

Thrips-fungus association with special reference to the sporophagous *Bactrothrips idolomorphus* (Karny). (Tubulifera: Thysanoptera)

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Abstract. Aspects of feeding and fungal spore preference in terms of the percentage of gut-spore composition, and the relative preference of sporophagous Tubulifera to Coelomycetes, Ascomycetes, Hyphomycetes are highlighted. A positive correlation between the width of the maxillary stylets and the fungal spore size indicates the relationship between the two in the choice of the spore type for feeding. The incidence of reproductive polymorphism among the majority of large spore feeding thrips and their absence in hyaline spore feeders, the role of abiotic factors such as temperature and relative humidity in determining the type of reproduction and their influence on the post-embryonic development in *Bactrothrips idolomorphus* are discussed. Numerical variation in the pre-vitellogenic, vitellogenic and developing oocytes during oviparity, ovoviviparity and viviparity is also discussed.

Keywords. Fungal spore selectivity; fungal associates; reproductive polymorphism; maxillary stylets; *Bactrothrips idolomorphus*.

1. Introduction

Life cycles of mycophagous thrips species are intimately linked with the availability as well as utilization of fungal food resources. Different fungal food resources occurring in the same ecological niche have diverse influence on the life cycles of the sporophagous thrips species (Ananthakrishnan *et al* 1983a). Ecological succession of both mycophagous thrips species as well as their fungal food resources appear equally important and in many cases there appears to be a synchronisation of fungal growth and appearance of thrips species. While the role of biotic factors such as fungal food resources appears obligatory in the build-up of mycophagous thrips populations, the role of abiotic factors involving temperature and relative humidity in indirectly promoting the availability of host plants and their inhabiting fungal resources, also appear equally important. The tendency to aggregate also considerably influences the incidence of reproductive polymorphism, so that the biology of mycophagous thrips appears intimately interwoven with some of the above factors. Ananthakrishnan *et al* (1983b) for the first time attempted to study the impact of several environmental factors such as adverse climate, fungal food availability and aggregation behaviour in determining the type of reproduction. The results presented aim at an analysis of the feeding and breeding behaviour in terms of the availability of the fungal resources of some mycophagous thrips with special reference to *Bactrothrips idolomorphus* (Karny).

2. Materials and methods

Adults, larvae, pupae and unhatched eggs of *B. idolomorphus* were collected from dried fungi infested leaves of *Shorea robusta* Gaertn. F. from Sirumalai hills (1600-1700 MSL),

reared in plastic vials (3.4 × 4.5 cm) and trays (30 × 45 cm) with wet soil (to facilitate the fungal growth) and provided with fungi-infested leaves for feeding. One set of cultures were kept at 25°C, 80% RH and another set at 30°C, 90% RH in a BOD incubator. Other sporophagous thrips viz *Priesneriana kabandha* (Anan.), *Loyolaia indica* (Ramk.) etc., were cultured as indicated by Ananthkrishnan *et al* (1983b). Both the fungal spores obtained from the thrips gut as well as from the scraping of the host material were cultured in (i) potato-dextrose-agar medium, (ii) oat meal agar medium and (iii) Czapek's medium. The cultured fungi were mounted in lactophenol and stained with cotton blue (Ananthkrishnan *et al* 1983a; Ananthkrishnan William James 1983). Ovarian studies were made as indicated by Ananthkrishnan *et al* (1983b).

3. Observations

3.1 Fungal spore selectivity and fungal resource exploitation

Contrary to most of the mycetophagous thrips species with narrow (0.85–1.7 μ) maxillary stylets, in *B. idolomorphus* the maxillary stylets are comparatively broad enclosing a wider groove, the width of which primarily determines the size and nature of the fungal spore they feed on. The width of the maxillary groove in *B. idolomorphus* ranges from 13–13.5 μ enabling the thrips to feed on the large spores, including both mature and immature spores of *Lasiodiplodia theobromae* (Pat.) Griff and Maubl. (= *Botryodiplodia theobromae*) (12–13 μ), unidentified ascospores (6.1–9 μ), as well as on the spores of *Pestalotia* (6.5–8.2 μ). They were never observed to feed on the smaller spores of *Penicillium* sp, *Aspergillus niger*, *A. flavus*, *Mucor* sp and other hyphomycetes (0.5–1.7 μ), which occurred in the same niche. The width of the maxillary groove indicated general similarity in all larval and adult stages and hence both larvae as well as adult thrips exhibited a similar fungal feeding tendency and preferred the larger spores like *L. theobromae*, *Pestalotia* sp. and unidentified ascospores.

