunt; et deinde articulus tertius, omnium sua vice longior, apicem versus bis dividitur donec antennæ sexarticulatæ evadunt, articulis subæqualibus."

Notwithstanding these undefined characters, considerable interest attaches to the group on account of the peculiar economy shown by its members. When the insects are regarded as a whole, they certainly show to the eye a peculiar aspect, which separates them from all the genera previously described.

One of the notable life-peculiarities concerns their relations to ants. With few exceptions, all the species are denizens of ant-hills; and it is singular how insects of such diverse habits and conformation can live and thrive together.

Many isolated observations have been made with reference to this very curious subject of what may be called *Paracletism*. More correctly, perhaps, its discussion belongs to the historian of Formica than to that of Aphis, since the Ant, with its superior intelligence (?), chooses the company of Aphis, and makes it more or less to conform to its own economy.

But the question arises, and has not been yet satisfactorily answered, what part in the economy of Formica, &c., does Aphis really take? From the days of Huber the older, and the younger, we have been aware that Ants draw occasional food from these creatures, and this Monograph has already noted that many species of Aphis voluntarily yield honey-dew from their nectaries at the call of the Ants; but what is to be said of those insects which possess no nectaries, as is the case with the Rhizobiinæ?

True, they have certain dorsal pores apart from the stomata; and in some cases the aerial drops of liquid may be seen to exude from such orifices.

In these root-feeding Aphides, however, the function of the pores is to exude waxy or silk-like filaments, which are employed to cover and protect the insect from the water of the soil and to make a nidus for its eggs. I am far from denying that these pores are capable of giving food to the Ants, but clear observation to substantiate the fact is yet desirable.*

Perhaps this question may be relevant to the matter: What is the significance of the presence of the blind Claviger, of Julus, of Oniscus, and Scolopendrum, which equally share the shelter of the Ants' nest?

It cannot here be argued that they are kept by the Ants for food. The whole question is an interesting one, and is sufficiently puzzling; for these curious fostering habits obtain also in other Hymenoptera. Thus, the handsome *Apathus barbatellus* is the petted,

* Kaltenbach is distinctly of this opinion. He says of Forda, "Dieses Thierchen gibt durch die Afterwarze zuweilen an Tropfchen Flüssigkeit von sich, welche von den Ameisen begierig aufgeleckt wird."—Kalt., 'Mon. der Pflan.,' p. 210.

but apparently idle, tenant of the nest of the common humble-bee, *Bombus terrestris*, and numerous similar examples may be cited.

As regards the association of ants and Aphides it may be remarked that the light, sandy, and warm locality chosen by Ants for their nests are just those which the subterranean Aphides would choose. Mr. James Hardy, the active naturalist, of Cockburns-path, Northumberland, who has paid attention to the root Aphides not uncommonly found on the moors around writes to me, "When *Forda formicaria* prevailed in the nests of *Formica fuliginosa* I noticed that the ants paid no attention to *them* when the hillocks were disturbed. The Aphides slowly re-covered themselves with earth, and those which failed to do so were left quite unnoticed by the numerous ants running about them." In other cases, and notably in that of *Formica umbrata*, shortly after a similar disturbance, the Aphides were carried off by the Ants, "and they and I had a contest about a particular example."

The Ants are in the habit of keeping open runs to carry their offspring nearer to the light and heat, and these runs afford convenient and free spaces also for entrance of the Aphides.* In many cases the Ants doubtless choose for their nest such tufts of grass on a dry hillock as are already infested by Aphides. This is a more simple operation than a marauding expedition, attended by a forcible transplantation of Aphides from the leaves of plants to subterranean cavities, as noted by Huber. Such a change of life seems to be very improbable, and involves so many difficulties which it would be well to have removed.

Goedart† was I think the first to observe the friendly relations between Ants and Aphides. He went so far as to imagine conversations between the two insects relating to the attacks of their enemies and the like.

* Kalt., 'Mon.,' p. 210, "Veim Zutritt der kühlern Luft von den meisen in deren Gänge geschleppt."

† Goedart, 'De Insectis,' London, 1685.

## Genus XXXII.—FORDA,* *Heyden.*

Ant-Aphis. Ameisenlaus.

Antennæ 5-jointed, the last articulation furnished with a small tubercle or nail. The third joint much the longest. Eyes very small. Abdomen convex. Cornicles none. Tarsus provided with two claws. Winged forms unknown.

The species of this genus occurs in small scattered companies. They feed on the fine fibres of the roots of various grasses. They very commonly affect the nests of *Formica flava.*

Both Kaltenbach and Passerini consider the above-noted tubercle to be a true antennal joint. As it is very small, and is not articulated to the fifth joint, I do not count it such.

Koch remarks that the young have much resemblance to Trama. They, however, may be distinguished from such by their more simple antennæ and minute eyes.

The eyes of Trama are rather large than otherwise.

### Forda formicaria, *Heyd.* Plate CXXVI.

*Rhizoterus vacca*, Hartig.
*Forda formicaria*, Heyd., Kalt., Koch, Pass.

*Viviparous female.*

Very variable as to size and colour. Large specimens measure—

| | Inch. | Millimètres. |
|---|---|---|
| Length of body | 0·100×0·060 | 2·53×1·52. |
| Antennæ | 0·040 | 1·01. |

* Probably from *fero,* which ordinarily makes *latus,* but irregularly *fordus,* pregnant, or prolific; thus *forda vacca,* &c. However, this genus is far less productive than most other kinds of Aphides

White, greenish, dull yellow, or dark green. Rather glossy. Long oval. Head blunt, smooth. Eyes black, prominent, but very small. Body ringed. Adult specimens often have a dark green stripe half way down the dorsum. Legs moderately long, pale brown. Antennæ 5-jointed, the last of which has a nail, which Kaltenbach counts as a joint. Rostrum stout, and reaches beyond the mid-body. Cornicles none.

Young examples are slimmer, and have longer antennæ. Their rostra project beyond their tails.

Found in light sandy soils, and usually in ants' nests under the root-stocks of various grasses. The specimens figured were nesting in close proximity to a colony of *Formica flava*. In this instance I could trace no connection between the two nests, but there is abundant proof that Forda is a common companion of Ants. One difficulty of separating a particular species from another in such structures consists in the very mixed company that forms these assemblies. Thus in the same nest may be taken individuals belonging to the Aphis genera, Paracletus, Trama, Forda, and Endeis, and these insects are sometimes supplemented by representatives of Julus, Millepes, Oniscus, and a number of blind beetles.

When the full-fed individuals of Forda are gently pressed drops of a clear liquid exude from the dorsal pores, and this liquid probably is acceptable to these ants. This action, under the imaginative fancy of Hartig and of Kirby and Spence, is expanded into the likeness of milch kine, stabled underground for the winter use of the Ants.

Mr. J. Hardy kindly sent to me specimens of this insect from Berwickshire. They were smaller than the Haslemere specimens described above. They were found during the summer inhabiting the nests of Myrmica at the roots of *Holcus mollis*.

Sir John Lubbock also forwarded to me specimens taken in February from similar situations at Beckenham.

Mr. Walker obtained Forda from the roots of the sow-thistle, *Sonchus oleraceus.*

The habits of *Forda formicaria* are not apparently in all cases subterranean. I have taken them in April at Haslemere on the green leaves of *Triticum repens* just above the surface of the ground. I have represented such a modified habit in the plate above alluded to.

Koch figures and describes another species of this genus under the name *Forda marginata.* It is yellowish-white, and possibly may be the same insect as I figure, but the diagnosis agrees only in part.

FORDA VIRIDANA, *Buckton.* Plate CXXVII, figs. 1, 2.

*Viviparous female.*

| | Inch. | Millimètres. |
|---|---|---|
| Size of the body | 0·080 × 0·050 | 2·03 × 1·26. |
| Length of the antennæ | 0·035 | 0·88. |

Oval, dull, pilose, and velvety. Colours variable, from rich chocolate-brown and mouse-brown to an emerald-green; legs and antennæ ginger-brown. Vertex setose. Eyes very small and inconspicuous. Thorax and abdomen much corrugated and domed; nectaries none. Rostrum long, about three-fourths the length of the body. Tail blunt and carried slightly erect. Claws double, but often seen folded as if they were single.

Taken in small companies in Ants' nests covered by tufts of various grasses. It differs from the preceding species in several particulars, and chiefly in being smaller, more pilose, and deficient in the green dorsal stripe.

It occurs throughout May and June in the dry moors, near Wooler, in Northumberland.

Mr. James Hardy informs me the "malachite-green variety" may often be taken in quantity, nesting with *Formica fuliginosa.* This Aphis is particularly plentiful under *Aira flexuosa*, at the end of May, in the above locality.

The brown insect is so commonly mixed with the green, and it agrees so well with it, except in colour, that I assume that the insects are identical. It is not uncommon under the tufts of Carex, on the moors round Alnwick, in Northumberland.

I have not met with it under the sand heaps in Surrey.

## Genus XXXIII.—TYCHEA,* *Passerini.*

Antennæ composed of five *almost* equal joints. Abdomen marginate. Eyes none. Legs short, with two small claws. Cornicles and tail none. Rostrum variable in length according to age. Winged forms unknown. Habitat very similar to the preceding species; mostly being found at grass roots. Several species also are denizens of Ants' nests.

Passerini describes five species as inhabiting Italy, all of which, I believe, are inhabitants of Great Britain.

### Tychea trivialis, *Pass.* Plate CXXVII, figs. 3, 4.

*Viviparous female.*

| | Inch. | Millimètres. |
|---|---|---|
| Size of body | 0·050×0·040 | 1·27×1·01. |
| Length of antennæ | 0·015 | 0·38. |

Globose or ovate, rather flat, yellow or ochreous, smooth. Eyes none. Antennæ very short. The joints vary much in the different moults. In the full-grown insects the third joint is much the largest. In the fundatrix the antennæ and rostrum are both

* If from Τυχέω, *nanciscor*, or *assequor*, the allusion is not obvious.

very short, the joints being much more equal in length.

Taken in Ants' nests, at Beckenham, under tufts of Poa, in November.

Passerini gives for food the roots of *Triticum vulgare*, *Cynodon dactylon*, *Poa trivialis*, *Festuca duriuscula*, *&c.* He thinks that possibly *Coccus Zeæ-maidis*, of Léon Dufour, may be referred to this species; and notes that the presumed single claw may probably be due to a mistaken diagnosis.*

TYCHEA SETULOSA, *Pass.* Plate CXXVII, figs. 5—8.

*Viviparous female.*

| | Inch. | Millimètres. |
|---|---|---|
| Size of body | 0·075 × 0·060 | 1·89 × 1·52. |
| Length of antennæ | 0·020 | 0·50. |

Large, pearly white. Some are circular and domed. Vertex flat, head broad. Antennæ 5-jointed, with a rounded button or nail. Third joint much the longest, but there is a tendency to a constriction, which might suggest an additional joint, and make Passerini's phrase "articulis subæquilongis" more apposite. The whole insect is hirsute and tufted with setæ, particularly as to the head and antennæ. Eyes are merely red specks, and very minute. Legs short, the hinder pairs hardly protrude beyond the body. Tarsi with two claws which fold together so as often to appear but single. Rostrum very variable in length. The tip blackish. Cauda rounded. The younger or less developed forms greatly differ in proportion, and show only four antennal joints, with largely extended rostra. Some specimens are fuscous on the head and tail, and all are rather "mealy."

The larger insects contained from five to seven embryos. It is remarkable that the eyes and antennæ

* *Vide* 'Aphididæ Italicæ,' p. 82.

of these yet unborn insects are quite as much developed as those of their mothers. It is to be noted also that in these insects the antennæ are disengaged or freed from the body before the other limbs (fig. 8).

Taken by Sir John Lubbock in ant-hills near Beckenham, in April.

I kept several individuals alive in moist earth, together with three or four specimens of *Formica flava*, for six weeks, without noticing any tendency to become pupæ or to greatly vary in their general appearance. These insects partially change their colour and become darker by exposure to light.

In Italy the insects nestle at the roots of *Oryza montana*.

TYCHEA SETARIÆ, *Pass.* Plate CXXVIII, figs. 1—4.

*Viviparous female.*

| | Inch. | Millimètres. |
|---|---|---|
| Size of body | 0·060 × 0·045 | 1·52 × 1·13 |
| Length of antennæ | 0·030 | 0·76 |

Fundatrix short, oval, flat. Colour and texture like white kid leather, some with a faint tinge of green. Antennæ very short, about one fourth the length of the body, 4-jointed, with a rounded wart. The third joint much the longest, and often showing a tendency to a constriction in the middle. Eyes very minute. Dorsum has ten or more dusky transverse bands, each terminating with a pore. Antennæ, legs, and tail dusky brown. Rostrum short, reaching to the third coxæ. Legs hardly project beyond the disc of the body. Cauda conical, sometimes with two or more crescentic marks above it.

After several moults the legs and antennæ become much longer, the insect becomes rounder, and at the last moult an additional joint may be counted to the antennæ. In all stages the body is finely pilose.

The tarsi have two claws, but very commonly they are, like the preceding, so folded as to appear but one.

Taken in ant-hills at Beckenham.

The plate shows an insect just before moulting, when the old skin has separated from the new, yet it still envelops the insect itself.

The fundatrix attended by a few young may be taken as early as February.

## TYCHEA ERAGROSTIDIS. Plate CXXVIII, figs. 5, 6.

*Viviparous female.*

| | Inch. | Millimètres. |
|---|---|---|
| Size of body | 0·050 × 0·040 | 1·26 × 1·01 |
| Length of antennæ | 0·040 | 1·01 |

Ovoid or nearly circular, glabrous, whitish. Head broad, vertex flat and smooth. Antennal joints five, and almost equal. The fourth as small as the first, the fifth the longest, and furnished with a nail. Eyes and nectaries none. Abdomen domed and ringed. Legs stout and moderately long, claws double, but often folded together. Cauda obtuse. Rostrum about two-thirds the length of the body, but in the young it projects beyond the tail.

The queen Aphis or fundatrix is quite different in form, being shuttle-shaped. The antennæ, rostrum, and legs are much less developed. Isolated points of red pigment mark the seat of the fœtal eyes, which are only partially developed.

Taken in ant-hills at Beckenham, and also at the Cheviot, on the roots of *Poa annua.*

This insect feeds also on *Panicum glaucum;* and apparently also is viviparous, on the lower exposed leaves of sweet vernal grass, *Anthoxanthum odoratum.*

TYCHEA PHASEOLI, *Pass.* Plate CXXVIII, figs. 7, 8.

*Viviparous female.*

| | Inch. | Millimètres. |
|---|---|---|
| Size of body | 0·060 × 0·040 | 1·52 × 1·01 |
| Length of antennæ | 0·025 | 0·63 |

Large, globose or semi-globose. Opaque white. Slightly pubescent. Head flat and broad. Legs moderately long in the second brood, but short in the queen Aphis. The above measurement represents the size of the queen Aphis, which is blind. The brood proceeding from her are of different sizes according to their different conditions of development. The adults have 5-jointed antennæ, the fifth joint being rather the longest, and the fourth the shortest. Minute pigmentary spots represent the eyes in the full grown insects.

Sometimes this species is numerous at the roots of the scarlet-runner, *Phaseolus coccineus*, from which the above specimens were taken at Walthamstow. It occurs also upon the French-bean, *Phaseolus vulgaris*, and also upon the roots of Brassica, Euphorbia, and Amaranthus.

## GENUS XXXIV.—ENDEIS, *Koch.**

### MINENLAUS.

Rostrum moderately long. Antennæ 5-jointed. The first two and the fourth nearly equal; the third the longest; the fifth ends with a nail. Eyes very small, but prominent. Body cycloid or else pear-shaped. Cauda obtuse and bristly. Legs very short; tarsi and claws as in Tychea.

Koch remarks that, as far as his knowledge went, his two species, *Endeis bella* and *E. rosea*, lived in small companies about the roots of wheat in September.

* From ἐνδεής, *deficient.*

The proportions of the antennal joints as given above are slightly different from those given by Koch; but I prefer to group the following three new species under Endeis rather than form another genus out of the somewhat obscure characters furnished by the materials at hand.

Endeis formicina, *Buckton*. Plate CXXIX, figs. 1 and 3.

*Viviparous female.*

| | Inch. | Millimètres. |
|---|---|---|
| Size of body | 0·045 × 0·040 | 1·14 × 1·01 |
| Length of antennæ | 0·015 | 0·38. |

Opaque white, globose, smooth, somewhat mealy; narrow towards the head. Abdomen ringed. Head with two brown patches on the occiput. Eyes brown and very minute. Antennæ with five nearly equal joints. Legs and antennæ brown. Rostrum short and stout. Tarsi with two claws.

Taken by Mr. James Hardy under the dry stones formed from the porphyritic rocks on the Cheviot. In May they were numerous in the ant-hills under roots of *Carex dioica*. They mostly affected those nests of *Formica umbrina* which were located on the dry slopes.

Endeis pellucida, *Buckton*. Plate CXXIX, figs. 2 and 4.

*Viviparous female.*

| | Inch. | Millimètres. |
|---|---|---|
| Size of body | 0·035 × 0·030 | 0·88 × 0·76 |
| Length of antennæ | 0·015 | 0·38 |

Body very broad behind, narrowing to the head; pale greenish or opaque white; much ringed, pilose. Head stained reddish. Eyes none. Tail obtuse and rounded. Antennæ with five nearly equal joints. Legs pale and short. Rostrum stout and short.

Taken under tufts of grass, such as *Poa annua*, covering the nests of ants, and exactly in the same situations as noted in the preceding species. They were found at Beckenham during February.

### Endeis carnosa, *Buckton*. Plate CXXIX, figs. 5—8.

*Endeis bella*, Koch?

*Viviparous female.*

| | Inch. | Millimètres. |
|---|---|---|
| Size of body | 0·030 × 0·025 | 0·76 × 0·63 |
| Length of antennæ | 0·010 | 0·25 |

Body circular, much domed. Uniformly whitish-yellow, flesh-coloured, or pink. Brown at the tail. Antennæ short, with five nearly equal joints and the usual tubercle. With age the third joint lengthens. Head very broad, with a brown dot on the vertex. Eyes very small and brown. Legs exceedingly short, hardly produced beyond the circumference of the body. Cornicles none. Cauda, viewed from underneath, cylindrical and truncated. Tarsi with two minute claws. The whole insect is finely pilose. On the vertex the hairs are discoid and capitate.

Captured in February in an Ant's nest with several other Aphides, including Trama and Paracletus. They had many young wood-lice (Oniscus) in their company. Taken at Beckenham.

## Genus XXXV.—RHIZOBIUS,* *Burm.*

Rostrum very short, rises between the first coxæ. Antennæ very short, five-jointed, the first four joints

* From *ῥιζίον*, a rootlet; *βιόω*, I live.

nearly equal in length. Eyes inconspicuous. Body more or less furnished with woolly flocks. No nectaries nor tail. Legs short, tarsi terminated by a single claw. Winged forms unknown. Neither males, females, nor true ova have been yet described.

Passerini describes *Rhizobius menthæ* and *R. sonchi.* The latter insect is found at the roots of various plants, as Achillea, Sonchus, Stachys, Galeopsis, and Cichorium. I have not been able to identify these species in England. Passerini makes the antennæ six-jointed. The characters, however, are very inconstant.

RHIZOBIUS POÆ, *Buckton.* Plate CXXIX, figs. 9—14.

*Viviparous female.*

| | Inch. | Millimètres. |
|---|---|---|
| Size of body | 0·075×0·035 | 1·89×0·88 |
| Length of antennæ | 0·010 | 0·25 |

Long oval (in the spring individual fusiform). Colour dull ochreous yellow. Eyes, antennæ, legs, and two occipital longitudinal bands, brown. Antennæ very short, varying according to age; from three to five joints and a nail. Abdomen deeply ringed with numerous dark spots, ranged in transverse rows across the dorsum, from which woolly matter sparsely proceeds. A pale line passes from the vertex down the whole back. Eyes very minute. Legs very short; the coxæ being placed well forward on the sternum. The tarsus is armed by a single claw; but, as this has two bristles, a high magnifying power is necessary to show its single character. Rostrum very short, but this increases in length by age to the third coxæ.

Very numerous at the roots of *Poa annua* on the Northumberland moors. On moving the soil the white tufts of cotton-like fibre, spun from the dorsal pores, betray the presence of these insects. Sometimes the Aphides are solitary, at other times small companies of eight or nine may be found herding together. They occur from May to October, and then probably they burrow deeper and evade observation.

Occasionally the antennal joints differ in number on the two sides, thus development would seem to go on at uneven rates.

# APHIDES IN THEIR ECONOMICAL RELATIONS TO ANTS.

THE subject of favouritism amongst insects affords one of the most curious phases of their economy. At the same time the matter is one of the most obscure. It has exercised the imagination and ingenuity of Entomologists for more than two hundred years, and at present hypothesis, more or less probable, is put forward as to how far mere utility or intelligence, or even a quasi-civilisation, has produced such peculiar conditions of life.

These habits, which may be styled Sycophancy* or Paracletism,† differ from parasitism; for one insect does not prey on the other, but is nursed and cherished as a pet. The habit comes out most markedly amongst what may be considered the most intelligent insect-orders, like the Hymenoptera.

The wars, raids, slave-driving, huntings, stratagems, and singular architecture of this order has been described by many, but Sycophancy or, better perhaps, Paracletism would suggest a peculiar refinement beyond mere utility.

The handsome apathetic humble-bees are destitute of corbiculæ or pollen-baskets, usually developed on the thighs of the Apidæ. These large Bombidæ apparently neither work or gather honey. Have they become degraded, and have they lost at the same time, by disuse, the natural apparatus conducive to

* From *συκοφάντης*, a parasite, perhaps one who informed against persons plundering sacred fig-trees, from *σῦκον* and *φαίνω*.

† From *παράκλητος*, a patron or comforter.

work, whilst being fed and caressed by their industrious but less showy hosts?

Mr. Frederick Smith has shown how some of our active industrious bees (Andrenidæ) tolerate the presence, and, indeed, seem to have friendly relations with the mauraudiug and destructive bee-wasps (Nomada), which are permitted to enter their sand burrows, and steal the food stored for the use of the young Andrena.*

Prof. Westwood some years ago showed how *Formica flava* stores certain blind beetles, as *Clavager Duvallii*, in their nests; and solely, it would appear to him, for the sake of feeding on a gummy secretion which exudes from the bristles at the termination of their elytra.†

More recently Markel counted no less than fifty separate species of Coleoptera in the Ants' nests of Switzerland, many of which were quite blind, their eyes becoming obsolete and useless in the darkness of their subterranean dwellings.

M. Lespès regards these beetles as real domestic animals, and he has recorded several curious observations with reference to their economy, and that of the ants with which they consort.‡

It is remarkable that hitherto *Clavager Duvallii* has only been discovered in the nests of *Lasius niger*. But nests of this ant do not always contain such beetles; and if the last are forcibly introduced they usually are immediately killed and eaten by the inhabitants. The suggestion has been accordingly made, that some communities of Lasius are not so far advanced in civilisation as others, and that they have not yet developed the hospitable virtues. They are still, in short, barbarians.

* *Vide* Introduction to the British Apidæ, 'Cat. Brit. Hymenop. Brit. Museum.' by F. Smith, pt. 1, p. 210.

† Westwood's 'Int. to Modern Class. of Insects,' i, p. 176, and ii, p. 234.

‡ *Vide* Denny and Lespès, 'Annals and Mag. Nat. History,' vol. i, 2nd ser., p. 240; also 'Ann. des Scien. Natur.,' 1863.

Sir Joseph Hooker and Prof. Tyndall have each urged the injury done to discovery by the divorce of imagination from science. "Observation, enthusiasm, and imagination—these three are the prime factors to which is due all excellence in science and art." Doubtless a vivid and educated perception will greatly help a successful generalisation, and often present a working platform for subsequent experiment; but, on the other hand, the most correct idea may suffer by an expansion under the exuberant fancy of those who love marvels.

The fact that Aphides are most friendly to such dissimilar insects as Ants has been long known. Goedart, in Réamuer's time, allowed his fancy to run into imaginary conversations between them, relating to such subjects as warning each other against their foes and the like.

From a similar fancy it is, that the term "vaccæ," playfully given by Linneus to those Aphides which yielded their sweet secretions to the solicitation of ants, became "milch cows;" and the "thrumming" of the ant's antennæ on the sides of the abdomen has been since likened to the action of the fingers in ordinary milking!

Even Morren saw certain curious analogies between Aphides and Mammifers, and considered that the young Aphides were nourished by the quasi-milk furnished by the nectaries of its mother.

From Pierre Huber (the son of the historian of bees) we learn that certain continental Ants enclose portions of leaves, largely tenanted by Aphides, in a kind of wall constructed of mud. This enclosure soon afterwards became, in imagination, a paddock for the above milch cows. Again, the cavities below the roots of grasses near ant-hills, in which subterranean Aphides feed, are likened to stables or cattle-lairs.

Huber the younger was aware of the incredulity of his contemporaries; and that by them his discoveries were looked on as more or less romantic tales. Accordingly, in the commencement of his history of the indigenous ants of Geneva he affirms that he has neither been led aside by a fertile imagination, nor by a love of the marvellous.*

In this history Huber shows the way in which certain ants construct covered passages of earth or other materials through which they can, in all weathers, visit their Aphides, which live on the plants growing on the surface above, at short distances from their nests. I cannot myself prove that any of our British ants form such curious corridors; but Huber found in the neighbourhood of Geneva that a red ant constructed spherical lodgments over such thistle heads as were loaded with Aphides. In these chambers, which were formed of mud, the ants securely drew their sustenance from the plant-lice. On one occasion he discovered an earthern cylinder, $2\frac{1}{2}$ inches by $1\frac{1}{2}$ inch in size, which had been built near the root of a thistle, and the cylinder contained many Aphides and their attendant ants. But these tunnels, it appears, are not confined to the surface of the ground; for Huber found one five feet above the level of the soil, which enclosed a small branch of a poplar tree. The ants travelled through the decayed and hollow stem and emerged at a junction of this branch, immediately close to which an opening appeared. This was the entrance to a "blackish tunnel," within which they could feed without disturbance. Numerous such instances are related by Huber; and he adds that some covered ways were fabricated out of decayed wood instead of clay.

Huber's words are remarkable and worthy of quotation; since they state as facts that which is very difficult to realise without personal proof.†

* Pierre Huber (the younger), 'Recherches sur les mœurs des fourmis indigènes,' Paris: also a translation of the same, by Johnson, *vide* 'Natural History of Ants,' London, 1820.

† Pierre Huber, l. c., 'Transl.,' Johnson, pp. 228—231.

He says, " Four or five species of ants keep pucerons in their abode; but less constantly, and in much smaller numbers than the yellow ant; as they obtain a portion of their subsistence from those (Aphides ?) inhabiting trees. There are some who reach the branches loaded with these insects, under a covered way of earth leading directly from their nest. Here the ants are as well furnished with food as if they kept the pucerons in their own dwellings. As often as they wish to bring these insects to their nests, they can accomplish it without the knowledge of other ants, and without incurring any risk. . . ." " The turf ant . . . which from its small size (being only half a line in length) may be called the microscopic ant, finds pucerons proportional to its own size. They are of a white colour, and but a little larger than the ant itself. Pucerons are thus the domestic animals of the ants."

Again in another place Huber says that the Ants transport the Aphides to their nests, rather than the Aphides come to the nests of their own accord. Indeed, he thinks that the Ants make systematic searches for Aphides amongst their galleries, which sometimes extend to perhaps thirty or forty feet under the soil. Subsequently the captives are brought into the immediate vicinity of the nests of their captors, and located under the domes of the same. Huber says, " I have seldom discovered Aphides under the ground, without their being surrounded by yellow ants, who arrive at their haunts by the subterranean passages, and who probably convey the Aphides to their nests in the autumn."

Even here wonders do not cease, for he discovered that ants collect the ova of Aphides, and store them with every precaution to preserve their vitality; and that on the return of spring they place them in suitable conditions for hatching the young.

It is not easy to see how the Aphis eggs can improve in condition by all the treatment they are said to undergo when cared for by the ants. They are repeatedly licked over, and lubricated with a glutinous fluid, and treated as if they were eggs of their own species.

Huber discovered that disputes often occur amongst ants, as to the quiet possession of their pucerons. He says that when the ants of one nest succeed in entering the habitations of their neighbours, they purloin the insects, which again are sometimes triumphantly recovered by their original proprietors.

Sir John Lubbock has also made some interesting remarks on this subject of storing Aphis eggs, which bear out in great measure the observations of Huber. He finds that the English *Lasius flavus* collect their eggs and store them for perhaps six months of winter. In the spring these eggs hatch, and he noticed that whilst some of the Aphides issued of themselves from the ground and searched for their food; the others were taken by the ants and placed on suitable plants whereon they throve.

I have been unable to examine these Aphides, or learn their species. They are described as differing from the more common subterranean forms; and that generally they affect the axils of the common daisy, *Bellis perennis.* "The ants build up a wall of earth round and over them;" presumably for the same purposes as stated by Huber, viz. for ant-runs.

It is by no means easy to assign good reasons for this storage of eggs. Inclemency of winter would seem to have little to do with it; for the eggs, it is well known, will stand extreme cold; and they are covered by a natural varnish which is impervious to rain.

This opinion as to their hardihood does not however accord with Sir John Lubbock's explanation, for he says, "The eggs do not remain where they are laid, where they would be exposed to the severity of the weather.

Gould in early days noted these black eggs and mistook them for the female eggs of the ants.

It was not till March, 1880, that the hatching of these eggs was witnessed by Sir J. Lubbock who saw the process; and the produce of these eggs differed entirely from the subterranean species often found in such situations.

"Near one of my nests of *Lasius flavus*, in which I had placed some of the eggs in question, was a glass containing living specimens of several species of plants commonly found on or around ants' nests. To these some of the young Aphides were brought by the ants. Shortly afterwards I observed on a plant of daisy, in the axils of the leaves, some small Aphides very much resembling those from my nest, though we had not actually traced them continuously. They seemed thriving and remained stationary on the daisy. Moreover, whether they had sprung from the black eggs or not, the ants evidently valued them, for they built up a wall of earth round and over them. So things remained throughout the summer; but on October 9th I found that the Aphides had laid some eggs exactly resembling those found in the ant's nest; and on examining daisy plants from outside, I found on many of them similar Aphides and more or less of the same eggs. I confessed these observations surprised me very much." . . . "Here are Aphides not living in the ant's nest, but outside on the leaf stalks of plants. The eggs are laid early in October on the food plant of the insect. They are of no direct use to the ants, yet they are not left where they are laid, where they would be exposed to the severity of the weather and to innumerable dangers, but brought into their nests by the ants, and tended by them with the utmost care through the long winter months, until the following March, when the young ones are brought out and again placed on the young shoots of the daisy. This seems to me a most remarkable case of prudence. Our ants may not perhaps lay up food for the winter, but they do more, for they keep during six months the eggs which will enable them to procure food during the following summer.*

The veteran entomologists Kirby and Spence, who noted also the occurrence of Aphides in ant-hills, decidedly endorse the theory that "they are a provision to sustain the lives of their captors during their half-torpid condition until early spring. By an admirable provision these Aphides awake out of their torpor and at the same period the ants also awake."†

Again they say, "*Formica flava* receives almost the whole nutriment, both of themselves and their larvæ, from Aphides"; and that the prosperity and wealth of communities are in proportion to the number of their cattle. Here they follow Huber, who says that an ants' nest is more or less rich according to its stock of what he calls their "cows and goats." ‡

As before noticed, imagination may not be banished from science, yet caution is needed lest science should drift into fancy, or foster a more popular taste for description. Entomology is peculiarly liable to suffer from a florid style in the hands of those who write to amuse as well as to inform their readers.

I would ask attention to the following considerations before committing ourselves to any theory of Paracletism.

1. Many species of ants are partial to honey and the sweet secretions of insects, but it has not yet been satisfactorily shown that any Ant is dependent on Aphides for its exclusive support.

2. Some species of Aphis feed on roots which often intersect ant-nests, but most ant-hills are destitute of Aphides.

3. The roots of many grasses growing in light soils

* Sir J. Lubbock, 'Journ. Lin. Soc.,' vol. xiv, p. 610; and 1880, vol. xv, p. 182.

† Kirby and Spence, 'Introd. to Entom.,' vol. ii, p. 349 (1843).

‡ Germar, 'Mag. der Entom.,' iii, t. 2; also *vide* Boisier de Sauvages, 'Journ. de Physique,' tom. i, p. 195, "On the Relations between Ants and Aphides.

are attacked by several species of Aphis. Ants do choose such localities for their nests. In such cases they are on the best of terms with the Aphides; but the latter are no more necessary to their economy than the blind Coleoptera, Myriapoda, and the like, which are commonly found intermixed with them.

4. Many aërial Aphides are visited by ants whilst feeding on the sap of plants. Honeydew is secreted out of this sap by organs connected with their nectaries. Captive Aphides, condemned to underground life, are cut off from their usual food, and it is presumed they can no longer secrete honeydew.

Huber's cattle-lair theory is, therefore, unsatisfactory. If Aphides are imprisoned after marauding expeditions, it must be for a different purpose than for collecting food.

It will be unwise to put limits to the peculiar phases of insect economy. Extraordinary ingenuity and unexpected habits are continually pressing on the observation of the entomologist. Perhaps the only safe conclusion arrived at with reference to Aphis and Formica is, that the latter is a considerable sugar consumer, and that like Man, it also is a fosterer of pets and favourites.

In the tropical parts of India and Brazil, where Aphides do not exist except on the high table lands, ants show their appetite for sweets by thrumming the sides of the larvæ of certain species of Cercopis and Menebracis (Coccidæ). In England I have often noticed their resort to some of our Psyllida for the same purpose.

