

STUDIES ON THYSANOPTERA.

Thesis submitted by,

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for the

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MORPHOLOGY AND ANATOMY OF THYSANOPTERA.

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stylifera Trybom. These two varieties are chiefly distinguished by the number of antennal joints. Females are found throughout the year. Males are very rare and only few *A. stylifera* males were collected. No *stylifera* males were found by me. The larvae also occur on grass and are common. Pre-pupae and pupae are found with great difficulty. No male larvae, pre-pupal or pupal stages ever came to notice. The other species, *Limothrips cerealium* Haliday, is the well known corn thrips, which has been believed to cause sterility in oats and wheat. It is found during spring and summer on grasses, wheat and oat plants. The eggs are laid in slits made in leaves and the larvae after hatching go inside the leaf sheaths or core of corn. Almost all the stages were found simultaneously on wheat and oat plants in summer.

I. INTRODUCTION.

The present piece of work deals with the external morphology of two species of thrips, Aptinothrips rufus and Limothrips cerealium; and the internal anatomy of some of the species representing the two sub_orders of Thysanoptera. Aptinothrips rufus Gmelin, is the common grass inhabiting species and occurs either singly or mixed up with its variety stylifera Trybom. These two varieties are chiefly distinguished by the number of antennal joints. Females are found throughout the year. Males are very rare and only few A. rufus males were collected. No stylifera males were found by me. The larvae also occur on grass and are common. Pre_pupae and pupae are found with great difficulty. No male larval, pre_pupal or pupal stages ever came to notice. The other species, Limothrips cerealium Haliday, is the well known corn thrips, which has been believed to cause sterility in oats and wheat. It is found during spring and summer on grasses, wheat and oat plants. The eggs are laid in slits made in leaves and the larvae after hatching go inside the leaf_sheaths or ears of corn. Almost all the stages are found simultaneously on wheat and oat plants in summer.

A review of the previous literature shows that except a short description of adult stages, the young forms of A. rufus, and L. cerealium have never been completely described. The female pre_pupae of A. rufus and the male pre_pupae and pupae of Limothrips cerealium are described here for the first time. The collection of Aptinothrips rufus revealed the presence of certain unusual antennal deformities, which are also described here in detail. The mouthparts of L. cerealium were studied, and are described here, establishing the homology as far as possible. A short note on the embryology of L. cerealium is also included.

The internal anatomy of Thysanoptera has been very little studied. This is partly due to the minute size of insects. Most of what is known is due to the pioneer work of Jordan (1888), Uzel (1895) and Buffa (1898). In 1915, Peterson made a study of the salivary glands and head_glands in H. femoralis and Cephalothrips yuccae. In 1926, Klocke published a paper on the anatomy and histology of Thysanoptera. But his work does not present a connected view of the different internal parts.

Ten common species were taken for dissection purposes which are:-

AEOLOTHRIPIDAE:- 1. Melanthrips fuscus (Sulzer).

THRIPIDAE:-/

THRIPIDAE:- 1. *Aptinothrips rufus* (Gmelin); 2. *Odontothrips ulicis* (Haliday); 3. *Limothrips cerealium* (Haliday); 4. *Heliethrips haemorrhoidalis* (Bouché); 5. *Taeniothrips vulgarissimus* (Haliday); 6. *Taeniothrips atratus* (Haliday); 7. *Thrips tabaci* (Lindeman); 8. *Kakothrips robustus* (Uzel).

PHLOETHRIPIDAE:- 1. *Haplothrips distinguendus* (Uzel).

The digestive system presents some peculiarities and in order to homologise the parts in the three families of thrips, with the typical digestive system of other insects, certain new nomenclature has been introduced where considered necessary. So far only four rectal glands were known to occur in thrips and I also found usually four in most species; but in *Melanthrips fuscus*, five rectal glands were found for the first time in Thysanoptera. The salivary glands also show difference of form and attachment, and in the course of anterior ducts. The female reproductive organs are more uniform except the difference in the form of receptaculum seminis; but the male reproductive organs show sometimes great dissimilarity. In *Odontothrips ulicis*, a third kind of unpaired gland is found and in *Taeniothrips atratus*, the two testes are connected by a commissure. These structures are not found in other species of thrips examined. Besides, other/

other minute details of form, and internal structures or their abnormalities are noted and described.

The work was done in the Department of Agricultural Zoology, University of Edinburgh, under the supervision of Dr C.B. Williams. I am greatly indebted to him for suggesting this work to me and for placing at my disposal, all his collections and literature on Thysanoptera without which the present paper could not have been written. I am also grateful to Dr G.D. Morison for identifying a few species of thrips for me, and for sending me a specimen of the male of Aptinothrips rufus var stylifera.

1. Chloral hydrate	30 cc.
2. Glycerine	40 cc.
3. Dist. Water	50 cc.
4. Chlorhydrate of Cocaine	0.5 gm.

Filter after mixing:

This medium had the advantage that it was very convenient. Killing, fixing and mounting was done in a single operation by placing the specimen directly in a drop of the fluid. The first stage larvae, which in alcohol tend to shrink, died in an extended position in this medium; and the heads on the body of the young and adults were also clearly seen.

The study of chitinous parts and the distribution of hairs on the body, was done by boiling the specimens for

II. TECHNIQUE.

Thrips were first collected on a white sheet of thick paper-board; and killed by transferring them in 70% alcohol with a fine brush. They were later on passed through 90% and then absolute alcohol. Clearing was done in Carbol-xylol, and specimens were mounted in balsam.

The other medium recommended by Dr Imms (1929) was also tried and found very satisfactory for these insects. The medium consists of the following ingredients.

- | | | | | | |
|----|-------------------------|---|---|---|---------|
| 1. | Gum arabic | . | . | . | 30 gr. |
| 2. | Chloral hydrate | . | . | . | 50 gr. |
| 3. | Glycerine | . | . | . | 20 cc. |
| 4. | Dist. water | . | . | . | 50 cc. |
| 5. | Chlorhydrate of Cocaine | | | | 0.5 gr. |

Filter after mixing:-

This medium had the advantage that it was very convenient. Killing, fixing and mounting was done in a single operation by placing the specimen directly in a drop of the fluid. The first-stage larvae, which in alcohol tend to shrink, died in an extended condition in this medium; and the hairs on the body of the young and adults were also clearly seen.

The study of chitinous parts and the distribution of hairs on the body, was done by boiling the specimens for/

for ten minutes in a 10% solution of KOH. They were again reboiled in water to remove alkali and finally placed in 70% alcohol. Staining of chitin was done with Acid fuchsin.

Dissection was done with a pair of fine needles under Leitz binocular microscope (X75 ; X150.) in the following way. Living thrips were placed in a drop of clear water or physiological salt solution and stunned by pricking them on the head. For the dissection of alimentary canal, the head capsule was opened, and the anterior part of oesophagus was cut from the pharynx, then the last abdominal segments were quickly pulled out; drawing the whole alimentary tube outside. The dissection of the glandular system, their ducts, and the nervous system required gradually breaking away the chitin carefully in small pieces. In all cases, idea should be concentrated in dissecting out one system only; and in no case should thrips be killed in any fixing fluid before dissection. Preserved or fixed specimens are useless for successful dissection as the internal parts become coagulated and tend to remain inside the body, making the dissection all the more difficult.

The internal structures were fixed in Bouin's fluid and first washed in water and then in weak alcoholic/

alcoholic solutions to remove picric acid. Corrosive sublimate also proved good fixing reagent. Carnoy's fluid proved unsatisfactory as the presence of absolute alcohol created internal currents with the water in the tissues and crumpled the delicate internal parts. The usual stain used was haematoxylin and eosin. Carmalum and methyl green was also tried, and gave good results with glandular tissues and the enteric epithelium of the mid-intestine.

It is comparatively very large in proportion to the size of the abdomen, and the simultaneous development of several eggs inside the body causes a considerable distention of the ovary. The eggs are seen inside the body through the whitish body wall.

The middle ----- part, and the anterior and posterior ends seem to have been drawn out in the form of a neck. The anterior part is slightly broader than the posterior (fig 1.8, Pl. 1) and the dorsal and the ventral surfaces correspond to the convex and the concave sides.

It is enclosed in a thin chorion which has a smooth shining white surface. Inside this is the vitelline membrane. These being thin and flexible, the egg assumes a pear shape also with a small neck. It occurs more usually, i. e. the egg is not fully mature.

III. MORPHOLOGY.A. APTINOTHRIPS RUFUS (GMELIN).1. EGG.

The egg (Fig 1, Pl.1) is a soft, lightly bluish, translucent white, more or less kidney-shaped object, as is typical of the family. It measures from .266 - .313 mm. in length and .08 - .116 mm. in breadth. It is comparatively very large in proportion to the size of the abdomen, and the simultaneous development of several eggs inside the body causes a considerable distention of abdomen. The eggs are seen inside the body through the chitinous body wall.

The middle part appears thickest, and the anterior and posterior ends seem to have been drawn out in the form of a neck. The anterior part is slightly broader than the posterior (Fig 1-2, Pl.1) and the dorsal and the ventral surfaces correspond to the convex and the concave sides.

It is enclosed in a thin chorion which has a smooth shining white surface. Inside this is the vitelline membrane. These being thin and flexible, the egg assumes other shapes also within certain limits. It occurs more usually, if the egg is not fully mature.

(a) Segments:-	1	2	3	4	5	6	Total
Length(right)	16	20	20.25	30.40	10	16.20	.113-.123 mm.

2. LARVAL STAGES.(a) First Stage larva.

(left) 20 20 20.25 30.40 10 16.20

(Fig 7, Pl.2)

Total length .657 - .842 mm.

General body colour pale yellow or whitish yellow. Head lighter or slightly darker than the body which is yellowish. The inter-segmental areas appear as white bands. Antennae, legs and tenth abdominal segment shaded. Mouth-cone dark.

The antennae (Fig.8, Pl.2) are six-segmented, a little longer than the head. The measurements from one and five individuals are:-

(1) Segments:-	1	2	3	4	5	6	Total
Length(right)	16*	20	20	30	10	16.6	.113 mm.
" (left)	20	20	20	23.3	10	13.3	.113 mm.
Breadth(right)	23.3	20	20	23.3	10	6.6	-
" (left)	23.3	20	26.6	26.6	10	6.6	-

(5)/

* The measurements of the segments of antennae are given in microns.

(5) Segments:-	1	2	3	4	5	6	Total.
Length(right)	16	20	20-26	30-40	10	16-20	.113-.133 mm.
" (left)	16-20	20-23	16-26	23-40	10-13	13-20	.113-.13 mm.
Breadth(right)	23	20	20-26	20-26	10	6	-
" (left)	23	20-23	23-26	20-26	10	6	-

First segment (Fig8, Pl.2) bowl-shaped, wider than long, shaded at the inner sides; second segment club-shaped, almost as long as wide, darker at the proximal two-thirds part and whitish distally, giving a banded appearance; third segment wine-glass shaped, pedicellate, longer than the preceding ones and slightly wider than the second, the peduncle and the base whitish, while the middle part dark with a whitish anterior edge; fourth segment oblong, about twice as long as the first, the proximal and distal part shaded with a whitish area in between; fifth segment shortest, almost as long as wide, dark; sixth segment conical, longer than the fifth and uniformly dark.

Head lighter yellow with darker carina having very dark sides almost touching the base of the first antennal joints, the central part of the carina varies from light to darker. The mouth-cone dark with light brown labium and the sutures. The head is slightly longer than broad with two small orange coloured eyes at/

at the cephalic angles of cheeks. The length of the margin, above the eyes and the first antennal joint, very small, cheeks parallel, or very slightly curved. The mouth cone small, lies between the coxae under the prosternum. The measurements are:- Length .093 - .12 mm.; Breadth .066 - .076 mm.; width across eyes .066 - .07 mm.; width of vertex (between eyes) .033 - .036 mm.; length of eyes .023 - .026 mm.; width of eyes .0166 mm.

Prothorax pale yellow, almost as long as the head, but broader than the head. It is broader than long with sides sub-parallel, having anterior and posterior rounded angle. It measures .086 - .1 mm. in length and .126 - .14 mm. in width.

Pterothorax also pale yellow, longer than the head or prothorax and also broader than either of them. It is almost as long as broad. It measures .1 - .17 mm. in length and .166 - .176 mm. in width.

The fore, middle and hind coxae, and all femora shaded at the basal part and lighter at the distal. The tibiae and tarsi of all the legs shaded with lighter areas. The fore, middle and hind legs are almost equal. The fore coxae and the fore femora are slightly broader than others.

The abdomen (Fig.9, Pl.2) is pale yellow except the last two segments. The ninth segment yellowish and lightly shaded; the tenth segment completely dark.

Abdomen/

Abdomen fusiform ending posteriorly in a circular opening. The first segment is very short and is seen with difficulty. The rest of the segments are clearly visible. The length and (breadth) of ten abdominal segments are:- .02 - .03 (.14 - .18) m.m; .03 - .046 (.156 - .19) m.m; .03 - .053 (.153 - .2) m.m; .03 - .053 (.156 - .203) m.m; .033 - .053 (.153 - .2) m.m; .04 - .053 (.146 - .19) m.m; .036 - .04 (.133-.183) m.m; .036 - .05 (.09 - .153) m.m; .036 - .05 (.07 - .103) m.m; .036 (.046 - .066) m.m. The first few segments from second backwards are almost equally long and broad and the segments at the hind part slope down gradually and the breadth decreases.

CHAETOTAXY:-

There are ^{more} many hairs on the last antennal segments than on the basal ones (Fig.8, Pl.2). The hairs on the head are very minute; while the maxillary and labial palpi are also provided with short thin hairs. The hairs on the sides from 1 - 5 abdominal segments are very minute and not clearly seen, and dorsally also they are small. Counting from the sixth abdominal segment, the following spines of consequence are seen on the sides of the segments (Fig.9, Pl.2). The length of segments is also given for comparison.

No/

No. of Segment.	Length of the segment.	Length of the side hairs.
6	.056 m.m	.024 m.m
7	.056 m.m	.11 m.m
8	.054 m.m	.044 m.m
9	.05 m.m	.112 m.m
10	.05 m.m	.11 m.m

The length of the hair on the sixth segment is like the preceding ones and is the smallest of the hairs that occur on the sides. On the seventh segment laterally, there is a very long hair on each side; dorsally also four short hairs are seen. On the eighth segment, on the sides the hairs are smaller, and dorsally also are four almost equal hairs; On the ninth segment a long hair on each side and a pair of shorter hairs situated dorsally; On the tenth segment besides the two side hairs, there are two long hairs dorsally. All these hairs are long, situated almost round the distal margin of the last segment.

b. Second Stage larva.

(Fig 10, Pl.2)

Total length 1.01 - 1.21 m.m.

Longer than the first stage larva. General body colour pale yellow with darker antennae, head, legs and the last two abdominal segments. Mouth cone dark.

Antennae/

Antennae six segmented (Fig 11, Pl.2) about one and one-third times as long as the head. The segments are clearly visible and the length and breadth of segments from one and five specimens are as follows:-

(1) Segments:-	1	2	3	4	5	6	Total.
Length(right)	20	26.6	26.6	40	13.3	16.6	.14 m.m
" (left)	20	26.6	26.6	36.6	13.3	16.6	.14 m.m
Breadth(right)	26.6	20	23.3	20	10	6.6	-
" (left)	26.6	20	23.3	20	10	6.6	-
(5) Segments:-	1	2	3	4	5	6	Total.
Length(right)	16-20	23-26	23-30	36-40	10-13	16-20	.14-.153 mm.
" (left)	16-20	23-26	26-33	36-46	10-13	16-20	.14-.156 mm.
Breadth(right)	23-26	20	20-26	20-23	10-13	6-10	-
" (left)	23-26	20	20-23	20-23	10	6-10	-

The form and shape of the segments are similar as in the first stage larva. First segment (Fig 11, Pl.2) much wider than long, shaded at the inner sides, less so at the base; second segment longer than the first and longer than wide, shaded at the basal half and lighter anteriorly; third segment longer than the preceding two and almost as wide or wider than the second segment, darker in the middle with the peduncle and the anterior part whitish; fourth segment longest, about/

about twice as long as the first and almost as wide as the second or third, unlike the first stage larva it is completely shaded dark with fine thin white lines, giving the appearance of large black bands with thin white lines; fifth and sixth small and completely shaded.

Head lightly shaded, with prominent dark carina. Two orange coloured eyes at the anterior cephalic ends. Facets not distinct, cheeks parallel, similar as in the first stage larva. The measurements are:- length .11 - .113 m.m; width .0866 - .093 m.m; width across eyes .08 - .09 m.m; width of vertex (between eyes) .043 - .05 m.m; length of eyes .0233 mm; width of eyes .0133 - .016 m.m.

Prothorax pale yellow, almost as long as the head but much broader. Sides almost parallel with anterior and posterior angles rounded. It measures .1 m.m in length and .143 - .156 m.m in width.

Pterothorax also pale yellow, longer than the prothorax and also much broader. Sides sub-parallel. It measures .183 - .25 m.m in length and .183-.23 mm. in width.

Legs shaded with lighter areas. Fore, middle and hind legs almost equally long and broad.

The abdomen (Fig 12, Pl.2) in the second stage larva is much broader and longer thanⁱⁿ the first stage larva; fusiform; general colour pale yellow with ninth/

ninth and tenth segments darker as in the first stage larva. The length and (breadth) of ten abdominal segments are:- .04 - .053 (.173 - .226) m.m; .056 - .073 (.196 - .246) m.m; .06 - .083 (.206 - .273) mm; .056 - .093 (.206 - .273) m.m; .066 - .093 (.196 - .273) m.m; .066 - .093 (.183 - .256) m.m; .066 - .09 (.166 - .2) m.m; .056 - .073 (.136 - .2) m.m; .063 - .066 (.11 - .13) m.m; .046 - .066 (.066 - .073) m.m; The first abdominal segment is short. The first few abdominal segments from second onwards are almost equal.

CHAETOTAXY:-

The hairs on the distal segments of antennae are profuse (Fig 11, Pl.2), and are similarly distributed to those in the first stage larva. The hairs on the head, thorax, legs and first to fifth abdominal segments either laterally or on the dorsum, are sparse and very minute. Taking the sixth abdominal segment as the representative of the preceding ones, the following hairs are found on the sides (Fig 12, Pl.2).

No. of segment.	Length of Segment.	Length of lateral hairs.
6	.0933 m.m	.04 m.m
7	.09 m.m	.0733 m.m
8	.0766 m.m	.0533 m.m

The/

The lateral hairs on the sixth and eighth segments are slightly longer, and the long hairs on seventh, ninth and tenth segments are shorter than the lateral hairs on the first stage larva. Similarly the hairs on the dorsum are also shorter than the 1st stage larva. This differentiates the first and second stage larvae. The longest hair is seen laterally on the seventh segment, the hairs preceding it being very small and the succeeding ones also smaller. Dorsally on the seventh, four short hairs are present; On the eighth segment also are four short dorsal hairs, besides two long lateral ones; On the ninth segment two long hairs are seen on the sides and two short ones dorsally at the distal end of the segment (Fig 12, Pl. 2). The length of the outer hairs is .066 m.m, almost as long as the segment (.06 mm.) and the inner short ones .03 mm. On the tenth segment also four long hairs are present at the distal end of the segment. The outer ones are smaller than the dorsal ones which are .05 m.m. long, almost as long as the segment (.05 m.m.)

3. Pre_pupa (female).

(Fig 13, Pl.3)

Total length:- 1.1 m.m.

Almost as long as the second stage larva. General body colour pale yellow, antennae, legs and abdominal tip lighter and whitish. No shading on the head, mouth-cone, antennae, legs, and abdominal tip. Eyes reddish black. Thorn-like spines on the abdominal tip yellowish.

The antennae (Fig 15, Pl.3) lie straight in front of the head, clothed in a thin membrane, various segments not clearly distinguishable. A few faint constrictions divide the antennae obviously into four joints. The length and breadth of visible joints and the total lengths are as follows:-

Segments	1	2	3	4	Total.
Length(right)	20	30	36.6	53.3	.146 m.m
" (left)	16.6	40	36.6	53.3	.15 m.m
Breadth(right)	36.6	33.3	30	23.3	-
" (left)	36.6	33.3	30	23.3	-

The antennae are about one and one fifth times as long as the head. All the segments whitish. First joint more or less bowl-shaped much wider than long; second segment longer than the first; third still longer/

longer but less wide than the first or second; fourth is longest about three times as long as the first and very much less wide, oblong with a blunt anterior end. The bases of the antennae are situated near each other.

Head lighter yellow, rounded above eyes, almost as long as broad, cheeks parallel, eyes short. No carina visible. Mouth cone not seen, only a short faint outline gives the presence of the mouth-cone lying somewhere between the fore coxae. The measurements are: length .12 m.m; width .126 m.m; width across eyes .113 m.m; width of vertex (between eyes) .04 m.m.; length of eyes .0166 m.m; width of eyes .06 m.m.

Prothorax lighter yellow, longer and wider than the head, and wider than long, slightly wider posteriorly, sides sub-parallel with anterior and posterior rounded angles. It measures .13 m.m. in length and .16 m.m in width.

Pterothorax also lighter yellow, longer than the head or prothorax, almost as long as the breadth of prothorax and wider than long. It measures .166 mm. in length and .186 mm. in width.

Legs whitish, various parts not clearly defined, tibiae and tarsi enclosed in a membrane as the femora. The legs end in a rounded, blunt, club-shaped structure. The length of the fore, middle and hind legs almost equal.

Abdomen/

Abdomen is pale yellow, whitish at the tip, fusiform, wider anteriorly and gradually tapering posteriorly, ending in a blunt tip. The segments are not so clearly differentiated as in the larvae. The length and (breadth) of first to seven abdominal segments are: .04 (.176) m.m; .066 (.186)m.m; .073 (.21) m.m; .073 (.22) m.m;.076 (.22) m.m; .083 (.21)mm; .07 (.196) m.m. The last three segments are not well differentiated.

CHAETOTAXY:-

The hairs present on the last antennal segments in the larval stage are absent here. Antennae almost smooth (Fig 15, Pl.3). The head bears very minute hairs, one hair on each side below the lateral profile of the eyes. On the prothorax one very small hair behind the coxae and two other short hairs about .023 m.m. long situated at the posterior corners. Pterothorax bears very minute hairs on the sides. The hairs on the abdominal segments are also very minute. Each segment bears one short lateral hair and from first to fifth segments, the lateral hairs measure about .023 m.m in length; on the sixth and the succeeding segments, the hairs are proportionately longer, about .043 m.m in length. On the dorsum also are situated very minute hairs. The long hairs present on the sides and dorsum in larval stages are absent in this stage. On the ninth segment, at the/

the posterior part, a short distance from the tip are visible four stout, strong, thorn-like yellowish spines (Fig 14, Pl.3). These spines are absent in the larval stage. Each measures .025 m.m. in length and .0083 m.m broad at the base. These thorn-like spines at the posterior part of ninth segment with undifferentiated antennae lying in front of the head and pale whitish-yellow colour are characteristic of pre-pupal stage.

4. Pupa (Female).

(Fig 16, Pl.3)

Total length .88 - 1.071 m.m.

Almost as long as the pre-pupa. General body colour pale yellow, antennae and head not so pale as in the pre-pupa. Legs and abdominal tip whitish. Eyes deeply reddish black. No dark shading on the head, thorax, abdomen or legs; resembles pre-pupa in colour.

Antennae instead of lying in front as in the larval and pre-pupal stages, are turned upwards and lie on the back of head (Fig.16, Pl.3); reaching as far back as the end of head or a little over the prothorax. The antennae are clothed in a thin membrane and the various segments, which are somewhat indistinct in the pre-pupal stage, are not seen at all/

all in the pupa. Each antenna appears as a simple club with no trace of segmentation (Fig 31, Pl.5). The basal portion of each antenna lies over the front margin of head, from where it bends upwards, and appears as a wide round basal segment. The antennae are wider basally and narrower distally. At the distal end each gives rise to about four short conical projections. In advanced stage, when the adult is partially formed and is about to emerge in a few days, the outer skins of antennae with four short conical distal projections, are seen enclosing the true segments of the future adult form (Fig 32, Pl.5). The antennae as lying backwards on the head measure about .14 - .156 m.m in length and the broad basal part about .043 m.m in width.

Head resembles pre_pupa in form and colour. It is slightly longer than broad, with short eyes situated at the anterior sides. Cheeks almost parallel. A distinct mouth cone is not visible; but under higher magnifications, an impression of the cone may be seen lying between the anterior coxae as in pre_pupae. The measurements are:- Length .13 - .143 m.m; width .11 - .123 m.m; width across eyes .096 - .11 m.m; width of vertex .05 - .0566; length of eyes .04 - .05 mm.; width of eyes .0166 - .0266 m.m.

Prothorax pale yellow as in pre_pupae. Slightly shorter than the head, but much wider. It measures .11/

.11 - .133 m.m in length and .153 - .173 m.m in width.

Pterothorax is also pale yellow as in pre_pupae. It is almost as long as the head; but broader than the head and prothorax. No wings present. It measures .133 - .153 m.m in length and .166 - .186 mm. in width.

The segments of the fore, middle and hind legs are not clearly differentiated and resemble pre_pupa in colour and form. The length and breadth of fore, middle and hind legs are almost equal.

The abdomen resembles pre_pupa in form and colour. It is broader anteriorly and gradually tapers posteriorly ending in a blunt tip (Figs 16, 17, Pl.3).

The length and (breadth) of first to seven abdominal segments are:- .03 - .0366 (.166 - .183) m.m; .063 - .066 (.17 - .236) m.m; .053 - .063 (.176-.256) m.m; .063 - .07 (.19 - .263) m.m; .056 - .07 (.2 - .266) m.m; .066 - .073 (.196 - .253) m.m; .066 - .073 (.193 - .226) m.m.

CHAETOTAXY:-

Antennae are almost smooth with two visible short hairs at the basal wide part and four short projections distally (Fig 31, Pl.5). Head also is almost smooth; on the prothorax two short hairs may be seen on the distal part behind the coxae. A few short hairs may also be seen on pterothorax. The distribution/

distribution of hairs on the abdomen (Fig 17, Pl.3) either dorsally or on the sides is more or less of the same nature as in pre_pupa. Each side of the first to five abdominal segments, bears a very small hair about .0166 m.m long; On sixth segment the lateral hair is slightly longer than the preceding and measures about .0266 m.m in length; On the seventh segment, laterally there is a still longer hair about .05 m.m long; dorsally there are four short hairs. On the eighth segment, there are four short dorsal hairs almost as long as on the previous segment, the lateral hairs are longer. On the ninth segment, there are two long hairs on the sides and two short ones dorsally about the middle of the segment. Posteriorly there are four xxxxx thorn-like stout spines about .0166 m.m long and .0066 m.m wide at the base (Fig 17-18, Pl.3). The spines are yellowish, sub-erect and thorn-like, and are similar to those found on the ninth abdominal segment of pre_pupa. The position of antennae over the head, and the spines on the ninth abdominal segments are characteristic of Aptinothrips pupa.

5. ADULTS.(a) Female.

(Fig 19, Pl.4)

Total length .97 - 1.3 m.m.

Body slender, general colour pale yellow, lighter yellow in the middle of head, thorax and abdomen, deeper on the sides and at places where two chitinous surfaces overlap.

The antennae are about 1.27 times as long as the head, approximate at the base and composed of six segments (Fig 27, Pl.5). The measurements from one and five specimens are:-

(1) Segments:-	1	2	3	4	5	6	Total.
Length(right)	23.3	36.3	30	23.3	23.3	70	.193 mm.
" (left)	26.6	33.3	30	30	23.3	66	.2 mm.
Breadth(right)	30	26.6	20	20	20	20	-
" (left)	30	23.3	20	20	20	20	-
(5) Segments:-	1	2	3	4	5	6	Total.
Length(right)	23	33-36	30-33	23-30	23-26	66-70	.193-.2 mm.
" (left)	23-26	33	30-33	26-30	23-26	63-66	.19-.2 mm.
Breadth(right)	26-30	23-26	16-20	20	18-20	16-20	
" (left)	26-30	23-26	16-20	20	18-20	16-20	

First segment light yellow, bowl-shaped, short, broader than long and broadest of all; second segment (Fig/

(Fig 27, Pl.5) yellowish, more or less cup-shaped, with a broad basal handle, longer than the first and longer than broad; third segment yellowish, spindle-shaped with a peduncle to join with the second segment, the peduncle at the anterior end broad with very short minute processes, one on each side, shorter and thinner than the second segment; fourth segment yellowish spindle-shaped, shorter than the third but almost equally wide as the third; fifth segment similar in form ~~as~~ ^{to} the fourth, slightly brownish black at the distal part, almost equally long and broad as the fourth segment; sixth segment longest, resembling a cone, lightly brownish black at the base and deeper brownish black at the distal part with shining hair bases. It is over twice as long as the second or third segments. The segments three to six are almost equally broad.

Head yellow or paler, longer than broad, having two small eyes at the anterior edges of cheeks. The margin of the head above the eyes forms an obtuse angle with the cheeks, the two sides meeting in between the two basal joints of the antennae, where a short angle is formed. The cheeks are parallel. The eyes are small black, slightly protruding, with about five facets in the lateral profile. The mouth cone with mouth parts brownish black, palpi yellow. The mouth cone is short and blunt and lies between the fore coxae. The/

The maxillary palpi three segmented (lengths 15. 4. 6) and the labial palpi two segmented (length 2. 9). No ocelli present. The measurements are:- Length .143 - .16 m.m; width .113 - .126 m.m; width across eyes .103 - .116 m.m; width of vertex 33 - 50 mic.; length of eyes 40 - 43 mic.; width of eyes 23 - 30 mic.

Prothorax yellow, concolorous with the head. It is about as long as the head and slightly wider than the head, the sides diverge posteriorly with rounded angles. Length .143 - .196 m.m. and width .116 - .15 m.m.

Pterothorax yellow, concolorous with the head and prothorax. It is about as long as the head or the prothorax, wider than either of them and wider than long, sides almost parallel; no wings present. Length .15 - .16 m.m; width .186 - .206 m.m.

Legs yellow, coxae, trochanter, femora and tibiae concolorous with the body. The tarsi paler or whitish yellow with brownish black tip within, the length of fore, middle and hind legs almost equal. All coxae equally wide. Fore femora slightly wider than the middle and hind. All tarsi almost equal.

Abdomen yellow, concolorous with the rest of the body, having deeper yellow bands where segments overlap; the intersegmental areas in stretched specimens appearing as white bands; and the area occupied by ovipositor deeper yellow. The last abdominal segment deeper/

deeper yellow, dark brown at the distal part ending in a black abdominal tip.

The abdomen is cylindrical in form, broader at the anterior part, tapering posteriorly and ending in a conical point. The length and (breadth) of ten abdominal segments are: .03 - .05 (.186 - .2) m.m; .076 - .093 (.21 - .243) m.m; .07 - .083 (.213 - .253) m.m; .073 - .08 (.22 - .253) m.m; .073 - .083 (.216 - .256) m.m; .073 - .083 (.21 - .236) m.m; .073 - .083 (.19 - .2) m.m; .07 - .086 (.123 - .15) m.m; .056 - .066 (.06 - .08) m.m; .06 - .086 (ends in a point). The first abdominal segment is very short, and telescoped in the pterothorax. The second segment is longer and broader than the first. The segments three to seven are almost equally long and broad as the second, from the seventh segment onwards, the tapering begins, and the tenth segment ends in a point. The eighth and ninth segments carry the saw-like ovipositor.

CHAETOTAXY:-

Hairs are situated on all antennal segments; but are short and inconspicuous at the basal half, becoming more visible and profuse at the distal end especially the last segment (Fig 27, Pl.5).

The head, prothorax, pterothorax and legs are almost smooth, with short minute hairs visible in specimens treated/

treated with KOH. Hairs on the dorsum and on the sides of the first to eight abdominal segments are as a rule few and inconspicuous; but increase in size and prominence upon the last two abdominal segments. Taking the eighth abdominal segment as a representative of preceding ones, it will be seen that four very minute hairs are present near the posterior margin. Anteriorly also two short hairs are present. Besides, two pores are seen below the middle posterior pair of hairs (Fig 20, Pl.4). No long hairs are present. Similar short hairs are present on preceding segments.

On the ninth segment there are very long prominent hairs. At the posterior margin, there is a row of four long hairs; the outer pair is very long and measures 30 mic. in length (Seg. 19 mic.), the inner pair is shorter and measures 22 mic. in length. Besides, above the base of the outer pair is a short hair and down below near the margin is a shorter hair between the outer and inner long hairs (Fig 21, Pl.4). There are two pairs of pores, the first pair is situated anteriorly and the second pair between the outer and inner pair of long hairs (Fig 21, Pl.4).

Two rows of long and short hairs are situated on the posterior part of tenth segment (Fig 22, Pl.4). The proximal row consists of four long hairs, two situated on either side of the median fissure. The outer hair on each side is about 17 mic. long (Seg.

(N = Right / L = left)

27 mic.) and is shorter than the middle pair which is 21 mic. long. Slightly posteriorly there is the distal row of six short hairs, three being on each side of the median fissure. These are almost equal, and are much shorter than the proximal row of hairs. Beyond the tenth segment, a short structure is visible which is probably the vestige of 11th segment. It carries two minute terminal hairs (Fig 22, Pl.4)

(b) Female var. stylifera.

The female of this variety is similar to A. rufus in colour, length and the distribution of hairs on the posterior abdominal segments. It, however, differs in the number of antennal segments.

The antennae are eight segmented (Fig. 28, Pl.5) and the measurements of the segments from one and five individuals are:-

(1) Segments:-	1	2	3	4	5	6	7	8	Total.
Length(right)	23.3	33.3	30	23.3	23.3	40	10	13	.19 m.m.
" (left)	20	33	26.6	23.3	26.6	43	10	13	.19 m.m
Breadth(right)	30	26.6	16	20	16	16	6.6	3	-
" (left)	30	23.3	20	20	20	16	6.6	3	-

(5)/

(R = right; L = left)

(5) Segments.	1	2	3	4	5	6	7	8	Total.
Length (R)	20-23	30-33	26-30	23-26	23-26	40-46	10	13	.19-.21 mm
" (L)	20-23	30-33	26-30	23-26	23-26	40-43	10-16	13-16	.19-.206mm
Breadth (R)	30	23-26	16-20	20	16-20	16-20	6	3	-
" (L)	30-33	23-26	16-20	20	16-20	16-20	6	3	-

The form and colour of first to five segments are similar as in A. rufus. The basal part is concolorous with the head, shading distally to brownish black at the tip. Sixth segment here is much smaller than in the rufus; seventh is smallest, cylindrical and deeply shaded; and the eighth slightly longer and conical and concolorous with the preceding segment. The hairs are profusely situated on the distal segments.

The head, prothorax, legs and abdomen do not show any important morphological differentiation. The only difference noticeable is in the antennae mentioned above.

The antennae are about one and one-half times as long as the head.

(c) Male.

(Fig 25, Pl.4).

Total length:- .19 - .23 m.m.

