

Biosystematic studies on *Aphytis* in India—A promising area of research

A UMA NARASIMHAM and M J CHACKO

CAB International Institute of Biological Control, Hebbal Agricultural Farm Post, Bangalore 560 024, India

Abstract. Species of the genus *Aphytis* Howard (Hymenoptera, Chalcidoidea, Aphelinidae) develop as primary ectoparasites of armoured scale insects (Homoptera, Coccoidea and Diaspididae) and are the most important natural enemies of this group of pests. Several species have been successfully employed in the biological control of important armoured scale insect pests in different parts of the world. In spite of the importance of *Aphytis*, very little is known about the species occurring in India, a promising area for additional and important species. In the past although taxonomists have made significant contributions to our knowledge of Indian Chalcidoidea, the genus *Aphytis* has largely been neglected because the identification of the species in this group is extremely difficult for want of readily recognizable morphological criteria and due to the common occurrence of sibling and uniparental species. The recognition of sibling species and different biological races is often important in biological control. Hence there is a need in India to initiate studies on *Aphytis* to establish the identity of cryptic species and to recognize biological races and other infra-specific entities exhibiting morphological and biological differences, with special attention to those parasitic on armoured scale insects on economically important plants. These studies would pave the way for biological control strategies for pest species in India and elsewhere and also for those which may eventually attain pest status due to changing ecosystems.

Keywords. *Aphytis*; diaspine scale insects; sibling species.

1. Introduction

Armoured scale insects (Homoptera, Coccoidea and Diaspididae) have attained great importance particularly as pests of fruit trees and ornamentals, owing to high reproductive capacity, survivability and difficulty in controlling them with insecticides. Species of the genus *Aphytis* Howard (Hymenoptera, Chalcidoidea, Aphelinidae) are primary ectoparasites of these insects. The adult *Aphytis* female pierces the armour with the ovipositor and lays one or several eggs on the body of the host. Well protected by the armour, the larvae feed on the body fluids of the host and develop, pupating below the empty armour. In addition to the scale insects killed by parasitism, considerable mortality is caused due to the predatory host-feeding by the adult *Aphytis* females. *Aphytis* spp. are well recognised as superior in effectiveness to the endoparasites and predators of armoured scale insects (Rosen and DeBach 1979). Several species have been successfully employed in biocontrol projects and several others could be instrumental in keeping the populations of many potential pests at subeconomic levels.

Identification and separation of the species of *Aphytis* are extremely difficult, due to the minute size and relative scarcity of reliable distinguishing characters. The diagnostic adult morphological characters of value for the identification of *Aphytis* species include (i) number of antennal segments; (ii) ratio of length to width of the antennal club; (iii) ratio of the lengths of the various antennal segments;

(iv) number, size and relative melanization of the setae on the mesonotal sclerites; (v) shape of the crenulae on the posterior margin of the propodeum; (vi) number of setae in the abdominal cerci; (vii) wing shape; (viii) ratio of the length of the longest seta in the marginal fringe of the forewing to the greatest width of the disk; (ix) number of setae along the marginal vein; (x) number of bullae along the submarginal vein; (xi) number of setae in the delta area of the forewing; (xii) relative visibility of the interommatidial setae on the compound eye; (xiii) sculpture of the thorax; (xiv) general colour of live adults; and (xv) degree of melanization and its location. However there are considerable intraspecific variations in the length and number of setae and wing proportions but proportions of the antennal segments are quite reliable. In certain cases the relative length of the ovipositor to the size of the specimen may aid in specific identification. Though variable in number with the size of the specimens, the propodeal crenulae, particularly the shape which is quite stable, are useful. The degree of coarseness and melanization of the body setae and the wing pattern are quite stable. The pattern of pigmentation of the body and appendages is the least variable character. A combination of several characters, studied under binocular stereoscopic microscope and high-power phase-contrast microscope help in separating certain species from the others. Examination under a scanning electron microscope has helped to identify minute diagnostic morphological differences, thus resolving the status of some sibling species.

Extensive research on *Aphytis* by DeBach and his co-workers and others (cited in Rosen and DeBach 1979) has revealed that this group consists of rapidly evolving and highly specialised insects exhibiting different degrees of morphological and biological distinctness and the common occurrence of sibling and uniparental species, thus necessitating biosystematic studies. It is now well recognised that virtually no species of *Aphytis* can be identified for certain on morphological characters alone. In practical biological control, not only the recognition of cryptic species but even biological races is of great importance.