It is not a little remarkable that the friendly relations between Aphis and Formica have been of a very ancient date. There are unmistakable evidences that in the Middle Tertiary ages, when the Hymenoptera were so largely represented by ants (far more so than in modern times), the then existing Aphides were as much frequented by them for their secretions as now.

The Rhizobiinæ are all root-feeders; yet, as there are other subterranean species not included in this group, it may be useful to give a list of such, most of which are noted in this Monograph. It is probable that some of these, like Pemphigus and Phylloxera, have aërial forms.

List of Aphididæ which are known to effect part of their metamorphosis underground.

*Siphonophora tussilaginis (?).*

*Aphis farfaræ, A. lappæ,* Koch; *A. intybi,* Koch; *A. plantaginis,* Schr.; *A. ranunculi,* Kalt.; *A. subterranea; A. symphiti,* Sch.; *A. terricola,* Rond.

*Trama troglodytes.*

*Paracletus cimiciformis.*

*Schizoneura fodiens, S. venusta,* Pass.

*Pemphigus Boyeri,* Pass.; *P. cerulescens,* Pass.; *P. fuscifrons, P. lactucarius, P. ranunculi,* Pass.

*Forda formicaria, F. viridana.*

*Tychea eragrostidis, T. phaseoli, T. setariæ, T. setulosa, T. trivialis.*

*Endeis carnosa, E. formicina, E. pellucida.*

*Rhizobius pilosellæ, R. sonchi, R. menthæ, R. subterranea,* Kalt.; *R. poæ.*

*Phylloxera vastatrix.*

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## ADDENDUM.

Subsequent to the publication of my first volume, several large Aphides were kindly sent to me from Scotland in the summer of 1878 by Professor Trail, of Aberdeen. They were found feeding on *Rubus fruticosa,* and they showed all the characters of Siphonophora.

Unfortunately no winged forms could be secured, which would have permitted a more satisfactory diagnosis. The antennæ and legs of these specimens are remarkably long, the cornicles are more cylindrical than in *S. rubi* proper, and the body is hirsute.

The most striking character is their bright rufous colour, varied on the body with obscure bands and dots of rich brown. These differences are sufficient, I think, to mark the insect as a good variety of *S. rubi*, which in England is always, I believe, of a lively green colour.

The measurements are as follows:

SIPHONOPHORA RUBI, var. RUFA. Plate CXXX, fig. 1.

*Apterous female.*

| | Inch. | Millimètres. |
|---|---|---|
| Size of body | 0·090×040 | 2·28×1·01 |
| Length of antennæ | 0·160 | 4·06 |
| ,, cornicles | 0·040 | 1·01 |

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Numerous examples of Aphides mounted in Canada balsam by the late Mr. F. Walker, have at different times come into my possession. Most of them unfortunately are unnamed by him, but amongst those labelled I find specimens of pupæ with well-developed wing-cases belonging to the genera Forda and Trama.

Mr. Walker, in his 'Catalogue of Homoptera in the British Museum, states that the species, "*Trama troglodytes* and *Paracletus cimiciformis* occasionally but rarely assume wings."

In my diagnosis, vol. III, p. 67, I omitted to make drawings of these pupæ. I now figure them, Pl. CXXX, fig. 4, for reference, but upon Mr. Walker's authority, for I have never met with the alate forms, and I believe others also have been unsuccessful in the search.

On the same Plate CXXX, fig. 2, I depict the imago of *Aphis subterranea*, the living forms of which up to this time have escaped my notice. I have several slides containing the winged forms of this Aphis mounted for the microscope by the late Mr. F. Walker.

## I.—REPRODUCTION OF APHIDES.

"If this Essaye were worthy judged of, it might not greatly please the common and vulgar spirit, and as little the singular and excellent. The first will understand but little of it, the latter overmuch."—*Michael de Montaigne*, cap. liv.

### 1. GENERAL OBSERVATIONS.

A GREAT part of the interest attaching to the Aphis family is connected with their double mode of reproduction; a process represented by the terms gamic and a-gamic. It is true that when once this unexpected fact was substantiated by early biologists, it was discovered that the non-intervention of the male was of more frequent occurrence amongst the lower animals than was at first recognised. The discovery, indeed, was not quite so new as was at first assumed.

The philosophic Aristotle appears to have had some indistinct notion of a like phenomenon; and he seems to suggest something akin to non-impregnation in his remarks on the development of the egg of the drone or male bee.

W. Harvey commented upon and corrected the opinions of Aristotle and Fabricius, and declared against spontaneous generation. He did this very decidedly in the words "Omnia omnino animalia etiam vivipara, atque hominem adeo ipsum, ex ovo progigni;" and again later, "Cuncta animalia quodum modo ex ovo nasci affirmavimus."

In another passage, however, he seems to admit the current doctrine of production of worms by putrefaction, as an exception.*

* *Vide* W. Harvey, 'Omnia opera' 4to, 1766, p. 182, and p. 482. Also article "Harvey," 'Encyclopædia Britanica.'

Even before the time of Réaumur's and Bonnet's discoveries it had been asserted that the unimpregnated egg of some Papilionidæ had proved fertile, but such novel observations met with but scant attention; firstly, perhaps, from incredulity as to the fact, and secondly, from a notion that such was contrary to all experience.

Here the subject seems to have rested for nearly one hundred years. The phenomenon of multiplication by fission observed by Trembley in the fresh-water Hydra was too recent and peculiar to cause the naturalists of his day to infer analogous processes in Insects. Still an attempt towards an explanation was made with reference to Aphides both by Leuwenhoeck and Cestoni, who considered that these insects were hermaphrodite; and this belief accorded with the views of the best zoologists of that day.

Bonnet substituted another explanation, and argued that the chief difference between the viviparous and oviparous female consisted in the more or less perfect development of the two forms. According to his view, the conjunction of the male gave to the germ that which the mother, on account of her incomplete development, was unable to supply to her progeny. Abundance of food, and a high temperature, he thought, produced the first form; cold and insufficient food in autumn caused the appearance of the egg-laying female, viz. the second form.*

Trembley attacked the subject differently. He considered that the influence of the male in autumn transmitted itself throughout the whole generation of females of the following year; and this view, more or less modified, was accepted by Dutrochet, and by Kirby and Spence, who all rejected the hypothesis of hermaphroditism.

Reproduction amongst animals may occur through several processes, all of which are in a measure analogous to the propagation of vegetables. Amongst

* Bonnet, 'Considérations sur les corps organisés,' t. ii, 1776.

the Protozoa multiplication takes place by fission or separation into two or more individuals; or by budding or gemmation, where a separation of the smaller individual from its parent is preceded by a growth in the lesser form. According to Prof. Balfour, no essential portion of the parent is removed during this process. A portion of a nucleus may separate either externally or internally from the protoplasm. The spores of animals may break up into very numerous parts, all of which may materially differ from the form of their parents. In the Infusoria such spores are often furnished with a vibratile lash or flagellum, by which they progress through the water or other fluids in which they live.

Even in the lowest vegetable forms a conjugation of cells seems to be the condition of a renewed vitality; though the fact is remarkable, that the conjugation of two or more individuals does not invariably lead to immediate reproduction. Such conjugation, however, probably conduces to a fresh vigour in the animal, and conduces to a differentiation which checks the evils of self-fertilisation.

In the Metazoa both sexual and non-sexual phenomena obtain. The first consists of the fusion of the ovum and the spermatozoon, attended by a subsequent division of the compound cell. Development here mostly results in the production of forms similar to the parents.

La Hire, perhaps, was the first to observe the process of egg-laying in Aphis; and at the same time he demonstrated that both viviparism and oviparism might go on side by side in the same family of insects.

Prof. Owen, in more recent times, revived the theory originally started, it is believed, by Dutrochet, in a lecture delivered to the members of the Royal Institution of London. After giving an interesting definition of the *collective individual*, Prof. Owen stated that there was no scientific difficulty in conceiving the efficacy of the male influence as shown by Aphis, notwithstanding the wonderful dilution of energy which must occur throughout the countless components of the generations following.*

The propositions made by the Swedish naturalist, De Geer, in 1773, have been already noted.† He agreed with Bonnet in the modifying action of food and climate, and thought it highly probable that, if Aphides should be discovered in tropical countries, they would be exclusively viviparous. Leydig also entertained very similar views on this point.

Kyber‡ made experiments on the effects of food and temperature, and he came to the conclusion, which is now untenable, that such influence was sufficient to change the apterous oviparous female into the viviparous female; and this error seems to have been shared by the French anatomist, Charles Morren.

The close similitude of form of the ovarian chambers of the true female and the chambers which develop the germs from the viviparous individual doubtless misled both these observers. The latter observer made good dissections of the reproductive organs of both male and female Aphides; but he failed to note the significant absence of a spermatheca in the viviparous female. Such a knowledge also would have saved Bonnet from the error of supposing that viviparous germs and mature ova were often present in the same insect.

Considering the comparatively early date of Morren's memoir on the anatomy of *Puceron du pêcher*, his remarks and discussions are very suggestive. He says it is very difficult to bring one's mind to accept the hypothesis, that Aphides, up to the eleventh generation, are the results of the fecundation of their ancestors anterior to the first of the series. "The eleventh generation," he says, "does not exist at the moment of fecundation of the first." "He would

* Prof. Owen's lecture, 'Proc. Roy. Instit.,' vol. i, p. 9.

† Vol. i, p. 55.

‡ Kyber, 'Germar's Mag. der Entomol.,' 1815.

prefer to acknowledge his ignorance, rather than give an opinion in such a labyrinth." "S' il fallait une explication à toute force, j'admettrais que la génération se fait ici comme chez quelques Entozoaires, par individualization d'un tissue précédemment organisé."

He says that the generation on that account is not spontaneous, for such a generation ought to be the product of an organised being, "de toutes pieces," when the inorganic elements unite to produce an animal or plant. "This has never taken place, and is impossible." Again he continues: "La génération équivoque" is that when the tissues previously organised by a being provided with life individualise themselves, that is to say, separate themselves from the common mass, and still participate in the dynamic state of the mass after this separation for its own benefit. Thus it is that a tissue produces an Entozoon. It is a continued life.

He continues: "But suppose that the life has a sufficient energy to impress itself on the tissue which individualises itself . . . . in such a case you have the generation of the Aphis. This energy is lost at the end of certain generations; and then a new impulse becomes necessary; and this impulse comes from the male."*

It is obvious that such a process amounts to a non-sexual "budding," now so commonly known to prevail amongst the lower animals.

In another place Morren assigns the origin of the non-sexual viviparous Aphis to a body—"d'œuf formé de globules réunis, et sans enveloppe apercevable."

M. Balbiani remarks, it will be more rational to compare this body either to a true ovum or else to a germinative sac, after the example of other naturalists.

Morphologically ova may be regarded as buds, with this special difference that the latter are incapable of fertilisation. If this difference did not exist, some, like Leuckart, might assert that in certain kinds of

* Ch. Morren, "Puceron du pêcher," 'Ann. des Sc. Nat.,' p. 65, 1836.

animals the males do not exist. Von Siebold even surmised that in certain species a process of elimination was in action as regards the males, and that such a process finally would result in a strict parthenogenetic reproduction of such species.

But it will be very unsafe to dogmatize on negative evidence as to the non-existence of males. The male of the Entomostracan Apus was long unknown, but in 1858 it was discovered by Kozubouski. Still, this sex occurs so very infrequently, that not one could be found amongst the 5790 individuals said to have been examined by Siebold. Again, Sir John Lubbock examined 193 specimens of *Apus cancriformis* taken from a pond near Krakow; and amongst these he discovered but one single male. The fact seems to become more and more patent, that as we become better acquainted with the metamorphoses of the lower animals, and the very different larval aspect they can assume, such anomalies will disappear. Under the present conditions of life a conjuncture of male and female cells seems to be all but imperative for the renewal of life-cycles.

The absence of a spermatheca in some low aquatic forms might argue the non-existence of males; but here possibly a large volume of the male element, diffusing itself through the surrounding water, may ensure action on the ova, in a manner similar to the milting of fish, and make this sperm receptacle unnecessary.

In 1856 Von Siebold gave a rude shock to the prevailing current opinion; founded on Harvey's dictum "omne vivum ex ovo," * by showing that a true parthenogenesis obtains amongst moths and bees. Before his time it had been *almost* uniformly assumed that without the action of the spermatozoon on the ovum no fertilisation could occur.

In 1857 the same biologist demonstrated that the queen bee exhausts her store of sperm in fertilising

* This aphorism, usually attributed to Harvey, appears to be a contraction of his words, already quoted.

eggs, which uniformly under its influence produce female forms. In other words, the drone or male bee always hatches out from an unfertilised egg. At first this seemed to be a grand fact to generalize upon; but shortly afterwards it was satisfactorily proved, that in some other families of insects the converse was true; namely, that unfertilised eggs produced entire female broods to the exclusion of all males. This last peculiarity is true also in the crustacean *Apus cancriformis*.

Von Siebold's very important researches on the small social wasps, *Polistes gallica* and *P. diadema*, must be fresh in the memory of many. His observations go to prove that, whilst the impregnated queen wasp produces eggs, furnishing first the female and then the male forms, the virgin queen can alone produce the latter. He also states that the parthenogenetic progeny of the leaf-wasp, *Nematus ventricosus*, is male.*

It really would appear, that mere speciality of sex has but little to do with impregnation or otherwise, for the Lepidopterous genera Psyche and Selenobia are stated to furnish by impregnation females exclusively in the first case, and *almost* exclusively in the second.

M. H. Weijenbergh made some interesting experiments on the same subject with reference to the unimpregnated eggs of the Lepidopterous insect *Liparis dispar*. Of the caterpillars which hatched out in the following spring he destroyed all the males. The imagoes appeared in August from the remaining eggs. Although these were all virgins they produced eggs which hatched in the next April, just like the preceding batch. These unimpregnated broods appeared for three consecutive years, though with diminished vitality. Finally they ceased to hatch, inasmuch as the eggs dried up all together.†

* 'Beiträge zur Parthenogenesis der Arthropoden,' von C. Th. von Siebold.

† 'Archives Neerlandaises,' published by the Soc. Hollandaise des Sciences à Harleem, 1870. Also *vide* a summary of this subject by Prof. Ray Lankester, 'Nature,' October, 1872, p. 523.

Unexpectedly, the males and the females were nearly equally numerous in all the broods experimented upon.

It may not be considered out of place here slightly to remark on the ephippial eggs of Daphnia, which have been at different times described by Dr. Baird, Sir J. Lubbock, and others.

Dr. Baird showed, as regard the water-flea, *Daphnia* (which sometimes occurs in such quantity in our ponds as to colour the water red), that a single copulation is sufficient to fertilise the female through life; and Jurine thought that this fertilisation might extend even through fifteen generations.*

Two kind of ova are developed in Daphnia.

The ordinary ova are transferred from the ovary into a chamber near the back; but the extraordinary ova have their development in a kind of saddle attached to the little crustacean, whence the term *ephippial ovum.*

They are also called by some authors hybernating or winter eggs. From the impermeable integuments which encase them, they can resist either a dry heat or a considerable cold without loss of vitality. As these eggs, however, are often formed during the heat of summer, the term hybernating eggs, perhaps, is not a very happy one.

Von Siebold showed that these ephippial eggs contain no germinal vesicle; and Dr. Burnett maintained that they are instances of "internal gemmiparity," and just so he regarded the phenomenon of the agamic reproduction of Aphis to be a process of internal budding.

Prof. Allman likewise agrees that these winter eggs, which he styles statoblasts, are not true eggs; but separate granules, which contain no germinal matter, vesicle, nor macula; and that they do not undergo segmentation. Ephippial eggs, Dr. Allman says, may even be budded from the stomach-walls of an animal. Again, Prof. Huxley similarly shows a dissimilarity

* W. Baird, 'Brit. Entomost.,' Ray Soc., 1849, p. 80.

between the two bodies. The ephippial egg is usually twice the size of the true ovum, and is in effect an aggregation of cells; in fact, parts, or sometimes the whole of the ovary is encased in a shell with its membranes, so as to simulate true ova.

To summarise the foregoing remarks; two varieties of ova may be characterised. The first represents the ovum proper, which is the direct product of the sexual process. The second is altogether non-sexual, and is known by a variety of terms, as statoblast, ephippial egg, pseudovum, winter egg, gemma, bud-germ, or spore.

All recent research points to the belief that ova are the means finally resorted to by nature for specific maintenance; and that for reproduction, a conjugation of simple cells of different potentiality is a constant phenomenon.

In almost the identical words of Dr. Allen Thomson,* "Multiplication entirely without any known sexes has been remarked in very few instances. In others, the non-sexual process of generation gives rise eventually to sexes which are simply the repetition of the parent. If a non-sexual multiplication occurs, it takes place during the incomplete condition of the animal."

A remark by Prof. E. Ray Lankester may be here added, as it refers to the eggs of the little Entomostracan Apus, which "escape from follicles as a matter of course, and pass along the canal leading from it to a primary branch of the ovarian tube, and then two or three eggs fuse into one mass, around which a shell is accreted, and this forms the actual egg."

In Pyrosoma five embryos may come from one egg; but this is the converse of the foregoing. Prof. Huxley remarks to me that this is really a process of budding.

The unimpregnated ovum of the hen, and even of

* Dr. Allen Thomson, "Ovum," 'Todd's Cycl. of Anat.' Sup., pp. 33, 37, 137.

the sow, has been said to undergo something like a segmentation. But as one swallow does not make a summer, so great caution must be exercised before any idea of parthenogenesis can be extended to these higher animals, based upon observations so few in number.

Space does not permit here to enter on the vexed question as to the difference between animal buds and true and fictitious ova. The subject has been already treated by Von Siebold, Leydig, Leuckart, Huxley, Claperède, and others. Indeed, it would seem to be difficult to come to a unanimous opinion, whilst sexuality is allowed by some to have little or no weight in the argument. Brandt remarks as to parthenogenesis, "It is partly to be met with as a normal condition, and partly as an exceptional condition; as we find to be the case with so many insects. However interesting the fact of the want of a seminal receptacle in the oviparous Aphis may be, from a physiological or a morphological point of view, one can nevertheless hardly attribute to it a fundamental significance, but rather view it as of secondary, adaptational import."* This would seem to imply that there is but little real difference between an impregnated and unimpregnated egg (?).

Amongst Insects a modified parthenogenesis has been observed in *Sphinx populi*, *S. ocellata*, *Arctia caja*, and several other genera of Lepidoptera. Mr. Davis raised three parthenogenetic generations from the eggs of the egger moth, *Lassiocampa quercûs.* The marked rareness of the male in Cynips is well known; and the same scarcity may also be noticed in Coccus. Doubtless, however, in some cases males are overlooked on account of their diminutive proportions.

Von Siebold some years ago noted the remarkable fact that reproduction occasionally takes place in the larval phases of some insects. He gave the term *Thelytoky* to the process usually known as partheno-

* Dr. A. Brandt, 'Ueber das Ei und seine Bildungsstätte,' p. 55.

genesis, and Leuckart proposed the term *Arrenotoky* to express the power of certain virgin females to produce males.*

## 2. THE REPRODUCTIVE ORGANS OF THE VIVIPAROUS APHIS.

The body-cavity of the viviparous Aphis during the summer time is almost exclusively occupied by the embryos and the organs subservient to nourishment. In Aphis proper, in Siphonophora, and the higher genera, the embryos are exceedingly numerous. As many as thirty may be often counted, if the abdomen be snipped with sharp scissors, and the insect be compressed under the microscope. These embryos may be seen in all stages of maturity; those placed nearest the vulva being by far the largest, and showing the eyes, antennæ, and limbs fully formed. Their posterior ends are turned towards the vulval opening. Thus the young ones are always born tail foremost.

The first thing which calls attention is the multiplicity of the ovarian chambers. As in most insects, these cæca unite end to end, and form several long strings, somewhat like threaded beads of different sizes. These strings; which vary in number in different species, compose two bundles or fasciculi, one of each is disposed laterally. Each fasciculus unites with an oviduct; and finally the two oviducts coalesce before they join the vaginal passage.

Thus the ovarian chambers are largest at their attachment to the ovarian duct, and become more and more attenuated as they penetrate deeper into the body-cavity. The terminal chambers are very small; but each has a delicate filament united to the anterior part, supposed by some to be in communication with the organ which has the function of a heart.

This end chamber is the seat of important action, for within it the first germinal matter is elaborated.

* Dr. Burnett's transl. Von Siebold's 'Comp. Anat.'

Like all the other chambers; it is formed of membranous walls studded with epithelial scales. Within the terminal chamber, several nucleated cells are visible, which are embedded in the periplast. These cells, have, according to Brandt, an amœboid movable nucleus, and correspond to the ordinary germinal vesicles with their usual spot. After a time a constriction forms at the lower end of the terminal chamber, and one of these germ-vesicles passes through, and then it greatly increases in size. This body finally becomes the pseudovum, which is composed of a pseudo-vitellus encompassed by its nucleated cortex; which Prof. Huxley likens to the blastodermic layers of the true eggs.

The resemblance between the pseudovum and the ovum is completed by the formation of the vitelline membrane which completely envelops the pseudovum. The blastoderm separates into two portions, the outer of which forms a sort of hood over the inner. This hood eventually becomes the abdomen of the larva. Other parts of the blastoderm, in a similar way, separate into the thoracic and cephalic segments.

"The most probable hypothesis as to the nature of the process effecting these changes is that the endoplast of the pseudovum (germinal spot) divides and subdivides so as to give rise to the endoblasts of the germ. This is more in accordance with what we know of histological development."*

Brandt endorses all the principal views expressed by Prof. Huxley as above sketched, and, indeed, thinks that the resemblance between the early products of the viviparous and oviparous females of Aphis is so marked, that the terms pseudovum, &c., might be dropped altogether.†

A few remarks may here be added as to the significance of the yolk-cord discovered by Prof. Huxley in Aphis, and by others in Coccus and Psylla. It may

* Huxley, "Reprod. of Aphis," 'Linn. Trans.,' 1858.
† Brandt, 'Ueber das Ei;' *vide* note, p. 55, also p. 56.

be found also amongst some Coleoptera and Hymenoptera.

Dr. A. Brandt has devoted some thought to the import of this element; but the function it performs may still be considered yet to want complete elucidation. Dr. Brandt states that the basis of the yolk-passage (Dottergange) is sharply bounded by the neighbouring epithelium of the ovary where it appears conical; whilst towards the apex its outline is terminated by the adjoining germinal vesicle of the yolk-forming cells. Its designation of a *yolk-cord* (employed previously by Huxley and translated Dotterstrang) perhaps best accords with what is really *known*, than the term yolk-passage, for it has not yet been proved that the vesicles pass through it as a tube. Huxley has not drawn the vesicle as situated within such; and Brandt, in 1878, had not been able there to trace it. This cord occurs both in the parthenogenetic and the fully sexed female organs, though some differences of condition connected with these forms may be pointed out.

This yolk-cord passes from the end chamber of the ovary, through one or more chambers, to any other particular one; that is, in such cases where the ovaria are many-chambered. This disposition is remarkable; and Brandt offers the following as a possible explanation of its action:

"Let us imagine that, instead of a single ovarian chamber, one or more (connected with the terminal cyst by its yolk-cord) form at the basis of the same. Then those formed earlier will, together with their yolk-cords, be pushed aside by those formed later. After the whole stock of egg-rudiments (Eianlagen), together with their yolk-passages, has been differentiated, then, by the splitting up of the terminal cyst into yolk-forming cells, the change of its remaining undifferentiated elements will take place."

Further on he says, "Every break in the epithelial partition which separates the yolk-forming elements from the egg-rudiments (Eianlagen) can be morphologically considered as a yolk-passage. If the yolk-forming elements be immediately upon the yolk, with broad surfaces, and without the separating epithelial layers, then a perfect yolk-passage would seem to be unnecessary, and its production (Zustandekommen) difficult to realise.*

The vagina of the viviparous female is furnished with two muciparous or colleterial glands, the office of which has been before indicated. The spermatheca or sexual pouch is wanting in the organs of the agamic female.

### 3. REPRODUCTIVE ORGANS OF THE OVIPAROUS FEMALE APHIS.

The reproductive organs of the oviparous female have anatomically much in common with those of the viviparous; but the vulva sometimes terminates in a short ovipositor, as may be seen in Drepanosiphum and Phylloxera. This prolongation of the vulva is figured in Pls. CXXI, fig. 1, CXXV, fig. 1.

In *Thelaxes dryophila* the vulva, which is always situated between the eighth and ninth abdominal rings, closes by a sphincter; the action of this is controlled by several bundles of contractile muscles, *vide* Pl. E, fig. 1. The opening thus may appear as a long slit forming the lips of an oval.

The vulva opens into a wide and thick-walled vagina, which is provided with a longitudinal and transversely striated muscular coat. After its continuation forward for a short distance, it is perforated by the duct leading from the colleterial glands, and shortly above this by the opening from the spermatheca.

Beyond this the vagina divides into two wide branches, constituting the oviducts, which spread towards each side of the body. Each of them finally divaricates into five or more tubes, which end in the ovarian chambers or ovisacs.

* *Idem*, pp. 48, 51, Taf. iv, figs. 103—109, 130.

The number of these ovarian chambers varies with the genus and species of Aphis. As a rule, the chambers composing the ovaries of the true female are less numerous than the pseudovarian cysts of the viviparous insect.

In Chermes, however, the ovarian cysts are very numerous during the summer: as many as ninety or one hundred may be counted in one individual. In respect to such species as only elaborate a single egg, the corresponding organs are more simple in form.

Just as with the agamic winged females, these chambers communicate one with another, so as to form many distinct branches; and these branches again unite so as to form two fasciculi, each ending in their respective oviduct.

Early in October Mr. Foran kindly forwarded to me several specimens of the oviparous female of *Callipterus quercûs*, taken on the oaks near Eastbourne. They were of a bright yellow colour; and similar ones have been figured on Plate XC, fig. 3, Vol. III, of this Monograph.

They differed much as to the number of forward eggs within; for some specimens contained ten, twelve, thirteen, twenty, and thirty-eight eggs respectively. Some eggs were yellow, whilst others were of different shades up to black. Balbiani thinks this change of colour does not take place until the eggs be fecundated. However this may be, all shades of colour may be traced in the unimpregnated pseudo-eggs of Chermes.

It is difficult to speak with certainty as to the exact number of branches which arise from the fasciculi of different species. In genera like Pemphigus the reproductive organ must be very simple, since it gives rise only to a single egg of great size. On the contrary, the fact that thirty or more eggs may be seen in one female of *Callipterus quercûs* leads to the supposition that each fascicle in this species contains five or six branches. In the figure given in Pl. F, fig. 3, six branches are drawn as seen from the camera; but probably two of these belong to a fascicle which has lost the other two by the accidents of dissection. I thus should group the organ as composed of two fascicles, each containing four branches. If Prof. Huxley's figure relating to Vacuna should be accepted as really applying to Callipterus, this would entirely agree with his description of the same.

The colleterial glands of Callipterus are very obvious. They appear as somewhat pear-shaped bodies, deflected at their summits, and narrowing at their bases so as to form a kind of blunt hook. They discharge the mucus-like secretion they elaborate into the vagina, by a duct situated close to the vulva.

These glandular pouches have very dense walls, which are much corrugated within. The supposition that their office is to form a shell to the egg before its exit would seem to be untenable, because similar organs are to be found in the larval females. As the young Aphides at birth are well lubricated, this mucous covering may be furnished by the glands in question.

The spermatheca is not easily separated from the other organs. It occurs in Callipterus as a blind pyriform cæcum, the mouth of which opens into the vagina above the colleterial glands. Its coat is plentifully supplied with muscular fibre. From the interior of a specimen I examined, an immense number of spermatozoa were expressed, and these disseminated themselves into the weak glycerine used during dissection. I could not say that they showed *no* independent motion, but what motion there was, consisted apparently of a feeble movement, almost "Brownian."

It has been before noted that the number of ovigerous tubes which form a fascicle, and the number of the ovarian capsules, vary in separate genera; but we cannot yet state how far this numerical variation is a constant factor. In Aphides low in the scale of development we have seen that a single egg only comes to maturity, the other germs atrophy, or become mere pabulum for the support and development of this one egg of great size.

Prof. E. G. Balbiani states, however, that there is a constant identity of number in the ovigerous tubes of the oviparous Aphis, and in the tubes which give rise to the living young of the viviparous Aphis of the same species. More than this, he says that there is a numerical relation between the number of ovaries and the number of the spermatic capsules in the male. He thinks, however, that of these last, some may coalesce, and others may sometimes become arrested in growth.

Whilst the sperm-capsules of the male Aphis are always free and unattached at their summits, the ovarian tubes of the female are always, according to Balbiani's experience, united amongst themselves by terminal filaments of great tenuity. Much is yet uncertain as to the final attachment of the anterior portion of these filaments to a dorsal vessel.*

As examples occurring in the genera Siphonophora, Aphis, Drepanosiphum, &c., may be cited the following:

| | Ovarian tubes. | | Spermatic capsules. |
|---|---|---|---|
| *Siphonophora sonchi* . . . | 7 | ... | 5 |
| *Aphis persicæ* . . . . | 6 | ... | 3 |
| *Aphis genistæ (rumicis ?)* . . | 5 | ... | 3 |
| *Siphonophora solidaginis* . . | 6 | ... | 5 |
| *Drepanosiphum platanoides* . . | 5 | ... | 3 |
| *Lachnus agilis* . . . . | 7 | ... | 5 |
| *Chaitophorus populi* . . . | 4 | ... | 3 |

### 4 *a*.—THE MALE APHIS AND ITS REPRODUCTIVE ORGANS.

The occurrence of this sex amongst Aphides is comparatively rare. Some explanation of this paucity

* Balbiani, 'Mém. sur la Génération des Aphides,' p. 5, 1870. I have often seen these ligaments in the pseudovaria, but, like Prof. Huxley, I have not met with them in the true ovaria.—G. B. B.

perhaps may be found in the fact that the male is polygamous, and will visit many females.

The males nevertheless occur in two forms. The winged varieties are large insects, whilst the apterous males are very small, and sometimes so diminutive that they were for a long time overlooked altogether.

Kyber's opinion of the non-necessity of the male to perpetuate a cycle doubtless was in a measure formed from a belief in its non-existence. The necessity of the male at certain periods, however, would seem now to be proved by this dimorphism. The winged insect is fitted for long flights, and by its visitation makes a provision against "in and in" breeding; whilst the influence of the minute apterous insect, which is often incapable of nourishing itself, must be very circumscribed.

The winged males of the higher genera of Aphides are often elegantly marked and of bright colour. They are fully-developed insects, provided with large eyes, compound and otherwise, and also with long, well accoutred antennæ, to assist them in their roving expeditions.

The apterous males also are often brightly coloured; but in the lower genera, such as Schizoneura, Pemphigus, and Chermes, &c., they appear to be little more than animated locomotive sperm-cells. They possess neither eyes nor mouths, they have only rudimentary digestive apparatus, and consequently, after fulfilling their office, they speedily die.

The external genital organs of the male Aphis have been well described by Balbiani, and his memoir is elaborately illustrated.* If exception can be taken to his illustrations of Aphis, it may be said that they are too diagrammatic. The figures are symmetrical, and they form elegant drawings; but the conditions are not such as can be seen immediately, and at one view, under the microscope.

* Balbiani, "Génération des Aphides," 'Ann. des Sc. Nat.,' 1869, 15 ser., t. xi.

The original drawings I here offer the reader are perhaps crude, and are not put forth in competition with the more finished work of others. They may have some interest, however, as being almost exclusively *camera drawings*, and as having been produced under a comparatively small amplification (the twelfth of an inch objective not being often resorted to); and particular adroitness in dissection will not be required if their verification be desired.

The penis is of large relative size in Aphis. It is of a peculiar shape, recurved and enclosed within the cavity of the body, and only exserted during the act of fecundation. A gentle pressure on the abdomen, however, causes the organ to protrude; and when once it has been artificially exserted, it does not appear to return to the body-cavity. It is supported in its action by the embrace of a coriaceous ring and certain plates known as the copulative armature. The act, which requires some time for its completion, is many times repeated; one male being sufficient for the fecundation of many females.

Réaumur and De Geer have given ludicrous accounts of the wooing of the males of the great oak Stomaphis. Lichtenstein, who has witnessed the operation, says, the males are very ardent.

Perhaps the best method for examining the internal generative apparatus of Aphides is to make a clean cut with sharp scissors across the abdomen; and place the portions in water containing a little syrup or glycerine. Under gradual pressure, or by the aid of needles, a group of tubular vessels, variable in number, come into view. These tubes, having more or less pyriform extremities, are the spermatic capsules, converging at their bases into a fasciculus or bundle, which appears to lie under the intestinal canal of the Aphis. There are two fasciculi present, and they unite into one single canal before passing into the penis.

These testes seem to float unattached within the liquids of the body-cavity, that is, they are not enclosed in any common envelope. The corresponding organs of *Aphis padi*, however, according to the researches of Leuckart, would seem to vary somewhat from this general type; and Prof. Balfour points out, also, that there is something abnormal in the female organs of this species.

Balbiani states that the form and position of these sperm-capsules vary at different ages of the insect. In the larvæ and pupæ they appear as elongated sacs; in the adult they appear shorter and more ovoid.

Each capsule is terminated by a short peduncle which, communicating with its corresponding deferent duct, finally unites into a single branch towards the medial line of the body. Just below this point of coalescence there are expansions of the walls of the ducts, which Balbiani thinks are comparable to the vesiculæ seminales of other insects. These vesicles descend in the form of two cords and insert themselves close together into the ejaculatory tube.

The sperm-capsules have a knotty or tuberculose exterior, and when partly transparent they are highly refractive to light.*

The vasa deferentia are lined with epithelial cells, which, however, can only be seen under treatment with acetic acid, and under high magnifying powers. Male Aphides have a single pair of muciparous glands, the secretion from which probably forms a vehicle for the transport of the spermatozoa through the efferent passages. These muciparous glands of Aphis were noticed by Morrens; but he, like Léon Dufour, mistook their nature, and considered them to be vesiculæ seminales.

