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Biological Studies on Some Gall-Thrips

S VARADARASAN and T N ANANTHAKRISHNAN
Entomology Research Institute, Loyola College, Madras 600034

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Biological studies on six species of Thysanopterocecidia and their predatory inquiline thrips are discussed with reference to ovarian development from prepupal to the ovipositing adult stage, the rate of development differing with species. Faster ovarian development has been indicated in the predatory inquiline, *Androthrips flavipes* Schmutz as compared to the gall-forming prey species, an adaptive feature enabling completion of the life cycle much earlier than the Cecidozoa. Another aspect of interest relates to the considerable reduction in the duration of life cycle of *Thilakothrips babuli* Ramakrishna within inflorescence galls than in leaf galls. Analysis of the different mating types of the Mimusops gall thrips *Arrhenothrips ramakrishnae* indicated a preference of the major female to the gynaecoid male contributing to higher fecundity.

Key Words : Gall-thrips, Biology

Introduction

Biological studies on gall-thrips appear restricted in comparison with those for free-living Thysanoptera, available data relating to contributions by Canizo (1945), Ananthakrishnan (1973, 1978), Ananthakrishnan and Varadarasan (1977), Ananthakrishnan and Swaminathan (1977). Information on such aspects of reproductive biology as sex ratio, fecundity, oviposition sequence, ovarian development, and duration of life cycles in gall-thrips would therefore appear useful in view of their confined microhabitats. *Arrhenothrips ramakrishnae* Hood, *Teuchothrips longus* (Schmutz), *Gynaikothrips flaviantennatus* Moulton, *Schedothrips orientalis* Ananthakrishnan, *Crotonothrips dantahasta* (Ramakrishna), *Thilakothrips babuli* Ramakrishna, and *Androthrips flavipes* Schmutz are involved in this study, the first six species being gall-formers, the seventh a predatory inquiline. An attempt has also been made to study the fecundity, oviposition sequence, as well as the impact of the occurrence of different morphs of *Arrhenothrips ramakrishnae*, on mating behaviour and types of resulting offspring.

Material and Methods

Second instar nymphs of different species were collected and reared in the laboratory and as and when they emerged from the previous stage, they were dissected for ovarian study under a stereoscopic bionocular-dissection-microscope in Ringer's solution mixed with a drop of safranin and preserved in 70% alcohol, subsequently stained in haemotoxylin/basic fuschin and methylene blue/alcoholic eosin, dehydrated, and mounted in Canada Balsam.

Adult thrips and immature stages were reared in transparent plastic cages (5×2.5; 8×2.5 cm) covered with moist muslin to observe mating, oviposition sequence and post-embryonic development. The insects were provided with fresh galled leaves at regular intervals of 12 hours and the eggs laid were collected every 12 hrs. Care was taken to remove any water vapour accumulated on the sides of the plastic cages due to transpiration.

The morphs involved in the mating of *Arrhenothrips ramakrishnae* relate to:

Major female vs Oedymerous male;
Major female vs Gynaecoid male;
Normal female vs Oedymerous male;
Normal female vs Gynaecoid male;
Minor female vs Oedymerous male;
Minor female vs Gynaecoid male.

Observation

Sexual Dimorphism, Sex ratio, and Mating

In all the seven species of gall-thrips, the females generally outnumber the males, the sex ratio being 3:1 to 4:1 during the peak abundance of the respective populations. In *A. ramakrishnae*, *S. orientalis* and *C. dantahasta* the female:male ratio was 4:1 and 3:1 in *T. babuli*, *G. flaviantennatus*, *T. longus* and *A. flavipes*. Earlier studies on mating behaviour of Thysanoptera indicate that adults usually mate within two or three days after the last pupal moult (Lewis 1973). After their emergence from the final pupal moult, males and females of the gall-thrips remain quiescent for some time and later congregate at a place within the galls. Owing to the precocious development, males mature faster and try to copulate even on the 'O' day or the day of emergence. Receptivity of females to males was observed only after 1st or 2nd day of emergence. Gravid females migrate to younger leaves and buds to form new galls. Because of their confined habitat, both polyandry and polygamy appear quite common, but once copulated, females always resist further matings.

