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Patterns of fungal resource utilization and feeding range in some mycophagous Tubulifera (Insecta: Thysanoptera)

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Abstract. Adaptive specialization in terms of survival due to diverse fungal feeding preferences and seasonal dispersal is indicated in the sporophagous species *Loyolaia indica* (Anan). Feeding behavioural patterns of six species of mycophagous Tubulifera reflect diversity in fungal resource utilization and feeding range. Influence of fungal food on the strategies of survival, reproduction and aggregation has been discussed.

Keywords. Mycophagous thrips; fungal resource utilization; feeding range; mycophagous tubulifera; *Loyolaia indica*.

1. Introduction

Feeding processes in mycophagous thrips as in phytophagous species involve ecological manipulations, an assessment of which appears to be an important aspect of their biology, particularly in view of feeding and growth being active, dynamic processes. Some sporophagous species like *Loyolaia indica* (Anan.) respond to changing environments by altering their physiological and behavioural processes entering reproductive diapause followed by efficient dispersal to more congenial niches with more adequate fungal food resources. The patterns involved in the feeding process particularly concerning the range of mycophagy — narrow *versus* wide, and associated exploitation of niches both for survival and reproduction also appear important. That reproductive strategies form an integral part of the adaptive strategy of individuals of a particular species has been confirmed in terms of their ability to reproduce by oviparity, ovoviviparity and viviparity (Ananthakrishnan *et al* 1983a). While considerable information is available regarding phytophagous thrips, that relating to feeding preferences and their influence on physiological and behavioural processes in mycophagous thrips appears very meagre (Joshi 1974; Ananthakrishnan *et al* 1983b and Ananthakrishnan and William James 1983). An attempt has, therefore, been made to assess aspects relating to fungal resource utilization in terms of their availability in specific niches as well as the patterns involved in such utilization.

2. Materials and methods

Adults, larvae, pupae and unhatched eggs of *Loyolaia indica* (Anan) *Tiarothrips subramanii* (Ramk.), *Dinothrips sumatrensis* Bagnall, *Priesneriana kabandha* (Ramk)., *Elaphrothrips denticollis* (Bagnall) and *Hoplothrips fungosus* Moulton, were collected from the field, reared in the laboratory with their natural fungus infected host material as food. The stock materials were maintained in BOD incubator at 27°C. For identification of specific species of fungi associated with the mycophagous thrips, the host scrapings and hand sections of the fungus infected host materials (for identification of fructifications embedded inside the host materials) were stained with lactophenol blue, mounted in lactophenol and identified. Host washings, washec host materials and the gut washings were subsequently plated on potato dextrose agar and oat meal agar media.

The specific feeding sites of the mycophagous thrips in the host material were fixed by observing the location of the colony/individuals, and cut pieces transferred to a 100 ml Erhlenmeyer flasks containing sterile distilled water (25 ml) over an UV lamp. This was shaken vigorously so as to bring the surface mycoflora into the sterile distilled water resulting in host washings. Once sterile distilled water washed host bits were transferred to another 100 ml Erhlenmeyer flask having sterile distilled water, washed well so as to remove any more surface fungi. This procedure was repeated by transferring the bits to 6-7 flasks containing sterile distilled water and washing them successively. The gut of the different sporophagous thrips was dissected out and washed with sterile distilled water. The dissected gut was slit open and the contents were released under aseptic conditions, diluted in sterile distilled water and plated on potato dextrose agar and oat meal agar media. The emerging individual colonies in the petri plates were picked out and transferred to the petri plates containing fresh media and individual pure cultures were obtained for identification. Comparisons were made of the fungi in the host sections, host scrapings, plating of washed host material and plating of host washings to gut spore content and the fed fungal species were identified.

