

STUDIES ON THE MANGO SHOOT-GALL PSYLLID, *APSYLLA CISTELLATA* BUCKTON

I. DESCRIPTIONS OF DEVELOPMENTAL STAGES, BIOLOGY AND HABITS

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Amongst the recent publications on the biology of *Apsylla cistellata* Buckton, a pest which now has assumed major economic importance in the cultivation of the mango trees in Uttar Pradesh and Bihar, mention may be made of the work of Mathur (1946), Lal (1950-54), Gupta (1953), Singh (1954), Sen (1957), and Prasad (1957). All these accounts deal mainly with the broader aspect of life-history, and give no details with regard to the various developmental stages, nor about the aftermath behaviour of the immature stages, particularly the first instar nymph on its emergence. This paper presents information in three sections. In the first section, various developmental stages of this insect have been indicated. In the second section, a correlation between the habit of the newly emerged nymph and its habitat has been suggested, and in the last section the role of *Apsylla cistellata* in causing the malformation in the shape of conical galls on the twigs of the mango trees has been discussed.

THE DEVELOPMENTAL STAGES

Egg : The egg soon after deposition looks, like a rectangular block with rounded corners. At this stage (in March) there is no differentiation between the inner contents and the chorion. The egg is almost transparent and it can not be readily separated from the embedding tissue without being ruptured or damaged.

It is after about a month and a half, that is, by the middle of May, that a slight change in the size is perceptible. By this time, the inner watery substance also stiffens to more viscous consistency, and the eggs can be taken out of the crevices, if handled carefully. It is slightly translucent at this stage and measures about 0.318 mm. in length and 0.289 mm. in width (Plate fig. 1).

Further development is discernible after about another month (middle of June) when it starts assuming conical shape, with the apex pointing downward. The colour becomes milkywhite and the inner contents become differentiated from the chorion which is transparent. From the middle of July onward, the embryonic development proceeds with somewhat faster pace and the maximum growth in size

appears to be attained by the end of this month. By the middle of August, the downwardly pointing end becomes conical, the eye-spot begins to be visible, and there is a suggestion of the leg-pads (Plate figs. 2, 3 and 4).

In September, the embryonic development is very rapid, and almost all the organs, such as, eye, antennae, mouth, legs and abdominal segments become, more or less, distinct, although there is no differentiation in the body region. In the third week of September, most of the eggs are ready to hatch (Plate fig. 5, 6 and 7).