2. Biological tools in systematics of *Aphytis*

While a brief account of biological attributes with reference to their utility in systematics of *Aphytis* is given here, no attempt is made to discuss biosystematics of *Aphytis* which has been reviewed by Rosen and DeBach (1979).

2.1 Morphology of eggs and larvae

While the eggs of *Aphytis* spp. are indistinguishable, slight differences in shape of mandibles, spiracles, spiracular tubercles, number and position of minute cuticular tubercles and pores in the cephalic area of the third instar larvae are observed. Although some of these characters differ in the representatives of different groups, they are of little practical value.

2.2 Pupal pigmentation

It is an important supplementary diagnostic character that proved to be the first clue to indicate the distinctness of some cryptic species (e.g. *A. lingnanensis* Compere and

A. chrysomphali (Mercet)). Species that are almost inseparable in adult stage, e.g. *A. holoxanthus* DeBach, *A. melinus* DeBach and *A. fisheri* DeBach have distinct pupal pigmentation.

2.3 *Meconium*

A detailed study of the meconial pellets in 12 species, using scanning electron microscope, revealed specific differences in their size, shape and surface pattern which are characters useful in identification.

2.4 *Duration of life cycle*

Although it was observed that the duration of life cycle was longer in members of the more primitive species groups, the ranges overlapped in closely related species.

2.5 *Longevity and fecundity*

Longevity under various constant temperatures differed in species of *Aphytis*. However, it appears to be a difficult tool in practical systematics, in view of the necessity to conduct the study under strict standardised conditions. Although fecundity is characteristic of species, it is of some value only when the study is conducted under uniform conditions.

2.6 *Host range*

In well established cases of monophagy, the host record can be a short cut to the identification as with *A. lepidosaphes* Compere or when a species is known to restrict to a particular genus of the host, e.g. *A. cylindratus* Compere to *Pseudaonidia* spp.

2.7 *Cytological characters*

Preliminary studies on the number, shape and size of chromosomes of *Aphytis* have not yielded any useful criterion.

2.8 *Reproductive isolation*

The final proof of the specific status of bisexual organisms is reproductive isolation. Hence experimental hybridization is the most reliable tool in identification of sibling species. Extensive studies on experimental hybridization have revealed common occurrence of semispecies and sibling species in *Aphytis*, e.g. experimental hybridization between sibling forms, *A. lingnanensis*, *A.* '2002' and *A.* 'R-65-23', reared from different hosts and from different geographical areas exhibited that *A. lingnanensis* and *A.* 'R-65-23' were good species in relation to each other but both were semispecies in relation to '2002'. Methods to quantify the extent of reproductive and sexual isolation and criteria to delimit species and semispecies categories have been worked out, based on the coefficients of joint isolation.

2.9 *Thelytoky*

Although a different mode of reproduction is an indication of the existence of biological differences in *Aphytis*, there is occurrence of uniparental and biparental sibling forms with or without complete reproductive isolation. A further complication is the occurrence of uniparental sibling species with distinct biological attributes. For the purpose of utilization in biological control, it is necessary to recognise these, whatever their specific status may be.

2.10 *Ethological characters*

Direct observation of acceptance or rejection is a simple means of distinguishing live cultures and differences in mating behaviour appears to be consistent in different species and warrant further study.

2.11 *Biochemical characters*

Only preliminary studies using paper chromatography and slab-gel electrophoresis have been conducted which indicate a promising area of research.

3. *Indian species of Aphytis*

In their treatise on *Aphytis*, Rosen and DeBach (1979) listed 8 species from India. These records of *Aphytis* were a result of collections made in India for biocontrol in other parts of the world. These are listed below along with their hosts recorded in India:

Parasitoid	Host
<i>A. coheni</i> DeBach	<i>Aonidiella orientalis</i> (Newstead)
<i>A. lepidosaphes</i> Compere	<i>Cornuaspis beckii</i> (Newman)
<i>A. lingnanensis</i> Compere	<i>Aonidiella aurantii</i> (Maskell)
<i>A. melinus</i> DeBach	<i>A. aurantii</i>
<i>A. paramaculicornis</i> Rosen and DeBach	<i>Parlatoria oleae</i> (Colvee)
<i>A. peculiaris</i> (Girault)	<i>A. ?orientalis</i>
<i>A. philippinensis</i> DeBach and Rosen	<i>A. aurantii</i>
<i>A. theae</i> (Cameron)	<i>Fiorinia theae</i> Green

It is interesting to note that all the hosts listed above are major pests elsewhere but are of little importance in India. The *Aphytis* spp. listed against them are recognised as of great importance in biological control.