3. Observations

Adaptive specialization in terms of thrips inhabiting specific niches on fungus infected hosts with preference to drying culms of grasses during acute summer, with a tendency to migrate to other hosts with the onset of more favourable conditions when diverse fungi become available, is typical of the spcies *Loyolaia indica*. Their restriction to drying grass tussocks as well as fungal infected basal drying sheaths of different grasses is correlated with a reproductive diapause when only adults are available during June-September. With the onset of more favourable conditions in September (28-33° C, 72% R H), the individuals reproduce oviparously, each adult female laying 2-5 eggs on hosts such as *Cynodon dactylon* Pers., *Panicum repens* L. and *Chloris barbata* SW. During the reproductive diapause (June-September) the adults survive in drying grass clumps consuming spores of *Fusarium oxysporum* and *Penicillium* sp., while during favourable seasons they feed on the spores of *Lojkania cynodontifolii* (on *Cynodon dactylon*), *Haplosporella* sp. (on *Chloris barbata*), as well as on bicelled spores and 4 celled spores (on *Panicum repens*), which appear essential for reproductive fitness. An analysis of the mycoflora at the niches occupied and the specific fungal spores consumed during favourable and unfavourable conditions revealed the relative preference to specific fungal species among the spectrum of fungal species available as indicated in table 1. Dispersal from drying grass clumps in the fields to the drying basal leaf sheaths of *Cynodon dactylon* (October-June) and *Panicum repens* (November-March) in the bunds appears characteristic of this species. In April-May the species occurred dispersed in the drying basal leaf sheaths of *Chloris barbata* (figure 1). Studies on the life cycle of this species on the grass hosts showed the mean duration to be around 15 days (incubation period of the eggs 3-4 days; Ist larvae 2-3 days; IInd larvae 4-5 days; prepupa 1 day; Ist pupa 1-2 days; IInd pupa 2-3 days). The change of microhabitats during different seasons, completion of life cycles during a particular season and the diverse feeding range of this thrips appear to be adaptive strategies.

Table 1. Comparative analysis of the fungal species fed by some species of mycophagous Thysanoptera.

Thrips sp.	Host	Fungal spores present: at the feeding site	Fungal spores present: in the gut (qualitative) (+/−)
Tiarothrips subramanii	Dry leaves of *Borassus flabellifer*	*Anthostomella phoenicicola*	+
		Anthostomella sepelibilis	+
		Anthostomella consanquinea	+
		Pestalotia algeriensis	+
		Melenographium citri	+
		Diplodia sp.	+
		Alternaria sp.	+
		Gnomonia sp.	+
		Camarosporium sp.	+
		Phoma sp.	+
		Coniothyrium palmarium	−
		Stigmina palmivora	+
Elaphrothrips denticollis	Dry leaves of *Tectona grandis*	*Pestalotia* sp.	+
		Phomopsis tectonae	+
	Dry leaves of *Areca catechu*	*Pestalotia* sp.	+
		Pythomyces sp.	−
		a pycnidial fungus	−
		Penicillium sp.	−
		Aspergillus niger	−
		Aspergillus sp.	−
	Dry twigs of *Zizypus oenoplea*	*Pestalotia* sp.	+
Loyolaia indica	Dry leaves of *Cynodon dactylon*	*Lojkania cynodontifolii*	+
	Dry twigs and clumps of grass	*Fusarium oxysporum*	+
		Penicillium sp.	+
		Torula herbarum	−
		Aspergillus niger	−
		Aspergillus flavus	−
		Aspergillus fumigatus	−
		Mucor sp.	−
Dinothrips sumatrensis	Dry bark of *Piper nigrum*	*Botryodiplodia theobromae*	+
		Verticicladium sp.	−
		Aspergillus niger	−
		Penicillium sp.	−
		Mucor sp.	−
	Dry bark of *Hevea braziliensis*	*Botryodiplodia theobromae*	+
		Fusarium oxysporum	−
		Penicillium sp.	−
		Aspergillus niger	−
	Dry bark of *Anacardium occidentale*	*Aspergillus niger*	−
		Botrydiplodia sp.	+
		Fusarium oxysporum	−
		a pycnidial fungus	−

Table 1 (Contd.)

	Dry bark of *Mangifera indica*	*Botryodiplodia theobromae*	+
		Candida sp.	−
		Mucor sp.	−
		Lichen	−
	Lannea coramandelica	*Botryodiplodia theobromae*	+
		Fusarium oxysporum	−
		Penicillium sp.	−
	Mallotus alba	*Botryodiplodia theobromae*	+
		Trichothecium roseum	−
		Graphium sp.	−
		Verticicladium sp.	−
		Penicillium sp.	−
Priesneriana kabandha	Dried thorny twigs	*Rhytidhysterium rufula*	+
	Dead bark of *Eucalyptus globulus*	*Cytospora* sp.	+