Body much more slender; wingless as females; much smaller than the female. General body colour light yellow, dark brownish within the tarsi; mouth cone and the fifth and sixth antennal segments dark brown/

brown. The last abdominal segment bluntly rounded (Figs 33-34, Pl.5), and not ending in a black pointed tip as in females.

The antennae six segmented (Fig 29, Pl.5), and similar in form and shape as in females. The length and breadth of antennal segments in two specimens are:-

(1) Segments:-	1	2	3	4	5	6	Total.
Length(right)	20	30	26.6	23.3	23.3	56.6	.166 m.m
" (left)	20	30	26.6	23.3	23.3	56.6	.18 m.m
Breadth(right)	26.6	23.3	16	16	16	16	-
" (left)	23.3	23.3	16	16	16	16	-
(2) Segments:-	1	2	3	4	5	6	Total.
Length(right)	20	30	26.6	26.6	20	60	.17 m.m
" (left)	20	30	26.6	23.3	23.3	56.6	.17 m.m.
Breadth(right)	23.3	23.3	16	16	16	16	-
" (left)	23.3	23.3	16	16	16	16	-

The antennae are about one and one-half times as long as the head. The total length and individual segments are much shorter than ⁱⁿ the female. The colour and shape resembles the antennae of females. The basal part being yellow and the distal dark brownish.

Head pale yellow, slightly longer than broad, with two small black eyes situated at the anterior margin of cheeks where it forms an obtuse angle with the slightly arched anterior margin of head as in females; /

females; cheeks parallel; ocelli wanting. Mouth cone dark brownish reaching to about three-fourth distance of the prosternum. The measurements are:—

Length .116 - .123 m.m; width .1 - .103 m.m.; width across eyes .096 - .10 m.m; width of vertex .033 - .046 m.m.; length of eyes .033 - .036 m.m; width of eyes .0266 - .03 m.m.

Prothorax concolorous with the head, almost as long as the width of the head, and slightly wider than the head, sides sub-parallel, slightly widening posteriorly with anterior and posterior angles rounded. It measures .10 - .103 m.m in length and .13 - .14 m.m in width.

Pterothorax short, concolorous with head and prothorax. It is about as long as the head and almost as wide as the prothorax, slightly wider than the head. Wings absent, resembling female. It measures .12 - .123 m.m in length and .136 - .146 m.m in width.

Legs are pale yellow concolorous with the body, almost equal and shorter than the female. Fore femora broader than the rest. All the tarsi almost equal.

Abdomen is also pale yellow, concolorous with the rest of the body. It is a much smaller and less broader structure than in the female. The yellow testes are visible through the translucent body wall in sixth and seventh abdominal segments (Fig 25, Pl.4). The first abdominal segment is comparatively much shorter/

shorter than the rest; the second segment is broader and longer than the first; and the third to seventh segments are almost equally broad; eighth, ninth and tenth slightly become narrower at the hinder end; the tenth abdominal segment unlike female is broader and bluntly rounded. The male genital apparatus is carried by the ninth and tenth abdominal segments. On the ventral side, the demarcation between ninth and tenth sternites is not clearly seen. The length and (breadth) of ten abdominal segments are:-

.02 - .023 (.133) m.m; .053 - .066 (.153 - .166) m.m;
 .053 - .063 (.15 - .176) m.m; .053 - .0669 (.15 -
 .176) m.m.; .053 - .066 (.15 - .176) m.m; .053 - .066
 (.15 - .176) m.m; .053 - .066 (.15 - .16) m.m; .056 -
 .066 (.133 - .146) m.m; .04 (.1 - .11) m.m; .083
 (.033) m.m.

CHAETOTAXY:-

Hairs are present on all antennal segments, but more densely on the last antennal segment than on the basal joints (Fig 29, Pl.5). The hairs on the head, prothorax, legs and pterothorax are very minute and sparsely situated. Similarly, on the first to eight abdominal segments, the hairs are very minute on the sides and on the dorsum. On the eighth segment a few minute hairs are present dorsally (Fig 33, Pl.5). Very characteristic hairs are present on ninth abdominal/

abdominal tergite. Laterally there is a very long hair; dorsally at about one-seventh from the anterior end of the ninth tergite, are a pair of long hairs about .04 m.m long. These hairs are thin and long. Further backwards in the middle of the dorsum, about one-third from the anterior end are situated two strong, yellow, thorn-like spines, which are much stouter and shorter than the preceding ones. These resemble pointed thorns and are about .022 m.m long and 6 mic. wide at the base. Slightly posterior to these and slightly away from the middle, are two spines, resembling the preceding ones, but much shorter. These are about .014 m.m long. On the tenth tergite such structures are not seen, only a few short ones may be seen.

(d) Male var. stylifera. (Tryblom)

(Fig 26, Pl.4).

Total length:- .185 m.m.

Slightly shorter than the rufus. Body slender, colour light yellow, dark brownish within the tarsi. Mouth cone and distal antennal segments dark brown. Closely resembles rufus male in colour and form. It differs from rufus male in the number of antennal joints. (Fig 30, Pl.5).

The/

The antennae are eight segmented and are similar in form and shape as in the rufus male; except that the terminal segment is divided here into two joints. The length and breadth of antennal segments in one specimen are:—

(1) Segments:—	1	2	3	4	5	6	7	8	Total.
Length(right)	18.5	25.9	29.6	22.2	22.2	33.3	7.4	11.1	.159 mm
" (left)	14.8	25.9	25.9	22.2	22.2	33.3	7.4	11.1	.17 mm.
Breadth(right)	25.9	20.3	14.8	17.7	17.7	16.6	5.5	3.7	-
" (left)	22.2	22.2	14.8	18.5	18.5	18.5	7.4	3.7	-

The antennae are about one and one-half times as long as the head, as in rufus. First segment bowl-shaped (Fig 30, Pl.5) wider than long; second long; third also long pedicellate. Segments one to three pale yellow as in rufus. Segments fourth and fifth almost equal; fourth lightly shaded at the anterior part and fifth slightly darker; sixth spindle-shaped much shorter than in the rufus, uniformly shaded; seventh and eighth segments smallest, also uniformly dark. The total length of the antennae is almost equal to rufus; the individual segments slightly shorter; otherwise similar.

Head slightly arcuate anteriorly, with deep dark eyes at the cephalic ends. Cheeks parallel; ocelli wanting. Colour pale yellow; almost as long and broad as in rufus. The measurements are:—

Length/

Length. .114 m.m; width .1 m.m; width across eyes .092 m.m; width of vertex .047 m.m; length of eyes .033 m.m; width of eyes .0222 m.m.

Prothorax concolorous with the head, sides slightly diverging posteriorly, almost as long and as broad as in rufus. It measures .088 m.m in length and .14 m.m in width.

Pterothorax is short and yellowish as in rufus. It measures .129 m.m in length and .148 m.m in width. The legs are similar in colour and measurements, as in rufus.

The abdomen is pale yellow bluntly rounded at the posterior end. It very closely resembles in form and measurement with rufus. The length and (breadth) of ten abdominal segments are: .029 (.14) mm; .055 (.17) m.m; .055 (.177) m.m; .047 (.18) m.m; .047 (.18) m.m; .047 (.177) m.m; .055 (.155) m.m; .047 (.133) m.m; .055 (.107) m.m; .047 (.077) m.m. With slight individual variation and the allowance for pressing, the measurements of abdominal segments in stylifera and rufus are alike.

The distribution of hairs are similar on the body and the last abdominal segments. The ninth tergite possesses the characteristic thorn-like spines as in rufus. Except the difference in the antennae, no other differentiating morphological characters are noticeable.

Described/

reveal the intermediate form also. The commoner form
 of Described from one male collected by Dr G.D.
 Morison, on 18.8.28 at Muchalls, Kincardine, Scotland.

1. Reduction in the number of joints.
2. Malformation of individual joints.
3. Presence of a single median seta.
4. Fusion of two joints.

6. STRUCTURAL DEFORMITIES.

During the collection of Aptinothrips rufus, a few cases of deformities were noticed. Such deformities were found commonly in the number, size and form of antennal joints and rarely in head, thorax or abdomen. In all cases it was the females that were deformed. The males, however, are rare and a few which were captured were normal. Deformities in larvae rarely came to notice and the larval antennae were never found abnormal.

There are two forms of Aptinothrips rufus, the commoner six-jointed form and the scarcer eight-jointed. Priesner (1918) found a single case with seven-jointed antennae which he has described as forma intermedia. I never came across any specimen in which both antennae were seven-jointed. Once I found a specimen with one antenna seven-jointed and the other eight-jointed. But the sixth joint was not normally formed. This may lend support that probably a much larger collection of eight-jointed form may reveal/

reveal the intermediate form also. The commoner forms of antennal deformities are grouped here under five divisions:-

1. Reduction in the number of joints.
2. Malformation of individual joints.
3. Presence of a single median antenna.
4. Fusion of two joints.
5. Presence of normal six and eight-jointed antenna in the same individual.

Of all these five forms, the presence of six and eight-jointed antenna in the same individual is very striking and throws some light on the linkage of the two forms of the species. The deviation from the normal in the number of antennal joints does not appear to interfere with the breeding, as some of the thrips contained mature eggs.

1. Reduction in the number of joints (Fig 35, Pl.6).

This form of deformity is by far the commonest and is frequently met with during collecting. The reduction is found usually in one antenna or occasionally in both.

Thus in figure 35, pl.6 a specimen is shown in which the left antenna is five-jointed and the right one six-jointed normal.

The/

The measurements are:—

Antennal joints	1	2	3	4	5	6	Total
Right.Length	.0222	.0333	.02592	.02592	.02592	.0666	.1925 mm.
" Breadth	.02592	.02592	.01851	.0222	.01851	.01851	-
Left.Length	.0222	.0296	.01851	-	.0222	.0555	.13703 mm.
Breadth	.02962	.01851	.01851	-	.0222	.0222	-

Right antenna normal. Left antenna abnormal, shorter than the right; first joint normal; second shorter and smaller than the right; third joint also shorter but as wide as the right. All 1 - 3 joints pale yellow concolorous with the joints of the right side; fourth joint absent; fifth joint almost as wide as long but shorter from the right side, slightly dark pigmented showing resemblance with the fifth of the right side. The sixth joint shorter, but wider, smokey dark.

In figure 36, Pl. 6, the right antenna is eight-jointed and normal; and the left antenna is seven-jointed and abnormal. The measurements are:—

	1	2	3	4	5	6	7	8	Total
Right.Length	.0222	.02962	.02962	.02592	.02592	.0444	.0111	.0148	.191 mm.
" Breadth	.02962	.02592	.01851	.01851	.01851	.01851	.0074	.0037	-
Left.Length	.0222	.02962	.0222	.0222	.0333	.0222	-	.0148	.155 mm.
" Breadth	.02962	.0222	.01851	.0222	.01851	.0148	-	.0037	-

First and second joints normal; third slightly shorter than the right; 1 - 3 joints pale yellow, concolorous with the three joints of the right; fourth joint similar in form as in the right, but shorter; fifth joint larger and darkly pigmented resembling the fifth of the right side; sixth joint shorter and less wider than the right; seventh joint absent; eighth joint similar in size and form as the right joint.

Priesner mentions a case in which he found a form with seven antennal segments. Here, though seven segments are present, the fifth and sixth are deformed. If these had been normally formed, this antenna would resemble the normally formed eight-jointed antenna with the seventh segment missing.

In figure 37, Pl. 6 the right antenna is deformed and five-jointed; while the left is normal and six-jointed. The measurements are:-

	1	2	3	4	5	6	Total.
Right.Length	.02592	.02962	.0222	-	.0222	.05925	.1518 mm.
" Breadth	.02962	.0222	.0166	-	.01851	.0222	-
Left.Length	.02592	.0333	.02962	.02962	.02962	.0666	.196 mm.
" Breadth	.02962	.02592	.01851	.01851	.01851	.01851	-

First and second joints similar to the one on the left side and normal; third joint shorter and less wider than the third of the left side; fourth joint absent; fifth/

fifth joint shorter but as wide as the left one and slightly pigmented; sixth joint shorter but slightly wider than the left one. The left antennal joint normal and well formed.

In figure 39, Pl. 6 the left antenna is deformed and much more grotesque than the right one which is normal and six-jointed. The measurements are:-

Antennal joints	1	2	3	4	5	6	Total.
Right Length	.02592	.0333	.02592	.02592	.02592	.0629	.192 mm.
" Breadth	.02962	.02592	.01851	.01851	.01851	.01851	-
Left Length	.02592	.02962	.01851	-	.02962	.01851	.1074 mm.
" Breadth	.02962	.0222	.0148	-	.02592	.0111	-

First and second joints of the left antenna normal and similar to ones on the right side; third joint very small in length and width from the one on the right side; 1-3 pale yellow concolorous with these segments of the right side; fourth joint absent; fifth joint much swollen, grotesque having smoky pigmentation; sixth segment very short, appearing as a nodule with small terminal hairs and deep dark pigmentation.

In figure 40, pl. 6 both antennae are deformed and the reduction of joints is much greater than previously seen. The left antenna contains only four joints and the right antenna six, but the joints are abnormal. The measurements are:-

Antennal/

Antennal joints	1	2	3	4	5	6	Total.
Right Length	.02592	.0333	.0222	.02592	.0333	.02592	.159 mm.
" Breadth	.02962	.02592	.0148	.0222	.0222	.0148	-
Left Length	.02592	.03703	-	.03703	-	.0629	.148 mm.
" Breadth	.02962	.0222	-	.0222	-	.01851	-

Owing to the absence of two joints in the left antenna, the total size is much reduced.

Right antenna six-jointed; first and second joints normal; third joint short; fourth normal; fifth joint longer and wider than the normal size and slightly pigmented, sixth joint much smaller and deeply pigmented.

Left antenna only four segments; first and second normal and pale yellow, concolorous with these on the right side; third joint absent; fourth joint much longer and as wide as the one on the right side; fifth joint also absent; sixth joint is long and normal.

In figure 43, pl. 6 the right antenna is deformed with six joints, while the left antenna is eight-jointed and normal. In this case the reduction is still greater than the 2nd example and the eight-jointed form possesses one antenna six-jointed. But this has no resemblance with the normal six-jointed form. The measurements are:—

Antennal/

Antennal joints	1	2	3	4	5	6	7	8	Total
Right Length	.0222	.02962	.0222	.02592	-	.0592	-	.0222	.17407 mm.
" Breadth	.0333	.02592	.0148	.0222	-	.0222	-	.0037	-
Left Length	.02962	.0333	.02962	.02962	.02592	.0444	.0111	.0148	.207 mm.
" Breadth	.02962	.02592	.01851	.0222	.01851	.01851	.0074	.0037	-

Right antenna six-jointed; first and second joints shorter than these on the left; third joint shorter and less wider than on the left; 1-3 pale yellow and concolorous with the three basal segments on the left; fourth joint shorter but as wide as the left; fifth joint absent; sixth joint longer and wider than the normal; seventh joint absent; eighth joint longer but as wide as the normal.

2. Malformation of individual joints.

It will be seen from these figures that in most cases, the reduction or fusion is followed by malformation of joints. The joints are shorter or longer than the normal size and have grotesque appearances. The two basal joints are invariably normal. The greater number of individuals were found to have malformation of the terminal joints. (Figs 35, 37, 39, 41. pl.6).

3. Presence of a single median antenna. (Fig 38, Pl. 6)

This was a very unique specimen in which no trace of the second antenna was visible. In addition, the joints are not well formed. The measurements are:-

Antennal joints.	1	2	3	4	5	6	Total.
Median antenna:-Length	.01851	.03703	.0333	.0222	.01851	.05925	.188 mm.
Breadth	.0222	.02962	.01851	.01851	.01851	.01851	-

First antennal joint not well formed; the basal boundary not clearly seen, situated slightly on the right side; second joint very prominent and large; third joint longer; 1-3 joints pale yellow; fourth joint curved and depressed on the left side; fifth joint rounded and as long as broad; sixth joint long and deeply pigmented like the normal.

4. Fusion of two joints. (Fig 41, Pl. 6).

Occasionally the two joints are fused together to make a single long joint. In most cases there is an indication showing the place of fusion; but in some cases no trace is visible. The measurements are:-

Antennal joints	1	2	3+4	5	6	7	8	Total.
Left.Length	.02592	.0333	.044	-	.0407	-	.0111	.1516 mm.
" Breadth	.02962	.0222	.0222	-	.01851	-	.0074	-

First and second joints normal and pale yellow; third and fourth joints fused and the slight constriction reveals the boundary; fifth joint absent; sixth joint deeply pigmented; seventh joint absent; eighth joint small and short, like normal.

5. Presence of normal six and eight-jointed antenna in the same individual. (Fig 42, pl.6)

The presence of six and eight-jointed antenna in the same individual came to notice from a large number of examinations of eight-jointed forms. The measurements of one specimen are:—

Antennal joints	1	2	3	4	5	6	7	8	Total.
Right Length	.02592	.02962	.02962	.02592	.02592	.0444	.0111	.0148	.196 mm.
" Breadth	.02962	.02592	.01851	.01851	.01851	.01851	.0074	.0037	-
Left Length	.0222	.02962	.02962	.02592	.02592	.0518	-	-	.1851 mm.
" Breadth	.02962	.0259	.01851	.01851	.01851	.01851	-	-	-

The right antenna is eight-jointed and the left six-jointed. The lengths, breadths and pigmentations of individual parts agree with normal ones, on two separate forms. It is possible to conceive that this and the seven-jointed intermediate form (Priesner) suggests the connection between the six and eight-jointed forms which are only distinguished by the antennal/

antennal characters.

No deformity of the head was noticed. Rarely a few thrips with distorted thorax and abdomen were noticed. In one case the anterior part of the thorax was considerably constricted, which appeared as a neck; and in the other case the abdomen at the posterior part was greatly constricted.

The eggs taken out from the leaf sheath or from inside the body of thrips are delicate, more or less kidney-shaped structures (Fig 3, Pl. I) with light bluish white tinge, as is typical of the family. They measure .25+312 m.m in length and .02+11 m.m in breadth. The anterior part is broader and the posterior narrower, while the dorsal and ventral sides are the convex and concave sides of the egg. The lower end in the ovarian tubes are the first to reach maturity, and the simultaneous development of two or more eggs causes a distention of abdomen; and the eggs occasionally lie up to the second abdominal segment. The mature egg is very large and is even visible through the dark chitinous body wall.

Externally, the egg contains a delicate, shiny chorion. Below that is the vitelline membrane which is also delicate and thin (Fig 3, Pl. I).

B. LIMOTHRIPS CEREALIIUM.1. THE EGG.

The eggs are laid in slits made in leaves and appear as white spots through transmitted light. Oviposition in the beginning is heavier at the leaf-bases, but later on spreads to any soft green part and even to glumes.

The eggs taken out from the leaf sheaths or from inside the body of thrips are delicate, more or less kidney-shaped structures (Fig 3, Pl.1) with light bluish white tinge, as is typical of the family. They measure .284 - .315 m.m in length and .094 - .11 m.m in breadth. The anterior part is broader and the posterior narrower; while the dorsal and ventral sides are the convex and concave sides of the egg. The lower ova in the ovarian tubes are the first to reach maturity, and the simultaneous development of two or more eggs causes a distention of abdomen; and the eggs occasionally lie up to the second abdominal segment. The mature egg is very large and is even visible through the dark chitinous body wall.

Externally, the egg contains a delicate, smooth shining chorion. Below that is the vitelline membrane which is also delicate and thin (Fig 3, Pl.1).

Owing/

Owing to the soft nature of chorion and the vitelline membrane, the egg is capable of changing form within certain limits. The less mature eggs change their forms very easily with light pressure. Inside the vitelline membrane may be seen a large number of large and small yolk spheres (Fig 3, Pl.1).

2. NOTES ON EMBRYOLOGY.

The eggs when laid are whitish; but in course of development become slightly brownish and finally two red eyes begin to appear, a few days before hatching. This change in colour is due to the profound changes that are taking place inside the egg. Several workers agree that the germ band is immersed and that rotation of the embryo takes place, when the appendages come to lie finally on the concave side of the egg.

In one of the earlier stages it is seen that the embryonic area is small, and the spherular embryonic mass lies at the anterior end towards the convex side. This stage may be taken analogous to a stage prior to rotation. In a later stage, as seen in one of the eggs (Fig 4, Pl.1) the embryonic area is considerably larger. At the posterior end, it/

it is curved twice and also proceeds anteriorly with a curve. From the anterior end it slightly projects downwards towards the concave side. Five embryonic lobes are also visible situated near the embryonic area. These are probably the rudiments of certain future structures. This stage may represent one in which rotation has taken place. Such an egg measures .284 m.m X .094 m.m. The yolk droplets are few and scattered widely inside. ^{Neither} No eyes nor the division of the embryonic area is seen.

In later stages, the embryonic area is considerably developed and gives the shape of an embryo with eyes, antennae and rudiments of legs (Fig 5, Pl.1). At this stage the embryo is enclosed in the chorion, with antennae turned downwards and the tail part projecting upwards. In the middle, at the concave side, are the rudiments of legs. These appear to have been formed from the three posterior embryonic masses. What is the fate of the other two is not clear. The segmentation of the body is not visible, while the head appears to be separated from the thoracic region. The eyes are clearly visible and the antennae are projecting downwards closely applied to the anterior part of the head region. No yolk spherules are seen. Such an egg measures .37 m.m X .15 m.m

In still later stages, the embryo has grown much larger/

larger inside the egg-shell. The legs and antennae are well formed and the division of the body into head, thorax, and abdomen is faintly visible (Fig 6, Pl.1). The eyes are situated at the sides of head as red spots. These eggs measure .33 - 34 m.m X .11 - .15 m.m. The antennae are seen segmented and turned downwards. In further advanced stages, the embryo is still larger. Although it remains folded up, it has well developed legs crowded in the middle at the concave side, and the segmented antennae are bent downwards. The segmentation of the body into head, thorax and abdomen is clearly visible. At this stage, paired thin maxillary stylets and an unpaired stout yellowish mandible are seen for the first time (Fig 111, Pl.18). It measures when dissected out .44 - .5 m.m in length ; .094 m.m. across the head; .12 m.m across the thorax; .11 m.m across the mid-abdomen and .03 m.m between the eyes. After this stage the embryo hatches out as the first stage larva.



	(1)	(2)	(3)	(4)	(5)	(6)	Total
Length (R)	11.14	22.25	33.33	44.44	11	14.15	136.145 mm
" (L)	11.14	22.25	33.33	44.44	11	14.15	136.145 mm
Breadth (R)	22.25	22.25	25.25	25.25	11.14	7.71	
" (L)	22.25	22.25	25.25	25.25	11.14	7.71	

3. LARVAL STAGES.(a) First stage larva.

(Fig 44, Pl.7)

Total length .44 m.m - .86 m.m.

Newly emerged larva very small, about .44 m.m in length. Body colour yellowish white; antennae, legs and tip of abdomen white. Mouth cone yellowish with a chitinous yellow unpaired mandible clearly visible. After feeding, the colour changes. Body colour slightly deeper pale yellow. Antennae, legs and tip of abdomen shaded lightly.

The antennae are small (Fig 45, Pl.7), with six clearly visible segments. The measurements of segments from one and five specimens are:-

(1) Segments	1	2	3	4	5	6	Total.
Length(right)	14	22	33	44	11	14	.1407 m.m
" (left)	14	22	33	44	11	18	.144 m.m
Breadth(right)	25	22	25	25	11	7	-
" (left)	29	25	29	25	11	9	-

(5) Segments	1	2	3	4	5	6	Total.
Length(R)	11-14	22-25	29-33	40-44	11	14-18	.133-.148 mm.
" (L)	11-14	22-25	29-33	44-48	11	14-18	.129-.148 mm.
Breadth(R)	25-29	22-25	25-29	25-29	11-14	7-11	-
" (L)	25-29	22-25	25-29	25-29	11-14	7-11	-

The antennae are about one and a half times as long as the head. First segment rectangular, broader than long, lightly shaded at the basal part and slightly deep on the inner side; second joint longer with rounded sides, slightly more pigmented at the basal two-thirds and whitish anteriorly; third joint cup-shaped and pedicellate, the pedicle as well as the anterior part whitish and the lower middle part shaded; fourth joint oblong, longer than broad, and more than thrice the length of the first segment, colour whitish with very light pigmentation, five or six indistinct rings present, the anterior part being very prominent so as to represent a separate segment; fifth segment shortest almost as long as broad and slightly more deeply pigmented than the rest; sixth joint shorter, almost as long as the first, but about one-third or less in width as the first segment and more deeply pigmented than the fifth.

Head pale yellow with two round orange red eyes situated at the anterior angles of the cheeks. It is almost as long as broad or slightly broader. An area at the extreme anterior part of frons, between the antennae, lightly shaded, and bounded on each side by two deep dark lines. The mouth cone darkish, with the tip deep dark. Labium and other sutures, also lightly pigmented. Cheeks almost parallel; the mouth lying between the anterior coxae under the prosternum.

The/

The measurements are:- length .077 - .096 m.m; breadth .081 - .103 m.m; width across eyes .077 - .092 m.m; width of vertex .048 - .055 m.m; width of eyes .011 - .017 m.m.

Prothorax pale yellow, slightly broader than long and almost as long as the head. Sides parallel with anterior and posterior corners rounded. It measures .0703 - .096 m.m in length and .11 - .144 m.m in breadth.

Mesothorax pale yellow, shorter in length than the prothorax but slightly broader. Sides almost parallel. It measures .0481 - .077 m.m in length and .107 - .155 m.m in breadth. Metathorax also pale yellow with parallel sides. Almost as long and as broad as the mesothorax. It measures .055 - .074 m.m in length and .103 - .155 m.m in width.

All the legs are almost equal and lightly shaded; the sutures and lines being darker. On the inner sides a deep dark line from tarsi to tibiae is clearly visible.

Abdomen fusiform tapering posteriorly and ending in a circular opening. All the segments pale yellow with whitish intersegmental bands, except the last segment which is whitish and is shaded with very light pigmentation. The length and (breadth) of ten abdominal segments are:- .0185 - .0259 (.092 -.137) mm;

No. of Length of Hairs on Dorsal
 .0296 - .037 (.096 - .1407) m.m; .0225 - .037 (.1037 -
 .144) m.m; .0259 - .033 (.1037 - .148) m.m; .0259 -
 .037 (.1037 - .144) m.m; .0259 - .037 (.1037 - .137)
 m.m; .0296 - .037 (.096 - .1296) m.m; .0259 - .037
 (.077 - .1074) m.m; .0259 - .0333 (.055 - .074) m.m;
 .0296 - .037 (.0407 - .055). The first segment

shortest of all; the breadth of the segments from
 second to fifth almost equal, the rest of the segments
 tapering gradually.

CHAETOTAXY:-

Three basal antennal joints devoid of
 conspicuous hairs. Fourth joint possessing a few at
 the distal part; one conspicuous hair on the inner
 side below the last ring and one on the outer side
 beyond the last ring (Fig 45, Pl.7). The segments
 fifth and sixth possessing a few long and short hairs.
 Hairs absent or very minute on the head, thorax and
 legs. Very minute hairs present dorsally, and on
 1-6 abdominal segments, none seen on the sides,
 probably being very small. The first conspicuous
 and very long hair visible on the sides of seventh
 segment. Measuring the hairs situated dorsally and
 laterally, the following measurements are obtained
 (Fig 48, Pl.8).

No./

No. of Segment	Length of Segment.	Hairs on the side.	Dorsal hairs.
7	.0296-.037 mm.	.055-.066 mm.	.0111 mm.
8	.0259-.037 mm.	.0148-.0259 mm.	.0111 mm.
9	.0259-.033 mm.	.051-.062 mm.	.0148 mm.
10	.0296-.037 mm.	.0148-.0185 mm.	.0407-.0518 mm.

From the above measurements it is seen that the lateral hair on the seventh segment is much longer than the length of the segment, dorsally there are four minute hairs indistinctly seen. On the eighth segment laterally there is a short hair almost as long as the length of the segment; the four dorsal short hairs are as long as on the previous segment. On the ninth segment again there is a very long hair situated laterally, dorsally only two short hairs are seen. On the tenth segment the lateral hairs are comparatively shorter while the median ones are very long.

(b) Second Stage larva.

(Fig 46, Pl.7).

Total length 1.04 - 1.64 m.m.

Body colour pale yellow, antennae, head, legs and the last abdominal segment deeply shaded.

Differentiated from the first stage larva in size and in/

in colour which is darker on the parts above mentioned.

The antennae are long (Fig 47, Pl.7), six segmented and the average measurements from one and five individuals are:—

(1) Segments	1	2	3	4	5	6	Total.
Length(right)	18	29	48	55	11	18	.185 mm.
" (left)	18	29	48	55	11	18	.177 mm.
Breadth(right)	25	22	25	22	11	7	-
" (left)	25	25	29	22	11	7	-
(5) Segments	1	2	3	4	5	6	Total.
Length(right)	18	29-33	48-51	51-59	11	18-22	.181-.196 mm.
" (left)	18	29-33	48-51	51-59	11	18	.177-.192 mm.
Breadth(right)	25-29	22-25	25-29	22	11-14	7	
" (left)	25-29	25	25-29	22-25	11-14	7	

Antennae are about one and a half times as long as the head or a little longer. First segment almost rectangular with anterior angles rounded, wider than long, darkish for the most part, except a little whitish anterior part, more deeply shaded on the inner side and at the outer basal corner; second segment almost cylindrical, longer than broad with anterior rounded angles, much longer than the first, deeply shaded at the lower two-third part and whitish anteriorly; third joint more or less cup-shaped, pedicellate, as long as the first or second, the pedicel/

pedicel and the anterior part whitish, the middle part shaded; fourth segment oblong, over three times as long as the first and almost twice as broad as the fifth, whole segment completely shaded with six whitish rings, the sixth ring wider; fifth segment shortest, almost as long as broad; sixth segment almost as long as the first but least in width. Both the terminal segments deeply shaded.

Head dark with yellowish tinge, almost as long as broad or a little longer. Two dark eyes at the lateral angles of cheeks. The area at the extreme anterior of frons, extending between the two antennae, dark, with dark lateral lines, appearing very contrasted. Mouth cone dark with the tip almost black. Labium and other sutures shaded. Cheeks parallel. Mouth lying between the anterior coxae under prosternum. The measurements are:— Length .1037 -.122 m.m; breadth .1037 -.118 m.m; width across eyes .0922 - .1037 m.m; width between eyes .055 - .0703 m.m; width of eyes .0148 -.0185 m.m.

Prothorax yellow, broader than long, slightly longer and broader than the head, sides wider posteriorly and sloping anteriorly with corners rounded.

Mesothorax yellow, shorter than the prothorax; but much broader, sides almost parallel. It measures .1 - .133 m.m in length and .214 - 255 m.m in width. Metathorax also yellow, sides parallel measuring .118/

.118 - .137 m.m in length and .214 - .277 m.m in breadth.

All the legs almost equal in size, dark with light areas; sutures and lines darker, deep dark lines on the inner sides of tarsi and tibiae visible.

Abdomen much longer and wider than the first stage larva. All the segments yellow, wider anteriorly and tapering posteriorly, with white intersegmental areas. Ninth segment lightly shaded posteriorly. Tenth segment slightly more shaded throughout. The length and (breadth) of ten abdominal segments are:- .0481 - .0629 (.185 - .274) mm; .0629 - .0925 (.2 - .292) m.m; .0703 - .0814 (.214 - .314) m.m; .0703 - .0851 (.229 - .318) m.m; .066 - .0851 (.229 - .314) m.m; .0703 - .0851 (.222 - .307) m.m; .066 - .0851 (.211 - .292) mm; .074 - .0851 (.174 - .233) mm; .055 - .0841 (.111 - .129) m.m; .0407 - .0629 (.0518 - .066) m.m.

The first segment is the shortest, while second to sixth segments almost equally wide, the rest tapering, the tenth is least wide.

CHAETOTAXY:-

First three antennal segments possessing very minute hairs. On the fourth segment one very stout hair on the inner side before the sixth ring and a similar one on the outer side beyond the fifth ring/

ring (Fig 47, Pl.7). On the mesothorax, two long conspicuous hairs in the middle, slightly inside, about 96 mic. from the sides and measuring 59 mic. in length and situated 130 mic. apart. Two similar long hairs about 55 mic. long on the metathorax. Dorsal hairs on the first to fifth abdominal segments very minute, about 11 mic. long. No hairs visible on the sides of first to six abdominal segments. On the fifth segment, there are six short dorsal hairs, as on previous segments, about 11 mic. long (Fig 49, Pl.8). Similarly, six hairs 11 mic. long situated dorsally on the sixth segment. On the seventh segment, one very long hair about 51 mic. long on each side; dorsally four shorter hairs, outer pair slightly longer about 22 mic. long and the inner pair shorter about 14 mic. long. On the eighth segment, long lateral hairs about 37 mic. long but shorter than the lateral hairs on the preceding segment. Four dorsal hairs present, outer pair slightly longer, about 25 mic. long and the inner pair about 18 mic. long. On the ninth segment, a row of important hairs are situated at the distal part of the segment. The outermost hair situated on the side is about 48 mic. long, longer than the preceding one, the first inner pair very short, about 11 mic. long, the second inner pair very long and conspicuous, about 51 mic. long, as long as the/

the lateral one on the seventh segment, the third innermost pair, slightly longer than the first pair, xxx measuring 14 mic. On the tenth segment the dorsal pair of hairs is much longer (about 44 mic. long) than the shorter lateral ones, 14 mic. long.

Head is wider than long, widest posteriorly and rounded anteriorly. Two red eyes present. Traces of ocelli visible in some. Mouth cone not seen.

The measurements are: in length and

4. PRE-PUPAL STAGES.

(a) Female Pre-pupa.

(Fig 50, Pl.7)

Total length 1.2 - 1.68 m.m.

Body colour pale yellow, or slightly deeper in some; antennae, legs, wing rudiments and part of head more transparent and almost colourless.

Antennae lie straight in front of the head, and various segments not clearly visible. The first two segments (Fig 51, Pl.7) more clearly differentiated; while the last one may be divided into two by a small constriction. The measurements are:—

Segments	1	2	Last Segment.	Total.
Length	29-40	29-37	85-122	.159-.196 mm.
Breadth	37-44	33-44	25-29	-

First and second joints shorter than the last, broader/

broader than long. Last segment having two indistinct joints, the first measuring 48-55 mic. long and 29 mic. wide; and the second one 37-74 mic. long and 25 mic. wide. The segments are not differentiated as in the larval stages.

Head is wider than long, widest posteriorly and rounded anteriorly. Two red eyes present. Traces of ocelli visible in some. Mouth cone not seen. The measurements are:- .11 - .137 mm. in length and .148 - .185 mm. in width; width across eyes .137 - .159; width between eyes .08 - .11; width of eyes .0148 - .0296 mm.

Prothorax pale yellow, sides parallel, anterior and posterior angles rounded; longer and wider than the head. It measures .142 - .173 m.m in length and .22 - .26 m.m in width.