B. idolomorphus, in so far as has been noticed both in the field as well as in the laboratory, exhibited a diversity in fungal food utilisation, but showed a restricted or narrow niche diversity. *B. idolomorphus* occurs as dense aggregates of 22–67 individuals per dried leaf and the time taken to completely exploit the fungal resource of a single leaf ranges from 1–3 days, depending upon the number of individuals in a colony. The adult also exhibits movements of colony as a whole from one branch to another of fungus infested leaves, and the time lapse involved in completely utilising the fungal food of a branch ranges from 7–10 days. *B. idolomorphus* is highly specific to the large and darker spores in the absence of which, they never attempted feeding on the other spores infesting the same niche. Similar cases of specificity towards spores as well as to specific niches have been observed in *Tiarothrips subramanii* (Ramk.) and *Elaphrothrips denticollis* (Baghall) inhabiting the fungi infested leaves of *Borassus flabellifer* and *Areca catechu* respectively, the former being specific to the large and darker spores like species of *Anthostomella*, *Pestalotia algeriensis* and *Melanographium citri*, and the latter to *Pestalotia* sp. *B. idolomorphus* did not feed on the spores of *P. algeriensis* infesting the *B. flabellifer* spores of *L. theobromae* infesting *Mangifera indica*, indicating their selectivity towards species specific fungus as well as their niche specificity.

3.2 Fungal associates and gut spore composition

B. idolomorphus, a large spore-feeding thrips has been observed to feed on the spores of Coelomycetes and Ascomycetes infesting the drying leaves of *Shorea robusta*. Gut-spore analysis of both adults as well as larvae in the field revealed the presence of spores of *Pestalotia* sp. (Coelomycetes), mature and immature spores of *L. theobromae* (= *Botryodiplodia theobromae*) (Coelomycetes) and ascospores of an unidentified Ascomycetes (figure 1). Gut spore analysis revealed that they mainly fed on the spores of *Pestalotia* sp. (47.44%) and unidentified ascospores (48.85%). Both adults and larvae preferred to feed more on mature spores of *L. theobromae* (3.3%) than on immature spores (0.39%). Undigested spores were located in the I zone of the mid gut, whereas in the II zone of the mid gut, more of the spores were either in a partially digested condition or in the process of digestion.

Of the total of five species of sporophagous thrips so far studied, viz *Dinotrrips sumatrensis* (Bagnall), *E. denticollis*, *Loyolaia indica* (Anan.), *Priesneriana kabandha* (Ramk.) and *T. subramanii* fed on the 17 species of fungal spores, which includes 5 species of Ascomycetes (29%), 9 species of Coelomycetes (63%) and only 3 species (8%) of Hyphomycetes. Sporophagous thrips species showed preference in the order Coelomycetes, Ascomycetes and Hyphomycetes.

