

STUDIES IN PSYLLIDAE.

THESIS

PRESENTED FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY (SCIENCE - AGRICULTURE)
UNIVERSITY OF EDINBURGH.

BY

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29th September, 1933.

STUDIES IN PSYLLIDAE (HEMIPTERA - HOMOPTERA)

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ACKNOWLEDGEMENTS.

The subject of this thesis was suggested to me in 1931 by Dr. C.B. Williams under whose supervision the work was commenced. Following Dr. William's departure to Rothamsted Experiment Station the work was continued under the supervision of Dr. A.E. Cameron, to whom for constant advice and much helpful criticism, I am deeply grateful.

I have great pleasure in expressing my thanks to Mr. F. Laing for either confirming or correcting the identifications of the species of Psyllidae which I submitted to him; to Sir Guy A.K. Marshall and Dr. Ch. Ferrière for the determination of the hymenopterous parasites and to Dr. H.F. Barnes for identifying the species of Cecidomyidae, reared by me.

I am also indebted to the Imperial Institute of Entomology and particularly to Dr. S.A. Neave, for the loan of reference literature not available in Edinburgh.

Finally I wish to gratefully acknowledge a grant given by the Trustees of the Moray Endowment Fund, which helped to defray part of the expenses of this work.

SECTION I.

GENERAL

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INTRODUCTORY.

Psyllidae are a family of small phytophagous insects universally characterised by their habit of jumping and hence often called jumping plant lice. In appearance they resemble minute cicadas but in feeding habits come closer to Aphidae, Coccidae and Aleurodidae and according to the recent work of Pussard (1933) produce the same kind of stylet sheath on their host plants as do the latter on theirs. Some species are monophagous, but many live and breed on more than one member of the host genus, although usually there is a favoured species on which the greatest infestation occurs. Again recent advances in our knowledge of the biology of these insects have revealed the fact that many species have alternative host plants to which they migrate in winter, to live and feed but not to oviposit.

In size Psyllidae are small insects, measuring, on an average, 3 to 4 mm. in length. The smallest known member is an Italian species, Aphalara menozzii Laing, 1 mm. in length while Rhinocola ericae Curt, another very small species, measures about $\frac{1}{4}$ mm. more. The greatest length, on the other hand, is attained by a species from Borneo, Megatrioza grandis Crawford, measuring 8 mm. or more from head to tip of folded wings. Other large species are Creiis longipennis Walk, Phacopteron (Phacosoma Kieff.) lentiginosum Buck, and Psyllia alni Lin. In some cases the body itself is small but the wings extend far beyond the tip of the abdomen and

give the insect a greatly exaggerated appearance of size. Some of such species are Leuronota magna Laing, Macrohomotoma (= Pseudoriopsylla Newst) nyasae, var nigrofasciata Laing, Mycopsylla fici Frogg, and Pauropsylla beelsoni Laing.

HISTORICAL ACCOUNT.

The study of Psyllidae may be said to date from the time of Linnaeus who named and described many species. A large number were described and figured, in the last century, with short biological notes in some cases by Löw in Germany and Scott in Britain. The latter's contributions scattered mostly throughout the pages of the Entomologists' Monthly Magazine, served to make known the British species of Psyllidae and his monograph (1876) largely formed the basis twenty years later (1896) of Edward's work on British Psyllidae, which is still the authoritative work for this family in the British Isles. Of the other early workers mention may be made of Förster (1848) in Germany, who described many new European species, of Ashmead (1881), who besides other contributions gave, for the first time, brief accounts of the life histories of three new species from Florida, and of Maskell (1899), who made the first contribution to our knowledge of the Psyllidae of New Zealand, by describing the adult, 'pupa' and 'larva' of four new species.

It seems natural that the only detailed life history study in the last century was made on a species of economic importance, Psyllia pyricola, Först, by Slingerland (1892) while it is probably this same species which, under the name of P. pyri Lin, was studied biologically by Curtis (1842)

fifty years earlier in England.

An outstanding anatomical work on Psyllidae in the last century is that of Witslaczil (1885), of which mention is made subsequently.

Early in the present century Froggatt (1900-1902) published descriptions of all stages of some Australian species and gave a short review of the references made to them by previous workers not specifically concerned with the study of Psyllidae of that region. Sulc (1907-1913) a little later, contributed a number of papers, chiefly on the genera *Psyllia* and *Trioza*, including a systematic study of the species living on willows, and about the same time Japanese Psyllidae were studied by Kuwayama (1907-1910). During more recent times considerable work on this family, mostly systematic, has been done by Crawford (1904-1928), firstly on American and lately on subtropical and tropical species. In particular mention may be made of his monograph of New World Psyllidae (1914) which in addition to being a systematic work, contains a useful summary of the morphological characters of the family. A useful publication on Psyllidae is a purely systematic work by Aulmann (1913). In Britain recent systematic work on Psyllidae has been done by Laing (1922-1930). Other recent and present workers on the family, including Brittain (1922-1923) Ferris (1923-1933) Boselli (1929-1932) Klyver (1930-1933) Speyer (1929) Minckiewicz (1924-1927) and Weber (1929) are mentioned in relevant places in the next two sections.

With the growing appreciation of the economic importance

of the family in the last two decades, many studies have been made of injurious species, of which by far the greater attention has been given to Psyllia mali Schmidberger and the pear psyllids. During the last few years the former has been chiefly studied by Brittain (loc. cit.) in America, Speyer (loc. cit.) and Weber (loc. cit.) in Germany and Minckiewicz (loc. cit.) in Poland. The latter comprise more than one species and work on them has been done variously in the United States and the Central European countries by several authors.

So far as Scotland is concerned there has been no previous work on Psyllidae.

ECONOMIC IMPORTANCE.

A fairly large number of Psyllidae are pests of varying degrees of importance and of these Psyllia mali, P. pyricola and some species of Trioza are the most serious and have necessitated elaborate control measures. The cultivated hosts are usually fruit or ornamental trees and shrubs and injury in most cases is done by the nymphs sucking the sap from the host tissues. As a rule the first two immature stages are not so harmful as the last three. There are, however, two cases known in which injury is said to be committed by the adults. The first is that of P. pyricola Först, which according to Awati (1915) "secrete honey-dew and wet the surfaces of the leaves" on which grows an injurious fungus, Cladosporium herbarium. The second instance is that of Paratrioza cockerelli Sulc, about which evidence has recently been brought forward by Binkley

(1929) to show that this species is at least concerned in transmitting and spreading a virus disease of certain solanaceous plants, especially potato and tomato in Colorado. Mention may also be made in this connection of the investigations of Chatterji (1932) on the spike disease of sandal in South India, in which he showed that the percentage incidence of Psyllids in diseased areas was much greater than in healthy ones. It is possible that these insects may turn out to be vectors of the virus of spike disease, but definite evidence against them is so far lacking. The only case of economic benefit, though of very minor importance, is furnished by Eurhinocola eucalypti Maskell, whose secretion according to Maskell (1889), under the name of 'Mana' was largely collected by the aborigines of Australia for food.

The following are the chief species of economic importance:-

Species.	Host	Locality	Author	Remarks
1. <u>Psyllia mali</u> Schmidberger	Apple	Europe Canada	Speyer 1929 Brittain 1923	Very serious pest.
2. <u>P. pyricola</u> Först.	Pear	N.Amer- ica. Europe	Slingerland 1892	"
3. <u>P. pyrisuga</u> Först	"	Austria & other parts of Europe.	Miestinger 1920.	
4. <u>P. pyri</u> Lin	"	Europe	Gudkov 1914.	
5. <u>P. hexastigma</u> Horv.	"	Hungary Eastern Siberia Japan	Sulc 1914	

Species	Host	Locality	Author	Remarks
6. <u>P. buxi</u> Lin.	Box	America Europe	Hamilton 1926	Not serious
7. <u>Psyllopsis fraxinicola</u> Först	Ash	America Europe	Felt 1911	
8. <u>Eurhinocola eucalypti</u> Maskell	Eucaly- ptus	New Zealand	Maskell 1889	Also reported in Britain by Fox Wilson in Gard. Chr. 1924.
9. <u>Trioza alacris</u> Flor.	Laurel	America Europe	Miles 1928	
10. <u>T. viridula</u> Zett	Carrot	Europe	Ozols 1926	
11. <u>T. tripunctata</u> Fitch	Black- berry	America	Peterson 1923	
12. <u>T. merwei</u> Petty.	Citrus	South Africa	Van Der Merwe 1923.	
13. <u>T. litseae</u> Giard	Vanilla Laurel Orchid	Reunion	Bordage 1914.	
14. <u>T. buxtoni</u> Laing	Fig	Palestine	Buxton 1924	
15. <u>T. flavipennis</u> Först	Lettuce	France	Noel 1913	
16. <u>T. nigricornis</u>	Turnip	"	" "	
17. <u>T. diospyri</u> Ashm.	Persim- mon	America	Britton 1927	
18. <u>Euphyllura olivina</u> Costa	Olive	Europe	Todd 1927	
19. <u>Diphorina citri</u> Kuw.	Citrus	India	Husain & Nath 1927.	
20. <u>Paratrioza cockerelli</u> Sulc.	Tomato	America	Essig 1917 Binkley 1929	Carrier of virus Disease.

SECRETION

Practically all the Psyllidae, whose habits are known, produce secretions in their immature stages. Sometimes adult females like those of Psyllopsis fraxinicola Först and Psyllia melanoneura Först, also secrete tiny droplets of waxy substance. The only exception to this universal secretory habit has been recorded by Uichanco (1921), who noted that Paurocephala kleinhofiae Uichanco, a species from the Philippine Islands, produced no secretion in any of its stages. As a rule, the secretion is exuded through the sets of pores surrounding the anal aperture. Sometimes there are additional pores, situated generally on the surface of the body, as in Psyllopsis fraxinicola, which supplement the secretion of the circumanal pores. In the nymph of Pachypsylla venusta Osten Sacken, the circumanal pore ring is absent, but the habits of the nymphs being unknown, nothing can be said of the secretory activity of this species.

The physical nature of the secretion in the different groups of species of the family differs considerably. In some species (Psyllia mali, P. buxi, Aphalara nebulosa, etc.) the secretion takes the form of white waxy droplets, or ribbons or tubes surrounded by a coating of lighter texture. In the nymphs of Trioza urticae and adults of all species, which secrete in that stage, the secretion takes the form of little pellets of waxy matter. In other species (Psyllia alni, P. försteri, Psyllopsis fraxinicola etc.) in addition to the waxy paste-like substance, there is a huge mass of fluffy cottony exudation, which entirely covers the nymph in a maze of extremely fine cottony threads. More uniformly

regular structures are also secreted by the nymphs of many species of Trioza and Psyllopsis, which take the form of long stiff shafts, arising from the bases of small marginal setae which they severally enclose. These structures are fragile, break away easily, and are of varying lengths, the longest easily exceeding the length of the body. Psyllia pyricola is probably the only species which secretes a transparent liquid instead of a waxy substance, in which is said to grow the injurious fungus Cladosporium herbarium.

Chemically the nature of these secretions does not seem to vary much. They are insoluble in water, mineral acids, caustic potash solution, ether and chloroform. Ethyl alcohol dissolves them more readily when they are freshly secreted than when they have been exposed on plants for some time. The shaft-like secretion arising from the bases of the marginal setae withstands the action of alcohol longest. The fine thread-like and silky white mass secreted by the ash psyllids is, however, scarcely soluble even in alcohol.

DISTRIBUTION IN TIME.

Fossil psyllidae have been taken from the lower Permian beds of Kansas, a well known species being Permopsylla americana Tillyard. Later finds include species from the upper Permian rocks of New South Wales and the Oligocene beds of the Isle of Wight. To accommodate many of these species a new fossil family, Permopsyllidae, was erected by Tillyard (1926) and later Carpenter (1931) formed a new fossil

division Palaeorhyncha to include Psyllidae and other Homoptera, whose characters partook of both the Auchenorrhyncha and Sternorrhyncha. The identification of the species is based chiefly on the characters of the tegmina, as these alone were found well preserved in the majority of cases.

DISTRIBUTION IN SPACE.

Psyllidae are abundant in most parts of the world, one species, Psyllia borealis Horvath having been taken as far north as Greenland, while another Psyllia simlae Crawford was collected in Simla at an altitude of 2100 meters. As a rule members of the genera Psyllia, Psyllopsis and Trioza are mostly confined to the temperate zones while species of the subfamilies Pauropsyllinae and Carsidarinae inhabit the Tropics chiefly.

MORPHOLOGICAL NOTES

Studies on the morphology of Psyllidae are confined chiefly to species of economic importance and of these most attention has been given to Psyllia mali. The earliest work dealing with the internal anatomy of this family is that of Witslaczil (1885), which has been mentioned by most subsequent workers. Later Stough (1907) described the morphology of Pachyopsylla celtidis-nama Riley in some detail, and Patch (1909) published a paper in which she homologised the wings of Psyllidae, Aphidae, Coccidae, and Aleurodidae. These works have been briefly reviewed in Crawford's monograph (1914), wherein a short account of general psyllid morphology is also presented. Important

works on Psyllia mali include an anatomical description of the head and mouth parts with a discussion on their functions by Grove (1919), morphological accounts of the adult, by Brittain (1923) and Minkiewicz (1924), of all stages by Speyer (1927) and a study of the morphology of head and thorax by Weber (1931).

In the following account only a broad outline of certain anatomical features of Psyllidae is given in so far as they bear upon characters of systematic importance.

These, as was pointed out by Crawford (1914) are no longer merely venational but include peculiarities of the head, thorax and apex of abdomen. The characters used to separate species in this work, have been mostly those of the antennae, genal cones, elytra and the genitalia.

Head. This is characterised by two conical projections of an area known as the gena, situated latero-ventrally one on each side. The projections now called genal cones are very variable in form and are absent in the subfamily Liviinae. At and between the bases of the cones is a small and often inconspicuous rhomboid area, called the frons, which carries on it the median ocellus, the other two ocelli being near the bases of the antennae. The greater portion of the head dorsally is comprised by the vertex, which is divided vertically downwards, in the middle, by a distinct suture and is often referred to as the 'crown' in systematic descriptions. Behind the eyes and connected with the genae is a narrow sclerite called the occiput.

In continuation with the frons and lying downwards and backwards is the prominent clypeus ending in the labrum and

a very inconspicuous epipharynx. The labium is three segmented, its proximal half being held immovably between the forecoxae, while its distal extremity ends in a number of black sclerotised ¹ teeth. A little behind the base of the labium arise two pairs of mandibular and maxillary setae, which are elongated structures passing through it.

The antennae, are, as a rule, ten-segmented and forked terminally. Except in species of *Livia*, the first two basal segments are always short and of about equal length.

Thorax. The prothorax includes the pronotum, always narrow and collar-like and the greatly reduced prosternum, which is buried between the two forecoxae. In addition there are a number of pleurites, which with the pleural sutures are said by Crawford (1914) to be of taxonomic value. The mesothorax comprises the triangular dorsulum, followed by a large scutum (mesonotum) and a smaller mesoscutellum and postscutellum, together with mesopleurites and a relatively large mesosternum. The metathorax consists of a metanotum, followed by a small scutellum and a postscutellum, in addition to meta-pleurites and a small metasternum. The praescutum of metanotum is suppressed.

A typical psyllid fore and hind wing is shown in Figure I, figs. and . The chief feature is the presence of a principal vein, in the forewing, formed by the joining of the stalks of R₁ and Cu M and the absence of cross veins. The venation of the hind wing is still simpler and although it has been taxonomically utilised by Enderlein (1921), it is only

1 The term 'sclerotised' has been used throughout this work in preference to 'chitinised' in accordance with the views of Ferris and Chamberlin (Ent. News. July 1928. pp.212-215) Snodgrass (Smithson.Misc. Coll., Vol. 85. No. 6. Part 1. pp.6-7) and others.

reliable if supported by other characters.

The characteristic feature of a psyllid leg is the relatively large femur, developed in consequence of the habit of jumping. The tibiae have often a number of black spines at their apices, which are sometimes of taxonomic value. The tarsi are always two-jointed.

Abdomen: The number of abdominal segments is given as eleven by Crawford (1914) against 10 by Witslaczil (1885). Of these only five are easily seen, and of the rest some are suppressed or reduced and some are comprised in the genital segments of the female and male.

Male genital apparatus. This consists of the anal valve (Supra anal plate of Stough), which carries the anal opening at its tip and the ventral genital valve to which are attached distally the pair of forceps (parameres of Singh-Pruthi). Touching the base of the anal valve and lying in the hollow of the ventral genital valve is the aedeagus, a long tubular structure jointed in the middle and usually bent, the distal part over the proximal. Anteriorly the aedeagus is connected with the ejaculatory duct, which runs some distance in the abdomen and ends in a striated spool-like structure. In Psyllopsis fraxinicola the two ends of the spool are much expanded and, according to Ferris (1923), are of some systematic value.

Female genital apparatus. This consists of a dorsal anal and a ventral subgenital valve, holding between them the ovipositor proper. The anal valve carries at its base the anal opening surrounded by, usually, two rows of wax pores. The systematic value of these pores has been pointed out by

Klyver (1930) in the case of Aphalara calthae; they have been utilised in distinguishing Psyllia alni and P. forsteri in this work, and are likely to prove of systemic significance. The ovipositor proper is formed by a dorsal median plate and two sclerotised rods lying dorso-laterally, the three forming the roof of the tunnel, through which the egg passes. Distally the two rods expand into spongy, fan-shaped structures, proximally they are each attached to a thick crescent-shaped structure, which joining with its fellow forms an entrance for the egg. Each of these rods is connected at both ends to a pair of long, stout sclerotised rods, which together, form the floor of the tunnel, giving egress to the egg. Distally the tips of these four rods join and form a sharp point, which is used in piercing the tissues at the time of oviposition.

RELATIONSHIP TO OTHER FAMILIES.

The exact relationship of Psyllidae to other Homopterous families is not quite settled. According to Crawford (1914) they have more affinities with Cicadoidea than with Aphidae, Aleurodidae or Coccidae, as has been usually believed. Pruthi (1925) as a result of his studies on the male genitalia in Rhynchota places this family close to Fulgoridae. This position is not accepted by Muir (1930) who thinks that "we cannot place the Psyllidae near to the Fulgoroidea as they have the typical Cicadoid type of male genitalia". Recently Weber (1932) has briefly discussed the systems of classification of Homoptera given by Borner¹ (1904) Heymons² (1915) Handlirsch³ (1925) and Stellwaag⁴ (1928) and is inclined to

 1, 2, 3, 4 cited by Weber (loc. cit.)

accept that of the third author in which Psyllidae are grouped with Cicadidae, Aleurodidae, Aphidoidea and Coccidae as a suborder. Examination of the tegmen of a fossil Psyllidae, Permopsylla americana Tillyard, shows it to be nearer to the Auchenorrhyncha than the Sternorrhyncha. Till more definite relationships are established it is perhaps best to regard Psyllidae as a family of Sternorrhyncha, one of the three subdivisions of Homoptera, the other two being Auchenorrhyncha and a comparatively recent division Coleorrhyncha formed by Myers and China (1929).

CLASSIFICATION INTO SUBFAMILIES.

In this work the classification of Psyllidae as given by Crawford (1914) is followed in preference to that of Edwards (1896). The latter author regarded Liviidae, Aphalaridae, Psyllidae and Triozidae as distinct families, which opinion, in view of the close similarity of their genitalia and immature stages, among other characters, is not justified. Crawford has divided Psyllidae into six subfamilies: Psyllinae, Triozinae, Liviinae, Carsidarinae, Pauropsyllinae and Ceriacreminae. Of these the first three alone include British species and representatives of all three have been found in this region.

COLLECTING AND PRESERVING

In collecting adults the method of beating the insects on a white tray and transferring them to a tube by means of a brush, applies to the majority of Psyllidae. The operation is greatly facilitated by the jumping habit of the insects and when the mouth of a tube is held close to them and a slight

stimulus applied with a brush from the opposite side they are left with no option but to jump into the tube. This method works very satisfactorily and correctly manipulated enables one to catch a large number of Psyllids in a short time. Sometimes sweeping may be more desirable as when collecting Aphalara nebulosa from Epilobium angustifolium.