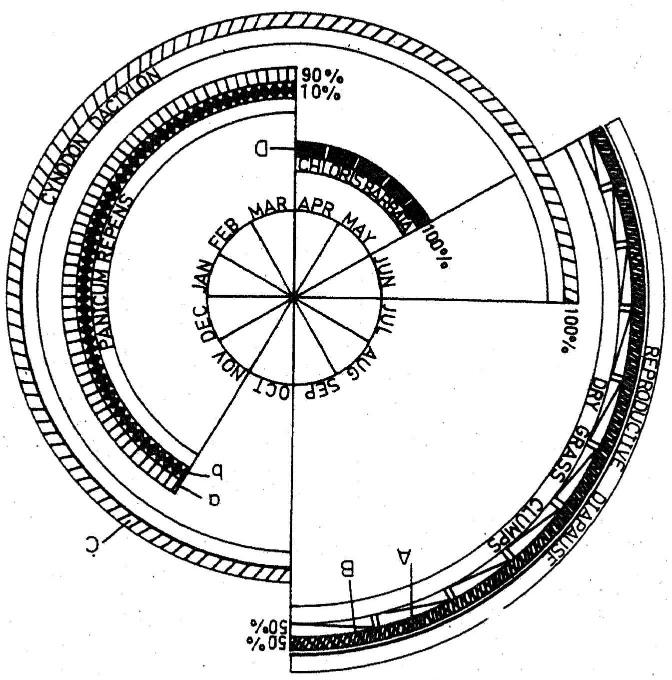

Figure 1. Seasonal incidence of *Loyolaia indica* on different grass hosts and gut spore composition when fed on different hosts **A.** *Fusarium oxysporum* **B.** *Penicillium* sp. **C.** *Lojkania cynodontifolii* **a.** bicelled spores **b.** 2-celled spores **D.** *Haplosporella* sp.

For a better understanding of niche diversity in relation to fungal feeding preference, an assessment of the feeding preference of four species of sporophagous thrips is made. An extreme case of specialization in food preference is offered by *Dinothrips sumatrensis* which when observed on the drying barks of different hosts (such as *Hevea brasiliensis* M. Arg., *Mallotus albus* M. Arg., *Lannea coromandelica* (Hoult.) Merril., *Piper nigrum* L., *Anacardium occidentale* L., and *Mangifera indica* L.) appear to feed only on *Botryodiplodia theobromae*. Niche diversity becomes a necessity to such species which have a highly specialized food preference. An opposite picture is evident in *Tiarothrips subramanii* inhabiting a single host (*Borassus flabellifer* L.) but showing a wider spectrum of fungal food utilization. Gut spore analysis of individuals of