The ejaculatory canal ends at its posterior part in a *cul-de-sac* or bulb, into which the deferent vessels debouch; and the other extremity terminates at an orifice in the neighbourhood of two horny valves, forming the copulative armature before alluded to.

Balbiani has fully described the curious and highly-

* Balbiani, 'Mém. s. l. Génér. des Aphides,' l. c., p. 55.

complicated penis, which is a true intromittent organ. According to his explanation the erection is caused by a regular turning inside out (renverser au dehors), like the finger of a glove. It is caused by a pressure from behind; and it can be therefore easily made to protrude by artificial squeezing.

The penis may easily be seen to be composed of two independent membranous tubes, one within the other. The interior tube is much plicated, and is somewhat of a resistant nature. It shows no direct attachment except through the connections with the deflecting ducts and the accessory glands, the secretions of which pass directly into its cavity. The copulative armature consists mainly of two chitinous valves; which by their approximation protect and perhaps compress the genital opening.

Two pilose mammiliform processes are connected with the semicircular border-plate of the orifice, but their exact import is obscure. Probably they act as compressors.*

From the inverting action of the penis it is obvious that the four separate ducts which are attached to its posterior portion are drawn into the inner channel at the moment of its protrusion.

The great size of this organ is remarkable. In some cases it equals one third of the length of the animal's body. A notable example of such may be seen in *Chermes abietis* which I have figured. The sebific glands of the male may be considered, perhaps, homologous to the colleterial glands of the female.

In most male Aphides from three to five sperm-capsules may be counted as ranged in fascicles on each side of the body. In the species *Siphonophora millefolii*, *Drepanosiphum platanoides*, and *Aphis persicæ*, each lateral fasciculus contains six capsules; but the number appears to be inconstant in species of

* For plates illustrating the above see vol. iv, Plate CXVIII, fig. 8, and Plate G. The principal figure relating to the male organ is copied from Balbiani's Memoir above cited. Some of the smaller details are also drawn from the same source.

the same genus. *Siphonophora jaceæ* is thus said to contain ten follicles in all. In masses so tangled, and so liable to injury during dissection, it is not easy to speak very decidedly on this point. Nevertheless, this point of number would have some importance, if Balbiani's views are correct, viz. that there is a close numerical relationship between the sperm-fascicles of the male and the ovarian chambers of the female. Here it may be remarked that, just as germ-masses are visible in the female fœtus, so sperm-capsules may be distinguished in the males just after their birth.

### 4 *b.*—THE SPERMATOZOA.

The sperm-cells of Insects, like those of other animals, are furnished with a vibratile filament, which some have likened to the filament of the vegetable stamen.

Notwithstanding the name, these minute bodies are to be looked upon rather as a peculiar product of organic growth within the sperm-capsules, somewhat analogous to the fine moving processes of the ciliated texture, than as distinct organisms.*

If a gentle pressure on the abdominal rings of the male Aphis be continued after the protrusion of the penis, a copious escape of minute bodies from the ejaculatory tube will be noted, and these will scatter themselves throughout the weak solution of sugar or albumen used during dissection. Difficulties occur in the examination of these minute cells which constitute the spermatozoa of Aphis. Pure water after a time through endosmosis breaks them up; but by a judicious use of acetic acid or other menstruum, parts otherwise invisible may be brought into view. These cells contain a nucleus and also a nucleolus.*

In all cases that I have examined, where the male is adult, these cells have shown only a slight motion,

* Dr. Allen Thomson, art. "Ovum," Todd's 'Cyclop. of Anat.'

more easily described as gyratory, than like that energetically displayed by sperm-cells in the higher animals. These spermatozoids have a tendency also to gather into knots.

The process of separation of these elements from their capsules is discussed by Balbiani. It does not materially differ from that in other Insects.

The before-noted capsules contain numerous cyst-like bodies, composed of a definite membrane enclosing a multitude of minute cells disposed at one end of the cyst, and a bundle of filaments ranged parallel-wise at the other. When the sperm-cells are mature the cysts break up or burst, and the filamented cells disentangle, and are then free to move down the vessels into the suitable vesicles.

As to the motion of these sperm-cells exterior to their containing vessels and the spermotheca of the female, I will quote the substance of Balbiani's words, which have also reference to the nuclei and nucleoli of these bodies. As I have not possessed the requisite address to exhibit these mere points, which approach the limits of microscopic definition, I may be permitted to do so.

"I will add that even when the sperm-cells have attained their independent existence, they have never presented to me (ne m'ont *jamais* présenté) any trace of spontaneous movement; but on subjecting them to the action of a weak alkali, which notedly evokes the movements of sperm-cells of other animals, it often provoked feeble contractions; but these disappear in a short time. It is not, however, uncommon to see the spontaneous movements of the spermatozoa actively executed in the generative organs of the female."

Balbiani considers that there is a close analogy between the sperm-capsule and the true ovum, and if so, that there should be analogically a nutritive mass and a germinal centre in the former. The first is thought by him to be represented by the nucleus known to all histologists; the second is represented, according to Balbiani, by the still smaller vesicle or globule seen by him as furnished with a filament. This he thinks he has established in the spermatozoid, and it perhaps has been before indicated by Lavalette Saint-George. Prof. Balbiani styles this last point "le vesicule spermatogène," to suggest that it is analogous to the corresponding element placed in the germinative focus of the egg, that is to say, in the germinal vesicle.* But there are good reasons for believing that the sperm-capsule is the sole representative of the ovum. The spermatic cells originate from cells indistinguishable from the primitive ovum; so that the fusion that takes place (at impregnation) is the fusion of morphologically similar parts in the two sexes.

Whatever function may be assigned to the nucleus of the spermatozoon, it would appear that a single head of the same penetrates into the vitelline substance, to seek the homologous body (*female pronucleus*). These fuse together, and the result is fertilisation, followed by segmentation of the yolk.

The functions of the micropyle in Aphis perhaps are of a double nature. Thus apparently it forms an orifice for the entrance of nutritive matter, and also for the spermatozoa. These functions may coexist. In *Phyllaphis fagi* the micropyle appears as a distinct lipped orifice; but in *Lachnus longipes* the appendage beyond the summit of the ovum leads me to suppose that this part really represents the polar cell or cells of the ovum with its projecting spindle; rather than the simple micropyle.

If it be so, the knot of cells at the base of the spindle might well represent the star-shaped body seen by Fol. On the other hand, my figures are not unlike those given by Prof. Huxley as probably constituting micropyles.†

* Balbiani, 'Gén. de Aphides,' p. 82, *et seq.*

† Balfour, 'Treat. Comp. Emb.,' pp. 20, 58, 69; also *vide* my figs. 6, 7, 8, 9, Plate H.; also Huxley, l. c., Plate 40.

# II.—BIOLOGY AND MORPHOLOGY OF APHIDES.

## 1.—GENERAL OBSERVATIONS.

It may be said that Aristotle initiated the science of biology, when he detailed the observations contained in his *Hist. Animalium* and in his *De Partibus.* Amongst other things, he made the acute observation that the young cuttle carried its own yolk-sac, for some time after birth, protruding from its mouth; and that drones apparently were produced from unfertilised eggs.

As biology may be considered to be the science which comprehends life in all its branches and relations; so we may severally regard physiology as the science which treats of function, morphology the science which deals with development and form, phylogeny the genealogy of tribes, and ontology the history of germs.

In discussing this last section Prof. Haeckel urges that philosophic reflection ought to have equal value with what he calls empiricism, that is, scientific experiment. In other terms, that philosophy and experiment should blend.* Much here will depend on the definition we may give to the term "philosophy," in order that

* If these threads be blended, they must not be confounded. The caution of some of our early thinkers in separating general laws from hypothesis may be shown by the following remarks of Euler and Laplace. The former says:

"Laws may not be enunciated upon insufficient experience." Thus he shows that "$x^2+x+41$ up to the 40th term produces a prime number, that is, a number incapable of an exact division by a smaller number. Let $x=$ any number less than 41; then, if multiplied by itself, and added to itself, and added to 41, the number is non-divisible; by which it might be inferred that a law had been discovered. Such experience, however, is erroneous; as the next term so treated gives a divisible number."

Laplace says, in introducing his famous theory, "I present this hypothesis with the distrust which everything ought to inspire that is not a result of observation or of calculation."

it shall not on one hand mean barren hypothesis, or degenerate into a mere truism on the other.

In his numerous investigations, Prof. Haeckel takes up the strong ground, that the germ is an epitomy of the history of descent; or more explicitly, that the forms through which an organism passes from the ovum to development is a compressed representation of the forms through which the ancestors of that organism have passed from its earliest period to the present time.

This hypothesis had its origin in the sagacious foreshadowings of Dollinger and Von Baer.

An unbroken succession of animals has been represented by the formula A, B, C, to Z; but, as links may be lost or unknown in the sequence, the recognised order may in reality be A, B, D, F, to Z. These gaps in the ancestral chain may, however, be theoretically bridged over, through considerations based on comparative anatomy and embryology, and thus the series might become as A, B, Δ, D, Θ, F. In this way Prof. Balfour shows how these missing links may be shadowed forth by the ontogenic history of B and D; and this might lead to a more or less correct representation of the tribal sequence.

Formerly it was believed that all the parts to be found in the adult animal were really included in the embryo; that they were in a certain manner wrapped together, and that the passage from infancy to age was a real growth; but a new light appeared in Leuwenhoeck's important discovery of the spermatozoon. The explanation then offered, however, did not really advance a knowledge of the subject; or, at least, the general belief then was that each sperm-cell contained the living individual in miniature, and that the ovum merely acted as a nidus for its development.

The vast majority, doubtless, are guided and live up to the lights of their age. It is reserved for the relatively few to shake themselves clear of current prejudices, and by their far-sighted originality to direct thought into its true channels. Even the great Leibnitz in his theory of monads leant to the belief that all men were contained in the sperm-cells of the first man.

This theory of "encasement" was thought by some to have a certain support from Bonnet's discovery, made about that time, of the parthenogenetic reproduction of Aphides.

A wholly different view, however, was taken by C. F. Wolff, who, following Harvey, and more distantly Aristotle, experimentally showed that there was a true conversion and assimilation of material around a particular spot or germ in the egg; but his explanation met with the greatest opposition; and, indeed, this doctrine of epigenesis was almost ignored by anatomists for many years after the death of its propounder. Haller strongly opposed this development of organs around the "punctum saliens," and gave his dictum as an unanswerable truth "Nulla est Epigenesis." Wolff, however, may be said to be the father of the theory of development from the germinal layers; a theory which Pander more fully investigated in 1817, and Von Baer further expanded in 1828.

Although the primitive germs of all animals are so similar that the microscope scarcely shows a difference between them, Von Baer believed that the four great animal groups, Vertebrata, Arthropoda, Mollusca, and Radiata develop from the egg by processes somewhat different from each other. Nevertheless all recent progress tends to show a fundamental uniformity.

The ovum may be regarded as a simple cell which undergoes division and repeated subdivision, so that the segmentation may appear as 2, 4, 8, 16, or other such portions; each of which in turn becomes a separate cell.* These cells differentiate, spread themselves into layers, form membranes, and finally out of these are elaborated the special organs and tissues of the animal body.

* See Pl. II, figs. 1 to 5, copied from Gegenbaur.

This segmentation of the yolk seems to have been first noticed by Swammerdam. The change in the ovum is produced by the action of the sperm-cell or male element upon the ovule with its nucleus or germinal spot. The ovum then becomes fertilised and undergoes remarkable changes in its constitution. The two masses of protoplasm contained in the male and female cells mingle, the nucleus or germ-spot disappears, and shortly afterwards the above-mentioned yolk-cleavage commences. The parent cell (cytula) thus becomes of a mulberry-form ("morula" of Haeckel), and then a kind of hollow is formed within the circumference of the cells.

This becomes dented inwards at one spot, and somewhat elongated; by which alteration that which appeared as a single membrane becomes two through the formation of a groove or a cavity with an outlet or blastopore. This constitutes the bilaminar Blastoderm, called also Gastrula by Haeckel because it always comprises the alimentary organs.

Thus the first stage of the development of the ovum consists of an accumulation of food-material at one part of the layer, whilst the cells become larger in this part. An invagination or cupping in the wall of the blastophore (Schäfer) occurs; then the edges of this cup approach, and the opening left forms what Haeckel* considers to be the primitive mouth, or the "blastopore" of Prof. Ray Lankester. This invagination, which appears to obtain in all animals above the Protozoa, would seem to occur at the spot where the greatest amount of nourishing cells have accumulated.

In this manner two germinal layers are formed; and finally a third layer, which last, however, by some is thought to have a less significance and to arise from the first two.

The body-cavity known as the Archenteron† is probably never produced by invagination in the Tra-

* Βλαστὸς, a germ; πόρος, a channel or pore.

† ἀρχὴ, commencement; ἔντερον, intestine.

cheata, though it does so arise in the Crustacea. Prof. Balfour also states that it is very unlikely so to occur in Myriapoda.*

Dollinger first used the term Blastoderm†, and he early distinguished the three layers under the heads serous, mucous, and vascular. Von Baer studied under Dollinger, and he produced his great work on the evolution of animals during the periods from 1828 to 1837.‡

The membranes of the germinal disc or blastoderm are known by the under-mentioned terms, and out of them the various organs are elaborated.§

Questions are confessedly difficult to answer, as to the complete or partial homology of these layers, and of the organs proceeding from them; and in particular there appears to be uncertainty as to the exact derivative of the sexual organs of animals.

In the hydroid polyps, and in the low sponges like Haliphysema, the male and female cells are placed in juxtaposition, and on the same primitive layer, viz. the Entoderm. In many instances amongst higher animals the male organs are derived from the ectoderm or skin-layer; whilst the female organs develop from the intestinal layer or entoderm. But yet again there are instances where both the sexual organs seem to arise from the two layers combined. This may be from adaptational causes.

| | | |
|---|---|---|
| Ectoderm or Epiblast | Elaborating | Skin, sensory organs, including brain, spinal cord, and nerves. (Male sexual organs ?) |
| Mesoderm | | Flesh, bones, ligaments. |
| Entoderm or Hypoblast | | Nourishing organs, including liver, lungs, and intestines. (Female sexual organs ?)‖ |

* F. M. Balfour, 'Treatise on Comparative Embryology,' vol. i, p. 451.

† Βλαστὸς and δέρμα, skin, membrane.

‡ Von Baer, 'Entwickelungeschichten der Thiere.'

§ *Vide* Plate H, figs. 13 and 14.

‖ As authority for the above grouping, *vide* M. Balfour, *op. cit.*, vol. i, p. 103; and E. Haeckel, *op. cit.*, vol. ii, pp. 389 to 401.

Thus the rudimentary embryonic form may be roughly likened to a tube the walls of which are fourfold. These layers may be mechanically separated from each other. All animals go thus far through this stage in development; and the steps have been distinctly traced in the higher Insects, including Aphides.

All ova may be grouped under two divisions, dependent on the manner in which the vitelline cells are arranged. The first group is called Telolecithal, in which the yolk when present is concentrated at the "vegetative pole" of the ovum. In the second group, called Centrolecithal, this food-yolk (*Dotters Elemente*) is concentrated at the centre of the ovum.* The segmentation of Aphis belongs to this latter division.

Metschnikoff has shown that in *Siphonophora rosæ* the first segmentation-nucleus divides in two, each part of which takes up a position in the clearer peripheral protoplasmic layer of the egg. After further subdivision, the nuclei, which are enveloped in protoplasm, arrange themselves so as to form a peripheral blastoderm composed of columnar cells.†

Brandt divides Hemipterous (Homoptera) Insects into two great groups dependent on the differentiation of their respective ova; but too much stress should not be given to classification on mere segmentation.

*Homoptera.*

| Without yolk-elements. (mit panoistichen Eiröhren) | With yolk-elements. (mit meroistichen Eiröhren) |
|---|---|
| Aphidæ neut. | Psylla, Aphidæ fœm., Coccus, Pediculus. |

Prof. Moseley‡ has recently produced an interesting memoir on the habits and morphology of *Peripatus capensis*, a Julus-like animal, found under rotten

* Balfour, *l. c.*, vol. i, p. 100; also see Brandt, 'Ueber das Ei,' p. 48.

† Metschnikoff on "Aphis rosæ," 'Emb. Stud. Insecten,' Band xvi. *Vide* my Pl. H, fig. 12.

‡ Prof. H. N. Moseley "On Peripatus," 'Phil. Trans.,' 1874, vol. 164, p. 757.

wood, at the Cape of Good Hope. It has been variously grouped as a Mollusc, an Annelid, and a Myriopod. It is now shown to possess a complete tracheal system. This organisation, and the characteristic form of the embryo coiled within the egg, are confirmatory of the affinities now acknowledged to exist between Annelida, Myriapoda, and Insecta.* Such relations have been before indicated by George Newport; and the illustrations furnished in Prof. Moseley's memoir, and by Prof. Balfour for the Section Prototracheata, fully bear this out from their embryonic stages of development. The remark, that "Peripatus points to the connection of the ringed and flat worms, by means of this intermediate step, with the classes only of the Arthropoda—the Myriapods, Spiders, and Insects, *i.e.* the Tracheata," shows the importance of this animal as a link in the construction of the great zoological tree.

Although superficially the hexapod larva of the Centipede has a striking resemblance to some insect larvæ, there really is no comparison; for, even if the legs in the two are thought to be homologous, it is clear by *embryology* that the insect has sprung from an ancestor with numerous legs, which have become atrophied; and not from a hexapodous larval form prior to the development of the full number of adult appendages.†

The morphology of Aphides has been well studied by many French and German biologists, yet it may be noted that, with the exception of the single memoir by Prof. Huxley already alluded to, the contributions of English authors have been very scanty. It is true that we have a short paper on "The Ovum of Aphis," by George Newport, and incidental remarks on this subject are scattered through the works of Dr. W. B. Carpenter, Dr. Allen Thompson, Prof. Balfour, and a

* Balfour, chap. xvii, 'Tracheata,' p. 316.

† Balfour, *l. c.*, see note, vol. i, p. 323; also G. Newport, 'Phil. Trans.,' on "Myriapoda,' 1841.

few others; yet only one exhaustive treatise exists in English on this subject.

Although open to the charge of telling a thrice-told tale, the author puts forth the following remarks, which embody some of the more recent labours of continental workers; but they are intended chiefly for the use of those who may not have leisure or inclination to consult such in their original forms. For those who look for pure histology and complete embryology, references may be found in the appended bibliographic list of authors.

The science of embryology as it now exists is comparatively of a recent date. Much of its present value and importance consists in its bearing on phylogeny, or the history of races. It seems now to be a recognised truth that the embryos of the higher animals, though not resembling the adult forms of the lower animals, nevertheless show a close similitude to the embryos of the latter. Physiologists are multiplying proofs in this direction almost daily.

Prof. Balfour points out that these phenomena have an explanation in the somewhat antagonistic principles of heredity and variation. The first law enunciates that "the characters of an organism at all stages of its existence are reproduced in its descendants at corresponding stages." The second law asserts "that offspring never exactly resemble their parents." By the common action of these two principles, continuous variation from a parent type becomes a possibility, since every acquired variation has a tendency to be inherited.

Again, "each organism reproduces the variations inherited from all its ancestors at successive stages in its individual ontogeny, which correspond with those at which the variations appeared in its ancestors."*

It will be interesting, therefore, to ask if any and

* Prof. F. M. Balfour, 'Treatise on Comparative Embryology,' Introd., vol. i, p. 3.

what information may be gained by the study of embryonic and larval forms in Aphis; to watch if any ancient type really shows itself as recurrent in such; and to learn if any organs, traceable in the larvæ, are lost or atrophied in the adult; such organs having been beforehand persistent in a lower group.

Von Siebold, in 1839, carefully investigated the organs of reproduction of *Aphis loniceræ*, and he confirmed Dutrochet's discovery of the spermatheca and the colleterial glands of the oviparous female. He described three forms of *Aphis loniceræ*, viz. the winged male, the winged viviparous female, and the apterous oviparous female, which last insect he showed was the produce of the winged female.

The curious reproductive phenomena of these insects led Steenstrup* and other authors to consider the parents not as ordinary females but nurses (Ammen). Some regarded the whole reproductive apparatus as a collection of germinal stalks, and others looked on them as fictitious or false eggs. The arguments for and against have been considered by numerous investigators, and therefore it will not be well here to enter upon the intricacies of so large a subject. On the other hand, Siebold, Owen, Victor, Carus, and Burnett asserted that there was a clear difference between the true ovum and the yolk-mass which appears in the chambers of the larval forms. These last bodies develop without concurrence of any male element. Some denied that they possessed a germinal vesicle.

Leydig, Huxley, Brandt, and others state their conclusions that there is no histological difference between the young organic germ and the true ovum.

In 1858 Prof. Huxley discussed the development of the false egg or "pseudovum," and then described, in another genus of Aphis, the ovum or true egg, together with its manner of development from the ovarian chambers. Finally, he compared, in the same paper, the organic and the sexual processes of generation.

* Steenstrup, 'Alternation of Generations,' p. 108, &c., Ray Society.

He states his views thus: "I look upon it as an established fact, that the primary steps in the agamic development of Aphis are: First, the enlargement of the periplast around one of the pseudovarian vesicles and its detachment as a separate body, which from its resemblance to an ovum I will call a pseudovum. Secondly, the contemporaneous formation of a distinct chamber—the penultimate chamber of the pseudovum. Thirdly, the disappearance of the vesicle of the pseudovum, and the conversion of the latter into a germ-mass composed of cells embedded in intercellular substance.*

## 2.—DEVELOPMENT OF THE OVUM.

The examination of the ova of Aphides after laying is attended with some difficulty, on account of their dense and highly coloured shells. Usually when first excluded these tough membranes are pale and yellowish, but they speedily become brown or black; a change which commonly takes place after impregnation. No light passes through them in this condition, but a treatment with olive oil would seem to render them less opaque, and if precautions be taken the maceration is not necessarily attended by the death of the egg.† However, some of the changes within are much more readily studied before than after extrusion from the ovaries.

I have made many dissections of Aphides for my own satisfaction, and some of the drawings I venture to place before the reader in Plates H and I. Notwithstanding their simplicity they may not only give confirmatory evidence, but here and there perchance suggest something of interest to the practised morphological eye.

The letterpress in connection with these plates will

* T. H. Huxley, "Morphology of Aphis," 'Trans. Linn. Soc.,' vol. xxiii, p. 201.

† Balbiani, 'Mém. d. Gén. des Aph.'

supply sufficient information to the general reader to carry him through the series.

Ocular proof is easy to be obtained microscopically, that the ovum and the pseudovum arise from organs essentially similar. What has been before said of the pseudovarium may, in almost the same terms, be also said of the ovarium.

The ovarian chamber has a translucent terminal cæcum, within which eight or more nucleated movable masses are disseminated. These eventually pass down into the constriction which occurs below, and probably through or by means of the yolk-cord discovered by Huxley, and more recently noted by Brandt.

In passing the spermatheca (which does not occur in the viviparous female) the ova meet with the issuing spermatozoa; or, as segmentation may be seen in the eggs before they descend into the ovaries, it is possible that the sperm-cells travel into the chamber above, just before the egg makes its descent and issue.

The body of the ovum is filled by a mass of active living protoplasm, which exerts its influence on the food-yolk about it. The yolk-cells often congregate more densely at the poles of the ovum, whilst the germinal vesicle, which is situated at the other end, is freer from the same. The germinal spot usually occupies the centre of the egg; but, as the last matures, it travels towards the side, where important changes set in which are attendant upon fertilisation.

The division of the blastoderm into membranes so as to form a kind of loop has been already alluded to. If the edges of this loop or protostome do not close, only one opening is formed in the ectoderm; but if otherwise, two openings arise, and these form the apertures of the alimentary canal.

The localisation of function is carried on by cells segregating or separating for definite ends. Some cells organise themselves for reproduction, others for nutrition, and others for the production of scales, wool, skin, and the like.

The reproductive organs are a development from the hypoblastic membrane or entoderm.

A description of the gradual evolution of these organs is far above the scope of this Monograph: the subject is of a nature too special; and, moreover, it has been adequately treated by others whose memoirs may be advantageously studied in detail.

Relative to the development of the ovum in Aphis much interesting information (by way of analogy) may be gathered from Prof. Schäfer's article on ova in the 'Quart. Journ. Microscopical Science,' and also from another article, in the same number, by Prof. Balfour on development of the Araneina.

### 3.—SEX IN APHIS.

The significance of the polar cells in the ovum is not certainly known. They occur in the unimpregnated egg, and they result from and are coexistent with the breaking up of the germinal vesicle, parts being apparently extruded from the ovum. After the formation of the polar cells, it would appear that impregnation only will develop the egg, but possibly before their occurrence parthenogenesis might occur.

The evils of self-fertilisation, viz. the want of sufficient differentiation in the sexual elements, would apply with far greater force to cases of parthenogenesis; and it has been suggested by Prof. Balfour that this evil is prevented by this very function of forming polar cells.*

Although Bütschi was unable to see any polar cells in the pseudova of the viviparous Aphis, they may be certainly brought into view by due precaution.

Von Siebold's investigations led him to believe that the eggs bring from the ovary the capacity of differentiating themselves into living male individuals; and that the same eggs can be changed as to their proper-

* Balfour, 'Treat. Comp. Embryol.'

ties by the influence of the male sperm-elements, and proceed to develop as females.*

Mr. Darwin suggests that the union of individuals has the effect of fusing two life-experiences in the progeny, which thus obtains other and wider tendencies and impulses. Thus self-impregnation and parthenogenesis would have to yield to the more active and developing process of di-genesis, that is to say, of the concurrence of two individuals.

E. Witlaczil † has recently made observations on the general reproductive anatomy of Aphides. In the same paper he describes the fat secreting body, which is largely developed in the abdomen of these insects. It has been before noted by me that the oil globules, secreted as minute drops from the above tissue, take various tints, such as pink, green, yellow, or red; and that the coloration of certain species of Aphis is due to their presence.

The above-mentioned author discusses the muscular system of these insects, and he divides the same into a motor and respiratory grouping; such being respectively distributed either to various parts of the abdomen or to the tracheæ and the stigmata. The cephalic ganglia are connected with the eyes, antennæ, and œsophagus; and marks are made in the memoir on the pits in the antennæ, which are here referred, not to organs connected with hearing, but to those of smelling. The antennæ would seem to serve, he thinks, not so much for finding the female as for discovering suitable food.

The wax-glands (silk?) which I have before described as present in *Chermes abietis* (*vide* vol. i, Pl. C, fig. 6) he finds also to be present in *Pemphigus bursarius*. This species has four on the pro-thorax, six on the meso- and meta-thorax and the first six

* Von Siebold, 'Comp. Anat.,' transl. by Dr. Burnett. Also *vide* 'Nature,' October 24th, 1872, p. 523; notes by Prof. E. Ray Lankester.

† E. Witlaczil, 'Arbeit. Zool. Ins. Wien,' iv (1882), pp. 397—441 (2 pls). Abstract, 'Quart. Journ. Mic. Sc.,' ser. 2, vol. iii, p. 49.

abdominal rings, four on the seventh, and none on the remaining rings. The development of these wax organs on the backs and sides are said to be correlated with the abortion of the nectaries; yet, as the honey-tubes never exceed two in number, the above relation is not clear.

The reader is referred to this memoir for the author's views as to the origin of the setæ of the proboscis and their relation to the rudiments of the mandibles and maxillæ. These points have been generally discussed by others in the case of Hemiptera. Like myself, M. Witlaczil was unable to make out the walls of a dorsal vessel. I have, however, repeatedly noted in some transparent species an alternating and pulsating action down the dorsal regions.

Germinal vesicles were, on many occasions, distinctly visible to M. Witlaczil, and he states that the formation of the blastoderm proceeds from behind forwards, and that the cleavage is essentially equal.

In adverting to the questions on Phylogeny, glanced at in the Introduction to my third volume, and touched upon at page 134, &c., of this volume, it must be confessed that the details now offered are more of a suggestive than a conclusive character. The high antiquity of the family Aphididæ, and the fact that the fossil forms very closely resemble those of recent genera, render it difficult to indicate with any sureness the passage of Aphis out of any lower type of Insect.

The general reader, perhaps, will agree that in a monograph which is chiefly systematic, so large a subject as Reproductive phenomena should be but lightly touched upon. In the meagre sketch now offered I have freely used the writings of Profs. Huxley and Balfour. When I employ almost their identical words, it is from the feeling that any attempt on my part to recast them would be a loss to the reader.

# INTRODUCTORY NOTES ON THE ANTIQUITY OF THE HEMIPTERA,

AND PARTICULARLY WITH REGARD TO THE

## APHIDINÆ AS REPRESENTED IN THE SEDIMENTARY ROCKS AND IN AMBER.

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Although it will be out of place here to discuss the sequence of insect life in primæval times, for such a discussion belongs to the province of Geology, yet the Entomologist who has a particular group under study will be interested in comparing the older with the more recent representatives of that group. Accordingly, a few remarks may be permitted as to the first ascertained occurrence in geological times of the Aphidinæ.

Perhaps the most ancient insect yet discovered is *Xenoneura antiquorum*, a fly of the Devonian age, with very long wings reticulated somewhat like those of a cricket. Highly differentiated as this insect was at such an early date, we must suppose that numerous other complex forms existed long previous to it, and there seems to be good reason for inferring, so far as America is concerned, that insects were living far back in Silurian times.

Later on, amongst the Coal-measures and their contiguous strata, we find various marsh-inhabiting beetles and forms allied to the Curculionidæ and Buprestidæ. These remains occur in situations favorable to the growth of large Equiseta and Calamites.

Professor O. Heer discovered in the Carboniferous beds at Erbignon in Switzerland, a fine cockroach, which he considered to be one of the most ancient animals of that country. He figures the wings, and names this insect *Blatta helvetica.* It must have been quite two inches long, excluding the antennæ. Numerous Termites, and species belonging to the Orthoptera, were also denizens of those coal forests and swamps.*

The Hemiptera are nearly as ancient as the Coleoptera, and apparently they take precedence of the Diptera, Hymenoptera and Lepidoptera.

The family types of insects are of vast antiquity, and, what is not a little remarkable, all the remains of the Arthropoda, hitherto discovered, have been referable to existing orders. Yet, from Mr. Darwin we learn that "from the continued tendency to divergence, the more ancient a form is the more generally it differs from those now living." This persistence of type in insects, it must be admitted, does not furnish much direct evidence in support of the theory of evolution of the higher insects from lower forms. The oldest insects on record were highly specialised, and in their organisation show no inferiority to their modern representatives.†

In a letter addressed to me, March, 1882, by Mr. S. Scudder, he states that he "has now clear evidence of the presence of the Heteropterous division of the Hemiptera in America, in beds credited with being Carboniferous. Certainly they are not younger than the Permian period."

It has been thought probable that the Homoptera, which are less developed insects than the Heteroptera, would have preceded the latter in time; yet the occurrence of the latter at the earlier date as shown by fossils would lead to the idea that the coriaceous wing was an elaboration from the simpler membranous wing. Although the oldest known Coleoptera and Dycteoptera possessed horny elytra, it cannot thus be proved

* 'Die Urwelt der Schweiz,' Prof. Oswald Heer, trans. by W. S. Dallas, 1876, vol. i, p. 20.

† 'Geolog. Antiquity of Insects,' H. Goss, 1880, p. 4.

that the earliest insects did not possess wings composed of simple membranes. Mr. S. H. Scudder comes to the conclusion that the front and hind wings of Palæozoic Insects were similar; and that membranous heterogenity made its appearance in Mesozoic times.*

Our ignorance of the steps in a natural process need be no barrier to an hypothesis, if it be supported on reasonable evidence, or even analogy. Whether chemical and other forces were more active in geological times may be a point for discussion. Life under excitement is usually intensified, but perhaps at the cost of duration. Under extreme surroundings we might suppose intermediate links quickly filled up; or at that distant period they might overlap and produce modifications too rapid, for us to follow. Time doubtless is an important factor, and we are liable to consider an event marvellous or otherwise in proportion to the time consumed in its production or disclosure.

For instance, the effects involved in the alteration in brilliance of one whole magnitude of a well-known star in our system, in the course of two days and a half, might appear to us little short of miraculous, if we could so live as to see them.

The fragmentary condition in which fossil insects are commonly found renders their examination difficult. Several Continental observers have done good work in this direction; but the investigations in England are comparatively scanty. To Mr. H. Goss's papers† on "Fossil Entomology" I am indebted for many details; and also to Mr. S. H. Scudder for his numerous memoirs on the fossil insects of America.

Professor Haeckel, with his usual bold stroke of hypothesis, supposes that the very ancient Zoopoda have been the ancestral forms of the Crustacea, and that

* 'Early Types of Insects,' Samuel H. Scudder, 1879, p. 21. N.B.—Mr. Scudder has pointed out to me that in my introductory remarks in vol. iii on the antiquity of insects I have not given sufficient antiquity to the Homoptera. I am glad to be corrected by so able an authority.

† "Introductory Papers on Fossil Entomology," by H. Goss, 'Ent. Mon. Mag.,' vol. xv, p. 52, *et seq.*

in later times they developed tracheæ (Prototracheata), and that in this manner they became capable of air respiration. They would thus shadow out the Arthropoda, and thus far the Insecta.

Dr. Friz Müller also looks to the Crustacea as a channel through which the Insecta may have risen.

On the other hand, Professor Balfour places Crustacea in order after Insecta in his 'Comparative Embryology.'* Certain it is that insects, with their comparatively high condition of intelligence, appeared long before the epoch of the great Saurians, and afterwards we find them contemporaneous with the Pterodactyl of the Lias.

Mr. A. R. Wallace remarks :—"At this remote epoch the chief families of insects, as set forth by Linnæan genera, were perfectly differentiated and recognisable."