Reproductive System and Postembryonic Development of Ovary

A pair of paniostic ovaries is present, with each ovary comprising four ovarioles grouped on either side of the abdomen. The ovarioles in each group open posteriorly into the lateral oviducts which join to form a common median oviduct. While in all the thrips studied, each ovary comprises four ovarioles, with only *Lygothrips jambuvasi* (Ramakrishna), a gall-forming species on *Anogeissus latifolia* wall, appearing to be an exception in that each ovary is composed of only two ovarioles.

Muller (1927), Melis (1934), and Davies (1961, 1969) have discussed histological details on the internal changes taking place during pupal stages. Heming (1970) observed that in the prepupal stage the first indication of the approaching division of each ovary of the ovarian rudiment into four ovarioles appears in the cells of median ligament. These cells are arranged in eight rows, each row eventually becoming a terminal filament of one ovariole. Present observations also confirm Heming's findings (figures 1, 2 & 3). In the prepupal stage the ovarian rudiment appears as two flattened structures, the oviduct being long and thin. Each of them begins to divide into four ovarioles only during the first pupal stage (figure 1), the partition commencing from the apical end towards the base. The large oocytes situated in the posterior region of each rudiment are arranged serially in four rows. During the first pupal stage, the four ovarioles are separated from each other, and in the second, they coalesce at their apices into a common germarium. In *Androthrips flavipes* all the four ovarioles coalesce to form a common germarium (figure 3), whereas in the rest of the gall-forming species they fuse in pairs at their apices