Klyver (1930) has advocated the collecting of Psyllids individually by hand, in preference to beating and sweeping where host relationships are to be established. If the beating, however, is done with discrimination, no serious objection to the method can be offered, and, in any event, the mere taking of an insect by hand will not necessarily imply that it did not migrate to the plant from some neighbouring host.

The insects were preserved in 80% alcohol to which 5 parts by volume of glycerine was added. Pampel's fluid (Imms; Bull. Ent. Res. 1929. p. 169) was found equally satisfactory. The following method of Jackson (Canad. Ent., May 1919 p. 117) was also tried and the claim made by him that it preserves the insects in their natural colors, was found to be justified to a great extent:-

After being killed the insects are put in the following fluid:-

Cane Sugar	10	parts
Glacial acetic acid	5	"
Formalin	2	"
Distilled water	100	"

The sugar is dissolved in water and the acetic acid and formalin subsequently added. Specimens are allowed to remain for 24 hours, after which they are transferred to another fluid,

identical in composition except that the acetic acid is omitted, it being, in fact, simply a 10% solution of sugar in 2% formalin. This fluid should be changed once or twice till all traces of acetic acid are removed.

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SECTION II.

BIOLOGY OF SCOTTISH PSYLLIDAE.

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Two figures, four photographs and three photomicrographs.

BIOLOGY OF SCOTTISH PSYLLIDAE.

The present account is based on a study of eleven species of Psyllidae occurring in the vicinity of Edinburgh. In working on the family it was aimed to concentrate attention chiefly on its biology and to report on as many species as could be collected in S.E. Scotland. On this account the present work has become more extensive than intensive, but in sacrificing details of observations on any one species, it has been found possible to devote fuller attention to questions of parasitism and differentiation into biological races.

Of the eleven species originally studied, one is dealt with in a separate section as a species furnishing two biological races. The account of the other ten is given here in groups, arranged according to host plants, if more than one species were present on them. For the sake of convenience the descriptions of their nymphal stages are given in Section III under a separate heading.



Green-house, attached to the department of Agricultural Zoology, University of Edinburgh, showing the host plants of species of Psyllidae and two of the cellophane cages in which the latter were confined for various experimental purposes.

ALDER PSYLLIDS

PSYLLIA ALNI LIN AND P. FORSTERI FLOR.

(SUBFAMILY PSYLLINAE.)

Seven species of *Psyllia* have been recorded on alder of which two *P. alni* and *P. försteri* are European and British and were found in this region. Of the other five *P. fusca* Zett and *P. alpina* Först have been reported from various parts of Europe and the remaining three, *P. floccosa* Patch, *P. galeaformis* Patch and *P. trimaculata* Craff from Canada and the United States. In addition to these a species of *Trioza* from North Germany, *T. lepidoptera* Rud, is questioned as living on alder by Aulmann(1913).

The chief American species of alnus infested by the Psyllids are *incana*, *tenuifolia* and *rhombifolia*; in Europe *glutinosa* and *incana* are most commonly attacked, while *alnus viridis* is said to be the host of *P. alpina*. My specimens were collected from *glutinosa*, *incana* and *nitida* and judging by their occurrence round Edinburgh *glutinosa* is most favoured by *P. alni* and *P. försteri*.

Neither of these two species can be regarded as pests, although in cases of heavy infestation, the nymphs retard the growth of new shoots and to that extent the early maturing of young trees.

DISTINCTION BETWEEN THE SPECIES.

Although color is not always a sure criterion in determining species of *Psyllidae*, yet in the field throughout the summer until early Autumn, *alni* may be recognised as the green

and larger and försteri as the yellow and smaller species. The following table gives the chief differences between the two:-

<u>P. alni.</u>	<u>P. forsteri</u>
1. Larger species. Length 5mm.	1. Smaller species. Length 4mm.
2. Costal vein and stigma green, other veins except basal piece of subcosta black. Elytra whitish hyaline.	2. Veins dull yellow. Elytra hyaline with a feeble ochreous tinge.
3. Anal valve of female narrowing posteriorly, apical third blade-like, beset with long setae dorsally and smaller ones ventrally. Subgenital valve sword-like, broad in its basal two-thirds, narrowing abruptly in its apical third beset with numerous large, pointed setae.	3. Anal and subgenital valves uniformly tapering to apices; former irregularly corrugated dorsally in its apical third. Setae small and few. Subgenital valve shorter than anal valve and ovipositor.
4. Anal pore-ring two-layered, outer pores round, inner elongate and conical, so arranged that apex of one usually coincides with base of another.	4. Anal pore-ring two-layered (3 in places) outer pores round, inner elongated, the two often confluent.
5. Forceps of male slightly semi-lunar, thickly beset with long pointed setae on inner side. Tips heavily sclerotised and pigmented, ending in 2 or 3 thick small claws.	5. Forceps with tips slightly swollen, heavily sclerotised and pigmented ending in 7 or 8 sharp pointed setae.

LIFE HISTORY.

The life history of P. alni resembles that of P. försteri except that the various stages of the latter precede those of the former in point of time. The degree of infestation due to P. försteri in the Edinburgh locality is distinctly less than

that due to P. alni, where the latter species is about six times as numerous as the former. In the London district, on the other hand, P. alni, according to Edwards (1896) is said not to be common, whilst P. försteri is very common.

Both the species have but a single generation in the year and winter is passed in the egg stage.

ADULT. The adults of P. alni appear towards the end of June and those of P. försteri about 10 days previously. The insects are active on warm bright days and may often be seen poised in the air about alder trees. Very soon, however, they become dispersed to other neighbouring trees, so that the number of adult insects on alder does not compare with that of the earlier occurring nymphs. P. försteri starts mating about the second week of July and P. alni a week later. The following account is drawn from an observation made on P. alni:-

Shortly before mating the male is seen to make excited advances towards several females before it finally approaches and settles on top of one. Immediately the male abdomen is curved towards the genital opening of the female and the anal valve and forceps of the former serve to separate the anal and subgenital valves of the latter, when the now straightened aedeagus is inserted into the opening thus revealed. The heads and thoraces of the pairing insects are always kept apart by an angle varying from 75° to 180° , when they face in opposite directions, often moving about with posterior ends thus linked. Mating may last from 10 to 40 minutes.

Egg laying does not commence till the third week of

September. By this time the ovaries are well developed and contain many mature eggs together with a larger number of immature ova. In females of P. alni captured on 20.IX.32 and dissected the same day, the number of ovarioles in either ovary was found to vary from 30 to 40 and the total number of mature eggs in each ovary was 12 to 18. From this time onwards eggs may be found out of doors. The greatest egg-laying activity of P. alni seems to occur about the first week of November and of P. försteri some days before, as the latter disappear earlier than the former. Both, males and females, die a few days after oviposition has ceased. Before it commences, however, there is a return migration of the dispersed insects to the original host as evidenced by the greater numbers captured on alder towards autumn.

EGG. In spite of careful search the eggs of P. försteri were not found in the field. Since they are invariably concealed from view, their discovery is more or less a matter of chance. Examination and comparison of the eggs dissected from the abdomen of females during the egg-laying period, however, readily helped to differentiate those of the two species and in this way eggs collected in the field were all identified as those of P. alni.

The following description of the egg of P. försteri is based on an examination of the ovarian egg:-

Length .55 mm. Greatest breadth .20 mm. Length of basal stalk .08 mm.

Broadly oval with apex slightly narrower and very blunt, base rounded with a narrow hollow stalk into which the inner membrane of egg penetrates as a thin transparent streak.

Distal stalk absent.

Egg of *P. anli* (field specimen)

Length .47 mm. Greatest breadth .19 mm. Length of basal stalk .15 mm. Length of distal stalk .05 mm.

Elongated oval, sharply narrowing towards apical end; with two stalks, basal long with a prolongation into it of inner membrane, distal shorter having no communication with egg cavity. Chorion smooth and shiny. White when first laid, deep yellow after about 10 days.

Eggs are laid concealed in the crevices of the bark of the older branches of alder. Each is attached to the wood by its broad end, where the long stalk arises and pierces the host tissue. Their disposition is never linear, but often divergent in all directions from a central point and sometimes scattered irregularly but rather closely in groups. The maximum number of eggs found in a group was 16.

NYMPH. Eggs of *P. alni* start hatching in the first week of April, those of *P. försteri* about a week later, but the latter contrive to reach the adult stage more quickly because of their shorter nymphal life. By the middle of April first instar nymphs of both the species may be encountered on alder shoots, just beginning to open. Altogether there are five nymphal instars, and wing rudiments appear in *P. försteri* towards the beginning, and in *P. alni*, towards the end of the second instar. Moulting takes place by a dorsal longitudinal splitting of the cuticle of the head and thorax and immediately after each ecdysis the insect is pale yellowish and somewhat transparent.

HABITS OF THE NYMPHS.

The first two instars of both species occur on and between the opening leaf buds. Later instars feed in the axils of leaves and even of small twigs. Little or no secretion is produced by the first two instars, but with the beginning of the third instar, a white sticky, paste-like substance appears at the posterior ends of the nymphs, which are, further, soon enveloped in a mass of white fluffy silk-like and extremely fine threads. The secretion thus is clearly of two kinds and its production is greatest in the last two instars. The nymphs in all stages are active when disturbed and do not live gregariously.

COLORATION OF THE ADULT.

As in many other species of Psyllidae, the color of the adults changes with the season. Although the change is gradual and transitions abound, it is possible to differentiate typical summer and autumn forms. These are described below:-

SUMMER COLORATION OF P. FORSTERI.

General body color greenish yellow. Head yellowish green. Antennae brown with distal third of segments 4-6 and segments 7-10 black. Eyes deep brown edged with a lighter band of same color. Ocelli deep orange. Thorax: Pronotum greenish yellow. Dorsulum and mesoscutum yellow with indistinct brown patches. Metathorax green. Elytra hyaline with an ochreous tinge. Legs brownish yellow. Abdomen yellowish green with posterior margins of segments dark. Female genitalia progressively yellowish, brown

towards tip. In males tips of forceps dark, rest of forceps and anal valve brownish green.

SUMMER COLORATION OF P. ALNI.

General body color deep green. Head green with two broad yellow spots on vertex. Basal segment of antennae green, second segment brown, rest progressively dark. Eyes deep brown. Ocelli deep orange. Thorax: Pronotum yellowish green anteriorly, yellow posteriorly. Mesothorax green with brown patches. Metathorax brown. Elytra whitish hyaline. Legs yellowish brown, green in places. Abdomen yellowish green, becoming progressively darker posteriorly. Genitalia in female green in basal half brownish posteriorly; in males, forceps deep green, anal valve yellow.

AUTUMN COLORATION OF P. FORSTERI.

General body color brown. Head brownish yellow. Antennae deep brown. Eyes dark. Ocelli deep red. Thorax: Pronotum yellowish. Dorsulum brown, green at corners. Mesoscutum brown with dark patches. Metathorax brown. Wings with a deep brown tinge. Legs brown. Abdomen brown.

AUTUMN COLORATION OF P. ALNI.

General body color reddish brown. Head dark red. Antennae and eyes deep brown. Ocelli deep red. Thorax: Pronotum red at sides, greenish towards middle. Dorsulum, mesoscutum and rest of thorax deep red with dark patches. Wings with a dusky tinge. Legs dark brown. Abdomen deep red. Female genitalia dark brown, male brown.

ASH PSYLLIDS.PSYLLOPSIS FRAXINICOLA FORST AND P. DISCREPANS FLOR.

(SUBFAMILY PSYLLINAE.)

The following six species of Psyllidae have been recorded as living on ash, all belonging to the genus *Psyllopsis*:-

1. *P. fraxini* Lin;
2. *P. discrepans* Flor;
3. *P. distinguenda* Edwards;
4. *P. meliphila* Low;
5. *P. fraxinicola* Först;
6. *P. mexicana* Crawf.

Of these the last two are American species, the first five European and the first three and the fifth British. In S.E. Scotland *P. fraxinicola* is very abundant, *P. discrepans* less common and *P. fraxini* scarce.

The one and only host species in the Edinburgh locality is *Fraxinus excelsior*, although other species of *Fraxinus* are also infested elsewhere. *P. discrepans*, however, is recorded by Edwards (1896) to have been taken by beating *Circaea lutetiana* and other low growing plants, and *P. fraxinicola* is said by Krause (1916) to live on *Corylus* as well. The former of these two records at least is very doubtful.

Economically, *P. fraxinicola* is mentioned many times as a pest of ash in the United States, especially by Felt (1910-1915) in the reports of the State Entomologist. The same author (1911) writes that this species does little damage in Europe, a statement not borne out by my observations. In Scotland, at least, not only *P. fraxinicola*, but *P. discrepans* and *P. fraxini* are capable of doing damage, although only the first named becomes sufficiently abundant



A small plant of ash, Fraxinus excelsior, in a wire-gauze cage, heavily infested with Psyllopsiis fraxinicola Först and P. discrepans Flor and nearly succumbing to the attack.

to cause appreciable injury.

SPECIFIC DISTINCTION.

The following table will serve to separate the six species of the genus *Psyllopsis*:-

<i>Psyllopsis</i>	
<p>Body yellow to yellowish brown. Tegmen free from dark markings.</p> <p>1. <u>fraxinicola</u>. 2. <u>meliphila</u> 3. <u>mexicana</u>.</p> <p>Smallest species, slightly darker - <u>meliphila</u>.</p> <p>Antennae over 4 times as long as width of head. Male anal valve very slender, forceps long and triangular - <u>mexicana</u>.</p> <p>Antennae about $2\frac{1}{2}$ times as long as width of head. Male anal valve broad in lateral aspect forceps notched in middle hairy at sides - <u>fraxinicola</u>.</p>	<p>Body brown to blackish brown. Tegmen with conspicuous dark markings.</p> <p>4. <u>fraxini</u>. 5. <u>discrepans</u>. 6. <u>distinguenda</u>.</p> <p>Largest species, markings on tegmen sharply defined. Forceps in lateral aspect an irregular triangle attached by apex -- <u>distinguenda</u>.</p> <p>Forceps hatchet-shaped with a tuft of setae on inner sides, attached by very slender stalk - <u>discrepans</u>.</p> <p>Forceps hammer shaped, thickly beset with setae on inner side—<u>fraxini</u>.</p>

LIFE HISTORY

Felt (1911) stated that P. fraxinicola had a life history similar to that of the pear psylla and the adults overwintered. My observations do not bear out this statement and in this region both P. fraxinicola and P. discrepans pass the winter in the egg stage and are univoltine.

ADULT. The adults of P. fraxinicola appear about the middle of June and those of P. discrepans a little later. Ten or twelve days after emergence the ovaries begin to mature and

the insects start mating. In a number of females of fraxinicola dissected on 17.VI.33 there were on an average about 20 mature eggs in the ovarian tubules of each insect, this number being 7 in the case of discrepans. Oviposition, however, does not begin till early autumn.

EGG. Except for a small difference in size, the eggs of P. fraxinicola and P. discrepans are exactly similar. It was, therefore, not easy to identify them when collected in the field and the following average measurements are of eggs dissected out from the ovarioles:-

Species.	Length in mm.	Greatest Breadth in mm.	Length of Stalk in mm.
<u>P. fraxinicola</u>	.36	.13	.09
<u>P. discrepans</u>	.43	.17	.13

Eggs of both species are oval, rounded towards ^{the} ends, with a stout stalk about one fifth from the proximal side. They ^{end/} are laid singly on unopened leaf buds, their stalk often inserted on the inner side i.e. next to the stalk of the twig and on this account are difficult to detect. They are white when first laid becoming brownish later.

Hatching starts about the second week of April just when the leaf buds are about to open and continues for a considerable time afterwards. This synchronisation of hatching and the opening of the leaf buds has been discussed for Psyllia mali eggs by, among others, Theobald (1909) Lees (1916) Brittain ¹ and Minckiewicz (1927), the last author believing that eggs hatch early or late according to the degree of development achieved before winter begins. This agrees

1, cited by Minckiewicz (loc. cit.)

with my observations in which three green twigs of apple bearing a large number of eggs of P. mali, and kept in the laboratory in moist sand, burst into leaf in the last week of February, but the first eggs did not hatch till the third week of March. In the case of the eggs of Psyllopsis two facts are noteworthy: (i) hatching occurs first when the buds of the ash are about to open; (ii) it continues for a considerable time after the first ones have opened. These observations suggest that in Psyllopsis while the time of oviposition is probably the most significant factor in the hatching of the egg the physical condition of the host may also be important by reason of the heat generated by the flow of sap in developing trees as stated by Theobald (loc. cit.) or by a physiological connection existing between the egg and the host as mentioned by Lees (1916) or through both.

NYMPH. The first instar nymphs of P. fraxinicola and P. discrepans are encountered in the field towards the middle of April and thence various immature stages may be collected till the end of June. The first two instars of the former are yellowish, those of the latter pinkish in color. The nymphs of both species moult five times before becoming adult and the duration of each instar, where available, is as follows:-

<u>P. fraxinicola</u>	IV instar	9	days.
	V	"	11 "
<u>P. discrepans</u>	II	"	11 "
	III	"	11 "
	IV	"	9 "
	V	"	10 "

HABITS OF NYMPHS AND ADULTS AND THEIR EFFECTS ON THE HOST

The first nymphs to hatch creep in between the folds of the half-opened leaf-buds and start feeding singly on them. Towards the end of the second instar, the characteristic curling of the ash leaves becomes evident and many third instar nymphs together with a large number of first and second instars from later hatched eggs may now be found inside the curled leaves.

The last three stages of development are passed entirely inside the galls. In the case of fraxinicola nymphs of the last two instars may also be observed moving outside on both surfaces of the leaves, and in heavy infestations they may be found assembled on the petioles as well. The most pronounced habit of the adults is to attach themselves to the hard woody parts of the ash tree, where they are found sometimes arranged in a line one above the other.

The nymphs produce three kinds of secretions differing mainly in their physical characteristics. A few hours after hatching small droplets of a white sticky substance are secreted from the circumanal pores and simultaneously there is also produced long ~~still~~ waxy filaments rising from the bases of each of the setae surrounding the body margin. These filaments are very fragile and easily break off but they withstand the macerating action of alcohol longer than the material exuded from the circumanal pores. A third kind of secretion, produced in the later stages of the nymphal life, is in the form of a profuse fluffy cottony substance that often envelops the nymphs, and adheres to all parts of



A photomicrograph of a second stage nymph of *Psyllopsis fraxinicola* Forst showing some of the long shafts of white waxy secretion arising at the bases of the lanceolate setae surrounding the abdominal and the costal margins.

the host tree like strands of cotton wool. This secretion emerges from the numerous pores that occur on the dorsum of the nymph. Droplets of white waxy substance are also secreted by the adult females.

As a result of the feeding activities of the nymphs on the host there is formed copper-colored galls due to the involution of the leaves from the margins inwards. At first the gall is small and spindle-shaped and only a small area of the leaf is affected; later larger parts of the leaf surface are rolled up until the whole leaf is involved. On being unfurled the gall reveals a seething mass of nymphs of all stages invested by their fluffy, cottony secretion.

Late in summer when many of the nymphs have become adults, the galls are infested by other insects which often prey on the adult psyllids and in time become the sole occupants of the erstwhile habitation of their nymphs. These include earwigs, capsids, thrips and spiders. Of these the first two are predators on both the species of *Psyllopsis*.

COLORATION OF THE ADULT.

Unlike many other Psyllidae *P. fraxinicola* and *P. discrepans* change little in color with the advance of the season. The former, however, becomes a little more yellowish and brownish and the latter, likewise, a little darker in shade towards autumn.



