

OBSERVATIONS ON THE BIOLOGY AND BEHAVIOUR OF *CERATOSOLEN MARCHALI* MAYR (AGAONIDAE, CHALCIDOIDEA, HYMENOPTERA)

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Ceratosolen marchali Mayr breeds in the gall figs of *Ficus hispida* L. The females of this species are responsible for cross pollination in this *Ficus*. *C. marchali* is protandrous and the males are apterous, vermiform and short-lived. Observations on certain aspects of the biology and behaviour of *C. marchali* are given and discussed. Brief accounts of the morphology of the egg, larval and pupal stages are also given. Six distinct generations of the wasps are traced in a year. The sex ratios show variation during different generations. The probable reason for this is discussed.

INTRODUCTION

Ceratosolen marchali MAYR was reported from India by JOSEPH (1953) among the fig wasps emerged from *Ficus hispida* L. from Kottayam, Kerala. WIEBES (1963) reported the species from various countries including Ceylon, India, China, Malaya and Queensland. Earlier, MAYR (1906) had described the species from Java and GRANDI (1928) had redescribed the same species from his collections of fig wasps.

The females of *C. marchali* MAYR (Fig. 1A) are 1.4 to 1.5 mm in length; dorsum of their head, thorax and abdomen mostly brownish-black; antennal segments four to eleven smoky-brown; remaining parts of the body with pale brownish yellow colouration. Wings are hyaline and closely pubescent. The males (Fig. 1B) which are between 1.1 mm and 1.3 mm in length are uniformly pale yellowish-brown. As in the males of other genera of fig wasps, they lack wings

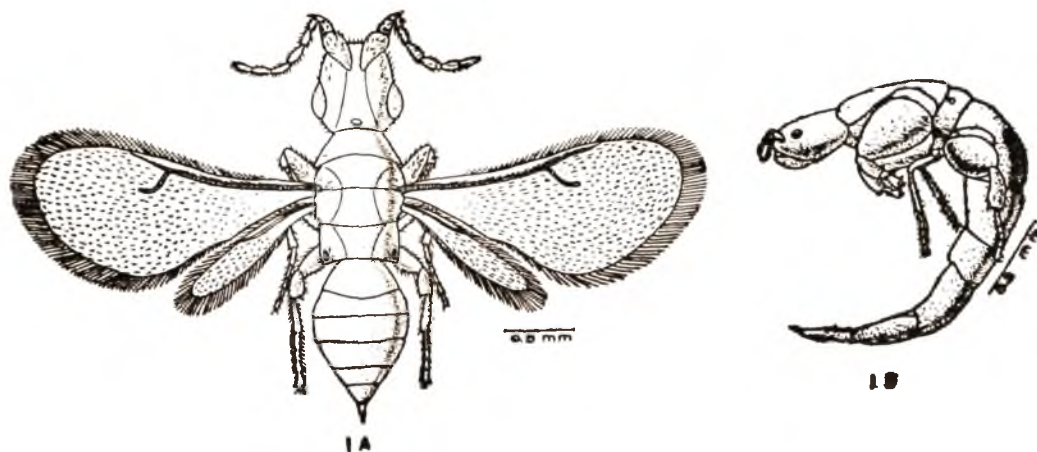


Fig. 1. *Ceratosolen marchali* MAYR—Adults
A : Female (dorsal view) ; B : Male (lateral view).

and the abdomen is tucked under the rest of the body.

Certain aspects of the biology and behaviour of this species of insect that breeds in the receptacles of *Ficus hispida*, are dealt with in this paper.

MATERIAL AND METHODS

Ficus hispida trees, commonly available in Calicut where the work was undertaken, are dioecious bearing seed flowers and gall flowers on separate trees. Seed flowers have long-styled ovaries and gall flowers have short-styled ones; the fig wasps develop only in the latter type of ovaries. Regular collection of gall figs containing insects in different stages of development were made and were brought to the laboratory to study their breeding biology and the behaviour of the adults. Galls (modified ovaries) of the figs were dissected out to remove the egg, larval and pupal stages for study.

Rearing of the larval and pupal stages of the fig insects and breeding them in the laboratory is not possible, as the insects can survive only inside the fig ovaries. However, rearing of the adults was attempted after their eclosion in the laboratory. The females fed on diluted honey were utilized for the study of their oviposition behaviour and longevity.