The earliest notice of any fossil Aphis that I have met with is that furnished by J. Curtis, who, in 1829, catalogued, but did not figure, "an Aphis of the middle size," forming one of his specimens (No. 25) taken from the Eocene Beds of Aix (Ligurian). This notice occurs in a joint paper by Murchison and Lyell. It describes many insects taken from these Tertiary deposits. Curtis says of these specimens :—"Although there are sufficient characters preserved to determine with certainty the genera to which many of the insects belong, the parts which would best do so are indistinct, the antennæ, tarsi, and trophi being generally very obscure and distorted.†

In the year 1839 the Rev. P. B. Brodie gave a short description of some English fossil Homoptera. Afterwards, in 1845, he published his book on the 'Fossil Insects of the Secondary Rocks of England,' to which Professor Westwood added an Introduction and descriptions. In this work (now difficult to be procured) Mr. Brodie first notices numerous insects preserved in

* See F. M. Balfour "On the Affinities of *Peripatus capensis* with the Tracheate Arthropoda," 'Comp. Embryology,' vol. i, p. 316.

† 'Edinb. New Phil. Journ.,' pp. 287—294, 1829.

the Wealden [Purbeck] Beds of Wilts, in the Vale of Wardour. At another time he referred to similar forms taken from the Purbeck Beds in the neighbourhood of Swindon, Wiltshire. Remains of the insects, which were found in plenty, comprised examples of Coleoptera, Trichoptera, Diptera, many Hemiptera, and one Libellula.

In 1845 the Rev. F. W. Hope described several insects discovered at Aix, in Provence, and amongst these he shortly noted a specimen (marked No. 85) "as a mass of insects resembling Aphidæ."*

About this time Dr. Mantell indicated the occurrence of numerous insects in the stone quarries of Hartwell, Bucks, and also very similar remains in the shales near Tunbridge and Maidstone. These fragments chiefly consisted of Coleoptera, but I find no Homoptera mentioned in his list.

In the above-cited work of Mr. Brodie, figures are given of seventy-four species of insects, selected from 239 specimens found in the Wealden [Purbeck]. The insect limestone of Wainlode (Rhætic), which is about one foot thick, furnished him with many well-preserved examples. Of all these, three only can be fairly referred to Aphis, and of them only one (No. 6) can be considered as undoubtedly belonging to that family. It is named by Brodie *Aphis valdensis*, and I have figured the specimen, Pl. CXXXII, figs. 4 and 5. The veining of the only wing preserved, at the side of the fossil, is well marked; and it sufficiently characterises the genus. Nos. 6, 9, and 10 of the same list are named by Brodie *Aphis plana* and *A. dubia*, but the remains are too fragmentary for useful identification of the species.†

Many of these fossil species are of microscopic dimensions; and Mr. Brodie calls attention to the fact that the greater part of the insect remains which he found, both in the Lias [Rhætic] and the Wealden [Purbeck], are of a "most diminutive character."

* 'Trans. Ent. Soc. Lond.,' p. 252, vol. iv, 1845.

† 'Fossil Insects of Secondary Rocks of England,' pp. 33—120, 1839.

Professor J. W. Westwood believed that most of these insects were aquatic in habit, and that they affected the neighbourhood of fresh-water streams, over which they hovered during life and became submerged after death.

The last author remarks:—"It is scarcely to be supposed that a state of things could have existed in which we should find such a collection of insects as the Wealden [Purbeck] series exhibits, without there being parts of the world inhabited by giant Cicadæ, immense beetles, locusts, and grasshoppers, with wings expanding little less than a foot, and other insects of the size at least of those of the present creation."*

Elsewhere he says:—"It is not an invariable rule; but climates of low temperature produce insect forms of small dimensions. The presence of Aphides in the Wealden beds leads to the supposition that the existing climate was that of a warm temperature rather than that of a subtropical character."

Discoveries of fossil Aphides have hitherto been comparatively rare, and perhaps the reasons are not difficult to find. Independently of the delicacy of their structure and their minuteness, the circumstance that a mild and temperate climate seems necessary to their existence must limit their horizon, and also the area possible for their preservation.

In present times, as a rule, under tropical heats Cicadidæ and Fulgoridæ take the places of Aphididæ. Again, it is pretty obvious that those Aphides inhabiting swamps and the banks surrounding still waters were the most suited for preservation. The finest muds and sediments are requisite to yield obvious impressions, and moreover such sediments must be very rapidly deposited to prevent the disintegration of frail insects. Accordingly we find that the fresh-water beds of Œningen, within the valley of the Rhine, and the basins of the ancient lakes of Florissant in America, are the localities which up to the present time have

* 'Quart. Journ. Geol. Soc. Lond.,' vol. i, p. 400, 1845.

furnished the geologist with the finest specimens of extinct Aphides and allied insects.

There are, however, other sources which yield evidences of the existence of Aphides in ages long past. The fossil resin known as amber has been studied by Hope, Menge, Germar, Berendt, Goeppert, and others; and within the masses well-marked genera of insects, closely related to recent ones, are clearly indicated.

In the Permian and Trias formations comparatively few fossil insects have been hitherto traced. Professor Heer noticed but one Orthopterous, three Neuropterous, and three Coleopterous forms.

On the other hand, the insects of the Lias are very abundant. Previous to the examination of the Lias beds of Schambelen, in the Canton of the Argau in Switzerland, only fifty-six species had been described; but Heer obtained later about 2000 specimens, which he referred to 143 species. Of these the Coleoptera were by far the most frequent; for they numbered 116 species. After them came the Hemiptera, which comprised twelve species of numerous individuals. A well-preserved portion of a wing, showing characters very similar to those of an ant, proves the occurrence of Hymenoptera in these early times.

Most of these insects are figured in 'Die Urwelt der Schweiz;' but I will only specially allude to the Hemiptera, as being the order more immediately connected with my present subject.

The ancient Hemiptera in great part appear to have had sanguinary habits, for such we may infer from the construction of their suctorial rostra, formed for drawing blood and extracting the juices of insects. Eight species are mentioned as obtained from the Liassic marls situated about half way between Zurich and Basle. Two of them are figured. One, viz. *Protocoris insignis*, is about half an inch long, and very decidedly shows its Hemipterous characters. We may remark that the English fossil Hemiptera were certainly not larger than our existing species.

We may gather from the occurrence of numerous termites, cockroaches, and buprestidous beetles, that the climate, if not tropical, was above what we know as temperate. We do not see Aphis represented; and perhaps the climate, which here yielded forests of gigantic cycads and tree-ferns, might preclude this family.

It is, nevertheless, true that many cycads and conifers appertaining to a hot climate penetrated into Purbeck-Wealden times; and there is unmistakable evidence that Aphis then existed. We find also that fossil plants belonging to the Cretaceous series extended into the Eocene of Switzerland, of Saxony, and of Moravia. Several large pines and firs of a similar type have been found likewise in the Greensand and Gault of England. Fine specimens of such trees, the stumps of which yet remain *in sitû*, are still to be seen on the south-west of the Isle of Wight.

As these trees indicate the existence of a cooler climate, there seems to be no reason why we may not yet find remains of Aphides in some of the finely-grained strata and deposits of this district.

The finely-textured marine muds which formed some sediments of the Chalk-series would have been well suited to yield impressions of insects, yet only a few beetles have as yet come under observation; and these must have been entombed in the neighbourhood of some ancient shore-line.

Far north, in early times Greenland showed a mild and genial climate, yielding good examples of several species of conifer (sequoia), poplar, and walnut. As yet, however, no traces of insects have come to light, though there seems to be no good cause for doubting that Aphides, like other winged insects, may have been wafted over on the wings of the wind, and have delighted the taste of the northern ants during the protracted days of Arctic summer.

Insects abounded in the localities inhabited by the Palæotherium, the Anoplotherium, the pig-like Hyopotamus, and the graceful, deer-like Xiphodon. In the Eocene beds of Central Europe cercopithecoid monkeys roved the trees, and bats also flitted after nocturnal insects.

The Eocene formations of both the old and the new world furnish abundant testimony to the existence of several genera of Aphidinæ. Where the fossil conifers abound the *Lachninæ* are chiefly represented; the deciduous trees mostly give examples of Aphis proper.

In Britain, probably the climate of what is now Alum Bay in the Isle of Wight did not greatly differ from that of the Eocene of Central Europe. At this early time Aralia, Sequoia, Carsia, and *Quercus ilex* flourished. Prof. Heer likens such a flora to that of the marls of Monte Bolca, near Verona, where the myrtles and sandalwood trees gradually replace the more tropical ferns and plants of an Indo-Australian type.*

Briefly I pass over the insects obtained from the Eocene beds of England, such as the Coleoptera of Corfe, in Dorset, and those repeatedly brought to light from the limestone of Gurnet Bay (Bembridge series), in the Isle of Wight, as no notices have been published of the occurrence of Aphides amongst them. Mr. Goss says "that there can be little doubt that the Insecta were then abundantly represented, and their rarity as fossils in the Eocene formations of Great Britain can only be accounted for on the assumption that the conditions under which they were deposited must have been generally unfavorable to their preservation."†

Although the Miocene beds of Radoboj, in Croatia, were not fully investigated till Prof. O. Heer commenced their study, Dr. J. Unger had described and figured sundry of their well-preserved fossil insects in 1839. They consisted of Diptera, Coleoptera, "Rhynchota, and Hemiptera." I cannot find, however, any trace of Aphides described in his memoirs.

* Prof. O. Heer, 'The Primæval World,' vol. i, p. 281.

† H. Goss, 'The Geol. Antiq. of Insects,' p. 37.

There are, nevertheless, many indirect indications of the presence of Aphides in early Miocene times. Then the gad-fly was present to scare the *Hipparion gracile*, the representative of our modern horse; and bright aphidivorous Syrphidæ glanced and hovered in the sunny glades of those forests, just as they do now with us. There are also evidences of the existence of many plants through the presence of such insects as are believed to confine themselves to particular kinds of vegetable food. From insects obtained from the Swiss Miocene, the occurrence of such genera as Myosotis, Rubus, Echium, Carduus, Trifolium, and others may be inferred. All these plants now afford food for special Aphides, and they may have done so then.

With reference to this period, Prof. Heer says some insects climbed to the summits of trees, as with us, to obtain honey-dew from the colonies of Aphides settled there. . . . Great Cicadæ hid themselves in the dense canopy of leaves, and filled the air with their monotonous chirping. . . . Gigantic water-beetles, and Hemiptera of different genera, by their presence give weight to the probability that the climate of Œningen was in late Miocene times of a warm, temperate, or possibly of a semi-tropical description. He suggests that at this period a broad arm of the sea passed from the Rhone Valley through Berne, Œningen, and Vienna; and thence it widened out as it stretched towards Belgrade and the Euxine Sea. Fresh-water rivers poured their contents into the basins of Œningen and Radoboj, the water being more or less loaded with the remains of the animals then living in these districts.

Probably in Miocene times the tract now occupied by the Baltic was dry land. This district is the fatherland of much of the amber of commerce, fine specimens of which adorn the museums of Königsberg, Danzig, and Berlin. The Aphides entombed in these masses of fossil resin show the antiquity of the family, and its early appearance in Northern Europe.

The alternation of marine and fresh-water formations frequently to be observed in these places is generally ascribed by geologists to corresponding upheavals and depressions of the existing sea-bottoms. Thus irruptions of the sea seem to have been frequent, and caused the intermingling of land and marine remains. Seals, sea-mollusks, and sharks may be from such causes closely located with trunks of trees, lizards, Aphides, and leaves of land plants.

In the Lower Miocene beds insects are numerous, but examples of Hemiptera at present discovered are comparatively few. Though Aphides have not yet shown themselves amongst these sediments, the Aphis-feeding Syrphidæ and Coccinellidæ would indicate that they were contemporaneous with other Rhynchota.

The marls of Radoboj, in Croatia, which belong to the Middle Miocene, possess much interest; for they contain many fine impressions of Aphides; and as we ascend to the Upper Miocene, specimens become much more plentiful; and thus we come to the famous insect beds of Œningen. These calcareous deposits formed the floor of a considerable fresh-water lake lying in the Rhine Valley between Constance and Schaffhausen. The sediment has been very favorable to the preservation of insects, the casts from their wings being in many cases very perfect. Even midges, with the hairs on their antennæ and legs, are clearly recognisable under the microscope. This will show how swiftly the insects must have been submerged and covered by mud before there was time for their decomposition.

This mass of insect remains occurs in an exceedingly fine-grained limestone, scarcely exceeding an inch in thickness. The stratum is so laminated that it may be cleaved into about 250 paper-like slabs, of such delicacy that even the original colours of the insects may sometimes be seen, as if they had been painted on the matrix.

Upwards of 5700 specimens have been examined from the Swiss Miocene, from which 876 species of insects have been deduced: 844 of these occur at Œningen. Coleoptera are by far the most abundantly represented, but still the Hemiptera number as many as 136 species.*

Apterous insects, as a rule, are more rare than winged. Probably they were less drifted by winds, and but little liable to drowning in the shallow waters. Thus, winged ants are in profusion; some having been killed with their wings yet expanded, whilst the apterous forms are infrequent. It is not improbable that some deleterious gaseous exhalations suddenly passed over these waters. Destruction was so rapid that several examples occur in which males and females remain conjugated; and now they rest together in their silent tombs.† The presence of larvæ shows that insect metamorphosis occurred then, much as it obtains now.

Although the climate of Miocene times here must have been at least as warm as that of Southern Italy, Aphides disported themselves side by side with large Cicadidæ and gigantic water-bugs. Mr. Walker thought that if Aphides exist in tropical climates, they will probably be found to be entirely viviparous, and then there will be no necessity for the egg. But the fact that Aphidian ova are quite as common in the South of France and Italy as in Britain proves that mere temperature has but little to do with the appearance of the true sexes and their issue.

Several fine examples of Aphis, of Lachnus, and of Pemphigus have been figured by Prof. Heer, some of which I have reproduced in Plate CXXXII. A gall-making Pemphigus clearly attacked the leaves of an ancient kind of poplar tree, and in a manner very similar to that to be observed on our own, and it made the like excrescences.

* 'Primæval World,' vol. i, p. 296, *et seq.*

† 'Prim. World,' vol. ii, p. 44.

Recent researches have proved that both the Heteropterous and Homopterous Hemiptera, including Aphididæ, are well represented in North America by fossil remains. Many specimens have been obtained from the districts of White River in Utah, and of Green River Station in Wyoming.

The remarkable lacustrine beds of Florissant, in Colorado, are now undergoing a thorough examination by Mr. S. H. Scudder, who has already thrown so much new light on fossil insects. The last gentleman gathers from the description of the fauna and flora (which is very abundant) that the remains belong to later Miocene time, and therefore they may prove interesting as supplementing Prof. Heer's labour in Europe.

Mr. S. H. Scudder kindly enables me to reproduce several of his fine figures of Aphides—figures which are prepared to illustrate his works on the Fossil Insects of North America, in connection with the Geological Survey of the United States.

These plates have not yet been published, but I have his permission to use them, and some figures are redrawn in Pl. CXXXIII, Vol. iv, of this Monograph.

The ancient lake at Florissant is situated high up in the mountains on the southern slopes of the Colorado Range. The existing basin is about five miles in diameter, but several creeks in former times ran up from the shallow water into the neighbouring valleys.

These Tertiary beds form the bottom of a basin which overlies the granite. Here and there this rock protrudes from the flat in the form of islets. The superincumbent beds comprise conglomerates and variously coloured sandstones, interposed with deposits of fine smooth, argillaceous material, well suited to the preservation of leaves and insects.

Below these beds, black, brown, and whitish-drab shales occur, containing large masses of opalised wood, probably the remnants of ancient Sequoiæ. Some of the stems still remain in the positions in which they grew; and within present memories they had a size from five to six mètres (diameter ?). Specimen-hunters have now greatly injured these fine fossil examples.*

Trachytic rocks, lavas, and remnants of old geysers, are in the immediate neighbourhood. These last are indicated by deep and polished funnel-holes sufficiently large to conceal a man, and their presence shows that formerly volcanic energy was periodically exerted over a considerable district.

The most prolific insect beds of Florissant appear to be the drab-coloured shales above indicated, of about sixty centimètres thick (=23·6 inches), the chemical constitution of which has been investigated by Dr. M. Wadsworth, of Cambridge, Mass. He is of the opinion that clouds of volcanic ashes must have fallen into a still lake. Perhaps a "moya" or a mud-flow "may have been worked over by water, covering the underlying beds and entombing the interesting remains now brought to light. The matrix is described as "a grey mass containing fragments of feldspar, augite, &c., cemented by a fine earthy ground-mass." These beds are wonderfully prolific in fossils, and in this respect they even outstrip the famous deposits of Œningen.

Mr. S. H. Scudder has already described 250 species, and thinks that probably at least 1000 more may be separated from the rich masses obtained from Florissant.

Hemiptera form about 11 per cent. out of the whole order Insecta, and they are nearly in the same proportion as those which occur at Œningen. Mr. S. H. Scudder thinks, however, that the fauna of his district more nearly approaches that of Radoboj; for 40 per cent. is represented by Hymenoptera at Florissant; against 14 per cent. only at Œningen. On the other hand, as at Radoboj, ants are largely preserved; as many as 4000 specimens have been examined, yielding to Mr. Scudder no less than fifty separate species.

* 'Bull. Geol. Surv.,' vol. vi, p. 284, S. H. Scudder.

We may pretty safely infer that many of these ants visited their favourite Aphides. Just as in Switzerland, these American Miocene times furnished large carnivorous Syrphidæ, the coloured patterns on whose bodies and broad abdominal bands, are still clearly recognisable.

From some unknown cause the Homoptera are better preserved in these deposits than the Heteroptera. Aphides are common, and include probably eight species,* all Aphidinæ, excepting a few referable to Schizoneurinæ. The details are amply sufficient to decide the family or genera to which they ought to be referred; indeed, these specimens seem to be the most perfect of all fossil Aphides yet discovered.

The same paucity of larvæ, of all sorts, to be noted in the Œningen beds, here also obtains. Almost all the American examples of Aphides yet figured are winged; and this leads to the supposition that large flying swarms may have been suddenly entangled in a volcanic mud shower, or in the downpour of some neighbouring geyser, which mud, after precipitation into the lake, carried them to the bottom, before decomposition of their delicate texture.

Lachnus is duly represented; and appositely amongst the flora of this period we find such usual food plants as Pinus, Juglans, Quercus, Carpinus, Betulus, Alnus, Salix, and the like.

There seems to be every probability that the waters of this lake were fresh; and both Mr. Lesquereux and Mr. S. H. Scudder infer from the general fauna and flora of Florissant that formerly a warm climate, like that of modern Southern Italy, prevailed.

Some doubts are expressed by Mr. S. H. Scudder† as to the exact age of these beds; but the most competent authorities seem to come to the conclusion that if they are not so old as the early Miocene, they must be placed in the middle section of that series. No safe

* Ibid., p. 293—298.
† *Vide* S. H. Scudder, *l. c.*, p. 300.

and certain conclusions as to their age can be made from the evidence alone of the entombed insects. Mr. S. H. Scudder thinks that some revision of the Œningen and Radoboj insects must be made before a good comparison can be of value between the two continents as to age.

It is remarkable that no certain traces of insects have yet been noted in beds of the Pliocene period; and this paucity of insects also in the Quaternary or Post-Tertiary superficial deposits is equally noticeable. Possibly the nature of the deposits in these comparatively recent times were unfavorable to their preservation, as has been suggested by Goss and others.

Remains of Coleoptera, chiefly elytra, have been found in peat-beds, and in brick-earth in several parts of Great Britain, Switzerland,* and North America; but the Hemiptera do not seem to have left their remains in such a condition as will allow of their identification.

The Glacial and Drift periods appear to have been ill adapted for the preservation of insects.

Probably the lower temperatures of the epoch just before the appearance of man on the earth were inimical to such. With the exception of a few beetles it is believed that no fossil insects have been described.

* Prof. Heer, 'Der Urwelt,' 1865, p. 481, &c.

## 1.—ON THE ANTIQUITY OF APHIDES AS EXEMPLIFIED BY THEIR REMAINS IN AMBER.

THE occurrence of insects, twigs, fruits, seeds, and other organic remains in amber has been remarked from very early times. But although the old Greeks knew the resinous substance that forms the matrix, and surrounds these small beings of ancient days, they chiefly prized this material, known by them as electron, on account of the many hidden virtues supposed to reside in it.

Buffon singularly regarded amber as hardened honey; Pliny, however, had more acutely suspected its truer vegetable origin. He says*:—"Nascitur autem de fluente medulla pinei generis arboribus, ut gummi in cerasis, resina pinis. Erumpit humoris abundantia, densatur rigore vel tempore autumnali. . . . Archelaus, qui regnavit in Cappadocia, illinc pineo cortice inhærente tradit advehi rude. . . . Liquidum primo distillare argumento sunt quædam intus translucentia ut formicæ, aut culices, lacertæque, quas adhæsisse musteo non est dubium ut inclusas indurescenti."

Berzelius investigated the chemical properties of amber, and showed that it has considerable hardness and inflammability, and is strongly resistant to most agents as regards its solubility. He regarded it as an exudation from a plant, which, originally in the condition of a balsam, afterwards hardened, having previously entangled insects, &c., within its tenacious substance.†

Although there is now no doubt as to the true nature of this resin, the exact age in which the parent trees flou-

* 'Historia naturalis,' Pliny, Lib. xxxvii, xi.

† The Latin succinum probably is from *succus* juice. The Greek word ἤλεκτρον is not so clear as to its signification. Perhaps the resin took its name from the golden alloy known by that name, the splendour of which, amber is thought to imitate.

rished is not certain. There seems, however, to be no hesitation in ascribing its age to the middle or later Tertiary times.

The amber-bearing tree has been long extinct, but the causes which led to its disappearance can only be inferred. Probably they were chiefly of a climatal nature.

The present principal sources for European amber occur on certain coast-beds of the Baltic Sea, and most noteworthy are those situated on the south and south-east parts which trend away from Memel towards Königsberg, skirting the Gulf of Danzig, and the whole delta of the Vistula. The narrow necks of land which here jut into the sea also furnish numerous nodules of the resin. But although the sea-board offers great facilities to the amber-hunter on account of the eroding action of the waves, other localities occur inland; and the gravel beds of various countries contain concretions in comparative abundance. Masses have been found in Prussia between Palmnicken and Habenicken, said to weigh thirteen, and even eighteen pounds. These specimens are to be seen in the Royal Cabinet at Berlin.

The amber area, however, is very large, and comprises the shores of the Adriatic, Sicily, and Poland; the clays of the Paris basin; deposits near Gayhead in the United States of America; Canada; Cape Sable in Maryland; Madagascar; and it occurs also in Norway. In Great Britain amber is found in small quantities on the Norfolk, Suffolk, and Essex coasts; and Dr. Aikin found nodules also in the alluvial gravels near London.

In a general way amber may be distinguished from copal and animé by its different density (specific gravity = 1·070 and hardness = 2·5), and its greater infusibility.* Of these resins, amber alone, perhaps, belongs to primæval times. Copal, which most nearly

* Aikin's 'Dict. of Chemistry,' i, 57; also Berzelius' 'Traité de Chemie,' vi, 589; Watts' 'Dict. of Chemistry.' *Vide* also Fothergill, "On the Origin of Amber," 'Phil. Trans.' for 1744 and 1745.

resembles amber, is, though perhaps not exclusively, the produce of the Mexican *Rhus copallina.* Its sp. gr. is 1·39. Resin animé is easily scratched, has a sp. gr. of 1·35, and is the produce of *Hymenæa courbaril.* This last resin is exceedingly rich in enclosed insect remains; but I have been unable as yet to discover amongst the many specimens kindly lent for my inspection any trace of Aphides. As both these resins are of tropical origin, their absence need not cause any surprise.

It is probably due to the fact that so many kinds of fruit, seed, and woody fragments have been embedded in amber, that such discordant views have been advanced as to its origin. The resin has been referred at different times to the oak, the poplar, and even to the palm-tree.

From the peculiar character of the cellular tissue entangled in the masses, Prof. Goeppert refers the exudation to an extinct conifer, to which he gives the name *Pinus succinifer.* This is now generally believed to be the true source of amber; although, from the fact that other conifers are to be found associated with the amber masses, it is not certain that the excretions have but one single origin.

There are several allied resins of different densities; and probably they represent eras of different geological times. We have ambrite from New Zealand, walchowite, copalite, schlerotinite, and damar.*

The examination of insects enclosed in resins of such high refractive power as amber and copal presents some difficulty. The rounded masses often act as lenses, and so scatter the light that the microscope can be rarely used until the specimens have undergone some manipulation. The most obvious and efficient mode is that of slitting and polishing the masses by aid of the lapidary's wheel. This is somewhat troublesome and costly, and has the disadvantage of injuring masses valued for ornament.

* J. D. Dana, 'Manual of Mineralogy and Lithology,' 1879.

The Rev. F. W. Hope, many years ago, dissolved some of his specimens and successfully extricated the entombed insects; but this must be a hazardous process, for amber is singularly indifferent to the action of most solvents.* Besides all this, insects in amber have been sufficiently prized to make attempts of their imitation remunerative, by slitting portions and again uniting them by a dense varnish after the surreptitious introduction of certain objects.

When amber specimens are too valuable to cut up, much information may be gained optically by temporarily cementing with Canada balsam small discs of thin microscopic glass, or even mica, over the specimens to be viewed. Sometimes a similar disc on the opposite side will be necessary; care being taken to keep the surfaces of both these discs parallel, otherwise the transmitted light will not come direct to the eye. The objective of the microscope will then penetrate far into the amber mass, and bring out details quite invisible without such a treatment.

At other times the whole specimen may be merged in a glass trough containing castor-oil, or some liquid of high refractive power, that does not act on the amber itself. After examination the specimen can be easily cleaned by using spirits of turpentine, which does not act on the amber.

The earliest notices that I have met with as to Aphides in amber are by Dr. G. Carl Berendt, who, at various periods from 1830 up to the appearance of his great work in 1845, published papers on the fossil insects of the ancient world.† Amongst these earlier memoirs I find notices of seventeen specimens of Aphides of the genera comprising Aphis, Lachnus, and Schizoneura. Unfortunately, they are not figured, and it is not possible to compare other like specimens except by means of the identical ambers referred to.

* F. W. Hope, "On Succinic Insects," 'Trans. Ent. Soc.,' Lond., iii, pp. 133 to 147.

† G. C. Berendt, 'Ein Beitrag zur Thiergeschichte der Vorwelt.'

In the year 1856 Victor de Motschulsky communicated to M. Ménétries, of Helsingfors, certain entomological notes, amongst which he describes an apterous Aphis with long upturned cornicles. He says :—" Les Aphides se trouvent en très grand nombre, surtout le *Lachnus dryoides*, Germari ; et parmi lesquels ils se trouve une espèce que je nomme *Aphioides succifera*, qui resemble en peu à notre *Aphis pinophila*, mais qui a les appendices de l'extremité de l'abdomen très long et dirigés vers la tête. Il parait que c'est l'Aphis qui habitait l'arbre au succin, le *Pinites succifer*, Goeppert."*

I have reproduced the small figure of this apterous Aphis, which was embedded in a yellow amber mass ; " the produce of some tree analogous to our thuja " (Plate CXXXII, fig. 7).

The same fine collection of ambers at Danzig, which contained upwards of 700 examples of various sizes, furnished four other examples of Aphides. Unfortunately no figures have been yet given of these specimens. They are catalogued by Prof. Menge amongst insects of the Eocene, and from beds referable to the Ligurian series. They are named respectively *Aphis largiflua*, *A. retrolacteus*, *A. longicornis*, and *Lachnus glandulosus*.

Dr. George Carl Berendt issued the first volume of his fine work on the organic remains of the ancient world, as embedded in amber, in 1845. The second volume did not appear till 1856. Dr. Berendt died in 1850, and his collaborateur, C. L. Koch, shortly before that period, viz. in 1849. The Orthoptera and Hemiptera were described by Prof. Germar, but the editing of this second volume was by Dr. H. Hagen, and to this portion the reader is referred for many details not suited for this sketch of the amber Aphides.

The succiniferous beds of the Baltic and Prussia are referable to the "Molasse." They overlie, or rather

* 'Étude Ent.,' V, p. 29, fig. 8. Edited by V. de Motschulsky, 1856.
† Menge, 'Progr. Petrischule,' Danzig, p. 19, 1859.

they date just after the era of the great salt formations of Gallicia and the North of Austria. A synopsis of these beds, as given by Berendt, is as follows :

| *Fruit-bearing Shales.* | *Alluvium.* |
| --- | --- |
| Younger diluvium. | Northern gravel (Nordische Geschiebe). |
| Younger sandstones. | Beetle-clay in Cerithienkalk. |
| Plastic clay. | Brown coal (lignite) with Amber. |
| Gallician salt formation. | |
| Limestone. | |

I believe that a more detailed examination of the specimens themselves, with greater microscopic aid than has been hitherto used, will modify some of the genera ascribed by Berendt to these insects.*

## 2.—DIAGNOSIS OF APHIDES IN AMBER, AND DESCRIPTION OF THE FIGURES IN PLATE CXXXI.

APHIS ARANEIFORMIS, *Germar* and *Berendt.* Plate CXXXI, fig. 4, of this Monograph.

Berendt's description, very shortly given, is as follows :

Antennæ pilose and nearly the length of the body. 7-jointed. Legs not hairy. Rostrum not visible in this specimen.

From the characteristic cornicles and general appearance of the insect, I (the present author) would refer it to the genus Rhopalosiphum rather than to Aphis.

In Berendt's description,* to which the reader is referred, the insect is thought to have some affinity with *Aphis pomi* of De Geer (*A. mali* of Schr.), but in

* E. J. Germar u. G. C. Berendt, 'Die im Bernstein befindlichen Hemipteren u Orthopteren der Vorwelt.' Berlin, 1856. 'Organische Reste im Bernstein,' Band ii, Tab. i, figs. 4—8, and Tab. ii, fig. 1. 'Aphidina,' pp. 4, 5 6, and 7.

the absence of living specimens for comparison, no safe conclusion can be come to as to identity.

*Vide* vol. ii, p. 6, Germ. and Berendt.

Aphis (?) hirsuta, *Ger.* and *Ber.* Plate CXXXI, fig. 5.

Body lancet-shaped, studded with hooked bristles. Colour yellow or greenish. Darker beneath.

This insect probably has more affinity with our recent *Siphonophora rosarum*, than with *Aphis picridis*, to which Berendt refers it.

The amber must have been in a fluid state to have permitted the preservation of the minute hairs so distinctly seen in Berendt's figure.

See a full description, *op. c.*, p. 6, Germ. and Berendt.

Lachnus (?) dryoides, *Germ.* and *Ber.* Plate CXXXI, figs. 6 and 7.

Long oval, flatter above. Antennæ less than half the length of the body. First joint short and thick, the second equally thick, but longer; third somewhat shorter than the second and drawn out thinner; the fourth smallest of all; the fifth and sixth as long as the third; and the seventh appearing as a nail-like process. The rostrum is very long, and projects about one third beyond the tail. It is 4-jointed and shows an acute and narrow labrum.

Berendt points out the resemblance this insect shows to "le Puceron du chêne" of Réaumur, and to *Lachnus quercûs* of Burmeister. The general colour of the amber insect is yellowish-brown. *Vide* Germ. and Berendt., *op. c.*, vol. ii, p. 4.

The articulation of the antenna is different from that in recent Lachninæ, and the rostrum also differs both as to length and articulate proportion. No nectaries are marked in the amber specimen; though the recent Lachninæ show these organs clearly as papillæ. The size of the insect is small as compared with the modern *Stomaphis quercûs;* but identity with this recent species is not to be expected at such a great interval of time, though affinities may be clearly traced.

LACHNUS (?) CIMICOIDES, *Germ.* and *Ber.* Plate CXXXI fig. 8.

This insect, as represented by the figure, is small and globular in shape. The details of the antennæ are best obtained by a reference to the figure. It is difficult to make any safe references here to any modern representative species, from the scanty materials at hand.

The abdomen is slightly bristly; and small tubercles are to be found near the spots from which they rise, and on the edges of the back.

*Vide* Germ. and Ber., *op. c.*, p. 5.

LACHNUS (?) LONGULUS, *Germ.* and *Ber.* Plate CXXXI, fig. 9.

Body three times as long as broad, its greatest width being at the post-thorax. Antennæ hardly half the width of the body, 6-jointed, *not* counting the bristle-jointed apex. Cornicles wanting. Legs very short. Tail moderately long; colour above, pale, with five long striped brown spots; head and thorax brown, with the edges towards the joint brighter in colour.

A comparison of the proportional joints of the antenna of this and the preceding Aphis will show that they cannot both belong to the same genus. Without speaking positively on such small evidence as I possess, I would suggest an affinity with *Brachycolus stellariæ*, p. 147, vol. ii, of this Monograph, and figured on Plate LXXXV, figs. 1—3.

*Vide* Germ. and Ber., vol. ii, p. 5.

APHIS (?) TRANSPARENS, *Germ.* and *Ber.* Plate CXXXI, fig. 10.

"Supra fusca, subtus pallida, pedibus fuscis, alis albis, nitidissimis, vena costali fusca."—BERENDT.

Perhaps a Lachnus; but as the antennæ are imperfect and the wings cover the hinder part of the body, it is difficult to determine. The resemblance both in size and appearance to *Aphis pini* perhaps justifies its reference to the genus Aphis. Berendt's diagnosis in substance is as follows:—Head rounded in front, broader than the thorax, black above, pale below; rostrum rather shorter than the body. Back (thorax ?) black, and divided into four lobes by a depression forming a St.-Andrew's cross. Abdomen short and broad. Lower parts of the sides seem to be raised into tubercles, but this may be due to the nodular form of the amber. Only one antenna is perfect. It is curved, with two small rounded basal joints, and a long clavate third joint, followed by two vasiform equal articulations, which together do not equal the third in length. The fourth joint is awl-shaped; and perhaps a fifth and sixth joint once existed. Wings unusually large; round at the points, with a broad vein running parallel to the outer edge (cubitus), from which these oblique veins proceeded; one of these has the usual furcation of Aphis. The hinder wings are small. The veins are not easily traceable.