A portion of an ash plant showing the characteristic curling of the leaves and the formation of copper-colored galls by the nymphs of Psyllopsis fraxinicola Först and P. discrepans Flor. The commencement of the process is seen on the two leaves at the bottom left, and the fully-formed galls in the centre, towards the left. The small white patches on the leaves indicate the presence of the nymphs surrounded by their secretion of white fluffy, silky material.

BOX PSYLLIDPSYLLIA BUXI LIN.

(SUBFAMILY PSYLLINAE.)

This species is common Europe and in the United States though it has been entirely neglected in Crawford's monograph of the New World Psyllidae. It is very abundant in S.E. Scotland on box hedges and in heavy infestations greatly detracts from the appearance of the plants. Economically it has very little importance, although control measures have been undertaken in Holland and New Jersey where box plants kept for ornamental purposes have been greatly disfigured by the insects.

Spanioneura fonscolombi Förster, the only other species living on box occurs in England but was not found by me in this region. It is reported from Europe and the United States.

P. buxi was designated as the type of a new genus Asphagidella, erected by Enderlein (1921). This genus is differentiated from Asphagis (also created by Enderlein at the same time) by the absence of R1 in the hind wings. Asphagis itself is separated from Psyllia by the absence of a pterostigma, the thickening of the costa distal of R1 and the development of R1 as a vein in the hind wing. Neither of these genera seem to be well founded and it is very doubtful, especially in the case of Asphagidella, as pointed out by Ferris (1926), if the mere absence of a vein in the hind wing, where veins are usually reduced or faintly

developed, is sufficient to justify the formation of a new genus. In the present work, therefore, the old generic name *Psyllia*, of this species is retained.

SPECIFIC CHARACTERS.

P. buxi may be distinguished from other closely allied species by the following characters:-

Antennae half the length of costa. Genal cones as long as vertex down the middle, pubescent, bluntly rounded, divergence less than base of either. Wings with pterostigma absent, veins concolorous with elytra. "Genital segment of the female nearly as long as the remainder of the abdomen, both tergite and sternite beset with a longitudinal band of small, black, tubercle-like setae. Male with the anal valve moderately long and slender beset with numerous fine setae; claspers slender, terminating in a single small tooth on the inner side." (Ferris, 1926).

HOST

P. buxi is known to breed and live only on Buxus sempervirens, the common box plant. Curiously enough Taylor (1901) emphatically stated that it occurred on "various garden plants but certainly not on box." Extensive observations have shown this remark to be entirely without foundation.

LIFE HISTORY.

ADULT. The adults appear towards the end of April and continue to live on box hedges till about the end of August. They are green robust insects, markedly broader towards the head than towards the abdomen, the female having

a long pointed ovipositor. The entire life is passed on box, there being little dispersal of the insects to other plants at any time.

Mating starts in the beginning of August, and the method is very similar to that described for Psyllia alni. The time taken is usually not more than 20 minutes. Oviposition commences shortly afterwards and is completed in the last week of August, when the females die, the males dying a little earlier. After August no adults were found in the field.

EGG. Length without stalk .35 mm. Greatest breadth .15mm.
Length of stalk .10 mm.

Color dull orange. Elongated oval, bluntly pointed distally, with a small stalk at basal end.

Eggs are laid singly in slits made in the axils of leaves and twigs by means of the long and sharply pointed ovipositor and, on this account, are very difficult to detect by a casual examination of the plant. Contrary to the observation of Hamilton (1926) and in spite of the host being an evergreen, on which adults might be capable of living, the egg stage lasts throughout the winter.

NYMPH. The eggs hatch in early April, just when new leaf buds are beginning to appear and by the end of the first week, large numbers of first instar nymphs may be encountered in the field. The entire nymphal period takes about fifty days during which five moults occur, the last ecdysis preceding the adult stage. The duration of the different stadia was determined in the laboratory greenhouse, to be, on

an average, as follows:-

I instar	6-8	days.
II	"	6-8 "
III	"	8-10 "
IV	"	7-8 "
V	"	10 "

HABITS OF THE NYMPHS AND THEIR EFFECTS ON THE HOST.

Immediately after hatching the nymphs pass to the new leaf buds, which are just opening and conceal themselves in the folds of the partially-opened leaves. It is remarkable how even the previous year's leaves are wholly neglected although the nymphs have an equal choice of both the old and the new shoots. They may, therefore, be said to be negatively geotropic and positively thigmotropic. The nymphs are active when disturbed and have each a globule of white secretion at their posterior end. This secretion does not markedly differ from that secreted by Psyllia mali. The curling of the leaves so characteristic of box plants infested by this Psyllid starts when the insect is approaching the end of the second instar and after some twelve days when the nymphs are in the fourth stage, the cabbage-like appearance of the shoots is quite noticeable. Each of the galls is formed of three or four curled leaves and harbours from 6 to 10 nymphs from third stage onwards, secreting copiously.

COLORATION OF THE ADULT.

Like the majority of Psyllidae, the color of P. buxi changes with the advance of the season. The following forms occur typically in summer and autumn:-

SUMMER FORM.

Head green, antennae light brown, tips of segments 4-8

and entire segments 9-10 black, eyes reddish white, ocelli deep yellow. Thorax green with dull brown markings, elytra dusky, legs brown. Abdomen green, female genitalia brown in distal half, male anal valve yellow, forceps white. *al/*

AUTUMN FORM.

Head white, antennae brown, last two segments black, eyes blackish brown, ocelli deep orange. Thorax with dark brown markings, elytra dusky, legs dark brown. Abdomen blackish brown, female genitalia brown, male anal valve dull white, forceps brownish distally.

ABNORMALITY.

Although no cross veins normally exist in the wings there appeared in the fore wing of one specimen of P. buxi a cross vein joining Rs with M at the point of its bifurcation into M₁ and M₂. An exactly similar case of a vein between Rs and M is recorded by Boselli (1930) in Spanioza cinnamom Boselli. A number of other instances of abnormality in Psyllid wings was recorded by Frauenfeld (1867), who in his account of Anisostropha ficus gives figures of 23 forewings of the genera Anisostropha, Trioza and Psyllia, showing various forms of abnormality in the veins. According to this author the variations are most frequent in the genus Psyllia and very scarce in Trioza; further they usually occur in one wing only and are seldom symmetrical. The abnormality is not confined to wings only and Crawford (1920) records a case in which Aphalara (Anomocera) anomala Crawford possessed nine-segmented antennae instead of the usual ten, and a supernumerary marginal cell in the fore wings.

HAWTHORN PSYLLIDPSYLLIA MELANONEURA FORST.

(SUBFAMILY PSYLLINAE).

Many species of Psyllidae, all belonging to the genus *Psyllia*, have been recorded on hawthorn, but only two have been found in S.E. Scotland, *P. mali* discussed in a separate section and *P. melanoneura*. This latter species can be distinguished from *P. mali* and other allied species by the following characters:-

Genal cones short, narrowly pointed in distal half, their divergence equal to or less than base of either, their outer edge sinuate, inner almost straight. Antennae less than half the length of costa. Female genitalia a little less than length of abdomen, not markedly pubescent, anal valve longer than subgenital, latter dark and sharply pointed at extremity. Male forceps shorter than anal valve, bent at base, distal extremity dark and rounded, spool at proximal end of spermatic duct short, anteriorly rounded and well expanded.

This species has two sets of seasonal host plants, *Crataegus oxycantha* and other species of *Crataegus* in summer and early autumn and various conifers chiefly *Taxus baccata* in late autumn and winter. Harrison (1915) recorded it from Clevelands as being common on oak and conifers late in the year and Mokrzecki (1916) reported it as occurring on pear in Simferopol.

Economically *P. melanoneura* is of slight importance having been recorded only once by Mokrzecki (loc. cit.) as

injuring pear trees in Simferopol. According to the same author this insect had two generations in 1915, hibernated in the adult stage in groups on the trunks of pear trees and oviposited during the first half of March on the branches. My observations in S.E. Scotland show an entirely different life history, in which P. melanoneura has a single generation in the year and overwinters in the adult stage.

LIFE HISTORY

ADULT. The adults first appear towards the end of May and after the second week of June nymphs may no longer be found in the field. They are at first greenish but about two days after emergence become reddish and are then easily distinguished from P. mali which is rich green. They remain on hawthorn till about the middle of autumn, when with the approaching leaf-fall they migrate to neighbouring evergreen plants. In one locality under observation the winter was passed on Taxus baccata and other conifers and in another where there were no conifers at hand, on broom. This change of host is made only for food and shelter and not for oviposition. Observations made on P. melanoneura seem also to support McAtee's (1915) view, based on previous records of other species that the habit of resorting to conifers is not restricted to the cold season.

About the middle of March there is a return migration to hawthorn and the insects start mating. Oviposition begins 5-7 days later, after which the adult insects live for a considerable time and it is only towards the end of April that they die and disappear in the field. There is

thus an interval of only about five weeks between the overwintering adults of the first generation and those of the second or spring generation.

Six females and six males confined on hawthorn on 21.3.33 laid 755 eggs in all, during a period of 20 days i.e. an average of 156 eggs per female. At the time of oviposition the female becomes very sluggish and fails to respond by jumping even when repeatedly touched. The most noticeable habit of the female at this time is the secretion of long tubes of white waxy material which issue from the circumanal pores.

EGG. Length .32 mm. Greatest breadth .15 mm.

Length of stalk .04 mm.

Broadly oval with a stalk at basal end. Color deep yellow.

Eggs are laid in groups on the newly opened leaves chiefly on the undersurface but sometimes on the upper. The largest number of eggs is inserted by the basal stalk, near the midrib, but other parts of the leaf and rarely even the petioles may be selected. The number of eggs in a group varies from 2 to 15.

Hatching commences about 2 weeks after oviposition and a few days before, the two red eyes of the embryo are visible through the chorion at the narrow distal end of the egg, the abdomen lying towards the basal extremity.

NYMPH

The first instar nymphs appear in the second week of April and have a life of about six weeks, during which they moult five times, the last ecdysis being followed by the



Photomicrograph of a portion of hawthorn, Crataegus oxycantha, leaf showing a group of eggs deposited by Psyllia melanoneura Först.

adult stage. The duration of each stadium in the greenhouse was roughly as follows:

I	instar	8	days.
II	"	7	"
III	"	7	"
IV	"	8	"
V	"	12	"

HABITS OF NYMPHS

The first instar nymphs feed gregariously for the first few days at the site of their emergence from the egg. Later in the second and third instars they move towards the growing shoots and cluster on the opening leaf buds. In the last instar they may be met with anywhere on the leaf and live singly. The nymphs start secreting a white waxy substance in little droplets or ribbons about 12-20 hours after hatching. The secretory activity progressively increases with the age of the nymphs and is at its maximum in the last two instars.

COLORATION OF THE ADULT.

The typical summer and winter forms of P. melanoneura differ markedly from each other, in color, which are described below:-

SUMMER FORM.

Head white with brownish yellow markings, distal half of genal cones and first three segments of antennae brown, rest of antennae progressively black, eyes brownish, ocelli deep red. Thorax yellow with brown markings, pronotum grey, elytra pale yellow, veins and legs light brown. Abdomen yellowish green, female genitalia in distal half, and male and valve and forceps brown.

WINTER FORM.

Head yellow with dark brown markings, genal cones white in proximal, brown in distal half, eyes and antennae blackish brown, ocelli deep red. Thorax pronotum yellow with black markings, rest of thorax and legs blackish brown, elytra dusky, veins brown. Abdomen black, intersegmental margins yellowish brown, female genitalia black, male blackish brown.

PEAR PSYLLID.PSYLLIA PYRICOLA FORST.

(SUBFAMILY PSYLLINAE).

There is some confusion with regard to the number and identity of the species of Psyllidae attacking pear and the following have been recorded on this host in Europe and the United States:-

1. Psyllia pyricola Först.
2. P. simulans Först.
3. P. pyri Lin.
4. P. pyrisuga Först.
5. P. hexastigma Horvath
6. P. melanoneura Först.
7. P. mali Schmidberger.

Of these the last two are entirely different from other pear psyllids, and pear is not their chief food plant.

P. hexastigma occurs chiefly in Eastern Siberia and Japan.

Of the remaining four P. pyrisuga is the largest species and unlike the other three, is without any dark markings on the wings. The first three have been variously treated as synonymous by Crawford (1914) or as two species by Edwards (1896) or as three distinct species by Riley (1891). My observations confirm the fact of P. pyricola and P. simulans being the summer and winter forms respectively of one and the same species. It is also probable that P. pyri is identical with P. pyricola, with occasional, very slight differences, probably due to geographical isolation, although it has been

frequently reported as a separate species from various parts of Europe, during the last two decades.

Although said to occur on apple at times P. pyricola lives chiefly on pear and is a very serious pest of this tree in the United States and to a lesser extent in Europe. In the orchards where my observations were made, apple and pear trees were growing side by side yet no P. pyricola was ever found on apple trees.

LIFE HISTORY.

Psyllia pyricola, in this region is trivoltine and the imago hibernates in winter. In the United States it has four broods in the year, which are not sharply divided. The allied species P. pyrisuga had one generation in 1913 and two in 1914 in Salgir, according to Mokrzecki and Bragina (1915) and the authors think that the number of broods depends on climatic conditions. In the same locality Mokrzecki (1913) reported P. pyri to have overwintered in the egg stage, but in view of the fact that the eggs did not have stalks or filaments like those of P. pyricola, it is very probable that he was dealing with a different species altogether.

1ST GENERATION. The hibernating adults emerge from the crevices of the barks early in March and start mating towards the end of that month. Oviposition commences 3 or 4 days after mating. Eggs are laid on the outer surfaces of the leaf buds (i.e. the undersurface of leaves) parallel to the long axes of the latter, singly but close together, though not exactly in groups as recorded by Brocher (1926) for P. pyrisuga. In rare cases they may be laid at the bases of leaf petioles or on the upper surface of the leaves along the midribs.

The egg is white when first laid, gradually turning yellow. It is broadly oval, with a short stout stalk towards the proximal end which is embedded in the leaf tissue and a long filament-like process at the distal end. Its measurements are: length .30 mm., greatest breadth .18 mm., basal stalk .06 mm., distal filament-like stalk .18 mm.

Hatching commences in 2 to 3 week's time and the first nymphs appear in the third week of April. The entire nymphal life lasts for about five weeks and during this time five moults occur. The duration of each stadium in mid-summer was, approximately, determined to be as follows:-

I	instar	9	days
II	"	7	"
III	"	7	"
IV	"	7	"
V	"	9	"

2ND AND 3RD GENERATIONS.

The adults of the first generation appear at the end of May; mating occurs shortly afterwards and eggs of the second generation are laid about the middle of June, in the grooves of the leaf petioles, usually parallel to their long axis and scarcely any on the leaves. Hatching occurs about 10 days later and the adults of the second generation appear towards the end of July. Eggs being again laid, the adults of the third generation appear about the third week of October. The generations are well defined but some overlapping takes place and nymphs of several different stages may usually be found before the emergence of the adults. The last generation of adults hibernates in the crevices of the bark of the pear tree and may sometimes be captured in the middle of winter.

HABITS OF THE NYMPHS.

The nymphs on hatching feed singly on the underside of leaves, often near midribs, and remain immersed in a drop of transparent but sticky liquid, which they start secreting about 20 hours after hatching. The greatest production of this secretion commences after the second moult when a sooty mould develops and the presence of the nymphs can only be detected by tiny patches of moist dark areas on the undersurface of the leaves. Awati (1915) in England had this injurious fungus identified as Cladosporium herbarium. The nymphs are usually very sluggish and, unlike those of P. pyrisuga described by Bröcher (1926), do not at any stage feed in colonies.

SPECIFIC CHARACTERS AND COLORATION OF THE ADULT.

P. pyricola may be distinguished from allied species by the following set of characters, based mainly on the description of the adult by Crawford (1914):-

Body length: Summer form 1.6 - 1.9 mm. Winter form 1.9 - 2.3 mm. Vertex about as long as broad, with two foveae, conspicuously emarginate in front at median line with anterior ocellus in emargination and genal cones about two thirds as long as vertex, their divergence less than base of either, outer edge concave, inner straight, subacute at tips, pubescent. Legs slender hind tibiae with basal spur very small or wanting. Male anal valve a little longer than forceps, sides subparallel, pubescent, forceps simple, rather acute at tips, tapering uniformly from base to tip.

Female genitalia short, dorsal valve a little longer than ventral, both acute.

SUMMER COLORATION.

General color orange to reddish brown with darker markings. Antennal segments 7-10 and apices of those of 4-7 black. Legs yellow except brown femora. Wings transparent with a slight yellowish tinge, specially in distal cells, with a conspicuous black patch at tip of clavus and another above it. Veins pale yellow.

WINTER COLORATION.

General color reddish brown with black markings. Antennae black. Legs brown except blackish brown femora. "Elytra hyaline or lacteo-hyaline, the disk of the cells feebly and suffusedly fuscous, a broad fuscous stripe occupying almost the entire length of cell 1, apex of clavus blackish, veins blackish" (Vide Edwards, for P. simulans, 1896).

THE WILLOW PSYLLIDPSYLLIA AMBIGUA FORST

(SUBFAMILY PSYLLINAE)

The following is a list of the species of Psyllidae recorded as living on willows:-

Species	Host. Genus Salix	Locality
1. <u>Psyllia ambigua</u> Först	<u>S. caprea</u> and other species	British Isles and Central Europe.
2. <u>P. salicicola</u> Först	<u>S. caprea</u>	"
3. <u>P. brunneipennis</u> Edwards	<u>S. pentandra</u>	British Isles
4. <u>P. americana minor</u> Crawf	<u>S. rostrata</u>	North America
5. <u>P. iteophila</u> Low	<u>S. incana</u>	Europe
6. <u>P. klapaleki</u> Sulc	Salix sp.	"
7. <u>P. elegantula</u> Zett	<u>S. caprea</u>	"
8. <u>P. parvipennis</u> Low	<u>S. rosmarinifolia</u>	"
9. <u>P. nigrita</u> Zett	<u>S. purpurea</u>	"
10. <u>P. dudai</u> Sulc	Salix sp.	"
11. <u>P. ornata</u> Meyer Dur	Salix sp.	"
12. <u>P. abdominalis</u> Meyer Dur	Salix sp.	"
13. <u>P. ulmi</u> Först	<u>S. caprea</u>	"
14. <u>Trioza salicivora</u> Rent	<u>S. caprea</u>	British Isles & Europe & Japan
15. <u>T. albiventris</u> Först	<u>S. purpurea</u> , <u>S. alba</u> , <u>S. fragilis</u>	"
16. <u>T. unifasciata</u> Löw	<u>S. purpurea</u>	"
17. <u>T. striola</u> Flor	<u>S. caprea</u>	British Isles
18. <u>T. varians</u> Crawf.	Salix sp.	North America

Species	Host. Genus Salix	Locality
19. <u>T. salicis</u> Mally	<u>S. lasiolepis</u> and other species	North America
20. <u>T. maura</u> Först	<u>S. alba</u> , <u>S. purpurea</u> , <u>S. lasiolepis</u>	Europe and North America.
21. <u>Ceropsylla californica</u> Crawf.	<u>S. rostrata</u>	North America

In this region P. ambigua alone has been found by me, although it is possible that some other species also occur. It is a noteworthy fact that Salix and Citrus are perhaps the only two genera among the host plants of Psyllidae to harbour species belonging to at least three genera and two subfamilies.

Economically psyllids do little injury to willows in the British Isles and the same may be said of them in the United States. They are however, included by Willocks (1922) in the list of pests of the willow in Egypt and certain species are said to cause serious damage at times.

SPECIFIC CHARACTERS.

P. ambigua may be distinguished from other allied species by the following characters:-

Antennae scarcely half as long as costa. Genal cones slightly pubescent about as long as crown down middle, their inner edge straight, outer concave, their divergence less than base of either. Male anal valve and forceps beset with setae, former broadest about middle, latter smaller and slender, each ending in a small brown claw. Female anal valve bluntly, subgenital sharply pointed,

former longer than latter, both beset with setae. Anal pore ring three-layered anteriorly.