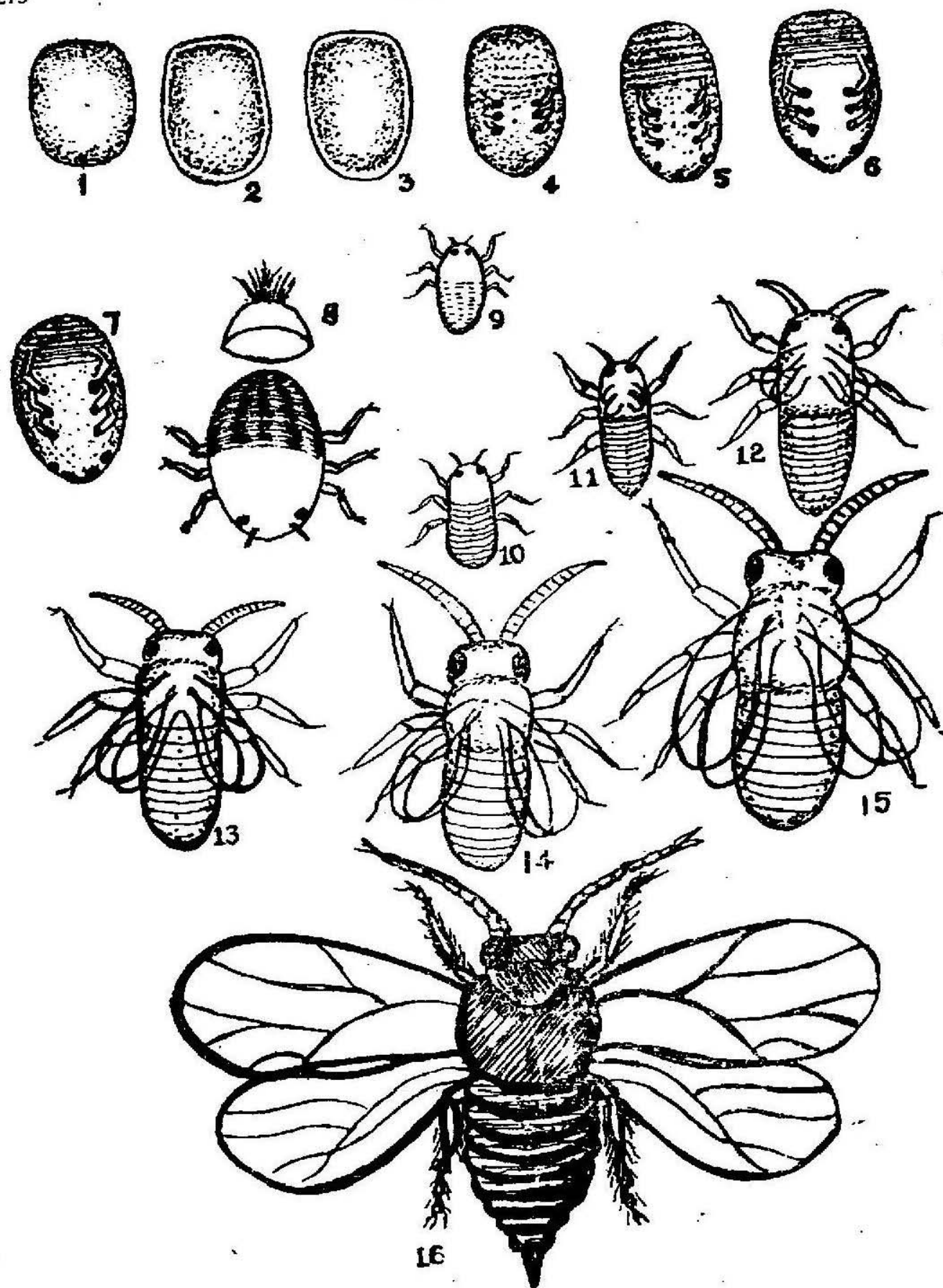
Nymph : The newly emerged nymph is a minute creature, not bigger than a pin-head and is almost invisible to the naked eye. The general colour of the body is yellowish with red markings all over when seen under a lens. These red streaks are arrayed horizontally in a series of broken lines on each segment so as to give an impression of undulating bands in longitudinal rows. There are five such rows (one on the mid dorsal region, two addorsal bands on either side and the two on dorso-ventral margin) visible on the posterior end of the body. All these five rows of red streaks seem to converge at the abdominal end (Plate fig. 9).

The head and thorax are not differentiated at this stage. The eyes are red and conspicuous in front of which two unsegmented setaceous antennae can be seen. The whole body is naked, that is, all the segments are devoid of setae, or hair, excepting on the leg where a pair of very small hook-like spurs at the tarsal end is visible. The first instar nymph is of 0.356 mm. to 0.364 mm. in length and 0.233 mm. in breadth.

At the end of October, there is a perceptible growth in size and all the red markings, excepting the red colour of the eye disappears. The body segments are more conspicuous and translucent. The ground colour of the body is brownish yellow. This stage corresponds to the second instar (Plate fig. 10).

In the fourth week of November, wing-pads develop in the majority of the individuals. Antennal segmentation is noticeable by this time. The individuals grow up in size, but no differentiation in head and thorax can yet be seen. The ground colour of the body remains brownish-yellow, and the colour of the eye deepens. This stage corresponds to the 3rd. instar nymph (Plate fig. 11).