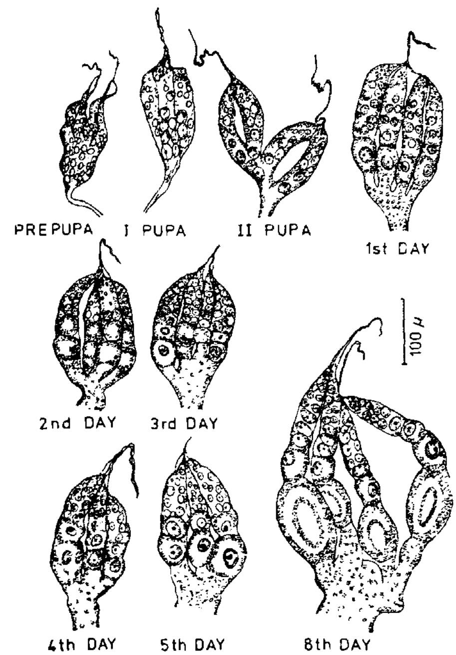

Figure 1 Postembryonic development of ovary in *Crotonothrips dantahasta*

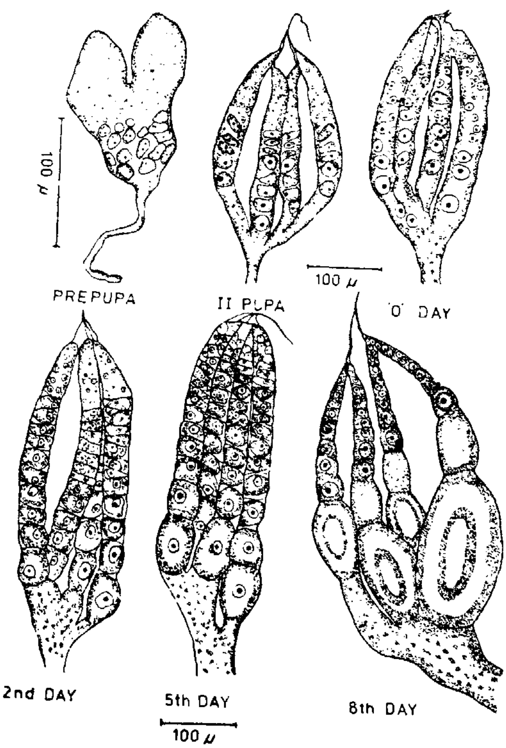

Figure 2 Postembryonic development of ovary in *Arrhenothrips ramakrishnae*

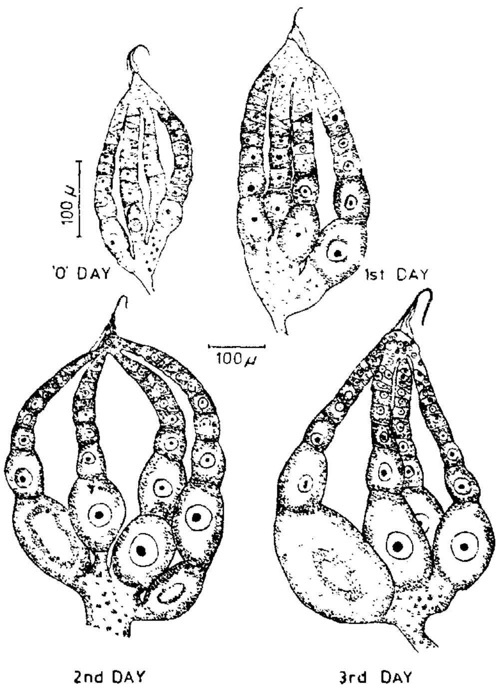

Figure 3 Postembryonic development of ovary in *Androthrips flavipes*

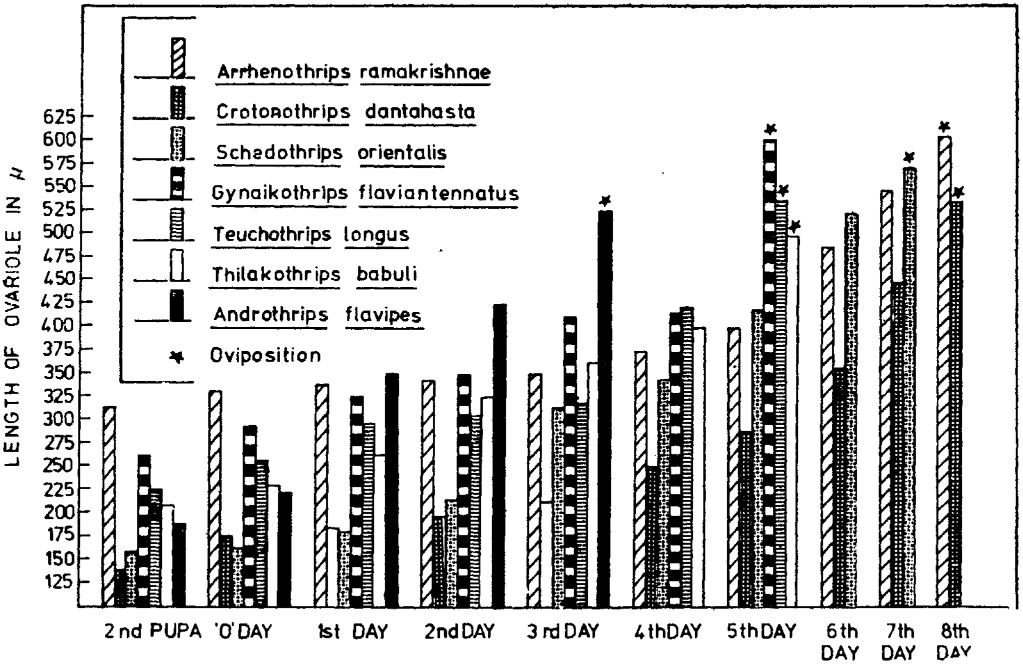

Figure 4 Postembryonic growth of ovary among different gall thrips

(figures 1 & 2). With the development of the individual ovarioles and their basal oocytes from the 'O' day, changes in their length/width occur.

