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Biological and Systematic Studies of Developmental Stages in *Aphytis* (Hymenoptera: Aphelinidae)

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David Rosen and Avner Eliraz

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I. Developmental History of *Aphytis chilensis* Howard

Species of *Aphytis* Howard (Hymenoptera: Aphelinidae) are the most effective natural enemies of armored scale insects (Homoptera: Diaspididae). Their classification, based on the morphology of adult wasps, is difficult. The studies herein were intended to explore the possibility of using morphological characteristics of developmental stages in the systematics of this genus.

The developmental stages of *A. chilensis* Howard, the generotype of *Aphytis,* are described. The ovarian egg is double-bodied, whereas the deposited egg is stalked. The larva passes through three instars, each of which differs markedly in shape and size of the mandibles. First-instar larvae have four pairs of spiracles; the second and third instars have eight pairs, *viz.,* one pair in the mesothoracic segment and one in each of the first seven abdominal segments. The cephalic skeleton, respiratory system, and various integumentary structures of the third-instar larva are described. The morphology of the pupa was studied with light and scanning electron microscopy.

At 28 ± 1° C, egg development takes 2 to 3 days, larval development (including the prepupal period) 10 to 12 days, and pupal development 6 to 7 days. Rearings under various constant temperatures gave the theoretical threshold of development as 14.1° C and a thermal constant of 270.2 day-degrees for the completion of development.

II. Larval Criteria in the Systematics of *Aphytis*

Eggs and larvae of six species of *Aphytis,* representing five of the seven species-groups currently recognized in this genus, were

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II. Larval Criteria in the Systematics of *Aphytis*

INTRODUCTION

THE PRINCIPAL AIM of this study was to evaluate the validity of larval characteristics as possible systematic tools for the separation and classification of the species of *Aphytis* Howard (Hymenoptera: Aphelinidae).

Since previous descriptions of developmental stages—especially larvae—of *Aphytis* were rather inaccurate, the first paper in this series (Rosen and Eliraz, 1977), which included a detailed morphological study of the various developmental stages of the generotype, *A. chilensis* Howard, is intended to serve as a basis for comparison with other members of this genus. The present paper includes a comparative morphological investigation of the developmental stages of several species of *Aphytis*, with special emphasis on larval characters.

The genus *Aphytis* now comprises seven more-or-less distinct groups of species (Rosen and DeBach, 1976, 1977). Representatives of five of them —the **chilensis, proclia, mytilaspidis, lingnanensis,** and **chrysomphali groups** —were available for study. Two closely-related members of the **lingnanensis group,** and one member of each of the four other groups, were selected for this investigation. The primitive **vittatus group** and the aberrant **funicularis group** were not available to us in live culture, and were not included in this study.

MATERIALS AND METHODS

The following six species of *Aphytis* were studied.

The chilensis group. *A. chilensis* Howard, the generotype of *Aphytis,* a thelytokous, nearly cosmopolitan parasite of the oleander scale, *Aspidiotus nerii* Bouché. Obtained from the biparental oleander scale on English ivy in Israel and reared on that host on potato tubers and squash vines.

The proclia group. *A. hispanicus* (Mercet), a uniparental, widely distributed parasite of the chaff scale, *Parlatoria pergandii* Comstock. Obtained from the chaff scale on citrus in Israel, and reared on the latania scale, *Hemiberlesia lataniae* (Signoret), on potatoes.

The mytilaspidis group. *A. mytilaspidis* (Le Baron), a uniparental parasite of the latania scale from Crete. Obtained from the insectary of the University of California, Riverside, where it was reared on the cactus scale, *Diaspis echinocacti* (Bouché), on *Opuntia* pads.

The lingnanensis group. *A. melinus* DeBach, a biparental, oriental parasite of the California red scale, *Aonidiella aurantii* (Maskell), and the yellow scale, *Aonidiella citrina* (Coquillett), introduced into Israel from California. Obtained from the California red scale on citrus in Israel, and reared on the oleander scale on squash.

A. coheni DeBach, a biparental parasite of the California red scale from Israel, presumably of Oriental origin.

Obtained from the California red scale on citrus in Israel, and reared on the oleander scale on squash.