Mesothorax pale yellow, concolorous with prothorax; sides almost parallel; much longer and wider than the prothorax. It measures .12 - .18 m.m in length and .28 - .33 m.m in breadth. Metathorax also of the same colour as mesothorax; wider than long; sides parallel; almost as long and wide as mesothorax. It measures .12 - .18 m.m in length and .28 - .34 m.m in breadth.

Legs almost equal and whitish with rounded ends. Distinct tarsi not visible. Rudiments of wings visible/

visible and short; the first pair on the mesothorax about .36 m.m long and reaching up to the middle of second abdominal segment; the second pair arising from the metathorax .34 m.m long, almost as long as the first pair, and reaching up to the anterior part of third abdominal segment.

Abdomen long and fusiform tapering posteriorly, pale yellow, concolorous with the thorax. The first segment shortest as in larvae, the rest few almost equal, and tapering posteriorly, the last segment being small; ninth and tenth segments not very clearly visible except under higher magnifications. The length and (breadth) of xxx ten abdominal segments are:-
 .063 - .0784 (.25 -.3) m.m; .094 - .11 (.3 - .363) m.m;
 .11 (.31 - .39) m.m; .094 - .12 (.34 - .41) m.m;
 .094 - .11 (.33 - .39) m.m; .094 - .11 (.33 -.37) m.m;
 .094 - .11 (.31 - .33) m.m; .0784 - .094 (.25 - .28) m.m;
 .0784 - .094 (.12 - .15) m.m; .0784 - .094 (.078) m.m.

CHAETOTAXY:-

Antennae almost smooth. On the head two hairs 11 mic. long below the ocellar traces; posteriorly four long hairs 11 mic. long situated below the eyes. Four moderately long hairs about 25 mic. situated near the posterior margin of prothorax. Hairs on legs scattered and very minute; none visible on wing rudiments. Abdomen more or less smooth; none/

none visible on the sides of first to six segments and few visible dorsally about 14 mic. long. Four minute hairs present on the dorsum of first to sixth segments (Fig. 54, Pl. 8). On the seventh segment one long hair about 44 mic. long on each side; dorsally four as on preceding segments, shorter than the lateral, and 29 mic. long. On the eighth segment laterally one hair on each side about 44 mic., as long as on the preceding segment; dorsally four hairs about 29 mic. long, as long as on the preceding segment. On the ninth segment one long hair on each side about 37 mic. long, shorter than the preceding; dorsally three pairs; the outermost pair very minute and thin about 18 mic. long, and situated above the posterior row; the posterior two pairs minute, weak and thin; the outer pair slightly longer (18 mic.) and thicker than the inner pair which is small (11 mic.), and thin. On the tenth segment, a longer pair situated dorsally (25 mic.) and a smaller, laterally (14 mic.)

(b) Male Pre-pupa.

(Fig 52, Pl. 7)

Total length .88 - 1.48 m.m.

Shorter than the female pre_pupa. Colour pale yellow or still lighter in some; antennae, legs, almost/

almost translucent white or colourless. ~~xxxxxx~~
~~xxxxxx~~. Several dark pigmentary bodies scattered
 inside the abdomen.

Antennae straight, lying in front of the head.
 Segments not clearly visible. Indications of three
 segments apparent (Fig 53, Pl.7), the first two small
 and the third long; but the last one may also be
 considered to have two joints. The measurements are:-

Segments	1	2	Last Segment.	Total.
Length.	25-37	25-33	96-114	.148 - .174 m.m
Breadth	29-40	33-40	22-40	-

Antennae shorter than the female pre-pupa and
 also the first segment shorter and thinner. The first
 joint and second joint shorter, and the third joint
 about four times as long as the first. The first and
 second joint wider than long. The last joint divisible
 into two joints, the first measuring 44 - 55 mic.
 long and 22 - 40 mic. wide; and the second one 51 -
 59 mic. long and 22 - 25 mic. wide. The various
 segments not so clearly differentiated as in the
 larvae.

Head wider than long, widest posteriorly and
 slightly rounded anteriorly. Two ~~xxxxx~~ reddish dark
 eyes present. No trace of ocelli visible. The
 measurements are:- .1037 - .14 m.m long; .11 - .166
 m.m in width; .1037 - .151 m.m across the eyes; width
 of eyes .014 - .022 m.m and width between the eyes
 .059/

.059 - .107 m.m.

Prothorax pale yellow, widest posteriorly and slightly sloping anteriorly. Longer and wider than the head; but wider than long. It measures .126 - .157 m.m in length and .157 - .25 m.m in width.

Mesothorax pale yellow, concolorous with the prothorax; sides almost parallel. Longer and wider than the prothorax, and wider than long. It measures .094 - .174 m.m in length and .205 - .31 m.m in width. Metathorax also of the same colour as the mesothorax, wider than long and almost as wide as the mesothorax. It measures .078 - .14mm. in length and .205 - .31 m.m in width.

Legs almost equal and whitish, having rounded ends. Separate structures not well made out. Tarsal ends round and not distinct. Wing rudiments absent unlike female pre_pupa which ^{has} ~~have~~ short wing rudiments.

Abdomen long, concolorous with the thorax. First segment shortest, rest few almost equal, and hind ones tapering. The length and (breadth) of ten abdominal segments are:-

.047 - .063 (.205 - .284) m.m; .078 - .094(.221-.315)mm;
 .063 - .094 (.221 - .347) m.m; .063 - .094(.236-.363)mm;
 .078 - .094 (.221 - .363) m.m; .063 - .094(.205-.347)mm;
 .078 - .11 (.189 - .331) m.m; .063 - .094 (.173-.3)mm;
 .078 - .11 (.126 -.222) m.m; .063 - .094 (.063-.11) mm.

CHAETOTAXY:-/

CHAETOTAXY:-

Hairs on the antennae, head, thorax and legs, very minute and more or less inconspicuous. Hairs on the first to sixth abdominal segments either dorsally or laterally very small. On the sides of first to five segments very minute hairs about 11 mic. long and on the sixth slightly longer about 14 mic. long. The first long hair visible on the side of seventh abdominal segment about 37 mic. long. Similarly on the sides of eighth and ninth segments long hairs present, as long as on the sides of seventh segment. Dorsally on the eighth segment four long hairs present about 22 mic. long (Fig 55, Pl.8). On the ninth segment dorsally four weak thin hairs, situated posteriorly, the outer pair slightly longer about 18 mic. long and the inner pair shorter and weak about 14 mic. long. On the tenth segment two hairs fairly long, situated dorsally, about 18 mic. long, and two very small side ones, about 11 mic. long.

5. PUPAL STAGES.(a) Female Pupa.

(Fig 56, Pl.9)

Total Length 1.04 - 1.8 m.m.

Slightly larger than the pre_pupa; colour pale yellow or still lighter in some; antennae, legs, wing rudiments and tip of abdomen whitish or very lightly yellowish. Mouth cone not visible.

Antennae laid back along the top of head reaching beyond the head, a little over the anterior part of pronotum. Length of antennae over the head from the basal rounded point about .21 m.m. The segments not visible, three or four light projections visible on the outer sides, the fourth or the last bearing a short hair; terminally three or four projections with short hairs; similarly on the inner side two or three short hairs on light projections; basally one long thin hair about 18 mic. long on the outside; and a short one slightly inside. (Fig 61, Pl.9).

Head wider than long, widest posteriorly and slightly sloping anteriorly. Two dark red eyes present, situated slightly anteriorly, and the traces of three ocelli present between the eyes, appearing in some as deep brown mass. Mouth cone not visible.

The/

The measurements are: Length of the head = .142
 - .234 m.m; width of the head .173 - .221 m.m; width
 across eyes .142 - .173 m.m; width between eyes .047
 - .11 m.m; width of eyes .031 - .063 m.m.

Prothorax pale yellow, sides sub-parallel, widest posteriorly and sloping anteriorly with anterior and posterior corners rounded; wider than long, almost as long as the head; but wider than the head. It measures .157 - .205 m.m in length and .189 - .284 m.m. in width.

Mesothorax pale yellow, concolorous with the prothorax; shorter than the prothorax but much wider. It measures .126 - .189 m.m in length and .236 - .363 m.m in width; sides almost parallel with anterior corners rounded. Metathorax of the same colour as the mesothorax, wider than long, sides almost parallel. It measures .11 - .173 m.m in length and .236 - .363 m.m in width.

Legs almost equal, whitish, with rounded ends. Distinct parts not present, tarsi not differentiated. Two pairs of long wing rudiments present, one pair on the mesothorax and the second pair on the metathorax. The first pair measures .663 - .773 m.m in length and extends to the fourth or the fifth abdominal segment. The second pair almost equal to the first, measures .631 - .709 m.m in length, and extends to the fifth or sixth abdominal segment. In cases where the abdomen/

abdomen is much telescoped, the wing rudiments reach much posteriorly, as far back as the seventh abdominal segment. The long length of the wing rudiments and the position of the antennae over the head, apparently differentiate the pupal stage from the pre-pupa.

Abdomen long and large, pale, the tip whitish and tapering posteriorly. The first segment shortest as in pre-pupa, the rest few almost equal. Ninth and tenth segments not well differentiated, except under high magnifications.

The length and (breadth) of xxx ten abdominal segments are:- .031 - .078 (.268 - .315) m.m;
 .047 - .142 (.284 - .363) m.m; .047 - .126 (.315 - .394) m.m; .063 - .126 (.315 - .4) m.m; .063 - .126 (.315 - .4) m.m; .047 - .126 (.3 - .37) m.m; .063 - .126 (.284 - .347) m.m; .063 - .126 (.236 - .315) m.m;
 .1 - .13 (.25 - .3) m.m; .07 (.17 - .19) m.m.

The abdominal segments are slightly longer and wider than ⁱⁿ the pre-pupa.

CHAETOTAXY:-

Two hairs (37 mic.) situated between the eyes above the ocellar pigment. Below each eye is a pair of shorter hairs (29 mic.). On the prothorax at each anterior corner is a hair about 22 mic. long. Slightly below the anterior line, in the middle, is a short pair situated 74 mic. apart measuring 18 mic. long/

long. About two-thirds down at the sides slightly inwards is a longer hair on each side about 29 mic. long. On the extreme hind part, a short distance from the posterior margin, is situated a row of long prominent hairs about 55 mic. long. On the pterothorax; besides some minute hairs, a few distinct ones are made out. There are two pairs of short hairs situated in the middle between the first pair of wings. The first pair of hairs is short, situated above and is about 14 mic. long; the other pair situated posterior to the first pair is slightly larger and is 25 mic. long. The first pair is separated about 48 mic. from each other and the second pair about 74 mic. from each other. Slightly posteriorly in the middle, between the second pair of rudiments of wings, is a pair of hairs about 37 mic. long and separated 59 mic. from each other. At the costa of the first pair of rudiments of wings are situated 5 or 6 very short hairs. Hairs on the legs minute and scattered widely.

On the abdomen, dorsally all the segments are provided with hairs; while no hairs are visible on first to sixth segments laterally. On the second abdominal segment there are six hairs, the outermost about 11 mic. long and the inner four hairs equal and about 25 mic. long. Similar arrangements prevail on the/

the succeeding segments as far as sixth. On the sixth, typical of the preceding type, there are six dorsal hairs, the outermost shortest, about 14 mic. long and inner four hairs equal about 29 mic long. (Fig 57, Pl. 8).

On the seventh abdominal segment, a very long hair on the sides (55 mic.) at the posterior part of the segment. Dorsally there are four hairs, all equal, about 48 mic. long. Similarly on the eighth segment, four dorsal hairs about 62 mic. long, longer than the preceding dorsal hairs; and on each side a long hair about 70 mic. long, much longer than the lateral hairs of the preceding segment.

On the ninth segment, posteriorly a long hair about 62 mic. long on each side. Dorsally, besides 2 short pairs of hairs, there are four stout strong hairs situated almost at the posterior margin. The first short pair is situated a little ^{posterior} to the anterior margin of the segment and measures about 7 mic. long. The second short pair is situated still further back, slightly above the outer stronger hairs. It measures 11 mic. long. Then are the four thorn-like spines very characteristic; but not very prominent. The outer pair is about 25 mic. long and 3 mic. thick at the base, is longer and slightly thicker than the inner pair. The inner pair is 22 mic. long, and slightly less thick at the base. These four stronger hairs/

hairs stand almost straight from the body segment. The tenth segment is provided with two stronger hairs dorsally, about 29 mic. long, and the side ones are longer and thinner, about 44 mic. in length.

(b) Male Pupa.

(Fig 58, Pl.9)

Total length 1.0 - 1.44 mm.

Shorter than the female pupa, and almost as long as the pre_pupal stage. Colour pale yellow or still lighter, antennae legs, and tip of abdomen whitish, mouth cone not visible.

Unlike the pre_pupal stage, antennae are laid back over top of head, reaching in some up to the anterior part of pronotum. Length of antennae over the head shorter than the female pupal stage and measure .144 - .166 mm. from the basal rounded point. Segments likewise not visible, a few weak elevations both outside and inside seen and also at the terminal part.

Head almost as wide as long, cheeks parallel. Two large deep red eyes present at the anterior cephalic ends. No trace of ocelli present. Colour light yellow. The measurements are:- Length .126 -

.173 mm.; width .126 - .173 mm.; width across eyes .11 - .15 mm.; width between eyes .031 - .094 mm.; width of eyes .031 - .063 mm.

Prothorax paler, sides parallel with posterior rounded corners. Wider than long. Almost as long as the head and wider than head. It measures .142 - .173 mm. in length and .189 - .236 mm. in width.

Mesothorax also paler, concolorous with the prothorax. Shorter than the prothorax; but much wider, sides sub-parallel. It measures .094 - .126 mm. in length and .205 - .3 mm. in width. Metathorax of the same colour as mesothorax, sides almost parallel, slightly longer than the mesothorax; but as wide as the mesothorax. It measures .063 - .142 mm. in length and .205 - .3 mm. in width.

Legs whitish, almost equal, with rounded ends. Tarsi not visible as separate structures. No wing rudiments present.

Abdomen shorter and not so wide as in the female pupa. Colour light yellow, almost cylindrical and slightly sloping posteriorly, the terminal segment not ending in a conical point. The length and (breadth) of ten abdominal segments are:- .031 - .063 (.173 - .268) mm.; .078 - .094 (.205 - .3) mm.; .063 - .094 (.221 - .331) mm.; .063 - .11 (.221 - .331) mm.; .063 - .11 (.236 - .347) mm.; .063 - .11 (.236 - .347); .063/

.063 - .11 (.236 - .331) mm.; .078 - .11 (.205 - .315) mm.; .094 - .142 (.173 - .268) mm.; .047 - .11 (.078 - .173) mm.

CHAETOTAXY:-

Two hairs about 22 mic. long situated in the middle between the eyes. Two shorter hairs about 11 mic. long below each eye. On the prothorax a short hair at each anterior corner about 11 mic. long; in the middle a short distance from the anterior margin a very short pair of hairs about 7 mic. long. On the mesothorax in the middle, there are two short pairs of hairs, the anterior pair about 11 mic. long and the posterior longer about 18 mic. long. Similarly on the metathorax, there is a pair of hairs about 18 mic. long, situated in the middle.

Laterally no hairs are visible from first to sixth abdominal segments. Six short dorsal hairs on second segment, about 18 mic. long. Six hairs are present on the sixth abdominal segment almost as long as on the previous segments. On the seventh segment a long hair at the posterior side, about 29 mic. long. Hairs of similar length are present dorsally. On the eighth segment the lateral hairs are rather long, about 37 mic. long; dorsal hairs almost as long as on the previous segments. (Fig 59, Pl.8).

On the ninth segment posteriorly, four short hairs/

hairs present somewhat stouter than the dorsal hairs on previous segment. All the hairs are straight, the outer ones slightly longer (14 mic.) and stouter than the inner ones (11 mic.). Laterally a hair on each side (37 mic.), as long as on the previous segment. These hairs which are characteristic of pupal stages are very small and difficult to see in comparison with the hairs found on the ninth segment of other species. On the tenth segment terminally, there are two dorsal hairs about 18 mic. long and two lateral about 22 mic long.

6. ADULTS.

(a) Female.

Total length .1.3 - 1.66 mm.

Winged. Body elongate, slender and tapering posteriorly ending in a blunt point. General colour deep dark, yellowish brown or slightly lighter at some places and very deep at other places.

Antennae eight segmented (Fig 64, Pl.10) lying in front of the head, about one and a half times as long as the head or slightly more, widely separated at bases. The measurements of segments from one and five individuals are:-

(1) Segments	1	2	3	4	5	6	7	8	Total.
Length(right)	25	40	55	44	44	62	14	18	.303 mm.
" (left)	22	40	55	44	44	66	14	18	.303 mm.
Breadth(right)	37	29	22	20	20	20	7	3	-
" (left)	37	29	22	22	20	20	7	3	-

(5) Segments	1	2	3	4	5	6	7	8	Total.
Length(R)	22-25	37-40	48-55	40-44	40-44	59-62	11-14	14-18	.274-.303 mm.
" (L)	18-22	37-40	48-55	40-44	40-44	59-66	11-14	14-18	.274-.303 mm.
Breadth(R)	33-37	25-29	20-22	20-22	20-22	18-20	7	3	-
" (L)	33-37	25-29	22-25	22	18-21	18-20	7	3	-

The length of individual segments and the total length varies within certain limits. Segment one short, much wider than long, more or less rounded, cup-shaped, dark yellowish anteriorly and darker posteriorly; second segment longer than the first but less wide, sloping posteriorly and wider anteriorly, deep dark brown; third more than twice as long as the first and less wide than the second, slightly pedicellate, pale darkish brown; fourth and fifth clavate more or less equal in length and width, slightly deeper brown than the third; sixth segment fusiform, longest, almost two and a half times as long as the first, as wide or nearly as wide as the preceding, colour dark brown as on the previous segment; seventh segment and eighth segment short, cylindrical; seventh shortest of all and the eighth segment /

segment much more slender. Both segments concolorous with the preceding segment. Outer angles of third and fourth developed, specially strongly developed on the third outer side, each bearing one long sense cone. Sixth also bears one long slender sense cone on the inner side at about two-thirds of its length.

Head dark brown, with a tri-radiate spot connected with the curved line below the left eye and a similar detached spot below the right. The line over the anterior margin of head below the bases of antennae and the sides below the eyes also slightly darker brown. Head is little longer than wide, slightly sloping anteriorly; cheeks parallel or very slightly arched. Surface of head not reticulated. Front strongly arcuate produced between the bases of antennae. Two dark eyes of moderate size situated at the cephalic ends, and surrounded by a yellow margin, triangular above and slightly protruding, with about eight or nine small yellowish facets visible. Three ocelli distinct, arranged in the form of a triangle between the eyes, well separated, the two side ones almost equal and larger than the anterior one which is shortest. All the ocelli having dark red crescents on the inner margins. Mouth cone short, lying under the prosternum, between the anterior coxae. Maxillary palp short, two-jointed; labial palp two-jointed. Mouth cone with tip deep dark brown.

The/

The measurements are:- Length .157 - .189 mm.; width .157 - .173 mm.; width across eyes .14 - .157 mm.; width between eyes .063 - .078; length of eyes .063 - .078; width of eyes .039 - .047 mm.

Prothorax dark brown concolorous with head.

It is as long as the head and much wider; sides widening from the head posteriorly; posterior corners rounded, transverse margins nearly straight. It measures .157 - .189 mm. in length and .205 - .236 mm. in width.

Mesothorax dark brown; or more or less rusty brown, deeper dark at anterior overlapping areas and over sutures. It is slightly shorter or as long as the prothorax, and much wider; wider than long, about one and a third times as wide as the prothorax; sides slightly arched with anterior corners rounded.

It measures .126 - .189 mm. in length and .268 - .331 mm. in width. Metathorax also dark brown, and concolorous with mesothorax, almost as long as the mesothorax and slightly less wide, sides parallel and abruptly getting narrower. It measures .14 - .173 mm. in length and .236 - .3 mm. in width.

Legs almost equal, rather short and not thickened.

Coxae, trochanter, femora of all legs almost equally dark brown; the femora of the first pair slightly darker and thicker than the middle and hind. Fore tibiae, all tarsi and terminal parts of middle and hind/

hind tibiae yellow. Fore tibiae darker at the outer than the inner margin; the basal part is dark yellow; while the middle and the anterior part are yellow.

Wings present, long, slender, and membranous, folded back on the abdomen in normal position, and tapering gradually from the base to the tip. Fore-wing dark brown, slightly clearer at the basal part and having a lobe or scale at the hind part of the base (Fig 62, Pl.10). It is about one-seventeenth as broad in the middle as long. The anterior fringes consisting of few long hairs (26-29) and posteriorly numerous longer hairs (66-67). Two longitudinal veins present, and represented by areolar areas, the fore-vein continuous from the base, and the second branching from the fore-vein from about one-fourth its length from the base. Both veins and costa bearing short, stout, dark brown spines. Twenty-two to twenty-four are present on the costa. Fore-vein in all having eleven spines of which nine are close and continuous, and the apical two widely separated from them and situated at the anterior two-third part; the three basal spines very small and minute, while the rest strong and easily seen. The second vein bearing about ten stout short spines. The lobe or scale is darker brown with two conspicuous long spines at the outer angle and about six at the inner margin. The fore-wing measures 1.04 - 1.1 mm. in length/

length and .063 mm. in width. The lobe or scale measures .157 mm. in length. The second pair of wings is much clearer and whitish or very slightly yellowish, with long and thin costal fringes (Fig 63, Pl.10). A darker line running throughout the length indicates the presence of a single vein. The lobe or scale is present, with two long thin hairs at the outer angle. It measures .97 - 1.05 mm. in length and .047 mm. in width in the middle.

Abdomen long and cylindrical, dark brown, darker at the tip and having dark transverse bands due to overlapping. The first segment short and the remainder almost equal in length; width almost equal up to seventh and then abruptly decreasing. The last three segments sub-conical and the tenth segment ends in a blunt tip. The length and (breadth) of ten abdominal segments are:- .063 - .078 (.189 - .252) mm.; .094 - .126 (.268 - .315) mm.; .094 - .126 (.284 - .363) mm.; .094 - .126 (.3 - .378) mm.; .078 - .126 (.315 - .394) mm.; .078 - .126 (.3 - .378) mm.; .078 - .11 (.284 - .331) mm.; .078 - .11 (.236 - .3) mm.; .047 - .078 (.142 - .173) mm.; .078 - .11 (.078 - .094) mm.

CHAETOTAXY:-

Hairs are present on all antennal segments and are very minute and fine on the first joint; on the/

the rest they are fine but longer, a few scattered here and there but majority situated more or less in one whorl at the anterior parts of the segments. Third segment has a sense cone about 18 mic. long at the anterior outer angle; a similar sense cone slightly longer about 22 mic. long, present at the anterior outer part of the fourth segment; the rest having no sense cones except the sixth which has one on the outer side anteriorly about 14 mic. long and one slightly larger about one third from the front on the inner margin about 22 mic. long. (Fig 64, Pl.10).

Several hairs present on the head, two moderately long hairs about 29 mic. long situated between the eyes, each anterior to the two lateral ocelli; posteriorly below the eyes, a row of four shorter hairs about 18 mic. long. A row of very short hairs at the anterior margin of prothorax. Posteriorly a row of short and long hairs; at each outer corner a very long hair about 70 mic. long; slightly inside, a very short one on each side about 11 mic. long; further inside, a slightly longer hair on each side about 14 mic. long; further inside one hair on each side, shorter than the preceding, about 11 mic. long; in the middle a pair of long hairs about 25 mic. longer than the preceding, except the corner ones. On the pterothorax in the middle, four pairs of hairs present/

present, each pair arranged transversely, the first and second pairs small about 18 mic. long, the third pair longer about 37 mic. long; the fourth pair short almost as long as the first or second. Other short hairs are scattered all over the surface.

Hairs on the first and second pair of legs very minute or long, but much more slender and thin, widely scattered over the surface; coxae, trochanter and femora of the third pair of legs having small thin hairs; on the tibia at the inner sides a row of stout spines present used for combing the fringe of the wings (Fig 65, Pl.10); at the inner posterior angle a very stout and long spine about 37 mic. long, slightly above that towards the outer side another spine about 25 mic. long, at the inner margin there are about eight spines shorter and thinner, the last one being very small and weak. On the tarsi, two stout spines on the inner margin and a pair situated almost diagonally, the middle spine being on the dark line that runs to the tibiae. Beside these, there are several other shorter hairs situated near the surface.

Hairs are present on all abdominal segments but are conspicuous only on the posterior part. First to fifth segments have very short dorsal hairs. On the sixth segment, dorsally, at the posterior part is a thin short hair on each side about 22 mic. long, dorsally four hairs, the outer pair on each side about/

about 25 mic. long and the inner middle pair shorter, about 18 mic. long. On the seventh segment dorsally four hairs in the middle and two at the posterior sides, the posterior side hairs longer and stronger about 33 mic. long. (Fig. 69, Pl.10). Of the dorsal four hairs, the outer pair on each side about 25 mic. long and the inner about 22 mic. long. On the eighth segment, the posterior side hair is very strong and stout about 44 mic. long; dorsally about the middle four hairs, the outer pair about 29 mic. long and the inner about 18 mic. long. Posteriorly on this segment are two pores. Also a similarly long and stout hair is visible from the side about 44 mic., like the one situated at the posterior dorsal side. On the ninth segment, the hairs are most numerous and some are very long and some very small. The hairs are situated in a whorl at the posterior part of the segment. The outermost hair on each side is very long about 155 mic. long; above that on each side is a very short hair about 14 mic. long; slightly inside is a moderately long hair on each side about 37 mic. long; further inside is another very long hair, about 155 mic. long, as long as the outermost; further inside is a shorter hair about 22 mic. long; in the middle is a pair of long hairs about 96 mic. long; Anterior to the third pair of hairs from the outside is a small hair about 14 mic. long; situated anteriorly are/

are two pores. On the tenth segment, there is a cleft in the middle; terminally two very thin hairs are situated on each side of the cleft and measure about 18 mic. long; slightly anteriorly towards the sides is a thin long hair about 74 mic. long. Further anteriorly on each side of the cleft is a pair of very strong, deep dark brown thorn-like spines about 40-48 mic. long and about 7 mic. wide at the base; near the bases of each of these thorn-like spines are present one pore. All the stout strong hairs are dark brown in colour.

(b) Male.

(Fig 66, Pl.9)

Total length 1.04 - 1.4 mm.

Apterous. Body shorter and stouter than the female, bluntly rounded at the posterior tip. General colour dark brown, paler than the female, becoming yellowish brown at places.

Antennae eight segmented (Fig 68, Pl.10), shorter than the female, about one and one-third times as long as the head or slightly more, widely separated at the bases. The measurements of various segments from one and five individuals are:-

(1)/

(1) Segments	1	2	3	4	5	6	7	8	Total.
Length(right)	22	33	40	33	33	48	7	11	.233 mm.
" (left)	22	33	40	33	33	48	7	11	.233 mm.
Breadth(right)	29	22	22	22	22	18	7	3	-
" (left)	29	24	22	22	20	18	7	3	-

(5) Segments	1	2	3	4	5	6	7	8	
Length(R)	18-22	29-33	37-40	29-37	29-37	44-48	7-11	11-14	.214-.24 mm.
" (L)	18-22	29-33	37-40	29-37	29-37	40-48	7-11	11-14	.218-.244 mm.
Breadth(R)	25-33	22-25	20-24	20-25	20-22	18	7	3	-
" (L)	29-33	22-25	19-24	18-24	20-22	18	7	3	-

the inner margin: when only two feet are present.

First segment short, wider than long, more or less cup-like, dark brown for the most part except the anterior white margin; second segment longer than the first but less wide, longer than wide, sloping posteriorly, concolorous with the first, and uniformly dark brown; third segment about twice as long as the first, broad anteriorly and sloping posteriorly, ending in a pedicel, colour pale yellow, having a sense cone at the outer anterior part; fourth and fifth segments clavate almost equally long and broad, slightly darker than the third, fourth joint having a sense cone at the anterior outer angle. Sixth segment fusiform, much longer than any of the preceding ones, uniformly darker than the preceding ones; seventh and eighth segments short and cylindrical; concolorous with the sixth segment; eighth very slender.

Head dark brown. As long as broad, slightly/

slightly sloping anteriorly; cheeks parallel or very slightly arched; surface not reticulated. Front strongly arcuate produced between the bases of antennae. Two dark eyes present at the anterior cephalic ends, surrounded by a yellow ring, triangular above and protruding very slightly if at all; ocelli usually absent, but rarely with three, or two ocelli; all the ocelli when present small and almost equal, arranged in the form of a triangle between the eyes and well separated, all having dark red crescents on the inner margins; when only two ocelli are present, it is the anterior one that is missing. Mouth cone short, lying under the prosternum between the anterior coxae. Maxillary palp short, two segmented and labial palp dark brown. Mouth cone with tip dark brown. The measurements are:- Length .142 - .173 mm.; width .142 - .173 mm.; width across eyes .134 - .142 mm.; width between eyes .063 - .0789 mm.; length of eyes .063 mm. and width .031 - .039 mm.

Prothorax yellowish brown or rusty brown with a light dark tinge, lighter in colour than the head, as long as the head or a little shorter; wider than long and much wider than the head; sides almost parallel with anterior and posterior corners rounded, transverse margins nearly straight. It measures .126 - .142 mm. in length and .142 - .221 mm. in width.

Mesothorax/

Mesothorax yellowish brown or rusty brown concolorous with the prothorax, slightly shaded at some parts, almost as long as the prothorax or a little shorter, wider than long and slightly wider than prothorax, sides very slightly arched, rounded anteriorly. It measures .1105 - .142 mm. in length and .189 - .252 mm. in width. Metathorax also yellowish brown concolorous with mesothorax, slightly shorter than the mesothorax or almost equal, wider than long and as wide as the mesothorax or a little less, sides almost parallel. It measures .063 - .126 mm. in length and .173 - .252 mm. in width. No wings or wing rudiments present.

Legs almost equal, short and not thickened; yellowish brown; fore femora slightly thicker and darker than the other femora. Fore tibiae, all tarsi and terminals of middle and hind tibiae, yellow. Fore tibiae more darkly shaded at the outer margin than on the inner.

Abdomen shorter and narrower than in the female; cylindrical; bluntly rounded at tip; yellowish brown becoming darker posteriorly; segments overlapping, giving a dark banded appearance. Segment one shortest, and the second to seventh almost equal; the anterior two or three segments slightly wider posteriorly. Third to seventh segments having each a roundish clear transparent area situated in the middle of sternites/

sternites. Ninth segment very large and bluntly conoid. Segment ten small, cylindrical and clearly seen, retracted within the ninth; copulatory apparatus projecting a little from the tenth segment. The measurements of abdominal segments are:- Length (Breadth):- .047 (.142 - .189) mm.; .078 - .094 (.189 - .252) mm.; .078 - .094 (.205 - .268) mm.; .063 - .094 (.221 - .284) mm.; .063 - .078 (.221 - .3) mm.; .063 - .094 (.221 - .3) mm.; .063 - .078 (.205 - .284) mm.; .063 - .078 (.189 - .268) mm.; .094 - .126 (.173 - .221) mm.; .047 - .094 (.063 - .078) mm.

CHAETOTAXY:-

Third and fourth antennal joints have each a sense cone at the anterior outer angles, shorter than the sense cones on these segments in the female. The sense cones are also present on the inner and outer sides of the sixth segment (Fig 68, Pl.10). The two hairs between the eyes anterior to the two lateral ocelli if they are present and a pair of hairs below the eyes are almost equal to those present in the female. A row of short hairs are present on prothorax also. At the hind part of prothorax at each corner is a long hair (44 mic.) shorter than in female, slightly inside are three shorter hairs on each side; in the middle is a pair of hairs longer than the preceding three pairs. On the pterothorax, in the middle, are situated/

situated four pairs of short hairs, each pair in transverse rows. All the legs are more or less smooth, with short and thin hairs scattered at long distances.

Very small hairs are present on the first to seventh abdominal segments. On the sides of seventh segment is a thin small hair (22 mic.). On the eighth segment, the lateral hairs are longer (29 mic.) than on the preceding segment (Fig 67, Pl.9). Dorsally are present six short hairs. Near the posterior margin slightly towards the sides on each side is a hair about 29 mic. long, as long as the lateral hair.

Hairs on the ninth segment are very characteristic and quite unlike those present in the female (Fig 67, Pl.9). Laterally there is a very long hair on each side about 77 mic. long, slightly inside on each side are three very short hairs, each about 11 mic. long, the two are in a line and one slightly anterior. Dorsally about the middle are two very long thin hairs about 74 mic. long. In the centre are black chitinous areas ending in a point anteriorly. At the posterior end, each black area has a short thick, dark brown thorn-like spine about 14 mic. long and 3 mic. wide at the base. On each side of this is a pore, and posteriorly is a pair of short thick hairs (14 mic.). Posteriorly towards the sides also are two black chitinous areas carrying dark brown thorn-like spines, about 18 mic. long and as wide as the pair/

pair in the middle of the segment. On the sides of the tenth segment are another pair of long hairs. The tenth segment bears distally a row of 8 - 10 very minute hairs.

7. MOUTHPARTS.

The mouthparts of Thysanoptera have been the subject of study for a very long time and the literature on it shows the great divergence of views held with regard to the interpretation of parts. The earliest work on the subject is by Karl Jordan (1888) on Parthenothrips dracaenae. Garman (1890) described the mouthparts of Limothrips cerealium and called to attention for the first time, the asymmetry of certain structures. Later on Bohls (1891), Uzel (1895); Buffa (1898); and Hinds (1902) described the mouthparts of various thrips, interpreting the parts differently. Uzel (1895) while agreeing with Garman (1890) on certain points differed as regards the unpaired mandible. In 1896, Garman further supported his interpretations. In March 1915, Peterson made a detailed study of twelve species of Thysanoptera, and gave a detailed account of the mouthparts. He interpreted certain parts differently, and also correlated/

correlated the interpretation in the various families of Thrips. In June 1915, the same year, Borden gave another account of the mouthparts based on considerable comparative study of thrips and made out certain new parts not dealt with by Peterson (1915) and adopted Garman's view.

In the light of these studies, it seemed desirable to re-describe the mouthparts of L. cerealium and to see how far these interpretations can be applied.

The head of Limothrips cerealium is smooth and all the sclerites are so thoroughly welded together that no trace of different sutures is visible. Therefore, such parts as frons, vertex, genae and occiput are used in a general sense. (Fig 70, Pl.11).

The sucking mouthparts form a broad unjointed cone lying under the prosternum and reaching about the middle of fore coxae. The mouth cone is short, bluntly rounded and very dark brown. When seen dorsally the mouth cone is connected with the frons (Fig 70, Pl.11) by a strongly chitinized dark thickening running obliquely across the front of the head. This thickening is much nearer to the left eye than to the right one, where it takes a sloping course. This oblique part of the front thickening is connected with a strongly chitinized dark spot situated below the left eye, by a strongly curved thickening (Fig 70, Pl.11). Such a connection is wanting on the/

the right; although a rudiment of chitinized part is present below the right eye. The mouth parts are lodged in a short, strong, blunt cone, and consist of the following parts. The figure 70, Plate 11, shows the mouth parts as seen ventrally.