3.3 Reproductive polymorphism

Reproductive polymorphism, essentially involving diverse modes of reproduction viz oviparity, partial and complete ovoviviparity and viviparity, is a significant adaptation exhibited by the sporophagous idolothropines, to overcome the rigours of the environment (Ananthakrishnan *et al* 1983b; Viswanathan and Ananthakrishnan 1973). This diversity is well represented in majority of the large spore feeding thrips like *B. idolomorphus*, *E. denticollis*, *E. procer* (Schmutz) and *T. subramanii*. However such a reproductive polymorphism is not evident among hyaline spore feeders and mycetophagous thrips species. Factors such as environmental conditions, fungal food availability and aggregation behaviour either independently or in combination appear to trigger reproductive polymorphism. Field observations revealed the occurrence of both oviparity and ovoviviparity in *B. idolomorphus*, whereas under laboratory conditions, all the three types of reproduction were noticed. Under a normal field temperature of 28°C and 92% RH the oviparous females laid 27 eggs and the preoviposition period was three days. When reared at 25°C and 90% RH, reproduction was by oviparity and the preoviposition period was three days. The incubation period ranged from 8–9 days, and 36 eggs were laid at the rate of 4–5 eggs/day. When reared at 30°C and 80% RH they reproduced both by ovoviviparity and viviparity. The incubation period ranged from 1–2 days when reproduction was ovoviviparous, each ovoviviparous individual laying 2–12 eggs in a scattered manner, with a mean of 1–2 eggs per day, whereas 10–17 larvae emerged in viviparous forms with a mean of 2–3 larvae per day. Variations were evident in pre-oviposition period in the oviparous and ovoviviparous individuals and pre-larviposition period in viviparous individuals, ranging from 9–15 days in viviparous forms, a comparatively shorter pre-oviposition period ranging from 5–7 days in ovoviviparous individuals and a very short pre-oviposition period of about 3 days in oviparous forms. The incubation period was indirectly proportional to the pre-oviposition period/pre-larviposition period; being