The chrysomphali group. *A. chrysomphali* (Mercet), a uniparental, cosmopolitan parasite of the California red scale. Obtained from the California red scale on citrus in California, and reared on that host on lemons.

The methods used in rearing these species, and in preparing their various developmental stages for microscopic examination, were identical with those reported by Rosen and Eliraz (1978).

Before any meaningful comparisons between uniparental and biparental species could be made, it was deemed important to compare the developmental stages of males and females. In arrhenotokous species, unmated females give rise to male progeny only. Female pupae of *A. melinus* were therefore isolated in small vials, and the emergent females were allowed to oviposit in suitable hosts for 24 hours. Their developing (all-male) progeny were sampled daily, mounted, and compared with samples of developmental stages taken from a standard insectary culture of *A. melinus,* comprising about 70 percent females. Male and female eggs and larvae were identical in all morphological characters. Only in the pupal stage can the sexes be separated by the presence of two minute, rectangular, ventral plates near the tip of the abdomen of the female, which are absent in the male pupa, as described by Rosen and Eliraz (1978) for *A. chilensis.* The duration of development was also identical in both sexes. Sex was, therefore, ignored in all our subsequent comparisons of the eggs and larvae of *Aphytis* spp.

RESULTS

There were no morphological differences evident among the eggs of the six species under study. The ovarial eggs are double-bodied; and the deposited eggs are stalked in all species, and are indistinguishable from the eggs of *A. chilensis,* as described by Rosen and Eliraz (1978). The head capsule of the fully formed embryo always faces the stalk end of the egg.

First-instar larvae appear identical in all six species. Like the first-instar larva of *A. chilensis,* they all possess four pairs of open spiracles: one pair in the mesothoracic segment and one in each of the first three abdominal segments. The shape and dimensions of the spiracles, the cephalic skeleton, and the mandibles are similar in all six species, and do not offer any diagnostic characters for their separation.

The second-instar larvae of the six species possess eight pairs of open spiracles: one pair in the mesothoracic segment and one in each of the first seven abdominal segments. The larvae differ from both the first and third instars in the shape and size of their mandibles, which proved to be taxonomically indistinguishable in all the species studied.

The third (i.e., final) instar larvae of all six species are practically indistinguishable in most morphological characters. The tracheal system, the spiracles (eight pairs, as in the second-instar larvae), the cephalic skeleton, and the mandibles are virtually identical. The "bacilliform" rod formations, described by Rosen and Eliraz (1978) on the dorsal aspect of the three thoracic segments and on the seventh, eighth, and ninth abdominal segments of the full-grown larva of *A. chilensis,* are present in all other species as well (see figs. 1 and 2). Their position is rather constant, whereas their shape is quite variable, and they do not constitute a reliable diagnostic character. Most other integumentary formations and sensoria are also similar in all six species.

The only significant morphological

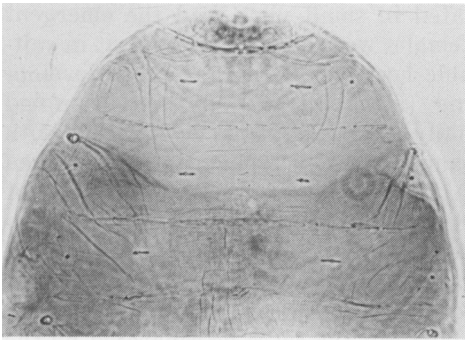


Fig. 1. *Aphytis melinus:* "bacilliform" rod formations on thoracic segments of third-instar larva.