(i) Clypeus and Labrum.

The clypeus and labrum are the mesal structures lying on the ventral side of the mouth-cone. The clypeus is a small membranous portion (Fig 70, Pl.11) separated from the frons by a thick chitinized rim above, and below by the proximal margin of the thick dark brown triangular plate. It is asymmetrical as it curves up on the left side forming a broad part of the membranous connection with the labrum. The labrum forms the front part of the mouth-cone, appearing as a triangular highly chitinized plate. It consists of two parts, the distal symmetrical round socket at the tip and the proximal asymmetrical piece. The proximal part is drawn out considerably towards the right side, while the left part is quite symmetrical.

There has been considerable difference of opinion regarding the parts to be designated as clypeus and labrum. Garman (1890) held that the whole triangular, two-jointed, heavily chitinized piece is the labrum, and the anterior membranous part is the clypeus.

Peterson/

Peterson (1915) on the other hand, interprets from the study of the homology of parts in the two sub-orders, that the clypeus consists of proximal membranous part and the distal chitinized part; while the labrum is the terminal socket at the tip of the mouth. According to him clypeus is highly asymmetrical and the labrum is symmetrical. In my description above, I have followed Garman's view; because it seems to me, that the membranous portion is very clearly separated by the thicker chitinous part. Besides, the two parts of the labrum are separated from surrounding area by distinct sutures or thickenings and are equally chitinized and concolorous.

(ii) Maxillae,

The maxillary sclerites are two triangular pieces situated by the sides of labrum and form the side walls of the mouth cone. Laterally they gradually taper towards the tip and are closely applied to the tip of labrum. The palpi are two segmented having a few tactile terminal hairs. The maxillary sclerites are also asymmetrical, the left one reaching further forward owing to the greater space there, than the left one.

The maxillary stylets are paired structures lying inside the mouth cone. Each consists of three parts (Fig 71, Pl.11). The first or proximal part is/

is heavier, slightly twisted and is applied to the cephalic margin of the maxilla. The second part is shortest and is separated from the distal part by a faint suture. The third or distal part is very long and needle-shaped. It is thicker basally and ends in a sharp point. Occasionally, the suture between the distal and the middle pieces is not clearly visible and the whole piece appears one-segmented. But an examination of many specimens reveals that the stylet is three-segmented. Garman (1890) in his work on L. cerealium, and other workers on other thrips have described and shown the stylets as composed of two parts only. So far as is known, Peterson (1915) has been the first to demonstrate that the maxillary stylets are tri-segmented, and my observations on L. cerealium confirm his statement.

As regards the homology of these parts, it appears that these are some parts of maxillae as they are associated with them. Garman (1890) and Peterson (1915) seem to agree that these parts are modified galea or lacinia. Jordan (1888) considered these stylets as mandibles basing his observations on embryonic development. Similarly Uzel (1895) adopted this view. But this view is not tenable as it appears evident when their connections with the cephalic margin of maxillae are made out. Besides, in the embryonic/

embryonic development long before the embryo hatches out, these paired thin structures are evident along with the thicker structure. (Fig 111, Pl.18).

(iii) Mandible.

The mandible is a single large strongly chitinized structure situated on the left side of the mouth cone. It is joined by its broad base to the chitinous thickening at the place, where the chitinous band runs to the left eye. It consists of two parts, the basal bulbous part and the distal, long needle-shaped part, separable by a faint suture (Fig 72a, Pl.11). Longitudinal sections reveal the presence of a canal throughout most of its length, but whether there is an aperture at the end, is difficult to say. On the right side, no such structure is visible; but a rudimentary piece homologous with the left mandible may be found. This rudimentary piece of the right side is distinguishable from the left piercing mandible by the size and the position of attachment. It is a small structure, slightly wide anteriorly and posteriorly, and ^{with} a slight constriction in the middle. It is applied to the cephalo-lateral side of the pharynx. Although several workers have invariably recorded this or an equivalent piece on the right side; yet Borden (1915) mentions that he never found anything corresponding to it

on the right side in Euthrips tritici, and other thrips he examined. However, this rudimentary piece, has been found in all specimens of L. cerealium, I examined.

As regards their homology, Garman (1890) was the first to call the left piercing organ, the left mandible; and the right rudimentary piece as homologous to the left mandible. Jordan (1888), however, interpreted the left mandible as modified epipharynx. His conclusions were derived from embryological studies. In the figure of the embryo, he showed the asymmetrical piercing organ as the upper portion of the anterior end of alimentary canal and concluded that when the adult stage is reached, the connection of the epipharynx with the alimentary canal is lost and it becomes firmly fixed to the head capsule. Peterson (1915) and others homologize the parts as Garman (1890) has done and my observations confirm their statements. As regards the embryonic stage, I have found the asymmetrical piercing organ (mandible) as a yellow shining structure after a certain stage of development of the egg. It has not been observed as forming part of the alimentary canal as Jordan (1888) suggested; but appears to be attached to the same place as in the adult stage after hatching. As regards the parts comprising the mandible, Garman (1890) found in L. cerealium/

cerealium that the mandible was single jointed. On the other hand, I have invariably found the mandible two-jointed, separable by a faint suture at the junction of the basal and distal parts. Occasionally the suture looks fainter and the piece appears single-jointed. In this case my observations agree with Peterson (1915)

(iv) Labium,

Labium or the lower lip forms the hind part of the mouth cone. It is a broad, trough-like structure. It is attached on the sides to the triangular maxillary sclerites, and consists of two sclerites separated by a suture (Fig 73, Pl.11). The proximal part is the sub-mentum and the distal the mentum. At the distal end of mentum is a whitish membranous area, which carries the labial palpi. The palpi are two segmented, the proximal piece being very small and the distal longer and cylindrical bearing a few terminal tactile hairs. At the distal end a few chitinous elevations are visible which probably have gustatory function.

(v) Hypopharynx.

This is a long, heavily chitinized sabre-shaped structure (Figs 70-72b, Pl.11). It consists of a distal, flat, pointed part; and a proximal piece/

piece which consists of very long muscular attachment radiating far under the frons of the head. The distal chitinous part appears to lie in a dark brown spindle-shaped groove of the pharynx. Jordan (1888) figured this piece correctly and showed a similar position in Heliothrips dracaenae; but he did not describe it.

What he called hypopharynx, is the lower vestibular part, described here as pharynx, in which the anterior chitinous part rests. Buffa (1898) also did not describe this structure. He described a chitinous structure as epiglottis, lying under the vestibule, his hypopharynx. It appears that Buffa (1898) called the posterior tubular part of vestibule, described here as pharynx, as epiglottis. Borden (1915) first described this structure under hypopharynx; but he did not show the connection with pharynx. He has moreover neither described nor figured the pharynx. Garman (1890) and Peterson (1915) also do not seem to have described this structure at all.

(vi) Pharynx.

This is a moderately long, heavily chitinized, dark brown vestibular structure, lying under the membranous clypeus and the labrum (Fig 70), Pl.11). It appears to consist of a single piece only. However, with regard to shape and size, it is divisible into/

into two parts. The proximal part is wide and vestibular; while the distal part is a small chitinous tube opening within the ental groove of the labrum. On the right side of the vestibular part, is attached the rudiment of the right mandible. As mentioned above, this part was called hypopharynx by Jordan (1888) and his epipharynx was, what has been described as the left mandible. Peterson (1915) describes this part as pharynx and mentions that it is a structural modification of alimentary canal, homologous with the pharynx of sucking insects. My observations in L. cerealium agree with his.

IV. ANATOMY.1. DIGESTIVE SYSTEM.

The digestive system consists of a tubular alimentary canal, and in all thrips is divisible on structural basis into three parts; the fore-intestine; the mid-intestine and the hind-intestine. The surface and histological structures of fore and hind-intestine are similar, but different from the mid-intestine. The fore and hind-intestine are lined with chitin.

The alimentary canal in Aptinothrips rufus (Fig 75, Pl.12) is about twice as long as the insect, and consequently lies in a convoluted form in the body cavity. It measures about 2.3 mm. in length.

The fore-intestine (Fig 75, Pl.12) is a small, very short thin tubular part, about one-eighth the length of the whole intestine. It consists of a chitinous pharynx, an oesophagus and a short crop. Long muscular fibres are situated in its walls, having small nuclei scattered at long intervals. Clear and distinct cell walls are not visible.

The pharynx is a short dark brown highly chitinized vestibular structure lying under the membranous clypeus and chitinized labrum. There are also certain muscles attached to it which help suction.

The/

The sucking pharynx leads into the oesophagus at its hind part, and this is a short delicate thin walled tube of even calibre about one and three-fifths of the length of fore-intestine, measuring about .16 mm. in length and 13.3 mic. in width (Fig 75, Pl.12).

The oesophagus slightly dilates posteriorly where it joins with the mid-intestine. This part I have called crop, since it is homologous with the crop in other insects. The crop is about three times as wide as the oesophagus, and in fresh dissections, it is visible as a clear white hinder part of oesophagus. Jordan (1888) in Heliothrips dracaenae Heeg, called the whole tube behind the pharynx to the beginning of the mid-intestine, oesophagus (Schlund); and Buffa (1898) in Heliothrips haemorrhoidalis Bouché, called the hind part, the cardias; while Uzel (1895) called the hind part, a dilation of the oesophagus (Erweiterungen des oesophagus). This part I have called crop, since in other species of thrips it is much widened and is decidedly homologous with crop in other insects. The crop measures about .1 mm. in length and .0366 mm. in width.

The mid-intestine (Fig 75, Pl.12) is the longest part of the alimentary canal, and lies in a convoluted form in the body cavity. It is about six times as long as the fore-intestine and three times as long as the hind intestine. Anteriorly it is dilated to form/

form a cylindrical wide tube where it joins with the crop. This front portion of the mid-intestine (Fig 75, Pl.12) is about three times as wide as the crop and is like a cylindrical tube, which is about one third of the length of the mid-intestine. It is .528 mm. long and .1 mm. wide. Further back it narrows into a long narrow tube, which again dilates posteriorly where it joins with the hind intestine. The middle portion is about 42 mic. in width at its front end and widens slowly to 71 mic.; and finally to 85 mic. where it joins with the hind-intestine. At the junction of the mid and hind intestine are situated four malpighian tubes (Fig 76, Pl.12).

The structure of the mid-intestine is altogether different from the fore and hind-intestine, as is easily seen in stained preparations under high magnifications even without sectioning. The walls of the mid-intestine are composed of enteric epithelium which consist of large, clearly demarcated, polyhedral cells paved all through (Fig 98, Pl.18). The cells are flat and contain one or apparently more than one nuclei which are very large and prominent. Some of these cells are very large while others are smaller. Some measure 36-41 micron in length and 28 micron in width with two or more nuclei, each 13 micron across. The chromatin granules and other parts of the cells are also clearly seen within the nuclei and the cell walls/

walls.

The hind_intestine in Aptinothrips rufus (Fig 76, Pl.12) is shorter than the mid_intestine, and its beginning is marked by the insertion of malpighian tubes. It is about twice as long as the fore_intestine and one_third as long as the mid_intestine. The hind_intestine is not a tube of even calibre but is dilated at certain places (Fig 76, Pl.12). Jordan (1888) did not homologize the parts of hind_intestine in Heliothrips dracaenae. Uzel (1895) in Aeolothrips fasciatus divided the hind_intestine into small intestine and large posterior intestine. Buffa (1898) divided the hind_intestine in Heliothrips haemorrhoidalis on the basis of rectal glands into:-

1. Pre_glandular part. 2. Glandular part. 3. Post-glandular part, and his division has been accepted and applied by Klocke (1926) in Thrips physopus.

I find that this classification is not based sufficiently on homologous structural basis to justify their application in A. rufus and other species; although they are correct. I, therefore, propose to divide the hind_intestine into, ilium and rectum, on the basis of the presence of a definite constriction separating one from the other. The pre_glandular part of Buffa (1898) will now be ilium. The rectum, however, may, for the sake of convenience, be further divided/

divided into glandular and post_glandular part as done by Buffa (1898).

The ilium is a short tubular structure wider anteriorly at the junction of malpighian tubes and separated forwards from the mid_intestine histologically, and posteriorly from the rectum by a slight constriction. Klocke (1926) has also shown that there are definite ring muscles between the ilium (pre-glandular part) and rectum (glandular part). The ilium measures about 123 mic. long and 70 mic. wide at the top and 33 mic. in the middle. The colon is considered here as absent or undifferentiated with ilium.

The rectum (Fig 76, Pl.12) is a wide pyriform structure distinct and swollen in fed and un_pricked specimens and rather shrunken otherwise. It is about 28 micron in length and 100 micron in breadth. The bladder_shaped rectum carries four oval rectal glands which are well separated from one another in the walls of the rectum. Each rectal gland is about 50 mic. in length and 38 mic. in width. The glands when stained appear to contain very large nuclei, each about 20 mic. across. The hinder part of the rectum which does not possess any glands is a tube of almost even calibre, opening finally to the exterior through the anus.

The alimentary canal in Aptinothrips larvae is proportionally/

proportionally shorter; but is of the same form, parts and structures, as in imagines. There are four rectal glands present in the first stage larvae (Fig 77, Pl.12) and similarly in the second stage, as in the imagines.

The digestive system is similar in Limothrips cerealium Haliday; Odontothrips ulicis (Haliday); Taeniothrips atratus (Haliday); Taeniothrips vulgatis-simus (Haliday); Thrips tabaci (Lindeman); and Kakothrips robustus (Uzel). In Heliethrips haemorrhoidalis (Bouche), the alimentary canal (Fig 78, Pl.12) is, as described and figured by Buffa (1898), and differs from A. rufus and other species, that the mid-intestine after the constriction of the cylindrical front portion of mid-intestine, instead of narrowing as in A. rufus, widens out considerably and proceeds backwards for a short distance and then narrows as shown in the figure. The rest of the mid and hind-intestine (Fig 78, 79 Pl.12) is similar to A. rufus. The mid-intestine is similarly paved with enteric epithelium as in A. rufus (Fig 78, 79 Pl.12).

In Melanthrips fuscus (Sulzer) (Aeolothripidae), the fore-intestine is a very large, long, and wide structure (Fig 80, 82, Pl.13). The mouth leads into a sucking pharynx which leads into a tubular thin oesophagus. The oesophagus widens out considerably at the posterior end into a long wide chamber, the crop/

crop. The wide posterior chamber of the fore_intestine in this species gives the true shape of a crop of other insects. In A. rufus and other species the crop on the contrary is attenuated.

The mid_intestine is a long wide structure as in A. rufus. The front portion of the mid_intestine (Fig 80, Pl.13) instead of being tubular as in A. rufus, is a much wider, spindle-shaped and shorter structure, narrowing posteriorly into a thin tube and widening again slightly before joining with the hind_gut. Occasionally specimens were found, in which the front portion of the mid_intestine was slightly constricted in the middle (Fig 82, Pl.13); but these may be considered as abnormal cases. The walls of the mid_intestine are composed of clearly demarcated polyhedral enteric epithelium (Fig 97, Pl.15) as in A. rufus.

The hind_intestine of M. fuscus consists of a short ilium which is broader anteriorly and tubular posteriorly (Fig 81, Pl.13), separated from the rectum by a short well defined constriction as in A. rufus. The rectum is long and wide at the anterior glandular part or slightly shrunken when pricked; and tubular and thin posteriorly. There are five rectal glands situated in the anterior part of the rectal wall, and are widely separated. The presence of five rectal glands in Thrips has not been previously noted, as Jordan (1888), Uzel (1895), Buffa (1898), Klocke (1926) and myself/

myself found only four rectal glands in other species of thrips. The post-glandular part of rectum is short (Fig 80, 81, 82, Pl.13).

In Haplothrips distinguendus Uzel (Phloeothripidae, Tubulifera), the alimentary canal is a shorter and much wider structure (Fig 83, Pl.13) unlike that of A. rufus and other species of Terebrantia. The mouth leads into a vestibular pharynx which leads into a thin tubular oesophagus. The oesophagus opens posteriorly into a crop which is wider than in A. rufus and other species of thrips; but shorter than in Melanthrips fuscus (Aeolothripidae). The crop opens posteriorly into a wide mid-intestine (Fig 83, Pl.13)

The mid-intestine is shorter but very much wider structure than in Terebrantia. The front portion of the mid-intestine is long and cylindrical and very much wider than in other species of thrips examined. Posteriorly, instead of narrowing as in A. rufus or other species of Thripidae or in Melanthrips fuscus, it opens into a wide globular chamber. The wide chamber gradually narrows down into a thin short tube which dilates considerably posteriorly before opening into the hind gut. The entire structure of mid-intestine is composed of clearly defined enteric epithelium with prominent nuclei, as in other species. The hind gut of H. distinguendus (Fig 84, Pl.13) consists anteriorly of a short ampulla-shaped ilium, which/

which is separated from the rectum by a well defined sharp constriction. The rectum is pyriform, very wide at the anterior glandular part, becoming tubular and thin at the posterior, post-glandular part. There are four oval rectal glands in the globular wall of the anterior part of rectum. The post-glandular part is thin and tubular. The general outline of alimentary canal in this species resembles that of Trichothrips copios as described by Uzel (1895) and Phloeothrips brunnea as described by Jordan (1888).

2. GLANDULAR SYSTEM.

A review of the previous work on salivary glands in Thrips, shows that there has been considerable difference of opinion regarding the number of salivary glands, and the course of their ducts, in various species of thrips in the two sub-orders of Thysanoptera. Below is summarised according to their nearest homologies, the number of salivary glands as found by Jordan (1888), Uzel (1895), Buffa (1898), Peterson (1915), Klocke (1926) and by me, in various species of thrips; and are arranged according to the three families of Thysanoptera.

It will be seen from the above table that in Aeolothrips fasciatus (Aeolothripidae), Uzel (1895) described two pairs of salivary glands, one pair short and thick and the other pair long and tubular. He did not trace the anterior course of ducts, and his short glands are separate posteriorly. In Melanthrips fuscus (Aeolothripidae), I have found only two pairs of salivary glands. The first is very much smaller, more or less cylindroid with a thin anterior duct, similar to the short, paired, salivary glands of A. rufus and other species (Fig 90, Pl.15). The second pair of salivary glands is thin and tubular (Fig 91, Pl.13), similar in structure to that of other species and arising similarly from the sides of the hind part of the front portion of the mid-intestine (Figs 80, 82 Pl.13). These two short and tubular salivary glands are therefore homologous with the short and tubular glands of various species of thrips.

In Heliothrips dracaenae (Thripidae) Jordan (1888) described two pairs of salivary glands, one pair short with large cells and nuclei, and the other pair tubular and long. He showed the short pairs separate and did not trace the anterior course of ducts. Buffa (1898) in Heliothrips haemorrhoidalis found three kinds of paired salivary glands. According to him, the first pair is the smallest, having/

having large cells and nuclei. The second pair is globular or spherical with larger cells and nuclei. Proximally each ends in a thin duct and distally each gland is separate and is joined with the terminal filament from each group of ovarian tubes. The third pair is long and tubular. He likewise did not trace the course of anterior ducts. Buffa (1898) on the other hand found one pair of extra salivary glands besides those two pairs already mentioned by Jordan (1888) in H. dracaenae (Thripidae), and by Uzel (1895) in Aeolothrips fasciatus (Aeolothripidae). Peterson (1915) in Heliothrips femoralis found only two pairs of salivary glands, one short and one long, homologous with the first (short and thick) and second (long and tubular) pairs of Jordan (H. dracaenae, 1888) and Uzel (A. fasciatus, 1895), and the second (short and thick) and third (long and tubular) pairs of Buffa (H. haemorrhoidalis, 1895). Moreover his two short thick salivary glands are separate posteriorly in H. femoralis and anteriorly the ducts go straight to the common duct. In addition to these glands, he mentions a third type of gland which he designates as the head gland, being different in histological structure from thoracic glands. Recently Klocke (1926) described three pairs of salivary glands in some of the Thysanoptera, he studied. Most of his work was done on Thrips physopus; but he does not exactly mention/

mention the species in which he got the first pair. According to him the first pair of salivary glands is pear-shaped, extraordinarily small, and lies dorsal to the alimentary canal, bending downwards between the brain and the sub-oesophageal ganglion. He has not been able to find the openings of these glands and he mentions that Jordan (1888), Uzel (1895) and Buffa (1898) have not described this kind of gland. The other two pairs are similar and homologous with the short and thick, and long and thin salivary glands.

In Aptinothrips rufus there are two pairs of salivary glands, one pair being short and thick, and the other pair long and tubular (Fig 85, Pl.14).

The first pair, more or less oval (Fig 86, Pl.14), is situated in the metathorax and the first abdominal segment; and lies either dorsally or laterally.

The two glands which normally lie on each side are not separate, but are joined at the posterior end by a small fine connective tissue (Fig 86, Pl.14).

If not properly manipulated, the connection breaks during dissection, and the two small glands appear as unconnected organs on either side of the alimentary canal (Fig 85, Pl.14). Two very short ducts which lie embedded in the central glandular tissue arise at the anterior ends of the short glands (Figs 85, 86. Pl.14). These ducts pass forwards and after joining with the sides of the "widened parts" or the reservoirs of/

of the second long salivary glands, proceed forwards. The ducts are of uniform diameter throughout. The connection of the ducts with the sides of the reservoir is so intimate and close, that I have not been able to separate the ducts without breaking.

Apparently the ducts do not open in the reservoir, as they continue their course forwards, as separate and distinct structures, and are separate from the ducts of the other pair of salivary glands. The duct from the right short gland unites with the duct of the left salivary gland much anteriorly and forms the common duct which opens into the common duct of the other pair of long and tubular salivary glands; thus forming the main duct of the salivary glands, which opens more anteriorly into the oesophagus (Fig 85, Pl. 14).

The cells of these glands are very large and distinctly differentiated, and sometimes their nuclei are even visible in unstained preparations. One or two deeply staining nuclei are present in each cell and sometimes various stages of nuclear division can be seen. The gland is about 134 mic. long and 61 mic. broad; while one of the component cell is 71 mic. long and 33 mic. wide, with the contained nuclei about 16 mic. across. In fresh dissections, they appear as clear translucent structures.

The second pair of salivary glands is a long, narrow, /

narrow, clear, thin-walled tube, situated laterally to the alimentary canal and extends to a much greater length in the abdomen than the first pair (Fig. 85, Pl. 14). In some this pair of glands is a very narrow structure, while in others, it is slightly broader. Posteriorly the glands originate as tubes on each side of the cylindrical hind part of the front portion of the mid-intestine. They extend anteriorly, more or less, as homogeneous tubes except near the sides of oesophagus where the ducts widen out to form reservoirs to which are attached the ducts of the short salivary glands already mentioned. The enlarged portion of the lumen probably functions as a storage chamber. Anteriorly the right and left ducts unite to form a common duct of the short salivary glands as already described.

The cells of these glands are very long with very fine central winding lumen (Fig 87, Pl. 14). The nuclei are short, scattered at long distances. Distinct cell walls are not seen which give the appearance of a syncytium. The tubular glands are about 6 mic. wide with the nuclei about 3 mic. across.

In Limothrips cerealium, the short pair of salivary glands (Fig 88, Pl. 14) is much longer and thinner than in A. rufus. It is two cells thick with well differentiated cell wall. Each cell contains usually two nuclei, but one only may be present.

Anteriorly/

Anteriorly there is a thin duct arising from each, and posteriorly the glands are joined together by a short connective tissue as in A. rufus. The other pair of glands is tubular, and is similar to A. rufus in structure and place of origin.

In Odontothrips ulicis, the short salivary glands are long and thin, having a duct anteriorly in each gland, and joined posteriorly by a connective tissue (Fig 89, Pl.14) as in A. rufus and L. cerealium.

Two more or less similar pairs of short and thick; long and tubular salivary glands are present in Taeniothrips vulgatissimus and atratus (Haliday); Thrips tabaci Lindeman; Kakothrips robustus (Uzel) and H. haemorrhoidalis (Bouché). These two pairs of salivary glands are homologous with the first (short and thick) and second (long and tubular) pairs of glands of Jordan (H. dracaenae, 1888), Uzel (A. fasciatus, 1895) and Peterson (H. femoralis, 1915); and with the second (short and thick) and third (long and tubular) pairs of glands found by Buffa (H. haemorrhoidalis, 1898), and Klocke (Thrips physopus etc. 1926). I have not been able to find the first pair of glands described by Buffa in H. haemorrhoidalis (1898) or the head gland of Peterson (1915) or the very small pear-shaped gland found by Klocke (1926), in A. rufus and other species, except H. haemorrhoidalis Bouché. Further it is important to note that the short salivary/

salivary glands in A. rufus; O. ulicis and L. cerealium are joined posteriorly, and in A. rufus their anterior ducts meet the reservoirs, before proceeding forwards, to form the common duct as discussed previously.

In Heliothrips haemorrhoidalis, three kinds of salivary glands are found. The first gland is unpaired. It is thin and small, wider posteriorly, gradually becoming thinner anteriorly (Fig 92, Pl.15). Inside, a few scattered nuclei may be seen, with a thin clear lumen. It is situated on the left side and appears to be associated with the left mandible. The second gland is paired, ovoid and thick (Fig 93, Pl.15), similar to the short and thick pair in A. rufus etc. Posteriorly, these short salivary glands are not joined with each other by any connective tissue, but are connected with the terminal filaments from each separate group of ovarian tubes in the female. Males of this species are not known. Each short gland has a duct anteriorly. The third gland is paired, tubular and long, arising from the hinder part of the front portion of the mid-intestine (Fig 78, Pl.12), as in other species. This species is the same which Buffa (1898) also studied. As will appear from the description given above, I have found three kinds of glands, similar in structure and form as described by Buffa (1898). But the first gland has not been found paired as Buffa (1898) describes. In all my dissections,
I/

I have found a single, unpaired gland, on the left side, if the dissection is made dorsally, and on the right side if ventrally, appearing associated with the mandible. Buffa (1898) has figured it in his longitudinal section of thrips on the right side only, which position it will always take, if the sections are seen from the ventral side. The mandible in this case will be seen on the right side.

In the sub_order Tubulifera, Jordan (Phloeothrips brunnea, 1888) described two pairs of salivary glands, one pair short and thick and the other pair long and thin. In Trichothrips copiosa (Phloeothripidae), Uzel has described three pairs of salivary glands, first pair very small, the second pair short and thicker, and the third pair long and thinner. Peterson (1915) described a long and a short pair of glands in Cephalothrips yuccae, homologous with the two pairs of glands found by him in H. femoralis.

In Haplothrips distinguendus, two pairs of salivary glands are present (Fig 94, Pl.15), and unlike the previous species of Terebrantia, none of them are connected with the mid-intestine. The first pair is shorter and thicker than the second pair which is longer and tubular (Fig 94, Pl.15). The first pair is thick, slightly constricted in the middle, and connected posteriorly with the long salivary glands by/

by a thread-like, fine, connective tissue. The cells are large and the cell-walls are well differentiated, each with one or two prominent nuclei (Fig 95, Pl.15). Anteriorly a thin duct is present. The second pair of salivary glands is longer and much thinner (Fig 96, Pl.15). Posteriorly each is connected by a thin filament to the terminal part of each side of ovary (Fig 95, Pl.15). Several small nuclei are seen scattered inside the gland, and a clear lumen is also seen (Fig 96, Pl.15). Anteriorly a fine duct is present. In Trichothrips copiosa, Uzel (1895) has shown that the short thicker pair is connected by a fine filament with the ovary. In Haplothrips distinguendus the connection is always with long thin pair of salivary glands.

As regards the form of the first pair of short thick salivary glands in Terebrantia, they are bladder-shaped (Jordan; H. dracaenae, 1888), globular to thick spindle form (Priesner; Aeolothrips, 1928) or sac-shaped (Priesner, Taeniothrips 1928). In Aptinothrips, they may be described as long oval. In other species of Terebrantia, some are long and thinner, while in others oval and thicker. In Haplothrips distinguendus (Tubulifera), the form of the first pair is quite unlike those shown by Jordan (1888) and Uzel (1895). All the previous workers agree as regards the long and tubular form of salivary glands in Terebrantia, and/

and in Aptinothrips rufus and other species of Terebrantia studied here, they are tubular and alike.

With regard to the position of the first pair of short salivary glands in the abdomen, they are situated according to Jordan (H. dracaenae, 1888) in the beginning of abdomen or in the hind burst or after Buffa (H. haemorrhoidalis, 1898) in mesothorax or after Priesner (T. vulgatissimus, 1928) partly in mesothorax and partly in metathorax. In Aptinothrips rufus, I have found them partly in the metathorax and partly in the first abdominal segment.

In the larval stages of Aptinothrips rufus, I have found the same number of salivary glands situated similarly as in the imagines. Priesner also (Aeclothrips fasciatus and Taeniothrips ericae, 1928) found only two pairs of salivary glands in the larval stages.

3. EXCRETORY SYSTEM AND FAT-BODY.

The excretory products are principally discharged through malpighian tubes, which are present in all Thysanoptera. Besides these, certain fat bodies are also present.

Malpighian/

Malpighian tubes:-

Jordan (1888) described four malpighian tubes in H. dracaenae and Phloeothrips brunnea. In H. dracaenae, he mentioned that the two anterior lobes lie contorted with each other and with the mid-gut. Uzel (1895) mentioned the same number of malpighian tubes in A. fasciatus and Trichothrips copiosa; but in A. fasciatus, he has described and shown that the two malpighian tubes of each side join to form a common canal on each side which finally opens at the place of union of mid and hind-gut. Buffa (1895) also described the same number of malpighian tubes in H. haemorrhoidalis and showed them lying by the sides of mid and hind-intestine.

In Aptinothrips rufus, there are four slender, moderately long, cylindrical malpighian tubes, a pair lying on each side of alimentary canal, and opening at the junction of mid and hind-gut (Figs 75, 76, Pl.12). They do not lie free in the body cavity or intertwined with each other. Two anterior tubes, one on each side, run forwards, and two posterior ones run backwards; so as to be closely applied to the mid and hind-gut. The malpighian tubes running posteriorly are more firmly applied to the sides of the hind-gut than the anterior ones. The anterior ones, therefore become easily separated from their positions and appear to lie free in the body cavity, while the posterior pair remains/

remains applied. Each tube opens by a separate opening into the ilium.

In fresh dissections, the malpighian tubes appear brownish and it has been observed that they contain some minute granules which are quickly thrown out in the ilium by a kind of rhythmic movement.

In stained preparations, the nuclei appear very large (8 - 11 mic. across) and are clearly seen near the sides; while the central part is occupied by a long winding lumen (Fig 99, Pl.16). Each tube measures about 457 mic. in length; 16 mic. wide at the base, 13 mic. in the middle and 10 mic. at the apex.

In Aptinothrips larvae, I have found the same number of malpighian tubes opening separately into the ilium, as in the imagines.

Four similar cylindrical malpighian tubes of various length are found in L. cerealium; Odontothrips ulicis; Heliothrips haemorrhoidalis (Figs 78, 79, Pl.12); Taeniothrips atratus and vulgatissimus; Thrips tabaci; Kakothrips robustus; Melanthrips fuscus (Figs 80, 81, 82. Pl.13); and Haplothrips distinguendus (Figs 83, 84. Pl.13), opening separately at the junction of mid and hind-gut. In Haplothrips distinguendus (Tubulifera), the malpighian tubes are rather longer, and deep brownish, opening very closely together between the mid-gut and the ampulla-like ilium (Fig 84, Pl.13)

Fat-body:- form and size. It lies in the head capsule

The fat-body in Aprinothrips rufus lies primarily in the form of two long lobes (Fig 100, Pl.14) on either side of the body cavity; but secondarily may form several lobes packed round the various internal structures. It consists of large globular cells loosely connected together, which become easily broken into small groups of cells. They appear greenish in colour in fresh dissection. In stained preparations, they appear as a mass of vacuolated round cells (Fig 101, Pl.14). The nuclei are large and round, and are present in some cells and completely absent from others. Fat-bodies are found both in larval and adult stages. Similar fat-bodies are found in L. cerealium (Fig 117, Pl.18) and may also be present in other species of Thysanoptera.

4. NERVOUS SYSTEM.

The nervous system in Aptinothrips is represented by a strongly developed brain and a greatly concentrated chain of large ganglia lying in the thorax and abdomen.

Brain:-

The brain is relatively large and can be easily differentiated from other ganglia by its position, /

position, form, and size. It lies in the head capsule and in A. rufus appears to consist of two flat broad lobes (Fig 102, Pl.16). Each lobe is wider anteriorly and arched at the outer angles; and is narrower posteriorly. There is a short depression at the anterior middle part of brain where two lobes seem to meet. On each side, the lobes slope down and make an inverted Y-shaped depression posteriorly at the place of union. Slightly below the anterior outer angles, each lobe has a very short thick optic nerve which bears distally a globular optic ganglion (33 mic. across). No definite suture across the vertical median line of the brain is seen; except the notch anteriorly and posteriorly already mentioned. The brain measures about 83 mic. in length and 133 mic. in greatest width. Behind the brain are a series of four large ganglia which according to their position can be named Prothoracic, Mesothoracic, Metathoracic and Abdominal ganglia.

Prothoracic ganglion:-

This is a moderately large and thick ganglion lying in the prothorax. Anteriorly it is joined with the brain, and posteriorly with the mesothoracic ganglion by a strong and thick commissure.

Mesothoracic ganglion:-

This is the second thoracic ganglion situated in the mesothorax. It is almost as large as the/

the Prothoracic ganglion. Anteriorly it is joined by a very short thick commissure with the prothoracic ganglion; so that the pro and mesothoracic ganglia are very close together.

Metathoracic ganglion:-

This is the third large ganglion almost equally broad as the two previously mentioned. It is connected by a thick commissure with the mesothoracic ganglion anteriorly and first abdominal ganglion posteriorly. Posteriorly is attached a nerve on each side.

First abdominal ganglion:-

The first abdominal ganglion is a large spindle form structure slightly widely separated from the metathoracic ganglion; and therefore the commissure joining the metathoracic and the first abdominal ganglia is clearly seen. It is longer than thoracic ganglia, and measures 90 - 116 mic. in length and 50 - 66 mic. in width. It is situated behind the pterothorax, probably occupying the first and second abdominal segments, but not in the metathorax. At the posterior end medially, it gives rise to the unpaired nerve chord. At each posterior side of the ganglion is attached a fairly thick nerve.

Nerve/

Nerve chord:-

The nerve chord is a median unpaired structure originating from the hinder part of the first abdominal ganglion and extending to the whole length of the body. It is slightly thicker anteriorly, and thinner posteriorly. At regular intervals, it gives rise to a pair of fine nerves in each segment. There are no visible thickenings or ganglia at the places where the segmental abdominal nerves originate. The first pair of abdominal nerves arises about 50 mic. from the first abdominal ganglion and the second pair is about 86 mic. from the first pair. The width of the nerve chord between the first and second pair of abdominal nerves is about 10 mic. Posteriorly it becomes still thinner.