In nature, the development of the figs of *Ficus hispida* was followed from the time of their appearance till maturity to estimate the duration of one life cycle and to calculate the number of generations completed in a year. Field observations also were made on penetration of the female wasps into the young syconium, the nature and time of eclosion of the adults and the behaviour of the female adults before flying off in search of tender figs.

OBSERVATIONS AND DISCUSSION

1. Emergence, copulation and eclosion

The protandrous males come out of their galls by making exit holes by means of their mandibles. Soon after emergence, they are busily engaged in searching, locating and opening the galls containing the females of their own species. Normally they do not fail to identify the galls containing their own females. On locating one such gall, the male makes a small opening on it

by means of its mandibles and then introduces the terminal extensile sigments of its abdomen into the gall, holding on to the fig gall firmly with its legs. In this way while the females are still inside their galls, the males fertilize them. During this process, most of the males are found to introduce their heads slightly into the gall. This probably enables the male insect to keep in sensory contact with the female by means of their antennae. The act of copulation is also accomplished by waves of contractions originating at the base and passing towards the terminal part of the abdomen. The abdomen is withdrawn from the gall after copulation. Each male often mates with 4 or 5 females in succession. After the females are fertilized, the males help them in emerging out of the galls.

In nature, the eclosion, i. e. the exit of females in large numbers out of the syconium through the ostiolar opening, usually takes place initially during the early part of the morning and later irregularly during the day time. Since the females are highly phototactic, those that emerge during the night remain inside till the next morning. The duration of eclosion from a single syconium may last from three to four days. Prior to eclosion, the figs will be sufficiently swollen and their ostiolar opening becomes enlarged. For a given tree for the completion of eclosion it normally takes about seven to ten days. In a given locality the maturity of the figs and eclosion of the insects in different trees are spread out for a duration of one and a half months.

2. Sex ratio

The sex-ratio of the individuals emerging from *Ficus* receptacles was not uniform. When the sex-ratios from different receptacles belonging to the 6 generations of a year were calculated, an average ratio of 38 males for 100 females was obtained.

3. *Post-emergence behaviour and oviposition*

After emergence, the females of *C. marchali* remain inside the syconium for some time. The males which do not normally go out of the syconium die inside it.

After exit, the females remain for a short time on the surface of the fig to clean their body and wings with the help of their legs. The fore and hind tibiae provided with specialized setae and spines are used in the cleaning work. By the time the wasps eclose from one crop of ripe figs, the next crop of tender figs in the same tree will have reached a suitable stage to receive the eggs of *Ceratosolen* females. The females walk over the surface of the tender figs, their antennae feeling the surface till they locate the site of the ostiolar opening, which at this stage is blocked by the ostiolar bracts. They then struggle to enter inside the fig through the ostiole. The general shape of the head and body, the strongly built fore tibiae and tarsi as well as mandibular appendages (having serrated ridges) help them in forcing their way into the interior of the figs. During this strenuous effort, the females get mutilated, generally losing their wings and parts of their antennae. This task of penetration into the cavity of the fig generally takes 5 to 10 minutes.

The females after locating the ovaries inside the receptacle start oviposition. They lay one egg in each ovary. The ovipositor which is kept horizontally inside its sheaths, is taken out and lowered. The abdomen is raised. In this position, the ovipositor will be vertical to the axis of the body and the tip of the ovipositor is introduced into the style of the ovary. Slowly the abdomen is lowered so that the ovipositor can penetrate into the style and into the region of the ovule, where the egg is deposited. The egg proper comes to be deposited between

the nucellus and the ovarian wall, with its peduncle attached to the latter. A single female lays about hundred eggs in as many ovaries at a stretch. Along with the deposition of the egg, the insect also injects a certain amount of poison from its well developed poison gland into each ovary. Such secretion of *Blastophaga psenes* has been found to induce the parthenogenetic development of the endosperm of the *Ficus* ovary, thereby creating a suitable milieu for the growth of the insect embryo (LONGO, 1909; GRANDI, 1929).

