STUDIES ON *Oliarus atkinsoni* Myers (HEM. CIXIIDAE), VECTOR OF THE "YELLOW-LEAF" DISEASE OF *Phormium tenax* Forst.

II.—THE NYMPHAL INSTARS AND SEASONAL CHANGES IN THE COMPOSITION OF NYMPHAL POPULATIONS

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Summary

The determination of the number of nymphal instars of *Oliarus atkinsoni* is described. Descriptions and figures of the five instars enable their recognition. The seasonal variation in the percentages of the different instars is shown.

INTRODUCTION

The incrimination of *O. atkinsoni* as a vector of the yellow-leaf disease of *Phormium* and the habits of the insect have been described (Cumber, 1952a, 1952b). The present work indicates the method used in determining the number of nymphal instars, and shows how each may be recognized. Recognition of the different instars is necessary in nymphal transmission experiments. In experiments on control measures, likewise, it is desirable to be able to recognize the different stages and to know the seasonal variation in the relative numbers of these stages.

THE NUMBER OF NYMPHAL INSTARS

The number of instars of *O. atkinsoni* has been determined by measuring a sufficient number of specimens to ensure an adequate size representation and plotting the frequency distribution of these measurements.

The nymphs possess few heavily chitinized "hard-parts," this being due, no doubt, to their dark and well-protected habitat and to the fact that nourishment is obtained by sucking. Measurements made on the head capsule, however, have proved adequate for the determination of the number of instars present. The width of the head capsule at the level of the eyes has been measured with a micrometer eyepiece (188 units = 1 mm.). The sample of nymphs measured was collected on 7th September, 1951. It contained only two first-instar nymphs, however, so additional measurements from nymphs hatched out in captivity (March, 1950) have been included.

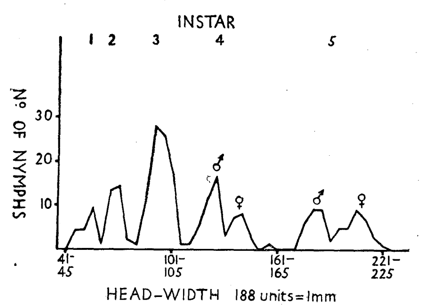

FIG. 1.—Frequency distribution of head-widths (188 units = 1 mm.) of nymphs, sample collected 7th September, 1951.

The frequency distribution of the head-widths is shown in Fig. 1, where five instars are plainly indicated. The double peaks of instars 4 and 5 are due to the differences in size of male and female nymphs, the former being the smaller. Table I shows the head-widths for each instar and the ratio of the mean head-width to that of the preceding instar.

TABLE I.—Mean Head-widths of Instars and Ratio to Preceding Instar

Instar number	No. of specimens	Mean head-width of instar*	Standard σ deviation	Ratio to preceding instar
1	17	54·2	4·55	—
2	31	69·7	4·19	1·27
3	83	95·5	5·16	1·37
4	55	130·7	9·83	1·37
5	56	196·8	13·10	1·51

*188 units = 1 mm.

DESCRIPTION OF NYMPHAL INSTARS

INSTAR 1 (FIGS. 2 AND 3)

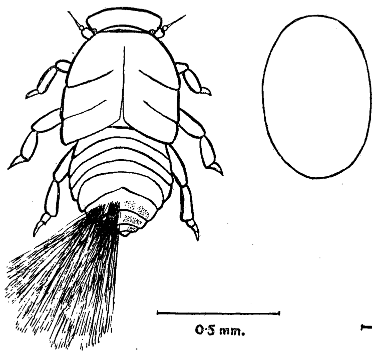

FIG. 2.—First instar nymph, dorsal view, and egg. Tail tufts are shown on left side. On right side are well-defined patches visible after removal of filamentous material.

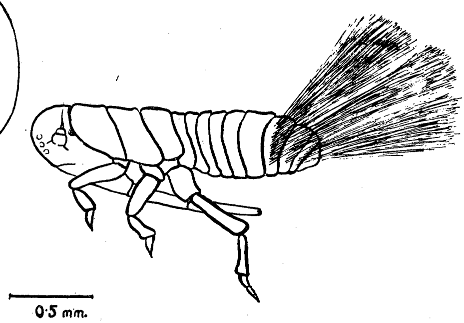

FIG. 3.—First instar nymph, lateral view.

The first instar nymph is milky-white in colour and measures approximately 0·9 to 1·2 mm. in length and 0·5 mm. in width. (Eggs measure 0·7 to 0·8 mm. in length and 0·4 to 0·5 mm. in width.) In each instar, as the nymph becomes older, the abdomen becomes larger through feeding, so that it is useful to notice the size of the abdomen relative to the rest of the insect in determining stadia. Eyespots are present as small reddish areas on the margins of the head capsule just above the level of the insertion of the antennae. Small circular pits, which in later instars give a characteristic pattern to the head, thorax, and abdomen, are represented only by indistinct markings in the region of the vertex. A central longitudinal groove in the thorax is plainly visible, but the separation of the thoracic segments is not so well defined. Filamentous fluffy material issues in tufts from the dorsal surface of three posterior abdominal segments and reaches a maximum length of about 1 mm. When the nymph is at rest, the tufts lie closely together to form a compact posteriorly-projecting tail, but if the nymph is disturbed, the tufts are raised to give a more vertical array. As the nymph moves about, it stops every now and then and waggles its abdomen from side to side, a behaviour which is characteristic of all instars.

