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Biosystematics of Chalcididae (Chalcidoidea : Hymenoptera)

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Abstract. The Chalcididae represent a large group of parasitic Hymenoptera which parasitise pupal or larval stages of various insects including several pests. Their phylogeny is not so far clearly known, but a Eurytomid—Torymid line of accent could be postulated. There is a general resemblance in their adult behaviour such as emergence, courtship, mating, oviposition, feeding etc. Their hosts belong to Lepidoptera, Diptera, Hymenoptera, Neuroptera, Coleoptera and Strepsiptera.

Keywords. Chalcididae; Biosystematics.

1. Introduction

The Chalcididae (S. Str.) represents a large group of parasitic wasps (Hymenoptera: Chalcidoidea) which parasitise various insects, many of which are of economic importance. Their hosts include the blackheaded caterpillar of coconut, the cotton leaf-roller, the padyskipper, the diamond back moth of cabbage, the gypsy moth, the castor capsule borer as well as extremely large number of other pests. Unfortunately many species of Chalcididae look very much alike while they differ widely in habits. Hence, precise identification of the species or infraspecific categories is highly important in any host-parasite studies involving these insects which are important, interesting and difficult (taxonomically) parasitic insects.

The study of Chalcididae may be said to have begun well before 200 years ago when Linnaeus (1758) discovered and reported a few species. Since then several authors have contributed to the knowledge of this family and some of the important contributions are those by Fabricius (1775, 1787), Walker (1834, 1841, 1862), Westwood (1829), Dalla Torre (1898), Dalman (1820), Spinola (1811), Motschulsky (1863), Forster (1859), Fonscolombe (1840), Cresson (1872), Klug (1834) and Kirby (1883). Since, the monumental work of the classification of Chalcidoidea by Ashmead (1904) our knowledge of the family has been greatly enhanced by the studies of Cameron (1897, 1906), Crawford (1910), Schmitz (1946), Waterston (1922), Girault (1915), Gahan (1938), Gahan and Fagan (1923), Ruschka (1922) and Masi (1929). During recent years contributions to our knowledge has been made by Boucek (1952, 1982), Burks (1940, 1960), Grissell and Schauff (1981), Steffan (1951, 1961), Erdos (1955), Habu (1960, 1962), Nikolskaya (1952), Mani (1938) and Narendran (1975, 1984).

While most of the above contributions were mainly on the taxonomy of these Chalcids, the following authors also studied many aspects of their biology. Some of the important contributions are of Dufour (1841), Parker (1923), Roberts (1933), Howard and Fiske (1911), Burgess and Crossman (1929), Dowden (1935), Paillot (1923), Faure (1926), Kamal (1938), Hanna (1934), Cherian and Basheer (1938), Schneider (1939, 1940), Garthwaite (1939), Taylor (1943), Haroonkhan and Verma (1946), Jayaratnam (1941), Clausen (1940), Steffan (1961), Sychevskaya (1966), Roy *et*

al (1940), Narendran (1975), Joy (1976), Leonard (1971), Simser and Coppel (1980) and Thompson (1983).

2. Phylogeny and systematics

The family Chalcididae is perhaps the oldest of all other Chalcidoid families. They have evolved probably from the same ancestral stem from which the Torymids and Eurytomids evolved. Among the members of the family Chalcididae it is difficult to construct a phylogenetic tree in the absence of a clear knowledge of the various important characters that played significant roles in the evolution of these families. It is thus necessary to arrive at some conclusion regarding the plesiomorphic and apomorphic features before attempting to interpret phylogeny of the subfamilies of Chalcididae and such an attempt is beyond the scope of this paper. At present we do not have conclusive points to postulate any theory or cladistic analysis to show the possible lines through which evolution has progressed among the various subfamilies of Chalcididae. At the same time students of this group should remember that every existing subfamily has developed specializations of its own and different features have evolved at different rates.