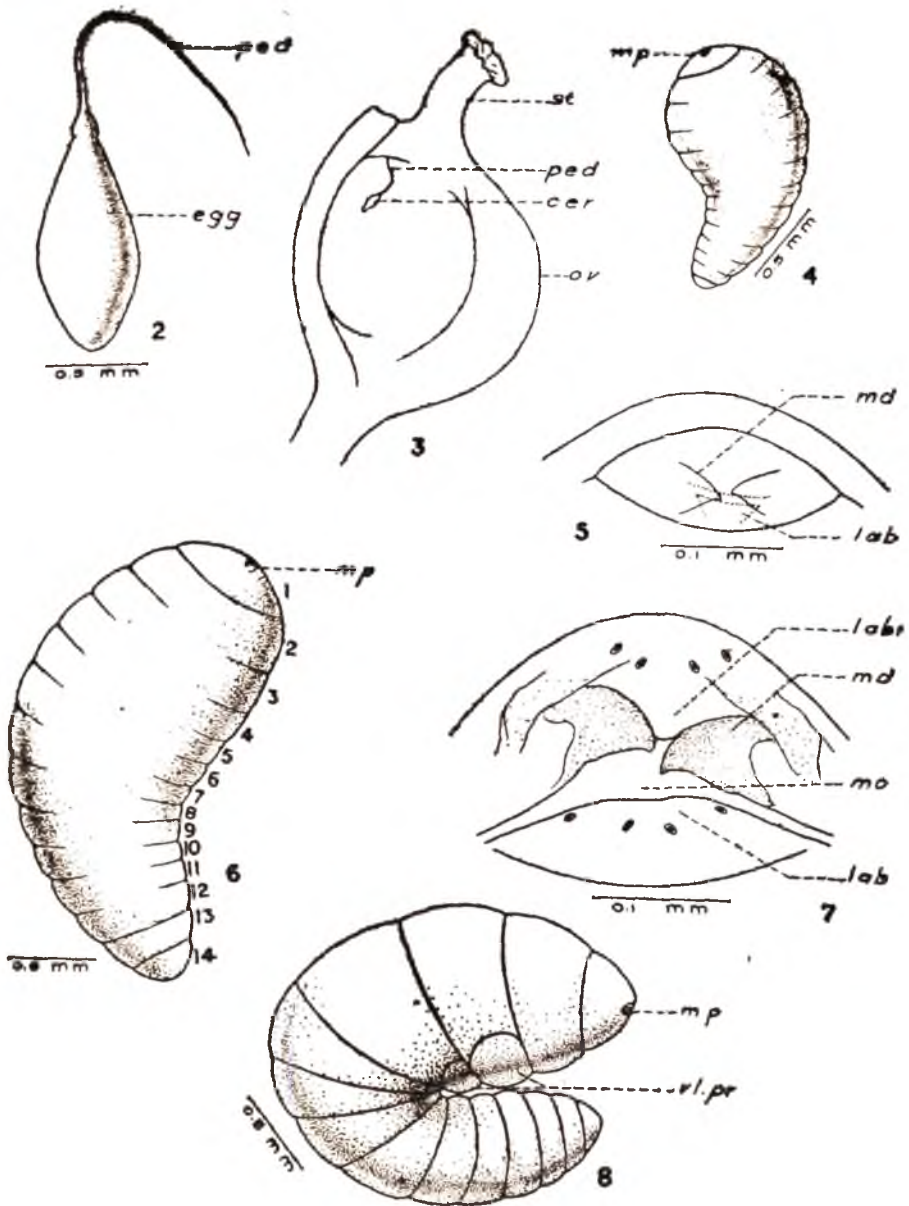
The females of *C. marchali* are found to penetrate the syconium of the seed figs also, by mistake. These females that emerged out of the ripe fig carry pollen grains on their body and when they reach the female flowers and attempt to oviposit, the transfer of the pollen is effected. In several instances 10 to 15 dead females of *Ceratosolen* were observed inside such receptacles.

4. *Longevity*

Adult male and female *C. marchali* have a short life span. The males normally do not come out of the interior of the fig. After their emergence they survive only for 20 to 28 hours. The females live longer, but most of them die within 24 to 30 hours. However, a few were observed to live for a second day, thus having about 48 hours of maximum longevity.