INSTAR 2 (FIG. 4)

The second instar nymph measures approximately 1·4 to 1·7 mm. in length. It resembles instar 1 in appearance, but may be separated from it by the comparison of the size of some hard part—i.e., the width of the head. The segmentation of the thorax is well defined, and pitting of the head and thorax has occurred.

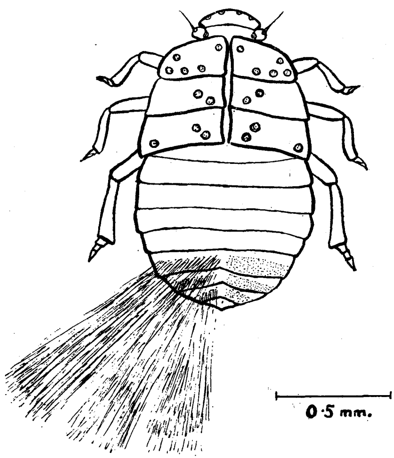

FIG. 4.—Second instar nymph, dorsal view.

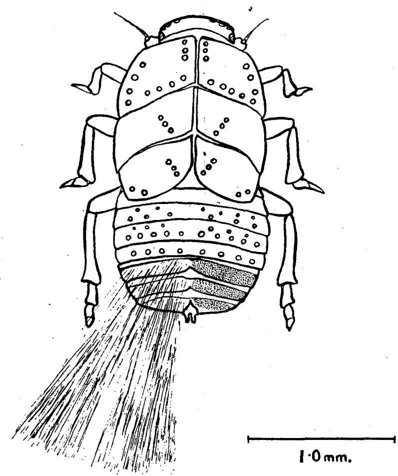

FIG. 5.—Third instar nymph, dorsal view.

INSTAR 3 (FIG. 5)

The third instar nymph measures approximately 1·8 to 2·4 mm. iin length. It closely resembles instars 1 and 2 except for its greater size. Pitting of the head, thorax, and dorsal surface of the abdominal segments 3 to 5 is well defined, and some pigmentation of the more sclerotized portions is apparent. The eyespots, as in the preceding instars, are small and red. The areas on the abdomen from which the filamentous fluff is produced are more readily discernible than in earlier instars. Either the posterior portions of the tergites (abdominal segments 6 to 8) have been modified or the intersegmental membranes have been modified and come to resemble posterior extensions of the segments; the former is probably the correct explanation. These secreting areas are covered with fine pores through which the filaments grow.

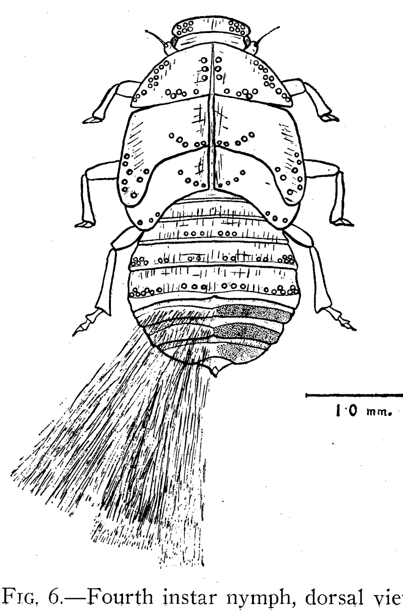

FIG. 6.—Fourth instar nymph, dorsal view.

INSTAR 4 (FIG. 6)

The fourth instar nymph measures approximately 2·5 to 3·5 mm. in length. Pitting is well defined and the pigmentation of the sclerotized portions is noticeably greater than in instar 3, so that there is a buff-grey over-all appearance. The eyespots are still relatively small reddish areas. The lateral areas of the meso-thorax and meta-thorax show some prolongation as wing rudiments.

INSTAR 5 (FIGS. 7–8)

The fifth instar nymph measures approximately 3·7 to 6·7 mm. in length, the wide range in size being due to feeding and sexual dimorphism. Pitting gives a strong pattern to the head, dorsal surface of the thorax, and the anterior abdominal tergites. As the nymph becomes older and the time approaches when it shall emerge as an adult, the eyespot enlarges until the whole eye becomes dark red and finally black. The prolongations of the lateral margins of the meso-thorax and meta-thorax as wing rudiments now extend to the level of the second abdominal segment. In the posterior abdominal tergites, the areas devoted to the secretion of the filamentous fluffy material appear as well-defined duller patches when the material is removed. Considerable distension occurs during the feeding-up prior to the final moult, and the white intersegmental membranes are plainly visible between the buff-grey tergites, giving a striped appearance to the nymph.