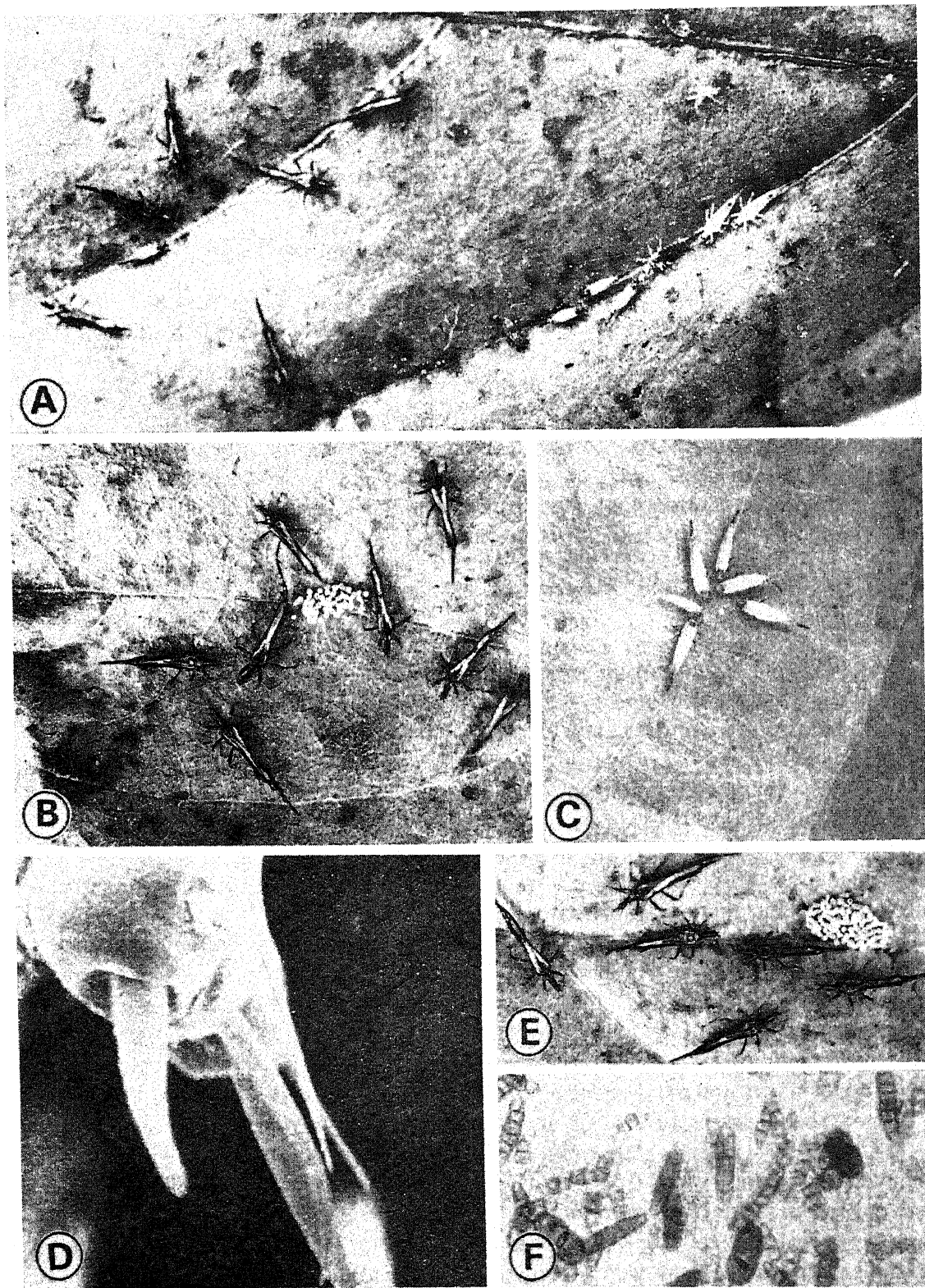


Figure 1. A. Adults, Pupae, and Larvae of *Bactrothrips idolomorphus* in fungi infested leaf of *Shorea robusta*; B & E. Adults of *B. idolomorphus* with the egg mass; C. Orientation in second larvae of *B. idolomorphus*; D. Scanning Electron Micrograph of Sensilla on the maxillary palp of *B. idolomorphus* (for spore recognition); F. Gut spores of *B. idolomorphus* showing *Lasiodiplodia theobromae*, *Pestalotia* sp. and an unidentified ascomycetes.

longest among oviparous forms (9 days), comparatively shorter (1–2 days) among ovoviviparous individuals, while in viviparous individuals, larvae emerged as such.

Eggs were laid in vertical clusters, each cluster with 27–154 eggs. However under laboratory conditions, the ovoviviparous individuals laid eggs in a scattered manner, each group having 1–2 eggs. Under laboratory conditions no egg mortality was observed. The fecundity also greatly varied with the type of reproduction, being highest (36 eggs/female) in oviparous forms and comparatively low among ovoviviparous individuals (2–12 eggs/female) and viviparous individuals (10–17 larvae/female). Like many other sporophagous Idolothripinae studied, *B. idolomorphus* also exhibited a greater tendency for egg guarding, where both male and female sit over the egg cluster or in the vicinity of the egg cluster. However no defensive behaviour was noticed. When a female guarding an egg mass was separated and introduced in the vicinity of another egg mass, they did not take over the function of guarding the eggs. A similar tendency was also exhibited by other large spore feeding thrips.

In addition to normal variation in the pre-oviposition/pre-larviposition period, incubation period and fecundity, considerable variation in the number of oocytes accumulated with yolk (vitellogenic oocytes) and the number of developing oocytes in the lateral oviduct was also observed. However the number of oocytes (6–16) in the developing stages of the ovarioles (pre-vitellogenic oocytes) did not show any significant change. But the number of eggs laden with yolk material (vitellogenic oocytes) were numerous (4–5) among oviparous forms and the number of oocytes undergoing subsequent development in the lateral oviduct was numerous among viviparous forms (5–12) than the ovoviviparous ones (9).

The duration of development of the immature stages also appeared to be greatly influenced by temperature and RH, a longer time being taken to complete development at lower temperature of 25°C. When reared at 25°C and 90% RH the incubation period of the eggs, first larval, second larval, pre-pupal, first pupal and second pupal duration ranged from 7–9, 2–5, 3–7, 1–2, 1–2, and 2–3 days respectively. The total duration of development ranged from 16–28 days. When reared at 30°C and 80% RH the incubation period was 1–2 days in ovoviviparous forms, first larval duration 2–3 days, second larval duration 3–6 days, prepupal duration one day, first pupal duration 2–3 days and second pupal duration 1–2 days, the total duration thus completed in 10–17 days.