LIFE HISTORY.

P. ambigua has one generation in the year and the adults hibernate.

ADULT. The adult insects appear towards the end of May and continue to live practically all the year round. Near the end of autumn migration to other plants ensues and in winter the leafless willow is free from the psyllids. In an area kept under observation, the cold season was passed on broom bushes, from which adults were collected in January and February. A little before the approach of spring there is a return migration to the willow just when the leaf buds are beginning to burst and in the last week of March the insects begin mating. The method is the same as that described for P. alni. Oviposition commences 4 to 6 days after mating and continues for about three weeks. Immediately before laying the female becomes fluffy and extremely sluggish; the antennae vibrate and the ovipositor is curved at base, its tip being inserted into the leaf tissue a moment later. One female was observed in the act of oviposition at the same spot for 1 hour 40 minutes.

Three males and three females, while still mating, were confined on a willow twig and in 22 days' time laid 468 eggs i.e. an average of 156 eggs each.

EGG. Length without stalks .38 mm. Greatest breadth .20 mm
Proximal stalk .07 mm. Distal stalk .05 mm.

Oval with a stalk at each end. Color pale yellow when

first laid turning deep orange later.

Eggs are laid in irregular groups, as many as 40 together, on the half-opened leaf buds, or on the undersurface of leaves, rarely they are inserted in the tender green twigs.

NYMPH. Hatching started in the second week of April in the greenhouse and a few days later in the field. The nymphal life continues till the third week of May and during this period of about 40 days, five moults occur, the last being followed by the adult stage. The period of each nymphal instar was determined in the green house to be as follows:-

I instar	12	days
II	"	8 "
III	"	9 "
IV	"	5 "
V	"	10 "

HABITS OF THE NYMPHS.

The newly hatched nymphs creep in between the folds of the opening leaf buds and lie with their mouth parts buried in the tissues till they are exposed by the fully opened leaves. Even then they have the thigmotropic tendency to move towards leaf bases in between the axils. The nymphs are definitely gregarious in the first two instars, in the third instar they are less so, while in the last two instars they are met with singly. There is usually very little secretion; sometimes however, little white waxy droplets exude from the apices of the abdomen, but there is no marked period of secretory activity such as is noticed in some allied species like Psyllia mali.

UNUSUAL APPEARANCE OF NYMPHS.

Nymphs of the second and third stage were found in the

third week of March. These were concealed in the spaces between the stem and the leaf buds and a slight waxy secretion was noticeable. Extensive search showed no trace of eggs on the plants. A number of female adults captured on 13.1.33 and dissected the same day showed no development of the ovary. The early appearance of the nymphs may, however, be attributed to an occasional deposition of eggs at the end of autumn, which may hatch earlier than spring. The other possibility that the nymphs hatching before winter hibernate to appear again in March seems remote.

COLORATION OF THE ADULT.

P. ambigua in summer is a light green insect, while in winter it is dark brown. The typical coloration of the two forms is as follows:-

SUMMER FORM.

Head and thorax yellowish green with brown markings. Eyes brown, ocelli orange. Antennae brown, segments 4-8 progressively black. Elytra pale yellow with veins brown; Legs brownish yellow. Abdomen yellowish green, female genitalia brown in distal third, male genitalis yellowish green, tips of forceps brown.

WINTER FORM.

Head and thorax dull white heavily marked with deep brown. Eyes and first six antennal segments deep brown, last four black, ocelli reddish brown. Elytra dusky with veins deep brown, legs brown. Abdomen including male and female genitalia blackish brown.

THE NETTLE PSYLLID.TRIOZA URTICAE LIN.

(SUBFAMILY TRIOZINAE)

This species is the only representative of the subfamily Triozinae found by me in S.E. Scotland; nevertheless it is very common and heavily infests stinging nettle, Urtica dioica, its sole food plant in many parts. Like many other species of the genus it is said by Pape (1921) to form harmful leaf galls on nettles in Germany, a fact not borne out by my observations in Scotland. Economically T. urticae is of no importance, though many other species of the genus are serious pests (see General Section: Economic importance).

It is interesting to compare the genus Trioza with the genus Psyllia of the subfamily Psyllinae. Both belong mainly to the North Temperate regions, having a large number of species with distinctions amongst some of them very obscure. Both contain some serious pests, e.g. T. merwei Petty, T. citei Laing, P. mali Schmidberger, P. pyricola Forst. Many species of Trioza form galls on their hosts, have usually three or four generations in the year and almost always overwinter in the adult stage; while in Psyllia very few species form galls, there is in many cases a single generation in the year and overwintering occurs in the egg as well as in the adult stage.

LIFE HISTORY.

T. urticae has four overlapping generations in the year and winter is passed in the adult and possibly in the

nymphal stage. The only evidence for the latter statement is the presence of the last instar nymphs as late as the end of the year on old nettle plants in England, from which it is considered probable that at least some of the adults emerge at the approach of the spring. The former may be found all the year round except for a short period after the first batch of spring eggs is laid. They overwinter on any convenient green plants, box, holly, but preferably conifers and sometimes on the half dead stumps of the old nettle. Records show that the habit of overwintering on conifers, if available, is fairly widespread in Psyllidae (McAtee 1915, Peterson 1923).

ADULT. The adults emerge from their retreats about the middle of April, when the nettle comes into leaf, mate and start laying eggs about 5 or 6 days later. At the time of oviposition the female is very sluggish and refuses to jump even when repeatedly disturbed. The egg laying period lasts over a month in captivity, after which both the males and females die. Three females confined with three males on a nettle plant on 24.4.33 deposited 529 eggs in all at the end of 34 days i.e. an average of 176 eggs per female. The average seems to fluctuate widely in different species of Trioza; it is said to be 611 in the case of T. merwei by Van Der Merwe (1923) and 93.5 according to Peterson (1923) in the case of Trioza tripunctata Fitch.

EGG. Length .30 mm.; greatest breadth .17 mm; basal stalk .05 mm.; distal stalk .12 mm.

Oval, broad at base with a stout stalk, sharply-pointed distally ending in a long tapering stalk. White when first

laid; becoming yellow later.

Eggs are scattered irregularly on the undersurface, rarely on the upper surface, of the leaves, with the basal stalk inserted into the leaf tissue. The incubation period is about 10 days in spring and summer and about two weeks in autumn. A day or two before hatching the two red eyes of the embryo appear towards the distal end of the egg.

NYMPH. In the greenhouse the first instar nymphs appeared on 10.5.33; and after an interval of about 5 weeks the adults. During this period five moults occur. Rudimentary wingpads become visible after the first moult and the adult emerges after the fifth. As in most other Psyllidae, moulting occurs by a longitudinal dorsal slit in the cephalo-thoracic region.

SUBSEQUENT GENERATIONS.

The first generation of adults, appearing about the middle of June, mate and start laying eggs a week later. As the warm season advances, the life-cycle becomes shorter and by the end of July a large number of eggs of the second generation are laid. After this, it becomes very difficult to define the generations, but from the periodical abundance of eggs and adults in the field as well as in the greenhouse, it is believed that two further generations occur. The last generation takes longer to complete its life cycle than the previous ones, and the adults and possibly some of the last instar nymphs of the fourth brood overwinter. As pointed out before, there is considerable overlapping of generations and all stages of the insect may be found throughout the summer and early autumn. After the end of September, only

advanced nymphs and adults are found.

HABITS OF THE NYMPHS AND ADULTS.

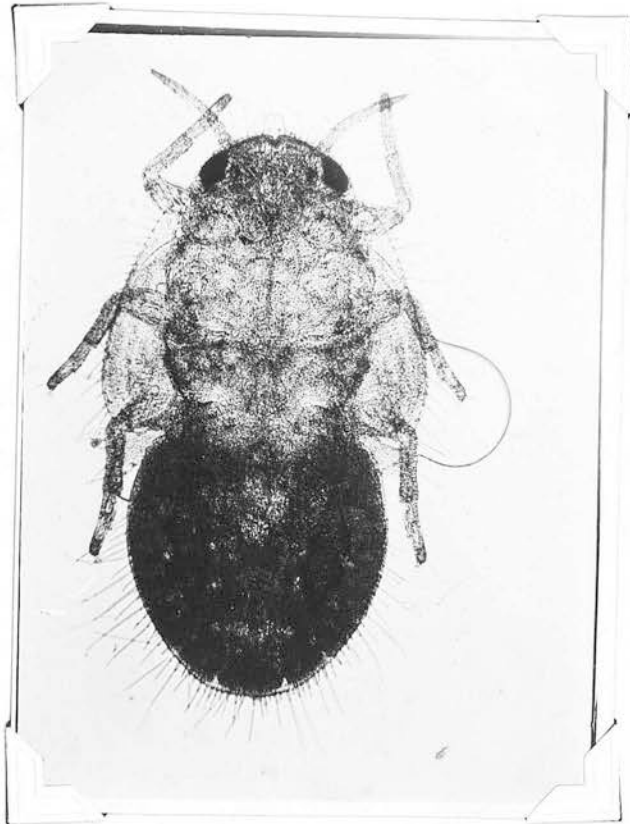
The nymphs on hatching attach themselves to the leaf surface and feed singly. In heavy infestations as many as 20 or more nymphs may be found on a single leaf. They are extremely sluggish and seldom move. About 2 days after hatching they produce a regular series of long flat waxen shafts each arising at the bases of the sectasetae and enclosing them entirely. These shafts are very fragile and are secreted in two or three instalments as evidenced by nodes in their lengths. Their production continues till the end of nymphal life and in later stages their length is often greater than the length of the whole body. The secretion of these flat waxen shafts is a common feature in many nymphs of the subfamily Triozinae and of some species of the genus *Psyllopsis*. In addition, in the last three instars, small white pellets of waxy substance are also secreted from the apices of the abdomen but there is no formation of a continuous ribbon or tube from the circumanal pores as reported in *Trioza tripunctata* by Peterson (1923). The adults also secrete white pellets of waxy substance.

COLORATION OF THE ADULTS.

Although there is no marked seasonal variation in color *T. urticae* assumes many different hues which may be described thus:-

Vertex and thorax white to yellow, with brown or dark brown markings. Genal cones darker in distal two-thirds, whitish in proximal one third. Antennae entirely dark or

only the distal two-thirds, rest yellow to brown. Wings with a dusky tinge, veins brown. Legs and abdomen yellowish to deep brown.



A photomicrograph of a fifth stage nymph of Trioza urticae Lin showing long shafts of white waxy secretion arising at the bases of the setae surrounding the body margin.

THE WILLOW HERB PSYLLIDAPHALARA NEBULOSA ZETT

(SUBFAMILY LIVIINAE).

This species is of no economic importance but is interesting chiefly because of its passing the autumn and winter in the nymphal stage. This habit is rare in Psyllidae, the only other authentic case of seasonal nymphal dormancy being that recorded by Boselli (1929) in which nymphs of Spanioza (Trioza) galii aspinovelutina Sulc aestivate in summer during the resting period of their host Rubia peregrina. Aphalara nebulosa is also the only representative of the subfamily Liviinae found by me in this region where its sole host is Epilobium angustifolium, although it is also reported as living on E. gessneri in various parts of Europe and Japan.

LIFE HISTORY.ADULT.

The adults appear about the middle of May and may be found in the field till the end of June. Mating occurs about a week after emergence and eggs may be laid from 6 to 10 days afterwards. It was early discovered that the ratio of the males, emerging after the last nymphal ecdysis was greater than that of females and this was substantiated by occasional counts of the insects captured at random in the field. Some of these figures are given below:-

SEX RATIO OF ADULTS OF A. NEBULOSA CAPTURED IN THE FIELD.

Captured on	3.VI.32	8.VI.32	9.VI.32	15.VI.32	16.VI.32	29.VI.32	7.VII.32
Males	49	20	16	6	28	75	7
Females	33	17	9	5	16	34	14

This disparity in the number of the sexes of these insects is reflected in the manner of their mating. Although only one male and one female are actually concerned in the process, usually there are two and sometimes three males applied to each female at the time of copulation. As the insects at this time are very sluggish, it is easy to watch them on a leaf blade under the binocular. The following description is drawn from actual observation:-

A number of males are seen to attend a female and finally two approach her. The elytra of the latter is then partly covered over by the adjacent outspread elytra of either male, one on each side, the heads of all the three insects pointing in the same direction. Soon after the aedeagus of one of the males is inserted into the genital opening of the female exposed by the forceps of the former, which pushes apart the anal and subgenital valves of the latter. The other male remains close to the body of the female with the apex of its abdomen attach to the ventral surface of the latter. Sometimes a pair was seen to be mating when a third male arrived and attached itself to the female. Copulation may last with an additional male in attendance for about 50 minutes.

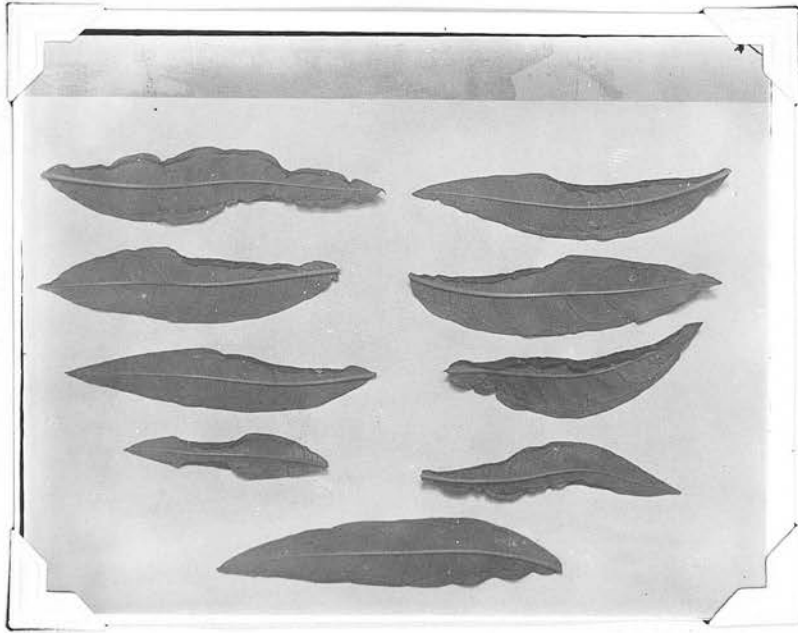
EGG. Length .32 mm., greatest breadth .16 mm., basal stalk .06 mm., distal stalk .07 mm. Oval, somewhat pointed at both ends, each end with a stalk, of which the basal is inserted in the leaf tissue. Color white when first laid, turning yellow in a few days.

Eggs are deposited in linear arrangement, at the edges of the leaves on the undersurface, the edges turning backwards and enclosing the eggs in flat sheaths. Seven to ninetyseven eggs were counted in such sheaths. Sometimes they were not exactly linear in position but scattered irregularly. Eggs may be laid on both margins of a leaf.

Hatching occurs towards the end of June, about 10 days after oviposition. Three to five minutes before hatching there is slight movement inside the egg, and soon after the shell ruptures abruptly with a snap on the dorsal side of the nymph, along a transparent longitudinal streak which is noticed about 10 hours before hatching. After 1 to 1½ minutes rest the nymph starts pushing its head forwards in an effort to free itself from the egg shell, which is still covering it ventrally and laterally. After the body is freed the egg shell becomes a crumpled transparent mass. The whole process of hatching till the nymph moves away takes from 10-15 minutes.

All the eggs in a leaf sheath do not hatch on the same day.

NYMPH. The nymphs remain in the sheaths/3 or 4 days after hatching and in about 10 hours the rate of its production is



Leaves of willow-herb Epilobium angustifolium, showing the sheaths formed at the edges as a result of the laying of eggs by Aphalara nebulosa Zett.

greatly increased. A few days later, about the end of July these first instar nymphs begin to disappear from the leaves and from August, no apparent trace of Aphalara nebulosa in any of its stages is found on the exposed parts of its host. As the nymphs do not migrate to neighbouring plants it was surmised that they had descended to the roots in the soil. This proved to be the case, as was shown by scraping the soil from the roots of willow-herb over a white sheet of paper, when many living second instar nymphs were found attached to them. These nymphs secrete very little waxy substance from the circumanal pores but waxy shaft-like structures are often secreted from the bases of the dagger-shaped setae, surrounding the body margin, the shafts enclosing the setae completely. The nymphs in this stage have small but well developed wing pads and obviously a moult occurs soon after they arrive at the roots. It is believed that one or possibly two further moults occur and winter is passed actually in the third or fourth stage. These premises are confirmed by the fact that early in April when fresh shoots are sprouting up from the previous year's rootstock of the willow herb, nymphs of the last two stages are found clustering amongst the roots and on the half-opened leaf buds. At this time there is no trace of egg or adult. The nymphs continue to increase in abundance as bud after bud opens on the plant and there seems to be perfect synchronisation between the appearance of the two.

These advanced nymphs are always found in the top shoots, clustered together in between the folds of the half-

opened leaves. They are therefore gregarious in the last two instars and positively thigmotropic. A white waxy secretion also exudes from the circumanal pores in the form of little ribbons or masses. The nymphs are very sluggish.

INQUILINES.

Two other insects, a capsid nymph and a thrips larva were often found in the leaf sheaths in association with the first instar nymphs. These are believed to be inquilines.

COLORATION OF THE ADULT.

Unlike many other Psyllidae there is no seasonal change in the coloration of the adult. Immediately after emergence the insect is pale yellow and transparent, but soon the brown hue of the typical adult is assumed.

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SECTION III.

A CONTRIBUTION TO THE KNOWLEDGE OF THE IMMATURE STAGES OF
SCOTTISH PSYLLIDAE

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A CONTRIBUTION TO THE KNOWLEDGE OF THE IMMATURE STAGES OF
SCOTTISH PSYLLIDAE.

In presenting an account of the biology of Scottish psyllidae it seemed desirable to describe their immature stages in a section by itself. This procedure not only relieved the previous section of long systematic descriptions but also permitted certain general observations to be made on the nymphs. The importance of their study has been increasingly appreciated in the last decade, both from the economic and systematic points of view. Harmful species of Psyllidae do damage almost entirely in their immature stages and in only two cases, so far, Psyllia pyricola Först and Paratrioza cockerelli Sulc, have the adults been found equally injurious. On the other hand the specific determination of the immature stages has been rendered difficult owing to the fact, first, that many published descriptions of the nymphs cannot be strictly applied only to the species to which they refer and second, that sometimes the nymphs of two closely allied species differ so greatly that they warrant the adults being placed in different genera and even subfamilies. Such cases have been mentioned by Crawford (1919) Ferris (1928) Husain and Nath (1927) and have been summarised by Rahman (1932) in the introductory part of his paper. During the course of the present work also it was found that Psyllia mali, the pest of apple, while having a

biological race on hawthorn and morphologically indistinguishable from it as adult differed from it in its immature stages. It is clear, therefore, that in classifying adults more attention must be paid to the affinities of their nymphs and this account aims at contributing to the knowledge of the latter by giving specific descriptions of the nymphs of Psyllidae collected chiefly in South East Scotland.

PREVIOUS WORK.

Descriptions of the nymphs of Psyllidae are by no means numerous: some are included as part of the general account of the life histories of individual species. During the last century Löw and Scott respectively gave a number of random descriptions of different species while Witlaczil (1885) described a number of Psyllid nymphs and figured those of Psyllopsiis fraxinicola and Trioza remota. Other references are made in connection with the species later described in this section. Two works may be mentioned now, as opportunity to do so does not occur again in this account. Descriptions of the nymphs of the following four species of Philippine Psyllidae were published by Uichanco (1921) with short biological notes:-

Pauropsylla triozyptera Crawford, P. tuberculata Crawford,
Paurocephala psylloptera Crawford, Megatrioza pallida
 Uichanco.

The chief criticism of this work is that it is overladen with too many details of measurements to the exclusion of characters of real systematic importance, while the

complete absence of figures greatly detracts from the value of the descriptions.