The rate of development of the ovarioles and individual oocytes shows a distinct correlation with that of preoviposition period in different species (figure 4). In *A. ramakrishnae* and *C. dantahasta*, the preoviposition period is the same, as long as eight days, there occurs a gradual growth in the individual ovarioles and oocytes from the second pupa to the second day adult and a steep rise from the third day up to oviposition. Ovariole development in *S. orientalis* appears gradual up to the fourth day, and the length and width increase from the fifth day onwards. Growth of ovarioles and basal oocyte is steady and gradual from the second pupa through oviposition day in *G. flaviantennatus*, *T. longus*, and *T. babuli* and the preoviposition period is comparatively short. In the predatory thrips, *A. flavipes* the development of ovarioles and individual oocytes presents a unique pattern; they grow enormously from the second pupa onwards up to the third day adult at which stage they begin to oviposit (figure 4).

Oviposition and Fecundity

Normally, one female (sometimes along with a male) of *A. ramakrishnae* inhabits a fresh gall and only in rare instances do two females occupy the same gall. They lay their eggs in a cluster on the surface in the midrib area near the base, at the apex, or in the middle of the gall. If two females occupy the same gall, each lays its eggs in separate clusters. In the case of other thrips, viz., *G. flaviantennatus*, *S. orientalis*, *T. longus*, *C. dantahasta*, and *T. babuli*, more than one female occupy the same gall and oviposit. *G. flaviantennatus* and *T. longus*, which occupy comparatively spacious galls, lay their eggs scattered all over the inner surface of the gall. *S. orientalis* and *C. dantahasta*, which inhabit rather small areas lay the eggs in a crowded manner. *T. babuli*, occupying the rosette galls, oviposits at the inner basal surface of the leaflet. The predatory inquiline, *A. flavipes*, deposits its eggs in groups near or between the egg clusters of *A. ramakrishnae*. In the other cases, this predator lays eggs, also in groups, but only in areas where numerous host eggs are found. In a gall only one female of *A. flavipes* is seen, two females rarely inhabit the same gall to deposit their eggs. The oviposition records and the fecundity of gall-thrips is given in figure 5. Out of the six mating pairs of *Arrhenothrips ramakrishnae*, outlined earlier, the major female-gynaecoid male pair laid the largest number of eggs in the laboratory and in the field conditions. The egg laying sequence, oviposition rate, and fecundity of different mating pair are given in table 1, and the bar-chart (figure 6) shows the resulting offspring of the different mating types.

Postembryonic Development

Observations on the duration of life cycle of gall-thrips were made in the laboratory. The nymphs start feeding on the host-plant soon after hatching and, as the duration of oviposition is spread over a long period and the larvae do not leave the gall, all immature stages are associated together in the same gall.

Gall-thrips complete the life cycle almost in a month (table 2) coinciding with the monthly production of young leaves in their respective host plants (Varadarasan & Ananthakrishnan 1981). In species that occur throughout the year viz., *A. ramakrishnae*, *S. orientalis*

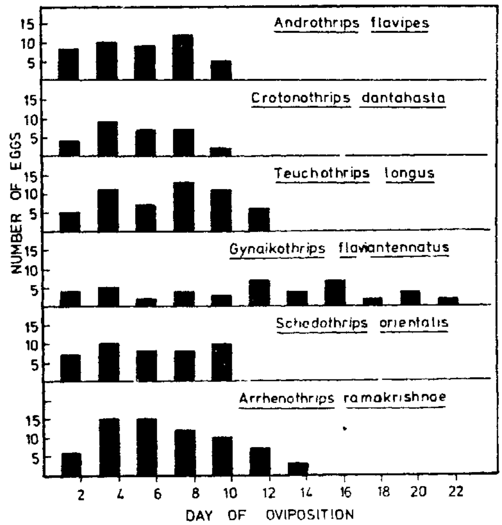

Figure 5 Oviposition records of gall thrips (egg count made every 2nd day)