There are more than 1500 valid species and more than 150 valid genera of Chalcididae in the world. They are found in all continents but more number of their representatives are found in the tropical regions. The family Chalcididae is divided into 6 subfamilies (Narendran 1986): Chalcidinae, Brachymerinae, Dirhininae, Epitraninae, Haltichellinae and Smicromorphinae. Extreme morphological variations occur within many species and genera of this family and for the same reasons several species and genera were redescribed by several workers under new names. This is the main reason in studying this family of Chalcids.

3. Emergence

The adult emerges from the host through an exit hole made with the mandibles. After emergence the adults rests for a while and then starts to groom itself with its legs. If it is disturbed the adult may jump or run or fly readily.

4. Feeding

Adults take sugary fluids like honey, nectar etc, and occasionally feeds on the body juices of their hosts. Thus the adults can be observed during the morning hours in bright sunshine on the extra-floral nectaries of several plants. However, an exception to this can be met in the case of most species of the genera *Epitranus* and *Smicromorpha* which are found to be mostly nocturnal in habits.

The females are synovigenic in Chalcididae and hence they require a source of protein for their continuous production of eggs throughout their effective adult life. These needs of protein may be supplied by feeding on honeydew or plant nectaries (both of which contain free aminoacids), and body juices of hosts. Stinging with ovipositor is not always accompanied by oviposition. Females like the fluid exuding from its victim's body at the site of the sting. Such feeding ensures adequate quanti-

ties of proteins in addition to the carbohydrates derived from the feeding of the naturally occurring sugary fluids thus favouring the normal metabolism of the individual. Feeding of honey alone is insufficient and feeding of host's fluid is necessary to obtain enough protein needed for ovigenesis. However, our experiments with some species of Chalcididae showed that sugar containing nourishment such as honey prolonged the life of the adults, whereas the albumen nourishment (protein) out of host pupae showed no life prolonging effect.

5. Reproduction

The Chalcidids are biparental. Mated females can lay both fertilized (diploid) and unfertilized (haploid) eggs, which develop into females and males respectively. Unmate females produce only unfertilized (haploid) eggs, which develop into males (arrhenotokous parthenogenesis). Consequently, as in other Hymenoptera, the female can produce both female and male progeny during her life time.

6. Courtship and mating

A qualitative and quantitative analysis of courtship and mating behaviour shows some remarkable variations among genera species. However, the courtship and mating behaviour is dependent upon the inter-relationship of releasor and response in an innate behaviour pattern. One of the simpler, basic patterns was observed in several species of *Brachymeria*. The sequence of events is as follows: Male head nod-antennal contact-copulation. A more advanced pattern is exhibited by several species of Haltichellines (species of e.g. *Antrocephalus*, *Hockeria*, *Invreia*, *Psilochalcis* etc). This pattern includes the following phases: Male head nod-antennal contact-mount-postmount antennation-backward movement of male-copulation-dismount. The post-mount antennation is certainly an advanced trait since the same is met with in some of the advanced families such as Eulophidae, Aphelinidae etc. The development of long antennae and consequent development of broad and deep scrobe must be regarded as advanced characters developed along with this type of advanced courtship behaviour.

7. Host selection and oviposition

The major stages of host selection by Chalcidids are (i) habitat selection, (ii) host finding, (iii) host acceptance and (iv) host suitability. Our knowledge of habitat selection is very limited. While several species of genera *Brachymeria*, *Antrocephalus*, *Haltichella*, *Hockeria*, *Nearretocera*, *Invreia* etc, are met with near flowers of plants like *Cassia tora*, *Pisum sativum*, different types of grasses etc, a few such as *Megachalcis*, *Trigonura*, *Notaspidium*, *Chalcis*, *Bucekia* etc, are rarely encountered. The Epitranines were seen mostly in woody plants in dry weather while *Smicromorpha* is very rarely found in localities near their host *Oecophylla smaragdina* Fabr.

The host finding behaviour of a few species studied shows that it is mainly depended upon chance-encounter and chance rules until the parasite was within a certain distance near the host. A random search on the surface of the host plant is the basic

feature of host finding and when the parasite reaches within the critical distance-range (this varies between the hosts and the parasite species depending on several factors such as effect of kairomones, chemoreception etc) the parasite quickly finds its host either by chemoreception or by visual stimuli or by the combined action of both these factors.