Larval Brain:-

In the larvae of Aptinotrips rufus, the brain is large in proportion to the size found in imagines. It consists of two long lobes united in the middle where a suture is distinctly seen (Fig 103, Pl.16). It is rounded at the posterior end, and presents two very deep notches, one anteriorly and the other posteriorly. Anteriorly each lobe gives rise to a nerve the "Antennal-ocellaris nerve". This nerve and its branches innerve the antennae and the eyes. The most interesting thing noticed in the larvae is the/

the situation of the brain. The larval brain has always been found in prothorax or partly extending in the mesothorax. The head capsule is entirely empty. Each lobe measures about 133 mic. in length and 50 mic. in breadth. The brain of the larvae; and the imagines with four ganglia, contain large number of small nuclei which stain deeply.

Similarly concentrated nervous system is found in the rest of the species of Thysanoptera examined. In Limothrips cerealium, the brain is long, wider anteriorly and having slight projections at the anterior angles showing the place of optic nerves. Posteriorly there is a concentrated chain of three thoracic and one abdominal ganglia with a median nerve chord (Fig 104, Pl.16). The commissure in this species is thick and clearly seen. In Haplothrips distinguendus (Tubulifera) the brain is much larger and of different shape. The optic nerves are situated at the anterior outer angles and are very short and thick with short thick optic ganglia. Posteriorly it has also a similar chain of three thoracic and one abdominal ganglia with a median nerve chord (Fig 105, Pl.16).

Jordan (1888), Uzel (1895) and Buffa (1898) have figured the shape of the brain differently in the species they studied. Since the shape of the brain depends upon the form of the head capsule, there is bound/

bound to be some difference, as I have also found in different species examined. As regards the position of ^{the} abdominal ganglion, I have always found it, after the pterothorax, lying in the first and second abdominal segments.

5. REPRODUCTIVE SYSTEM.

(a) FEMALE.

Externally the females of Aptinothrips (Thripidae) are distinguished by the presence of an ovipositor which is the most important external sexual character (Fig 19, Pl.4). It is attached to the eighth and ninth abdominal segments and is clearly visible through the body of insect. It is composed of four valves, between which the eggs pass out, two of which form the under pair, and two the upper pair. The under pair is attached to the eighth segment and the upper pair to the ninth segment. The ovipositor lies curved downwards, as in all Thripidae. Each pair of two valves are widely separated basally and closely lying distally. Their anterior and posterior surfaces are provided with saw-like teeth.

The two valves of each pair on each side are closely fitted together, so closely, as to move forwards and backwards upon each other without being displaced/

displaced. The upper or posterior valves are sabre-shaped, curved downwards and pointed at the end (Fig 23, Pl.4). The upper valve is provided with sharp, minute, large number of saw-like teeth, pointed basalwards, throughout the whole dorsal length, except a short distance from the base. Ventrally or on the lower edge of the upper plate is a ridge (Fig 23, Pl.4) which fits in the groove of the dorsal part of the lower or anterior plate (Fig 24, Pl.4).

The lower or anterior valve is similarly curved and sabre-shaped; and as mentioned above is provided with a groove at the dorsal part into which fits the ridge of the upper or posterior valve. The ventral or anterior side is indented with saw-like teeth for the greater part of its length (Fig 24, Pl.4). It carries sixteen sharp pointed teeth from tip to above the middle. Just inside are situated a second row of eight teeth which are also prominently seen.

Internally in Aptinothrips rufus, the reproductive organs consist of an ovary normally composed of eight ovarioles, lying in two groups, with four ovarioles in each, on either side of the hind gut (Fig 106a, Pl.16). Occasionally a few individuals have been found to contain an abnormal ovary (Fig 107, Pl.17). These have nine ovarioles altogether, lying in groups of five and four ovarian tubes. The ovarioles do not lie free in the body cavity, but the terminal filaments from/

from all ovarioles of one side or group, combine to form a single filament, and this combines with a similar one formed on the other side, to form a long median ligament. This ligament is finally joined with the posterior connective tissue of the short salivary glands.

Each ovariole is a long tube which holds the developing oocytes one behind another in a single chain (Fig 106b, Pl.16). The oldest oocyte is situated near the base where the tube meets the oviduct. During earlier stages of growth of the basal oocyte, the remaining upper part of the ovariole keeps the median position (Fig 106b, Pl.16). But when the oocyte has become very large and acquires the characteristic bean-shaped appearance of an egg, the upper part is tilted to one side, on the top of the egg (Fig 2, Pl.1). In each ovarian tube, only the basal oocyte reaches maturity at any one time; but several eggs in different tubes may develop simultaneously. In no case has it been observed that two oocytes of the same ovarian tube may reach simultaneous maturity. It is only when the basal egg has been pushed out that another oocyte takes its place. The wall of an ovariole is a delicate transparent membrane and is capable of great enlargement during the maturity of an egg.

Three distinct regions can be distinguished in an ovariole. 1. Terminal filament. 2. Germarium/

Germarium. 3. Vitellarium.

1. Terminal filament:-

This is a long hair-like thread, and is the terminal prolongation of the outer wall of ovarian tubes. The terminal filaments of all the ovarioles combine to form a ligament which is joined with the basal part of the short salivary glands. This maintains the ovary in position. (Figs 106a, 106b, Pl.16).

2. Germarium:-

This is represented by the long conical part of the ovariole, and consists of a mass of cells from which the primordial germ cells are differentiated (Figs 106b, 106c, Pl.16). The nuclei of the cells stain deeply. This portion contains a large number of small cells in various stages of development from up downwards, and which later on give rise to young oocytes (Fig 106c, Pl.16). The nuclei of the small germ cells also stain deeply and are prominent. No nutritive cells have been recognized.

3. Vitellarium:-

It constitutes the longest part of the ovariole, and contains the developing oocytes. The epithelial layer of the wall encloses each oocyte in a definite, clearly visible follicle. All the ovarioles/

ovarioles are panioctic, as no vitellogenous cells are present either apically or in between the oocytes. All the ovarioles open by a short thin duct into a fairly wide, short, tubular oviduct. From two to four oocytes have been observed to lie in vitellarium.

The oviducts are paired, short, tubular ducts which anteriorly receive the ducts of the ovarioles and posteriorly combine to form a common duct. Each oviduct measures about 33 mic. in length and 36 mic. in width. Posteriorly the common duct is continuous with a wider passage or vagina. The common duct anteriorly measures 66 mic. and posteriorly (Vagina) about 100 mic. in width.

Associated with the vagina is the receptaculum seminis (Spermatheca). It is an oblong retort-shaped, flat structure, clear and shiny in fresh dissections (Fig 108, Pl. 17). When stained the walls contain prominent nuclei. The receptaculum seminis leads by a moderately long, wide canal, situated at an angle, as in a retort, and opens dorsally in the vagina. Colleterial gland or other accessory glands and bursa copulatrix or their homologous parts have not been observed in any dissection. The receptaculum seminis measures 116 mic. in length and 50 mic. in width. The duct is about 25 mic. wide with nuclei 3 mic. across.

Similarly in other species of thrips, Odontothrips ulicis/

ulicis; Taeniothrips atratus and vulgatissimus; Thrips tabaci; Heliothrips haemorrhoidalis; Limothrips cerealium; Kakothrips robustus; Melanthrips fuscus and Haplothrips distinguendus, the ovary consists normally of eight ovarian tubes, divided in two groups of four, and lying on each side of the hind-gut. The ovarioles in some species are short and contain fewer oocytes, and in some long, containing several. This depends partly on the breeding time also. During the hibernation period, the ovary is much attenuated.

In Odontothrips ulicis, the ovary, at the breeding time, is a very long structure composed of eight ovarioles (Fig 109, Pl.17). Each ovariole is divisible into three parts as in A. rufus. There are greater number of oocytes arranged in a chain. The ovarioles open into the paired oviduct which posteriorly form the common duct. This widens out a little posteriorly to form the vagina. In the middle of the common duct is situated the brown body (Fig 109, Pl.17), characteristic of most species of Thysanoptera. Slightly below, opens the duct from receptaculum seminis. Anteriorly the terminal filaments join to form a ligament which is connected with the posterior connective tissue of the short salivary glands.

In L. cerealium also the terminal filaments form a ligament which joins with the connective tissue of the/

the short pair of salivary glands.

In Heliothrips haemorrhoidalis, however, the terminal filaments from each group of ovarioles of either side join separately with the posterior part of the short salivary glands which are separate. This connection of terminal filament with the short salivary glands is different from the above species; and my observations confirm Buffa's ⁽¹⁸⁹⁸⁾ finding.

In Haplothrips distinguendus (Tubulifera), the ovary is similarly composed of eight tubules, arranged in groups of two and lying similarly as ^{described in the species of Terebrantia} ~~in other~~ species (Fig 110a, Pl.17). Each ovarian tube is similarly composed of three parts with a mature oocyte at the base (Fig 110b, Pl.17). Anteriorly the four ovarian tubes of each side join to form a thick connective tissue which is connected with the long pair of separate salivary glands, by a fine thread-like filament (Fig 94, Pl.15). In this connection it differs from ~~other~~ ^{the} members of [^]Terebrantia.

The receptaculum seminis slightly differs in shape and the length of duct in different species of thrips. In Odontothrips ulicis (Fig 109, Pl.17) it is more or less oval, retort-like, with a very short duct opening directly in the vagina. In Limothrips cerealium, it is more or less similar flat structure, with a moderately long duct, opening in the vagina. The sides and body are lined with cells having prominent/

prominent nuclei. In the duct the outgoing canal is also seen. (Figs 112-113, Pl.18). In Thrips tabaci, it is spherical at the end, bent inwards, with a long winding duct (Fig 114, Pl.18). The canal is also seen throughout the whole length of the duct. In H. haemorrhoidalis, it is rounded or globular with a very short duct similar to that shown by Buffa. The cells lining the walls are fairly long (Fig 115, Pl.18). In Haplothrips distinguendus (Tubulifera) the receptaculum seminis is a long bladder shaped structure, with a fine duct, opening directly in the vagina. The duct slightly widens out before opening in the vagina. No ampulla-like structure is found in the duct as shown by Jordan^a (1888) in Phloeothrips brunneus and Uzel (1895) in Trichothrips copiosa but the widening may be homologized with that. The receptaculum seminis is brownish in colour and is filled with a fluid having a dense collection of sperms.

(b) MALE.

In Aptinothrips rufus, both sexes are wingless and the males are externally distinguished chiefly by their short size, and the form of last abdominal segment which is bluntly rounded (Fig 33, Pl.5). Dorsally the abdominal rings are complete and the/

the divisions of eighth, ninth and tenth abdominal tergum are easily distinguished. The ninth and tenth sternal plates appear to be fused, forming a single median plate. The male genitalia are carried by the fused ventral plate, and consist of a pair of rods or claspers, and a median unpaired rod, the penis or aedeagus. The penis is a yellowish chitinous structure wider basally and thinner distally. The paired rods or claspers are also chitinous and are closely applied to the greater part of the median penis. Basally the claspers form curved chitinous thickenings which enclose the thicker base of the penis.

Internally the reproductive organs consist of a pair of saffron yellow testes lying in the 6-7 or 7-8 abdominal segments. Each testis is more or less club-shaped structure composed of four chambers in some, which are filled with spermatozoa (Fig 118, Pl. 19). The testes are about 108 mic. long and 28 mic. wide at the top. Posteriorly the testes are connected with a pair of clear white vasa deferentia 55 mic. long and 8 mic. wide, which open separately into the bulbous part of ductus ejaculatorius. Slightly before they open into the ejaculatory duct, the vasa deferentia widen out a little, which swelling may be homologized with the vesiculae seminales of other insects. The vesicula seminalis is not pouch-shaped; but is simply the widened posterior part of vas/

vas deferens. Another very prominent structure associated with the reproductive organs is a pair of clear translucent white accessory glands. They are long bladder-shaped structures slightly constricted in the middle, and wider proximally and distally. In figure 118, Pl.19, the left accessory gland is slightly distorted at the top; while the right one is normal. In stained preparations (Fig 120, Pl.19) the sides and the whole wall of accessory glands are composed of large cells having prominent nuclei (5 mic. across). The glands measure 143 mic. in length; and 36 mic. wide at the top, 33 mic. in the middle and 43 mic. at the base. The accessory glands open separately by very minute openings into the bulbous part of the ejaculatory duct. The openings of vasa deferentia and accessory glands appear to be close together. The ejaculatory duct consists anteriorly of a bulb-shaped (Fig 121, Pl.19) highly muscular structure (28 mic. across), into which open the accessory glands and vasa deferentia. Posteriorly it continues its course as a fine canal to the intromittant organ. The spermatozoa in Aptinothrips lie in the chambers of the testes (Fig 119, Pl.19) and are very small, flagella-like bodies, measuring about one micron in length.

In Limothrips cerealium, the testes are saffron yellow, wider at the top, and more or less club-shaped/

club-shaped (Fig 122, Pl.19) as in A. rufus. They do not appear to be divided into chambers; and in the anterior wide part a mass of spermatozoa can be seen. The testes are about 196 mic. long and 59 mic. wide at the top. Posteriorly, the vasa deferentia are very thin, and translucent white, and slightly widen out before opening into the bulbous part of ejaculatory duct. There are also two pairs of long, cylindrical accessory glands; about 196 mic. long and 48 mic. wide in the middle. They have cellular structure, and open separately into the ejaculatory duct, but are not constricted in the middle. The ejaculatory duct is bulbous anteriorly, as in A. rufus; and this wide part is about 55 mic. long and 40 mic. wide. Posteriorly it continues backward as a fine canal. Associated with this thin part is a structure with very weak musculature, and having small scattered nuclei. Klocke (1926) calls this part "Ringmuskel des Ductus ejaculatorius" in Thrips physopus; and it appears a similar structure is present in L. cerealium too.

In Taeniothrips vulgatissimus, the testes and vasa deferentia are all coloured with orange-yellow pigment; and no demarcation of orange yellow testes and white tubular vasa deferentia are present (Fig 123, Pl.19). The whole part is about 114 mic. long. In the absence of any differentiation, the head part will be called testes and the posterior part as vasa/

vasa deferentia. The testes are pear-shaped about 44 mic. wide. Vasa deferentia are short, thicker, concolorous with the testes and before opening into the ejaculatory duct, widen out much more, than in the previous species, to form vesiculae seminales. The accessory glands are round or spherical, short structures about 66 mic. long and 48 mic. wide. These open separately into the anterior chamber of ductus ejaculatorius, which is smaller as in other species. The bulbous part of ejaculatory duct is about 25 mic. long and 22 mic. wide.

In Taeniothrips atratus, the testes and vasa deferentia are orange yellow as in T. vulgatissimus and measure about 151-188 mic. in length (Fig 130, Pl.21). The testes are pyriform about 51 mic. wide in the middle. Posteriorly the vasa deferentia are short, thick, concolorous with the testes, and widen out before opening into the anterior chamber of ductus ejaculatorius. The accessory glands are paired, large, bladder-shaped structures, about 111 mic. long and 62 mic. wide; longer and wider than in Taeniothrips vulgatissimus. The accessory glands have cellular structure and open separately into the anterior chamber of ejaculatory duct as in other species. The bulbous part of ejaculatory duct is 37-48 mic. long and 33-52 mic. wide. Posteriorly the duct is fine, /

fine, and is associated with the ring musculature, as in L. cerealium. The most unusual structure noted in this species is the presence of a commissure which connects the two testes (Fig 130, Pl.21). The commissure is concolorous with the testes and is very delicate, breaking away in dissection, if the reproductive organs are not carefully manipulated. So far as is known, this connection is not noted in any other species of thrips.

In Odontothrips ulicis, the testes and vasa deferentia are similarly pigmented; and are short, saffron yellow or orange yellow, measuring 155 mic. in length (Fig 124, Pl.20). The testes are club-shaped, short, about 59 mic. wide in the middle (Figs 124, 126. Pl.20). The vasa deferentia are very short tubes which widen slightly before opening into the ejaculatory duct as in all the previous species (Fig 126. Pl.20). The accessory glands are paired, round and small, about 85 mic. across, and open separately into the ejaculatory duct. In stained preparations, these appear having cellular wall with prominent nuclei (Fig 125, Pl.20). The anterior chamber of the ejaculatory duct is much more prominent in comparison with other structures, and is very long and wide, quite unlike what is found in any other species of thrips. It measures .205 mm. in length and .110 mm. in width in the middle. Posteriorly it is/

is continuous with a fine thin duct going to the intromittant organ. Associated with this part is a structure showing weak musculature and scattered nuclei (Fig 127, Pl.20) which has been previously called the ring musculature of ductus ejaculatorius. Connected with the posterior chitinous part is another structure concolorous with the testes, and is designated here as the third unpaired gland (Figs 124, 128., Pl.20). It is about .221 mm. long and .078 mm. wide. This gland is a large, orange yellow, bladder-shaped structure, and is filled with a slightly viscous brownish fluid. The exact function of this gland is not known; but probably the fluid is used during copulation. This gland is so characteristic, that it can be seen separate from testes, even through the dark chitinous body wall of males. This gland has not been previously noted in Thysanoptera.

In Melanthrips fuscus (Aeolothripidae), the testes are orange yellow, pyriform, differentiated from the posterior short vasa deferentia, by colour (Fig 129, Pl.20). Each testis is about 51 mic. wide and contains spermatozoa. Posteriorly the vasa deferentia are very short and pale, opening by small thickened bases into the anterior chamber of ductus ejaculatorius. The accessory glands are paired and spherical, opening separately into the bulbous part of ejaculatory duct. The anterior chamber of ejaculatory duct is wide/

wide; as found in most thripids and is 55 mic. long and 40 mic. wide. Posteriorly it is continuous as a small, thin canal as in other species of thrips.

In Haplothrips distinguendus (Tubulifera), the testes are long, wide, lanceolate or in some spindle-shaped structures, covered with dark reddish pigment (Fig 131, Pl.21). Occasionally specimens are found in which the testes are sub-globular and bilobed. Posteriorly they are connected with long thin vasa deferentia which widen posteriorly to form long vesiculae seminales in which a large collection of spermatozoa may be seen. These finally open into ejaculatory duct. Unlike the members of Terebrantia, there are two pairs of accessory glands. The first or the outer pair is long, wide, bladder-shaped, about .378 mm. long and .11 mm. wide (Fig 133, Pl.21). Posteriorly each opens by a short canal into the ejaculatory duct. The second or the inner pair is shorter and thinner about .284 mm. long and .078 mm. wide, opening similarly by a short duct into ductus ejaculatorius. Either of the two pairs of glands may be deformed and shorter. The openings of the accessory glands and vasa deferentia are very closely situated and the ejaculatory duct is very thin. In stained preparations, the walls of both pairs of glands appear to be composed of flat, polygonal, large cells, in each of which large, round, nuclei may be seen. (Fig 132, 133. Pl.21).

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Appendix.

Later on I came to know certain references on the subject which are included here. The work of Reyne(1927) on the mouth-parts of Thysanoptera is in agreement iwth my findings in L.cerealium.

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VI. LETTERING AND EXPLANATION OF PLATES.(a) LETTERING.

6s - 10s	=	six to ten segments.
a.	=	antenna.
an.	=	anus.
at.	=	anterior.
a.ch.ej.d.	=	anterior chamber of ejaculatory duct.
a.o.n.	=	antennal_ocellaris nerve.
a.gl.	=	abdominal ganglion.
ac. gl.	=	accessory gland.
ac. gl ₁ .	=	first pair of accessory glands.
ac. gl ₂ .	=	second pair of " "
br.	=	brain.
br. b.	=	brown body.
c.	=	cell.
ca.	=	canal.
ch.	=	chorion.
cl.	=	clypeus.
co.	=	constriction.
com.	=	commissure.
cr.	=	crop.
ct.	=	connective tissue.
c.d.	=	common duct.
c.g.	=	chitinous thickening.
dt.	=	duct.
d.ej.	=	ductus ejaculatorius.
d.s.sg.	=	duct of short salivary glands.
e.	=	eye.
em.	=	embryo.
em.a.	=	embryonic area.
em.sp.	=	embryonic spherules.
f.	=	filament.
fr.	=	frons.
f.e.	=	follicular epithelium.
f.i.	=	fore_intestine.
f.m.i.	=	front portion of mid_intestine.

g.	=	glandular part.
ge.	=	germarium.
gl ₃	=	third unpaired gland.
gr.	=	groove.
g.c.d.	=	grand common duct (main duct).
hyp.	=	hypopharynx.
h.i.	=	hind_intestine.
h.m.i.	=	hind portion of mid_intestine.
i.	=	ilium.
l.	=	left.
la.	=	labium.
lbr.	=	labrum.
le.	=	leg.
li.	=	ligament.
lr.	=	leg rudiment.
lu.	=	lumen.
l.md.	=	left mandible.
l.p.	=	labial palp.
l.sg.	=	long salivary gland.
md.	=	mandible.
mu.	=	musculature.
m.gl.	=	mesothoracic ganglion.
m.i.	=	mid_intestine.
m.t.	=	malpighian tube.
mt.gl.	=	metathoracic ganglion.
mx.pl.	=	maxillary palp.
mx.s.	=	maxillary sclerite.
mx.st.	=	maxillary stylet.
n.	=	nucleus.
ne.	=	nerve.
n.ch.	=	nerve chord.
ocel.	=	ocellus.
od.	=	oviduct.
oe.	=	oesophagus.
o.g.	=	optic ganglion.
ov.	=	ovariole.
oy.	=	oocyte.

p.	=	pore.
ph.	=	pharynx.
pos.	=	posterior.
pro.	=	protoplasm.
p.gl.	=	prothoracic ganglion.
p.g.	=	post_glandular part.
pr.g.	=	pre_glandular part.
r.	=	rectum.
rd.	=	ridge.
re.	=	reservoir.
r.g.	=	rectal gland.
rt.	=	right.
r.m.	=	ring musculature of ejaculatory duct.
r.md.	=	right rudimentary mandible.
r.s.	=	receptaculum seminis.
sp.	=	sperms.
su.	=	suture.
s.sg.	=	short salivary gland.
t.	=	testis.
te.	=	teeth.
t.f.	=	terminal filament.
vac.	=	vacuole.
vag.	=	vagina.
vit.	=	vitelline membrane.
v.d.	=	vas deferens.
v.s.	=	vasicula seminalis.
w.d.	=	widening of the duct.
y.	=	yolk.

PLATE VII.

11. Female pupa of *Antrostylops rufus*.
 12. Last abdominal segment of female pupa of *Antrostylops rufus*.

 13. Male pupa of *Antrostylops rufus*.
 14. Last abdominal segment of male pupa of *Antrostylops rufus*.
 15. Male pupa of *Antrostylops rufus*.
 16. Last abdominal segment of male pupa of *Antrostylops rufus*.
 17. Male pupa of *Antrostylops rufus*.
 18. Last abdominal segment of male pupa of *Antrostylops rufus*.
 19. Male pupa of *Antrostylops rufus*.
 20. Last abdominal segment of male pupa of *Antrostylops rufus*.

(b) EXPLANATION OF PLATES.

PLATE I.

- Fig. 1. Mature egg of Aptinothrips rufus.
 2. Mature egg of A. rufus, showing the terminal ovariole tilted on one side. X 330.
 3. Mature egg of Limothrips cerealium.
 4. An embryonic stage in the development of L. cerealium, showing the curved embryonic area and embryonic lobes.
 5. Further advanced stage in which eyes, antennae and leg rudiments are formed. The antennae do not appear divided.
 6. Still further advanced stage in which the antennae are divided and legs have grown larger. The embryo is still enclosed in the chorion.

PLATE II.

- Fig. 7. First stage larva of Aptinothrips rufus.
 8. Antenna of first stage larva of A. rufus.
 9. Sixth, seventh, eighth, ninth and tenth abdominal segments of first stage larva of Aptinothrips, showing hairs on the dorsal side.
 10. Second stage larva of A. rufus.
 11. Antenna of the second stage larva of A. rufus.
 12. Seventh, eighth, ninth and tenth abdominal segments of second stage larva of Aptinothrips, showing the distribution of hairs on the dorsal side.

PLATE III.

- Fig. 13. Female pre_pupa of Aptinothrips rufus.
 14. Last abdominal segment of female pre_pupa of A. rufus showing the four thorn-like spines.
 15. Right antenna of pre_pupa of A. rufus.
 16. Female pupa of A. rufus.
 17. Last abdominal segment of female pupa of A. rufus, showing the distribution of hairs and thorn-like spines on the ninth segment.
 18. Ninth abdominal segment of pupa of A. rufus showing thorn-like spines.

PLATE IV.

- Fig. 19. Female Aptinothrips rufus.
 20. Dorsal aspect of eighth abdominal segment of A. rufus female.
 21. Dorsal aspect of ninth abdominal segment of adult female A. rufus, showing the distribution of short and long hairs.
 22. Dorsal side of tenth abdominal segment of the female A. rufus, showing short and long hairs.
 23. Upper or posterior valve of the ovipositor of A. rufus.
 24. Lower or anterior valve of the ovipositor of A. rufus female.
 25. Male of A. rufus Gmelin.
 26. Male of A. rufus var stylifera, Trybom.

PLATE V.

27. Antenna of female Aptinothrips rufus.
 28. Antenna of female var stylifera.
 29. Antenna of male A. rufus.
 30. Antenna of male var stylifera.
 31. Antenna of female A. rufus pupa.
 32. Antenna of an advanced stage of female A. rufus pupa, in which the internal segments are formed.
 33. Eighth, ninth and tenth dorsal abdominal segments of male A. rufus, showing the distribution of hairs and the characteristic thorn-like spines on the ninth segment.
 34. Ventral segments of male A. rufus, showing the ninth and tenth sternites and the ventral plate.

PLATE VI.

- Figs. 35-43 Various forms of antennal deformities found in Aptinothrips rufus female.

PLATE VII.

- Fig. 44. First stage larva of Limothrips cerealium.
 45. Antenna of the first stage larva of L. cerealium.
 46. Second stage larva of L. cerealium.
 47./

- Fig. 47. Antenna of the second stage larva of L. cerealium.
 50. Female pre_pupa of L. cerealium.
 51. Antenna of female L. cerealium pre_pupa.
 52. Male pre_pupa of L. cerealium.
 53. Antenna of male pre_pupa of L. cerealium.

PLATE VIII.

- Fig. 48. Last abdominal segments of first stage larva of L. cerealium showing the distribution of hairs on the dorsal side.
 49. Last abdominal segments of second stage larva of L. cerealium, showing the distribution of hairs on the dorsal side.
 54. Last abdominal segments of female pre_pupa of L. cerealium, showing distribution of hairs on the dorsal side. The hairs on the ninth segment are all weak.
 55. Last abdominal segments of L. cerealium male pre_pupa, showing the hairs on the dorsal side.
 57. Last abdominal segments of female L. cerealium pupa, showing the number and distribution of hairs on the dorsal side.
 59. Last abdominal segments of male L. cerealium pupa, showing the number and distribution of hairs on the dorsal side.

PLATE IX.

- Fig. 56. Female pupa of Limothrips cerealium.
 58. Male pupa of L. cerealium.
 60. Male pupal antenna of L. cerealium.
 61. Female pupal antenna of L. cerealium.
 66. Male of L. cerealium.
 67. Last abdominal segments of male L. cerealium, showing the hairs and spines on the dorsal side.

PLATE X.

- Fig. 62. Fore_wing of female Limothrips cerealium.
 63. Hind_wing of female L. cerealium.
 64. Antenna of female L. Cerealium.
 65. Hind tibia and tarsus of female L. cerealium, showing the presence of characteristic thorn-like spines on the inner side.
 68/

- Fig. 68. Antenna of male L. cerealium.
 69. Last abdominal segments of female L. cerealium, showing the distribution of long and short hairs on the dorsal side.

PLATE XI.

- Fig. 70. Ventral aspect of the mouth cone and head capsule of Limothrips cerealium.
 71. Maxillary sclerite, and maxillary stylet in L. cerealium.
 72a. Left mandible of L. cerealium.
 72b. Hypopharynx of L. cerealium.
 73. Labium of L. cerealium.

PLATE XII.

- Fig. 75. Alimentary canal of Aptinothrips rufus.
 76. Hind part of the alimentary canal of Aptinothrips, showing the insertion of malpighian tubes, division of hind gut and the presence of four rectal glands.
 77. Hind gut of first-stage larva of Aptinothrips, showing the presence of four rectal glands.
 78. Alimentary canal of Heliothrips haemorrhoidalis, showing the origin of long salivary glands and the enlarged mid intestine.
 79. Hind gut of H. haemorrhoidalis showing the insertion of malpighian tubes, and four rectal glands.

PLATE XIII.

- Fig. 80. Alimentary canal of Melanthrips fuscus.
 81. Hind gut of M. fuscus showing the insertion of malpighian tubes and the presence of five rectal glands.
 82. Alimentary canal of M. fuscus, showing the abnormal fore mid intestine.
 83. Alimentary canal of Haplothrips distinguendus.
 84. Hind gut of H. distinguendus, showing the insertion of malpighian tubes, ampulla-like ilium, and the presence of four rectal glands.
 91. Long salivary gland of M. fuscus.

PLATE XIV.

- Fig. 85. Anterior part of the alimentary canal of Aptinothrips, showing the anterior course of ducts from two pairs of salivary glands.
86. Short pair of salivary glands in Aptinothrips.
87. Long salivary gland of A. rufus.
88. Short pair of salivary glands in L. cerealium.
89. Short pair of salivary glands in Odontothrips ulicis.
100. Fat body in Aptinothrips rufus.
101. Two cells of the same fat body, showing vacuolated appearance.

PLATE XV.

- Fig. 90. Short salivary gland in Melanthrips fuscus.
92. First kind of short and thin salivary gland in H. haemorrhoidalis.
93. Short and thick salivary gland of H. haemorrhoidalis.
94. Two pairs of salivary glands in Haplothrips distinguendus, showing posteriorly the connection with the ovary.
95. Short salivary gland in H. distinguendus.
96. Long salivary gland in H. distinguendus.

PLATE XVI.

- Fig. 99. A part of the malpighian tube in A. rufus.
102. Nervous system of Aptinothrips rufus.
103. Larval brain of A. rufus.
104. Nervous system of Limothrips cerealium.
105. Nervous system of Haplothrips distinguendus.
- 106a. Normal ovary of Aptinothrips.
- 106b. A single ovariole from A. rufus ovary.
- 106c. Terminal part of an ovariole showing germarium and oocytes.

PLATE XVII.

- Fig. 107. Abnormal ovary of Aptinothrips rufus.
108. Receptaculum seminis of A. rufus.
109. Female reproductive organs of Odontothrips ulicis.
- 110a. Female reproductive organs of Haplothrips distinguendus.
- 110b/

- Fig. 110b. A single ovariole from the ovary of H. distinguendus.
 116. Receptaculum seminis of H. distinguendus.

PLATE XVIII.

- Fig. 111. An advanced stage embryo of Limothrips cerealium, showing the presence of paired maxillary stylets and a single thick mandible.
 112. Receptaculum seminis of L. cerealium.
 113. Receptaculum seminis of L. cerealium, showing the cellular outline.
 114. Receptaculum seminis of Thrips tabaci.
 115. Receptaculum seminis of Heliethrips haemorrhoidalis.
 117. Fat body of L. cerealium.
 98. Enteric epithelium from the mid-intestine of Aptinothrips rufus.

PLATE XIX.

- Fig. 118. Male reproductive organs of Aptinothrips rufus.
 119. Testis, vas deferens and a short vesicula seminalis of Aptinothrips.
 120. Accessory gland of male A. rufus.
 121. Anterior muscular chamber of ejaculatory duct of A. rufus.
 122. Male reproductive organs of L. cerealium.
 123. Male reproductive organs of Taeniothrips vulgatissimus.

PLATE XX.

- Fig. 124. Male reproductive organs of Odontothrips ulicis.
 125. Accessory gland of male O. ulicis.
 126. Testis, vasa deferens and vesicula seminalis of O. ulicis.
 127. Ring musculature of ejaculatory duct.
 128. Third unpaired gland in male O. ulicis.
 129. Male reproductive organs of Melanthrips fuscus.

PLATE XXI.

- Fig. 130. Male reproductive organs of Taeniothrips atratus, showing the connection between the two testes.
131. Male reproductive organs of Haplothrips distinguendus.
132. Short accessory gland of H. distinguendus.
133. Long and large accessory gland of H. distinguendus.
134. A single cell from these accessory glands, highly magnified.
135. Photomicrograph of the male reproductive organs of Odontothrips ulicis, showing the third unpaired gland.
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II.

PAPER II.

BIOLOGY AND LIFE-HISTORY OF TWO THYSANOPTERA

FEEDING ON GRAMINEAE.

(PLATES 1-4., 1 DIAGRAM., 1 GRAPH)



BIOLOGY AND LIFE-HISTORY OF TWO THYSANOPTERA

FEEDING ON GRAMINEAE.

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I. INTRODUCTION.

Limothrips cerealium has been known in this country as a pest of cereals, especially wheat, for many years. The communications by Marsham to Rev. Samuel Goodenough in the years 1796 and 1798 show that this insect even then was doing appreciable damage to wheat crop.

Kirby was the first to detect this insect, and call it Thrips physapus. In a letter dated 27th August 1795, he mentioned his findings (Marsham, 1796) on the nature and extent of damage to wheat crop. He described it briefly, found the early stages, and noted the apterous male for the first time in the ears of corn. According to him, this insect was responsible for considerable damage to wheat crop that year.

Haliday in 1836 gave its correct systematic position, and described it as Limothrips cerealium. According to him in 1805 the wheat crop in England suffered immensely; and at Piedmont (1805) about one third of the wheat crop was destroyed. The contemporary journals of that year give some idea of the same (Haliday, 1836). Since then, Limothrips cerealium has been recorded at various localities in Britain by Williams (1913); Bagnall (1910); Morison (1928) and others.

Miles (1921) draws attention to the fact that the pest damaging cereals in 1918 in England was probably L. cerealium or L. denticornis which caused sterile spikelets in oats. Theobald (1922) found that Limothrips cerealium and L. denticornis seriously damaged wheat in Kent; and occasionally oats and other cereals also. He gave a short description of damage with remedial measures. Since then, there have been no observations on this pest in this country.

In other parts of the world, it is also reputed to damage cereals especially wheat and oats. It has a very wide field of distribution, and is found as a pest of cereals in France; Italy; Germany; Austria Hungary; Norway; Sweden; Rumania; Russia; Holland; Denmark; Finland; Spain; Australia; United States of America; Egypt; India and North Africa.

In the absence of any work on the biology and life-history of this species, the nature and extent of damage to crops has been hitherto overlooked in this country and elsewhere; and occasionally it is stated that it is not capable of damaging the crops. In this paper, therefore, a study of the details of bionomics and life-history of Limothrips cerealium has been made along with its economic status as a pest of wheat and oats by experiments in Laboratory and fields, in the neighbourhood of Edinburgh, Scotland.