More recently Boselli (1929-1931) has studied a number of Italian Psyllidae and given descriptions of the nymphs of thirteen species accompanied by excellent figures (See list on pp.70-73). In the case of the following seven species, all the nymphal stages are described:-

1. Spanioza galii aspinovelutine Sulc.
2. S. tawainica Boselli.
3. S. erythraea Del Guercio.
4. Euceropsylla russoi Boselli.
5. Rhinocola succincta Hegeer.
6. Paurocephala chonchaiensis Boselli.
7. Homotoma ficus Lin.

In the case of the remaining six, descriptions of only the last instar nymphs are given.

During the last decade a large number of nymphs of British and American psyllidae have been described by Ferris (1923-1933) and lately by Klyver (1930-1933) with the avowed objects of permitting "the positive determination of the species concerned in the absence of material for comparison" and of arriving "at an evaluation of the various characters in order to obtain a classification based upon the nymphs as a check upon that based upon the adults." These two objects have been kept in view in describing the nymphs in the present work.

Other nymphs described on these lines, include five species by Rahman (1932) one species by Husain and Nath (1927) and another by Ferris and Hyatt (1923). The following is a list of species whose nymphs have been described in detail. A similar table given by Rahman (loc. cit.)

is not only out of date but also contains several omissions:-

Subfamily	Species	Nymphal type	Author & date
Pauropsyllinae	1. <u>Pauropsylla tuberculata</u> Crawf.	Pauropsylline	Rahman 1932.
"	2. <u>P. depressa</u> Crawf	"	" "
"	3. <u>Microceropsylla nigra</u> Crawf.	Triozine	Boselli 1930a.
"	4. <u>Paurocephala chonchaisensis</u> Boselli	Psylline	" 1929a.
"	5. <u>Paurocephala fremontae</u> Klyver.	"	Klyver 1931
Carsidarinae	6. <u>Freysuila cohahuayanae</u> Ferris	"	Ferris 1928.
"	7. <u>Carsidara gigantea</u> Crawf.	"	" "
"	8. <u>Tenaphalara elongata</u> Crawf.	"	Rahman 1932.
"	9. <u>Synoza floccosa</u> Ferris	"	Ferris 1928
"	10. <u>Homotoma ficus</u> Lin	Triozine	Boselli 1929a
"	11. <u>Mesohomotoma lineaticollis</u> Enderlein.	Psylline	" 1930a
Psyllinae	12. <u>Euphyllura arbuti</u> Schwarz	"	Ferris & Hyatt 1923.
"	13. <u>Psylloopsis fraxinicola</u> Förster.	"	Ferris 1923.
"	14. * <u>Psyllia alni</u> Lin	"	" 1925.
"	15. * <u>P. buxi</u> Lin	"	" 1926.
"	16. <u>Pachyopsylla venusta</u> Osten Sacken.	"	" "

Subfamily	Species	Nymphal type.	Author and date.
Psyllinae	17. <u>Euphalerus galli-</u> <u>cola</u> Ferris	Psylline	Ferris 1928
"	18. <u>Euphyllura arcto-</u> <u>staphyli</u> Schwarz	"	" 1928
"	19. <u>Arytaina puncti-</u> <u>pennis</u> Crawf.	"	Rahman 1932.
"	20. <u>Diaphorina citri</u> Kuw.	Triozine	Hussain and Nath 1927.
"	21. <u>Pachyopsylla</u> <u>celtidie-mamma</u> Riley	Psylline	Boselli 1929b
"	22. <u>Euceropsylla</u> <u>russoi</u> Boselli	"	" 1929d
"	23. <u>Psyllia toroen-</u> <u>ensis</u> Kuw.	"	" 1930a
"	24. <u>Rhinocola</u> <u>succincta</u> Hegeer	"	" 1930b
"	25.* <u>Psyllia mali</u> Schmbdg.	"	Klyver 1931.
"	26. <u>P. pyricola</u> Förster	"	" "
"	27. <u>P. uncata</u> Ferris and Klyver	"	Ferris and Klyver 1932.
"	28. <u>P. albizziae</u> F. & K.	"	" "
"	29. <u>P. acaciae</u> Maskell	"	" "
"	30. <u>Ctenarytaina</u> <u>thysanura</u> Ferris and Klyver	"	" "
"	31. <u>Psyllia Försteri</u> Flor.	"	Present paper.
"	32. <u>P. ambigua</u> Först	"	" "

Subfamily	Species	Nymphal type.	Author and date.
Psyllinae	33. <u>P.melanoneura</u> Forst.	Psylline	Present paper
"	34. <u>P.mali</u> (race <u>Crataegi</u>).	"	" "
"	35. <u>Psyllopsi</u> <u>discrepans</u> Flor.	"	" "
"	36. <u>Eurhinocola</u> <u>eucalypti</u> Maskell	"	" "
Liviinae	37. <u>Aphalara</u> <u>calthae</u> Lin.	Pauropsyll- ine (Psyll- ine type- Klyver	Klyver 1930.
"	38. <u>A.martini</u> Van Duzee	Pauropsyll- ine (Psyll- ine type- Ferris	Ferris 1924.
"	39. <u>A.nebulosa</u> Zett	Pauropsyll- ine	Present paper.
Trioziinae	40. <u>Ceropsylla</u> <u>sideroxyli</u> Riley	Trioziine	Ferris 1923.
"	41. * <u>Trioza urticae</u> Lin.	"	" "
"	42. <u>Paratrioza</u> <u>cockerelli</u> Sulc.	"	" "
"	43. <u>Phyllopecta dios-</u> <u>pyri</u> Ashm.	"	" 1926.
"	44. <u>Leuronota</u> <u>michoacana</u> Ferris	Pauropsyll- ine (Triozi- ine -Ferris)	" 1928.
"	45. <u>Trioza albifrons</u> Crawf.	Trioziine	Klyver 1930.
"	46. <u>T.fletcheri</u> Crawf.	"	Rahman 1932.
"	47. <u>Spanioza galii</u> <u>aspinovelutina</u> Sulc.	"	Boselli 1929c.

Subfamily	Species	Nymphal type.	Author and date.
Triozinae	48. <u>S. taiwanica</u> Boselli	Triozine	Boselli 1930a
"	49. <u>S. erythrae</u> Del Guercis	"	" 1930c
"	50. <u>Cecidotrioza</u> <u>sozanica</u> Boselli	"	" 1930a
"	51. <u>Egeirotrioza ceardi</u> (De Berg) var <u>euphratica</u> .	"	" 1931a
"	52. <u>Kuwayama lavaterae</u> van Duzee	"	Ferris 1924.
"	53. <u>Trichopsylla</u> <u>walkeri</u> Thomson.	"	Present paper.
"	54. <u>Powellia vitreo-</u> <u>radiata</u> Maskell	"	Ferris and Klyver 1932.

*Indicates species whose last instar nymphs only were described in the papers mentioned, the remaining stages being described in the present work.

MATERIAL AND METHODS.

With the exception of two species the nymphs were all collected at various places in and around Edinburgh. They were preserved in 80% ethyl alcohol mixed with 1/10 to 1/20 part of 5% glycerine. For the study of their body parts the nymphs were macerated in caustic potash solution and mounted for microscopic examination in the usual manner. Mounting specimens in formaline in excavated slides as described by Huie (Scottish Nat. 1917. p. 227) was not found satisfactory for my purpose. It does not produce the necessary transparency of the insect and even the delicate first instar

nymphs of Psyllidae must be made quite transparent to permit observation of the circumanal pore rings. De Faure's and Berlese's fluids (Imms. Bull. Ent. Res. 1929. pp.165-166) were extensively used and found satisfactory especially for the earlier instars, the former showing the tracheal system with great clearness.

Staining, when necessary, was done with 1% basic fuchsin in 95% alcohol. Specimens cleared in caustic potash solution and brought to 90% alcohol were stained for a maximum of 10 minutes and then destained partially, dehydrated and mounted.

MORPHOLOGY OF THE NYMPHS OF PSYLLIDAE.

Witlaczil (1885) in his "Anatomy der Psylliden" first described certain features of nymphal morphology and in particular dealt with the nymphs of Psyllopsis fraxinicola Först, Trioza urticae Lin and Homotoma ficus Lin. Since then various authors have given brief accounts of the external anatomy of some part or other of psyllid nymphs. First, Awati (1915) in a life history study of Psyllia mali gave an account of the circumanal pore rings, which, collectively, he called the "heart-shaped organ", a term inappropriate in view of their very variable disposition. Later Bröcher (1925) dealt with the anatomy and physiology of the mouth parts of the nymph of Psyllia pyrisuga and described in detail their piercing and sucking mechanisms. His observations also extended to the nymphs of P. pyri and P. pyricola. In the same year "the construction and the functions of the larval labium (of P. mali) were recorded "by

Minkiewicz¹ in his report to the third International Entomological Congress at Zurich" and the same author in a later paper (1927) on the development and biology of P. mali describes the structure of the nymphal labium and discusses the hypotheses of Brocher (loc. cit) and of Grove (1919) with reference to the piercing and the retractile action of the maxillary and mandibular setae, in conjunction with the labium at the time of feeding. An anatomical account of the nymph of P. mali was recently given also by Speyer (1929) and a study of the mouth parts of the nymph of Homotoma ficus by Boselli (1929).

In the following notes a brief general account of the morphology of psyllid nymphs is presented, chiefly with a view to making clear the descriptions that follow later in this work.

In form the nymphs, in their last stages, are broad in comparison to their length, which measures 1 to 4 mm. The body is flattened dorso-ventrally and the flattening becomes more accentuated as the nymph grows. Sometimes this is very marked as in species of Trioza, which appear very thin while in species like Psyllia mali the body is more plump.

The head is broad, not clearly separated from thorax and is dorsally occupied by a pair of sclerites, often heavily pigmented and with a narrow strip of median membranous area between them. In the last instar nymph of Trioza

1 Cited in the author's next paper (1927).

fletcheri Crawford, as observed by Rahman (1932), the head is separated from the thorax by a thin membranous groove.

The antennae vary in their length in different genera of the family as compared to the width of the head and in the position of their origin. They are smallest in the nymphs of Ceropsylla sideroxyli Riley, being hardly more than a quarter of the head width, and arise ventrally, as is the case with all members of Triozinae, well away from the anterior cephalic margin. The greatest length of the antennae is attained in the nymphs of the genera Psyllopsis and Tenaphalera, where they also arise from a marginal rather than a ventral position. The intermediate position is held by the nymphs of the Pauropsyllinae. Antennae in all instars terminate in characteristic forked bristles and the most atypical ones are those of Pachypsylla venusta Osten Sacken. The number of segments varies in different species at corresponding nymphal stages, but in all, the first two segments are shorter and broader than the others following.

The 'rostrum' arises ventrally and is flexed backwards, its tip reaching the middle coxae. It is constituted by the triangular and conically pointed clypeus, at the apex of which is a small sclerite representing the labrum. The epipharynx of the adult is not seen in the nymphal stages and even in the former it is said to be very inconspicuous. Between the clypeus and the prosternum is the three-segmented labium, only the last segment of which is free and can be lifted off the body, the other two being attached to the

ventral aspect of the head and prothorax. The tip of the labium terminates in a number of hardened and deeply pigmented sharp, tooth-like processes, 4 to 6 in number, and a little anterior to the tip in the median region are a pair of elongated oval and deeply pigmented thickenings, between which the maxillary and mandibular setae pass. Towards the apex of the second labial segment are two pairs of triangular hook-like processes in the median region, which grip the maxillary and mandibular setae and are termed 'mamelion croteche' by Brocher (1925). The maxillae and mandibles are long slender seta-like structures arising near the base of the clypeus from long and narrow triangular plates. The mandibular setae are opposed to each other and their termination forms a long piercing structure. The maxillary setae are separate.

The thorax is not demarcated on either side and its anterior and posterior boundaries can be judged only with reference to the anterior pair of coxae and of the wing pads. The dorsum is heavily sclerotised and pigmented in places, the arrangement of sclerites giving the thorax, in many places, a sculptured appearance.

The wing pads differ greatly in shape and comparative size in different genera and their configuration with respect to the body contour determines principally the three forms, *Psylline*, *Triozine* (Ferris 1925) and *Pauropsylline* (Rahman, 1932), to which the nymphs of *Psyllidae* have been assigned.

In the newly-hatched nymph the legs are three-segmented

and remain so till the last instar when they acquire a distinct tarsal segment, the first three segments being coxa, femur and tibia. Towards the tibial apex, in the last instar nymph the position of the tibio-tarsal articulation of the adult is also indicated in many species. Trochanters are, as a rule, absent, the only exception being the fifth instar nymph of Pachypsylla venusta Osten Sacken. The extremity of the leg in all instars is terminated by a pair of claws and a median pad-like structure, besides a number of setae around the origin of the claws. The median pad-like structure is here called the empodium except where it is distinctly cleft when it is termed the pulvillus. The empodium may or may not be markedly petiolate, and in Eurhinocola eucalypti it is very rudimentary. Sometimes the claws as in Pauropsylla depressa Crawford or empodia or pulvilli as in Pauropsylla tuberculata Crawford are absent.

The segments of the abdomen are not easily discernible and the heavy sclerotisation of the integument often masks many intersegmental divisions. Witslaczil (1885) figures seven segments in the nymphs of Psylloopsis fraxinicola and Tricoza rhami and this is the number which seems to be present in the nymphs of the later instars of most species. In nymphs of the first instar the abdominal segments are more than seven, up to eleven. The number of paired spiracles on the abdomen is also seven in the later instars.

The anal aperture is, as a rule, placed on the ventral side of the abdomen. Its exact position is subject to many modifications. Typically it is situated fairly but

not too close to the apical margin as in Psyllia mali, P. pyricola, Psyllopsis fraxinicola, Arytaina punctipennis etc. In species in which the circumanal pore rings lie on the ventral as well as the dorsal sides, the anal opening is at the extreme apex as in Psyllia buxi, P. alni etc. In certain extreme cases of this type the anal aperture may be carried on a protuberance of the apical abdominal segment as in Pachypsylla venusta and Euphyllura arbuti. On the other hand the anal opening may lie a considerable distance from the apex of abdomen as in the species of Trioza and Kuwayama.

Two sets of pores typically in the form of rings surround the anal aperture and are hence called the outer and inner circumanal pore rings. The shape and size of the individual pores and their disposition vary greatly. Normally the rings lie ventrally and are oval or circular in outline, with the pores composing them one to many-layered. Such a condition occurs in practically all the subfamilies of Psyllidae. In the species where the anal opening is carried on the extreme apex of the body, the circumanal pore rings lie, asymmetrically, partly on the dorsal and partly on the ventral body wall as for example Psyllia alni, P. buxi. In many cases the circumanal pore rings occupy a considerable portion of the caudal area round the anal opening and are disposed in a variety of sinuate ways as in Psyllia försteri, ^{and} Euphyllura arctostaphyli. The inner ring of pores is often simpler and indistinct; in many species it is either one or many layered, consisting of irregularly scattered pores. In

rare cases, as in Psyllia försteri, it is also sinuate in disposition.

A number of setae often of more than one kind generally invest the body of psyllid nymphs. These have, unfortunately, been given different names by different authors. For instance the 'dagger-like' setae of antennae, wing pads, legs and abdomen in Paurocephala fremontiae as described by Klyver (1931) are not different from the 'sharply pointed sectasetae' of Ferris (1928) in Synozia floccosa. On the other hand the setae on the abdominal margin of Euphyllura arbuti, figured and termed by Ferris and Hyatt (1923) as lanceolate are obviously not the same as the marginal setae on the apical fourth of the abdomen in Tenophora elongata Crawford, also called lanceolate by Rahman (1932). This may easily result in confusion, and for this reason the names of the chief types of setae mentioned in this work are given below, together with short descriptions or explanations necessary to distinguish them:-

- | | |
|------------------------|---|
| 1. Setae | Small hair like bristles. |
| 2. Simple setae | Bigger than 1, elongated or curved but not structurally modified otherwise. |
| 3. Secta setae | Small, broad, stout setae, with sharply cut distal ends, occurring characteristically in the nymphs of the subfamily Triozinae. |
| 4. Spear-shaped setae | Very much like secta-setae but with the distal ends not sharply cut but pointed. |
| 5. Lanceolate setae | Of usually the same size as secta-setae, long oval, tapering at both ends and sharply pointed distally. |
| 6. Dagger-shaped setae | Long stout setae like the blade of a dagger, straight not curved. |

7. Spatulate setae Various modifications of long simple setae with bluntly or broadly ending extremities.
8. Ring-based setae Simple setae with the bases implanted in circular ring-like structures.

SEX OF THE NYMPHS.

The developing nymphs furnish no indication of their sex until the last instar when the genitalia may be seen through the cuticle. This, strictly speaking, does not pertain to any characteristic of the nymph but is merely a mechanical effect. Awati (1915) remarks that the parts of the reproductive system are early seen in the 4th and 5th instars, in which the external sexual differences begin to be visible; the males (the larvae which are destined to become males) being short and the females longer. This last criterion holds good in certain species only. In Psyllopsis fraxinicola nymphs which are destined to be males are, as a rule, more elongated than those destined to be females, in which the abdomens are markedly round and broad.

PSYLLIA FORSTERI FLOR.

(SUBFAMILY PSYLLINAE).

Host: Alnus glutinosa and A. incana.

Locality: Royal Botanic Gardens and Boghall, Edinburgh.

Fifth stage nymph (Fig. 1 A.)

Length 2.4 mm. Body yellowish green, eyes yellowish red, sclerotised areas brownish, antennal segments 1, 2 and 3, wing pads and legs greenish yellow, rest of antennae progressively black.

Form: Psylline. Sclerotisation on dorsum extending to a pair of elongate ocular areas on head, a number of small areas on thorax, four pairs of transverse areas on anterior half and to entire posterior half of abdomen. Ventrally sclerotised areas include a small part of apical abdomen and four pairs of submedian and three pairs of marginal areas on it. Dorsum with many bluntly-pointed ring-based setae and in places smaller but stouter setae of same kind. Venter beset with similar setae but with sharply-pointed ends.

Head as broad as abdomen, anterior margin with a number of setae. Antennae more than twice as long as width of head, of nine segments, third longest, weakly jointed in middle. Thorax broadest next to head. Wing pads uniformly oval with several stout spatulate setae and about 8 on costal margin of anterior and two of same kind at apical end of posterior pair. Legs long beset with numerous stout simple setae of various lengths, femora reaching beyond body

margin; trochanter absent; tibio-tarsal articulation distinct; pulvillus petiolate, cleft in middle with two claws at base. Abdomen round and elongate, margin with a number of long spatulate and a few smaller spear-shaped setae. Anal opening a short distance from apex with two sets of pore rings. Inner ring consisting of a single row of round pores disposed in a zigzag way, outer ring of long pointed oval pores also set in zigzag way and mostly three layered. Just beyond this layer of outer pores and for a short distance near each margin, ventral body wall studded with numerous round pores. (Fig. 1 G.)

Fourth stage (Fig. 1 M.)

Length 1.3 mm. Color same as in previous stage nymph. Differs from it in larger size of some sclerotised areas on thorax, in having seven-segmented antennae and in absence of tibio-tarsal articulation.

Third stage.

Length .94 mm. Body greenish yellow, eyes and sclerotised areas brown, antennal tips dark, rest of antennae, wing pads and legs yellowish brown. Differs from fourth stage nymph in possessing four-segmented antennae and its relatively much smaller size of wing pads.

Second stage (Fig. 1.H.)

Length .71 mm. Body yellow, eyes red, sclerotised areas brown, legs and antennae brownish yellow, antennae tips dark. Differs from third stage nymph in absence of marginal and two pairs of submedian sclerotised areas ventrally, in possessing three-segmented antennae, in wing

pads being very rudimentary with a seta at apical ends of each, and in absence of inner ring of circumanal pores, outer ring consisting of a single row of elongated slit-like pores not sinuately disposed.

First stage (Fig. 2 F.)