Host acceptance in Chalcididae involves mainly the use of antennae and ovipositor. The mouth parts and tarsi hardly played any significant role in the species so far studied. The female generally examines the potential host with a drumming of the antennae over its peripheral surface. The duration of this exploratory phase may vary even among species of the same genus.

Host suitability is frequently evaluated by ovipositor. The ovipositor of many species have sensillae with which the host suitability could be tested.

The oviposition process was more or less similar in most species studied though a little variation occurred in the position of the tarsi while ovipositing. In *Brachymeria* the whole hind legs are used to hold on the host pupa firmly while in *Kriechbaumerella*, *Hockeria* and in *Antrocephalus* the tarsal segments mainly hold the hosts.

8. Taxes

The adults of several species studied by us are positively phototactic (we have not studied the nocturnal species of Epitranus and Smicromorpha). In confinement they have been found preferring to remain in lighted areas. They were very active when placed in bright sunlight or electric light. The male's mating drive could be reinforced through the direct effect of the sunlight or electric light.

9. Death feigning behaviour

Some species of *Brachymeria* were found showing a death feigning behaviour as seen in several groups of beetles and other insects. When disturbed the adults were found dropping down from their resting places freezing and remaining still as though dead for about 10–20 s.

10. Fecundity

Chalcidid females are synovigenic. Eggs are produced in two ovaries, each composed of 3 ovarioles. They develop and mature continuously throughout the life span but after a short preoviposition period of 1–3 days. Data about the actual fecundity of Chalcidids are rather scarce. However, the reproductive capacity of most species of Chalcididae known is low. This is because they have only 6 ovarioles and eggs are relatively large and each ovariole can hold one ovariole at a time. Hence the maximum number of eggs laid in a day by a single female varied from 6–8.

11. Longevity

The longevity of adults depends on several factors such as availability and nature of food, weather conditions etc. Without food the adults survived for only 2–4 days. With adequate nutrition and between thermal thresholds, longevity is longer at lower

temperatures. In *Brachymeria lasus* at a constant temperature of 9–12°C females fed with honey (50%) lived for 32–130 days with a mean of 65·1 days.

12. Larval behaviour

There are 5 larval instars. They have well developed respiratory system with branching and ramified trachea. The circulatory, digestive and nervous systems are simple. The larval duration mostly lasts for 4–10 days and the pupal duration of about equal length. A prepupal stage is also met with, the size and shape of the mandibles and diameter of thoracic spiracles help determine the stage of the larva.

13. Seasonal history

This mainly depended upon local climatic conditions. In Southern India many species were found throughout the year. Their population however, dwindled during extreme summer and in extreme monsoon period. Their population was at its maximum during the postmonsoon period in the case of several species.

14. Hosts

The majority of the hosts of Chalcididae belong to Lepidoptera. A few species are parasitic secondarily on Dipteran and Hymenopterous parasites. Dipterous maggots or pupae are often parasitised by some Chalcidids as primary hosts. Sarcophagids, Calliphorids and Muscid mature maggots or pupae are attacked by some species of the genera, *Brachymeria*, *Dirhinus* and *Hockeria*. Tripetidae forms host of a few species of *Dirhinus*. A few species of *Chalcis* parasitise Stratiomyidae. Syrphidae is parasitised by a species of *Spilochalcis* (*S. hirtifemora* (Ashmead)).

Besides Ichneumonidae and Braconidae some other Hymenopterous species of Agridae, Elasmidae and Megachilidae are parasitised by the species of *Spilochalcis*, *Hockeria* and *Neochalcis* respectively.

Some species of *Trigonura*, *Brachymeria*, *Spilochalcis*, *Proconura* and *Phasganophora* are parasitic on Coleoptera. A few species of the genera *Lasiochalcidia* and *Hybothorax* are parasitic on Neuroptera. Strepsiptera forms host of some species of *Hockeria*.

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