The other thrips under investigation was Aptinothrips rufus, occasionally found on wheat and other Gramineae; but chiefly found in low grasses and turf. It is a very common species found in the adult stage throughout the year. In spite of its being wingless, it is known at present to have a very wide geographical distribution. This species is interesting on account of the presence of two forms differentiated by the number of antennal joints. Both these forms were found by the writer, the one with six-jointed antennae being much more numerous than the one with eight-jointed antennae. Beyond a short note about the occurrence of two forms by Williams (1913) and a similar note by Morison (1924), nothing has been said about it. A study of the habits and life-history was made in the summer of 1930; and the details of seasonal distribution of larval and adult forms, and variations in fecundity of the two forms, were studied in collections made from grass fields near Edinburgh throughout the year.

The writer during the course of investigation came across an external and an internal parasite of Aptinothrips rufus, the former was a Trombidium larva and the latter a new species of nematode.

The work was done in the Department of Agricultural Zoology, University of Edinburgh, under the supervision of Dr C.B. Williams. The writer has
great/

great pleasure in thanking him for suggesting this piece of work and for valuable advice received during the progress of work; and also for placing at the writer's disposal his collections and literature on thrips. The writer also wishes to thank Dr G.D. Morison for copies of his papers on thrips and for the loan of a slide of the very rare male of Aptinothrips rufus var. stylifera.

II. BREEDING TECHNIQUE.

Breeding of Limothrips cerealium was carried out in the departmental green house. Wheat seedlings were brought from fields when 4-5" high, and planted in flower pots with one seedling in each pot. Care was taken to have flower pots large enough for the plants to grow well. In certain cases some plants had to be excluded from observations on account of defective growth. After the plants had taken roots and were doing well, one female L. cerealium was placed at the bases of leaves touching the growing stem. Previous dissections had been made from the time of the first appearance of the adult to determine the maturity of eggs. When a greater majority of thrips contained mature eggs, they were liberated on plants. The thrips congregated at the bases of leaves, and a study of feeding, oviposition, and other habits of the adult were made in this way.

When the larvae hatched from the eggs, they generally tried to move inwards into the leaf-sheaths, which made it difficult to observe the stages. The larvae, therefore, after emergence were removed and placed on leaves having leaf-sheaths attached to them which were placed in petri-dishes lined with wet blotting paper. The blotting paper was kept moist, and/

and the covers of petri_dishes were kept slightly open so that excess of moisture may not prevail.

Great difficulty was experienced as the leaves would dry out or become rotten or larvae would wander over the wet blotting paper, and be killed by water while crawling at the margin or would go beneath the leaves. The larvae being voracious require fresh succulent leaves and any slight interference makes them restless. This resulted in great mortality in the beginning. Consequently during this method of breeding, the examination of leaves having thrips larvae, was made several times in a day to ensure that the larvae were free from water or other injuries. This method was abandoned later in the year, when ears of wheat were available; and the following method was found very successful for breeding these thrips. The habits of larvae, moulting, and other details were studied in this way.

It was noted in the fields that the larvae after hatching go down inside the leaf_sheaths and from there, later on, take up a position in between the calyx and corolla, after the emergence of the flower head from leaf_sheaths. They continue to feed there till adults emerge. Medium_soft calyces were removed from the ears and each newly hatched larva was placed into one of them which were placed in a thoroughly over_wet blotting paper forming the lining/

lining of petri-dishes. This gave great ease for examination under different magnifications of binocular microscope. The dish covers were placed slightly open to avoid condensation of too much moisture inside. The outer margin of calyx when removed from its position curls down a little, and gives a little of shade to the feeding larvae inside, and also leaves a little space open above for examination purposes. The outer surface of calyx becomes wet in 2-3 days, and keeps it succulent and juicy for the larvae to feed. The larvae did not try to wander away except at the beginning, when first placed with a brush. Any attempt to wander away was hindered by the hairs on the outer surface of calyx and the film of water down below. The calyces were changed every four or five days to allow the larvae to feed as much of green material as possible. Another advantage of this method was that by the time the larvae turned into pre-pupae and pupae, the margins dried up a little and curled down. These curved spaces proved suitable sheltering places for the resting stages, and the pupae often crawled down under them. By tilting the calyx slightly, the pre-pupal and pupal stages could be easily seen under the binocular microscope. The larval periods were the only difficult periods to get over. Occasionally after the second moult, the pre-pupae were placed into/

into dry calyx, where stages up to the adult were observed. The adults on emergence remain inside the calyx if it is green; and continue feeding till dry. Since the female is capable of laying over a long period, it was sometimes confined into a fresh calyx as described above, where it oviposited. The egg and larval periods in this case were observed in the same material.

The effect of continued feeding on wheat plants was investigated in the departmental green house. Limothrips cerealium were liberated on some wheat seedlings in very large numbers; while others were kept free. Similar conditions were given as far as possible in the greenhouse to the infested and non-infested plants. The results of their attack on the plants and ears were also noted.

The breeding of Aptinothrips rufus was tried in summer over grass seedlings sown in xxx small specimen tubes. The females of six-jointed form containing eggs were left on the seedlings, and the date of oviposition was noted. The larval stages were observed on grass blades with hand lens (X20) or sometimes the hatched larvae were placed inside wheat calyx and moulting and other habits were observed as in Limothrips cerealium.

III. LIMOTHRIPS CEREALIIUM.

(I) APPEARANCE.

The factors that seem to determine the emergence of Limothrips cerealium from hibernation is probably increased sunlight and warmth due to change of season. The meadow grass near the sown wheat fields at Liberton and Boghall Experimental Farm was examined from April onwards for Limothrips cerealium by sweeping with a net. But no thrips were found in April. The examination of wheat seedlings showed that they were free. Limothrips cerealium was first found in small numbers on 21st May 1930 in Edinburgh, from meadow grass situated by the side of wheat field at Liberton.

The dissection of these thrips showed that they had immature ovary with no developing eggs. At this time, in this district, wheat plants were small and had no thrips on them. According to the farmer the meadow grass had been sown in the field used in the previous year for wheat. From this date onwards, greater number of thrips were always captured in every sweep from meadow grass, till by the middle of June they were found in enormous numbers.

The emergence of Limothrips cerealium at Boghall Experimental Farm, situated on the slopes of the Pentland/

Pentland hills, was later; as they were first taken on 3rd June from meadow grass. The wheat here had just sprouted from the ground and had no Limothrips cerealium on it. The meadow grass at both these places was fairly high and good. Since the collection of Limothrips cerealium in late May and early June was made from meadow grass both at Liberton and Boghall Experimental Farm, it appears that the grass crop was the first to contain the emerging thrips, on which they appear to feed till the wheat crop was in a suitable stage of development. The ovary and alimentary canal of the earliest collected thrips were all small.

Immediately after the migration from the grass to wheat plants, Limothrips cerealium were invariably found at the bases of leaves, and consequently

in the beginning they originated chiefly at the bases of leaves. But later in the season, as position

changed, they were found on the upper parts of the leaves, and on the stems, and on the roots.

It is therefore probable that the thrips were first introduced to the wheat crop from the meadow grass, and that they subsequently migrated to the wheat plants.

(II) OVIPOSITION.

In the Liberton district, the wheat plants in the field adjoining the grass field where thrips had been found, had grown about a foot high by the first week of June. The thrips caught first on 21st May showed that they had no mature eggs, but the dissection of 18 females on 26th May revealed in two that the eggs had begun to develop. By 4th June all the wheat plants were heavily infested with Limothrips cerealium which had by now migrated from grass to wheat.

In some cases, eggs were also found embedded in the leaf tissue near the bases of leaves. It appears, however, that in the field eggs must have been laid earlier than 4th June when they were first noticed.

Immediately after the migration from the grass to wheat plants, ~~xxx~~ Limothrips cerealium were invariably found at the bases of leaves, and consequently in the beginning they oviposited chiefly at the bases of leaves. But later in the season, oviposition spread all through the plant. The females continued egg laying for a considerable time, and the eggs were laid from the apex to the base of leaf, inside the leaf_sheath or in the calyx also. On oats, females oviposited in the interior of leaf_sheath and calyx; but much less in the leaves.

In/

In Laboratory experiments no definite time for oviposition was noted, but generally more females were seen ovipositing in the morning than in the afternoon. The process of oviposition was closely watched and is as follows:—

The female when left on a wheat plant went to the base of leaf. There it kept on alternately feeding and moving till a suitable spot seemed to have been selected. It then arched the abdomen slightly and brought the ovipositor to an angle and forced it up to the hilt into the tissue of the leaf. The ovipositor seemed to penetrate the leaf tissue not at right angles but obliquely. After moving the ovipositor forwards and backwards into the slit, the female became motionless; and some motion at the tip of abdomen showed that the egg had passed into the slit. The ovipositor was then withdrawn and the insect moved to another place and began feeding. The time required was 2 minutes, and only one egg was laid in each pocket. It has never been observed, as some mention in other species, that the female lacerates the tissue with mouth, and then penetrates the ovipositor for laying eggs.

If the leaf be examined against light, after the females have oviposited, the eggs appear as small white specks scattered throughout the leaf surface, but more at the base. Some eggs are laid deep, others superficially occasionally even with the end projecting out.

(III) HATCHING.

The eggs when laid are whitish, but in course of time change to brownish with two visible red spots. If the shell of an egg is removed under a binocular microscope at this stage, a fully formed larva is found with flexed head, and antennae and legs closely applied to the body.

When the larva is fully formed, it breaks through the chorion, the head with two bright red eyes being the first portion to emerge. The larva then moves backwards and forwards or sideways with slight jerks. The whole larva, with antennae and legs applied to the body and not visible, appears at this time as a pale yellowish projection from the leaf surface and is seen moving itself. It emerges little by little with each movement until only the tip of the tail remains in the egg.

When the greater part of the body has come out, the antennae separate, and then the legs one after another. The larva now falls forward on to its legs and pulls itself free, moving a little away, and resting to harden before feeding. Hatching of eggs was observed throughout the day; but most hatching took place in the forenoon. The time required from the emergence of head to complete separation was usually 20 - 30 minutes; but may be accidentally more in some cases.

IV. HABITS OF ADULT AND LARVAL STAGES.

When Limothrips cerealium females come out of hibernation in spring, they go to the standing meadow grasses, and feed there till wheat plants have come up. Then they migrate to the wheat crop and take their position at the bases of leaves, inside the leaf-sheaths, or in the folds of the growing leaves when the plants are young. Here they feed and oviposit. When the earlier leaves become tougher, they move to other tender leaves and feed and oviposit there. Sometimes the number of females per plant is considerable, so that several can be found at the base of each leaf, and inside the leaf-sheaths. Later on when the ears are being formed, and are still enclosed inside the last folded leaves, they feed on the glumes in the tender stage. As ears grow out, they take their position inside the glumes and oviposit in it there. The process of feeding of adults was observed in the Laboratory inside single glumes under the high power of the binocular microscope and is as follows:— The female seeks out a tender place. After finding one it applies its mouth-cone and a thicker rod (probably mandible) is first inserted in the tissue and the mouth cone is slightly jerked, and then the thinner rods (maxillary stylets) work their/

their way in. This lacerates the tissue, and then it applies the mouth cone closely, so that the further process is not visible but probably consists of sucking the fluid. After remaining at that place for a short time, it moves to another place and repeats the operation. This method is repeated at short intervals often causing the formation of white spots or streaks.

The larvae on hatching from early laid eggs on lower leaves migrate to sheltered places inside the leaf_sheaths or folds of leaves and join the adults in feeding. The larvae seldom feed on or under leaves in the open in fields; but always in sheltered and tender places. As the larvae hatch out before the ears are out of the folding leaves, they may also feed on the young developing ears. When the ears come out, some larvae remain in the leaf_sheaths and some take their position inside the calyces or corollas of the flower. They feed in the same way as the adults. The chlorophyll of inside of the leaf_sheaths and glumes is as a result largely destroyed. Larvae hatching out from eggs laid later in the calyces or corollas join the older larvae from the leaf_sheaths and the adults; and all feed simultaneously inside the parts of wheat ears.

At these sheltered places in ears and in the leaf_sheaths, the larvae in due course turn into pre_pupae/

pre_pupae and then pupae. The pre_pupae are small, yellowish with small wing pads, and carry their antennae forwards. The pupae are also yellowish but with longer wing pads and with the antennae carried backwards over the head. These are the immature stages of females. Occasionally pre_pupae and pupae otherwise similar but with no wing pads are met with. These are the immature stages of males. During these stages no feeding is done. The pre_pupae and pupae are always found at sheltered places inside the leaf-sheaths or inside the calyces or corollas, but never on the leaves in the open. The females and males on emerging from pupae begin feeding temporarily at their places of emergence; but later on migrate to other places. The females feed during the rest of the season on wheat till harvested and do not oviposit. The males also feed and later pair with the females; but die out after the wheat season, about the end of August or September.

(V) MOULTING.

There are four moults during the development of Limothrips cerealium from egg to adult, giving two larval stages and two non-feeding pupal stages, the first pupal stage being of short duration.

The casts of skin of the first and second stage larvae are thicker than the pre-pupal or pupal skins. The chitinous coverings of antennae, legs, and internal mouth spines are visible in the first larval casts. Similar structures are also found in the second larval casts which are also thick; but slightly darker at the antennal, head and annal areas. These casts can be easily seen in the calyx both in fields and in the Laboratory. The pre-pupal and pupal casts are thinner and translucent; and are sometimes curled up. They are also found in the calyx but with difficulty. Occasionally the exuviae are seen sticking to the tail end of the pupae or the newly emerged adult.

The process of moulting has been observed several times in the Laboratory, and is as follows:-

The first stage larva does not appear to feed during a day or two before moulting and the intestine does not appear to contain any green stuff. It becomes sluggish and motionless. The colour at this time is pale yellow. A slight wriggling movement is observed. The antennae are brought close together and the head is/

is bent downwards, arching the body slightly. The tail part is first observed to empty and appears to have a shrunken skin. The legs are also slightly tucked in. Now the skin at the top of head bursts, and the larva slowly wriggles out separating the legs from the old skin one after another. The contraction of tail end and the legs inside the old skin appears to cause a force on the anterior region of the head from where the skin burst in a longitudinal fissure. The antennae and legs after moulting are soft. The old skin now remains sticking to the hind part, and though the larva is able to move its antennae and body, it is not at first able to walk. After gaining strength, the old skin separates. The process of ecdysis in second stage, pre-pupal and pupal stages are similar. The time required for moulting in the larval stages was found to be 12 - 20 minutes and in the pupal as much as 30 minutes or more. The old pre-pupal skin remains attached to the pupae and the pupae have been seen to move slowly without any hindrance.

(VI) LIFE-HISTORY.

Limothrips cerealium after emergence from hibernation feed for some time and lay eggs on wheat or oats from early June onwards. The eggs in course of time develop, and the stages are passed in leaf-sheaths or in ears of corn till it is time for harvesting. When the corn is ripe, about 23rd August, and is being harvested; only adult males and females, all of the new generation, are found. The following table gives the dates and the length of egg, larval, pre-pupal and pupal periods of Limothrips cerealium during June to early September in the Laboratory.

TABLE I.

Date of Oviposition	Length of stages in days.							Total life-cycle.			
	Date of hatching.	Date of 1st larval moult.	Date of 2nd larval moult.	Date of pre-pupal moult.	Date of pupal moult.	Egg	1st larva		2nd larva	Pre-pupa	
5.6.30	15.6.30	20.6.30	28.6.30	30.6.30	6.7.30	10	5	8	2	6 ♀	31
5.6.30	16.6.30	22.6.30	30.6.30	2.7.30	8.7.30	11	6	8	2	6 ♀	33
5.6.30	16.6.30	22.6.30	30.6.30	2.7.30	9.7.30	11	6	8	2	7 ♀	34
6.6.30	16.6.30	21.6.30	28.6.30	29.6.30	5.7.30	10	5	7	1	6 ♀	29
24.6.30	6.7.30	11.7.30	19.7.30	21.7.30	26.7.30	12	5	8	2	5 ♀	32
29.6.30	10.7.30	15.7.30	21.7.30	23.7.30	29.7.30	11	5	6	2	6 ♀	30
29.6.30	10.7.30	15.7.30	24.7.30	26.7.30	1.8.30	11	5	9	2	6 ♀	33
30.6.30	13.7.30	19.7.30	27.7.30	29.7.30	3.8.30	13	6	8	2	5 ♀	34
2.7.30	13.7.30	19.7.30	27.7.30	29.7.30	4.8.30	11	6	8	2	6 ♀	33
2.7.30	13.7.30	18.7.30	27.7.30	30.7.30	4.8.30	11	5	9	3	5 ♀	33
2.7.30	13.7.30	19.7.30	27.7.30	30.7.30	4.8.30	11	6	8	3	5 ♀	33
3.7.30	15.7.30	19.7.30	29.7.30	1.8.30	5.8.30	12	4	10	3	4 ♂	33
3.7.30	14.7.30	19.7.30	29.7.30	31.7.30	6.8.30	11	5	10	2	6 ♀	34
5.7.30	17.7.30	22.7.30	30.7.30	2.8.30	8.8.30	12	5	8	3	6 ♀	34
7.7.30	18.7.30	23.7.30	2.8.30	4.8.30	10.8.30	11	5	10	2	6 ♀	34
7.7.30	18.7.30	24.7.30	2.8.30	4.8.30	10.8.30	11	6	9	2	6 ♀	34
11.7.30	24.7.30	29.7.30	3.8.30	5.8.30	9.8.30	13	5	5	2	4 ♀	29

TABLE I continued.

Date of Oviposition	Date of hatching	Date of 1st larval moult	Date of 2nd larval moult	Date of pre-pupal moult.	Date of pupal moult.	Length of stages in days.				Total life-cycle.	
						Egg	1st larva	2nd larva	Pre-pupa		
11.7.30	23.7.30	29.7.30	7.8.30	9.8.30	15.8.30	12	6	9	2	6 0+	35
11.7.30	23.7.30	29.7.30	7.8.30	9.8.30	15.8.30	13	6	9	2	6 0+	35
12.7.30	23.7.30	28.7.30	3.8.30	5.8.30	11.8.30	11	5	6	2	6 0+	30
12.7.30	23.7.30	28.7.30	4.8.30	6.8.30	11.8.30	11	5	7	2	5 0+	30
13.7.30	24.7.30	29.7.30	6.8.30	8.8.30	14.8.30	11	5	8	2	6 0+	32
13.7.30	23.7.30	29.7.30	6.8.30	9.8.30	14.8.30	10	6	8	3	5 0+	32
19.7.30	30.7.30	4.8.30	12.8.30	15.8.30	21.8.30	11	5	8	3	6 0+	33
22.7.30	1.8.30	6.8.30	13.8.30	16.8.30	23.8.30	10	5	7	3	7 0+	32
23.7.30	4.8.30	10.8.30	18.8.30	20.8.30	27.8.30	12	6	8	2	7 0+	35
26.7.30	5.8.30	10.8.30	18.8.30	21.8.30	27.8.30	10	5	8	3	6 0+	32
1.8.30	13.8.30	19.8.30	27.8.30	29.8.30	3.9.30	12	6	8	2	5 0+	33
1.8.30	12.8.30	18.8.30	26.8.30	28.8.30	31.8.30	11	6	8	2	3 ♂	30
2.8.30	12.8.30	19.8.30	28.8.30	29.8.30	2.9.30	10	7	9	1	4 0+	31
3.8.30	14.8.30	21.8.30	29.8.30	31.8.30	6.9.30	11	7	8	2	6 0+	34

Table I gives the life-cycle of the eggs laid in June, July and early August. It will be apparent from this table that there is no appreciable lengthening of the life-cycle periods during July and August. The slight differences in days appear to be due to individual differences. The average egg period lasts from 10 - 13 days; the first larval period from 5 - 7 days, but once one first stage larva moulted in 4 days on 19.7.30. The second larval period is from 8 - 10 days usually, but once one second stage larva moulted in 5 days on 3.8.30. The pre-pupal period lasts usually 2 - 3 days but sometimes moulting occurred after one day. The pupal period lasts for 6 - 7 days generally, but occasionally moulting occurred on the 5th or even the 4th day; and once one male pupa moulted after 3 days. It appears to be a very unusual departure, and the figures of the male pupal period are not enough to give any conclusion. The total life-cycle, therefore, requires 30 - 35 days, but twice the period required for an adult to emerge was 29 days. The emergence of the last adult in the Laboratory was on 6th September. The wheat was already harvested in the field, and no young stages were found. Only adults of both sexes were found. At Boghall Experimental Farm, the wheat was sown rather late and there a few pre-pupal and pupal stages could be still found with difficulty, but no larvae.

(VII) FLIGHT.

The flight of Limothrips cereallium was observed several times on bright sunny days in wheat and oats fields; from the ears of standing corn or from the bundles lying about in the field after being harvested on 25th August. In the Laboratory it was also observed. A large number of wheat ears previously containing many pupae and adults were fixed into the soil contained in a wide-mouth jar. It was observed that on bright sunny days when the jar was placed in direct sunlight, males and females would come out and wander about over the ears of corn, some of them pairing and some of them going up to the top of ears. This would happen, even if the jar was in shade but the sun was bright near by. The females after reaching the top of awns or any other sharp point would turn round backwards, throw their front legs in the air. They would then turn their tails up several times, separating the wings each time which then extend nearly at right angles to the body; but close up when the tail is turned down. At one of these moments of extending the wings, the thrips would fly off. Occasionally they would jump only to another ear. So long as the sun was bright, a large number of thrips were observed flying on 5th September in the Laboratory. If by chance, some clouds /

clouds obscured the sun for some time, they would return to their hiding places, and in a short time were not visible at all. This was observed several times during September on bright sunny days. The distance covered by a single flight was found to be 5 - 8 ft. in the still air of the Laboratory. It appears possible, therefore, that during the period when the crop is ripe or is harvested, Limothrips cerealium fly off and may be carried long distances over the grass or near by crops or other places through the agency of winds.

(VIII) MATING.

Mating was observed in the field on ears of wheat where males and females congregated on sunny days. In the Laboratory also, mating was observed on ears infested with males and females and put in a jar for flight experiment as described previously.

Once on 30th August a newly emerged male and female were intentionally introduced within a calyx used for breeding purpose. The male did not seem to be able to see the female inside the calyx even from a short distance. The male and female kept on feeding and accidentally met each other inside the calyx, but the female moved aside. The male now seemed excited as the copulatory organ was seen coming out and retracting. The male again met the female and suddenly climbed over its back, turning its abdomen underneath, and pairing took place. This position was similar to that described by Buffa (1907). Then there were short abdominal jerks and after that the male remained motionless for about six minutes and then separated.

Occasionally it has been observed that females would pass males with no attempt on the part of males to follow. And once the tail part of a male was so forcibly jerked up that the curved and pointing male genitalia penetrated the thoracic region of the female and/

and remained there for a long time till separated.

Mating does not take place shortly after emergence from pupa. A male is able to fertilise several females.

The earliest collection of *Limothrips* was made on 1st May from meadow grass consisted of females only, and later only females were found over wheat and oats till late in June when males were first found on 29th June in fields after emergence from the pupae of the new generation. During the rest of the crop season (July, August and early September) males were found ----- various numbers.

The counts on various dates from oat and grass fields give a rough proportion of the two sexes collected.

From oats, 23rd July 432 ♂♂, 100 ♀♀. From wheat, 24th July 257 ♂♂, 231 ♀♀; 29th July 31 ♂♂, 33 ♀♀; 2nd August 4 ♂♂, 15 ♀♀ from one head; 5th August 7 ♂♂, 30 ♀♀ from 2 heads; 23rd August 1 ♂♂, 10 ♀♀. These collections were made from

Liberton fields. The crop was harvested on 25th August, and the bundles were left in the fields.

The collections from these bundles give this proportion of sexes: 1 ♂♂, 5 ♀♀; 4 ♂♂,

20 ♀♀. The total number of males collected was 51 ♂♂. By the end of September, all the

bundles of wheat and oats were lying in the fields. 15 other heads of wheat and 10 of oats were

for the following day.

(IX) PROPORTION OF SEXES.

The earliest collection of Limothrips

cerealium on 21st May from meadow grass consisted of females only, and later only females were found over wheat and oats till late in June when males were first found on 29th June in fields after emergence from the pupae of the new generation. During the rest of the crop season - July, August and early September - males were found and sometimes in enormous numbers.

The counts on various dates from oat and wheat fields give a rough proportion of the two sexes collected.

From oats, 23rd July 433 ♂♂ : 162 ♀♀. From wheat,

24th July 257 ♂♂ : 351 ♀♀ ; 28th July 61 ♂♂ :

28 ♀♀ ; 2nd August 4 ♂♂ : 15 ♀♀ from one head ;

5th August 7 ♂♂ : 30 ♀♀ from 3 heads ; 23rd August

1 ♂♂ : 10 ♀♀. These collections were made from

Liberton fields. The crop was harvested on 25th

August, and the bundles were left in the fields.

The collections from these bundles give this proportion.

27th August, from wheat 1 ♂♂ : 5 ♀♀ ; 4 ♂♂ :

20 ♀♀. From oats, on 3rd September 112 ♂♂ :

51 ♀♀. By the end of September, although the

bundles of wheat and oats were lying in the fields,

no males were found, except a few dead ones, and a

few living females. At Boghall, on 29th August, from

wheat/

wheat 6 ♂♂ : 21 ♀♀. From oats 5 ♂♂ : 10 ♀♀;
 and on 15th September, from oats 6 ♀♀ and no males.
 The last males were captured in the field on the 3rd
 September.

The females later on were found hiding in between
 the folds of leaf-sheaths of grass in the field, and
 were thus collected on bright days during late Sept-
 ember and early October. Males being apterous are
 not able to fly, and die on the plants after fertilis-
 ing the females. The preponderance of males occas-
 ionally in bundles of oats in fields may be due to
 the fact that the females had flown away. The females
 that hide in the grass are no doubt fertilised females.
 During the winter, fertilised females hibernate, and
 lay eggs on wheat and oats in the coming year; all
 the males dying by early Autumn. In the Laboratory,
 males were found alive over grass till 14th October,
 and after that only females were visible.

(X) FOOD PLANTS.

This species has been found to confine itself exclusively to Gramineae. It has been collected from various meadow grasses, wheat and oats. During summer it breeds on wheat and oats and partly on couch grass also. During the rest of the year, it lives on grass, probably feeding occasionally. In Russia it has been found on Brachycolus noxius causing the folding of leaf-sheaths, and in Norway on barley. The writer did not find this species on barley at Boghall Experimental Farm. In other parts of the world it has been mostly taken from wheat and oats.

(XI) NATURE AND EXTENT OF DAMAGE TO CROPS.(a) WHEAT.

In the fields when thrips migrate to wheat plants, they start feeding there, and oviposit in the leaf tissue, inside the leaf_sheaths and in the glumes later on. Heavy oviposition may cause the blotching of leaves which dry up soon showing white spots all over the leaf surface. The feeding of adult removes chlorophyll from the leaves which sometimes show considerable white patches. The larvae on hatching go inside the leaf_sheaths and in the leaf_folds joining the parents in feeding. The leaf_sheath is not destroyed to such an extent as the leaves, and sometimes one fails to notice the damage to leaf_sheaths; but in some plants it is obvious. The larvae continue feeding on the tender growing leaves of the wheat plant, and congregate in greater numbers in the inner folds where the ears are being formed. The newly emerged adults and the hatching larvae now feed on the tender parts of the growing ears both from above and from below; but less in the middle where they do not seem to penetrate in large numbers on account of the tight folding of the leaves. The developing flowers at the top and at the base of the ear are therefore subject to constant feeding of large/

large number of larvae and adults, as long as it remains inside the leaf. The top part is the first to emerge and the basal part the last, so occasionally the top part is not damaged; while the lower part is damaged. The middle part of the ear is usually little damaged but the top and the basal florets are sometimes so much damaged that they fail to develop seeds later on. When the ears grow out, the larvae and adults go up along with them, and take their position inside the glumes. Here they continue feeding and are joined by other larvae hatching from the eggs laid in the glumes. But the damage at this stage to individual floret is not visible, as only the chlorophyll of the inside of calyx is destroyed. When the larvae are inside the corollas, the anthers and ovary are destroyed, and the individual floret fails to develop seed. But this is rare and the damage is mostly done when the head is enclosed in the sheathing leaves. This feeding and damage continues till the end of the season when damage may be severe. Theobald (1922) found that the wheat crop in Kent was so much damaged that the tips of grain had become pallid and no grains were formed at these portions, and when corn was thrashed out, the grains were shrivelled. These he ascribed to L. cerealium and L. denticornis. The present writer, however, did not get any L. denticornis in the Edinburgh District/

District on wheat last summer. The wheat crop at Liberton was so badly damaged on account of heavy infestation of L. cerealium, that the effect on leaves and leaf_sheaths was very much apparent. The leaves dried up soon and gave a blotched appearance, while the inside of glumes was white. At the Boghall Experimental Farm wheat fields, the damage was not so apparent and the growth of plants and seeds was comparatively good.

Jablonowski (1926) while discussing the economic status of L.cerealium mentions that recently the importance of thrips in general has been over_estimated and that L.cerealium are not responsible for the injury to cereals that is constantly ascribed to them. He further states that the injury to stalks and ears of wheat has been superficial, and is due to mechanical causes chiefly wind. The writer in order to determine the nature and extent of injury to wheat plants, carried out a set of experiments in the Laboratory. One set of plants was infested with large numbers of L.cerealium in the beginning of June, and the other set was kept free. Both the sets of plants were grown in as similar conditions as possible. Plate 1 shows the ripe ears A_B from infested plants, and C_D from free plants. It will be seen in this plate, that in both ears A_B, the lower and top parts have failed to develop seeds; while the intermediate/

intermediate parts are also damaged with very small seeds (cp Theobald, 1922), and the length of the ears is small. In uninfested plants, the ears C-D are long, stout, with fully developed seeds both at the base and top. This experiment shows conclusively that Jablonowski's ideas are incorrect; and that L.cerealium in cases of heavy infestation is capable of causing serious damage to wheat ears, as shown in Plate 1, A-B. But such contrasting difference of damage side by side in the fields are never met with on account of other factors which keep a check on the abnormal damage of L.cerealium to ears of wheat.

An actual extent of damage to wheat seeds was established by taking ears of wheat at random from two fields. Since there was marked difference in the number of L.cerealium at Liberton and Boghall Experimental Farm wheat fields and their injury to wheat, counts from two fields were made. The number of immature and adult thrips found was also counted. The following figures give the results in a summarised form.

TABLE II./

TABLE II.

A. Liberton Wheat fields.

Date	No. of ears taken.	Total No. of florets	No. unset.	% damage	No. adults.	No. young.
24.7.30	50	1163	209	17.9	608	576

B. Boghall Expt. Farm fields.

8.8.30	10	208	4	1.9	12	11
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From the above figures, it will be seen that at Liberton wheat fields, the percentage infection was much greater than at Boghall. This was also apparent by the high infestation of thrips at Liberton wheat fields. The highest number of thrips found here was 125 adults and 25 larvae per head.

(b) OATS.

Limothrips cerealium has been known for a long time in this country as a pest of oats, and in 1920 was reported to cause sterility in oats in England and Wales. It is also recorded on the same host plant on the Continent and in the United States of America. Another species of thrips which has been reported to cause "blighted" ears or "white top"/

top" in Canada is Anaphothrips striatus, Osborn.

In the field, the adult female thrips on migrating to oats in late May or early June, do not oviposit in leaves normally, but inside the leaf-sheaths or later on in the glumes. The leaves unlike wheat leaves, remain green and do not show any sign of injury. The leaf-sheaths, however, are damaged by the feeding of adults first and later by the larval stages, but externally this is not visible. Later on the hatched larvae migrate to the tender inflorescence and join the larvae hatched from leaf-sheaths where the inflorescence is developing, and start feeding. The inflorescence is therefore attacked before it leaves the leaf-sheath. In proportion to the number of adults and larvae present inside the leaf-sheath, the basal part of the inflorescence is subject to injury for a longer time. The flowers at the base fail to develop seeds, and appear as thin, white, shrivelled spikelets in immediate contrast to the green big spikelets above. The longer the basal part remains inside the thrips infested leaf-sheaths, the greater is the damage. Later on when the inflorescence is completely out, the eggs laid in the spikelets hatch and the larvae along with the older larvae from leaf-sheaths feed inside the calyces or more rarely inside the corollas.

Sometimes/

Sometimes the whole of the inflorescence is damaged and no developed seeds are seen. But generally the basal or occasionally the top part is affected when it remains held up inside the leaf-sheath. Plate 2 shows the spikelets at the basal parts of the inflorescence damaged by thrips.

The extent of injury to oats was calculated by counting the unset seeds in the affected inflorescence. The following gives the results of examination in summarised form.

TABLE III.

Liberton oat fields.

Date	No. of damaged Inflo. Exam.	Total No. of spikelets	No. unset	% Damaged	Adult thrips	Immature forms.
23.7.30	71	1611	618	38.3	595	2976

From the above table it will be apparent that the percentage of unset spikelets in affected inflorescence is very high. But the percentage of affected inflorescence in the field was not very high this year.

(XII) HIBERNATION.

Some of the adult females, after feeding for some time on wheat and oats and after getting fertilised, fly off before the crop is harvested. During late July in wheat fields at Liberton, adults were found in greater proportion than the early stages. The examination of the crop later on showed that very few young stages could be found in early August and none whatsoever by late August or early September. The wheat and oat crops were harvested in these fields on 25th August. By this time most of the females had already gone away to the grass field close by. Some of course remained under the bundles of corn left in the fields; but these were mostly males. The number of females remaining in corn bundles further diminished by the end of September and none were found after this date. The thrips were, however, collected during late August and September, by pulling out grass blades and examining the inside of the folds of the leaf_sheaths. The females were found hiding deep in the folds of grass, where eggs and larvae of Aptinothrips rufus were also found.

This species therefore migrates on to the grass in the adult stage, before the crop is harvested and after, when the corn bundles are lying in the field. It takes shelter in late summer after the crop is harvested/

harvested over grass, probably feeding occasionally, and hibernating during autumn and winter months.

The dissection revealed that fat bodies were greatly developed and the intestine was shrivelled at this time.

Miles (1921) while carrying out investigation in Shropshire on insects of grasses thought that L. cerealium feeds through winter in the larval stages in the hollow stemmed grasses. Theobald (1922) thought that L. cerealium seem to pass the winter either as pupae or adults generally in the soil or in hollow stalks among grasses and stubbles. There is, however, no proof of these statements. The presence of Limothrips cerealium together with the eggs, larval, pre-pupal and pupal stages of Aptinothrips rufus which breed throughout the year in grass, might have led them to ascribe the larval stages to hibernating L. cerealium females.

(XIII) SEASONAL HISTORY.

The thrips were first collected over meadow grass on the 21st of May 1930. On subsequent dates, the number of thrips in each collection from meadow grass increased, till by 26th May, large numbers could be found. Wheat plants in the adjoining field at this time were small and did not contain any L. cerealium. Thrips later on migrated from meadow grass to wheat and by the 4th or 5th June, all the wheat plants were observed to be severely infested. By the end of June only a few L. cerealium could be found over meadow grass and that too with great difficulty. Males and females of the new generation were observed for the first time in the field on wheat by 29th June. By 27th July, the number of immature stages decreased, when more adult males and females were found. In August no 1st stage larvae were found in fields, and the stages found were pre-pupae and pupae. These also decreased, till by 23rd August no immature stages could be found. The thrips now migrated to meadow grass again. The crop was harvested on 25th August. No thrips were found by the end of August or September over the harvested wheat bundles. Thrips were, however, found in these months inside the leaf-sheaths of grass in the field. Only females were found. The accompanying diagram (No.1) gives a/

a sketch of the seasonal history as noticed in the Liberton district wheat field.