The colours appears to be pale, transparent, and shining.

The legs are long, slender, and brown; tarsi 2-jointed, with two claws (perhaps intended by the term Zweilappig).

As this is the only winged specimen figured by Berendt in the Prussian amber, I have given above his diagnosis pretty completely.

*Op. cit.*, vol. ii, p. 7.

## 3.—OBSERVATIONS ON THE ANCIENT APHIDES AS DEPOSITED IN THE TERTIARY BEDS OF ŒNINGEN IN THE RHINE VALLEY, AND AT RADOBOJ, IN CROATIA, AND DESCRIPTION OF THE FIGURES ON PLATE CXXXII.

Considering the minuteness of the insects, these Aphides are well preserved and represented. For a comparison of modern with ancient forms I have reproduced some of Heer's figures in Plate CXXXII of this Monograph, and I here subjoin some short abstracts of descriptions of the insects he names.*

Good authorities have expressed their opinions that names bestowed on fossil insects by the publication of descriptions, without accompanying figures, rank as mere catalogues or MS. names devoid of priority. Doubtless without the inspection of the actual fossils it is often hazardous to pronounce an opinion about them authoritatively; yet, if drawings are worth anything, they ought to represent all the salient points of generic value in a fossil if they are to be found in the specimen.

The impressions of the wing-veining are so perfect in some examples that nearly as much information can be got from them as from preparations in Canada balsam.

### APHIS (?) MACROSTYLA, *Heer*. Plate CXXXII, fig. 2.

Shining, with pallid abdomen; pronotum very short; mesonotum dilated at the sides. Cornicles very long, length $1\frac{1}{2}$ lines. Wings $1\frac{5}{8}$. Abdomen $1 \times \frac{1}{2}$. Cornicles $\frac{3}{4}$. Locality, Radoboj. Museum at Vienna.

The long nectaries are very distinct in this example, and the wing-veining is normal, as with recent Aphides. We cannot gather much from the antenna, as the last joint is absent, but probably it was setaceous. This

* 'Insectenfauna der Tertiärgebilde von Œningen und Radoboj in Croatia,' Prof. O. Heer, Leipzig, 1853, p. 121, &c.

insect might better be referred to Siphonophora, but I do not wish to speak with confidence. The last abdominal rings are wanting, but in Heer's figure they have been dotted in of their probable size. He says the stigma (Flügelmaal) is very long and thin, as we see in the Lachnus group. This specimen still has some local colour attached to it, for the abdomen is noted as darkish coloured, rather paler than on the breast, and its tail end is yellowish. Cornicles black.

For a more complete description of this insect *vide* p. 121, *op. c.*, Heer.

Lachnus (?) bonneti, *Heer*. Plate CXXXII, fig. 3.

This insect lived on a species of Pinus, and according to Heer was nearly allied to the recent *Lachnus pini* which affects *Pinus sylvestris*.

Black. Abdomen pallid; wings moderately large. Size of abdomen $1\frac{1}{4}$. Thorax $\frac{5}{8}$. Wing $1\frac{3}{4}$ lines.

Heer marks this as a Lachnus, but the length of the nectaries excludes it from this genus. The antennæ have not been preserved; the wing-veining is very obscure, and no stigma is distinguishable. Possibly the insect would better recall the modern *Aphis abietis*.

Aphis (?) delicatula, *Heer*. Plate CXXXII, fig. 6.

The remains of this insect are very fragmentary; and beyond the fact of its being an Aphis there are few characters to be relied on. The wing-veining appears to be a little abnormal.

Aphis (?) pallescens, *Heer*. Plate CXXXII, figs. 10 and 10 *a*.

Shining; abdomen pallid; mesothorax anteriorly very narrow. Total length to the tip of the wings

$3\frac{1}{2}$ lines. Head $\frac{1}{4}$; thorax $\frac{5}{8}$. Wing $2\frac{3}{4}$. Abdomen $1\frac{1}{2} \times \frac{3}{4}$. Radoboj.

This insect differs somewhat from the Aphis of modern times. Heer remarks that it to a certain extent recalls a Lachnus. Yet the long nectaries would certainly separate it from that genus. The wings are remarkably long. The antennæ are wanting, but the insect better suggests a reference to *Siphonophora longipennis*.

APHIS (?) MORLOTTI, *Heer*. Plate CXXXII, fig. 9.

Sides of the pronotum parallel; mesonotum dilated in the midst. Size $3\frac{1}{2} \times \frac{7}{8}$ lines. Wing $2\frac{3}{4}$. Radoboj.

This insect must have been large for an Aphis. Unfortunately no evidence can be gained as to its genus from the antennæ, which are wanting. Heer points out that the abdomen is wanting. I would suggest that the insect was a male, which in recent forms usually has a very small abdomen, and, like this insect, is well furnished with eyes and wings. No nectaries are visible.

LACHNUS (?) PECTOROSUS, *Heer*. Plate CXXXII, fig. 8.

Prof. Heer refers two of the fossil Aphides from Radoboj to the Lachninæ. One of these, viz. the following, is supposed to have fed on the bark of an oak.

Black; pronotum very short. Head rounded, and furnished with short 6-jointed antennæ. Mesonotum large, with equally dilated sides. Size $3\frac{1}{2} \times 1\frac{1}{8}$ lines. Length of wing $2\frac{1}{2}$. The thoracic region is broad and square; the wings are very short, and folded horizontally over the abdomen. The legs are long, with stout femora. These characters suggest a Lachnus. All the Aphides here described in the fossil state are well furnished with eyes. Prof. Heer points out that *L. pectorosus* stands in a near relationship to *L. quercûs* of Lin., which has a similar oak-bark habitat. The fossil species doubtless lived on one of the ancient oaks of Radoboj, and was visited by the contemporaneous *Formica occultata*, an ant nearly allied to the modern *Formica fuliginosa*, which has a similar habit of sucking Aphidian sweets. Heer says we know not only the fossil oak of Radoboj, but also an ant which climbed up and down these trees and extracted such quasi-honey.

A long diagnosis of this fossil Aphis and a reference to Kaltenbach are given by Heer, to whose work the reader is referred, p. 124. I would suggest a nearer approach of this insect to *Dryobius roboris* than to *Lachnus quercûs*.

LACHNUS (?). Plate CXXXII, fig. 11.

Heer figures the fragment of yet another Aphis, which might have some analogy (drawn principally from the wavy form of the wing-veins) to *Lachnus viminalis*, the great willow Aphis. As, however, the abdomen is too crushed to show the characteristic large dorsal tubercle it would be hazardous to say more on this point.

PEMPHIGUS (?) BURSIFEX, *Heer*. Plate CXXXII, figs. 12 *a* and *b*.

There is no direct evidence yet forthcoming of the characters of the insect which caused the galls on the leaf-stalks of the poplars growing at the period when the Œningen beds were deposited. A fossil leaf, with a portion of the pseudo-gall about the size of a pea, leaves, however, little doubt as to its having been caused by some kind of Pemphigan Aphis. The leaf of this poplar has been beautifully preserved, showing very distinctly its principal ribs and neuration. The swelling is placed at the juncture of the foot-stalk, "just as we see it with our *Pemphigus bursarius*." The gall has several rib-like corrugations. A similar gall formed on the leaf of *Populus transversa*, A. Br., was noted by Prof. Heer in the collection of Herr Lavater. In the Œningen specimen a small speck appears which is club-shaped, and possibly is the work of some gall-making gnat like the *Cecidomyia populnea* (*populea ?*) of Schrank.

Two traces of legs (Beinreste), probably belonging to an Aphis, are observable in proximity to this leaf.

Size of the gall $3 \times \frac{3}{4}$ lines.

### 4.—OBSERVATIONS ON THE ANCIENT APHIDES DEPOSITED IN THE TERTIARY BEDS OF NORTH AMERICA, AS EXEMPLIFIED BY SOME OF THEIR FOSSIL REMAINS FOUND IN THE FLORISSANT BASIN OF COLORADO.

Some interest and also surprise is raised at the comparatively perfect condition of the impressions left by these insects in strata, which must have been once a soft mud and must have settled down rapidly. There are nineteen separate figures already drawn in preparation for Mr. S. H. Scudder's fine contribution to our knowledge of Fossil Insects, shortly to be published in connection with the United States Government Survey of the Territories of North America.

These figures leave no doubt as to what family of insects they ought to be referred. The delicate antennæ, as might have been anticipated, have in great measure failed to leave such characters as would have surely pointed to recent genera; but in the figures of the plates above referred to, these organs, as drawn in connection with the Nos. 10 and 11 in Mr. Scudder's list, strongly recall the genus Siphonophora, whilst figures 4, 7, and 8 indicate, though modified, Aphis, Lachnus, and Pemphigus. The antennæ of the rest are too fragmentary to allow much to be gathered from them.

With the exception of the small conical tube on figure 5 no trace of nectaries can be found. This is remarkable, as these organs are generally as coriaceous and dense in texture as the legs.

The name of Mr. S. H. Scudder is so intimately connected with fossil entomology that any materials he offers to illustrate that branch of ancient biology will be very acceptable. Most liberally he has allowed me not only to inspect some of the beautiful plates in preparation for the fine work I have before alluded to; but also to figure some insects which bear on my subject, and which appear now on Plate CXXXIII of this Monograph.

The fully-developed cornicles shown by many European fossil Aphides prove that these organs are not the development of a recent era. Still it might be argued that, as there are no tails visible in any of the individuals I figure on Plate CXXXIII, they never possessed nectaries; since one organ is mostly accompanied by the others. Nevertheless, I think other characters are present so similar to those of recent genera, that their absence is due rather to accident than to a real deficiency in the species.

These remarks particularly refer to my figures 1, 2, and 3. The insects figured 4, 5, and 6 of my Plate, probably never possessed nectaries.

The suctorial habits of ancient Aphides are clearly shown in figure 2, where the insect is represented in profile; and also in figure 6, where the stout third and fourth joints of the rostrum point pretty distinctly to a Lachnus or to some allied genus. The exceedingly delicate wing-veining is finely detailed. As some of the wings are complete, even to their marginal tips, they are very characteristic; and they prove how very persistent these minute Hemiptera have been from early geological time, in their general morphological outlines.

Figures 4, 5, and 6 are more diverse from recent forms, but still they may be said to be referable to modern genera. No lower wings are here represented, though they must certainly have existed. It may be remarked, however, that the lower wings of recent Aphides are more fragile than the upper. Figure 6 has a somewhat mixed character, between Pemphigus and Chermes. The large costal cell here is notable, and possibly this and the position of the oblique veins might suggest the construction of a new genus in the classification of fossil Aphides.

The body of figure 4 has probably undergone pressure. The great breadth of the abdomen in the region of the nectaries might suggest a Lachnus; but, on the other hand, the well-defined wing, with its single furcation, starting from the cubitus, which is remarkably stout, would place this insect somewhat more correctly in Schizoneura.

The pressure on these insects has been so great that the details of both the upper and the lower surfaces can be seen at the same time on the faces of an opaque slab; much in the same manner as a spider may be viewed mounted on a slide for the microscope, after treatment with potash.

It is remarkable how distinctly the pigmental bands and spots can be traced on some of the bodies of these old Homoptera. One of Mr. Scudder's figures (12) might suggest that a viviparous embryo was enclosed. An examination of the fossils themselves would perhaps show whether parthenogenesis existed at this early era. A substantiation of such a fact would prove of interest, as connected with the early embryology and development of Aphis.

## 5.—DIAGNOSIS AND DESCRIPTIONS OF THE NORTH AMERICAN FOSSIL APHIDES DRAWN ON PLATE CXXXIII OF THIS MONOGRAPH.*

As the genera of fossil Aphides cannot be regarded as identical with recent genera, for classifying the Insects now to be described, I propose the following generic and specific names:

### Siphonophoroides antiqua, *Buckton*. Plate CXXXIII, fig. 1.

Winged female. Body fusiform. Abdomen oval and pointed. Antennæ setaceous and very long =1·4.† Expanse =3. Legs longer than the body. Cubitus straight; stigmatic cell very small; stigmatic vein nearly straight. Stigma narrow and inconspicuous. Cubital vein twice forked. Only one oblique vein is visible on this upper wing, but doubtless another existed. Cornicles and cauda absent. Faint bands of colour appear as fasciæ across the abdomen.

With the exception of showing no cornicles, which have probably been lost, this insect has all the chief features of a Siphonophora. As a reference to a recent form I specify *Siphonophora urticæ*. Mag. = 8 diam.

### Siphonophoroides simplex, *Buckton*. Plate CXXXIII, fig. 2.

Winged female. Head and body rather short.

* These figures are reproduced from Mr. S. H. Scudder's plate by his kind permission.

† For the convenience of measurement in these drawings I take the length of the whole body from head to apex as unity, to which all other measurements are referable.

Antennæ setaceous; length 1·7. Legs moderate, about equal in length to the antennæ. Rostrum normally long. Wings folded pent-wise; length =2.

As this insect is seen in profile, the exact veining of the wings is not obvious. The whole insect recalls a recent Siphonophora rather than an Aphis proper. Reference to *Siphonophora pelargonii*. Mag. = 10 diam.

ARCHILACHNUS PENNATUS, *Buckton*. Plate CXXXIII, fig. 3.

Winged female. Body long and spindle-shaped; 1·0 × 0·4. Antennæ about the length of the body, somewhat setaceous. Wings very long and narrow; expanse 3·3. Stigma also long and narrow. Cubital space partly filled with pigment. Stigmatic cell large. Cubitus twice forked. Insertions in the cubitus very far back in the wing. The two oblique veins spring very close to the insertion of the cubital vein. Hind wings wanting. No nectaries are visible. The abdomen seems to have been pale and spotted.

It appears to have been a fine species, perhaps allied to our recent *Lachnus pinicolus*. Mag. = 8 diam.

ANCONATUS* DORSUOSUS, *Buckton*. Plate CXXXIII, fig. 4.

Head, thorax, and abdomen very broad; 1·0 × 0·5. Two conical eminences seem to mark the seats of former cornicles. Wings with a strong cubitus and pointed stigma, which latter is carried partly round the stigmatic cell. Length of wing=1·5. The cubital vein has but a single fork. Oblique veins are two in number.

* (From ἀγκών, cubitus, an elbow).

This large Aphis recalls, chiefly by the wing-veining, a Schizoneura, but the form of the body better accords with a Lachnus. Mag. = 6 diam.

Schizoneuroides Scudderi, *Buckton*. Plate CXXXIII, fig. 5.

Body long and oval. Eyes large. Thorax broadly banded with pigment. Abdomen distinctly ringed and barred with spots and fasciæ very like a modern Aphis. Length to breadth as 1 to 0·3. Fore wing very broad, with a very indistinct stigma. Cubitus far removed from the costal margin. Stigmatic cell very large. Cubital vein once forked, and followed by two oblique veins, the second of which is much curved. An under wing still remains with this specimen, but it is much folded. Neither antennæ nor legs are to be seen in the matrix. The wing-veining is unusual, but possibly the insect may be referred for comparison to *Schizoneura ulmi*. Mag. = 12 diam.

Pterostigma recurvum, *Buckton*. Plate CXXXIII, fig. 6.

The body of this insect has some resemblance to the last insect, but it is too much crushed for a decision as to character. The abdomen is ornamented by six square patches of colour. The eyes are rather large. The antennæ are fragmentary, but show two basal and the remains of two other joints. A rostrum with three joints protrudes from one side of the head. The wing is very long and pointed, with a remarkably attenuated stigma like that of *Colopha ulmicola*, Monell. If the stigmatic vein is not displaced by pressure, it is remarkable. Probably the cubital vein had one if not two furcations. Recalls *Lachnus longistigma* of Monell. Mag. = 8 diam.

## 6.—DISTRIBUTION OF APHIDES.

We learn from their fossil remains that Aphides in ancient times were diffused over a large area of the world's surface. Their modern representatives are no less widely scattered. The fact also is interesting that so many well-known species are common to countries widely separated by distance. Thus, out of the 185 British species and varieties in this Monograph, the annexed very imperfect table has been drawn up, which shows, subject to the uncertainty attendant on the strict identity of species at such distant parts, the diffusion of these insects over certain areas.

| Aphidinæ. | England. | Germany. | Italy. | America. |
|---|---|---|---|---|
| Siphonophora . | 40 | 28 | 15 | 9 |
| Aphis . . | 45 | 29 | 20 | 5 |
| Other genera . | 45 | 32 | 28 | 11 |
| Lachninæ . . | 19 | 13 | 11 | 4 |
| Schizoneurinæ . | 7 | 4 | 4 | 2 |
| Pemphiginæ . | 10 | 8 | 6 | 1 |
| Chermesinæ . | 8 | 5 | 1 | 1 |
| Rhizobiinæ . | 11 | 1 | 6 | 0 |
| | 1[illegible]5 | 120 | 91 | 33 |

In answer to my inquiries, Mr. J. Monell, of St. Louis, writes that he thinks the most northern American Aphis yet described is *Pemphigus tessellatus*, Fitch. *Hermaphis rhois* also occurs far north in Ontario. Perhaps the most southern Aphis of North America is the cotton louse, *Aphis gossipii*, a published description of which is still wanting. It extends southwards to St. Louis, and eastwards throughout the whole length of the Mississippi valley. *Pemphigus vagabundus* is common over the greater part of the United States, and is found on the slopes of the mountains of Colorado.

The Aphis-eating Asaphes is a native of South America; and the Hemerobiinæ and Coccinellidæ are also widely spread over that continent. The presence of such insects, though strongly suggestive, is not conclusive as to the existence of Aphides in these districts. However, Aphides have been noted in Brazil by Lund, but I am ignorant of the species. This locality is the only one south of the equator where these insects are recorded as indigenous.

*Lachnus piceæ* is one of the most northern insects known, and is indifferent to very low temperatures. It inhabits the forests of pine on the frozen tracts of Northern Asia, having been taken near Lake Baikal and the banks of the Amur. This insect also flourishes on the snow margins, and close to the glaciers of Switzerland.

Dryobius lives on the oaks of Croatia, as in Britain. Edward Doubleday,* assisted by Haliday, described an Asiatic Aphis which seems to have some connection with the genus Pemphigus, since, amongst other characters, it punctures a species of Rhus, and raises pseudo-galls, which are valued by the Chinese for the tannin they contain.

A diagnosis is given by Doubleday, and also several figures; but as the winged form is at present unknown, no certain genus can be assigned to the Aphis. This same gall, or one very like it, has been also described by Walsh in America.

Tropical heats are not well suited to the wants of an insect family so dependent as Aphides are on succulent food. Yet, as we approach climates made more temperate through the elevation above the sea-level, examples occur even but a few degrees above the equatorial zone.

Through the kindness of Mr. Octavius Greig, two years ago, I received some insects from Kaladhungi, which is situated in the North-west Provinces of India. These proved to be Aphides. They were taken by him from rose trees in the garden of Sir Henry Ramsay in the month of October. These

* E. Doubleday, "An Aphis forming the Chinese Galls," 'Trans. Pharm. Soc.,' vol. vii, No. 7, p. 310, 1848.

insects, which were individuals out of companies of many hundreds, under the microscope showed all the characteristics of *Siphonophora rosæ*, and, indeed, they were identical with our English rose Aphis. They were pretty constantly attended by ants, which coursed up and down the trees for the honeydew.

The same gentleman also procured for me, in the following June, an Aphis which clustered on blades of grass growing on a wild flat in the neighbourhood of Bogsar in the same district. They belonged to the genus Aphis, and were exceedingly like the British *Aphis jacobææ*. Ants also affected their company, specimens of which last insect he mounted for me in resin.

Two or three winged forms were secured; but, as they were unfortunately lost during their transit to England, I cannot give their diagnosis, though I possess the apterous females in resin.

From Bogsar also I obtained specimens of a root-feeding Aphis possessing tarsi with a single claw and 5-jointed antennæ. They were infesting the roots of *Zizyphus jujuba*. No winged insects could be obtained though a search for them was made several times.

I give the following description of this Indian Aphis:

### Rhizobius jujubæ, *Buckton.*

*Apterous viviparous female.*

| | Inch. | Millimètres. |
|---|---|---|
| Size of body | 0·060 × 0·035 | 1·52 × 0·88. |
| Length of antennæ | 0·020 | 0·50. |
| Cornicles wanting. | | |

Body oval, yellow, furnished with numerous stout bristles. Eyes very small; composed of a single lens, mounted on a conical process, which rises near the base of the antennæ. Antennæ short and 5-jointed, the apical joint being somewhat clavate.

Legs short; tarsi long, single-jointed, and furnished with a single claw and bristles. Rostrum short and extending to the second coxæ.

*Habitat.*—North-west Provinces of India.

Thus the known area now covered by these interesting insects is a very large one, extending from Northern Siberia to the Brazils in the southern hemisphere; from Colorado in the far west to New York; from Britain to Croatia; and from the Himalaya to China in the east.

No notices yet have been published as to the occurrence of the family in Southern Africa, or in the temperate parts of Australia. Considerable interest will attach to any indigenous forms which may hereafter be shown to exist in these parts of the world.

## 7.—OBSERVATIONS ON THE NATURAL AND ARTIFICIAL CHECKS TO THE INCREASE OF APHIDES.

Although the primary aim of science is discovery, and the knowledge of laws which govern the universe, in a secondary manner we may well study phenomena in connection with our own economy, and their bearings on our material well-being and comfort. Some information may therefore be here expected, as to the methods, natural or artificial, which are of avail in controlling the spread of insect pests in general, and of Aphis in particular.

As to the former subject, several notices will be found scattered throughout my previous volumes relating to the parasitic insects which prey on Aphides; and these parasites will be found the most powerful checks to Aphis increase, if perhaps we except all electrical storms, rains, and winds. As to the artificial methods, it must be confessed that, the numerous nostrums advocated and published through various journals, both home and foreign, only prove how little we can do where the evil is spread over a large area; the immediate destructive agents are legion, and their economy is often obscure.

Some years ago Mr. F. Walker, after noticing the destruction of the water-lilies on the Thames near Hampton Court, suggested the artificial introduction, or transplanting, as it were, of diseased individuals of *Rhopalosiphum nymphææ;* these Aphides being very commonly infested by the larvæ of small Ichneumonidæ and Chalcidiæ.

These parasites would, after becoming winged, deposit their eggs in myriads of healthy Aphidian larvæ, and thus check their evil influence.

There can be no doubt that our corn harvest is repeatedly saved by the presence of the little black *Ephedrus plagiator*, which oviposits in the larvæ of *Siphonophora granaria.* The brown, globular, ichneumoned bodies of the rose Aphis is also familiar to most horticulturists. The common rape Aphis, *Rhopalosiphum dianthi*, and the cabbage Aphis, *Aphis brassicæ*, are so much attacked by parasites, that scarcely one individual in a hundred escapes and passes into the winged state.

The hop-grower knows the value of the "lady-bird," and will not allow them to be wantonly destroyed; and equal protection should be given to the Aphis-eating "golden-eye."

Some Aphides undergo a sugary degeneration; the internal organs apparently at first become abnormally charged with oily globules, which afterwards crystallise like grape sugar, and finally the insect is destroyed. The Aphides of the swede-turnip are often thus affected, and their bodies then turn to a foxy-yellow colour.

*Rhopalosiphum lactucæ* and many other species are often covered by a yellowish fur-like coat, which under the microscope has much the appearance of a fungus, not unlike the Empusa of the house-fly. The entire body of the insect becomes clothed with transparent ovoid bladders, interlaced with what appears to be a connecting mycelium. On cutting into such bodies their contents will be found leather-like and tough, and finally the insects dry into hard masses.

Dr. Worthington Smith states that the potatoe fungus, *Peronospora infestans*, passes its mycelium into the bodies of the Aphides, which commonly infest the stalks of that plant when diseased. That Aphides are liable to fungoid growths is clear from the observation of many investigators.

In 1873 Dr. J. Le Conte, of Philadelphia, remarked on the epidemic diseases of insects ; and with a view to their extermination, he proposed something like the inoculation of disease. Dr. Rees and Mr. A. Giard subsequently discussed the same subject with the like intent.

Very much to the same purpose Prof. Metschnikow suggested the deliberate cultivation of such fungoid growths as produce diseases in insects; and he proposed that the fungi so cultivated should be scattered in places infested by noxious insects, with a view to their extermination.

Dr. H. A. Hagen, of Cambridge, Mass., made experiments on the effects of common yeast on beetles, &c., and he states that sprinkling the bodies with this substance resulted in death of the insects within the space of three or four days. He thinks that destruction of the animal organs is caused by the penetration of the mycelium, which produces the consequent disintegration of the parts.

It is not clear how this yeast-plant is most advantageously applied ; but possibly a few insects, anointed with the scum from the brewing of beer, when set at liberty, would cause the required dissemination. I would commend such experiments to the notice of those who are overrun with the common cockroach.

A little attention will always keep the "green-fly" out of greenhouses and forcing-pits. The great thing to avoid is insect possession through a neglect of the early broods of the year. These broods, being less numerous as to individuals, may be overlooked; but they are the future centres of fresh companies.

Pots plunged for a few moments into water heated to 140° Fahr. will kill most insects; and probably in no case the treatment will injure the plants. Syringing with a weak solution of soft soap, that is, two ounces to the gallon of water, is efficacious. The potency of this wash is increased by boiling in it two ounces of flowers of sulphur. Sulphur, indeed, is the most important ingredient in the various washes offered to the public as insecticides.

A cheap solution of calcium sulphide may be easily prepared by boiling together—

| | |
|---|---|
| Flowers of sulphur . . | 1 lb. |
| Caustic lime . . . | 2 lbs. |
| Water . . . . | 4 gallons. |

To prepare the liquid for use take of the above,

| | | |
|---|---|---|
| Calcium sulphide . | 4 ounces | Mix together. |
| Soft soap . . | 2 ounces | |
| Add hot water . | 1 gallon. | |

Stir and allow to settle.

When cold, this liquid may be used as a bath, or sprinkled by the syringe or by the garden hand-engine, or by a brush; this last instrument most effectively rubs the solution into buds and bark infested by Aphis.

Some have strongly advocated a copious syringing of infected trees, when the thermometer is seven or more degrees below the freezing point. No injury is done to the trees by thus using the above solution; "but the freezing and thawing loosens and clears the Aphis eggs out of innumerable crannies."*

Smoke of all kinds has a sickening effect on Aphides; and the old plan of fumigation by the slow combustion of coarse and wetted tobacco is very convenient in glass houses and forcing-frames.

MM. Monestier and Lauland recommend placing an

* E. Ormerod, 'Manual,' p. 288.

uncorked phial containing about two ounces of carbon disulphide close to the roots of such vines as are infected with *Phylloxera vastatrix*. The vapour is heavy, and it affects the soil and the insects below.

The liquid must not be spilled; and, as the vapour is poisonous, great caution obviously is needed in its use.

During this last year (1882) M. Monillefert used the sulpho-carbonate of potassium on no less than three hundred and eighty-five vineyards, and he states he has met with great success. The cost varied from 0·05 to 0·03 of a franc per stock; which, considering the advantage gained, cannot be considered as an excessive cost to the grower.

With reference to the hop Aphis, *Phorodon humuli*, there would seem to be but little doubt as to the hybernation either of the oviparous female or her egg.

An application of this sulpho-carbonate to the soil close to the root-stocks early in the spring, when the fundatrix is expected to hatch from the egg, surely is worthy of a trial. Its application to the hop plant cannot have greater difficulties than those experienced in the grape-vine.

Both in France and America the substance known as Paris-green has been beneficially applied as an insecticide. But as the active principle is arseniate of copper, a highly poisonous preparation, and fatal to all animals, even in small doses, its use cannot be recommended.

Careful washing of the hop plants *soon after the appearance* of the hop Aphis has often insured a fine crop of blossoms to the grower, and notwithstanding the extra cost it will well repay him for his labour. This may be well understood, when one acre of ground may produce as much as seven hundredweights of hops, representing a value of £22. The loss over the United Kingdom caused by "the fly" during this last year is estimated by a large hop-grower at not less than £1,750,000, of which the labourers, through deficiency of wages, &c., are thought to have sustained at least £200,000.

The advice I here would give is to burn the vines immediately after the hops are picked; watch for the foundress as she rises from the soil, and takes to the young plant when it is only a few inches high; wash thoroughly, by hand at first; and in February or March, on a sufficiently large scale; and use the same means as our friends on the other side of the English Channel use to stamp out the Phylloxera.

There is yet another consideration I here offer to those most interested in destroying *Phorodon humuli*. As this species feeds on the green leaves, and has not been shown to be dependent on the root of *Humulus lupulinus* for its sustenance at any time, the life-cycle is complete in a single year. Therefore, if by mutual consent, no hops are grown (for say three years) on a district so wide that the winged insect is not likely to traverse it, a large portion of this area would be free from Aphis for an indefinite time.

There can be no doubt that, as rapid locomotion and ready transit transplant fresh species of insects, into new localities, so isolation will be a chief factor in stamping them out.

In connection with the economy of *Phorodon humuli*, I will here state that, through the kindness of a friend living at Staplehurst in Kent, a block of earth, containing the root-stock of a hop plant which had been infected with fly during the previous year, was consigned to me in March of this year. I spent nearly two hours in investigating the mass, taking a spoonful at a time, and viewing it under lenses of different magnifying powers. I could not find a trace of either Aphis or egg. The earth was rather pale in colour, so if a dozen eggs or even fewer had been present, I believe I should have seen them. A few small centipedes and the larva of a small beetle were the sole rewards of my pains.

This earth from Staplehurst is now reserved for the purpose of securing any Aphis that may yet appear above ground.

A similar negative result was obtained from the investigation of a quantity of half-dried leaves of the hop gathered from the neighbourhood of the hop vines in late autumn.*

I found many dead specimens of *Aphis humuli* which had been the prey of some small Ichneumon; but I failed to find either male, female, or the winter egg, the true nidus of which is so much in request for deciding the agriculturist as to the best mode of meeting his insect foe.

As investigators are likely to find the subterranean Tychea and Endeis in the soil of hop grounds, they must be prepared not to confound them with Phorodon, which has nectaries and the characteristic frontal tubercles.

## 8.—THE PRESERVATION AND MOUNTING OF APHIDES FOR THE MICROSCOPE.

A few remarks embodying the author's experience as to the best mode of transmitting living Aphides from one country to another for the purpose of comparison, and also the best method for killing and preserving such-like insects for future examination, may be acceptable.

As to transmission, the chief thing to be guarded against is desiccation. Tenacity of life is so remarkable in these insects, that, almost like plants, they may be cut up and yet the dismembered portions will retain their irritability for hours, if they be only kept in a moist atmosphere.

No plan appears to be so successful for the safe transit and security of the insects in a living

* These leaves were kindly forwarded to me by Miss E. Ormerod. The reader is referred to her useful 'Manual of Injurious Insects, and Methods of Prevention,' for much useful information therein contained.

state, as their enclosure in ordinary quills stopped by plugs of cork, or pellets of bees-wax. The substance of the quill is sufficiently porous to prevent mildew on the one hand, and a rapid evaporation on the other. In this way small insects may be sent through the post, and in a far better condition than can be secured in any tin boxes, even though they be filled with leaves. If a slip of some succulent leaf be rolled round each quill, to retain moisture, a bundle will conveniently pass through the post; and in such a manner I have received specimens from the north of Scotland and the south of France. Intimate domestic arrangements do not seem to be interfered with during such long journeys, for the family increase often continues in full vigour. Aphides placed in boxes, instinctively run to the light, and they commonly escape through any accidental chink. In such boxes they have often arrived at the end of their journey, drowned in their own sweets and exudations. A still more vexatious accident may happen in such consignments. For want of due attention the larva of a Coccinella or Syrphus, perhaps, has been overlooked; and the interloper has become fat on specimens set apart for other purposes.

### 9.—THE PRESERVATION OF APHIDES FOR THE MUSEUM.

The presence of air with its floating germs is now admitted to be necessary for the fermentation and decomposition of both vegetable and animal substances. It thus would appear that insects may be preserved for a time almost unlimited by sealing them from its influence in glass tubes.

To those accustomed to the use of the blowpipe and lamp this operation will present no difficulty. Small, flattened, glass tubes, partially filled with a suitable liquid, into which the insects have been dropped, may be drawn into a fine point. The end may be then broken off; and, by warming the empty space, or still better by expelling the air by a pump, a dozen or more tubes may, at the same time, be entirely filled with the liquid.

The capillary tubes can then be sealed by the blow-pipe flame, and the specimens may be labelled in the ordinary way.

As colours are liable to the bleaching action of light, the specimens are best ranged in a dark cabinet. Several liquids will be found effective, and they may be varied according to circumstances. I have had excellent results from very weak acetic acid, also weak glycerine. If alcohol be used, it must be exceedingly dilute, or it will render the insects opaque.

But after all, for ordinary microscopic work, such as taking measurements, and noticing the constituents of the antennæ and wings, nothing is better than careful mounting in Canada balsam, thinned, if necessary, with petroleum spirit. Just as insects are accidentally preserved in amber, they may be artificially and more completely secured, by embedding in any recent amber-like resin. If a few simple rules be followed, there is no difficulty in making these preparations; and as to their showing detail, there seems to be nothing more to be desired. Although the procedure has been already lightly touched on in my first volume,* a recapitulation with additions may be useful.

On a slip of ordinary-sized microscopic glass, dot from the head of a pin, in any desired order, five or a dozen spots of fluid Canada balsam, and by means of a hair pencil transfer as many living insects to them. The specimens at once adhere, and if the spots are small the insects spread out their limbs naturally, with a view to escape. They may be fixed on their backs or otherwise according to the views desired.