Length .54 mm. Color as in second stage nymph. Differs from it, in its two segmented antennae, in absence of wing pads, these being represented by two pairs of sclerotised plates each with a seta and in complete absence of circumanal rings of pores and those situated around them and marginally.

PSYLLIA ALNI LIN.

(SUBFAMILY PSYLLINAE)

The fifth stage nymph of this species was described by Ferris (1925). In this account, color notes on this stage and descriptions of the remaining four instars are given.

Host: Alnus glutinosa and A. incana.

Locality: Royal Botanic Gardens and Boghall, Edinburgh.

Fifth stage.

Body yellowish green, eyes pinkish, sclerotised areas on abdomen and thorax black, on head brown. Antennae except segments three and four, wing pads and legs except femora blackish brown. Third and fourth segment of antennae and femora brownish yellow.

Fourth stage (Fig. 2 E.)

Length 1.5 mm. Body greenish yellow, eyes red, sclerotised parts including antennae except segments three and

four, wing pads and legs blackish brown. Third and fourth segments of antennae brownish yellow. Differs from fifth stage nymph in relatively larger size of sclerotised plates on thorax, in possessing six-segmented antennae and in absence of tibiotarsal articulation.

Third stage.

Length .98 mm. Body yellow, eyes red, sclerotised areas brown, antennae except tips, wing pads and legs brownish yellow, antennae tips dark. Differs from fourth stage nymph in absence of ventral sclerotised areas at base of antennae, in having a belt of minute pointed structures on both sides, on ventral abdomen and in possessing four segmented antennae.

Second stage (Fig. 2 A.)

Length .83 mm. Head and thorax greenish yellow, abdomen yellow, eyes red, sclerotised areas brown, antennae and legs pale yellow. Differs from third stage nymph in absence of ventral sclerotisation, in having three segmented antennae and in absence of wing pads, these being represented by slight bulgings and by two pairs of sclerotised plates each with a seta.

First stage (Fig. 2 B).

Length .57 mm. Color as in second stage nymph. Differs from it in being relatively much smaller and in having circumanal pore ring encircling extreme apex, composed of two layers of small round pores (Fig. 2 C.).

PSYLLOPSIS FRAXINICOLA FORST.

(SUBFAMILY PSYLLINAE).

All the stages of the nymphs of this species have been described by Ferris (1923). Earlier, general descriptions of P. fraxinicola nymphs were given by Witslaczil (1885) and by Scott (1886). In the following account, measurements and color notes, which do not occur in Ferris' description, are given:-

Host: Fraxinus excelsior.Locality: Dalkeith and Boghall, Edinburgh.

Fifth stage.

Length 1.9 mm. Body whitish green, eyes black, wing pads pale whitish.

Fourth stage.

Length 1.0 mm. Body more yellowish than greenish, eyes deep brown, last segment of antennae and tips of last segments of legs black.

Third stage.

Length. .70 mm. Body yellow, eyes reddish brown.

Second stage.

Length .47 mm. Body yellow, eyes deep red.

First stage.

Length .37 mm. Color as in second stage nymph.

PSYLIOPSIS DISCREPANS FLOR.

(SUBFAMILY PSYLLINAE)

Host: Fraxinus excelsior.

Locality: Dalkeith and Boghall. Edinburgh.

Fifth stage (Fig. 3 A.)

Length 1.8 mm. Body greenish yellow, eyes brown, sclerotised parts including wing pads, blackish brown, legs and antennae except tips brown, antennae tips black.

Form: Psylline. Sclerotisation on dorsum extends to a pair of ocular areas on head, certain small areas on thorax (Fig. 3 A.) four pairs of areas on anterior and to entire posterior half of abdomen. Ventrally two small areas on thorax four pairs of submedian, five pairs of marginal and two areas at apical end of abdomen are sclerotised. Dorsum including wing pads beset with numerous round pores of various sizes and small ring based setae, the latter assuming a more or less transverse arrangement on abdomen.

Head: anterior margin with few setae, antennae of eight segments, third longest. Thorax broader than head. Wing pads oval, uniformly broad, costal margin devoid of setae except a few at apical ends. Legs long, femora just reaching body margin, trochanter absent, tibio-tarsal articulation distinct, empodium with two claws, petiolate. Abdomen broad, margin surrounded by small lanceolate setae. Anal opening a short distance from apex. Outer circumanal pore ring one layered towards median line, two to three layered near sides, individual pores elongate and oval inner ring consisting of round pores.

Fourth stage.

Length 1.1 mm. Color as in fifth stage nymph. Differs

from it in having six-segmented antennae and in absence of tibio-tarsal articulation.

Third stage.

Length .74 mm. Color as in nymphs of previous stages. Differs from fourth stage nymph in possessing four segmented antennae, in the lessening of round pores on dorsum and in outer circumanal pore ring being one-layered, except for a small distance near sides.

Second stage (Fig. 3. B.)

Length .66 mm. Body pinkish yellow, eyes deep red, antennae, wing pads and legs pale yellow. Differs from third stage nymph in its different arrangement of sclerotised plates on dorsum, absent ventrally, in possessing three-segmented antennae and very rudimentary wing pads each with a lanceolate seta apically.

First stage (Fig. 3. E.)

Length .48 mm. Color same as in second stage nymph. Differs from it in possessing two-segmented antennae and in absence of wing pads, these being represented by two pairs of sclerotised plates each with a seta.

PSYLLIA BUXI LIN.

(SUBFAMILY PSYLLINAE)

The fifth stage nymph of this species has been described by Ferris (1926); to this some additional notes and descriptions of the remaining four stages are now added.

Host: Buxus sempervirens.

Locality: Various places in and around Edinburgh.

Fifth Stage.

Body color deep yellow, with sclerotised parts brown, eyes deep red. Antennae of nine segments, last three imbricate, third twice as long as others following. Inner ring of circumanal pores situated ventrally only, six-layered and individual pores round.

Fourth stage.

Length 1.5 mm. Differs from fifth stage nymph in deeper brown color of sclerotised parts and in having antennae of five segments, third and fifth being twice as long as first and second together.

Third stage (Fig. 4.C.)

Length .97 mm. Body yellow, eyes red, sclerotised parts including antennae, wing pads and legs brown. Differs from fourth stage nymph in being more elongate, in possessing antennae of three segments, third twice as long as first and second together and in having smaller wing pads with not more than three or four setae near costal margin.

Second stage (Fig. 4. F.)

Length .72 mm. Body color same as in third stage nymph. Differs from it in different arrangement of sclerotised plates on dorsum and their absence ventrally except a small apical area, in absence of wing pads these being represented by slight bulgings in thoracic region and by two pairs of sclerotised plates each with a seta and in outer circumanal pore ring being at extreme apex dorsally consisting of a single row of slit-like pores, ventrally a short distance from apical margin, one-layered towards median line, three

near sides; inner ring of pores round, one layered.

First stage.

Length .61 mm. Body, soon after hatching, pale yellow, eyes red, antennae and legs pale white. Later, color of body deepens into yellow with sclerotised parts brown. Differs from second stage nymph in possessing two segmented antennae, in absence of any trace of wingpads and in having outer-circumanal pore ring one-layered at extreme apex of abdomen, inner ring absent.

PSYLLIA MELANONEURA FORST.

(SUBFAMILY PSYLLINAE)

Host: Crataegus oxycantha and other species of Crataegus.

Locality: Various places in Edinburgh.

Fifth stage (Fig. 5. A).

Length 1.5 mm. Body yellowish green, eyes pinkish white, antennae, legs and wing pads pale yellowish, antennae tips dark.

Form: Psylline. Body fairly broad. Sclerotisation on dorsum includes a pair of ocular areas on head, two large and five smaller pairs on thorax, three pairs of transverse areas towards base of abdomen and its posterior two-thirds. Ventrally a small apical part of abdomen and two pairs of submedian and three pairs of marginal areas on it are sclerotised.

Head as broad as thorax, anterior margin with four setae. Antennae of eight segments, third and eighth longest and weakly jointed in middle. Thorax: Wing pads large and oval. Costal margin devoid of

setae, apical ends of anterior pair having one and posterior pair two setae each, surface studded with minute points. Legs somewhat slender, femora reaching body margin, trochanter absent, tibio-tarsal articulation distinct, pulvillus with two claws at base and a long spatulate seta. Abdomen broader than head and thorax, broadest towards base, ventrally a number of bluntly pointed setae present and numerous small pointed structures near margin, marginal setae of two kinds: six spear-shaped and usually about ten long spatulate setae variously curved. Anal opening a short distance from apex, outer circumanal pore ring one layered, consisting of oval pores, inner ring mostly three or four layered, of round pores (Fig. 5. G.).

Fourth stage.

Length 1.1 mm. Body greenish yellow, eyes red, antennae, wing pads, and legs pale yellow, antennae tips dark. Differs from fifth stage nymph in having five-segmented antennae and in absence of tibio-tarsal articulation.

Third stage.

Length .88 mm. Body yellow, eyes red, antennae, wing pads and legs pale yellow, antennae tips dark. Differs from fourth stage nymph in its smaller size and in having three segmented antennae.

Second stage (Fig. 5. B.).

Length .51 mm. Color as in third stage nymph. Differs from it in absence of ventral sclerotisation and of wing pads, these being represented by slight bulgings in thoracic region and two pairs of sclerotised plates each with a seta and in

inner circumanal pore ring being one layered (Fig. 5. E.).
First stage (Fig. 5. F.).

Length .38 mm. Head and thorax yellowish white, abdomen yellow, eyes red, antennae and leg pale white. Differs from second stage nymph in having two segmented antennae, in absence of any trace of wing pads and of inner ring of circumanal pores.

PSYLLIA PYRICOLA FORST.

(SUBFAMILY PSYLLINAE)

The nymphs of this species were recently described by Klyver (1931). In the following account, therefore, only color notes are given:-

Host: Pyrus communis.

Locality: Dalkeith, Royal Botanic Gardens, Edinburgh.

Fifth stage.

Body yellow, eyes red, all sclerotised parts including antennae, wing pads and legs brown, antennae tips black. General appearance of nymph dark brown.

Fourth stage.

Head and abdomen pale yellow, thorax pale green, eyes red, antennae wing pads and legs pale whitish, antennae tips dark, sclerotised areas dark brown. General appearance of nymph brown.

Third stage.

Color as in previous stage nymph.

Second stage.

Head and thorax pale yellow, abdomen yellow, antennae and

legs pale white, antennae tips dark, eyes red, sclerotised areas not prominently pigmented.

First stage.

Head and thorax pale yellow, abdomen deep yellow, eyes red, antennae and legs whitish.

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PSYLLIA MALI SCHMIDBERGER, RACE MALI.

(SUBFAMILY PSYLLINAE).

Being an insect of economic importance the nymphs of this species have been figured and described by, among others, Awati (1914), Brittain (1923), Minkiewicz (1927) and Speyer (1929). Recently the fifth instar nymph has been described also by Klyver (1931) and the following descriptions of the remaining four stages together with color notes on the fifth stage, are referable to his account and figure:-

Host: Pyrus malus and other species of Pyrus.

Locality: Dalkeith, Royal Botanic Gardens, Boghall and Westmains Gardens, Edinburgh.

Fifth stage.

Body green, eyes pinkish white, antennae, wing pads and legs pale white, antennae tips dark. Antennae of eight segments, last longest (cf. Klyver).

Fourth stage.

Length 1.4 mm. Head and thorax yellowish green, abdomen green, eyes, antennae, wing pads and legs pale white. Differs

1 As shown in Section IV P. mali Schmidbg. has a biological race living on hawthorn, from which the apple form is distinguished by the addition of "race mali" after the specific name.

from fifth stage nymph in possessing a stouter, shorter antennae of five segments, third as long as first and second together, fifth slightly longer than third, and in absence of tibio-tarsal articulation.

Third stage.

Length 1.0 mm. Body pale yellow, eyes, sclerotised areas on head and a small area round anal aperture, brown, antennae, wing pads and legs dull white, antennae tips dark. Differs from fourth stage nymph in being more elongated in form, in having antennae of three segments, third twice as long as first and second together and in the spine-like structures being more concentrated towards margins of apical third of abdomen.

Second stage (Fig. 4 A.).

Length .77 mm. Body yellow, sclerotised parts including wing rudiments brown, eyes deep brown, legs and antennae pale brownish. Differs from third stage nymph in having slightly different arrangement of sclerotised areas on dorsum, absent ventrally except a small apical area on abdomen, in possessing rudimentary wing pads with only one long seta at each apical end and in outer ring of circumanal pores being two to three layered near sides, inner ring single-layered (Fig. 4. N.).

First stage.

Length .41 mm. Body yellow, eyes red, sclerotised areas brown, antennae and legs pale yellow. Differs from second stage nymph in complete absence of wing pads, their places being taken by two pairs of sclerotised plates each with a seta and in outer circumanal pore ring being single-layered;

inner ring absent (Fig. 4. 0).

PSYLLIA MALI SCHMIDBERGER RACE CRATAEGI.¹

(SUBFAMILY PSYLLINAE)

This race has been known so far under the name of Psyllia peregrina Först. As shown in the next section, its adults are morphologically indistinguishable from those of P. mali on apple. The nymphs of the two, however, differ in some particulars and the last instar nymph on hawthorn has a brown longitudinal streak on each of its wingpads, which was also mentioned by Löw (1879) and Scott (1880) in their descriptions of the last instar nymphs of Psyllia peregrina Först.

Host: Crataegus oxycantha and other species of Crataegus.

Locality: Various places in Edinburgh.

Fifth stage. (Fig. 6. A.)

Length 2.3 mm. Body yellowish green, eyes brown, antennae and legs pale brownish, wingpads pale yellow with longitudinal streak deep brown.

Form: Psylline. Sclerotisation on dorsum includes a pair of ocular areas on head, four pairs of small, each followed by a pair of smaller areas on thorax, three pairs of transverse narrow areas on anterior third of abdomen and to its entire posterior two-thirds. Ventrally posterior third of abdomen, together with three pairs of submedian and four pairs of

1 This race has been, so far, recognised as a distinct species under the name of Psyllia peregrina Först. For reasons given in Section IV it is here treated as a biological race of Psyllia mali Schmidberger, living on hawthorn.

marginal areas are sclerotised. Dorsum with numerous round tubercles, especially abundant on abdomen.

Head: anterior margin with a few setae. Antennae as long as width of head, of eight segments last about twice as long as others preceeding. Thorax narrower than abdomen. Wingpads broadly oval with a brown longitudinal streak running down middle of each, surface with numerous stout, minute, pointed structures, costal margin devoid of setae except apices which have one each. Legs with femora just reaching body margin, trochanter absent, tibio-tarsal articulation distinct, empodium fish-tail shaped with two claws at base and a long spatulate seta. Abdomen with numerous stout pointed structures in apical half and a few ring based setae, on ventral side, apical third scalloped, extremity of each scallop with a long spatulate seta, usually sixteen in number. Anal opening a short distance from apex, outer circumanal ring consisting of oval slit-like pores in two layers (three or four layers for a very short distance), inner ring of small round pores, six- or seven-layered (Fig. 6. F.)

Fourth stage.

Length 1.5 mm. Body yellowish green, eyes red, antennae, wingpads and legs brownish yellow, sclerotised areas brown. Differs from fourth stage nymph in having antennae of five segments, in absence of brown streaks on wingpads and of tibio-tarsal articulation.

Third stage.

Length .90 mm. Body greenish yellow, eyes red, antennae, wingpads and legs pale yellow, antennae tips dark, sclerotised

areas brown. Differs from fourth stage nymph in having three-segmented antennae and in outer circumanal pore ring being two layered, inner ring indistinct.

Second stage (Fig. 6. D.)

Length .61 mm. Body yellow, eyes red, antennae and legs brownish yellow, sclerotised areas brown. Differs from third stage nymph in its different arrangement of sclerotised plates on dorsum, absent ventrally, in wingpads being represented by bulgings in thoracic region and by two pairs of sclerotised plates each with a seta, in absence of round tubercles on dorsum and in outer circumanal pore ring being single-layered, inner ring absent.

First stage (Fig. 6.B.)

Length .42 mm. Body deep yellow, eyes red, sclerotised areas brown, legs and antennae brownish yellow. Different from second stage nymph in having two-segmented antennae, in complete absence of wingpads and in being fringed with minute pointed structures round abdominal margin.

PSYLLIA AMBIGUA FORST.

(SUBFAMILY PSYLLINAE).

Host: Salix caprea and other species of Salix.

Locality: Boghall and Liberton, Edinburgh.

Fifth stage (Fig. 7. A.).

Length 1.8 mm. Head and thorax green, eyes red, abdomen yellowish green, sclerotised areas blackish brown, antennae, wingpads and legs pale yellowish, antennae tips dark.

Form: Psylline. Body fairly broad. Sclerotisation on dorsum

includes a pair of ocular areas on head, a number of smaller areas on thorax, four pairs of narrow transverse areas on anterior abdomen and to its entire posterior half except along median line. Ventrally two pairs of submedian and two pairs of contiguous marginal areas on abdomen and its apical half are sclerotised.

Head narrower than thorax, anterior margin with a few setae. Antennae of seven segments, third and seventh more than twice as long as others and weakly jointed in middle. Thorax narrower than abdomen. Wingpads large, oval, studded with many stout, pointed structures, costal margin with a number of simple setae. Legs not very long, trochanter absent, tibio-tarsal articulation distinct, empodium petiolate with two claws at base and two long spatulate setae. Abdomen broadest about middle, covered with numerous small stout pointed structures and dorsally with long ring based setae, margin surrounded by long simple setae. Anal opening a short distance from apex, outer and inner circumanal pore rings one-layered, former composed of oval slit-like pores, latter of round pores. (Fig. 7. D.)

Fourth stage.

Length 1.1 mm. Color same as in fifth stage nymph. Differs from it in possessing antennae of five segments, third and fifth twice as long as others and weakly jointed in middle, in having fewer setae on costal margin and in absence of tibio-tarsal articulation.

Third stage.

Length .81 mm. Body yellow, eyes red, sclerotised parts, including antennae, wingpads and legs deep brown, tips of

antennae and legs dark. Differs from fourth stage nymph in possessing three segmented antennae, in its smaller wingpads and in having fewer setae on abdominal dorsum.

Second stage (Fig. 7. B.)

Length .55 mm. Body pale yellow, eyes red, sclerotised parts, including legs brown, antennae brownish yellow, tips dark. Differs from third stage nymph in slightly different arrangement of sclerotised plates on dorsum and their absence ventrally except for a small apical area on abdomen, and in its rudimentary wingpads each with an apical seta.

First stage (Fig. 7. G.)

Length .32 mm. Head and thorax pale yellow, abdomen orange, eyes red, sclerotised parts including antennae and legs brown. Differs from second stage nymph in absence of wing rudiments, these being represented by two pairs of sclerotised plates in thoracic region and in absence of inner circum-anal pore rings (Fig. 7. H.).

TRIOZA URTICAE LIN.

(SUBFAMILY TRIOZINAE)

The fifth stage nymph of this species has been described by Ferris (1925). The following descriptions of the first four instars and color notes on the fifth instar are given with reference to his account and figures which should be consulted. The nymphs of this species are very variable in color.

Host: Urtica dioica.

Locality: Various places in and around Edinburgh.

Fifth stage.

Body pale to deep yellow, with grey, brown or deep brown markings on dorsum and wingpads, especially near sides, eyes brownish.

Fourth stage.

Length 1.2 mm. Color same as in fifth stage nymph. Differs from it in being more elongate and in absence of tibio-tarsal articulation.

Third stage.

Length 1.0 mm. Color as in previous stages. Differs from fourth stage nymph in its smaller size and in possessing two segmented antennae.

Second stage (Fig. 4. L.)

Length .74 mm. Body pale yellow, eyes red, antennae, wingpads and legs pale whitish. Differs from third stage nymph in absence of sclerotisation ventrally and in weak development of wingpads.

First stage (Fig. 4. H.).

Length .58 mm. Color as in second stage nymph. Differs from it in absence of wingpads.

APHALARA NEBULOSA ZETT.