The species appears to be single brooded. Females oviposit and feed during summer on wheat or oats and finally migrate to grass, sheltering and hibernating there as adult female. As the early females keep on laying eggs for a considerable time, all the stages are found simultaneously over wheat plant, and there is an overlapping of the early females with the females of the new generation.

The dissection of the females of the new generation on 23rd July and on 1st August, and later on, showed that they contained no developing eggs in the ovary. Large fat bodies were present inside the abdomen at this time.

The eggs when mature appear dirty
brown with two small red spots near the surface of
leaf. The larvae break the shell, and come out by
slow forward and backward movements, similar to that
described by *Microgaster percellata*.

IV. APTINOTHRIPS RUFUS, GMELIN.

(I) EGG LAYING.

The females live on various grasses, and are found throughout the year. Eggs are found in Aptinotrips rufus (with six-jointed antennae) all the year round; but in the variety stylifera (with eight-jointed antennae) eggs have been noted only in the warmer months of the year. The eggs are laid in slits made in the leaf tissue, and are scattered all over the leaf surface. In transmitted light, the eggs appear as white spots which facilitates detection.

(II) HATCHING.

The eggs when mature appear dirty brown with two small red spots near the surface of leaf. The larvae break the shell, and come out by slow forward and backward movements, similar to that described in Limothrips cerealium.

(III) FOOD PLANTS.

This species lives, mainly, on various grasses, and can be collected at any time of the year, but in the summer has been found also on/

on oats, wheat and barley. Occasionally they lay eggs on wheat and the larvae feed inside the ears or the leaf-sheaths. Sometimes, they are found in considerable numbers in young wheat seedlings, inside the leaf-sheaths near the roots.

(IV) LIFE-HISTORY.

An egg laid on 31st July hatched on 18th August, and two eggs laid on 2nd September hatched on 21st and 22nd September respectively. This gives the egg period of 18-20 days in August and September. The first larva, hatching on 18th August, moulted on 26th August, giving the 1st larval period of 8 days; the second larval moult occurred on 1st September which gives the 2nd larval period of 6 days. The third moult occurred on 3rd September and the adult female emerged on 9th September. This gives the pre-pupal and pupal periods of 2 and 6 days. The whole life-history from the egg laid on 31st July required 40 days. This species is many brooded, as the eggs are always found in the abdomen; and in the grass leaves, along with larval stages, throughout the year; but the broods overlap.

(V) SEASONAL OCCURRENCE OF THE TWO FORMS AND MALES.

Both six and eight-jointed forms were found throughout the year on grasses at various places, in the vicinity of Edinburgh. The six-jointed form was found to be very common and widely distributed, and has frequently been found to occur alone without the eight-jointed form which is scarcer and has a more limited distribution. At certain localities, however, both forms were found in the same collection. It has been observed sometimes that movements of a few yards makes a difference and one begins to get the other form. But at certain localities only eight-jointed form occurred and no six-jointed form was collected. This isolated distribution of the two forms is very remarkable. Williams also informs me that he had a similar experience of the species in the South of England. He observed, that the commonest form was six-jointed, while scarcer and more local variety was the eight-jointed one. The two forms did not usually occur together, and out of many records, he only twice got both forms together. Morison during collections of thrips between 23rd October 1923 and 27th January 1924 from Aberdeen area, found that females of Aptinothrips rufus taken from beating grass at three different/

different localities (near Bridge of Dee Fishery Station, Craibstone Experimental Farm) were each time associated with *A. rufus* var *Connecticornis*, Uzel. He also found that six-jointed form was very common. The following is the summarised table of the collections made last year with the locality and forms collected therefrom.

TABLE IV/

TABLE IV. Locality Distribution of two forms of *Aptinotrips rufus*.

Month.	King's Park.			Blackford hill.			Morningside.		
	Areas.			Areas.			Areas.		
	A. 6 j. only	B. 8 j. only	C. Mixed 6j. 8j.	A. 6 j. only	B. 8 j. only	C. Mixed 6j. 8j.	A. 6 j. only	B. 8 j. only	C. Mixed.
November	579	-	16 10	-	-	-	-	85	6j. 8j. 112 104
December	292	-	54 45	-	-	-	-	100	172 98
January	115	-	31 16	-	-	-	-	212 Grass cut & removed.	-
February	71	-	-	-	-	209 139	-	-	-
March	52	-	-	-	-	170 131	-	-	-
April	42	-	22 2	138	-	21 42	-	-	-
May	88	-	10 29	-	-	-	-	-	-
June	107	-	59 22	-	-	-	-	-	-
July	130	-	-	-	-	270 44	-	-	-
August	57	-	-	-	45	78 99	-	-	-
September	117	28	-	-	-	-	-	-	-
October	126	28	-	-	-	-	-	-	-
Total:-	1766	56	192 124	138	45	748 455	-	397	284 202

6 j = six-jointed. 8 j = eight-jointed.

It will be seen from the above table that at King's park (Holyrood park), area A, only six-jointed form was found all through the year and no eight-jointed form was ever taken from this place. From the area B, only two collections were made in September and October and only eight-jointed form was found. At area C, the two forms were found mixed up in different proportions as given in the table. It is possible, however, that they were really separate as the area of collection was slightly larger. From the Blackford hill, area C, on the left side of the loch, the two forms appeared mixed up in different proportions, and once from area A, as many as 138 six-jointed form were collected with no mixture of eight-jointed form. From the area B, all the thrips were eight-jointed. From the Morningside locality, no six-jointed form was found at area A; and at area B, all the thrips collected were eight-jointed, with no mixture of six-jointed form at any time during the collection. At area C, the six- and eight-jointed form was found mixed up in different proportions. Unfortunately the collections at the area B were made for only three months, as the grass was later on cut and removed by the owners of the land.

Larvae have also been found all the year round, only from such localities where six-jointed form occurs/

occurs throughout the year. Greatest percentage of larvae were found during winter, and the collections even from under the snow gave adults and larvae with green material inside the intestine showing that they had been feeding quite recently. In Spring the percentage of larvae found was less; and in Autumn the percentage of larvae found was least. The numbers of larvae, pre-pupae, pupae, females and males collected during the year are summarised in table No.V.

It will be seen from this table that no pre-pupae were found in November and December 1929 from several hundreds of females collected. The first pre-pupa was found on 19.1.30. In February and March, none were found, and in April four were found, two from the same collection on 23.4.30 and one on 25.4.30 and one on 29.4.30. In May and June one pre-pupa was found on 30.5.30 and one on 18.6.30 respectively. From July to November 1930, no pre-pupae were found. In all seven pre-pupae were found throughout the year from a large number of collections. Pre-pupal stages seem to be rare, and as they remain at sheltered places, beating of grass does not bring them out so easily.

The number of pupae found was proportionately greater. No pupae were found in November. Two pupae were found in December, the first on 20.12.29 and the other on 30.12.29. In January also, two pupae were found, one on 13.1.30 and the other on 16.1.30.

In/

TABLE V.

1929-30.	6-jointed form.					8-jointed form.					Males and young stages of six-jointed form.									
	Months.	No.	No. with no. of eggs					Total	%	No.	No. with no. of eggs.					Total	%	No. Males	No. larvae	No. pre-pupae
		1	2	3	4	5			1	2	3	4	5							
November 1929	697	-	1	-	-	-	1	.14	209	-	-	-	-	-	-	-	1	50	-	-
December	515	14	7	2	1	-	34	6.6	153	-	-	-	-	-	-	-	-	102	-	2
January	156	42	7	-	-	-	49	31.4	16	-	-	-	-	-	-	-	-	44	1	2
February	280	15	25	1	1	1	43	15.3	139	-	-	-	-	-	-	-	3	106	-	-
March	213	21	16	-	-	-	37	17.3	131	-	-	-	-	-	-	-	-	49	-	-
April	302	126	42	6	-	-	174	57.6	48	39	6	-	-	-	45	93.7	2	43	4	17
May	82	35	13	7	1	-	56	68.2	54	16	29	1	1	1	48	88.8	-	22	1	8
June	189	70	20	10	1	-	101	53.4	30	11	5	1	-	-	17	56.6	5	30	1	4
July	270	48	19	4	-	-	71	26.2	44	-	-	-	-	-	-	-	3	20	-	1
August	135	8	6	2	2	-	18	13.3	45	-	-	-	-	-	-	-	-	19	-	2
September	117	13	15	1	-	-	29	24.7	18	-	-	-	-	-	-	-	1	3	-	1
October	126	10	11	-	-	-	21	16.6	28	-	-	-	-	-	-	-	-	6	-	-
November 1930	130	6	1	-	-	-	7	5.3	10	-	-	-	-	-	-	-	-	1	-	1
Total:-																15	495	7	38	

In February and March none were found. The greatest number of pupae was found in April. In a single collection, thirteen pupae were found on 11.4.30; while two were found on 23.4.30 and two on 28.4.30. In May eight pupae were collected, three on 5.5.30 and three on 13.5.30 and two on 20.5.30. In June four pupae were collected the same day on 6.6.30; and none were found in the collections made on other days. In July one pupa was found on 15.7.30, and in August two were found on 22.9.30. In October no pupae were found from several collections, and in November 1930 one was found on 5.11.30. Since, the larvae are found all through the year, the pupae also occur throughout the year, though in various proportions. Very few pupae were collected in winter, which seems to be correlated with the higher percentage of larvae found. In Spring and Summer greater number of pupae were collected; depending probably upon the less number of larvae found.

Males are very scarce in this species. Uzel in Bohemia and Hinds in America did not find any males. Bagnall and Williams also record the rarity of males. Williams in September 1913, found twenty males among many hundred females. Morison during his collections, between the 23rd October 1923 and the 27th January 1924 from the Aberdeen area, collected 200 females, 10 males, 35 larvae and 4 pupae. This gives a fairly large proportion of males.

In England, he found one male in Winter among several hundred females. The writer during the course of great search got only 15 males out of many females in the whole year. All the males collected were six-jointed and no male with eight-jointed antennae has been found. Recently, however, Morison has sent the writer a slide of the male of eight-jointed form, collected by him on 18.8.28 in Aberdeen. The monthly distribution of males is summarised in the same table (No. V). A male was found for the first time in November on 26.11.29. No males were found in December and January. In February three males were taken from one collection on 17.2.30; and in March none were found. In April two males were found, one on 11.4.30 and the other on 26.4.30. In May none were found. In June five were collected the same day on 6.6.30 in one collection. In July three males were found on 22.7.30 and in September only one on 16.9.30. No males were found in October and November 1930. According to this distribution, fewer males were found in winter and more in summer.

The greater preponderance of six-jointed females and the rarity of males restricted to some certain small areas, and the wider and commoner distribution of females only, suggests that over greater areas, the six-jointed form is purely parthenogenetic. At those places/

places where males occur, a limited percentage may be sexual, as even there the females are in greater majority. In eight-jointed form, no males were collected by the writer; but the collection of few males by Morison, is suggestive that this race is also only sexual in limited and small localities. For the greater part it is apparently parthenogenetic like the six-jointed form.

At this time it was very hard to get any of this form. In May, the percentage of females containing eggs was highest for the year. From July onwards, the number of females with eggs decreased, so much so, that again in November 1950, the number of females with eggs was lowest. Individuals with one or two eggs were found very commonly; but sometimes as many as five eggs were found in one female. The number of females with number of eggs found in various months of the year is also given in the next table.

The eight-jointed form which occurs usually singly or occasionally in pairs, was also collected in the same area as the six-jointed form. It was first collected in the same area as the six-jointed form in the same year. In the same area, it was also collected in the same year. In the same area, it was also collected in the same year.

(VI) SEASONAL AND RELATIVE FECUNDITY IN THE TWO FORMS.

Since the first collection made in November 1929, the six-jointed form has been found to contain eggs in various proportions all the year round. As seen from table V, fewer females contained eggs in November, but in succeeding months, the number of females with eggs increased. In Spring and Summer, a very great number of females were found to contain eggs. At this time it was very easy to get the eggs of this form. In May, the percentage of females containing eggs was highest for the year. From July onwards, the number of females with eggs decreased, so much so, that again in November 1930, the number of females with eggs was lowest. Individuals with one or two eggs were found very commonly; but sometimes as many as five eggs were found in one female. The number of females with number of eggs found in various months of the year is also given in the same table.

The eight-jointed form which occurs usually singly or occasionally mixed was not found to contain eggs till March in any of the collections. Eggs were first noted in them in April on 23.4.30, from a collection made at Balerno. In this collection about 93.7% of females contained eggs. During May and June also considerable number of females were found to contain eggs. From July onwards again, no eggs/



eggs were found. In this form also, during breeding season, individuals with one or two eggs were very common; but in May as many as five eggs have been found in a single female.

Table V also gives the summarised figures of the fecundity of the two forms; and the number of females with number of eggs from November 1929 to November 1930. The graph No.1 represents the fecundity curve of the two forms obtained from these figures.

It will be seen from this graph that the fecundity in six-jointed form is lowest in November and increases in December and January; but falls again in February. During succeeding months, the fecundity again progressively increases, when in May, it is highest for the year. Later on, the fecundity decreases. It will be further interesting to observe that there are two short fecundity peaks, situated exactly equidistant from the highest peak in May.

The fecundity curve of the eight-jointed is also drawn on the same scale, and shows the contrasting difference in the period and intensity of fecundity. It appears probable that breeding in this form occurs only for a short term of the year. Naturally the number of broods per year in this form must be considerably fewer than in the six-jointed form in which breeding takes place all the year round. Although the breeding of eight-jointed form was highest in April and/

and in six-jointed form in May, they seem to coincide that both forms had highest fecundity in April, May and June.

This difference in the rhythm of the breeding periods of the six and eight-jointed forms presents some interesting questions of specific importance. Recapitulating from what has been said before, it appears that the eight-jointed is a definite form with a life-cycle of its own; breeding for a short period, and usually living isolated and having fewer broods in a year. The six-jointed has been considered as variety of eight-jointed form by Uzel, Bagnall and others. But seeing that it differs in the number of antennal joints, usually lives separately and breeds all the year round, with considerable number of broods per year, it seems desirable that structural difference correlated with biological difference should be sufficient to warrant a specific distinction. However, there are certain other points which are also to be considered. Recently Radulesco (1930) experimenting at Saint Genis laval (Rhône), France, considers that eight-jointed form under certain conditions of temperature and dryness, gives rise to six-jointed form. The writer during field collections at certain areas always found eight-jointed form and no six-jointed; while if such occurred in nature, some six-jointed form/

form ought to have been found at those places. Similar had been the experience of Williams. But sometimes at places the two forms have been found mixed by Williams, Morison and the writer. Priesner during some of the collections found a form with seven-jointed antennae (f intermedia Pr, 1928), and the writer from a large collection of eight-jointed form, got some females having one normal six-jointed antenna and the other normal eight-jointed. These various records seem to lend support to the view that the eight-jointed form is a highly unstable form, and may under certain conditions give rise to six-jointed form.

The collection of eight-jointed male by Morison, in Aberdeen, opens up the field for supposing that eight-jointed form has also a small sexual race. It therefore appears to the writer that there are four races, the sexual and parthenogenetic six-jointed race, and the sexual and parthenogenetic eight-jointed race; and that the parthenogenetic race of each form occasionally gives rise to sexual race. Since these two forms are so closely allied, the eight-jointed form may under certain conditions produce freaks of the type of seven-jointed antennae (f intermedia Pr, 1928); and the six and eight-jointed antenna in the same individual noticed by the writer.

V. NATURAL ENEMIES.(1) Limothrips cerealium.

No parasites were found in the fields which may be said to be responsible for the mortality of the young or adult thrips. Chalcids were found on wheat plants, but they were never observed parasitising this species; nor was any parasitised thrips ever collected. Trioptenus russelli, parasitises the bean thrips, Heliothrips fasciatus, in the United States; and a related species has been found by Bagnall in England; but no species of this genus ever came to the notice here. The carnivorous Aeolothrips fasciatus, reported elsewhere to feed on thrips was also never captured in the fields

A very slight amount of mortality, no doubt, is caused among the young stages by rain; but this seems to be very little owing to the hidden positions of the larvae and adults. The eggs fail to develop when the leaves are hard and dry. The time of planting appears to have some influence on the intensity of attack.

(2) Aptinothrips rufus.

One external and one internal parasite came to the notice of the writer during the collection and study/

study of this species. The external parasite was a Trombidium larva and the internal parasite a nematode, Tylenchus aptini n. sp., infesting this species in large numbers. Uzel in 1895 found Trombidum larva infesting some thrips, and also nematodes inside Thrips physopus; but he gave neither description nor figures to make any comparison.

(a) Mite.

Many times in the year, it was observed that the red mite was attached to the thrips and was dragged along with it. The mite was always found to attack in the larval stage. It is scarlet red, soft bodied, with three pairs of legs (Fig.1, Pl.3) and measures .366-.433 mm. in length and .166-.2 mm. in breadth. The cephalothorax is large and is armed with chelicerae and pedipalpi. The pedipalpi are segmented stout structures ending in strong pointed claws (fig.2, Pl.3). The chelicerae are lancet-shaped and seem to be retracted inside, in fixed preparations. At the entrance of the mouth are situated two sharp hooks (Fig.3, Pl.3) which are probably used for attachment. No eyes are visible. The legs are six-segmented and end in three unguines (Fig.4, Pl.3). Hairs are sparsely distributed near the border of the hind margin.

The mite is so tenaciously attached that it is difficult/

difficult to remove. It has always been found to be attached near the base of hind coxa one or the other side, near the lateral margin of the body, so that the head remains attached and the rest of the body is free (Plate 4). One Trombidium larva has been found on one thrips; but the infestation in some of the collections was very high. These larvae appear to suck the fluid out of the abdomen; but otherwise do not seem to affect the thrips in any way, as some of the infested thrips have been found to contain as many as three eggs. It appears that the mite detaches itself after it is fully gorged.

(b) Nematode.

Nematodes were found in the body cavity of Aptinothrips rufus, and occasionally in large numbers. A study of the nematode parasite and its effect on the host is dealt with separately in Paper III.

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PAPER III.

A NEW NEMATODE PARASITE OF THYSANOPTERA

(APTINOTHRIPS RUFUS, GMELIN).

(PLATES 1-6; FIGS 1-66; 1 MAP; 1 GRAPH)



A NEW NEMATODE PARASITE OF THYSANOPTERA

(APTINOTHRIPS RUFUS, GMELIN).

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I. INTRODUCTION.

The collection and study of Aptinothrips rufus made last year, in the neighbourhood of Edinburgh, revealed the presence of an internal nematode parasite which seemed worthy of further study. There is at present very little known of the parasites of Thysanoptera in general, and no record of any parasite of Aptinothrips.

Uzel (15) in 1895 described a nematode in Thrips physopus. In 1910 P.R. Jones (Russell, 1912) found a nematode parasite "working in the full-grown larvae of the bean thrips", Heliothrips fasciatus at Lindsay, Cal. In the absence of any description or figures of either of these two, it is impossible to establish any identity with the one at present under consideration.

The nematode infesting Aptinothrips were first discovered in December 1929, and from that time a regular record of the parasitised thrips was kept to find out the degree of parasitism in various months of the year, and thrips from various localities were examined to find the local distribution of the parasite. A study of the morphology and bionomics was also made with various details of the parasitic life of the worm. It has been impossible to complete the/

the study of the free living stages which it is hoped may be completed by some other investigators.

Generally, eggs, larvae and females came out on dissection, but sometimes only eggs or highly modified females which can be easily overlooked were found, and occasionally only larvae. A closer examination of the larviform worms showed that two morphologically different forms were present together, one having conical tail and stylet; and the other having no recognizable buccal stylet, but possessing caudal alae, spicula and gubernaculum. This at the first sight appeared to be a different species; but later on, the examination of the parasitic stages disclosed the possibility of its being the male of the species. The larvae having conical tail and buccal stylet will be called form I and the males having caudal alae and no buccal stylet form II in the following descriptions. The form II was very scarce in proportion to form I, and was occasionally absent; while the form I was always present whenever larviform worms were found. All the stages of the two forms from the smallest to the longest, and also the various stages in the development of the parasitic females were found to exist together in certain dissections, though rarely. It was interesting to observe that the young forms of the males appeared morphologically similar to the mature forms, but that the early stages of females were/

were quite unlike the mature females.

The host Aptinothrips rufus has two varieties, one with six and one with eight jointed antennae and although the six and eight jointed forms were sometimes found together (eight jointed very scarce) in the infested locality; yet in no case so far have the worms been taken from the body cavity of eight jointed form. The infection also has so far been found in females only. Males are, however, very scarce in the species, and only four males, all of which worm-free, were captured throughout the year from the infested areas. It is possible that if more males could have been examined some would have been found to be infected. The infection has been found to be greater in adult females, the larval and pupal infection being rare and only established in a few cases.

The work was carried out in the Department of Agricultural Zoology, University of Edinburgh, under the supervision of Dr C.B. Williams. The writer is greatly indebted to him for many valuable suggestions and advice during the progress of work. The writer also wishes to thank Dr H.A. Baylis for some important suggestions.

2. TECHNIQUE.

Grass was collected, brought to the Laboratory and beaten over a white sheet of cardboard. The thrips crawled out from the fallen material. These were transferred by a fine brush into a glass dish containing a small quantity of water and floated on to this. As the thrips can stand considerable immersion, there was no danger of their being killed.

The dissection of live thrips was made on a microscope slide in a drop of clear tap water under a Leitz binocular dissecting microscope (X75; X150) with a fine pair of needles. As the thrips generally crawl out from the binocular field, they were first stunned by pricking the head and then the anterior and posterior parts were slowly drawn apart. The segments break apart and the contents pull out suddenly. Various internal parts were then slowly separated from chitin with the help of needles. Thrips previously killed in any fixing medium did not prove good for dissection purposes. In the case of infected specimens, eggs, larvae, males and females of the nematode came out immediately. The dissected skin of thrips was now removed. A very small quantity of water should be taken, as the worms being very small spread out over the slide with the likelihood of the various stages being missed.

The worms were studied after being killed on a slide over a heated plate or over the flame of a spirit lamp for a very short time. Excess heating cooks the specimens and the intestinal contents burst out. A coverslip was placed over the drop of water containing the worm and the edges were sealed down by a very thin layer of Asphalt or liquid wax to stop the rapid evaporation of water. In order to give a slight colour to the worms and their internal parts, a trace of 1% aqueous solution of Nile blue was added to the drop of water containing the nematodes. Excess of Nile blue stains the specimens deeply and various internal parts are not clearly seen. The details of the internal parts of the nematode stages were studied from these preparations with an oil immersion objective.

To preserve specimens of nematodes, the following medium suggested by Dr H.A. Baylis was used and found very satisfactory.

1. Carbolic acid	20 gms.
2. Syrup lactic acid	20 gms.
3. Glycerine	40 gms.
4. Dist. water	20 gms.

The specimens were killed in a drop of water over a heated plate and mounted directly in the above medium. The edges of the coverslip were sealed with Asphalt or gold size. The internal parts of/

of the mature females were very clearly seen in the above medium.

In addition to the above, the following method was also tried. The specimens were fixed over slide in a drop of Bouin's fluid, washed in 70% alcohol to get rid of Picric acid and finally brought into water. Staining was then done with Delafield's haematoxylin and counter-staining with eosin. The reproductive organs of the normal and parasitised thrips were also studied by this method.

3. SYSTEMATIC POSITION.

Uzel (15) in 1895 (p.367) found 200 nematodes and many eggs in Thrips physopus; but he gave neither description nor figures to make any comparison with the nematode stages found in Aptinothrips rufus. van Zwaluwenburg (18) in a recent paper gives a summary of the early accounts of worms found in insects. The only record in Thysanoptera that he mentions is that of Uzel.

The systematic position of the worm has to be determined from the stages that have been found in the body cavity of the host. These are the egg stage, early and advanced stages of the 1st form larvae, mature and immature stages of males (2nd form) and various stages in the development of parasitic female.

The writer has provisionally included the present worm as a highly modified member of the genus Tylenchus on the basis of behaviour and morphological characters and has given the specific name "aptini" after the generic name of the host, Aptinothrips rufus.

Dufour in 1837 described Sphaerularia bombi parasitic in various species of queen bumble bees (Hymenoptera, Bombidae). The male is a small tapering nematode with pharynx, alimentary canal, sperm-arium, ejaculatory duct and cloacal opening. The figure/

figure given by Wülker (16) p.479 also shows a pair of spicula and gubernaculum, although they are not so labelled. The males therefore can be said to resemble slightly the males of Tylenchus aptini, but the female is quite different. The early stages of the parasitic female of Sphaerularia bombi is nematode like with a pharynx, ovarium, eileiter and a small vaginal projection near the pointed tail. In successive stages of growth, the vaginal appendage of the parasitic female grows into a long appendage many times the size of the worm and the uterus, fat body and modified intestine come to lie in it. Comparing the descriptions and figures given by Wülker (16) p. 479 with Tylenchus aptini, it will be apparent how very different the early and late stages of parasitic females are. Similarly, Atractonema gibbosum, Leuckart 1887, parasitic in maggots of the Dipterous fly Cecidomyia pini is not closely related as the parasitic female like Sphaerularia has a different developmental history and the mature female is highly modified, with large uterus and vagina; while the small body is attached to the enlarged vagina as an appendage.

In 1921 Cobb (3) described Howardula benigna from the body cavity of the beetles Diabrotica vittata, D. trivittata and 12-punctata. There is no detailed description of the mature or the early stages of parasitic female or figures to enable one to make a comparison. From what is given, Howardula benigna/

benigna agrees with Tylenchus aptini in the mature parasitic female which in both species is a cylindroid sac, with no alimentary canal and with anus vestigial or absent. But aptini differs in not only not being syngonic and viviporous but in the presence of a distinct stylet at the anterior end. Moreover the presence of two types of larvae, one with conical tail and stylet, while the other having caudal alae and no stylet finally maturing into males, gives sufficient grounds for its separation. In 1926, Baylis and Daubney (2) placed Howardula under Allantonema, Leuckart 1884.

In 1923 Wülker (16) described a nematode Allantonema mirabile parasitic in the weevil Hylobius abietis. As would appear from the figures given by Wülker of the Allantonema parasitic female on p. 398 from imago, on pp. 440, 443 from larvae and on p. 445 from pupae, it is a large rounded inert organism in all stages. In the mature state, it consists of an inner and outer layer, a tubular ovary, lying on one side of the body wall, a short receptaculum seminis and oviduct, and a very large uterus occupying a greater part of the interior, filled with eggs and larvae: the vulva is situated at the posterior end. Bradynema, zur Strassen (19) is also a large sausage shaped organism with bluntly rounded head and tail. The mature parasitic female of Tylenchus aptini resembles/

resembles in being inert and sac-shaped; but differs in the presence of a distinct stylet, oviparity, the situation of vulva on the side, and above all in the early stages which are so nema like in shape, possessing a stylet, oesophagus and an alimentary canal. It is only in the later stages of parasitic life that the female is so modified and suggests kinship to Allantonema. The writer previously had included it under Allantonema, but the characters as made evident in figures 56-59, pls. IV-V lead to its separation from Allantonema and Bradynema.

Recently Goodey (8) established a genus Tylenchinema for the reception of a new species of nematode Tylenchinema oscinellae parasitic in the frit-fly (Diptera, Cecidomyidae). The parasitic female is a large coiled sausage shaped organism quite different from the thrips parasite.

The genus Aphelenchus and Heterodera include plant parasitic species, the characters of which are very different to include this species.

Now the insect parasitic nematodes in the genus Tylenchus remain for consideration. Fuchs (4) in 1915 described two species, Tylenchus contortus and Tylenchus dispar from Ips typographus and Cryphalus picae (Coleoptera, Scolytidae); making two varieties of the former and three varieties/

varieties of the latter. Wülker (16) described a third species Tylenchus hylastis from Hylastis ateri. (Coleoptera, Scolytidae).

The description of the parasitic female by Fuchs (4) and his figures (Plate 17 figs 12-13) resemble the early stages (figs. 50-52, Pl. III-IV) of the parasitic female from Aptinothrips. There is, however, a much greater morphological and biological similarity between the parasitic female, Tylenchus dispar curvidentis (Fuchs 5. p.196, fig.1) and the parasitic stages (figs. 58-59, Pl.V) of the present nematode female. The presence of a stylet, trace of oesophagus, constitution of ovary, oviparity, uterus and position of vulva (figs. 58-59, Pl.V) are, among others, common characters. The writer has therefore separated this worm from Allantonema, Bradynema and Howardula chiefly on the basis of the above mentioned characters, of which the presence of stylet in the early stages and a trace of it in degenerated later stage give resemblance to Tylenchus. If the second form of worm with caudal alae, spicula and gubernaculum be taken as the male of this species which is very likely, the relationship with Tylenchus is further enhanced.

The present worm is therefore included as a highly modified member of the genus Tylenchus. Since the degeneration of the mature parasitic female is much greater than hitherto known in insect infesting/
ing/

4. DESCRIPTION.(1) EGGS:-

The eggs are oval, broadly rounded anteriorly and posteriorly, and slightly constricted in the middle (Figs. 1-6, Pl.1.) The eggs measure .04 - .0607 mm. in length and .02 - .0285 mm. in breadth. They are provided with a thin smooth non-striated shell membrane or chorion filled inside with protoplasm in which small nuclei can be seen in permanent and stained preparations (Figs.1-2, Pl.1). Figure 3, Pl.1 shows the state of egg ready for coming out from the uterus. Large fat globules also appear to be present (Fig.3, Pl.1).

The eggs lie free in the body cavity and float in the body fluid of the host. During growth the protoplasm shrinks inside from the membrane or chorion (Figs. 4-6, Pl.1). The young larvae develop inside the eggs and reach a certain stage of development when the general outline of the larvae can be seen inside the eggs, lying in various positions (Figs.7-14, Pl.1). The larvae finally break away the shell and emerge outside, in the abdominal fluid of the host. Occasionally no eggs are present. The highest number of eggs found in a single individual so far has been 215. Statistics of the number of eggs found in various monthly dissections will be found below under seasonal distribution.

(II) LARVAE (FORM I).

The young larvae when they emerge from the egg membrane are very small (Figs.15-18, Pl.1).

The principal measurements are:- Total length .1206 - .1448 mm.; greatest width .0137 - .0172 mm.; length of stylet = .00833 mm.; width of the head across the middle of stylet = .01 mm.; length of stylet and oesophagus = .0216 mm.; length of oesophagus = .0133 mm.

They have a well rounded anterior mouth, wider in the middle, and a conical tail (Figs.15-18, Pl.1). The mouth is followed by a strong stout stylet which is connected with a thin winding oesophagus. The oesophagus opens finally into a wide long alimentary canal which now occupies the rest of the young larval body (Fig.16, Pl.1). Inside the intestine are also to be found large fat globules which stain deeply with Nile blue (Fig.16, Pl.1). Under lower magnification these larvae seem to have anteriorly some clear globular areas situated by the side of the stout stylet (Figs.17-18, Pl.1). After several ecdysis the larvae become larger and thinner (Figs.21-22, Pl.1). The figures 19 and 20, Pl.1, show the comparative size of the younger and maturer forms of the larvae under lower magnifications

These older larvae (Figs.21-22, Pl.1) are most often/

often found in large numbers. When dissected out of the abdomen of the host they wriggle about in the drop of water. The principal measurements are:-

Total length .25 - .3666 mm.; greatest width .01333 - .0178; length of stylet = .0133 - .0156 mm.; width of stylet .00083 - .00178; width of anterior tip = .005 - .00714 mm.; width of the tail end = .0033 - .00357; width across middle of stylet .00666 - .00833 mm. Length of oesophagus .0283 - .045 mm.

The body tapers anteriorly and posteriorly. The head is rounded and smooth (Fig. 23-24, Pl. I), directly continuous with the body having no constriction. The head is wider than the tail (Figs. 21 and 22, Pl. I). Posteriorly the body tapers and ends in a small sharp point. The cuticle is smooth and non-striated. Separate lips or papillae have not been observed. The general outline of these mature larvae resembles some figures drawn by Wülker (16. pp. 401, 404, 410) of the development of the larvae of Allantonema and by Fuchs (4. Plate 18, Fig. 18a) of the larva of Tylenchus dispar typographi.

The mouth is terminal and is connected with a small stout shining stylet (Figs. 25 and 31, Pl. II). Basal thickenings in the stylet have not been observed. The stylet is connected with a long winding oesophagus (Figs. 25 and 31, Pl. II) which opens posteriorly into the/

the intestine. At the junction where oesophagus opens into the intestine a glandular structure is observed (Fig 23, Pl.1 and Figs.25 and 31, Pl.II), the exact nature of which is not clear. The intestine later on occupies the rest of the body and is a long wide straight tubular canal (Figs.26-29, Pl.II). It appears to stop a short distance from the posterior tip (Fig.29, Pl.II) and contains a large number of reserve fat droplets (Figs.26-29, Pl.II).

The larvae obviously feed on the fluid contents in the abdominal cavity of the host and the intestine is therefore full of globules of reserve fat. No distinct anus or any other structure appears to be visible at the posterior end. The young and the advanced larvae of this form are therefore similar in essential morphological characters, except that of size. In one case the longest larva found was .3666 mm. in length and appeared to possess traces of reproductive organs. The length of the organs was .0416 mm. situated .0733 mm. above the tail end.

(III) MALE (FORM II).

The second form nematodes are different from the form I described previously, both in young and maturer stages. No case of the transformation of the first form into the second form has so far been observed. These are very small and the younger and maturer stages of this form are morphologically similar. The principal measurements of young larvae are: Total length .13103 mm; greatest width .01724 mm; length from the tip of head to gubernaculum = .1206 mm; length from gubernaculum to tip of tail = .01724 mm.; width at the mouth end = .00689 mm.; width at the tail end = .00344 mm.

These young larvae (Fig. 34, Pl. II) are found in very small numbers from some of the dissections. They are usually absent from larger numbers of dissections where only of larger sizes are found mixed up with the larvae of the first form and the early stages of the female nematode. They are distinguished by their peculiar movement and by their morphological characters. The body tapers anteriorly and posteriorly (Fig. 34, Pl. II). Anteriorly the head is flat and is separated by a slight constriction with the main body. No distinct mouth or stylet is seen and a degenerate oesophagus may be considered to exist. A pair of caudal alae, spicules and a very minute gubernaculum is/

is present, (Fig.39, Pl.III).

After several moults the larvae assume the mature form of male (Fig.36, Pl.II). Fig.35 gives an idea of the intermediate size between the younger and maturer forms of males. All the stages seem to be morphologically similar.