A very thin glass cover or, if very high magnifying powers are wanted, a small disc of clear mica is laid

* See Preface to Volume I.

over the insects, and then one or more drops of the fluid balsam are delivered from a glass rod at one of the sides of these covers. The balsam runs slowly under by capillarity, and it drives all the air before it, the small weight of the cover assisting it to spread, until the whole area is filled. No pressure is to be used, or the elastic bodies of the Aphides will change shape; and besides this, the juices will be forced through the cornicles and pores. If the balsam is thick, a very gentle heat, hardly exceeding that of the cheek, may be applied; but, as a rule, the temperature of a room is better than that which exceeds it. The insects die immediately they are cut off from air, and in almost every case their position will be good for examination. To spread the wings of a small insect, the above-mentioned small dots may be made in a row. The belly of the specimen is applied to the middle spot, and by a bristle one wing may be applied to the dot on the one side and the other wing to the third dot. The cover is then placed as before, and when the balsam runs in, it will not disturb the position of the spread wings.

It will be noticed that very soon after live insects have been mounted in a resinous substance that will not mix with water, a white cloudiness forms around each specimen. This is caused by the watery juices of the insect, which "chill" the medium and make it opaque.

This cloudiness, however, entirely disappears after perhaps a month, the moisture being carried slowly outwards. The same is to be said of stray air-bubbles. The oxygen of the air unites with the balsam and thus hardens it; but what combination is effected with the nitrogen is not so clear. However, air-bubbles in balsam disappear in time, provided the former is not in too hard a condition.

In cases when the above small pressure is undesirable, small circles, cut by round punches of different sizes out of very thin sheet lead, will be found more convenient to insert between the glass slip and its cover, than circles of card which are sometimes recommended. The thin sheet lead from the Chinese tea-chests is very suitable for punching, and as it is not porous like card, it yields no air-bubbles by heat.

Herr D. von Schlechtendal has, in the 'Entomologische Nachrichten,' iv, p. 155, described a method, by which it would appear that all the characters of form and colour (?) may be preserved in Aphides and other insects. The method consists of a rapid death and drying of the insect by means of a current of heated air. The Aphis, previously attached to some suitable support, is suddenly and momentarily subjected to the heat of a spirit or other flame, by which it is immediately killed and caused to retain its natural position. Several examples are then carefully roasted in a current of hot air, such as that passing through an inclined glass tube, duly made hot, or dried on a sheet of paper moved over a heated metal plate.

When dry, the specimens are mounted on card by attachment with gum-tragacanth; or, as Mr. T. W. Douglas suggests, more conveniently on mica, called "talc" in the shops, which, as it is incombustible, is well suited for a support both before and after drying.

This method is vouched for as good by Drs. Giebel, Taschenburg, Mayr, and Rudow.

I have not tried this roasting process, but it must require some address to prevent the shrivelling of wings in such delicately formed insects, and to provide against the bursting action of the boiling juices.

A more complete history of the process, than the foregoing, was given by Mr. T. Douglas in 1878.*

M. Lichtenstein has many times been good enough to forward in letters to me preparations of Aphides which have been secured between two films of mica. The insects, he explains, are immersed in a solution of resin in turpentine, "a natural amber," and, when all

* 'Ent. Month. Mag.,' vol. xv, p. 164.

are in due position, the mica films are placed over apertures in card, and then gummed papers, similarly perforated, are pressed upon them. This arrangement secures all in their places.

Methods and operations in science, like events in history, repeat themselves. Fifty years ago films of mica were used to cover objects for the microscope, and before the manufacture of the thin glass now so commonly used, it admirably answered its purpose. Under deep magnifying powers, such as $\frac{1}{12}$th of an inch, it will be found even now of great service. The mineral may be split by the lancet into films much thinner than glass can be blown in a flat state. Small unscratched pieces may be selected which are perfectly transparent and their cost is quite trifling.

On account of the high refracting power of Canada balsam, the colours of recently immersed Aphides show themselves very brightly; and it sometimes happens that tints, quite lost through irradiation or glance on the surfaces, become distinct by treatment with this resin.

The bright colours and markings of some species are due to the hue of the internal juices of the insects. These cannot be preserved by balsam, but it is otherwise with the pigments which stain the somewhat horny coverings of the thorax and abdomen. These colours are persistent.

## 10.—THE DISSECTION OF APHIDES

In the dissection of Aphides, much assistance may be often got by a selection of liquids. Some of these are best suited for the purpose of hardening the tissues, so that they may bear separation and tearing asunder without their destruction. Others are used for colouring the transparent organs, so as to make them more visible. These organs of Aphides are so delicate that pure water will in a great measure destroy them, In such cases a weak solution of common salt, or very dilute glycerine, or sugar and water, or albumen and water, all of which should nearly approach the density of the juices of the insect, will be found a considerable help.

Some Aphides are so large, so full of liquid, and so charged with oil-globules, that some treatment is necessary to reduce their bulk, and to allow of a sufficiently thin stratum of balsam for mounting.

In such cases the Aphides may be placed in spirits of turpentine, and just raised to the boiling-point in a small test-tube. After soaking in the turpentine for a few hours, all the oil-globules will be removed, and the insect, by this treatment, will have become very transparent, and the aqueous parts will not then chill the balsam.

To prepare Aphides for dissection, liquids may be divided into those used for hardening the tissues and those employed for colouring the same. For hardening, a digestion for several hours in weak alcohol will be of advantage. The alcohol must not be too strong, or the albuminous portions will be coagulated and become too opaque.

Weak acetic acid will render some portions tough, and the same action is also well effected by a weak solution of phosphoric or of nitric acid.

The action of ordinary ether upon Aphides is not well understood. Their bodies are speedily destroyed by plunging them into the liquid. At the same time a considerable stream of air-bubbles contained in the tracheæ is expelled, and of such a volume as would lead to the supposition that much of this air must be in some state of solution in the body-juices.

The reaction of weak potash has been before noted. As a rule, the germinal matter resists its action for a considerable time. Simultaneously this reagent usually stains it of a bright gamboge yellow. In some genera (notably Lachnus and Dryobius) potash deepens very markedly the violet dye natural to these Aphides.

In other cases, I have found potash to evoke the violet shade from specimens otherwise colourless. This dye is fugitive, and, if discharged by an acid, cannot be again recovered by the action of an alkali. Soda and ammonia also bring out this colour.

Advantage may be taken of the fact, that there is a certain order in which the tissues resist the intrusion of foreign matter, such as a dye. Thus the germinal and most vitally endowed organs reject dyeing by carmine, logwood, and such coal-colours as magenta; whilst the portions in process of exfoliation and decay absorb it the most readily. For such purposes, weak alcohol may be made slightly alkaline by ammonia, and tinged with a little carmine or cocchineal solution.

Dilute chromic acid both tinges the tissues yellow and renders them tough. Solutions of osmic acid also may be used with advantage, and, in short, the usual reagents employed for conducting minute anatomy may be taken with due circumspection and tenderness.

For labelling specimens, paste will be found much more adherent than gum. The former may be preserved for some months in a well-closed bottle, if a little aqueous solution of corrosive sublimate be stirred into it.

## 11.—SALICINE IN APHIDES.

Mr. C. T. Muller, of Eastbourne, informs me that he has been able to prove the presence of salicine in the juices of *Lachnus viminalis.* He digests the insects in chloroform, which liquid subsequently, on evaporation, leaves silky crystals, capable of polarising light, and giving the characteristic red coloration with sulphuric acid.

If these crystals be salicine, the polarised ray should have a rotation to the left. This experiment I have not tried. I am told that these crystals answer to the ordinary tests for salicine.

The elaboration, or even the concentration of vegetable alkaloids in the organs of insects is very interesting. *Chrysomela populi* is known to leave a track of salicylic acid behind it when irritated.

The botanical genera of Salix and Populus contain this bitter principle in their barks, and they are the chief sources for its commercial preparation, valuable as a febrifuge.

# APPENDIX.

Our modern facilities for transport are now so great, that it becomes necessary to modify our notions as to when an animal is entitled to the term indigenous; indeed, the naturalisation of a species now becomes merely a question of the period of time, and the degree of persistence.

Perhaps only two Aphides out of the series I have described have been introductions into Britain within historic times. They are the American apple Schizoneura and the grape Phylloxera. In the March of this present year I received from Mr. J. Anderson, of Chichester, an interesting addition to our list of Aphides. As they apparently infest only the palms, orchids, and a few other stove-plants, they must be looked upon as a species introduced from without.

An examination of these insects proves them to be identical with a species described some years ago by M. Boisduval, in his 'Entomologie Agricole,' to which he gave the name of *Coccus lataniæ;* but M. Lichtenstein has recently shown that it agrees with that family neither in the construction of their antennæ, nor in the characters of their tarsi. Besides this, M. Lichtenstein has satisfied himself that the rare winged form of this insect is a true Aphis; allied, perhaps, to Schizoneura, or to some near genus.

M. Signoret had previously shown that it differed from Coccus, and accordingly he changed the name to *Boisduvalia lataniæ.* M. Lichtenstein published at Montpelier a more complete diagnosis, and at the same time described the rare winged female. From the presence of two minute horns on the vertex of the apterous female, he gave it the generic name of *Cerataphis.*

Mr. J. Anderson this year has made this addition to our list of British Aphides; and thus he enables me to give a diagnosis of the insect as it appears in Great Britain. Unfortunately, the notice of its occurrence was forwarded to me too late to allow of its introduction into the body of this work.

### GENUS XXV, *bis.*—CERATAPHIS,* *Licht.*

Rostrum of the imago short. Antennæ 5-jointed; the first two joints smooth, all the rest ringed. The third joint the longest, the fourth and fifth nearly equal. Eyes large. Nectaries none. Tarsi with two claws.

Eyes of the larva nearly obsolete. Head furnished with two minute, characteristic, frontal horns. Legs and antennæ very short, and mostly concealed by a disc of wax-like material, which is expelled from a row of peripheral glands.

### CERATAPHIS LATANIÆ, *Licht.* Plate CXXXIV.

*Coccus lataniæ*, Boisduval. 1867
*Boisduvalia lataniæ*, Signoret. 1868
*Cerataphis lataniæ*, Lichtenstein. 882

*Apterous female.*

| | Inch. | Millimètres. |
|---|---|---|
| Size of body | 0·060 × 0·050 | 1·52 × 1·27 |
| Antennæ | 0·010 | 0·25 |

Coccus-like. Colour rich brown; to the naked eye, nearly black. Form oval, or nearly circular. Edge

* From κέρας, a horn.

of the body terminated by a string of minute transparent glands, from which a clear disc of wax-like substance is secreted. This disc is striated and slightly fimbriated. It entirely surrounds the insect, and hides the antennæ and legs below. In the Spring of the year, two or three pale folds occur across the dorsum of the insect.

Antennæ very short; 4-jointed, the first and second joints nearly equal; the third the longest, and about double the length of the second. The fourth joint ends in a considerable nail, which, added to the rest, makes the whole joint nearly as long as the third. The front is furnished with two short projections or horns, the use of which is unknown. Eyes very minute; brown. Legs very short, and normally formed like Aphis; ending with the usual tarsus and two claws, without the capitate hairs to be seen in coccus.

Rostrum about one fourth the length of the body. Cauda tuberculate, with two small papillæ. The underside is paler, and mottled with brown.

The young, born from the above insects, are much less coccus-like, and do not greatly resemble their parents. After a short time they moult, and become of a pale, ochreous green colour. The wax glands soon after show themselves at the circumference of their bodies, and the growth of the disc is rapid and very interesting under the microscope.

*Viviparous winged female.*

| | Inch. | Millimètres. |
|---|---|---|
| Expanse of wings | 0·160 | 4·06 |
| Size of the body | 0·0700×0·040 | 1·77×1·01. |
| Antennæ | 0·035 | 0·88. |

The imago apparently is very rare, for only three mutilated specimens are at present known. It has not yet been taken in England; but I have been able to make the above measurements from a specimen mounted by M. Richter, of Montpelier.

General colour, yellow. Antennæ with five articulations : the last three joints are much ringed. Vertex flat, and without the horns seen in the larva. Eyes large ; stemmata obvious. Wings folded flat on the back. Cubital vein is once forked ; and it does not reach to the cubitus. First and second oblique veins unite just before they touch the cubitus. Rostrum reaches to the second coxæ. Legs short, tarsi with two claws.

The general appearance of the larva is so coccus-like, that the venation shown by the imago is a little unexpected.

Although this Aphis takes its specific name from the palm-tree, it really affects many other plants in the hot-houses of the horticulturist. M. Lichtenstein says that the larva is very abundant on Latania, Calamus, &c. It occurs here on Orchis and other plants. To the naked eye, they appear as black spots surrounded with white rings. They make patches on the leaves composed of twenty or more individuals. When once the Aphis attaches itself, it does not appear again to move from its place, but the young rove about for some time after their birth.

M. Lichtenstein thinks that the imago has some resemblance to Vacuna (Thelaxes), but it certainly wants the characteristic cornicles. I am unable to state the venation of the lower wings.

I counted at least eight embryos within the abdominal cavity of the imago ; so the imperfect sexes of this species are clearly viviparous.

The generic name of this insect must not be confounded with Cerasaphis, of Amyot, which feeds on the cherry tree.

## CONCLUSION.

In taking a retrospective glance over the subjects treated of in these volumes, the author expresses his adherence to and entire belief in the old, but now often assailed doctrine of design.

Mr. Darwin never taught that any blind condition was involved in selection, though some modern writers have illogically asserted that gradual evolution is utterly fatal to the argument of teleology. It seems to be inconsistent that these thinkers commonly use, and apparently from necessity, such a phraseology as involves a doctrine, the significance of which they would otherwise deny.

It is the duty of the man of science to push back the sequence of cause and effect to the utmost attainable limits; but this process, whilst it enlarges the area of the known, at the same time surely expands the horizon, which at present cuts us off from the vast region of the unseen; for knowledge, like time, space, and number, is to us only relative. It is difficult to understand the position of that mind, which, whilst continuously acknowledging the sequence of cause and effect through a thousand instances, at the last stage of thought seeks, and apparently finds, some sort of relief in an inversion of this process, that is to say, by putting the effect first.

A denial of the *Causa causarum* invites back that chaos and despair which would land intellect in the monstrous dogma, that this universe after all is but a mistake, and to man a hideous enigma, instead of being the visible exponent of the Infinite. Carlyle thus speaks of the kosmos—"The universe is not dead, and demoniacal; a charnel house with spectres; but God-like, and my Father's."

And yet again, a student of old has nobly written to the same purpose. Bacon says, "Knowledge is not a couch whereon to rest a searching and restless spirit; nor a terrace for a wandering and variable mind to walk up and down with a fair prospect; nor a tower of state for a proud mind to raise itself upon; nor a fort or commanding ground for strife and contention; nor a shop for profit or sale; but a rich store-house, for the glory of the Creator, and the relief of man's estate."

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The above is not an exhaustive list of the writers on Aphides, but it is believed that all the chief known facts, as connected with their economy, can be extracted from the memoirs above named.

# GENERAL INDEX

TO

# VOLS. I, II, III, AND IV.

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## DESCRIPTION OF PLATE D.*

REPRODUCTIVE ORGANS OF THE VIVIPAROUS APHIS.

Fig. 1.—Portion of the pseudovarium of *Siphonophora pelargonii* with some of its cæcal chambers: *a a*, terminal chambers: each of which has become constricted in the midst: *b*, *c*, *d*, *e*, *f*, represent other chambers with their embryos in progressive stages of development. In *f f* the eyes have become differentiated, and the body shows incipient segmentation. The antennæ, rostra, and legs are clearly marked. The ovisacs are immediately connected with the oviduct, one of which is indicated at *h*. The caudal ends of the embryos are all turned towards the vulva or genital opening. I could not clearly separate out the colleterial glands of this specimen, but one probably is shown as a blind sac near the base of the vagina at *i*. *k*, the alimentary tube, charged with nutriment, and ending in the rectum *l*.

Only one branch of the oviduct is here represented, and some only of the ovisacs are drawn. In some species of Aphis the ovarian tubes number six on each side; and, as each tube may consist of six separate chambers, full scope is afforded for the multiplication of the insect. Dissected under weak syrup, January 6th. Mag. 34 diam.

Fig. 2.—One of the pseudovigerous tubes of *Siphonophora rosæ*, much magnified: *a* represents the apical chamber, containing several ovarian glands, one of which has been constricted off from the rest, and has become the germinal vesicle with its germinal spot.

* Plates, A, B, and C, will be found in Vol. I.

*b* and *c* represent other pseudova, in which the mass has undergone a coarse segmentation: *d*, the fourth chamber, in which the pseudovitellus shows a partial differentiation; *e*, the fifth chamber or ovisac, in which may be seen indications of a body-cavity (*s*) forming out of the blastodermic layer (*p*); *f*, the last pseudovarian chamber, in which the embryo has become more advanced; *p*, part of the procephalic lobe of the blastoderm; *y*, yolk-mass or pseudovitellus; *r*, rudimentary fold of the abdomen; *o*, rudiments of the fœtal pseudovum, which occurs thus early in these insects. Mag. 112 diam.

The details of this *sixth* chamber are after Prof. Huxley, but an error occurs in my present figure as to the position of the head, which, as before said, should have been turned in the opposite direction.

Both Huxley and Brandt have noted exceedingly fine ligaments proceeding from the free ends of the apical chambers of the pseudovaria. Such ligaments have not been observed, I believe, in the organs of the true female. These pseudovarian ligaments would seem to have some free intercommunication with the corresponding tubes (?) of the cæca situated at the other side of the Aphis. Their omission in this figure does not argue their absence in the living insect. (*Vide* Huxley, l. c., p. 199.)

Fig. 3.—Similar parts of the ovigerous tube of *Chermes abietis*. These ovisacs are very numerous, and number more than one hundred. The peculiar cord observed and described by Huxley in "*Vacuna dryophila*" (*Callipterus quercûs?*) is here readily seen at *b*. This cord is better seen in Plate F.

Fig. 4.—The forceps-like appendage at the tail of *Chermes laricis*, employed by the insect in arranging her eggs. Both figures = 52 diameters.

Fig. 5.—Much magnified apical chamber of *Myzus persicæ,* showing several large nucleated cells or clear vesicles, as at *v* and at *n*. These consist of periplastic and endoplastic layers. One of these at a time de-

scends and becomes differentiated into the pseudovum. The rest remain dormant, are absorbed, or perhaps they constitute the "Wanderelemente" of Dr. A. Brandt. 295 diam. (*Vide* Brandt, 'Ueber das Ei,' p. 51.)

Fig. 6.—A germ extracted from its chamber and treated with acetic acid. It has no pseudovitelline membrane: *v*, clear vesicle, with its endoplast or nucleus; *m*, blastoderm; *y*, pseudovitellus with granules. After Huxley.

PLATE D.


F. B. Buckton del. et lith.

West Newman & Co. imp.

Reproductive organs of the Viviparous Aphis

## DESCRIPTION OF PLATE E.

### Reproductive Organs of the Oviparous Aphis.

Fig. 1.—Reproductive organs contained within the last four segments of the body of *Callipterus quercûs: a*, left half of the oviduct, the elastic walls of which are composed of numerous circular transverse muscular fibres. The internal longitudinal fibres are not here seen. Shortly after the union with the right half of the oviduct a short vaginal tube is continued downwards. This last ends in a wide-mouthed vulva, the entrance to which, and walls also of the vagina, are effectively controlled by fasciculi of muscles; three on either side, so disposed that by their contractions the vagina and its entrance can be reduced to a narrow slit, and thus closed. *e e*, colleterial glands which end in attenuated ducts. These—the muciparous glands of other authors, anastomose into the walls of the vagina, into which passage they pour their lubricating secretion. The glands are large, very tough, and easy to be seen. Above these, but less obvious, is *d*, the spermatheca or pouch for storing the spermatozoa or male cells.

Balbiani says that the intromittent organ of the male penetrates into the spermatheca. I could not certainly trace the insertion of the duct into the vaginal walls, but Morrens, Huxley, and Balbiani locate it above the insertion of the colleterial glands.

Besides these organs, I have been able to note that the large trumpet-mouthed nectaries in this species end in capacious tubes, with corrugated walls. These taper as they pass downwards; and their delicate ends apparently terminate in the free fluids of the abdominal region, and in spots largely charged with oil globules: *b*, vulva; *c c*, fasciculi of muscles attached to the vagina; *e e*, colleterial glands and their ducts; *d*, spermatheca; *f f*, nectaries or cornicles; *g*, part of the alimentary canal, which here takes the form of a loop before its final descent to the tail; *h*, cauda. 112 diam.

Fig. 2.—Nearly similar parts from another specimen of *Callipterus quercûs;* but drawn *in sitû* and without compression. *o*, a large ovum, which has entered the upper part of the dilatable vagina *v*, on its passage towards *b*, the vulva. The liquid from the muciparous or colleterial glands would seem to affect the egg shortly before its expulsion. Probably these organs (*c c*) secrete part of the tough constituents of the dark shell, which hardens after exposure to the air. 52 diam.

Fig. 3.—Portion of a same insect under the compressorium. The colleterial glands (*c c*) are flattened so as to show their transparent muscular walls. On continuing the pressure on the specimen used, a short membranous ovipositor was protruded, which was found capable of retraction within the body-cavity by the action of two bundles of muscular fibres seen at *f f*. At the same time a stream of spermatozoa (*s*) diffused itself through the weak aqueous glycerine which bathed this specimen. The abdomen contained ten eggs in a forward stage of development. In another example I counted thirteen. In the Aphidian genera low in the scale, only one egg is produced by the perfect female. 53 diam.

Fig. 4.—Magnified view of one of the colleterial glands. Its cavity contains folds of an excretory membrane, from the walls of which the pouch is filled, as at *g* and *w*; *k*, excretory passage.

Fig. 5.—Part of the muscular coat of the last viscus,

which shows the numerous bundles of muscular fibre composing its walls. *g* and *w* as in fig. 4. 150 diam.

Fig. 6.—A portion of the same coat separated out with the needle. 295 diam.

Fig. 7.—Apical part of an ovarian cæcum, from the lower part of which, at *c*, an ovum has escaped. Eventually one of these nucleated, but immature glandular bodies (*a b*) will descend towards the cavity (*c*) and develop into another vesicle with its ectoplastic and endoplastic layers. The walls of the cyst are studded with epithelial scales, as shown at *d d*. Magnified 100 diameters. A more highly-magnified portion of such a wall enclosing an ovum may be seen in Plate F, fig. 2.

All the preparations in this plate here described are from dissections of the oviparous female of *Callipterus quercûs;* numerous living examples of which were kindly sent me, early in October, from Eastbourne, by Mr. Foran.

The insects were dissected after treatment with various fluids, such as chromic or acetic acids, alcohol, weak glycerine, petroleum spirit or solution of common salt, employed either to harden the tissues or for the purpose of rendering the parts more evident by varying their refraction of light whilst viewed under the microscope.

Notwithstanding the more elaborate treatise by Prof. Huxley on the anatomy of the oviparous female of Aphis, I offer the following contributions: and with the general remark that my camera-lucida drawings confirm me in the belief that what the last author has advanced as applicable to the species he examined, is in agreement with *Callipterus quercûs*, the diagnosis of which occurs in Vol. iii, page 21 of this Monograph.

PLATE E.


G. B. Buckton del. et lith.

West Newman & Co. imp

Reproductive organs of the Oviparous Aphis.

## DESCRIPTION OF PLATE F.

### Oviparous Aphis.

Fig. 1.—Three chambers of an ovigerous fascicle, reduced from a figure by Huxley : *e*, epithelial layer ; *g g′*, inner capsules of ovarian glands, which, originally round, have by the natural lateral pressure become elongated ; *c*, cord-like secretion of ovarian gland ; *v*, germinal vesicle of a nascent ovum in the terminal chamber ; *v′*, germinal vesicle of the second chamber of the cæcum.

Fig. 2.—Portion of the walls of the ovisac, with its epithelial cells, enclosing a nearly ripe ovum : *y*, vitelline mass of the egg ; *s*, clear space surrounding the yolk (zona pellucida ?) ; *e*, epithelial coat of ovary. From *Callipterus quercûs*. 130 diam.

Fig 3.—One branch of the oviduct of another example of the same species : *v*, vaginal tube ; *c c*, colleterial glands ; *s*, probably the insertion of the spermatheca not here visible. The ovarian cæca in the oviparous female are not so numerous as are the pseudovaria of the viviparous female. Although only six separate branches are visible in this figure, probably eight, viz. four on each side, are the correct number ; at *k* the constriction of the apical cæcum has commenced. Dissected in petroleum spirit. 40 diam.

Fig. 4.—Ovarian cæca with part of the alimentary canal of the pupæ of *Chermes abietis*. The embryonic masses forming the incipient eggs are green, and show different conditions of maturity. In some cæca the apical chamber is almost obliterated, but in all, the glandular masses are floating in a colourless fluid.

The alimentary tube is of a violet shade, and under a high magnifying power shows its surface to be paved with epithelial scales: *g g*, ovarian glands; *y*, granulated yolk mass; *c*, portion of intestine.

Fig. 5.—Similar cæca from the oviparous *Siphonophora rubi* with isolated germ granules and oil globules. The colleterial gland of the fascicle is seen at *c*.

Fig. 6.—A highly magnified view of the apical chamber of *Callipterus quercûs*. *g*, glandular bodies; *e*, epithelial coat; *n*, nucleated vesicles. 112 diam.

Fig. 7.—One of the above glandular masses separated, showing the clear ectoplast and the granular endoplast. 295 diam.

Fig. 8.—Spermatheca showing its clear and non-corrugated walls. By a gentle pressure the sperm-cells were made to escape.

Fig. 9.—Egg-tube within the lower chamber of which an ovum, *o*, has undergone its segmentation. The vacuity below represents the polar depression; *g y*, as before.

Fig. 10.—Part of a similar egg-tube or cæcum of *Siphonophora rosæ* in which the germinal vesicle with its nucleus has formed at the lower constriction. In the third chamber the ovum is fully developed, and the dark state of the chorion would show that the egg has been impregnated. *v*, vesicle; *y*, amorphous vitelline mass. The cæcum of *Drepanosiphum platanoides* has a form almost identical.

Fig. 11.—Pseudovum of *Phylloxera vastatrix* (*gallicola*) taken out of one of the leaf excrescences and placed under a very gentle pressure in syrup. July. The investing membranes, vitelline and otherwise, are clearly visible. The yolk-mass has become coarsely granular (segmented ?), and the reddish rudiments of the eyes have been already differentiated; *c*, chorion of ovum.

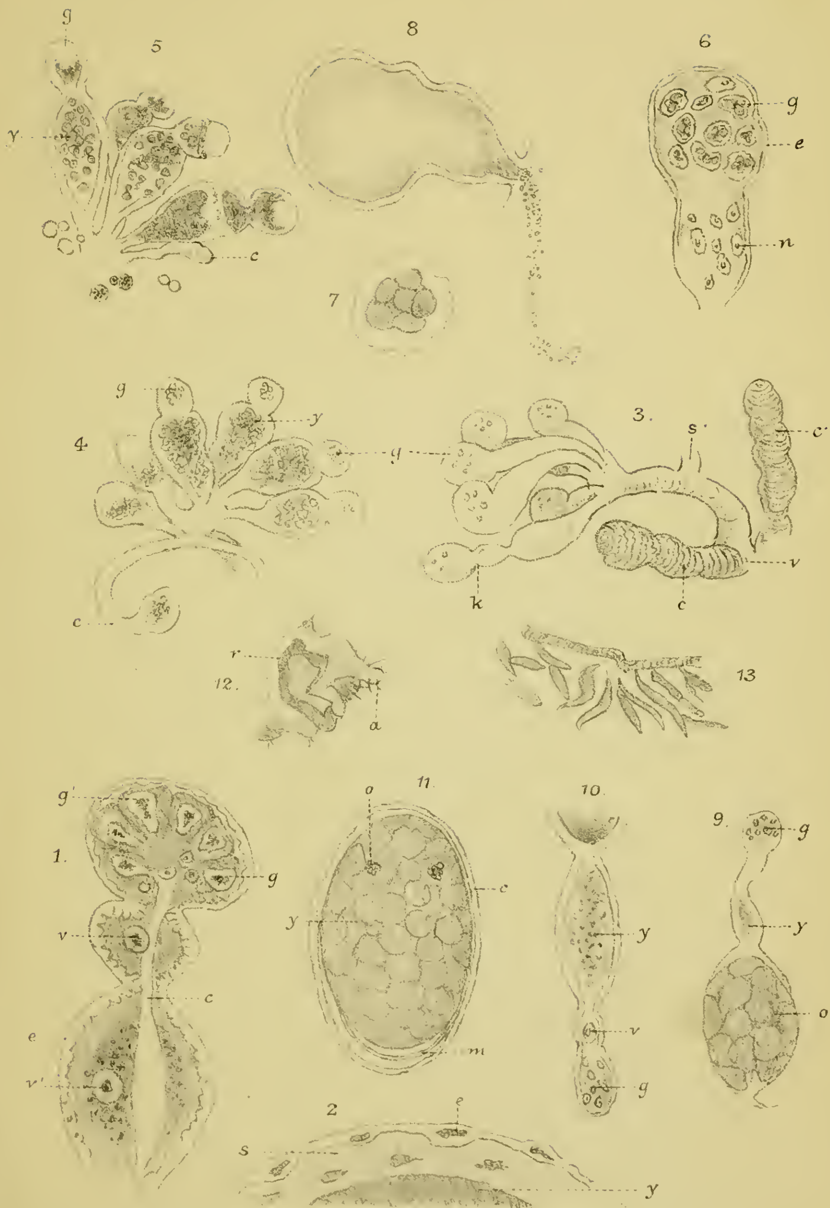
Although these ovoid bodies are expelled just like ordinary eggs; it is doubtful whether they ought not to be considered as pseudova, just as in other genera.

Certainly the single egg which commences the series is a much larger body; it is always impregnated, and therefore should be considered to be the true ovum, as in other cases; *y*, granulated vitellus; *m*, vitelline membrane; *c*, investing coat, answering to the chorion; *o*, eye rudiment. 112 diam.

Fig. 12.—Clasping armature and hooks of the winged female of *Myzus persicæ*. The cauda, *a*, anus, entrance to vagina, and genital armature, *r*, are here visible.

Fig. 13.—Bundles of muscular fibres forming part of the inner walls of the oviduct. They have been torn asunder to show the structure.

PLATE F.




G B. Buckton del. et lith.

West Newman & Co imp.

Reproductive organs of the Oviparous Aphis.

## DESCRIPTION OF PLATE G.

### Reproductive organs of the Male Aphis.

Fig. 1.—Profile view of the last abdominal rings of the male of *Drepanosiphum platanoides* with the exserted penis: *a*, anus situated immediately under the cauda; *r*, the copulative armature and part of the horny ring used to secure contact with the female; *o o*, opercula closing the genital opening; *k*, the outer sheath of the penis, which forms the inner lining when the organ is retracted within the body-cavity; *f f*, folds of the inner tube, which conversely becomes the outer lining on retraction; *m*, meatus penis, and part of the ejaculatory canal; *s*, seminal and muciparous ducts. The walls of the inner tube of the penis are more voluminous than the outer, and these folds (*f f*) are obliterated when the organ is turned inside out.

Fig. 2.—The same organs represented in plan, and seen *in sitû* before their protrusion, with the secretory glands attached. The same lettering, as a rule, applies to both these figures: *c*, the copulative sac; *j*, the ejaculatory tube; *d*, deferent duct; *v*, vesiculæ seminales; *g*, muciparous glands with their ducts; *p*, testes or sperm-capsules; *g*, genital opening.

Fig. 3.—View of a testis with included sperm-cysts in different conditions of maturity: *x*, immature cyst with sperm cells before they have developed filaments; *y* shows a cyst with the spermatozoa disposed in bundles.

Fig. 4.—A circular cyst more highly magnified, the filaments of which (*y*) are ranged in parallel order.

These four preceding figures are after Balbiani.

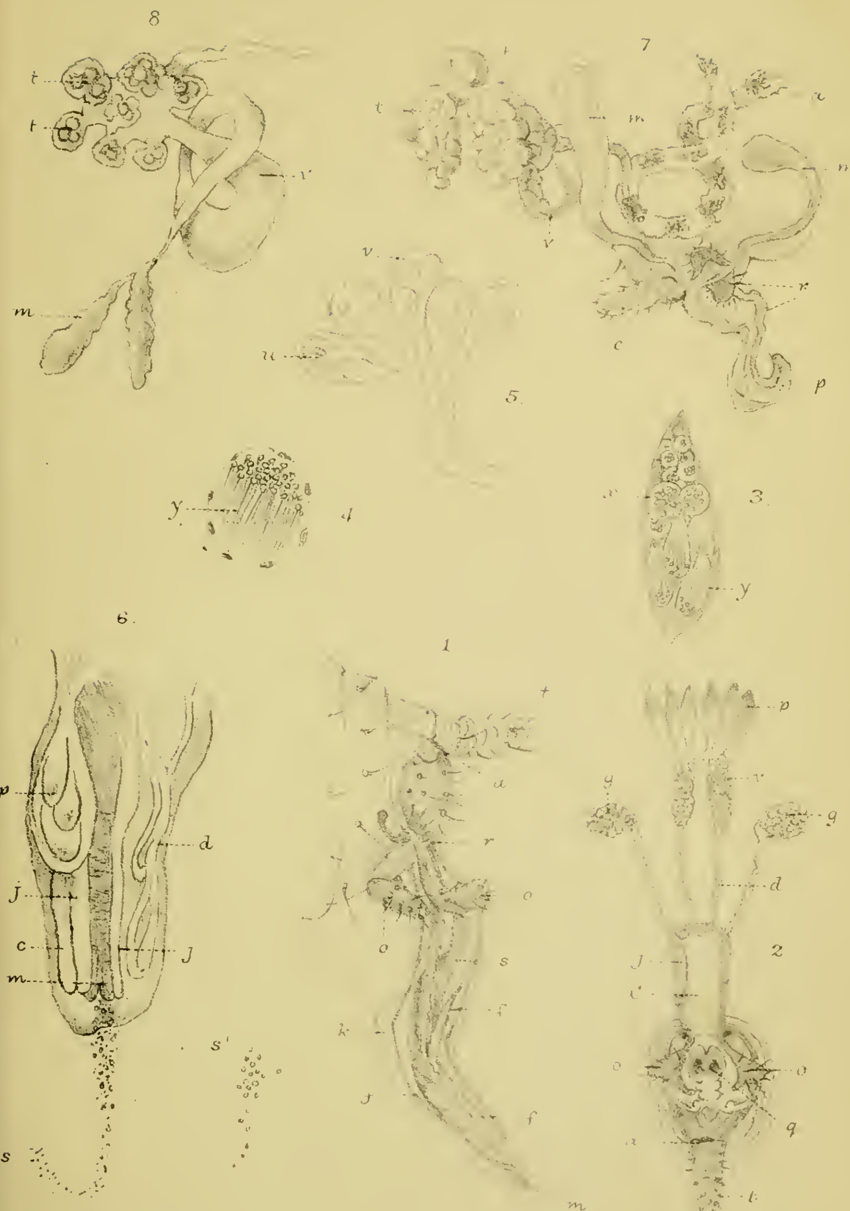
Fig. 5.—A fascicle of testes dissected from the winged male of *Lachnus pinicola* in October, showing the presence of similar sperm-cysts at *u* and *v*.