(SUBFAMILY LIVIINAE)

Nymphs of the first and the last two instars only are available and are described below. It is believed that the nymph of only one instar i.e. the third, is missing.

Host: Epilobium angustifolium.

Locality: Dalkeith, Galashiels, Edinburgh.

Fifth stage (Fig. 8. A.)

Length 2.2. mm. Body yellow, eyes deep pink, antennae, wingpads and legs brown, sclerotised areas dark brown.

Form: Pauropsylline. Sclerotisation on dorsum extends to a pair of broad areas on head, two pairs of large and a number of smaller pairs of areas on thorax, three pairs of transverse areas on anterior abdomen and to its entire posterior half. Ventrally apical fourth of abdomen, three median, three pairs of submedian and of marginal areas are sclerotised. Dorsum thickly covered with small irregularly rounded tubercles, those on abdomen radiating from three pairs of submedian and three or four pairs of marginal areas, which in turn are composed of groups of smaller oval areas up to a maximum of seven (Fig. 8. E.). Pigmentation immediately around these areas darker and sclerotisation heavier. Such areas also present on head and thorax, but not so well marked. Small ring-based setae sparsely scattered all over body.

Head narrower than thorax with a few setae anteriorly. Antennae shorter than width of head, of three segments, two small basal and a long distal one. Thorax about as broad as abdomen. Wingpads triangular bluntly pointed at apex, broadest at base, projecting but little from general contour of body, costal margin with a few minute setae. Legs with femora not reaching body margin, trochanter absent, tibio-tarsal articulation distinct, empodium (Fig. 8 D.) relatively small with two claws at base. Abdomen rounded,

width uniform, posterior half with a number of small dagger-shaped setae, marginally. Anal opening a short distance from apex, outercircumanal pore ring (Fig. 8 B.) composed of two to five layers of oval pores, innermost layer elongate and slit-like, inner ring also composed of two to five layers of round somewhat irregularly placed pores.

Fourth stage.

Length 1.4 mm. Color as in fifth stage nymph. Differs from it in its two segmented antennae and in absence of tibio-tarsal articulation.

Second stage (Fig. 8. F.)

Length .68 mm. Body dull yellow, sclerotised parts including wingpads brown, eyes red, antennae and legs light brown. Differs from fourth stage nymph in having few sclerotised plates on dorsum, absent ventrally except three pairs of small submedian and a small apical area on abdomen, in absence of any radiating arrangement of tubercles on dorsum, in each wingpad possessing only one seta at apex, and in having outer circumanal pore ring single-layered inner ring absent (Fig. 8. I.)

First stage (Fig. 8. J.)

Length .36 mm. Body yellow, eyes red, antennae and legs pale yellow. Differs from second stage nymph in complete absence of sclerotisation ventrally and in absence of wingpads, these being represented by two pairs of sclerotised plates each with a seta.

EURHINOCOLA EUCALYPTI MASKELL

(SUBFAMILY PSYLLINAE)

This species was first reported from New Zealand as Rhinocola eucalypti; later the generic name was changed by Petty (1925) to Eurhinocola. Besides England it has also been recorded from Australia and South Africa. All the stages occurred throughout the year from egg to adult, in England, where the insect was regarded as a pest unlike in New Zealand where it was said by Maskell (1889) to content itself by feeding on a 'white aromatic gummy matter' exuded by the leaves and cause no damage. An account of the biology of the insect has been given by Fox Wilson (1924) from which the following is taken:-

"Larvae are active and live gregariously surrounded by masses of thin cottony threads. Appearance yellowish, though they possess light purplish areas. Nymphs active, live together in colonies, surrounded by light mealy covering. The general appearance is dark on account of broad, dark purplish areas on the head."

The occurrence in England of this insect may be regarded as sporadic and localised as it has not been heard of again since 1924. Short descriptions of the immature stages of this species were also given by Maskell (1889).

The material, which was kindly supplied by Mr. G. Fox Wilson, contains nymphs of the last and three previous stages. On the assumption that this species, like other Psyllidae, has five instars, the first stage nymph must be taken as missing. The rest are described below:

Host: Eucalyptus globulus and E. cordata.

Locality: In England, Felixstowe, Leamington, Handcross (Sussex).

Fifth stage (Fig. 9 A.).

Length 1.2 mm.

Form: Psylline. Sclerotisation on dorsum includes a pair of ocular areas on head, two large pairs on thorax, three pairs of transverse areas on abdomen and to its entire posterior two thirds. Ventrally two pairs of small areas at bases of antennae, one pair next to eyes, a number of median, marginal and apical areas on abdomen are sclerotised. Dorsum studded with small round tubercles, venter with small ringbased setae.

Head as broad as thorax. Antennae of nine segments, third weakly jointed in middle, last longest. Wing pads long, oval, devoid of setae. Legs long and stout, trochanter absent, tibiae markedly swollen towards apices, tibio-tarsal articulation distinct, tarsal extremity with two claws and a cushion-like rudimentary empodium, with a pair of simple setae between it and each claw. Abdomen spherical about middle, a short distance from apex marginally notched inwards on both sides, margin surrounded by small lanceolate setae, ventrally two marginal longitudinal areas present on each side in posterior third of abdomen, consisting of small groups of pores, about thirty in each area. (Fig. 9.F.) Anal opening near apex, outer and inner circumanal pore rings one-layered, pores in former oval, in latter round (Fig. 9.D.)

Fourth stage.

Length .90 mm. Differs from fifth stage nymph in its

shorter seven segmented antennae, in absence of swellings at apices of tibiae and of tibio-tarsal articulation, and in abdominal margin towards apex being less notched.

Third stage.

Length .62 mm. Differs from fourth stage nymph in abdomen being uniformly heart-shaped, in antennae being four segmented and in smaller number of pore groups on ventral side margins, about ten in each area.

Second stage (Fig. 9 B.)

Length .48 mm. Differs from third stage nymph in absence of ventral sclerotisation except a small apical area and of round tubercles on dorsum and in smaller number of pore groups these being four and three in anterior and posterior areas respectively.

TRICHOPSYLLA WALKERI, THOMSON.

(SUBFAMILY TRIOZINAE)

Material kindly supplied by Mr. G. Fox Wilson and the nymph, herein described is of the last instar. The nymphs that are going to be males differ from female becoming nymphs in possessing longer abdomens.

Host: Rhamnus catharticus. Recorded by Edwards (1896) as having been found also on Prunus spinosus and Euonymus europaeus in various parts of England.

Locality: Wisley, Surrey, England.

Last stage. (Fig. 9 L.)

Length 2.4 mm. Body color in alcohol-preserved specimens dirty yellow, eyes deep brown.

Form: Triozine. Body elongated. Sclerotisation extends to entire dorsum and venter except a narrow transverse of abdomen. Body margin uniformly surrounded by closely spaced setae setae (Fig. 9. J.)

Head slightly narrower than abdomen. Antennae of six segments, arising nearer median than marginal line, of six segments, last longest. Wingpads as long as head and thorax together, produced forwards towards head, broadest in basal one third. Legs with femora just reaching wing margins trochanter absent, hind tibiae slightly swollen towards apices, tibio-tarsal articulation distinct, tarsal extremity with two claws and petiolate empodium. Abdomen spherical, with a few minute setae. Anal opening a short distance from apex, outer circumanal pore ring five layered near sides, two layered in anterior median and four-layered in posterior median region; the innermost row of pores oval, rest pentagonal with rounded edges, inner ring also many layered with individual pores round (Fig. 9. G.)

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SECTION IV.

PSYLLIA PEREGRINA FORST THE HAWTHORN RACE OF THE APPLE SUCKER,

PSYLLIA MALI SCHMIDBERGER

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PSYLLIA PEREGRINA FÖRST, THE HAWTHORN RACE OF THE APPLE SUCKER,
PSYLLIA MALI, SCHMIDBERGER.

My work on Scottish psyllidae revealed the occurrence, on hawthorn, of more than one species in the Edinburgh region, which were identified as Psyllia melanoneura Först, P. peregrina Först and P. mali Schmidberger. The first-named insect has always been recognised as a distinct species, but the adults of the other two were found to be practically indistinguishable. The nymphs of the two latter are also alike but different again from those of typical nymphs of the apple sucker. As their identity was in doubt it was resolved to elucidate their true systematic position by the following criteria:-

1. Comparison of the adults of the hawthorn insects, P. peregrina and P. mali with each other and with typical P. mali bred on apple.
2. Comparison of the nymphs of the hawthorn species with nymphs of P. mali from apple.
3. Experiments calculated to test the survival capacity of the hawthorn nymphs when transferred to apple and vice versa.
4. Mating experiments of adults bred respectively on hawthorn and apple and differential oviposition on hawthorn and apple of each of the two insects.
5. Comparison of the life histories of the two insects on hawthorn and on apple.

The conclusions based on a study of the above questions may be summarised in advance:-

1. Psyllia peregrina and P. mali of the hawthorn are identical in that they are only the seasonal forms of one and the same species. These insects are also morphologically indistinguishable from P. mali on apple.
2. The nymph of the forms occurring on hawthorn is different from the typical apple sucker nymph, and has long been known as the nymph of Psyllia peregrina. It however, produces a small proportion of variations in which the brown longitudinal streak on the wingpads, characteristic of the latter, does not occur.
3. Although similar morphologically, specimens of P. mali from hawthorn and from apple do not mate with each other, nor do they oviposit interchangeably on each other's host plants. Their nymphs when transferred to the food plants of each other do not survive very long.
4. Psyllia mali of the apple has a biological race on hawthorn which has long been known as P. peregrina. The correct name of this race should now be Psyllia mali Schmidberger race crataegi. These two races, the original one on apple and the other on hawthorn, in view of their dissimilar nymphs furnish a case of poecilogony.

LIFE HISTORY

The life history of the two psyllids on hawthorn and apple is similar and does not differ materially from the account given by Awati (1915) of the life history of the apple sucker in England. In S.E. Scotland the adults of both appear towards the end of May and may be found in the field till the end of October. Both the insects lay eggs on

twigs of their hosts in September and October and die, the winter being passed in the egg stage. Hatching occurs in the first week of April and the nymphs, especially the first three instars, are gregarious, concealing themselves in between the folds of the leaf buds. The nymphs, as is the rule in most psyllidae, moult five times, and wingpads appear after the first ecdysis in the apple forms, and a little later, sometimes not before the second ecdysis, in the hawthorn forms. There is no difference between the habits of the nymphs of the two forms.

Pyrus malus is favoured by the apple form and Crataegus oxycantha by the hawthorn form. Other species of the host genera are also attacked with varying degrees of intensity and there are certain species which are almost entirely neglected. An idea of this preference was obtained by examining the twigs of various hosts for eggs, at the height of the egg laying season. The results are tabulated below:-

Species of <u>Pyrus</u> .	Eggs laid.	Species of <u>Crataegus</u> .	Eggs laid.
1. <u>malus</u>	Very plentiful.	1. <u>oxycantha</u>	Very plentiful
2. <u>prunifolia</u> var <u>colvellei</u> .	"	2. <u>blanchardi</u>	"
3. <u>baccata</u> var <u>purpurea</u>	"	3. <u>tennowana</u>	"
4. <u>acuparia</u>	Plentiful	4. <u>pasgens</u>	"
5. <u>prunifolia</u> var <u>pendula</u>	"	5. <u>populnea</u>	"
6. <u>eleyi</u>	"	6. <u>sorbifolia</u>	"
7. <u>communis</u>	"	7. <u>heldreichii</u>	"

Species of Pyrus	Eggs laid	Species of Crataegus	Eggs laid.
8. <u>salicifolia</u>	scarce	8. <u>pyrifolia</u>	plentiful
9. <u>oblonga</u>	"	9. <u>crus-galli</u>	"
10. <u>commixta</u>	Very scarce	10. <u>hupchensis</u>	scarce.
11. <u>amygdaliformis</u>	"	11. <u>mollis</u>	"
12. <u>pubescense</u>	"	12. <u>pinnatifida</u>	"
13. <u>canescens</u>	"	13. <u>nitida</u>	"
14. <u>pinnatifida</u>	"	14. <u>coccinea</u>	"
		15. <u>penitagnyna</u>	Very scarce.

The above observations were made in the Royal Botanic Gardens, Edinburgh, where trees of both genera were growing on the same lawns and under exactly similar conditions.

ADULT MORPHOLOGY.

The forms of P. peregrina (old name) emerging in spring are green insects, noticeably smaller than P. mali of the apple. A large proportion of the nymphs, however, complete their life-cycle later in spring and early summer and from these emerge adults which closely approach the apple sucker in size and coloration and were invariably identified as such.

The chief characters used to separate species in Psyllidae are the shape and size of antennae, genal cones and the vertex, the shape, size, and color of the elytra and their veins and of the genitalia. In all these respects the two forms from hawthorn and apple resemble each other. Both have the antennae about twice the length of the head-width, with the last two segments invariably, and apices of segments 4-8

often, dark. Genal cones are somewhat pubescent and roughly triangular, their length less than the vertex down the middle and their divergence not more than the base of either. Both insects have typically the same shape and size of elytra with relatively long prostigmata and pale yellowish to brownish veins. The male genitalia in both are pubescent and have the anal valves moderately long and broad, ending in bluntly rounded apices. The forceps are narrower, slightly shorter, ending in black claws and equally pubescent. The female genitalia of both have the anal valve slightly longer than the subgenital, abruptly narrowed to a blunt point in distal third and pubescent.

The only difference noticeable in the two insects is with respect to their size, the hawthorn forms being slightly smaller, especially in early summer, than the apple ones and also less stout. The former measures 2 to 3 mm. in length; the latter 3 to 3.5 mm. This difference, however, is inconstant and occasionally adults of the hawthorn form are encountered which are stouter than the average and of the apple form smaller than the average.

MORPHOLOGY OF THE NYMPH.

In general shape and size the nymphs of P. mali of the hawthorn resemble those of the apple sucker. Both measure 2 to 2.5 mm. in length. The most characteristic difference, however, is the presence of a longitudinal brown streak on the wings of the last instar of the former which is absent in apple sucker nymphs. These streaks are not

apparent at all in a small proportion of the nymphs. Another difference occurs in the setae surrounding the abdominal margin of the two nymphs. In the hawthorn forms, they are all of one kind, long and spatulate; in the apple sucker they are of two kinds: long pointed variously curved setae and smaller spear-shaped setae. The nymphs of the former have also round tubercles on the dorsum in place of the very minute setae that invest the body of the latter. The circumanal pores are nearly similar in both.

EXPERIMENTS ON OVIPOSITION.

Adults from hawthorn and apple were collected in the field from the end of August to the beginning of October, and were confined on each other's host plants in small cellophane cages enclosing small twigs and having their entrances closed by means of cotton wool. The experiments were repeated, many times and the results were always negative. Control experiments were also made in which insects were put on their own food plants. In these cases eggs were laid, showing that the conditions prevailing in the greenhouse did not preclude oviposition.

Original host.	Number of Specimens.	Host on which transferred.	Number of eggs laid.	Duration of experiment.
Hawthorn	30 males & females.	Apple	0	1.IX.32 to 12.IX.32
"	20 "	"	"	20.IX.32 to 24.IX.32
"	20 "	"	"	20.IX.32 to 1. X.32
"	20 "	"	"	7. X.32 to 14. X.32

Original Host.	Number of Specimens.	Host on which transferred.	Number of eggs laid.	Duration of experiment.
Hawthorn	15 males & females.	Hawthorn	12	24.IX.32 to 14. X.32
"	16 "	Pear	2	7. X.32 to 14. X.32
Apple	25 "	"	10	24.IX.32 to 29.IX.32
"	25 "	"	26	29.IX.32 to 7. X.32
"	25 "	Mountain ash	4	24.IX.32 to 29.IX.32
"	40 "	" "	7	29.IX.32 to 7. X.32
"	25 "	Hawthorn	0	7.IX.32 to 24.IX.32
"	20 "	"	0	" " "
"	25 "	"	0	" " "

EXPERIMENTS IN MATING.

These were performed by confining large numbers of adults from apple and hawthorn, in large glass jars supplied with twigs of both trees stuck in moist sand. The top of the jar was covered with muslin and care was taken that insects of one sex from one host were confined with insects of the opposite sex from the other host. In this way it was ensured that males and females copulating inside the glass jars were derived from different hosts. This experiment was repeated many times and was also performed by confining the adults in cellophane cages on twigs of plants in pots. No case of mating was observed although there were many successful pairings in control jars, wherein adults reared on the same host were confined.

TRANSFERENCE OF NYMPHS TO DIFFERENT HOSTS.

To test their survival capacity when put on different food plants nymphs, of all instars, from apple and hawthorn

were put on hosts other than their own. This was effected either by confining the nymphs on fresh leaves in small wide-mouthed jars or putting them on labelled growing twigs of a potted plant. The nymphs travel little and so the possibility of their migrating to neighbouring twigs is remote. To obviate such a contingency, however, a band of cotton wool, was attached round the bases of the twigs, which the nymphs could not cross. The results are tabulated below:-

Original host.	Number of nymphs.	Host to which transferred.	Duration of experiment.	Result.
Apple	18 I, 2II	Hawthorn	April 7 to 17	The majority of the nymphs lived during this period, secreting and moulting.
"	15 III & IV.	"	April 17 to May 5.	"
"	18I & II	Raspberry	April 7 to 8	All died quickly.
"	20I & II	Mountain ash.	April 7 to 17	A few lived and secreted during the whole of this period.
"	20 I	Pear	April 7 onwards.	Many were reared to adult stage.
Hawthorn	20 I & II	Apple	April 7 to 11	A few lived during this period and secreted. None after it.
"	7 II & III	"	April 17 to 25.	"
"	20 IV	"	April 26 to May 2.	Only one nymph survived this period.

The Roman numerals indicate the instars of the nymphs.

DISCUSSION.

Since 1848 when it was first described by Förster, Psyllia peregrina has been treated by most authors as a species distinct from Psyllia mali. Scott (1880) in describing its nymph and adult doubtfully gave P. mali as one of its synonyms. P. peregrina and P. mali were also recognised as two separate species by Edwards (1896) and by Aulmann (1913). Sulc, however, (vide his synonymy of P. mali, cited by Speyer (1929)) regarded P. peregrina as a synonym of P. mali. In the descriptions of the former given by Löw (1879) Scott (1880), Edwards (1896) and Kuwayama (1907) there is little that is not equally applicable to P. mali and the same may be said of the descriptions of the latter given by various authors from time to time, with respect to P. peregrina. Löw's (loc. cit) and much of Scott's (loc. cit) descriptions of P. peregrina are based on the color of the various parts of body, a very inconstant feature in the genus Psyllia. Edward (loc. cit) separates P. mali from P. peregrina by the differences of food plant and size. The latter, again is not reliable and late in summer and early autumn insects reared on hawthorn are about as robust as the typical apple sucker.

The two insects from apple and hawthorn are thus morphologically indistinguishable as adults but, as stated before, differ in their nymphal stages. The question of their correct systematic position, therefore, largely turns upon what we accept as the criteria of specific separation

in these insects. It seems to the present writer that in Psyllidae, at least differences of biology, host plants and even of immature stages, can, at best, serve as confirmatory evidence in the differentiation of species which must be primarily based on constant peculiarities of adult morphology. Judged by this test P. peregrina is not specifically distinct from P. mali and the two must be regarded as one species.

Experiments detailed in the foregoing pages have shown that the insects on hawthorn and on apple are closely confined to their individual food plants and the nymphs of the one do not live long when transferred to the host plant of the other. Nor do they show any tendency to mate with each other or lay eggs on each other's host plants. In view of these facts it is concluded that P. mali on apple has a race on hawthorn inseparable from it in adult morphology but with differences in biology and immature stages. To this latter is given the name of Psyllia mali Schmidberger race crataegi.