The mature stages of this form (Fig.36, Pl.II) are more commonly found than the younger stages (Fig.34, Pl.II), in association with the larvae of the first form (Figs.21-22, Pl.I). Morphologically, the younger and the maturer forms have been found to be similar, except that the mature forms appear to possess testis. The principal measurements are:- Total length .2482 - .333 mm.; greatest width = .01379 - .206 mm.; length from anterior end to gubernaculum = .2916 mm.; length from gubernaculum to tail end .02166 - .0275 mm; length of spicula .078 - .01166 mm.; length of gubernaculum = .0416 - .00517 mm.; width at the anterior end = .00666 - .00689 mm.; width of the tail end = .0033 - .00344 mm.

The body of males (Fig.36, Pl.II) tapers anteriorly and posteriorly. The head is broader than the tail, flat, and separated from the body by a short constriction (Fig.38, Pl.II). The tail (Fig.37, Pl.II) is bluntly rounded. Lips or papillae are not present. The mouth aperture is not visible and there is no trace of a stylet or an oesophageal bulb.

A distinct oesophagus is not present. It appears to be degenerate. The indication of an oesophagus as a faint ill-defined wide area may be said to be present from the head backwards. No intestinal gland is visible.

Posteriorly the tail is curved and highly constricted, ending in a rounded point (Figs. 40 and 41, Pl. III). On each side of the tail end are the cuticular expansions or caudal alae (Fig. 40, Pl. III) which arise a little anterior to the anus from the ventral edge of the lateral field, and reach almost to the tip of the tail (Figs. 40 and 41, Pl. III). The free edges of the caudal alae are not crenate.

There is a pair of spicules (Fig. 37, Pl. 2 and Figs. 40, 41 Pl. III) each being broad anteriorly and tapering slightly towards the tip. A short gubernaculum is also present (Figs. 40 and 41, Pl. III). Figure 41, Pl. III shows the spicula and gubernaculum in a front position. The spermaries (Fig. 42, Pl. III) consist of a long strip of glandular area applied to the sides of intestine. In all these characters it resembles many species of Tylenchus.

The relationship of this worm is difficult to establish with certainty as the free living stages are not known. Whether this male and the other larval stages in thrips belong to a single or two different species, the writer is not able to say till further

light is thrown on the free living stages of the parasite. But since the males are found along with other forms, in most dissections, it appears to be associated with the nematode worm. That this form arises separately from its younger stages and not that the 1st form larvae give rise to the males in later stages of development is proved by the presence of its young stage (Fig.34, Pl.II) in the same dissections. In no case have these males been found passing out through the anus or have they been found to be present in rectum. This goes to show that they remain inside, and serve the purpose probably of the fertilization of the females in the early stages which are so worm-like in appearance and which after fertilization assume the degenerate form on maturity. The life-history of the parasitic female also confirms this possibility.

(IV) FEMALE:-

The early stages of the immature female (Figs. 43-47, Pl. III) resemble the early stages of the first larval form described previously, and it is therefore difficult to differentiate them by mere cursory look. The slightly advanced stages of the female larvae (Figs. 48a - 49a, Pl. III) can be distinguished by their greater breadth, size, and by their peculiar behaviour. The measurements from eight individuals of the early and late stages show the growth in width, which the females undergo in subsequent stages of development.

Figures	43	45	46	48a	49a	50	51	52
Length	0.2	.233	.25	.2448	.2482	.1551	.2166	.02333
Breadth	0.02068	.02413	.02413	.034478	.03448	.02724	.05	.05

In certain cases the length may exceed .275 and .291 mm. The larvae (Figs. 43-47, Pl. III) taper anteriorly and posteriorly. The head is broadly rounded and is not separated by any constriction with the body. It is provided with a short stylet (Figs. 43-49a, Pl. III) and has a long oesophagus opening into the intestine. The tail is pointed (Figs. 43 - 46, Pl. III). The body is filled with a large amount of reserve fat material (Fig. 49a, Pl. III) As regards their behaviour, they do not seem to be as active as the larvae of the first form. They moult several times/

times, as in some cases the empty old skin is clearly seen attached anteriorly (Figs. 45-46-48a, Pl. III).

After several ecdysis, the exact number of which is uncertain, the mature stage of female (Fig. 54, Pl. IV) is reached. In some cases all the stages of female larvae as well as adult are found in one dissection. Figures 50, 51, Pl. III and 52, Pl. IV show the female form, which are intermediate between the early and mature forms. In the larval forms the ovary is clearly seen as a tubular structure (Fig. 53, Pl. IV).

The mature stage of the female (Figs. 54 -56, Pl. IV and 58 and 59, Pl. V) is highly degenerate and does not show any relationship to its larval stages. It measures .266 - .316 mm. in length and .0666 - .083 mm. in greatest width. The stylet is .00714 - .0428 mm. in length. Immediately after dissection of the thrips the female nematode slips out and is so unlike a worm that it can be mistaken for some internal organ or be missed altogether. It is a thin cylindroid sac-shaped organism. Figure 54, Pl. IV shows the state of parasitic female in a drop of water drawn after five minutes after dissection. It appears brownish with clear transparent areas owing to the random/

random distribution of large quantity of reserve material in the interior. Anteriorly a short stylet shaped structure may be seen which under oil immersion becomes clearly visible (Fig.55, Pl.IV).

A trace of ovarian tube may be occasionally seen in fresh preparations, otherwise nothing is seen owing to dense fat globules. The margins are smooth and not crenate. The anterior portion is broader than the posterior which ends in a sharp pointed papilla-shaped short tail (Figs. 58-59, Pl.V). There is also to be seen a clear hollow cuticular structure attached anteriorly and in some cases extending to a great length which gives a clue that the previous stage was not as wide as this. The cuticular skin is found in almost all cases of careful dissections. The short stylet is only visible in fresh preparations or in carbol-lactic-acid medium. In fixed and stained preparations the stylet becomes obscure, while some indication of the tubular ovary can be seen.

Figure 56, Pl.IV shows a haematoxylin and eosin stained preparation of the female. The carbol-lactic-acid preparation reveals that there is no alimentary canal or anus (Fig.58-59, Pl.V). A trace of degenerate oesophagus may be located in some specimens with difficulty.

The reproductive organs are well developed (Fig. 58-59, Pl.V). The ovary is a long tubular structure/

structure reaching anteriorly up to the anterior end. Posteriorly it makes a loop (Fig. 58-59, Pl.V), and then widens out to form a uterus, opening to the outside by a small aperture, the vulva is situated by the side of tail papilla. Figure 59, Pl.V shows the cuticular skin attached anteriorly, the reserve material distributed in the interior; and a mature egg in the uterus at the verge of passing outside in the abdominal cavity of thrips.

The reproductive system when dissected out from the sac-shaped parasitic female consists of a chain of ova in various stages of growth (Fig. 57a, Pl.IV). Posteriorly the tube widens out and has mature ova. Figure 57b, Pl.IV is a detached part of the ovarian tube showing eggs of advanced stage. From the density of ova in the ovarian tube (Fig. 57a, Pl.IV) it appears that it is capable of producing a large number of eggs. The nematode is oviparous, as no trace of larvae are found in the uterus. The excretory and nervous system are too degenerate and are not visible by the methods adopted.

5. BIOLOGY.(I) LOCAL DISTRIBUTION:-

The collection of Aptinothrips rufus from various areas in the following places, in the vicinity of Edinburgh, was made for nematode infection:- 1. King's park. 2. Blackford hill. 3. Morningside fields. 4. Braids. 5. Liberton. 6. Gifford. 7. Boghall. 8. Aberlady (E. Lothian). 9. Gullane (E. Lothian). 10. Forth Bridge (W. Lothian).

Of these ten places only certain areas in the King's park were found to contain infested thrips. In the rest of the places no nematode infested thrips were found. The exact areas where nematodes were found are given for the use of any future worker. The first area is a few yards stretch of land on the left hand side of the Dunsapie loch. The second area is on the left hand side opposite the bridge on the Duddingston loch road. (Map 1)

It is very interesting to find the infection at two places only. It may be that this localised distribution may be associated with soil conditions or that a further comprehensive examination may reveal areas at this (King's park) or other places hitherto unknown. The infection in thrips has been found throughout the year.

(II) SEASONAL DISTRIBUTION.

Thrips were dissected on various dates in every month throughout the year from December to November 1930. An approximate count of the eggs, larvae and females was also made to find out the average density of infection. The following table gives the result in summarised form.

TABLE I.

Date.	Number Examined	Number Infected	% Infection	Eggs	Males and larvae	Females
17.12.29	75	12	16.0	233	341	24
19.12.29	114	26	22.8	213	242	35
20.12.29	42	6	14.2	48	10	12
24.12.29	9	2	22.2	28	15	2
Total for December 1929.	240	46	19.1	522	608	73
			Per female	11.3	13.2	1.5
8.1.30	18	2	11.1	73	55	4
16.1.30	41	10	24.3	95	79	23
17.1.30	29	4	13.7	47	41	4
23.1.30	25	6	24.0	47	72	12
28.1.30	12	4	33.3	23	90	4
Total for January 1930	125	26	20.8	285	337	47
			Per female	10.9	12.9	1.8

Date	Number Examined	Number Infected	% Infection	Eggs	Males & larvae.	Females.
5.2.30	44	6	13.6	138	162	12
7.2.30	38	5	13.1	63	34	5
24.2.30	131	52	39.6	624	1432	75
Total for February	213	63	29.5	825	1628	92
			Per female	13.09	25.8	1.4
3.3.30	53	9	16.9	63	108	15
17.3.30	27	3	11.1	45	34	6
27.3.30	25	1	4.0	15	24	2
Total for March	105	13	12.3	123	166	23
			Per female	9.4	12.7	1.7
7.4.30	42	7	16.6	38	21	10
11.4.30	65	12	18.4	144	187	15
23.4.30	22	6	27.2	203	23	7
Total for April	129	25	19.3	385	231	32
			Per female	15.4	9.2	1.2

Date	Number Examined	Number Infected	% Infection	Eggs	Males & larvae.	Females.
5.5.30	12	4	33.3	175	58	8
13.5.30	77	21	27.2	252	357	18
30.5.30	54	18	33.3	72	275	16
Total for May.	143	43	30.06	499	690	42
			Per female	11.6	16.04	0.9
7.6.30	39	15	38.4	94	315	19
16.6.30	24	7	29.1	35	78	15
28.6.30	44	6	13.6	87	203	13
Total for June	107	28	26.1	216	596	47
			Per female	7.7	21.2	1.6
15.7.30	120	33	27.5	358	452	38
20.7.30	82	45	54.8	139	398	29
31.7.30	22	6	27.2	189	74	7
Total for July	224	84	37.5	686	924	74
			Per female	8.1	11	.8
4.8.30	6	1	16.6	4	63	2
15.8.30	14	2	14.2	130	262	5
19.8.30	16	5	31.2	287	302	16
25.8.30	48	13	27.08	384	267	29
Total for August	84	21	25.0	805	894	52
			Per female	38.3	42.5	2.4

Date	Number Examined	Number Infected	% Infection	Eggs	Males & larvae.	Females.
2.9.30	14	3	21.4	15	25	6
16.9.30	36	13	36.1	232	411	36
22.9.30	76	19	25.0	265	545	33
Total for Sept.	126	35	27.7	512	981	75
			Per female	14.6	28.02	2.1
7.10.30	9	5	55.5	293	253	11
8.10.30	12	5	41.6	33	84	14
9.10.30	35	13	37.1	135	485	32
10.10.30	36	7	19.4	118	341	10
23.3.30	57	10	17.5	46	107	14
Total for Oct.	149	40	26.8	625	1270	81
			Per female	15.6	31.7	2.02
5.11.30	54	14	25.9	-	-	32
17.11.30	41	9	21.9	40	52	18
19.11.30	65	16	24.6	289	196	40
Total for Nov.	160	39	24.3	329	248	90
			Per female	8.4	6.3	2.3
Total for the year 1929-30	1805	463	25.6	5812	8573	678
			per female	12.5	18.5	1.4

From the above table, it will be seen that the percentage infection on various dates in different months of the year varies greatly and it does not seem possible to give any explanation of these fluctuations. The lowest infection was 4.0% on 27th March and the highest 55.5% on 7th October. The low and very high infection may be accidental, and due to the small quantity of material available for examination on these dates.

Coming to the monthly infection it will be observed that the infection had an undulating curve throughout the year. The lowest infection was 12.3% in March and the highest 37.5% in July. In other months it was different. It will be interesting to observe that during December to February the infection constantly rises and from September to November constantly falls.

Reducing these figures from monthly infection to seasonal infection, the following table is arrived at:-

TABLE II.

<u>WINTER.</u>			<u>SPRING.</u>			<u>SUMMER.</u>			<u>AUTUMN.</u>		
No. Exam.	No. Inf.	%	No. Exam.	No. Inf.	%	No. Exam.	No. Inf.	%	No. Exam.	No. Inf.	%
578	135	23.3	377	81	21.4	415	133	32.0	435	114	26.2

The infection was thus lowest in spring, and highest in summer; the infection in winter and autumn being intermediate. The graph A-B shows the monthly infection and the graph A¹ - B¹ shows the seasonal infection. The average infection of Tylenchus aptini in Aptinothrips rufus for 1929-30 was 25.6%, which is quite a high proportion.

The highest number of eggs found was 215 in a single individual; of larvae 255; and of females 8, the lowest number being a single female. The proportion of males (form II) to the other stages of nematodes was (27:228); (4:43); (6:18); (4:38) and (11:75) in various counts made in October and November.

The number of eggs, larvae and females found on various dates is summarised in table I, with the average number per female for different months, and for the year.

(III) EFFECT ON HOST.

The occurrence of parasitic nematodes inside the body cavity of insects has been recorded to produce profound effect on the host in some cases, while practically nothing in others. Thus Uvarov(14) mentions one case in which nematode parasites were responsible for an epidemic in locusts. Grasshoppers artificially infested with one or two nematodes fail to develop gonads. According to Fuchs (7) p.175 Tylenchus contortus diminishes the fecundity of the female to about half in most cases, and occasionally kills its host. Wülker (16) p.464 mentions that Allantonema parasitic in Hylobius has very little effect as he frequently found infested beetles in copulation and having ripe reproductive organs. But he found that Atractonema gibbosum p.465 parasitic in Cecidomyia pini larvae, kills the host or delays the metamorphosis. Sphaerularia bombi, parasitic in queen bumble bees, is reported to cause sterility, as the parasitized queens are unable to form new colonies.

According to Cobb (3) p.669, Howardula benigna parasitic in Diabrotica reduces the size and weight of the host and in cases of heavy infestation reducing the fecundity. There is no suppression of the ovary, as he found 10-20 thousand nema larvae deposited with the/

the beetle's egg. zur Strassen (19) p.7 found that 10-20 Bradynema has no effect on Aphodius fimetarius, as the gonads of the female can reach maturity.

Recently Goodey (8) also found that Tylenchinema oscinellae parasitic in frit-fly causes the sterility of both sexes.

In Thysanoptera Uzel (15) p.367 found that the presence of nematodes in Thrips physopus reduces the ovary; but no detailed information is given.

The presence of nematodes has not been found to produce any effect on the external characters of Aptinothrips rufus. The measurements of antennae, thorax and abdominal segments show that they are similar in both infested and non-infested thrips. In one case out of large numbers examined, it was found that the infested thrips had one deformed antenna. But this may be considered as a coincidence between infection and structural deformity of antennae so commonly found in this species. Apparently it is difficult if not impossible to differentiate the infested thrips from the non-infested, from external characters. But in course of examination, the writer could differentiate, to a certain degree of certainty, by seeing the wriggling material inside the semi-transparent cuticular body, correlated with the absence of eggs in such individuals, which facilitated the sorting, and quick dissection for examination purposes.

Internally the presence of nematode stages has been found to bring about complete degeneration of the ovary. A comparison of the normal and parasitised ovary will bring out this point clearly.

Normally the reproductive organs of the female thrips consist of an ovary composed of eight ovarioles arranged in groups of two (Fig. 60a, Pl. V). Terminally the ovarioles of both sides are attached together and these join with the hind end of the short salivary glands. Each ovariole is a long tube which holds the developing oocyte one after another in a single chain (Fig. 60b, Pl. V). The oldest oocyte is situated near the base where the tube meets with the common oviducts. The wall of the ovariole is thin and is capable of great distention on the maturity of the eggs. The ovarioles are paniole and three chief divisions can be distinguished (Fig. 60b, Pl. V).

1. Terminal filament: a long thread attached to the apical peritonia[?] ^{endothelial} layer. 2. Germarium. This is represented by a long terminal conical part and consists of a mass of cells from which primordial germ cells are differentiated. This part is apical and contains large number of cells with big nuclei in various stages of growth from up downwards. 3. vitellarium. This is represented by the rest of the ovariole and is the longest part. It contains developing oocytes with no nutritive cells. All these divisions/

divisions of an ovarian tube are seen in Fig. 60a, Pl. V. From a few to a large number of developing oocytes may be found from base upwards. The ovarioles open by a short duct into the common oviduct. Posteriorly the oviduct is continuous with the vagina. There is an oblong, flat, retort-shaped receptaculum seminis opening by a duct into the vagina (Fig. 60a, Pl. V).

In parasitised thrips the ovary as a whole becomes highly degenerate (Figs. 61a, b; 62, Pl. V), and the insect is not capable of producing any eggs. All the ovarioles may be degenerate and be represented only by a short thin germarium having terminal filaments (Fig. 61b, Pl. V). The vitellarium in such cases is absent or a few ovarioles in the ovary may show a trace of vitellarium (Fig. 61b, Pl. V). There is therefore a considerable variation in the shape and size of the degenerate ovary which occasionally appears like a rudimentary, small thread-like finger shaped structure. In cases of very high infection the ovary is so much attenuated that the whole structure appears thread-like or may not be seen during dissection. The oviduct, vagina and receptaculum seminis are also considerably reduced in size. Receptaculum seminis has been found to be present or absent. Figure 61a, Pl. V shows the ovary with some ovarian tubes highly degenerate consisting of germarium/

germarium only. Figure 61b, Pl.V is the highly modified two ovarian tubes of the same ovary. Figure 62, Pl.V shows that the vitellarium is completely suppressed and the ovary comes to be represented by germarium only. Figures 63 and 64, Pl.VI show the photo-micrograph of the normal and degenerate ovary.

Goodey (8) p.333 found that in few cases, the presence of two to three or four Tylenchinema worms in the abdominal cavity of frit-fly did not much affect the gonads which were healthy and of normal size. In every such case, the worms were degenerate and small; and only partly developed. In Aptinothrips rufus also a few cases were found in which only a few eggs and larvae or only one or two larvae and few females were present; yet the ovary was like normal. But in all such cases the worms were not degenerate at all. Whenever larvae were found with females and eggs and in large numbers, the degeneration of ovary was certain and evident. Besides, if the number of mature females was high, the ovary was degenerate. It may be that the presence of normal ovary, in spite of one or two larvae and fewer eggs, will be due to the beginning of infection or that the fewer parasites are not enough to show the degeneration. In all such cases unlike Goodey's (8) experience in frit-fly, the nematode eggs, larvae or females were normal and no sign/

sign of degeneration could be found. Some of the nematode females had mature egg in the uterus ready for passing out. It appears in Aptinothrips at least, that nematodes always got the upper hand in suppressing the growth and development of ovary.

The presence of Tylenchus aptini therefore inhibits the growth of ovary and the infested thrips are not able to lay any eggs. In most cases of infestation, other internal structures have not been found to be affected. But a few cases were observed in which a very high infection had made the thrips sluggish, and the dissection of these revealed that the intestine was highly attenuated and had also become very fragile. The salivary glands have never been observed to be affected.

So far as has already been explained the infection has been found to be restricted to female thrips only, and only in six-jointed form only, as these were in great majority. A few styliifera were present, but were worm-free.

(IV) TRANSMISSION OF INFECTION:-

The larvae are motile and the cavity of the head, thorax and abdomen being continuous, the larvae have been found wriggling about in the thoracic and abdominal cavity; but never in the head region. When the first form larvae reach a certain stage of development (Fig. 21-22, Pl. 1) they enter the intestine and pass out through the anus. The photomicrograph Fig. 66, Pl. VI shows the larvae coming out from the anus. The dark areas are the rectal glands characteristic of thrips. Schneider (12) and Wülker (16) have found the larvae of Sphaerularia bombi, Allantonema and Bradynema taking a similar course. Goodey (8) also found the similar course adopted by Tylenchinema in frit-fly; but Cobb (3) found that the larvae of Howardula pass out with the egg. None of the previous workers have so far actually seen or described the process of going from the abdominal cavity to outside.

The writer had been lucky in observing the process twice during the period of study. The first form larva when it is mature bores by actively applying the stylet which is protruded slightly against the wall of the mid gut. In this way the head passes in and then the larva quickly makes the characteristic wriggling movement and slips inside the lumen of the intestine. The/

The wall of the mid_gut is a cell or two thick and no difficulty is encountered. After reaching inside, it descends downwards probably due to the force of the downward current of the fluid contents, which can always be seen in this thrips. In this way it reaches the pyriform rectum.

In the rectum occasionally several larvae are found and it appears that they remain there for some time before passing out. Larvae have never been seen in the fore_intestine, in the anterior bulbous portion of the mid_gut or the malpighian tubes. All the process of boring and passing to the rectum is a matter of a few seconds only. It has been further observed that if any kind of irritant is applied to the rectum stocked with larvae, they either move up or down instead of boring the way through the rectal wall. When they move down, they pass out of the anus; and when they move up, they come in the mid_gut from which they have been seen to come out. The rectum together with hind_gut is very short in thrips and it does not take long to move up. It appears probable that the cuticular wall of the rectum offers the resistance. No second form of nematodes (males) has been found in the rectum or coming out of the anus. This is probably due to their not possessing a stylet and therefore incapable of boring their way out; thereby probably subserving the purpose of fertilizing the females.

6. DIAGNOSIS.Tylenchus aptini, n. Sp.1. EGGS:-

Length .04 - .0607 mm.; width .02 - .0285 mm.,
elliptical.

2. LARVAE (FORM I).

(a) Young Stages:- length .1206 - .1448 mm.;
width .0137 - .0172 mm.; length of stylet .00833 mm;
length of oesophagus .0133 mm.; width across
stylet .01 mm. Tapering anteriorly and posteriorly;
head rounded and broader than the tail which is
pointed. Mouth, stylet, oesophagus and alimentary
canal present. Found in very large numbers.

(b) Mature forms:- length .25 - .3666 mm.; width
.01333 - .0178 mm.; length of stylet .0133 -
.0156 mm.; width of stylet .0008 - .00178 mm.;
width at anterior tip .005 - .00714 mm.; width
of the tail tip .0033 - .00357 mm.; width across
mid stylet .00666 - .00833 mm.; length of oesoph-
agus .0283 - .045 mm. Longer than the younger
form. Morphologically similar having mouth,
stylet and oesophagus etc. Found in large numbers.

3. MALE (FORM II).

(a) Young Stages:- length .13103 - .2333 mm.; width .01724 - .0206 mm.; length from anterior tip to gubernaculum .1206 - .22068 mm.; length from gubernaculum to tail end = .0172 mm.; width at anterior tip = .00689; width of tail end .00344 mm.; small, smooth skin apparent; head flat and separated by a short constriction from the body; caudal alae present; spicula and gubernaculum present; no mouth opening visible; oesophagus degenerate. Found occasionally and in very few numbers.

(b) Mature forms:- Total length .2666 - .3666 mm.; width .01379 - .02068 mm.; length from anterior end to gubernaculum .2916 mm.; length from gubernaculum to tail end = .02166 - .0275 mm.; length of spicula .00755 - .01166 mm.; length of gubernaculum .00416 - .00517 mm.; width of the anterior tip = .0066 - .0068; width of the tail end .0033 - .00416 mm; length of caudal alae .0266 - .0366. Much longer than its young form. Body tapering anteriorly and posteriorly; head rounded and flat, set off by a constriction from the main body; mouth, stylet not visible, oesophagus degenerate; a pair of spicula and gubernaculum present. Testis mature and spermatozoa visible as small dots.

4. PARASITIC FEMALE.

(a) Young Stages:- length .02333 - .2482 mm.; width .02068 - .05 mm.; early stages worm-like, tapering anteriorly and posteriorly with mouth, stylet, oesophagus etc. Head broader than tail which is pointed. Found mixed up with the larvae of other forms.

(b) Mature Stages:- .266 - .316 mm.; width .0666 - .083 mm.; stylet .00714 - .0428 mm. A delicate thin cylindroid sac. Brownish, with clear areas owing to the dense deposition of reserve fat globules at certain places. Anteriorly broader, and rounded with a hollow cuticular skin attached. Posteriorly slightly tapering with a conical papilla at the end. Mouth opening very minute or not visible. Stylet visible under high magnification in fresh examinations, becoming obscure after fixation. Alimentary canal and anus absent. Excretory and nervous system highly degenerate and not visible. Reproductive system seen in carbollactic-acid medium. It has anteriorly a tubular ovary which takes a loop posteriorly, and then widens to form the uterus. Ovary consists of large number of ova in all stages of growth. Mature egg occasionally visible in uterus. Vulva situated slightly on the posterior side near the conical papilla. Mature forms inert and oviparous/

oviparous. 1-8 females may be found in a single thrips; one and two very common.

HABITAT:- Parasitic in the body cavity of Aptino-
thrips rufus ^(Gmelin) (Thripidae, Thysanoptera).

Found in the neighbourhood of Edinburgh, Scotland.

7. SUMMARY.

1. Eggs, larvae, males and various stages of females were found in the body cavity of Aptinothrips rufus, in the neighbourhood of Edinburgh, Scotland.
2. The eggs are broadly rounded anteriorly and posteriorly, occurring in very large numbers occasionally. The young develop inside the egg. Various stages of young ensheathed in egg membrane are also found.
3. The larvae have a mouth, a stylet, oesophagus and alimentary canal. The head is rounded and tail is smooth and pointed.
4. The younger as well as maturer stages of males are found. A distinct mouth or stylet is not visible. A degenerate oesophagus may be present. The spermarium may be seen in mature forms. The tail is tylenchoid with caudal alae, a pair of spicula and gubernaculum.
5. The early stages of female are broader and short. A mouth, stylet, oesophagus and alimentary canal is present. Several moults take place when it is changed into a cylindroid sac. Intermediate stages are also found.

6. Mature female is a highly degenerate inert organism with a short stylet. Alimentary canal and anus are absent; reproductive organs tubular, forming a loop posteriorly and then widening to form the uterus. Vulva situated at the side generally. Oviparous.
7. The larvae pass out through the anus of thrips by boring the mid_gut; coming down to rectum by the force of downward current of liquid food. No young or mature stages of males or females have been observed coming out of anus or seen in rectum.
8. The presence of parasites leads to complete sterilization of the ovary of the host. In very rare cases of heavy infection, the thrips become sluggish with fragile intestine. Gonads normal when few nematodes are present. No cases of degeneration of nematodes and presence of normal ovary observed as found by Goodey in frit_fly.
9. The parasite appears to have limited distribution on account of its being found only at two areas in the King's park. The extent of parasitism varies from 12.3% in March to 37.5% in July, the average annual infection being 25.6%

10. The systematic position of the worm is determined. It is included in the genus Tylenchus and has been given the name "aptini" after the generic name of the host. The characters which have lead the writer to form a new species are discussed in the paper.

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9. LETTERING AND EXPLANATION OF PLATES.(a) Lettering.

a.c.,	alimentary canal.	o.s.,	old skin.
b.w.,	body wall.	o.t.,	ovarian tube.
C.al.,	Caudal ala.	ov.,	ova.
c.ar.,	clear area.	p.,	protoplasm.
ch.,	chorion.	rec.,	receptaculum seminis.
e.,	egg.	re.m.	reserve mass.
e.l.,	ensheathed larva.	st.,	stylet.
f.g.,	fat globules.	sp.,	spermarium.
g.,	germarium.	spi.,	spiculum.
g.o.,	generative organ.	t.,	tail.
gu.,	gubernaculum.	t.f.,	terminal filament.
h.,	head.	t.p.,	terminal papilla.
l.,	larva.	ut.,	uterus.
m.,	mouth.	ut.w.	uterine wall.
n.,	nuclei.	v.	vulva.
od.,	oviduct.	vit.,	vitellarium.
oes.,	oesophagus.		

(b) Explanation of Plates.PLATE I.

- Figs 1-6 Illustrate the forms of eggs found in the body cavity of *Aptinothrips rufus*.
- Figs 1-2 Newly come out eggs with protoplasm completely filling the interior.
- Fig 3. The egg as seen in the uterine wall of the mature parasitic female, ready for coming out. Large fat globules are also seen.
- Figs 4-6 The eggs in which protoplasm has shrunk away from the chorion, large nuclei are also visible.
- Figs 7-14. The various advanced stages of eggs in which the larvae have developed. The larvae lie inside the egg membrane.
- Fig. 7. The shape of the protoplasm taken in the early stage of the development of larvae inside the egg. The large nuclei are visible in the protoplasm.
- Fig. 15. Early stage of the first form larva found in the body cavity of thrips.
- Fig. 16. The anterior end of the same larva showing stylet, a short oesophagus and alimentary canal. The fat globules are seen scattered in the alimentary canal.



Figs. 17-18. Slightly advanced stages of the first form larvae with clear areas visible anteriorly and also large fat droplets are visible.

Figs. 19-20. The younger and maturer stages of the first form larvae as seen under low power of the microscope.

Figs. 21-22. The mature stages of the first form nematodes as found in the body cavity of thrips.

Fig. 23. The anterior end of the same with a stylet, a winding oesophagus and an alimentary canal.

Fig. 24. The anterior end of a mature nematode as seen under low power. A stylet and a trace of oesophagus is visible.

PLATE II.

Figs. 25-29. Illustrates the internal anatomy of a first form mature nematode found inside the body cavity of thrips.

Fig. 25. Anterior end of a mature first form nematode with a mouth, a stout stylet, an oesophagus and an alimentary canal. By the side of the anterior part of alimentary^{canal} is a glandular substance.

- Fig. 26. The second part of the body of the same nematode with alimentary canal and lot of fat droplets.
- Fig. 27. The third part of the body of the same nematode with alimentary canal and fat globules.
- Fig. 28. The fourth part of the body of the same nematode with alimentary canal stocked with fat material.
- Fig. 29. The last part of the body of the same nematode with the alimentary canal terminating near the tip of tail.
- Figs. 30. Anterior, middle, and the tail part of another nematode with fat globules.
- Figs. 31-33. The anterior, middle and posterior part of the biggest first form nematode found inside the body cavity of thrips.
- Fig. 31. The anterior part with a stout stylet, an oesophagus opening in the alimentary canal.
- Fig. 32. The hind part of the same nematode showing the generative organs.
- Fig. 33. The part of the oesophagus with intestine and a glandular substance.
- Fig. 34. The earliest stage of II form of male nematode, with caudal alae, spicula etc.
- Fig. 35/

Fig. 35. The intermediate stage of the II form male nematode with caudal alae, gubernaculum and a pair of spicula. The stylet, oesophagus not visible. The head has a constriction.

Fig. 36. The mature stage of the II form of male nematode with no stylet or oesophagus. Spermarium is developed and spermatozoa are seen. Posteriorly there are caudal alae, a pair of spicula, and a gubernaculum.

Fig. 37. The hind part of the intermediate stage of the II form of male nematode showing gubernaculum and a pair of spicula. The fat globules are also visible.

Fig. 38. The head of the mature male nematode showing the constriction which sets off the head from the body.

PLATE III.

Fig. 39. The hind part of the earliest stage of the II form of male nematode showing caudal ala, a pair of spicula and a gubernaculum. The tail end is rounded.

Fig. 40. The lateral view of the hind part of mature male nematode showing caudal ala,
a/

a pair of spicula and a gubernaculum.
The tail is rounded.

- Fig. 41. The ventral view of the mature male nematode showing spicula and gubernaculum.
- Fig. 42. The hind part of the mature male nematode showing spermarium with spermatozoa.
- Figs. 43-51. Various stages of parasitic female found in the body-cavity of the thrips.
- Figs. 43-44. Earliest stages of the parasitic female, with a short stylet.
- Figs. 45-46. Later stages of parasitic female with old skin attached at the anterior end. A stylet is visible.
- Figs. 47-48. Later stages of parasitic female.
- Figs. 47a-48b The anterior part of the same with old skin attached anteriorly. A short stylet is seen.
- Fig. 49. A still later stage of parasitic female.
- Fig. 49a. The anterior part of the same.
- Figs. 50-51. Still advanced stages of the parasitic female.
- Fig. 50. An advanced stage of parasitic female with a thin stylet situated anteriorly.
- Fig. 51. The advanced stage of parasitic female with a big old skin attached anteriorly. Stylet present, vulva visible posteriorly at the side.

PLATE IV.

- Fig. 52. A much advanced stage of parasitic female with old skin attached anteriorly, a stylet; and a vulva situated posteriorly on the side.
- Fig. 53. A part of the ovarian tube with immature ova as seen in early stages of parasitic female.
- Fig. 54. A mature parasitic female which are commonly found in the body cavity of thrips as seen in a drop of water. Drawn 5 minutes after dissection. The dotted area represent the brownish reserve fat, anteriorly a short stylet is seen.
- Fig. 55. Anterior part of the parasitic female with the old skin. A stylet is also seen. The dotted part is the ovarian tube.
- Fig. 56. The mature parasitic female seen after fixing in Brown's fluid and staining with haematoxylin-Eosin. Some indication of the tubular ovary is visible. Stylet obscure and not seen. Anteriorly an old skin is seen.

- Fig. 57a-b. The ovary dissected out from the body of the mature parasitic female.
- Fig. 57a. Ovarian tube showing small and large ova.
- Fig. 57b. A detached part of the ovarian tube containing ova in various stages of growth.

PLATE V.

- Fig. 58. Mature parasitic female in carbolic-lactic-acid medium showing internal anatomy. Old skin is seen anteriorly and posteriorly a tail papilla is visible.
- Fig. 59. Mature parasitic female showing a ripe egg in the uterus at the verge of passing out. The old skin, and stylet is seen anteriorly. Posteriorly a tail papilla is seen. In the interior, the reserve fat material is also seen scattered.
- Fig. 60a. Normal ovary of *Aptinothrips rufus* showing the arrangement of ovarioles and the receptaculum seminis.
- Fig. 60b. A single ovariole highly magnified showing vitellarium, germarium and terminal filament.
- Fig. 61a. Degenerate ovary from parasitized thrips. The ovarioles are degenerate and some of/

of them have got only germarium. Drawn to the same scale as normal ovary.

Fig. 61b. The two ovarioles highly magnified drawn from the same degenerate ovary. One ovariole consists of germarium only; and the other with a big ova and a degenerate germarium at the top. The terminal filaments are also seen.

Fig. 62. The two ovarioles from a highly degenerate ovary of a heavily parasitized thrips. All the ovarioles consist of germarium only and a terminal filament.

PLATE VI.

Fig. 63. Photomicrograph of a normal ovary.

Fig. 64. Photomicrograph of a parasitized ovary.

Fig. 65. Photomicrograph of a mature parasitic female nematode.

Fig. 66. Photomicrograph of the rectum of aptinothrips rufus, showing the nematodes passing out of the anus. The dark areas are the rectal glands characteristic of thrips.