Fig. 6.—Highly magnified view of the apex of the penis of the winged male of *Dryobius roboris*, showing the different folds of the organ when protruded : *m*, meatus penis ; *c*, inner fold, as in fig. 2, which by its eversion has become the outer fold. In a similar manner *j*, as in fig. 2, has become the inner fold of fig. 6 ; *d*, duct from vesicula seminalis ; *p*, part of testis which has descended ; *s*, spermatozoa ; *s″*, the same magnified 296 diameters. Their motion in the liquid was very feeble, and I could detect no filaments.

Fig. 7.—Part of the male organs of *Aphis dirhoda* dissected in weak syrup : *c*, cauda ; *r*, armature ; *p*, hooked penis ; *m m*, muciparous glands ; *a*, alimentary tube ; *t t*, testes connected with the vasa deferentia *v*.

Fig. 8.—Single branch of testis from the winged male of *Aphis opima* : *t*, *t*, sperm capsules ; *v*, seminal vesicle ; *m m*. muciparous glands. The excretory duct was not visible in this preparation.

PLATE G




G. B. Buckton del et lith

West, Newman & C° imp

Reproducti[illegible] the
Male A[illegible]

## DESCRIPTION OF PLATE H.

### Development of the Ovum in Aphis.

Fig. 1.—A young ovum before segmentation has commenced. *b*. body of ovum; *g*, germinal vesicle; *s*, germinal spot; *n*, nucleolus. After Haeckel.

Figs. 2, 3, 4, 5.—Ova in different successive stages of segmentation or division into 2, 4, 8, &c. cells until the mulberry-form or morula-stage of Haeckel is attained. The cell ultimately forms a double wall, enclosing a central cavity with blastospore.

Fig. 6.—An ovum in process of fecundation by the intrusion of the spermatozoa, by the action of which segmentation commences: *z*, zona pellucida; *g*, germinal vesicle; *n*, spot and nucleolus; *sp*, spermatozoa just before penetration into the body of the egg.

The foregoing six figures, after Haeckel, are diagrammatic, and are only generally applicable to Aphides.

Figs. 7 and 8.—Polar cells and micropyles (?) of the ova of *Lachnus longipes*: *t t*, represents the spindle of Fol (?) formed from the metamorphosis of the germinal vesicle; *s s*, stellate body forming part of the eminence rising out of the chorion; *r r*, gelatinous investment of Huxley. This would appear to be the polar appendage of Balbiani. Treatment with acetic acid. 112 diam.

Fig. 9.—Polar mass and appendage of the ovum of *Aphis persicæ*: *a*, probably represents the spindle of Fol; *p*, the polar mass studded with green cells. The appendage is surrounded by an epithelial layer. After Balbiani.

Fig. 10.—Posterior appendage or micropyle of Aphis, treated with weak potash solution: *e*, eminence rising from the chorion *h*; *t*, appendage containing rod-like bodies; *r*, gelatinous investment. After Huxley

Fig. 11.—Ovum of *Phyllaphis fagi* soon after it has been laid. It is sufficiently transparent to show (*v*) the coarse segmentation; *m*, polar opening or micropyle. 40 diam.

Fig. 12.—Part of the ovum of *Callipterus quercûs* treated with acetic acid: *s*, annular congregation of cells forming a polar mass or pronucleus (?), *vide* Balfour, l. c., p. 59.

Fig. 13.—Centrolecithal* segmentation of the ovum of *Siphonophora rosæ*. Ovum is still in the ovisac. *n n*, two clear nuclei have appeared, and they are surrounded by *v*, the vitelline mass enclosed in a protoplasmic layer, *l*.

Fig. 14.—The same more advanced; in which the protoplasmic layer has been differentiated into a series (*c c*) of columnar cells; *p*, the pole of the blastoderm, which has no share in forming the embryo.

These two figures are copied from Metschnikow.

Fig. 15.—The germ-cup or gastrula-stage of Haeckel, in which the blastoderm has become dented in, and the original single membrane has become two. The ends have approximated to form the intestinal cavity or archenteron; and *b*, the stomodæum, blastopore, or primitive mouth; *e*, the entoderm or hypoblast; *k*, the ectoderm or epiblast.

Fig. 16.—A much magnified view of the ovum of *Aphis persicæ* still enclosed in the ovisac. It has begun its incipient segmentation. At the pole (*w*) a depression or invagination encloses a clear yellow space, which is comparatively free from yolk granules. The vitelline membrane is seen enfolding, *v*, the coarsely granulated yolk, which last is passing into the mulberry-like segmentation. The granules congregate

* From κέντρον, a centre, and λήκυθος, lecythus, an oil vessel. This kind of segmentation is almost confined to the Arthropoda.

round the polar space at *s* : *m*, the micropyle or polar appendage.

Fig. 17.—Ovum of *Siphonophora rosæ* showing the rudimentary organs of the embryo within: *a*, abdomen; *f*, visceral fold of the fœtal integument; *g*, genital gland; *s*, side-plate (Seiten-platten) bordered by a row of cells, partly seen in section; *v*, yolk vesicles; $l^1$ $l^2$ $l^3$, analogues of legs; *p*, parietes or walls. After Brandt, who adds the following remarks to the description of his figure:

"Die Bildung des Dottersackes nebst der mit derselben verknüpsften Umrollung oder Dochung des Embryo und seine Queraxe beruht auf einer selbstandigen contraction des Parietaten Blattes der Embryonalhülle."

*Vide* Dr. Alex. Brandt, "Beiträge zur Entwicklungsgeschichte der Libellulen und Hemipteren." 'Mém. Acad Imp. Sci. de St. Petersb.' t. xii, ser. 7, p. 33.

PLATE H.


C. B. Buckton del. et lith.

West Newman & C° imp.

Ovum of Aphis.

# DESCRIPTION OF PLATE I.

## Embryology of Aphis.

Fig. 1.—Unborn fœtus of *Aphis pruni*. The limbs have been disengaged from the folded mass by needles.

Fig. 2.—Another specimen, which has not been so unfolded: *c c*, of both figures, represent the cephalic lobes.

Fig. 3.—Unborn embryo from the pseudovarium of *Lachnus viminalis*: *c*, head; *g*, the rudiment of the pseudovaria, below which may be traced the antennæ, the legs, and the elements of the rostrum.

Fig. 4.—Another and less-matured embryo. Both these forms are invested in the membranes afterwards to be thrown off at birth. *c* and *g* represent the same organs as before.

Fig. 5.—Unborn fœtus of *Pemphigus lactucarius*. These embryos have been toughened by soaking in dilute alcohol. *a*, antenna; *r*, rostrum; *l*, legs.

Fig. 6.—Another example, drawn when nearly ready for birth. Similar parts may be distinguished as seen in the former examples: *l*, legs; *r*, rostrum.

Fig. 7.—Embryo of the same species, which would have furnished the pupal, and finally, the alate form. In this unborn condition the rudiments of wing-cases may be traced. Conditions analogous to the caterpillar are thus fulfilled on the fœtus within the body of the parent. *w*, wing case.

Fig. 8.—Embryo of *Pemphigus*, just born, showing that the antennæ (*d*), which are very simple in articulation, are disengaged before the other limbs.

Fig. 9.—A much-magnified front view of one of the late broods of *Pemphigus lactucarius*. *a*, antenna; *r*, rostrum; *l*, legs.

These examples are figured to exhibit the very diverse forms of the embryos of different genera and even broods of Aphis. Perhaps they may be suggestive of primæval types and represent an ancient ancestry.

Fig. 10.—Embryo extracted from the pedunculated

pseudovum of *Chermes laricis*, hardened previously by weak alcohol. The young are to be found here in a very perfect condition of development; the antennæ are well articulated, and the three remarkably long rostral setæ are very conspicuous. This specimen was taken from a pale yellow egg, which had not been much darkened by exposure to the air, and probably, therefore, it had been recently deposited. It may perhaps be inferred that, as the young in these eggs are in so forward a state just at the time of laying, there is some approximation to the ordinary viviparous production of the unfecundated egg. I have not been able to discover the fecundated egg (the true ovum) of *Chermes;* but we know that in allied genera of Aphis it is very large and often single. The (pseudo-) ovarian cæca of *Chermes* probably amount to one hundred.

Fig. 11.—Embryo from the pseudovarium of *Aphis pelargonii*, reduced from Prof. Huxley's figure and seen in profile: *c*, alimentary canal, taking a curved form and ending at the anus *a*; *lb*, labrum; *an*, antennæ; *l*, *l′*, *l″*, first, second, and third pair of legs; *ps*, rudimentary chambers of a fœtal pseudovarium; *v*, vitelline mass.

Fig. 12—Horny ring and armature on the apical segment of the male of *Lachnus pinicola*. They would appear by their contraction capable of embracing and rendering tense the organ when active: *a*, armature; *c*, lower plate; *p*, part of penis.

Fig. 13.—Similar parts in front view, from the male of *Callipterus quercûs*.

Fig. 14.—Last apical segments of the male of *Aphis dirhoda*, showing the genital organs *in sitû*. *a*, anus; *c*, cauda; *d*, clasper; *p*, penis; *n*, cornicle; *s*, stoma; *t*, testes; *m*, muciparous glands.

Fig. 15.—Upper and lower portions of the alimentary canal of *Lachnus viminalis*, showing the manner in which the walls are encased with broad epithelial plates.

PLATE I.

G.B.Buckton del. et lith. West Newman & C° imp.

Embryology of Aphis.

## PLATE CXV.

THELAXES DRYOPHILA. (Page 8.)

Fig. 1.—Foundress, or queen Aphis.

Fig. 2.—Head and antenna of the same. *a.* Rudimentary eye. *b.* Rostrum.

Fig. 3.—Pupa of the same insect.

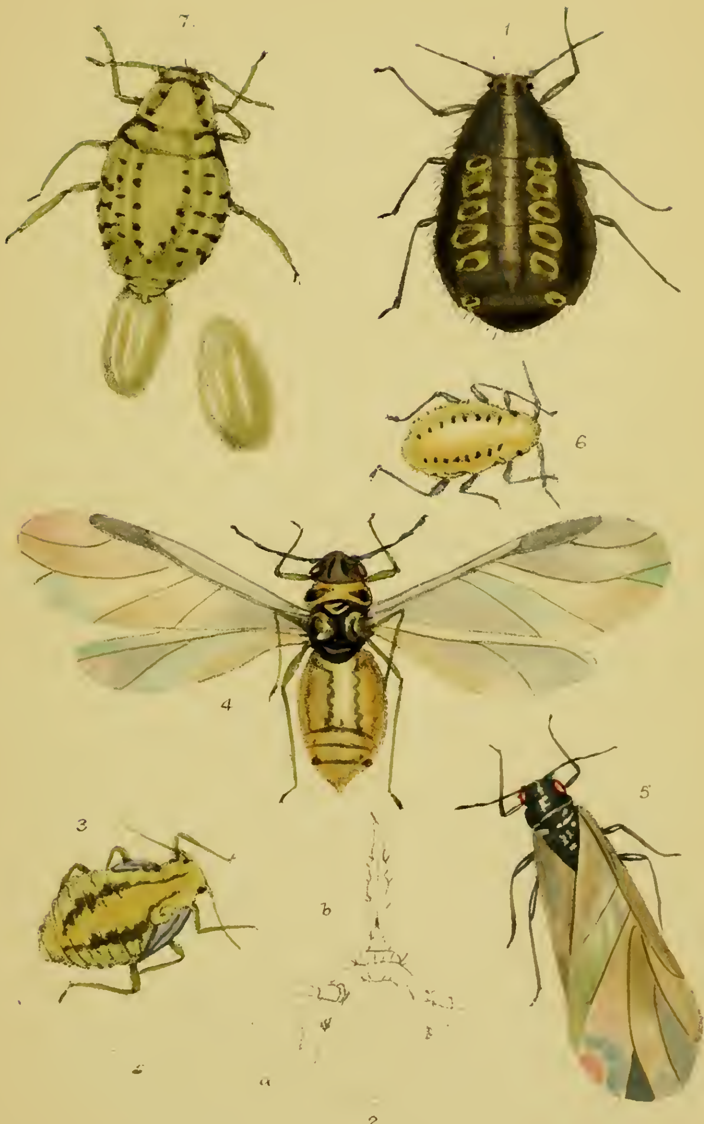
Fig. 4.—Imago, with the wings expanded.

Fig. 5.—A smaller variety, showing the manner in which the wings of Thelaxes are folded horizontally and differently from most Aphides.

Fig. 6.—Small apterous male.

Fig. 7.—Oviparous female of relative size to the last insect, with two ova.

PLATE CXV.




G.B. Buckton del. et lith.

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Thelaxes dryophila.

## PLATE CXVI. (Page 16.)

### Glyphina pilosa.

Fig. 1.—Larval form covered by its mealy coat.
Fig. 2.—Winged viviparous female.
Fig. 3.—Head and antenna of the same insect.
Fig. 4.—Part of tibia and tarsus. Claws double.

### Chermes abietis. (Page 24.)

Fig. 5.—False cones of the spruce fir, caused by the punctures of the queen mother Chermes; drawn of the natural size. One of these cones has been cut through after the insects have escaped, thus showing the empty cells. *a*. A portion of the original shoot, at the base of which the distortion has commenced. The winged Chermes are drawn of their natural size.

PLATE CXVI.

G. B. Buckton del. et lith. West Newman & C° imp.

Glyphina pilosa 1–4.
Chermes abietis 5.

# PLATE CXVII.

GLYPHINA BETULÆ. (Page 17.)

Fig. 1.—Larva seen from the underside.

Fig. 2.—Pupa of the same insect.

Fig. 3.—Imago, with some of her brood just born. One of these has not yet disengaged itself from the enshrouding membrane.

Fig. 4.—Antenna of the apterous female.

Fig. 5.—Antenna of the imago. The joints are much ringed or cupped.

CHERMES CORTICALIS. (Page 23.)

Fig. 6.—Cocciform larva denuded of her downy coat and showing her long prehensile setæ.

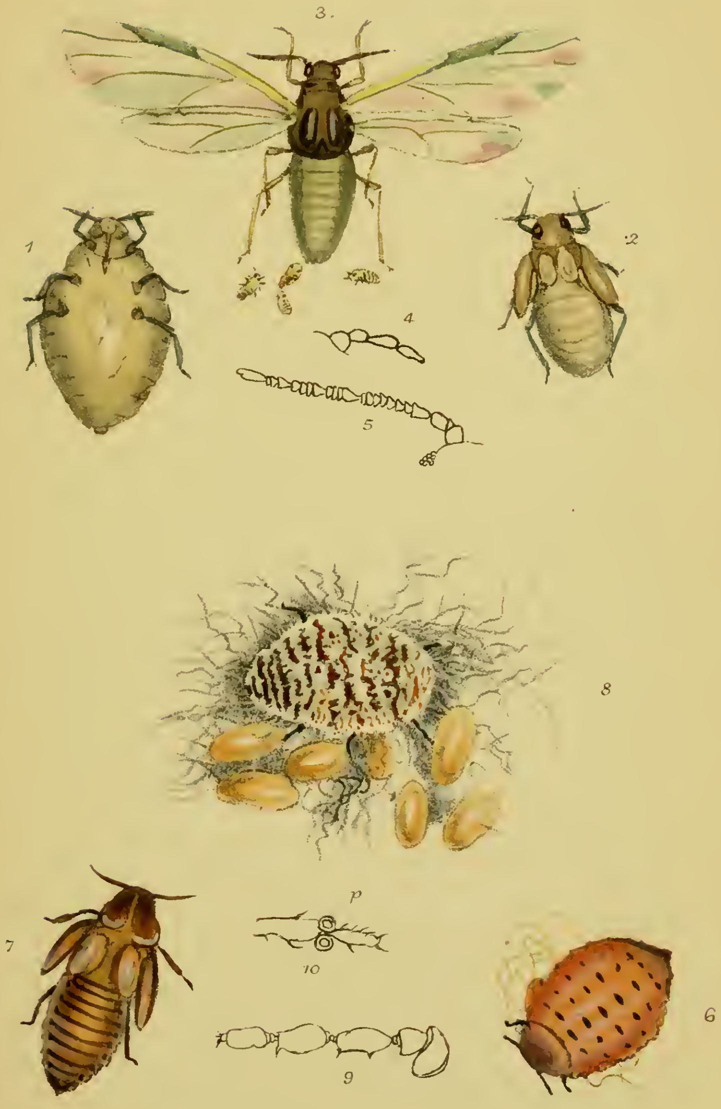
Fig. 7.—Pupa. The wing-cases are much detached at the points, and are not agglomerate.

Fig. 8.—Larva surrounded with cotton-like fibres, and also covered by bands of a mealy powder. She is arranging her eggs of different colours.

Fig. 9.—Antenna of the imago drawn on Plate CXVII *bis*, fig. 1.

Fig. 10.—Tarsus with claws and foot-discs.

PLATE CXVII.




G B Buckton del. et lith.

West, Newman & Co imp.

Glyphina betulæ 1 – 5.
Chermes corticalis 6 – 10.

## PLATE CXVII *bis*.

### CHERMES CORTICALIS. (Page 23.)

Fig. 1.—Winged viviparous female.

Fig. 2.—Abnormal wing from the same species, showing a variation in the venation. The 3rd oblique vein has united with the 2nd oblique. The cubitus of the lower wing is very coarse and has become cellular.

Fig. 3.—Head and antenna of the larva (drawn on Plate CXVII, fig. 6). The minute terminal bristles show an approximation to Coccus.

### CHERMES PINI. (Page 40.)

Fig. 4.—Larva seated on her pedunculated eggs.

Fig. 5.—A similar larva denuded of her woolly coat by its solution in ether.

Fig. 6.—Antenna of the same insect.

### THELAXES.

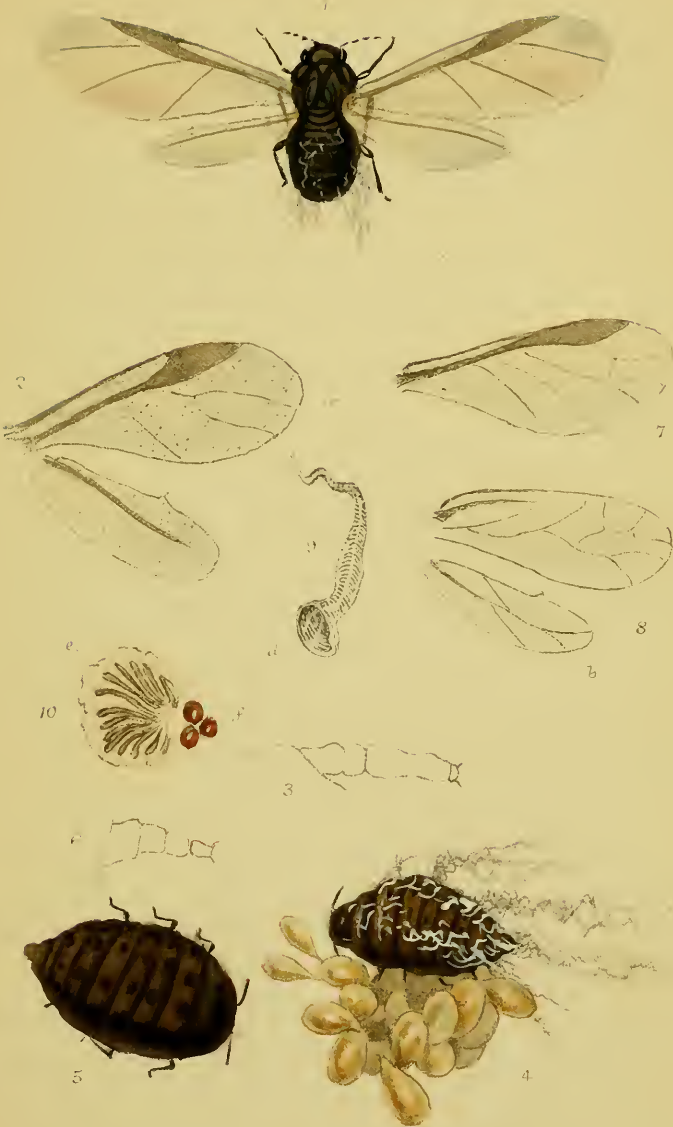
Fig. 7.—Abnormal upper wing of *Thelaxes dryophila*. Page 11.

Fig. 8.—Abnormal upper and lower wings of another example of Thelaxes. Such a complication of veining might be caused by a cross breeding; or otherwise it might show some forward movement in development.

Fig. 9.—One cornicle or nectary of *Thelaxes dryophila* separated from the other organs of the body. *d.* The mouth is expanded by circular muscular fibres. A long tube from this mouth is carried backwards into the body-cavity, and is lost in the viscera of the insect. Similar organs are seen *in sitû* on Plate E, fig. 1 *f*.

Fig. 10.—Portion of the eye of the larva of Thelaxes, showing the rod-like bodies at *e*, and three simple lenses in advance at *f*. These rods appear to be arranged differently from those connected with the ordinary faceted eyes of insects.

PLATE CXVII (Bis)



C. B. Buckton del et lith. West Newman & Co imp.

Chermes corticalis 1–3. Chermes pini 4–6.
Thelaxes dryophila 7–10.

## PLATE CXVIII.

CHERMES ABIETIS. (Page 24.)

Fig. 1.—Larva taken out of a pseudo-cone of the spruce fir, with several of the fæcal (?) globules noted in the text.

Fig. 2.—Underside of the pupa which develops from the last insect.

Fig. 3.—Upper side of the pupa.

Fig. 4.—Imago with expanded wings. The broad cubitus and large coreaceous stigma may be noted.

Fig. 5.—Alate female with wings at rest, folded horizontally.

Fig. 6.—Dead body of the same attached to a leaf of spruce fir. The dry body serves as a roof and protection to the young which have been hatched beneath it.

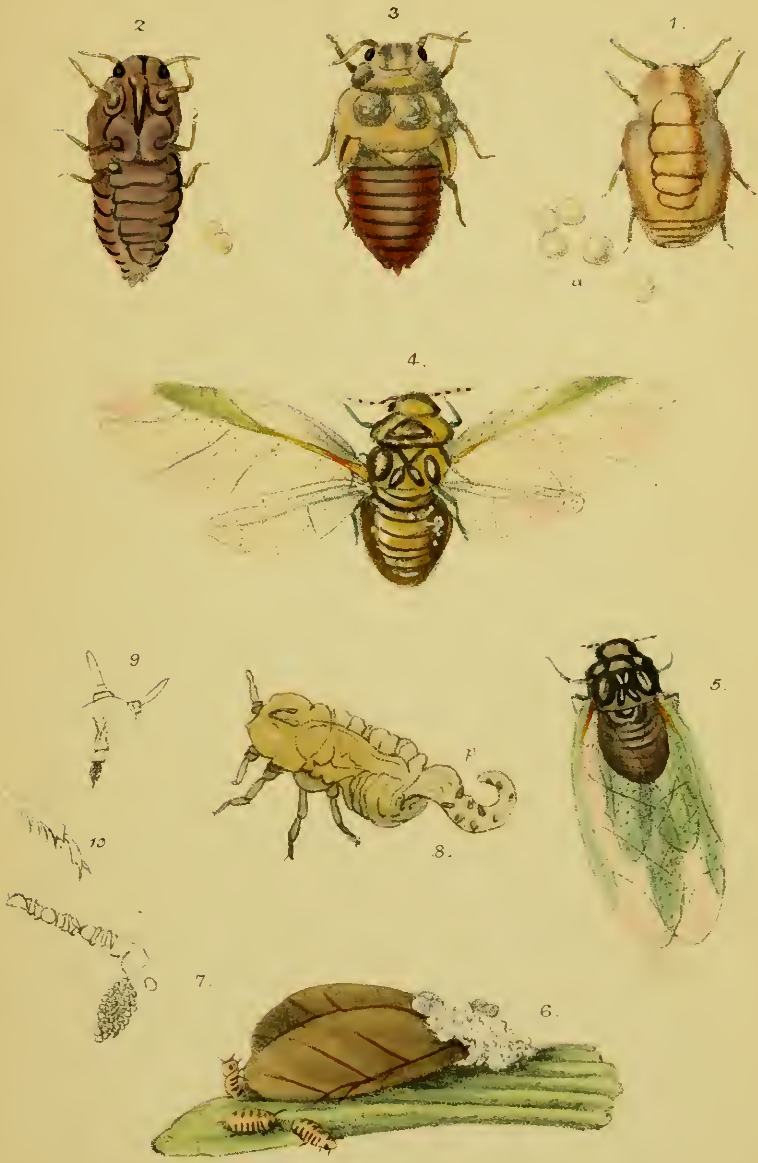
Fig. 7.—Head and antenna of fig. 4.

Fig. 8.—Minute male of *Chermes abietis* showing at *p* the remarkable development of the intromittant organ.

Fig. 9.—Underside of the head of male, showing that in this species the male is not wanting in the mouth parts.

Fig. 10.—Tarsus and claws of male.

PLATE CXVIII.




G. B. Buckton del. et lith.

West Newman & Co. imp.

Chermes abietis.

## PLATE CXIX.

### Chermes abietis. (Page 24.)

Fig. 1.—Half section of a portion of a twig of the spruce fir, showing how, by irritation of the rostrum of the queen Chermes, an approximation of the opposite sides of the leaflets is affected at *b*. A cavity results at *a* which encloses the insect, and finally the leaves form one of the cells of the false cone as seen on Plate CXVI.

Fig. 2.—Appearance of one of the cells of the false cone after one of the scales has been raised. All the pupæ are seen ranged side by side with their heads outwards, ready to escape after their change into imagos.

### Chermes laricis. (Page 33.)

Fig. 3.—Underside of a larva, just after it has moulted or shed its skin. The long hair-like setæ proceed from the rostrum at *r* to the empty sheath at *s* on the slough. This kind of retaining cable is to be seen also in other species of *Chermes*.

Fig. 4.—Portion of a larch leaf, on which the foundress is seated surrounded, at *o*, by her pedunculated eggs. These are of different colours, according to their conditions of maturity. At *t* a globule of resin is seen partly covered by cotton. This small drop is very constantly seen, wherever the Chermes fixes her station.

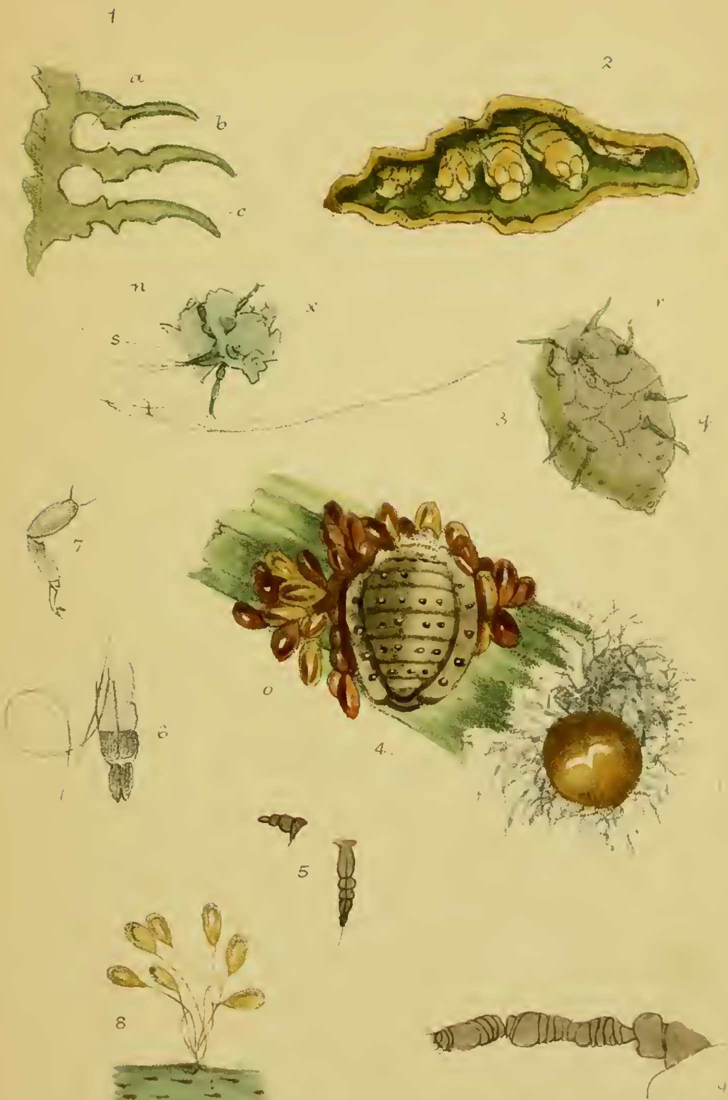
Fig. 5.—Antenna and proboscis of the last figure.

Figs. 6 and 7.—Magnified views of the rostrum and foreleg.

Fig. 8.—A tuft of pedunculated pseudova, cleared from the cottony covering.

Fig. 9.—Antenna of the winged female, showing the annulated form of the principal joints.

PLATE CXIX.




G B Buckton del et lith

W. Newman & Co

Chermes abietis 1 _ 2

 laricis 3 _ 9

## PLATE CXX.

### Chermes laricis. (Page 33.)

Fig. 1.—Apterous female which has been hatched from a pseudo-egg of the foundress. *t.* Secretion from one of the abdominal pores.

Fig. 2.—Pupa. The apical ring has three sharp terminal spines.

Fig. 3.—Antenna of fig. 1.

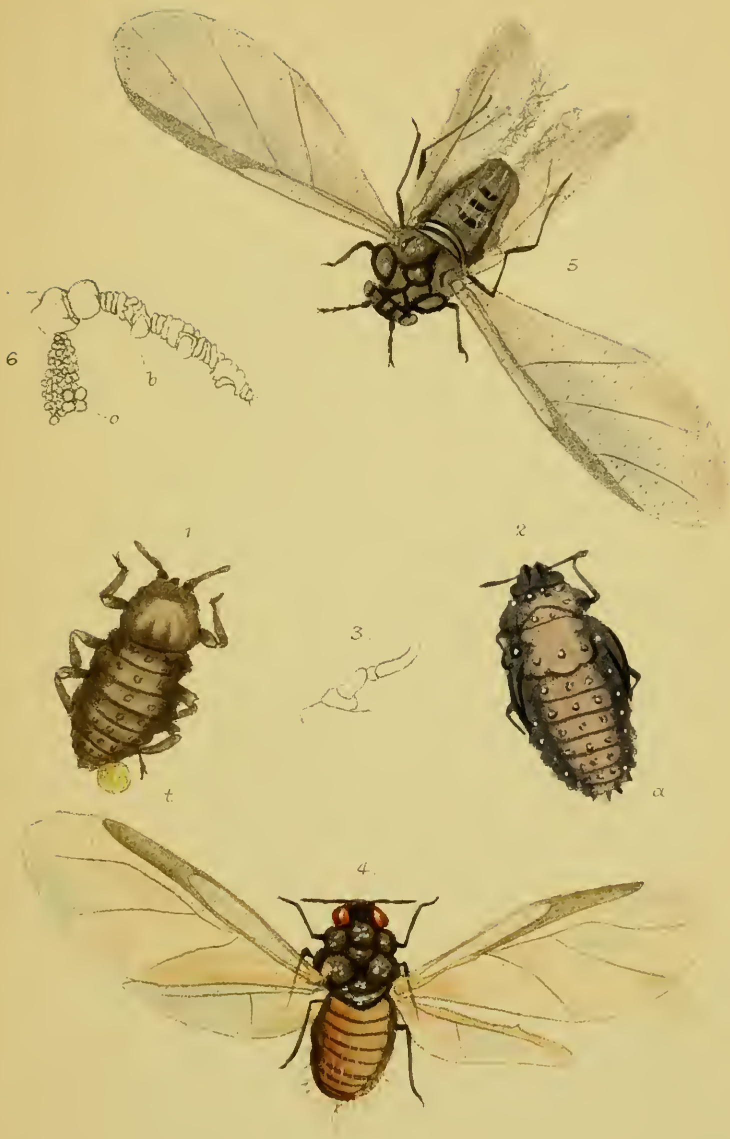
Fig. 4.—Imago showing the peculiar manner in which the upper cubital vein takes its origin.

### Chermes atratus. (Page 39.)

Fig. 5.—Imago. The great development of the thoracic region here seen is a characteristic of Chermes.

Fig. 6.—Eye and antenna of the last. The deeply ringed character of the joints, and the auditory (?) tubercles at *b* are worthy of note.