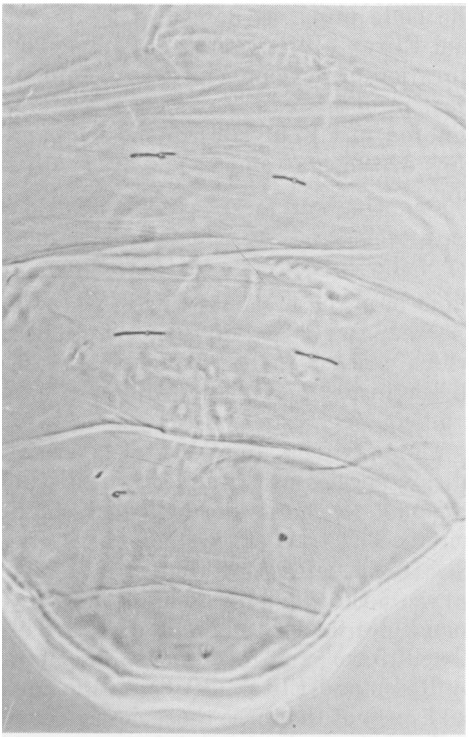


Fig. 2. *Aphytis melinus:* "bacilliform" rod formations on seventh, eighth and ninth abdominal segments of third-instar larva.

difference among the larvae of the six species under study was in the number and arrangement of minute cuticular tubercles and pores in the cephalic area, around the mouthparts and antennal discs (see figs. 3 and 4). *A. chilensis* has the lowest number, five pairs in all.

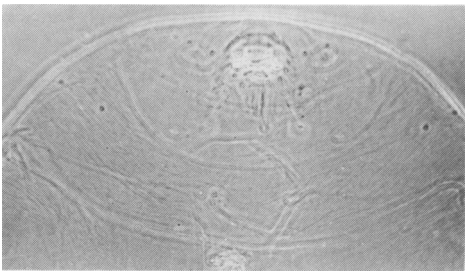


Fig. 3. *Aphytis hispanicus:* cuticular tubercles in cephalic region of third-instar larva.

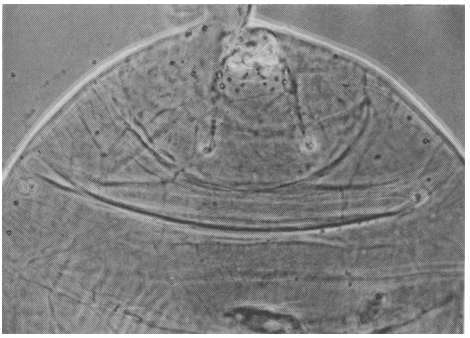
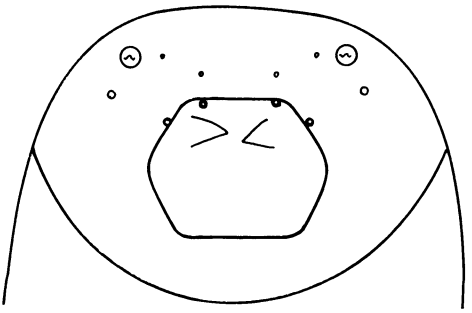


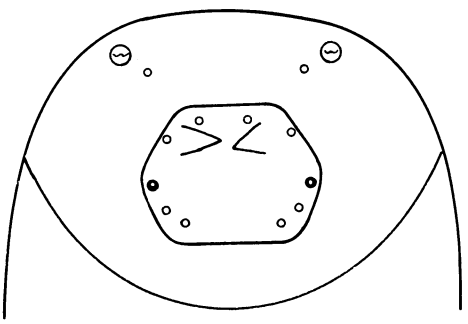
Fig. 4. *Aphytis chrysomphali:* cuticular tubercles in cephalic region of third-instar larva.

Of these, one pair is positioned immediately above the mandibles, one pair is opposite their bases, and one pair is between the antennal discs. The position of these three pairs is approximately the same in all species. The two other pairs found in *A. chilensis* can be seen in fig. 5.