5. *The egg, larval and pupal stages*

The egg is almost oval, with its two ends distinctly blunt (Fig. 2). One end of the egg is produced into a conical projection, which is connected to a long stalk, the peduncle. Inside *Ficus* ovary the eggs are laid nearer the base of style (Fig. 3). Incubation period of the egg lasts for 5 or 6 days. The larva that hatches out (Fig. 4) is transparent and has almost the shape of the egg. Segmentation and mouthparts



Figs. 2-8. *C. marchali* egg, larval and pre-pupal stages. 2: Egg; 3: Location of the egg inside the *Ficus* ovary; 4: First stage larva; 5: Mouthparts of the first stage larva; 6: Second stage larva; 7: Mouthparts of the second stage larva; 8: Pre-gupa.

cer: the egg; lab: labium; labr: labrum; md: mandible; mo: mouth; mp: mouthparts; ov: ovary; ped: peduncle; st: style; vl. pr: Ventrolateral prominences.

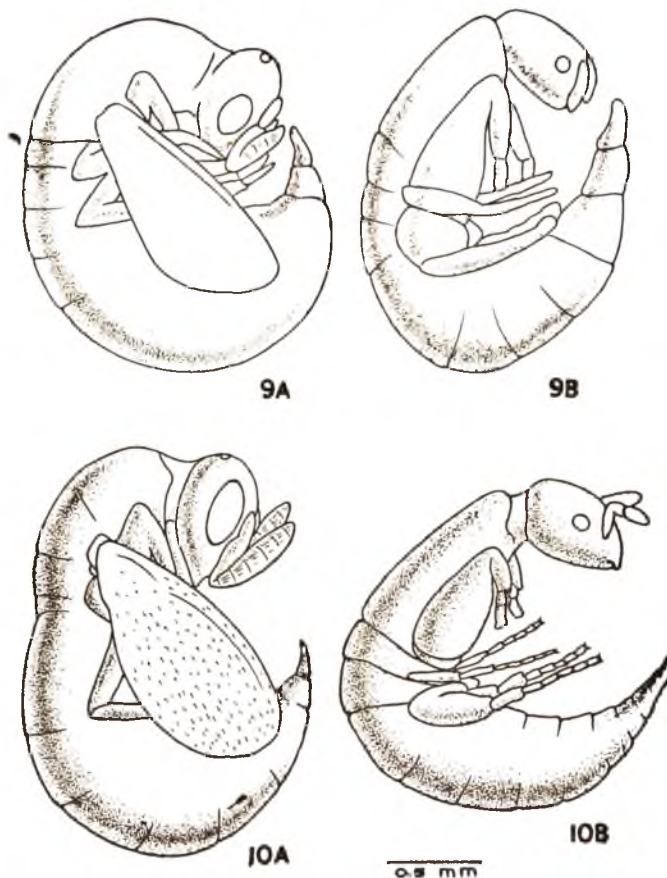
(Fig. 5) are indistinct. In about six days this transforms into the second stage larva (Fig. 6) which is distinctly segmented. The larva actively feeds on the food available inside *Ficus* ovary and grows in size. The mouthparts develop further (Fig. 7). The mandibles get further sclerotized.

After attaining its maximum size, the first four segments of the larva become enlarged. This is the prepupa (Fig. 8) which now shows a definite constriction at the region of the junction of the thorax with the abdomen. It enters the pupal stage within 8 to 10 days.

During the initial phase, the pupa (Figs. 9A & B) is whitish in colour, as the integument is not chitinized. The cuticle gets chitinized within five to six days and the pupa is then named 'brown pupa' (Figs. 10A & B). The final moult of the pupa gives rise to the adult that emerges out of its gall within a short time.

6. Number of generations in a year

The development, growth and maturity of the fig wasps of each generation occur simultaneously with the growth and maturity of the fig. In two trees of *Ficus hispida*,



Figs. 9-10. *C. marchali* pupal stages

9A : White pupa (Female) ; 9B : White pupa (Male) ;
10A : Black pupa (Female) ; 10B : Black pupa (Male).

six distinct eclosions of adults took place, one each in January, March, May, July, August and November, during the year 1966. Each generation of the wasps takes 50–60 days for completing the development from egg to adult stage.

On the emergence of *Blastophaga psenes* and *Philotrypesis caricae*, GRANDI (1929) and JOSEPH (1958) stated that the males of these forms attain maturity and come out of their galls by making exit holes themselves. This protandrous condition and the help the males render the females to come out of their galls, seen in *C. marchali* also, may be widespread and common in the Agaonids. Moreover in this family, as a rule, the females are fertilized while they are still inside their galls before their emergence.