As a rule the members of two biological races of a single species are morphologically identical in all their post-embryonic development. There are exceptions, however, of which two cases have been cited by Thorpe (1930), one of Paraphorocera senilis, a Tachinid parasite of the European corn-borer investigated by Thompson (1922) and the other of Pales pavida Meig, also a Tachinid, in both of which the biological races were indistinguishable as adults but showed constant differences in larval morphology. As pointed out by Thorpe (loc. cit.) such cases are rare among insects but

that they can exist as a practical possibility has been shown mathematically by Thompson (loc. cit) by taking two continuous series of curves - a circle and a Pascal's snail - expressed by different formulae and consequently fundamentally different when taken as a whole; nevertheless, under certain circumstances being practically indistinguishable in certain homologous portions of their trajectories. Thompson (loc. cit) also asserts that poecilogony cannot be considered to furnish any evidence either for convergence or divergence in evolution, because it can be understood without reference to either. This may be true theoretically but a static existence with no evolutionary role of any kind seems to be the least likely thing in nature and obviously two closely-allied forms grow either more or less alike in course of time. It has been pointed out that a small proportion of the nymphs of the hawthorn form show no brown longitudinal streak on their wingpads, a characteristic, which more than any other distinguishes them from the nymphs of the apple form. This might be taken to show that in cases of poecilogony, while the characters separating two larvae of two biological races are fairly constant, in a small number of cases, some of them shown by one may approximate to those shown by the other and hence lead to greater similarity between the two. This may not, however, necessarily mean an obliteration of the differences in their biology.

It is at best only possible to speculate whether such cases will lead to a convergence to one species or to a divergence into two. Thorpe (loc. cit) is of opinion that such cases,

can be explained more satisfactorily on the hypothesis of evolutionary divergence than of convergence. This explanation might possibly apply also to the races of P. mali, where the nymphs remains in intimate contact with their hosts throughout life and any changes of structure that might be attributable to differences of food plant would be more likely to appear in the nymphs than in the adults.

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SECTION V.

INSECT PARASITES OF PSYLLIDAE.

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INSECT PARASITES OF PSYLLIDAE.

This section contains an account of insect parasites bred out of Psyllid hosts in the course of studying their biology in Scotland. These belong to four families of Hymenoptera and two of Diptera, the total number of species encountered being eight. Of these one and possibly two more of the hymenopterous species are hyperparasites. The hosts involved include four species, of which only one Psyllia mali, race Crataegi may be said to have been fairly heavily parasitised. As observed by Ferriere (1926) species of Psyllidae, inspite of their nymphs leading a comparatively sedentary life, are less susceptible to attack by parasites than are the other Homoptera. As a rule the hymenopterous parasites attack them in the nymphal stage, while the dipterous species parasitise the adults as well.

Waterston (1922) has given a list of Chalcid parasites of Psyllidae with original descriptions of some of them. Since then some new records of Chalcid and other parasites have come to notice and it is considered advisable to list all of them here, omitting only those already mentioned in Waterston's paper (loc. cit.).

PARASITES ATTACKING NYMPHS.

Parasite species	Family & superfamily	Host species.	Country.	Referance
1. <u>Pachyneuron validium</u> Waterston	Pteromalidae (Chalcidoid- ea)	<u>Euphyllura arbuti</u> Schwarz	California	Waterston 1923
2. <u>Pachyneuron</u> sp.	"	<u>Psyllia mali</u> Schmidberger race <u>Crataegi</u> .	Scotland	Present work.

Parasite species	Family & Superfamily.	Host species.	Country	Reference.
3. <u>Asaphes vulgaris</u> Walk.	Pteromalidae (Chalcidoid- ea)	<u>Psyllia mali</u> Schmidberger race <u>Crataegi</u>	Scotland	Present work
4. <u>Pteroptrix maskelli</u> Ashm.	"	<u>Eurhinocola eucalypti</u> Maskell.	New Zealand.	Gourlay 1930.
5. <u>Prionomitus mitratus</u> Dalm.	Encyrtidae (Chalcidoid- ea)	<u>Psyllia pyrisuga</u> Först.	France	Ferrière 1926
6. "	"	<u>P. retamae</u> Pub.	Spain	Mercet. 1926.
7. "	"	<u>P. mali</u> Schmidbg. race <u>crataegi</u> .	Scotland	Present work.
8. <u>Cercobelus jugosus</u> Walk	"	<u>Psyllopsis fraxinicola</u> Forst.	"	"
9. <u>Psyllaephagus arbuticola</u> Gahan and Waterston.	"	<u>Euphyllura arbuti</u> Schwarz.	California	Gahan and Waterston 1926.
10. <u>P. euphyllurae</u> . Silv.	"	<u>E. olivina</u> Costa	Italy, Sicily, Portugal.	"
11. <u>P. iwayaensis</u>	"	Psyllid sp. on cinnamomum.	Japan	Ishi 1928.
12. <u>P. phytolymae</u>	"	<u>Phytolyma lata</u> Scott.	Nigeria	Ferriers 1931.
13. <u>Psylledontus viridiscutellatus</u>	"	Psyllid sp. on <u>Elaeagnus</u>		Ishi 1928.
14. <u>Aprostocetus roseveari</u>	Eulophidae Chalcidoid- ea.	<u>Phytolyma lata</u> Scott.	Nigeria	Ferriere 1931.
15. <u>Platygaster</u> sp.	Platygasteridae (Proctotrypoidea)	<u>Psyllia mali</u> Schmidbg. race <u>crataegi</u> .	Scotland	Present work.

PARASITES ATTACKING ADULTS.Order Diptera: family Cecidomyidae

Parasite species.	Host.	Country	Reference.
1. <u>Endopsylla</u> <u>agilis</u> de Meijere.	<u>Psyllia</u> <u>försteri</u> Flor.	(i) England (ii) Holland	(i) Bagnall and Harrison (1924) (ii) Barnes (1930)
2. <u>Endopsylla</u> sp. n.	<u>P. mali</u> Schmidbg. <u>P. pyricola</u> Fürst. <u>P. melano-</u> <u>neura</u> Fürst.	Scotland	Present work.
3. <u>Lestodiplosis</u> <u>liviae</u> 1 Rubo.	<u>Livia</u> <u>juncorum</u> , Latr	Germany England	Barnes (<u>loc.cit</u>)
4. <u>Lestodiplosis</u> sp.		Europe	"
5. <u>Bremia</u> sp.	<u>Psyllopsis</u> <u>fraxini</u> Lin.	"	"

HYPERPARASITES ATTACKING PRIMARY ENCYRTID PARASITES.

Hyperparasite	Family and superfamily.	Host: (Primary parasite)	Country	Reference.
<u>Lygocerus</u> <u>semiramosus</u> Kieff.	Calliceratidae (Proctotrypoi- dea).	<u>Prionomit-</u> <u>us mitrat-</u> <u>us</u> . Dalm. and an- other un- identified Encyrtid.	Scotland	Present work.

-
- 1 This species is also recorded by Bagnall and Harrison (loc.cit) as living as inquiline in the gall of Livia juncorum on Juncus sp., in Durham, England.

PARASITES OF PSYLLIA MALI SCHMIDBERGER RACE CRATAEGI.

Six of the eight species recorded in this section were found to parasitise P. mali race Crataegi. A short life history summary of this insect, is, therefore, given below:
Life history of P. mali race Crataegi.

The adults appear about the end of May and are found in the field till the first week of October. Eggs which are laid in the latter part of autumn, overwinter and hatch early in April. The nymphs creep to the half-opened leaf buds and feed gregariously in the first two instars. Later they distribute themselves over the undersurface of the leaves and on the petioles where they feed singly and secrete little tubes of white waxy substance. The nymphal life lasts for about seven weeks and nymphs of the last instar become abundant in the field about the middle of May. The adult insects are at first rather small (2.5 mm. in length) and green, later they are more robust and brownish and even reddish. It was observed that the color of the males changed earlier than those of the females. Mating starts in the last week of August and eggs are laid on the twigs of the host plant, a few days afterwards, till the middle of October, when the adult insects die. Hawthorn is the sole food plant and it is not possible to rear this race successfully on apple.

PARASITES ATTACKING NYMPHS.

The following hymenopterous species were reared in the

laboratory from parasitised nymphs brought from the field:-

1. Prionomitus mitratus Dalm (Encyrtidae: Chalcidoidea).
2. Encyrtid sp. (Unidentified) " "
3. Platygaster sp. (") (Platygasteridae: Proctotrypoidea)
4. Lygocerus semiramosus Kieffer (Caliceratidae: Proctotrypoidea)
5. Asaphes vulgaris Walk. (Pteromalidae: Chalcidoidea).
6. Pachyneuron sp. (" ")

Of these the first two species were fairly common and by an arbitrary estimate were reckoned to parasitise 20 to 30% of the nymphs. Prionomitus mitratus has been reported by Ferrière (1926) as a parasite of Psyllia pyrisuga Först and by Mercet⁽¹⁹²⁶⁾ as a parasite of Psyllia retamae Pub. Other species of the genus have been known as parasites of Coccids. Members of an allied genus Psyllaephagus, have also been known to parasitise many species of Psyllidae and the two are so alike in biology and morphology that they have sometimes been regarded as synonymous. This is especially the case because of the difficulty of separating the females of the two genera, the males being distinguished chiefly by the long hairs of the antennae in Prionomitus and short hairs of the antennae in Psyllaephagus. This view, however, is not upheld by Mercet (loc. cit) who has given characters differentiating the two genera. Parasitism by species of Platygasteridae was very rare. Lygocerus semiramosus is a hyperparasite of Prionomitus mitratus and the other unidentified Encyrtid. The last two species A. vulgaris Walk and Pachyneuron sp. are considered by Dr. Ferrière, to whom the insects were submitted for identification as hyperparasites as they have been also

bred from parasites of aphids. Two other species of Pachyneuron have been recorded by Waterston (1922, 1923) as parasites of Psyllidae; P. crassicium Waterston parasitising Rhinocola populi Laing, the psyllid attacking Populus euphraticus in Mesopotamia and P. validium Waterston parasitising Euphyllura arbuti Schwarz in California.

PARASITES: PRIONOMITUS MITRATUS AND THE UNIDENTIFIED ENCYRTID.

Parasitised nymphs of Psyllia mali race Crataegi occur in the field from the first week of June to the middle of September and may be recognised by their bloated appearance and deep brown coloration. Their protracted occurrence may be attributed to the fact of the hyperparasites attacking the primary parasites and starting their development when it was almost time for the latter to emerge. The assumption of brown color by the nymphs marks a late stage in the development of the parasite, when the viscera of the former has been almost completely devoured by the parasitic larva which then pupates in a membranous sheath inside the host's body. Husain and Nath (1923) have recorded a similar change in the color of the nymphs of Diaphorina (Euphalerus) citri Kuw. when parasitised by Tetrastichus radiatus Waterston (Eulophidae). The Encyrtids emerge through a round hole in the dorsum of the abdomen; seldom, the exit is made on the ventral side. A few days before emergence the black body of the parasite is apparent through the integument of the host and the head of the former is always turned towards the posterior end of the latter. The first batch of parasites appeared on 29.VI.33 in the laboratory. The adult insects are

black and shiny and have a pronounced sexual dimorphism in the antennae; the flagellar segments of which, except the last one, are triangular and hairy in males, and rounded and without hairs in females. Many specimens of P. mitratus were beaten from coniferous trees, growing in the vicinity of ash and hawthorn, in November and December, and hence, it is possible, that they pass the winter in the adult stage.

HYPERPARASITE. LYGOCERUS SEMIRAMOSUS KIEFFER.

From the parasitised nymphs adults of L. semiramosus were also reared. These were believed to be hyperparasites of P. mitratus and the unidentified Encyrtid. They appeared towards the middle of September and considering the fact that three of their egg-shells with the larvae just hatched were dissected from a nymph on 28.IX.32, it may be presumed that they were acting as tertiary parasites of a secondary parasite or of their own species. A parallel instance of hyperparasitism has been recorded by Haviland (1920) in the case of the quaternary Lygocerus cameroni Kieffer attacking a tertiary Chalcid or a Cynipid which was parasitic on a secondary Chalcid/Aphidius ervi, a Braconid which was parasitising an aphid, Macrosiphum urticae.

The egg of L. semiramosus is long elliptical, .67 x .28 mm., the whole surface being sculptured with fine longitudinal striae. The larva emerges through an opening at the anterior end at which an operculum separates from the remainder of the egg. The larva is a small grub, creamy-white in color and measuring .45 x .15 mm.

The male adult insect was first described by Kieffer (1907) and later redescribed by the same author (1914). The latter description is given below:-

Male. Schwarz, glanzend. Kopf fast glatt, brieter als der Thorax. Ocellen einen Bogen bildend. Die 5 proximalen Glieder des Flagellum medial mit einem Fortsatz, der $1\frac{1}{2}$ mal so lang wie breit und lang behaart ist, die Haare 2 mal so lang wie der Fortsatz, am 1. Flagellumglied ist der Fortsatz so lang wie am 2, aber breiter, 8-10. Glied fast viereckig, 11. walzenrund. Thorax fast glatt. Flügel glashell, Pterostigma halbkreisförmig, etwas kürzer als die Radialis, Subcostalis am Distalende verdickt. Beine schwarzbraun. Abdomen glatt, Petiolus quer und gestreift. L. 1.5 mm.

The female (Fig. 2.A.) measures 1.4 mm. in length and its antennae differ from those of the male both in shape and in the absence of long hairs. The basal segment of the latter is .27 mm. long and stout, followed by the 10 small, somewhat cylindrical segments of the flagellum, gently curved as a semicircle. The terminal segment is twice as long as others preceding and measures .11 mm.

Various species of *Lygocerus* have been recorded as parasites or hyperparasites of aphids and other Homoptera. *L. semiramosus* was recorded by Kieffer (loc. cit) from Scotland and France but its hosts were unknown.

PARASITE ATTACKING ADULT.

Parasites of adult Psyllidae have been recorded only from the Dipterous family Cecidomyidae (See list on p.124)

and Speyer (1929) recently recorded an unidentified Cecid species parasitising Psyllia mali (apple form), figuring the egg and the apparently full grown larva. In this region¹ the Cecid parasite discovered proved to be a new species of the genus Endopsylla, and its hosts were Psyllia mali Schmidberger race Crataegi, P. mali race mali, P. melanoneura Först. and P. pyricola. The first-named race of P. mali was the most heavily parasitised and observations recorded here refer chiefly to this species as host. The percentage of parasitism in P. mali race Crataegi in this locality may be judged from the following tabulated counts made on random collections:-

Date	Number of adults examined.	Number of adults parasitised	Percentage
13.IX.32	79	32	40.5
13.VI.33	67	14	20.8
26.VI.33	68	15	22.5
30.VI.33	57	13	22.8
21.VII.33	137	28	20.4
4.VIII.33	24	9	37.5

Observations showed that the incidence of parasitism was higher in female psyllids than in males.

EFFECT OF PARASITE ON HOST.

The first symptoms of the presence of the parasite appear when the parasitic larva pierces the abdomen of the host and passes into the homocœle. The psyllid gradually becomes more

¹ This species is being described from the material sent by me, by Dr. H.F. Barnes of the Rothamsted Experiment Station.

and more sluggish until it loses all power of jumping and the abdomen becomes swollen as a result of the growing larva inside. As the parasitic larva develops during the egg-laying season of P. mali, the swollen abdomen of the host may well be mistaken for that of a gravid female. In female hosts the ovarian eggs may develop up to a certain stage, simultaneously with the parasitic larva. A Cecid larva and 12 mature eggs were found in a female on 13.IX.32. Healthy females showed as many as 22 mature eggs at this period. When the larva is ready to emerge for pupation, however, no trace of eggs or viscera is left in the moribund psyllid body. Unlike their nymphs, the parasitised adults do not undergo any change of coloration due to the presence of the parasite.

BIOLOGY OF ENDOPSYLLA SP. N.

Egg. Very small, narrowly oval with a minute basal stalk, .17 x .06 mm.; chorion smooth.

Eggs are laid singly on the forewings, their basal stalk being inserted in the wing-membrane alongside one of the veins. As a rule one egg, rarely 2 or 3, is deposited on either wing of the host, seldom on both. (Fig. 3.E.) Color pale yellowish white turning deep yellow near hatching, when the two red eyes of the larva shine through the chorion. Eggs were first noticed early in June and may be found in the field as late as the middle of August.

Larva. The eggs hatch in about 8-13 days and the larvae crawl from the wings to the body of the host. There they usually feed for 3-4 days as ectoparasites, after which they

burrow through one of the intersegmental membranes into the hōemocoele of the psyllid. They remain inside for 6-10 days devouring the viscera of the host till they are well developed maggots. They then pierce the host abdomen at its base and make their way out again. They crawl and live a day or two on hawthorn leaves and then drop to the ground to pupate. Three stages of the larvae could be distinguished and these are described below:-

First stage. Just before burrowing into the host abdomen.

2 or 3 days old. Creamy yellow grub, 13-segmented including the cephalic segment. .47 x .21 mm.

Second stage (Fig.3.F) Dissected from host abdomen.

Differs from the previous larva in its larger size and more pronounced oral aperture carried on a minute papilla. .90 x .45 mm.

Third stage (Fig.3.A) Larva just emerged from host abdomen,

prior to pupating. Creamy yellow, often with deep green or orange pigmented material shining through integument. Differs from previous larva in possessing a pair of small single-segmented antennae a well developed retractile oral papilla and a sternal spatula in the post-cephalic segment. The mouth parts (Fig.3.C) are well formed (being used to cut through the integument of the host) and consist of a labium, a pair of slender but sharply-pointed maxillary stylets, a pair of stout forwardly projecting mandibular stylets, a labrum and two pairs of heavily sclerotised skeletal bars running posteriorly

Anal segment slightly notched in middle with two small setae each on a small protuberance on either side. 1.90 x .64 mm.

Pupa.

Just before pupation the larva starts weaving a fibrous case round itself which later takes the shape of the adult insect and is shed like a moulted skin after its emergence. The pupal stage lasts for about 6 days in early autumn and the adult emerges by rupturing the pupal skin anteriorly with its forelegs and pulling itself out by convulsive movements of the body. The entire body was observed to be free in 8 minutes while it took another 65 minutes for the insect to disentangle its antennae and hind pair of legs from the pupal covering which measured 1.14 x .43 mm. It has to be emphasised, however, that the observations were made on a pupa resting on the smooth glass surface of a watch-glass which provided no assistance for the ready emergence of the adult.

Adult (Fig. 4. A) The first adults, reared in the laboratory, appeared in the first week of July. As the eggs are found long after this period, it is possible that a second generation also occurs, although I have no definite evidence for this. The adult cecids are of bright orange color, with blackish brown eyes and are very active. They were invariably observed to be attracted to the top of the jars in which they were being reared, towards the light. The insects are characterised by marked sexual dimorphism of the antennae. In both sexes, the two basal segments are cup-shaped, one

fitting into the other. In the male antennae the segments other than the basal and the terminal consist of two bulbous portions, each a little different in shape, from the other and two tubular constrictions. Besides numerous minute pointed structures, the proximal bulbous portion is ornamented with a whorl of arched filaments [filets arquès of Kieffer (1913)] and the distal bulbous portion with two. In the female antennae each segment except the two basal and the terminal, has only one elongated bulbous part and a tubular constriction following it, and the arched filaments are replaced by small bristles. In both sexes the antennae are 12-segmented. The male adult measures 1.2 mm. in length and the female 1.4 mm.

PARASITES OF PSYLLOPSIS FRAXINICOLA FORST.

The only parasite bred from the nymphs of this psyllid was an Encyrtid, Cercobelus jugoeus Walker, a very rare species and known only from the British Isles, although its host was previously unknown. Parasitism due to this species was neither high nor widespread and the parasitised nymphs showed all the symptoms exhibited by the nymphs of Psyllia mali race Crataegi when similarly attacked by other Encyrtids. The parasitised nymphs were collected in the field in August at Boghall (Midlothian) and Dalkeith (Midlothian).

A specimen of Brachycerous parasite (Diptera) was dissected from a nymph of P. fraxinicola, but has not yet been identified.

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