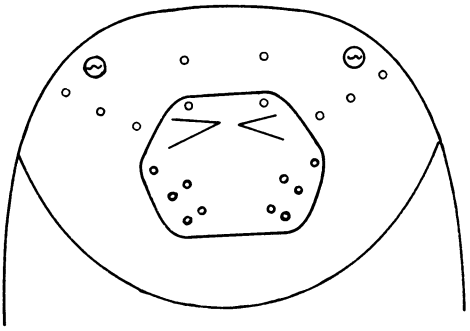
A. mytilaspidis (fig. 6) has six pairs of these minute structures: the three



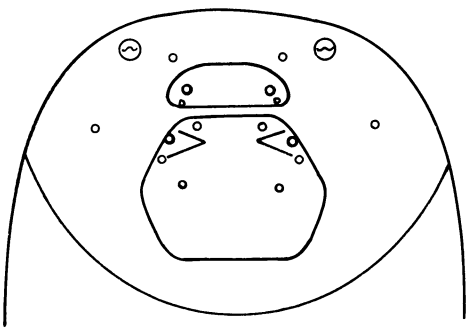
Figs. 5 to 9 (see also page 99). Arrangement of cuticular tubercles in cephalic region of third-instar larva (diagrammatic). Above (fig. 5), *Aphytis chilensis.*



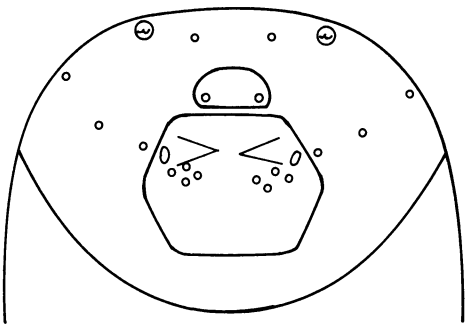
6. *Aphytis mytilaspidis*



8. *Aphytis hispanicus*



7. *Aphytis melinus* and *Aphytis coheni*



9. *Aphytis chrysomphali*

"constant" pairs, and three additional pairs mesad of the hypostoma. *A. melinus* and *A. coheni* are identical (fig. 7). Both have eight pairs of unequal size, the largest one being the pair situated opposite the bases of the mandibles. *A. hispanicus* (fig. 8) and *A. chrysomphali* (fig. 9) each have 10 pairs, arranged in a rather similar manner.

No other differences were noted among the developmental stages of the six species studied, with the obvious exception of pupal pigmentation, which has been recognized by several authors as a reliable diagnostic character for certain species of *Aphytis* (DeBach, 1959; Traboulsi, 1969; Yasnosh, 1972). The manner of adult emergence and the shape of the exit hole made in the covering scale of the host are also essentially similar in all these species (see Rosen and Eliraz, 1978).

DISCUSSION

Imms (1916), in the first detailed description of the developmental stages of *Aphytis,* stated that in the newly hatched larva of *A. mytilaspidis,* "eight pairs of spiracles are present, and they are situated on the same segments as in the fully developed larva": one pair in the prothoracic segment, one in the metathorax, and one in each of the first six abdominal segments.

Parker (1924) correctly pointed out that in both *A. mytilaspidis* and *A. chilensis,* the spiracles are situated on the mesothorax and on the first seven abdominal segments of the fully developed larva. However, he too, erroneously considered the first-instar to be similar in this respect to the third instar. It is possible that both Imms and Parker had mistaken the second instar for a newly hatched larva. In all the species included in the present study, representing five different species-groups, the first-instar larva was found

to possess four pairs of open spiracles. This appears to be the rule in the genus *Aphytis*. Azim's (1936*a*, 1936*b*) descriptions of the first-instar larvae of several species of *Aphytis*, showing six pairs of open spiracles, would, therefore, benefit from some corroboration.

Benassy (1955) compared the larvae of *A. mytilaspidis* and *A. proclia* (Walker), and described some differences in the shape and dimensions of their mandibles. However, Traboulsi (1969) was unable to confirm those differences. In the present study, the mandibles of each of the three larval instars were similar in all six species. It is possible that Benassy compared the mandibles of different instars.

Unfortunately, the only morphological characters were found in the present study to separate the larvae of *Aphytis* spp. are minute, obscure, cephalic structures that require special mounting procedures, and are, at best, barely visible even in cleared specimens. These characters were observed to differ in the species examined from different species-groups, whereas the two species belonging to the same species-group proved to be identical. Sometimes even representatives of different species-groups such as *A. hispanicus* and *A. chrysomphali* were very similar in this respect. More information should be gathered about additional species, but it seems doubtful that these cryptic characters will prove to be a practical systematic tool for the identification of the species of *Aphytis*.

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