The differences in the timing of eclosions permit the availability of the adult insects almost throughout the year. However, on the same tree when once eclosion has started it may last for a period of 7 to 10 days. This period is shorter than that required for the eclosion of insects from *Ficus carica*, which lasts for a total period of three weeks for a given tree. The shorter period of eclosion may be due to the fact that the wasps from *Ficus hispida* are able to complete their development in a shorter period synchronising with the maturity of the fig syconia in which they develop.

The average sex ratio of the males to the females of *C. marchali* eclosed in six different generations ranged from 30 to 40 males for 100 females. The higher proportion of the females could be due to the fact that in them the females are fertilized while they are inside the gall itself and hence their chances of emergence without fertilization are less. It is natural that a uniform sex-ratio is not obtainable due to the varying rate of parasitism by the two Torymids, *Philotrypesis pilosa* MAYR and

Apocrypta bakeri JOSEPH to which *C. marchali* generations are subjected. The incidence of parasitism as calculated in six different generations was found to vary between 3.2 % (for May generation) to 65.6 % (for November generation) in

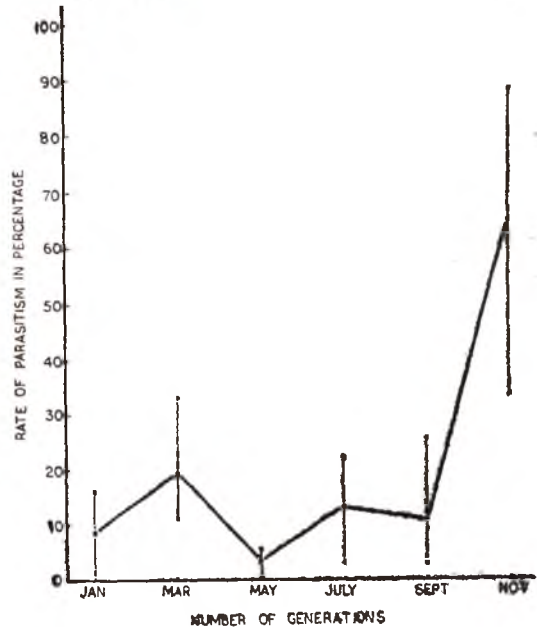


Fig. 11. Parasitism by *Philotrypesis pilosa* MAYR on *C. marchali* during six generations in a year.

P. pilosa (Fig. 11) and from 6.1 % (for May generation) to 49.4 % (for March generation) in *A. bakeri* (Fig. 12). The *Ceratosolen* larvae that are thus parasitized, irrespective of the sex into which they may develop, are killed by the more competent Torymid larvae thereby upsetting the otherwise little fluctuating sex ratio.

In *Blastophaga psenes*, the different aspects of oviposition were studied by GASPARRINI (1865), SOLMS-LAUBACH (1882) LONGO (1909) and GRANDI (1929). GALIL & EISIKOWITCH (1969) studied oviposition of *Ceratosolen arabicus* MAYR which breeds in *Ficus sycomorus*. In *C. marchali*, the manner of oviposition is similar to that of *C. arabicus*.

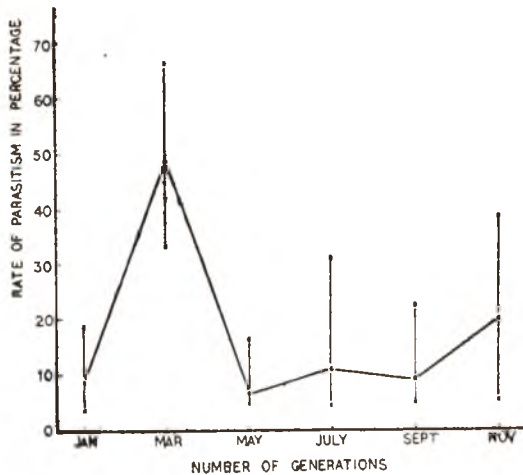


Fig. 12. Parasitism by *Apocrypta bakeri* JOSEPH on *C. marchali* during six generations in a year.

The number of generations of fig wasps in *Ficus hispida* completed in a year was found to be six. HILL (1967) reported four crops of figs of *Ficus hispida* in a year in Hong Kong.

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