4. Discussion

The present observations on the fungal association of *B. idolomorphus* indicated that they preferred to feed only on the dark, larger spores and not on the smaller, spores (*Aspergillus* sp, *Mucor* sp, *Penicillium* sp etc.) which occurred in the same niche. This has also been reported by Haga (1972) in *B. brevitubus* feeding on the spores of *Leptosphaeria* sp (*Pestalotia* sp) exhibiting a wider range of fungal food utilisation. The occurrence of a higher percentage of *Pestalotia* sp and unidentified ascospores in the gut of *B. idolomorphus* indicates their preference towards these spores than the spores of *L. theobromae*. The positive correlation between the width of the maxillary groove and the width of the spores they feed on clearly indicated the role of these maxillary stylets in fungal spore selectivity. The avoidance of several comparatively smaller spores of Hyphomycetes reflected spore selectivity in many of the large spore feeding thrips. The present observations suggest that sporophagous thrips species so far

studied showed preference in the order of Coelomycetes, Ascomycetes, Hyphomycetes and they never fed on the spores of Basidiomycetes or on lichens.

Incidence of diverse modes of reproduction in *B. idolomorphus* indicates their ability to adapt to all environmental fluctuations and overcome fungal food scarcity. The incidence of ovoviviparity as well as viviparity at higher temperatures and RH seems to be an adaptation by this species for survival. Similar observations on the influence of environmental factors in determining the type of reproduction were reported in *Tiarothrips subramanii* (Ramk.), *Elaphrothrips denticollis* (Bagnall), *E. procer* (Schmutz), (Ananthkrishnan *et al* 1983b), *Caudothrips buffai* Hood (Bournier 1957, 1966), and *Megathrips latriventris* (Heeger) (John 1923).

The duration of the pre-oviposition period is indirectly proportional to the duration of the incubation period. As the pre-oviposition period of the ovoviviparous individuals extended, the incubation period correspondingly reduced. However, among the viviparous forms, the pre-larviposition period is enormously long and hence the young ones emerge as such. The retention of the developing oocytes in the lateral oviduct to facilitate further development, is influenced by several environmental factors, which in turn induce the endogenous factors for their retention. Observations on the role of temperature on the duration of egg development of *B. brevitubus* by Haga (1974) also support the present observations. Similarly, Loan and Holdaway (1955) also reported that incubation period of eggs of *Haplothrips niger* was 4–6 days at 25°C under laboratory condition, and 10–12 days in the field.

Under field conditions as well as under laboratory conditions, *B. idolomorphus* laid their eggs in a vertical cluster. Ovipositional behaviour of *B. idolomorphus* very much resembles that of *B. brevitubus*, (Haga 1974, 1980) except for a small variation in the number of eggs in each cluster. The eggs were always glued vertically to the dorsal surface of the host leaf, on its posterior pole. Vertical egg clusters also appear specific among *Elaphrothrips denticollis*, *E. procer* and *Meiothrips menoni* (Ananthkrishnan *et al* 1983b). Like many other sporophagous thrips, *B. idolomorphus* also exhibit a greater degree of parental care towards their eggs. Presence of either male or female of *B. brevitubus* close to their egg mass has been reported by Haga (1974).

The number of pre-vitellogenic oocytes is more or less similar in all oviparous, ovoviviparous and viviparous ovarioles, but the number of vitellogenic oocytes and the number of oocytes undergoing embryonic development in the lateral oviduct vary considerably. In oviparous forms, the basal oocytes are fully laden with yolk to facilitate egg development after they are laid. In viviparous ovaries, the pre-vitellogenic oocytes itself descends down the lateral oviduct, where they receive the nutrients directly from the haemolymph. However, among the ovoviviparous forms, the basal oocytes of the ovarioles are provided with only little amount of reserve yolk, and as they descend through the lateral oviduct, they also derive the nutrients from the haemolymph for normal embryonic development. When the eggs are laid in a partially developed condition as in ovoviviparous forms, further development continues with the yolk reserves.

Considerable variation in the duration of the development of immature stages under different temperatures and RH, as well as variation among the two species of *Bactrothrips* viz *B. idolomorphus* and *B. brevitubus* were noticed, the former taking a longer time to complete post-embryonic development than the latter. Observations by Ananthkrishnan *et al* (1983a) on the role of different fungal food on the duration and rate of post-embryonic development of *T. subramanii* further support the influence of fungal food in the variation in the developmental duration.

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