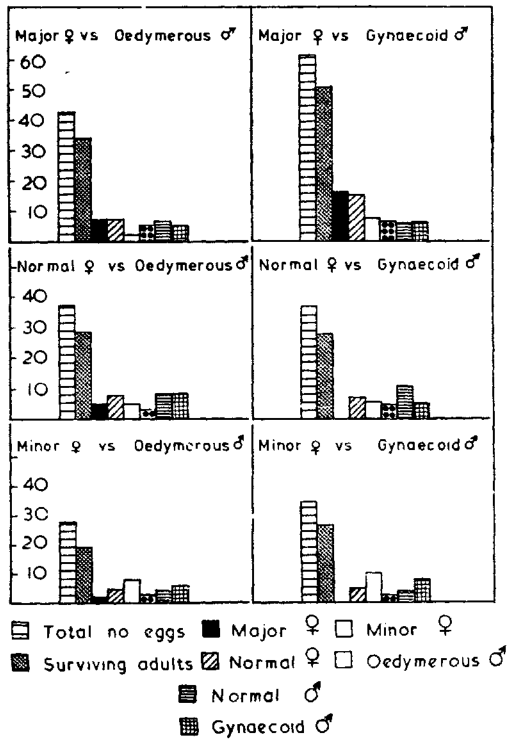

Figure 6 Fecundity number and progeny variation among different mating types of polymorphic *Arrhenothrips ramakrishnae*

Table 1 *Fecundity, rate of oviposition and egg-laying sequence of different mating types of* Arrhenothrips ramakrishnae *in laboratory and field conditions*

	Fecundity–No. of eggs	Oviposition rate/day	Egg-laying sequence
Major female vs gynaecoid male			
Field	68	5.6	2,4,7,8,8,7,6,6,5,5,4,3,3
Laboratory	48	5.3	3,5,6,6,6,5,6,4,5,2
Major female vs oedymerous male			
Field	47	4.8	3,4,2,5,6,6,4,7,8,2
Laboratory	30	5.0	3,4,7,8,6,2
Major female vs gynaecoid male			
Field	29	3.0	2,1,4,6,4,5,4,2,1
Laboratory	18	3.3	2,4,3,2,5,2
Normal female vs oedymerous male			
Field	40	4.6	2,5,1,2,7,8,5,7,3
Laboratory	22	3.6	3,5,2,5,5,2
Minor female vs gynaecoid male			
Field	42	5.0	3,4,5,4,6,7,6,5,2
Laboratory	20	3.0	2,3,4,5, 4,2
Major female vs oedymerous male			
Field	25	3.0	2,2,3,6,5,4,2,1
Laboratory	18	3.0	2,3,5,4,2,2

Table 2 *Comparison of the duration of developmental stages of the predatory inquiline and gall-making species (average of 6 replicates)*

Species	Incubation	I Larva	II Larva	Pre-pupa	I Pupa	II Pupa	Total
Predatory inquiline:							
**Androthrips flavipes*	**4–6	3–4	2–3	1	2–3	1–2	13–16
Gall-forming species:							
Arrhenothrips ramakrishnae	5–6	3–4	4–5	1	2–3	1–2	16–21
Schedothrips orientalis	5–8	2–3	4–5	1–2	1–2	2–4	14–21
Gynaikothrips flaviantennatus	7–9	4–5	4–5	1–2	1–2	2–4	19–27
Crotonothrips dantahasta	6–8	3–4	3–4	1	3–4	3–4	19–25
Teuchothrips longus	4–7	5–6	3–6	1–2	1–2	3–4	17–26
Thilakothrips babuli							
Rosette gall	5–6	3–4	2–3	1	2	2–3	15–19
Floret gall	4–5	3–4	2–3	1	2	2–3	14–17

* Duration of development stages were studied supplying with *Arrhenothrips ramakrishnae* pupae

** in days

and *G. flaviantennatus*, *T. longus* and *C. dantahasta*, which are seen abundantly only for seven months, 7–8 generations in a year are observed. *T. babuli* population is seasonal, with a span of 40–45 days in the rosette galls and 20–25 days in the floret galls. In the former, the gall-maker completes 2–3 generations while in the latter there are 1–2 overlapping generations. There is considerable reduction in the duration of life cycles of this gall-former in the floret galls compared to the duration in the rosette galls. The incubation period and the duration of various stages of the gall-thrips are given in table 2.