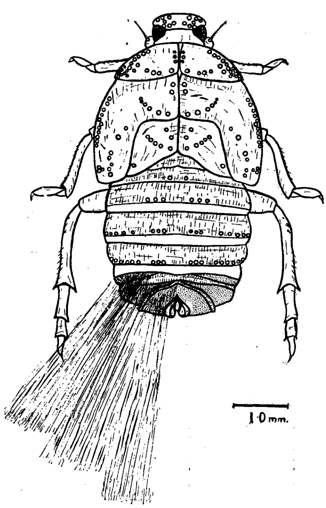

FIG. 7.—Fifth instar nymph, dorsal view.

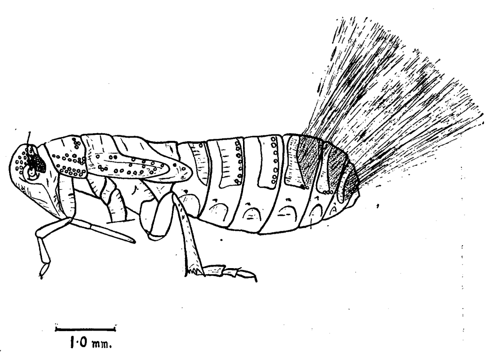

FIG. 8.—Fifth instar nymph, lateral view.

THE SEASONAL VARIATION IN THE PERCENTAGES OF THE DIFFERENT NYMPHAL INSTARS

Samples of nymphs collected between 25th July, 1951, and 1st April, 1952, have been analysed, and the percentages of the different instars present are indicated in Table II. In each instance, a quantity of material from the base of *Phormium* bushes and known to contain nymphs was taken into the laboratory and searched, It is realized that a considerable variation may exist in the composition of samples collected on the same date, and for this reason it is the relative absence or predominance of an instar or instars in a sample which gives the clue to the seasonal cycle.

The seasonal composition of samples indicates a two-year nymphal cycle. This has been verified by following the changes of nymphs of known instars held in captivity. Nymphs from eggs deposited in March towards the end of the oviposition period have in the majority reached the second instar by the following October. During the ensuing summer months, the succeeding instars are completed, so that by the following April the majority of the nymphs have reached the fifth or last instar and pass the winter in this stage. A few, however, appear to over-winter in the fourth instar. Whether these retarded individuals emerge later the same season, as do the normal individuals, or continue through a further winter to give a three-year nymphal cycle is not known.

The material collected for sampling from 16th November, 1951, to 7th January, 1952, contained many adults, and egg masses were commonly found in the samples collected on 7th January, 1952, and 1st April, 1952. In the samples collected on 6th December, 1951, and 7th January, 1952, the fifth instar nymphs could be separated into two categories—namely, the younger ones which recently had moulted from the fourth instar, and the older ones which had over-wintered in the fifth intsar. The younger ones had relatively small abdomens and small eyespots, whereas the older ones in preparation for adult life had distended abdomens and well-developed black eyes.

TABLE II.—Analysis of Nymphal Instars in Field Samples Collected, 1951–2

Date sample collected	No. of specimens	Instar 1	Instar 2	Instar 3	Instar 4	Instar 5
		% of Nymphs				
25/7/51	132	11	55	6	0	28
28/8/51	80	0	25	32	4	39
7/9/51	227	1	14	36	24	25
19/9/51	284	3	25	47	4	21
24/9/51	150	1	19	56	9	15
9/10/51	99	1	33	30	7	29
2/11/51	220	8	55	12	22	3
16/11/51	688	0	10	16	4	70
6/12/51	123	0	4	35	10	51
7/1/52	122	0	0	34	12	54
1/4/52	649	83	3	1	3	10

DISCUSSION

The method used in determining the number of nymphal instars is a standard one. Dyar's Law indicates that head-widths of successive instars follow a more or less regular geometrical progression. Since the head is not subject to growth during a stadium, it is possible by measurements to determine whether or not an ecdysis has been overlooked during life-history studies.

Although the degree of pigmentation and over-all size are valuable aids in separating the instars, the final separation is most readily obtained by a comparison of head-widths.

In any attempt to control the bug by drowning during the nymphal stages, knowledge of the seasonal changes in the relative numbers of the different instars and their relative susceptibility to flooding might assist considerably in formulating control measures. The use of natural flood waters and the limited number of occasions on which these flood waters are available will, however, probably determine the time of inundation.

ACKNOWLEDGEMENT

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REFERENCES

Cumber, R. A., 1952A: Studies on *Olearius atkinsoni* Myers (Hem. Cixiidae), Vector of the "Yellow-leaf" Disease of *Phormium tenax* Forst: I—Habits and Environment, with a Note on Natural Enemies. *N.Z.J.Sci.Tech., B 34*: 92.

———, 1952B: The Experimental Induction of the "Yellow-leaf" Condition in *Phormium tenax* Forst. by the Insect Vector *Oliarius atkinsoni* Myers (Hem. Cixiidae). *N.Z.J.Sci.Tech., A 34, Supp. I* (in press).