PLATE CXX.




G. B. Buckton del. et lith.

West Newman & Co. imp.

Chermes laricis 1 – 4.
– „ – atratus 5 – 6.

## PLATE CXXI.

Phylloxera punctata. (Page 45.)

Fig. 1.—Queen Aphis, the produce of the single egg laid by the true female. This insect has just passed a pseudovum which she is ranging in an inner circle by means of her blunt ovipositor. The corrugated state of the egg envelopes shows the forward condition of the enclosed embryos.

Fig. 2.—A larval form which has subsequently hatched from one of these eggs.

Fig. 3.—Upwards of 70 pseudova, showing the manner in which the eggs are disposed under an oak leaf in concentric circles. The larva of a small Myina is represented devouring these eggs.

Fig. 4.—The imago, showing the pseudova within. This insect shows no characteristic frontal tubercles. Late in the autumn the second brood of alate females occur, and these contain eggs of different sizes, disclosing the true males and the females.

PLATE CXXI.


G. B. Buckton del. et lith

West Newman & Co. imp.

Phylloxera punctata

## PLATE CXXII.

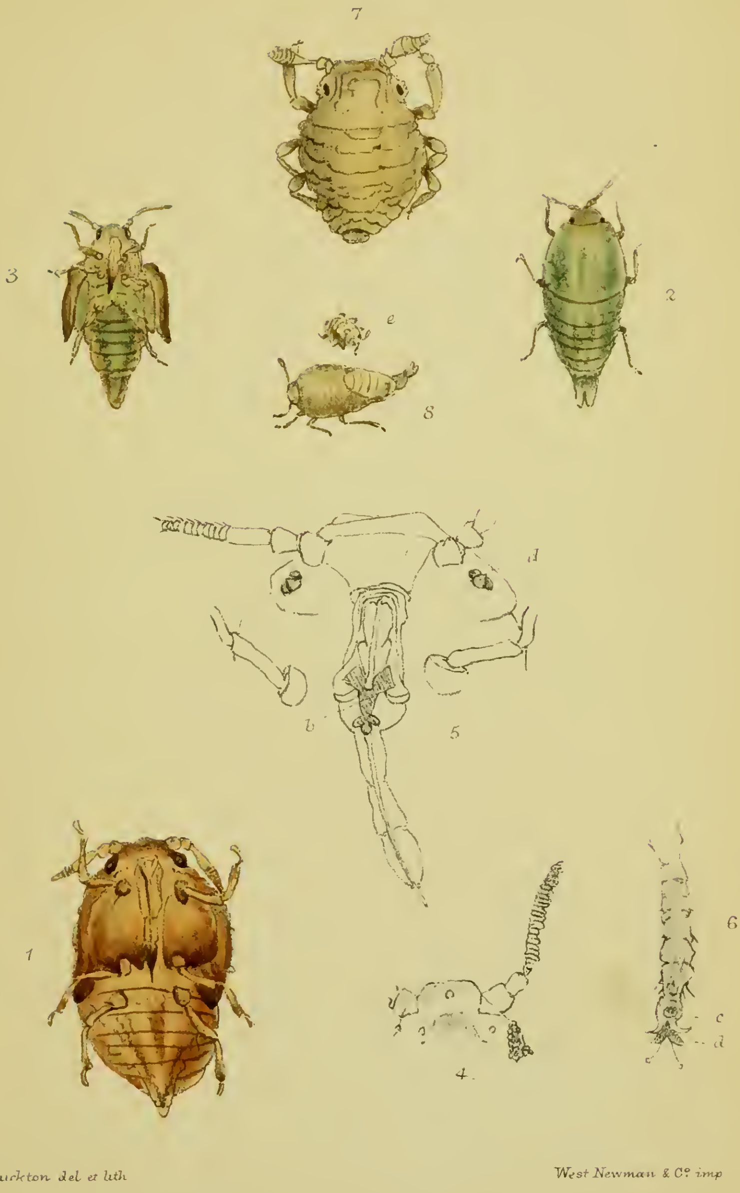
Phylloxera punctata. (Page 45.)

Fig. 1.—Under side of the pupa.
Fig. 2.—Larval form of a later generation.
Fig. 3.—Pupa of the same.
Fig. 4.—Head and antennæ of the imago, showing the complete visual system of oculus, ocellus, and stigmata. The ringed character of the third joint without any tubercle is to be observed.
Fig. 5.—Enlarged view of the underside of the head of the fundatrix (fig. 1 of preceding Plate). *d.* rudimentary eye composed of only three simple lenses. *b.* Labrum attached to the 4-jointed rostrum lying between the coxæ.
Fig. 6.—Foot of the same insect, showing the double claws, *d*, the pulvilli or foot pads, and capitate bristles.

Phylloxera vastatrix. (Page 57.)

Fig. 7.—Male. As this insect was four days travelling by post it probably is somewhat drier and shorter than those taken immediately from the vine. The insect, however, was quite lively when drawn. *e* represents the size it bears relatively to the perfect female below.
Fig. 8.—The female with her single fecundated egg. These two figures are drawn to the scale of the larvæ in Plate CXXV.

PLATE CXXII.




G. B. Buckton del et lith

West Newman & C° imp

Phylloxera punctata 1 — 6.
— „ — vastatrix 7 — 8.

## PLATE CXXIII.

PHYLLOXERA QUERCÛS. (Page 49.)

Fig. 1.—The queen; her whole body is studded with tubercular processes with large heads. She surrounds herself with irregular patches of shining green eggs.

Fig. 2.—The same insect seen from the under side.

Fig. 3.—Smaller and smoother individual taken in company with the last.

Fig. 4.—Imago showing the porrected vertex.

Fig. 5.—Head and antenna of the same.

Fig. 6.—Antenna much magnified to show the long apical channel *c* covered by membrane, and the circular pits *d* on the second joint. *a*. Porrected tubercles. *o*. Ocellus.

Fig. 7.—Tarsus and claws of imago.

Fig. 8.—Antenna and tubercles of Fig. 1. *b*. Tubercles.

Fig. 9.—Simple eye of the last insect.

Fig. 10.—Part of the under side of an oak leaf showing the yellow patch caused by the *Phylloxera*. The eggs and larvæ are *in sitû*.

For purposes of comparison I figure:

Fig. 11.—Antenna of *Ph. punctata*.

Fig. 12.—Antenna and horny processes of the larva of *Ph. coccinea*.

Fig. 13.—Antenna of the imago of *Ph. coccinea*.

PLATE CXXIII.


G B Buckton del. et lith.

West Newman & Co. imp

Phylloxera quercûs.

## PLATE CXXIV.

PHYLLOXERA VASTATRIX. (Page 57.)

Fig. 1.—Winged female containing a pseudo-egg, out of which the male or the female would proceed. The clear space round the ovum represents the rudiments of the egg-envelope. This M. Lichtenstein regards as a true *pupal* covering, and accordingly he calls this winged insect "Pupifer."

Fig. 2.—A vine leaf, natural size, studded with leaf-galls. These galls have been raised by a previous winged form, which issued from the ground earlier in the year.

Fig. 3.—Antenna of fig. 1.

Fig. 4.—Apterous female bred on the root as seen *in sitû* in fig. 5.

Fig. 5.—Fragment of a larger root of the vine, infested by larvæ and their eggs. This is the most destructive form of the pest in Europe.

A section of one of the above leaf-galls may be seen in the next Plate (fig. 2).

Prof. C. Riley groups the aerial forms under the head Gallicola, and the subterranean forms under that of Radicicola.

PLATE CXXIV.


E. Buckton del. et lith.  West, Newman & Co. imp.

Phylloxera vastatrix

## PLATE CXXV.

PHYLLOXERA VASTATRIX (GALLICOLA). (Page 57.)

Fig. 1.—Foundress taken from one of the galls on the leaf, fig. 2 of last Plate. She is larger than the root varieties, and she contains many hundred eggs.

Fig. 2.—Magnified section of one of the leaf-galls, showing the larvæ of several generations surrounded by their ova.

Fig. 3.—Antenna of foundress fig. 1.

PHYLLOXERA VASTATRIX (RADICICOLA).

Fig. 4.—Larger larva, taken from the root. She contained eight ova only.

Fig. 5.—A different generation of the same. Taken early in July.

Fig. 6.—Head and rostum of fig. 4.

Fig. 7.—Under side of one of the larvæ, feeding on the root fibriles.

Fig. 8.—Claw of the same. These claws fold parallel, one beside the other, so as often to appear as if they were single.

Fig. 9.—Profile view of larva (after Lichtenstein).

Fig. 10.—Portion of a vine root, showing how the fibriles become distorted by blebs and swellings. Drawn natural size (after Licht.).

The true sexes are drawn at Pl. CXXII, figs. 7 and 8.

The diverse forms taken by these larvæ after their moulting is remarkable.

PLATE CXXV


G. B. Buckton del. et lith. West Newman & Co. imp.

Phylloxera vastatrix

## PLATE CXXVI.

FORDA FORMICARIA. (Page 83.)

Fig. 1.—Larger apterous female taken whilst feeding at the roots of various grasses.

Fig. 2.—A smaller and whitish variety, commonly found intermixed with the former insects.

Fig. 3.—Another variety, probably a later generation of the same species.

Fig. 4.—Underside view of the head of fig. 1, showing the articulation of the antenna and the rostrum.

Fig. 5.—Stool of grass, *Triticum repens*, under which there was a nest of *Formica rubra*. The roots penetrated this nest, and the Aphides were feeding on these, as well as on the blades close to the soil, as drawn at *a*.


G.B Buckton del et lith.

West Newman & Co. imp

Forda formicaria.

## PLATE CXXVII.

### Forda viridana. (Page 85.)

Fig. 1.—Apterous form found under tufts of grass at Wooler in Northumberland. They tenant the nest of *Formica fuliginosa*.

Fig. 2.—Rich brown variety found intermixed with the former insects.

### Tychea trivialis. (Page 86.)

Fig. 3.—Apterous oviparous female taken under tufts of *Poa annua*. *a*. Antenna.

Fig. 4.—Younger specimen of the same with extended rostrum.

### Tychea setulosa. (Page 87.)

Fig. 5.—Viviparous female.

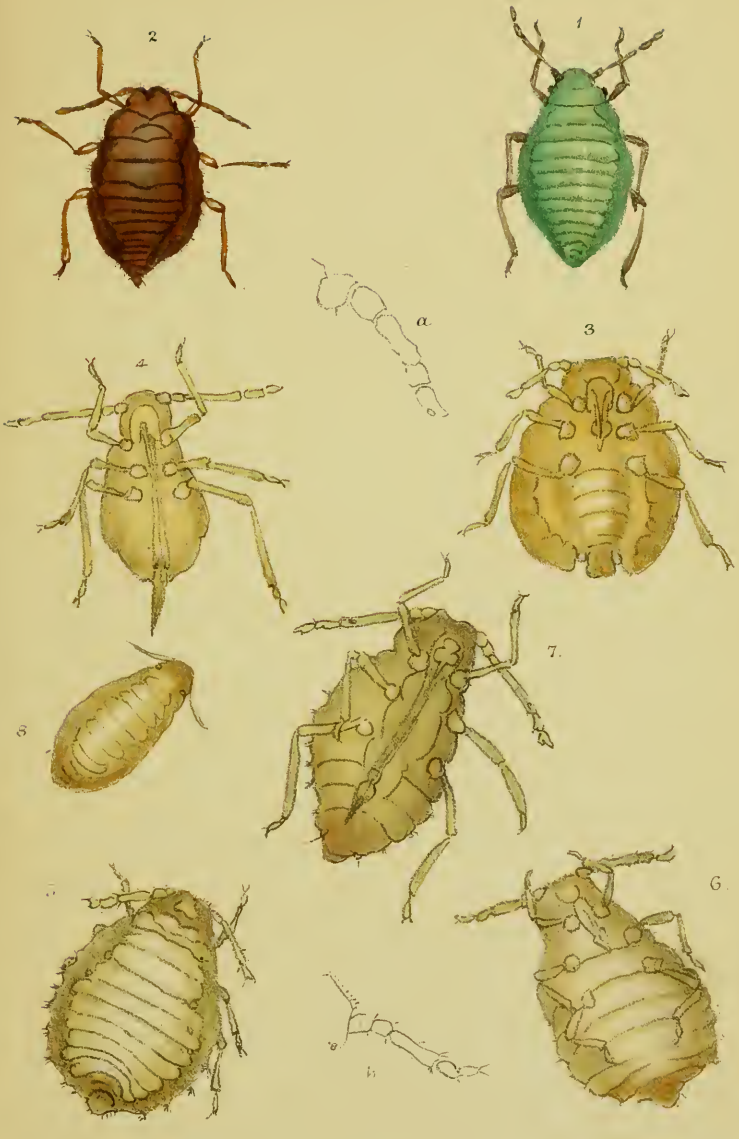
Fig. 6.—Another variety, probably part of a later brood. *b*. Antenna of the same.

Fig. 7.—Variety found intermixed with the last.

Fig. 8.—Young insect just after birth.

All the examples of these insects were in company, and taken by Sir J. Lubbock in anthills at Beckenham.

PLATE CXXVII



G. B. Buckton del. et lith. West Newman & Co imp.

Forda viridana 1–2. Tychea trivialis 3–4.
Tychea setulosa 5–8.

## PLATE CXXVIII.

TYCHEA SETARIÆ. (Page 88.)

Fig. 1.—Foundress (?) of the colony.

Fig. 2.—Underside of the same. 2 *a*. Antennæ.

Fig. 3.—Later and more developed brood of the same. 3 *a*. Antenna.

Fig. 4.—Matured individual. The altered character of the antennæ (4 *a*) is to be noticed. 4 *b*. Tarsus and double claws.

TYCHEA ERAGROSTIDIS. (Page 89.)

Fig 5.—Foundress of the colony. 5 *a*. Antennæ of the same.

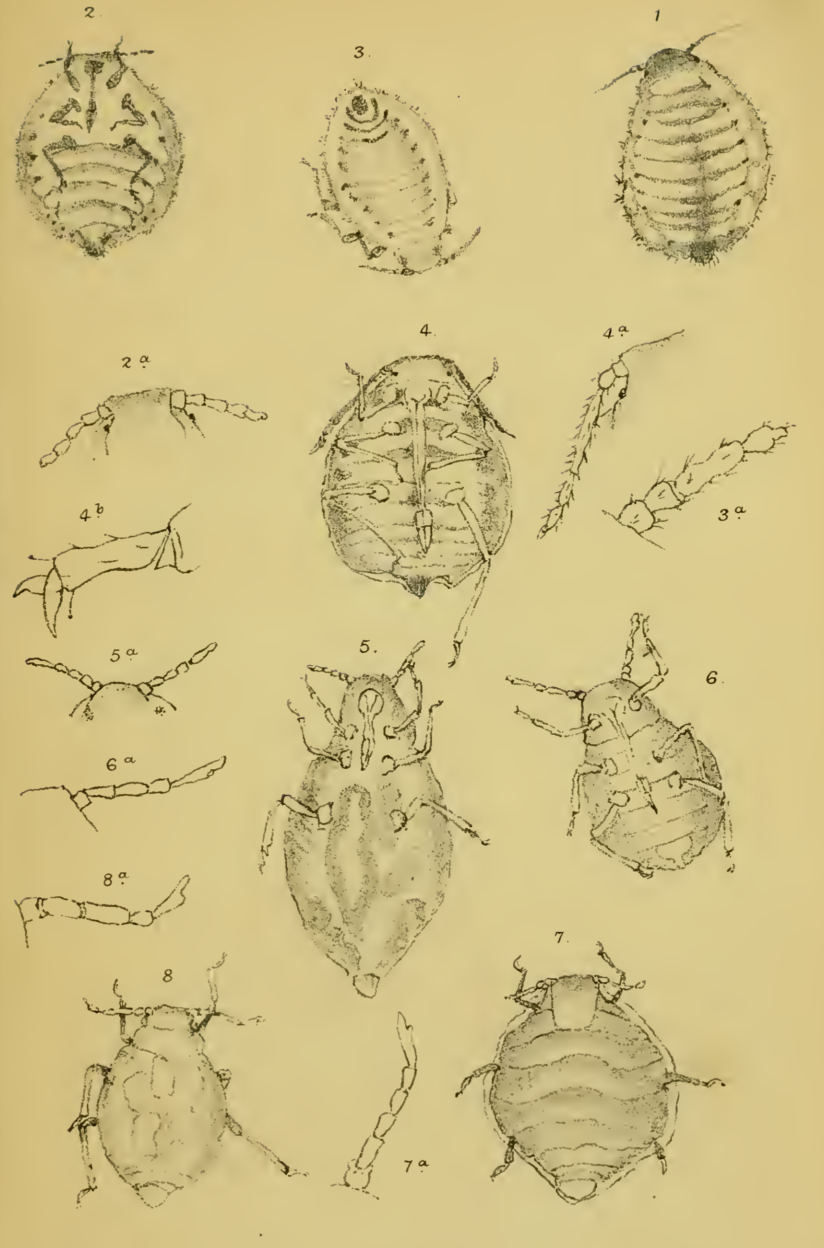
Fig. 6.—A later brood. 6 *a*. Antenna.

TYCHEA PHASEOLI. (Page 90.)

Fig. 7.—Foundress of the colony. 7*a*. Antenna.

Fig. 8.—More developed individual of a later brood. 8 *a*. Antenna.

PLATE CXXVIII.




G. B. Buckton del et lith

West Newman & C° imp.

Tychea setariæ 1 — 4
— " — eragrostidis 5 – 6.
— " — phaseoli 7 – 8.

## PLATE CXXIX.

ENDEIS FORMICINA. (Page 91.)

Fig. 1.—Viviparous female taken in anthills under stools of Carex. Fig. 3.—Head and antennæ, eyes rudimentary.

ENDEIS PELLUCIDA. (Page 91.)

Fig. 2.*—Viviparous female. Fig. 4.—Antenna and rostrum.

ENDEIS CARNOSA. (Page 92.)

Fig. 5.—Viviparous female. Fig. 6.—Apical rings and ovipositor. Fig. 7.—Part of the head and antenna. The capitate hairs on the vertex are remarkable. Fig. 8.—Tarsus and claws.

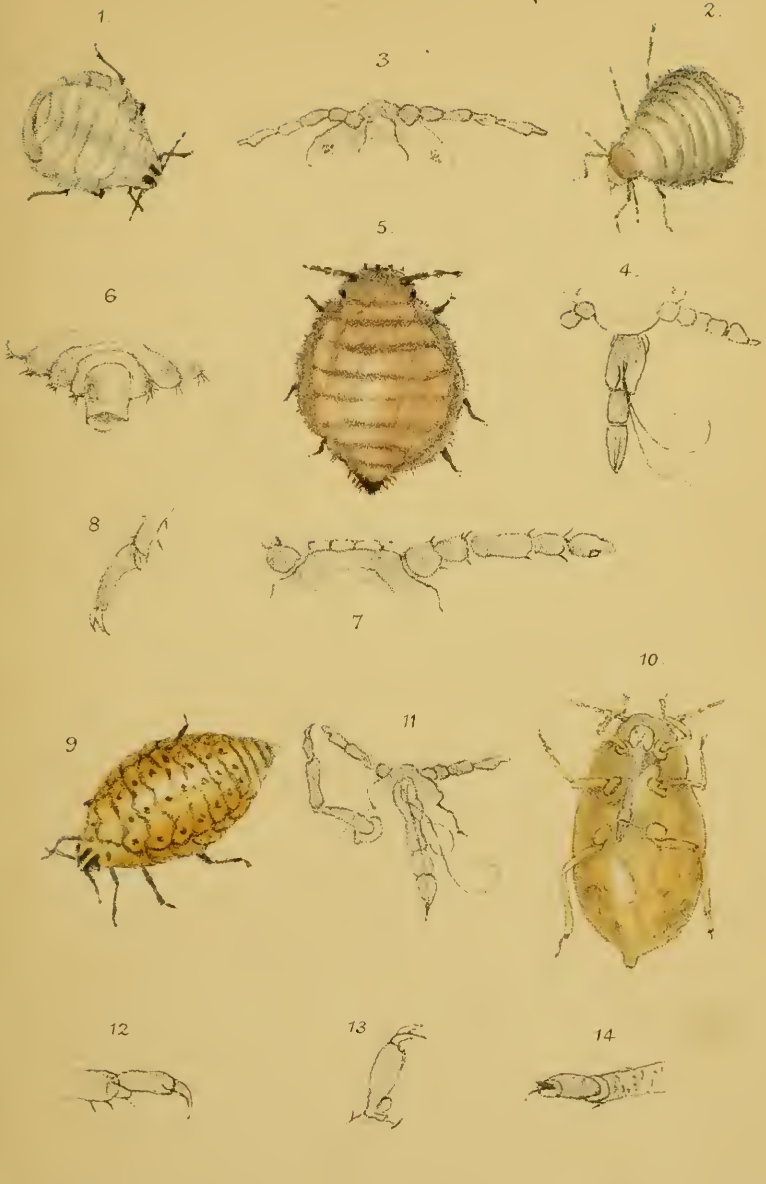
RHIZOBIUS GRAMINIS (POÆ). (Page 93.)

Fig. 9.—Queen Aphis or foundress.
Fig. 10.—Under side of a later generation.
Fig. 11.—Part of the under side of fig 9.
Fig. 12.—Tarsus with single claw of front foot.
Fig. 13.—The same, with double claw of middle foot.
Fig. 14.—The same, portion of the hind foot.

N.B. Since the figures of *Rhizobius poæ* were drawn on this Plate, and the species was named at page 93, I have found that Dr. Cyrus Thomas had discovered a Rhizobius in America, which feeds on the same grass as the Aphis I so named. The American *Rhizobius poæ* has much in common with the English insect; but, nevertheless, it cannot be, I think, identical. I give way, therefore, to Dr. Thomas's right of precedence, and I here correct the name I had given in my Plate to that of *Rhizobius graminis*. *Vide* Dr. Cyrus Thomas's 'Third Report on the Noxious Insects of Illinois,' p. 166, 1879.

* For 2—4 on the plate, read 2 and 4.

PLATE CXXIX.




G.B. Buckton del. et lith.

West Newman & Co imp

Endeis formicina 1. E. pellucida 2 & 4.
Endeis carnosa 5–8.
Rhizobius poæ 9–14.

## PLATE CXXX.

SIPHONOPHORA RUBI, *var.* RUFA. (Page 105.)

Fig. 1.—Taken at Aberdeen on *Rubus fruticosus.*

APHIS SUBTERRANEA. (Page 105. *Vide* Vol. II, page 38.)

Fig. 2.—Winged female of *Aphis subterranea.* *a.* Cornicle; *b*, antenna. The apterous forms are figured on Plate XLVII, Vol. II.

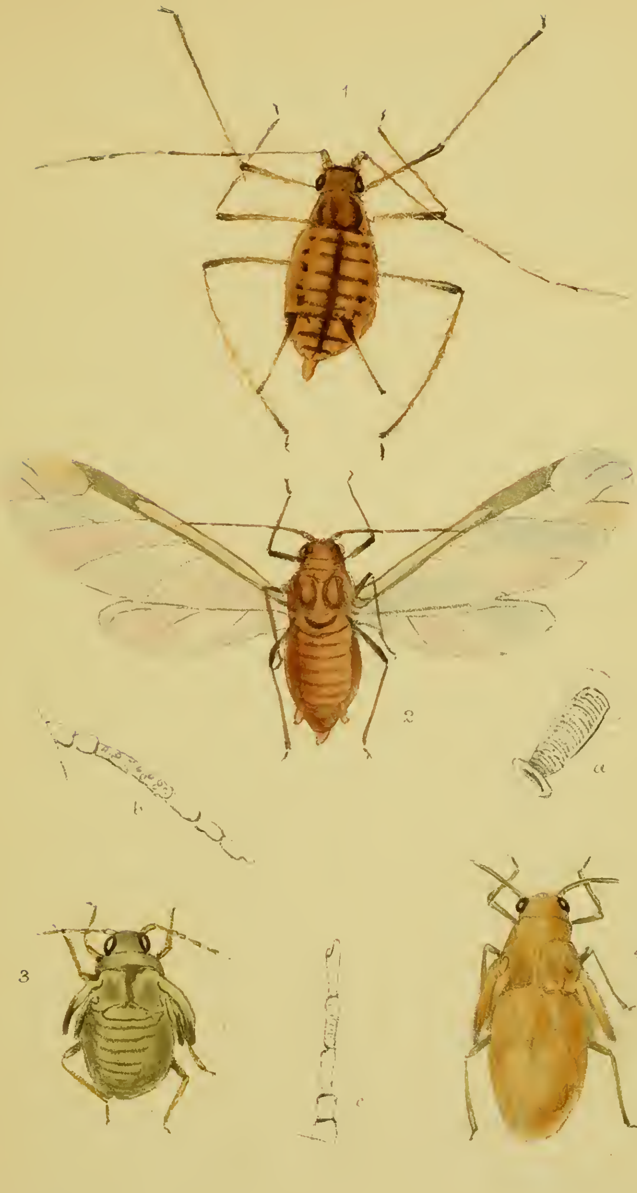
TRAMA TROGLODYLES. (Page 105.)

Fig. 3.—Pupa of Trama (?). *c.* Antenna. *Vide* Plate CII, and page 68, Vol. III.

PARACLETUS CIMICIFORMIS. (Page 105.)

Fig. 4.—Pupa of Paracletus, *vide* Plate CII, fig. 4, and page 67, Vol. III. The last two figures are drawn from microscopic preparations by Mr. F. Walker.

PLATE CXXX.




G.B.Buckton del. et lith.

West, Newman & Co imp.

Siphonophora rubi *(var rufa)* 1.
Aphis subterranea 2.
Trama ? 3. Paracletus ? 4.

## PLATE CXXXI.

PHYLLOXERA PUNCTATA. (Page 45.)

Fig. 1.—Apterous female from which the males and females are developed.

Fig. 2.—Underside of the male, showing the obliteration of the rostrum, and the buccal projections at *r*.

Fig. 3.—The female after she has laid her winter egg. Her body here consists of a mere membranous shell. The line *p* represents the size of the female as she would appear if magnified as much as the male, fig. 2, is drawn.

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### APHIDES IN AMBER.

APHIS (?) ARANEIFORMIS. (Page 165.)

Fig. 4.—*a*. Antenna. *b*. Last abdominal rings with the short cauda and clavate nectaries.

APHIS (?) HIRSUTA, (Page. 166.)

Fig. 5.—*e*. Antenna.

LACHNUS (?) DRYOIDES. (Page 166.)

Figs. 6 and 7.—The upper and lower sides are shown and also the rostrum.

APHIS (?) CIMICOIDES. (Page 167.)

Fig. 8.—*f*. Antenna of the same.

LACHNUS (?) LONGULUS. (Page 167.)

Fig. 9.—*g*. Antenna.

APHIS (?) TRANSPARENS. (Page 168.)

Fig. 10.—*h*. Antenna. *i*. Upper and lower wings. The veining here shown is abnormal.

The natural sizes are represented by lines.

PLATE CXXXI.


G. B. Buckton del. a nat. West Newman & Co. imp.

Phylloxera punctata 1-3. Aphides in Amber 4-10
*after Berendt.*

## PLATE CXXXII.

### FOSSIL APHIDES.

APHIS (?) LONGICAUDATUS.

Fig. 1.—Winged female. From Amberieux (Ain). After Milliere.

[M. Pierre Milliere, in 1853, published in the 'Ann. Soc. Ent. de France,' 3 ser., t. i, pp. 9—11, pl. 3, fig. 2, a description of a fossil insect which was embedded in the "Schiste Marneau," near Amberieux (Ain). He calls it an antediluvian Aphis, and from "les deux appendices, placés à l'éxtrémité de l'abdomen" (which are only cornicles), he styled it Aphis longicaudatus.]

APHIS (?) MACROSTYLA. (Page 169.)

Fig. 2.—Winged viviparous female.

LACHNUS (?) BONNETI. (Page 170.)

Fig. 3.—Winged viviparous female.

APHIS (?) VALDENSIS. (Page 148.)

Fig. 4.—Wing and apterous insect.

Fig. 5.—Shows these specimens in the matrix of the natural size. Purbeck limestone. After Brodie.

APHIS (?) DELICATULA. (Page 170.)

Fig. 6.—Portion of a winged female.

APHIOIDES SUCCIFERA. (Page 164.)

Fig. 7.—Apterous specimen from amber. After Motschulsky.

LACHNUS (?) PECTOROSUS. (Page 171.)

Fig. 8.—Winged viviparous female. *a.* Antenna.

APHIS (?) MORLOTTI. (Page 171.)

Fig. 9.—Winged female.

APHIS (?) PALLESCENS. (Page 170.)

Fig. 10.—Winged female. Fig. 10*a*.—Another specimen.

LACHNUS (?). (Page 172.)

Fig. 11.—Fragmentary specimen. This and figs. 2, 3, 6, 8, and 9 are from Radoboj, after Heer.

PEMPHIGUS (?) BURSIFEX. (Page 172.)

Fig. 12.—Ancient poplar leaf, from the Œningen beds, with a gall-like swelling, probably the work of a Pemphigian Aphis. *b.* A magnified view. The small puncture is supposed by Professor Heer to have been formed by some gnat-like parasitic insect.

PLATE CXXXII.

G. B. Buckton del. et lith. West Newman & Co. imp.

Fossil Aphides.
*after Brodie and Heer.*

## PLATE CXXXIII.

Fossil Aphides, after Scudder.

Fig. 1.—Siphonophoroides antiqua. (Page 176.)
Fig. 2.—Siphonophoroides simplex. (Page 176.)
Fig. 3.—Archilachnus pennatus. (Page 177.)
Fig. 4.—Anconatus dorsuosus. (Page 177.)
Fig. 5.—Schizoneuroides Scudderi. (Page 178.)
Fig. 6.—Pterostigma recurvum. (Page 178.)

PLATE CXXXIII.


G. B. Buckton del. et lith.

West Newman & C° imp.

Fossil Aphides.

*after S. H. Scudder.*

## PLATE CXXXIV.

CERATAPHIS LATANIÆ. (Page 198.)

Figs. 1 and 2.—Apterous female and part of another, surrounded by discs of wax. They are fixed to a portion of an orchis leaf.

Fig. 3.—Another individual, placed so as to show the underside, and the position of the rostrum. The disc has been removed.

Fig. 4.—One of the young born from fig. 1. It has passed a moult, and the wax disc has commenced to grow.

Fig. 5.—Inferior view of the head of fig. 1, showing at *g* the wax-glands; at *h* the small horns; and at *a* the antenna, much magnified.

Fig. 6.—The winged viviparous female. The lower wings are faintly drawn in their probable position; they were lost in the specimen from which the drawing was taken.

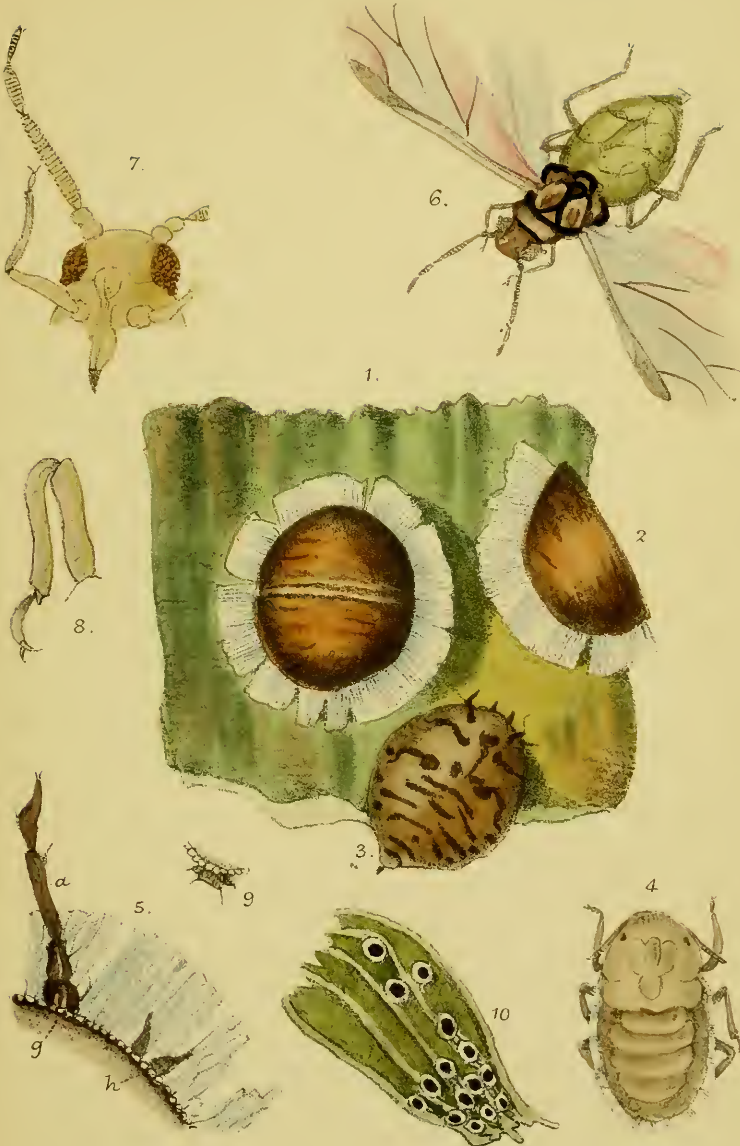
Fig. 7.—Head, antenna, and fore leg of the imago.

Fig. 8.—Magnified fore leg, showing the tarsus and claws.

Fig. 9.—Cauda and minute papillæ, from the same insect.

Fig. 10.—Part of the base of a palm-leaf, studded with numerous larvæ of *Cerataphis lataniæ*. Drawn of their natural size.

PLATE CXXXIV.




G. B Buckton del. et lith.

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Cerataphis lataniæ.