By the end of December, there is an increase in size of the wing, the antenna grows longer and its segmentation is more distinct. The mouth-parts in the form of a beak becomes visible. There is not much of change in the body colour, but the eyes take still darker shade. This stage corresponds to the fourth instar (Plate-fig. 12).



EXPLANATION OF PLATE FIGURES

- 1—3. Egg : 1. at the end of 2nd week of May, 2. at the end of 2nd week of June, 3. at the end of 2nd week of July ;
 4—7. Embryos : 4. at the end of 2nd week of August, 5. in 1st week of September, 6. in 2nd week of September, 7. in 3rd week of September.
 8. Hatching of the nymph
 9—15. Nymphs : 9. newly hatched nymph (1st week of October), 10. Second instar nymph (4th week of October), 11. Third instar nymph (4th week of November), 12. Fourth instar nymphs (week of October), 13. Fifth instar nymph (4th week of November), 14. Sixth instar nymph (4th week of November), 15. Seventh instar nymph (4th week of November).
 16. Adult fly

In the third week of January, differentiation between the head and thorax is faintly visible. An increase in the size of the wing, antennae and other parts of the body can be seen in most of the individuals. Segmentation in the antennae becomes much more prominent and ten segments can be distinctly seen on each antenna. Tarsal segmentation also becomes visible by this time. Towards the middle of February, the differentiation between the head and thorax becomes more distinct. The wing-pads grow up nearly to reach the abdominal end. The tarsal segments become clearer. This stage corresponds to the fifth instar (Plate fig. 13 and 14).

By the fourth week of February, the differentiation of the body regions, that is, between head, thorax and abdomen, becomes complete. The frontal suture can be seen at this stage. The antennal segments are exhibited more prominently. The wings grow to cover up the abdomen. The tarsal segments are also well developed by this time. The eyes become almost dark. This corresponds to the ultimate nymphal instar which is soon followed by the emergence of adult (Plate fig. 15).

The various stages described above are based on examination of large number of individuals from the galls at regular weekly intervals.

The adult : The adult psyllid measures from 3 to 4 mm. in length. The thorax and head are black and the abdomen is light brown in colour. The antennae moderately short and the head prominent. The thorax and abdomen are well-developed. The wings cover the abdomen entirely, rather exceed the length of the body. The antennae are setaceous with 10 segments. The leg is covered with setae, the tibia is long and the tarsus is segmented. The hind pair of legs is longer than the other two. The males and females are similar in appearance and general characters of the body, but the females are slightly longer than males; differences are also marked in the shape of the abdomen. In the case of female it is slightly bulged up whereas in males, it is tapering. (Plate fig. 16).

BIOLOGY AND HABITS

Adults : The life cycle of *Apsylla cistellata* is completed by the end of February, there being only one generation of the insect in a year. Emergence of adults from the conical galls commences from the first week of March; the pace being much slower at the beginning, reaching its peak by the third week when about 70 per cent of the psyllids quit their nymphal abode. Oviposition commences shortly after the adult psyllids make their exit from the galls. The pre-oviposition period is very short, ranging from a few hours to one day. The adults are very shortlived and die soon after oviposition.

Tables showing the co-relation between egg-laying and gall-formation (1957)

Particulars	No. of twigs	No. of leaves containing eggs	No. of leaves without eggs	No. of galls formed	No. of nymphs found inside galls
With eggs	1	17	1	21	57
	2	2	5	2	1
	3	17	2	33	91
	4	14	4	21	290
	5	10	6	12	18
	6	4	7	1	Nil
Without eggs	1	Nil	13	Nil	Nil
	2	Nil	11	Nil	Nil
	3	Nil	14	Nil	Nil
	4	Nil	9	Nil	Nil
	5	Nil	16	Nil	Nil
	6	Nil	7	Nil	Nil
(1958)					
With eggs.	1	5	17	3	18
	2	3	19	13	51
	3	6	12	13	43
	4	5	8	11	32
	5	3	9	7	44
	6	4	11	9	39
Without eggs	1	Nil	14	Nil	Nil
	2	Nil	18	Nil	Nil
	3	Nil	7	Nil	Nil
	4	Nil	15	Nil	Nil
	5	Nil	19	Nil	Nil
	6	Nil	21	Nil	Nil