Discussion

As in free-living thrips (Lewis 1973), the sex ratios of all gall-thrips studied show an abundance of females. Besides, *Thilakothrips babuli* which inhabits rosette/inflorescence galls, exhibits distinct morph ratios in different seasons. When they are in abundance, the population includes alate males and females, as well as brachypterous females. But during diapause the alate and brachypterous females are totally absent and only apterous females and very few males have been recorded. These diapausing apterous females have heavy granulations on their body and it may be for tiding over the adverse conditions. Similar observations have also been made where thrips exhibit structural and colour differences in the overwintering generations, as in *Thrips angusticeps* (Ward 1966). Such morphological variations are not seen in *Teuchothrips longus* and *Crotonothrips dantahasta*, which undergo 'akinesis' or temporary diapause. The ovaries of diapausing *Thilakothrips* are considerably different from those of normal females, with no indication of any oogenesis and vitellogenesis the few oocytes that are present not showing any follicular cells.

The internal male and female reproductive organs of gall thrips resemble those of the other Tubulifera studied (Lewis 1973). Cary (1902) described five ovarioles on each side in *Anaphothrips striatus* Osborne, Sharga (1933) recorded in *Aptinothrips rufus* totally nine ovarioles arranged in groups of five and four on either side. But in all the gall-thrips studied, each ovary is composed of four ovarioles. *Lygothrips jambuvasi*, may be mentioned as an exception wherein there are only two ovarioles in each ovary.

Mating is accomplished within old galls ensuring successful insemination of all females and such females migrate in search of young leaves for further gall-induction (Varadarasan & Ananthakrishnan 1981). This accounts for the absence of males in most young galls where newly migrated females are seen.

Heming (1970), who has described in detail the post-embryonic development of ovary in *Frankliniella fusca* (Hinds) and *Haplothrips verbasci* (Osborne), observes that changes in the rudimentary embryonic ovary commence from the prepupal stage onwards when the apices of germaria show a separation into distinct terminal filaments. He further reports that ovariole separation is attained before the embryo reaches the first pupal stage. In the present study the fusion of apices of ovarioles was observed to commence as early as the second pupal stage. In all the gall-forming thrips the apices of only two ovarioles are involved resulting in a pair of two fused ovarioles on each side, the adult showing four common germaria shared by eight ovarioles (figures 1 & 2). In the inquiline *A. flavipes* such a fusion involves the apices of all four ovarioles on one side and adults possess two common germaria, each shared by four ovarioles (figure 3). Haga (1975) has attempted to classify Tubulifera on the basis of fusion of germaria. The rate of development of the ovary is faster in the predatory inquiline *A. flavipes* (3 days), than the other gall-forming thrips (figure 4), an adaptation for a predatory life.

The egg-laying pattern of the gall-thrips varies in accordance with the type of gall they occupy. *A. ramakrishnae* inhabiting fold galls lay eggs in a cluster and *T. babuli* occupying the rosette galls oviposit along the basal inner surface of each leaflet, while other gall-thrips occupying leaf roll galls lay their eggs in a scattered manner. *A. flavipes*, the predator, invariably deposits the eggs near the egg clusters of its host or between eggs scattered in a 'crowded' fashion. This ensures ready food for the emerging larvae of the predator. The total number of eggs laid by each gall-thrips varies and can be correlated with the length of the ovarioles at the time of oviposition. It is evident that the greater the length of the ovariole, the greater will be the number of oocytes, and more the number of eggs laid. It is interesting to note that the predatory inquiline completes its life cycle much faster than the gall-forming thrips, a specialized adaptation for this predator. The inquiline inhabits the galls only after the cecidozoa have established their population, feeds on the gall-thrips, and completes the life cycle earlier than the cecidozoa. A similar adaptation is seen in *Thilakothrips babuli* which completes the life cycle faster in the floret galls than in the rosette galls (table 2). This acceleration is only to complete its life cycle before the inflorescence of *Acacia leucophloea* gets dried up.

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