In the past although taxonomists have made significant contributions to our knowledge of Indian Chalcidoidea, work on *Aphytis* in India remained neglected until a survey was conducted by CIBC to record natural enemies of diaspine scale insects (Anon 1986). This yielded an additional 3 identified species and over 20 partly identified species and also many additional host records of species already known to

occur in India. The additional species are *A. holoxanthus* DeBach and *A. pinnae* Rosen and DeBach from *Pinnaspis strachani* (Cooley), and *A. sankarani* Rosen and DeBach from *Pseudaulacaspis cockerelli* (Cooley) and *Aonidiella aurantii*, the last one being new to science and described along with another new species from India, *A. bangalorensis* Rosen and DeBach from *Pseudaulacaspis barberi* (Green) (Rosen and DeBach 1986).

4. Scope for future work

The partly identified species of *Aphytis* are only an indication of the scope for future work. The identity of many of these could be confirmed by biosystematic studies.

In India, diaspine scale insects of major economic importance include *Melanaspis glomerata* (Green) and *Quadraspidiotus perniciosus* (Comstock) and to-date there is no published record of indigenous *Aphytis* from these. Surveys for *Aphytis* parasitising these pests particularly on alternate hosts, might yield species which could be utilized in biological control. In India, *Aspidiotus destructor* Signoret is a sporadic pest on coconut and *Aonidiella aurantii*, though not a major pest on citrus, is important on rose. There is a need to study the role of *Aphytis* spp. as regulating factors of these scale insects on different plants and over wide areas. Biosystematic studies on *Aphytis* would have to be the foundation on which such studies could be based. Several diaspine scale insects occur in India which are serious pests elsewhere, e.g. *Chrysomphalus aonidum* (Linnaeus), *Parlatoria* spp., *Pinnaspis strachani* and *Cornuaspis beckii*. There is a need to learn about the *Aphytis* spp. parasitic on them which would prove helpful if these scale insects eventually attain pest status due to changing ecosystems. *Pseudaulacaspis pentagona* (Targioni-Tozzetti) occurs in India, and one of its hosts elsewhere is mulberry. In view of its potential pest status, it should also be included for surveys. Rosen and DeBach (1979) estimate a rough ratio of 1:1 between armoured scale insects and *Aphytis*. Varshney (1985) listed nearly 200 species of diaspidae from India. Therefore about 200 species of *Aphytis* could be expected from India. Since faunistic knowledge of this group in India, an area noted as one of the promising ones, is very restricted at present, there is an enormous scope for work on this group. To begin with, studies on *Aphytis* parasitic on those diaspidae which are pests and potential pests in India could be made. These would pave the way for biological control of diaspine scale insect pests in India and elsewhere. Special effort to study *Aphytis* reared from economically important diaspidid hosts on wild plants could prove rewarding rather than restricting to cultivated habitats which are subjected to heavy pesticide treatments, possibly resulting in complete exclusion of parasitoids.

References

- Anonymous 1986 *Survey for natural enemies of diaspine scale insects in south India*. Supplementary final technical report for the period November 5, 1983 to May 4, 1986. US PL-480 project. (CAB International Institute of Biological Control), Bangalore: pp 81
- Rosen D and DeBach P 1979 Species of *Aphytis* of the world (Hymenoptera: Aphelinidae). *Ser. Entomol.* 17 pp 801
- Rosen D and DeBach P 1986 Three new species of *Aphytis* (Hym.: Aphelinidae), parasites of *Pseudaulacaspis* spp. (Hom.: Diaspididae) in India and Australia; *Entomophaga* 31 139-151
- Varshney R K 1985 A review of Indian Coccids (Homoptera: Coccoidea); *Orient. Insects* 19 1-101