Oviposition : Eggs are laid singly in slits embedded in the tissue of the mid-rib of the underside of the new flush of leaves. They are inserted alternately by puncturing the tissue along the both sides of the mid-rib on the dorsal-face of the leaf in quick succession. The actual mode of egg-laying has been described in detail by Prasad (1957) and our studies, too, are in conformity with his observations. The number of eggs so laid largely depends on the leaf-space, and on an average 65 eggs were observed on a single leaf; the maximum being 73. It is in the egg-stage that the continuance of life-cycle is interrupted for a considerable period. The whole of summer and the rainy months are spent in this stage, although embryonic development proceeds on with quicker pace toward the latter part of the incubation period, that is from the middle of August onwards. The egg-spots along the mid-rib which are discernible at the beginning in the shape of tiny specks, become more and more

conspicuous with the advancement of time. The colour of the egg-spot which appears initially pale-green, changes to olive green and later on, to deep green bordering with brown. Most of these specks, turn into spindle-like bodies having dull brown colour with some blackish tinge. Dissection of large number of crevices revealed that viable eggs were recovered from only the greenish spots, while the blackish or brownish spots invariably contained dead or dried ones. Fungus identified as *Pestalotia* sp. was found growing over, veiling the entire egg region and confined only to the greenish specks containing viable eggs. It also protects the eggs by forming barriers against predators.

Nymphal Period : Hatching starts about the end of September, or beginning of October and continues throughout October, lasting up to the 1st week of November. It is at this time that new buds also appear which eventually differentiate either into shoot-buds or develop into conical shoot galls. Thus the first instar nymphs can be seen on the egg-infested twigs from the first week of October. This period of the emergence of the nymphs, more or less, synchronises with the plump stage of these leaf-buds which are just about to open.

The hatching out process is rather complicated and a nymph has to struggle hard for about 2-3 hours to disentangle itself from the crevices. The actual *eclosion* is effected by breaking the chorion into two unequal parts (2 : 1), the larger portion being left behind in the slit ; whereas the smaller piece is carried along with its abdominal end by the freshly emerged nymph. In order to free from the stuck end of the egg-shell, a nymph has to make special effort by contraction and expansion of its body up, down and sideways for about 15 minutes. A maximum hatching was observed to occur during the early hours from 6 to 9 A.M. (Plate fig. 8).

Habits of the newly hatched nymph : The newly hatched nymphs do not remain stationary near the seat of oviposition, as reported by previous workers. They start wandering about soon after emergence from the egg-shell and exhibit an instinct to migrate towards the leaf-buds. They appear to avoid any kind of obstacle in the way and change their course as soon as they come across any such thing like fungus colony etc. They prefer to travel along the edge of the leaf until they reach a stem or an axillary bud. The general tendency is to visit these new buds one after the other. While doing so, they stop for a while on the top of a bud, presumably with a view to explore the possibility of finding their way inside. Failing in their attempts to do so, in the event of the buds remaining compact and unsuitable at the beginning, they were noticed to move on to the adjacent or the proximal bud. In this manner, they keep on wandering ceaselessly for hours together with a few occasional halts. In one instance, this duration of wandering lasted for about 12 hours after which the nymph died for want of a suitable habitat.

Whenever the suitable stage of buds were available, these nymphs were observed to work their way inside by creeping in through the lower whorl of opening bud, but they did not stay back long and came out in about half a minute's time or so. Perhaps the entrance through the lower fold of the bud does not help in reaching them to the growing point of the shoot. But whenever they were able to enter through the upper three whorls of the opening buds, they invariably remained inside them. Thus the observations showed that even first instar nymphs can enter the bud provided the stage is suitable for entrance contrary to the observations made earlier (Lal, 1955). The present observations also further suggest that the first instar nymphs would fail to survive and grow up to the next stadium, if their emergence does not synchronise with the suitable stage of bud development. The entire development of the nymphal stage takes place inside the galls and is completed in approximately 5 months' time during which period they pass through six successive stages of growth including imagines. The inside of a gall when split open presents a seething mass of tiny nymphs smeared in white fluffy coating. As many as 80 individuals of over-lapping stages were seen in a single gall.

The life-cycle which commenced with the deposition of eggs in early March is completed in the following February, giving rise to only one generation in a year.

ROLE OF *Apsylla cistellata*, BUCK. IN CAUSING SHOOT GALL OF MANGO

There are divergent views on the relationship between psyllids and gall formation on mango shoots. A number of workers attributed the malformation to some physiological factor which in their opinion possibly upsets the plant metabolism quite independent of psyllid attack. Two principal considerations contributing this opinion may be: (1) The buds, sometimes, make their appearance 10-12 days earlier than the hatching of the nymphs from the 'resting' eggs and (2) A certain percentage (about 5 to 10 per cent) of galls have been observed to be free from Psyllid nymphs.

But it must be noted that at this time, the new buds remain in a sort of hard compact mass, not liable to be penetrated by psyllid. By the time they become plump, giving rise to separation of new scaly leaflets, hatching invariably commences. There is thus usually a synchronisation of emergence of the nymphs with the vulnerable stage of bud-development. In quite a good number of cases, such developed buds were found to contain first instar nymphs. The fact that the nymphs exhibit a tendency to go about in search of right type of bud soon after hatching, is rather significant. Then, again a special choice evinced by them for entering through the upper folds of the opening buds is also suggestive in as much as, it enables them to reach the growing point of the shoot. It is difficult to determine

the direct mechanical injury caused through the agency of psyllid nymphs. Perhaps, the arrest of growth, resulting in malformation, is brought about by some sort of toxic secretion by these nymphs. Further investigations as to how far the nymphal stage of *Apsylla cistellata* is responsible for initiating shoot-gall are in progress. As regards the second point advanced by earlier workers the author also came across certain percentages of galls (about 8 to 10 per cent) remaining free from nymphs. In this context, it may be mentioned that nymphs are liable to be destroyed by predators. In quite a good number of cases, remains of devoured nymphs as well as the predators were seen inside these galls.

There is, however, general agreement among the workers with regard to the relationship between the presence of eggs and the formation of shoot-galls. Our observations are also in conformity with the earlier findings in this regard. Both direct and indirect evidences collected in a series of observations have shown this consistent relationship. In the first series, there were three sets-two trees without eggs, two with mild infestation, and the other two with heavy infestations in the off-season i. e. in the month of June. The final observations were recorded in the 2nd week of December when it was noted that trees without eggs were completely free from galls, whereas those with less number of eggs recorded mild incidence and those with larger number of eggs showed severe attack of galls. In a second series, six twigs with varying number of eggs and six without eggs were bagged during the month of June and were examined during the third week of November. The observations revealed that the twigs without eggs were totally free from galls, whereas those with eggs were found to bear varying number of galls on each of them as may be seen from the accompanying tables.

In the third series, a large number of psyllid adults in pairs were introduced in bagged twigs of young mango trees bearing new flushes with a view to inducing them to lay eggs. Twelve pairs of psyllid adults were introduced in each of the six twigs where large number of eggs were laid by them in the third week of March. A similar number of twigs on the same tree were kept to serve as control and all these twigs were bagged with muslin cloth material. It was noted that a large number of eggs were laid on the young twigs infested with adult psyllids. It was interesting to find that all the leaf-buds which appeared on healthy twigs gave rise to succulent and tender shoots, whereas those on the infested branches developed into conical galls. It was not, however, known the part played by the young nymphs which hatched from the 'resting' eggs. This problem has to be tackled by devising suitable control measures, either by directing them against adults in March so as to stop egg-laying or against nymphs in October by working out a complete operational schedule.

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