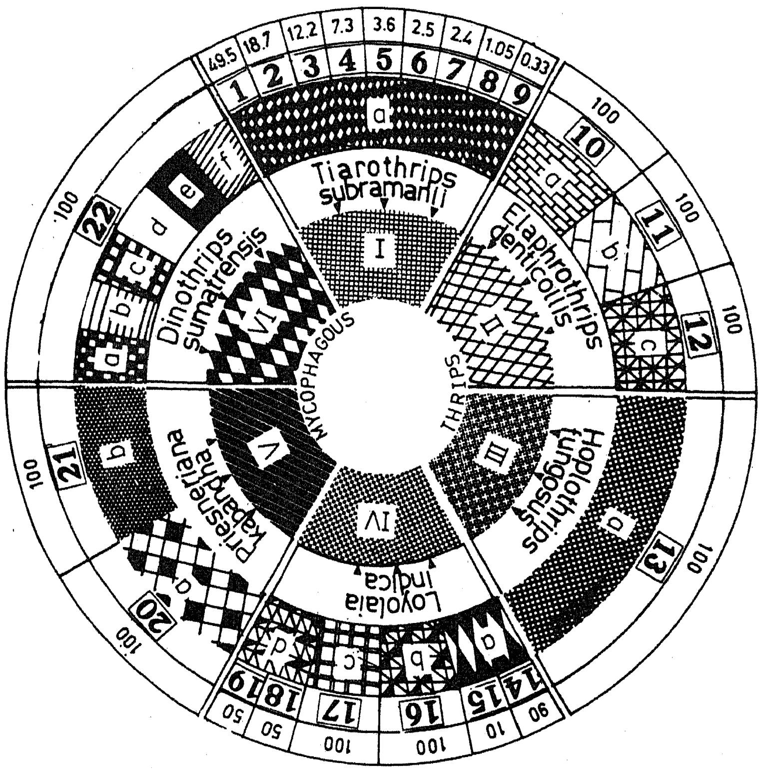

Figure 2. Thrips species, habitat diversity, fungal diversity and percentage of gut spore composition. **I.** *Tiarothrips subramanii* **a.** *Borassus flabellifer* **1.** *Anthostomella consanguinea* **2.** *Phoma* sp. **3.** *Diplodia* sp. **4.** *Anthostomella phoenicicola* **5.** *Stigmina palmivora* **6.** *Anthostomella sepeliblis* **7.** *Pestalotia algeriensis* **8.** *Gnomonia* sp. **9.** *Melanographium citri* **II.** *Elaphrothrips denticollis* **a.** *Tectona grandis* **10.** *Phomopsis tectonae* **b.** *Zizypus oenoplea* **11.** *Pestalotia* sp. **c.** *Areca catechu* **12.** *Pestalotia* sp. **III.** *Hoplothrips fungosus* **a.** *Polyporus* sp **13.** *Polyporus* sp. **IV.** *Loyolaia indica* **a.** *Panicum repens* **14.** bicelled spores **15.** 4-celled spores **b.** *Chloris barbata* **16.** *Haplosporella* sp. **c.** *Cynodon dactylon* **17.** *Lojkania cynodontifolii* **d.** Dry grass clumps **18.** *Fusarium oxysporum* **19.** *Penicillium* sp. **V.** *Priesneriana kabandha* **a.** *Eucalyptus globulus* **20.** *Cytospora* sp. **b.** Dry thorny twigs **21.** *Rhytidhysterium rufula* **VI.** *Dinothrips sumatrendsis* **a.** *Hevea braziliensis* **b.** *Piper nigrum* **c.** *Lannea coromandelica* **d.** *Mallotus albus* **e.** *Mangifera indica* **f.** *Anacardium accidentale* **22.** *Botrydiplodia theobromae* (Numbers in the outermost circle indicate percentage of spores in the gut).

natural population as well as the experimental feeding of the individuals on isolated fungi revealed the relative preferences among fungal species consumed (figure 2). Differences in the feeding preferences of individuals inhabiting different microhabitats of the same host (such as leaf folds, partially drying leaves, fallen and dried leaves of *Borassus flabellifer*) which harbour different species of fungi are equally evident; their presence in the folds of drying leaves throughout the year appears to provide an ideal microhabitat for the survival of the feeding thrips species.

Equally interesting are the species *Elaphrothrips denticollis* (which so far has been observed appears to feed on only *Pestalotia* sp. and *Phomopsis tectonae*) and *Priesneriana kabandha* (known to feed on *Rhytidysterium rufula* and *Cytospora* sp.) which have restricted food and host preferences as indicated in figure 2. Mycetophagous *Hoplothrips fungosus* known to occur in a wide range of habitats, also appear to utilize the fructifications of *Polyporus* sp.,the females laying their eggs within the numerous comb like structures of the fungus thereby ensuring sufficient food for the developing larvae. Other *Hoplothrips* species known to inhabit woody shelf fungi (*Polyporus* sp., *Ganoderma* sp. and *Sterem* sp.) are *Hoplothrips americanus* (Hood), *Hoplothrips angusticeps* (Hood) *Hoplothrips beachae* (Hinds) and *Hoplothrips terminalis* (Hood and Williams) (Graves and Graves 1970).

3.1 *Feeding behaviour and aggregation pattern*

Observations on the different thrips studied showed differences in the aggregation/dispersal pattern correlated with the food range diversity. *Tiarothrips subramanii, Elaphrothrips denticollis* and *Priesneriana kabandha* revealed aggregation/dispersal behaviour depending on the microhabitats occupied. Linear aggregations (3-1 cm × 0.5-1 cm) were typical of *Tiarothrips subramanii* within the folds of Borassus flabellifer, the dispersal pattern being evident on open surfaces of the leaves. Similarly *Priesneriana kabandha* and *Elaphrothrips denticollis* which form aggregations in the subcortical layers of *Eucalyptus globusus* and folded leaves of *Areca catechu* respectively, showed a dispersed pattern when on the surfaces of bark and leaves. The fungal flora in the diverse niches occupied by these thrips, as well as the nature of the consumed spores seem very different. In such microhabitats where the conditions appear conducive to luxuriant fungal growth as well as to the thrips (leaf folds and subcortical areas), aggregation behaviour by these thrips evidently appears typical. Dispersed patterns appear to be more characteristic with inhabiting leaf surfaces when conditions become more favourable for the growth of different fungi. In *Dinothrips sumatrensis*, though pupae were seen to aggregate, the larvae and adults tend to be dispersed, correlating with the restricted feeding range and openness of the microhabitats occupied and diversity in the fungal habitats. *Loyolaia indica*, a non-aggregating species, has a diversity in feeding range and host range as indicated earlier, and the influence of diverse fungal food consumed on their life cycle and reproductive fitness appears considerable. Observations on the feeding sites,fungal resources utilization, feeding range and dispersal by *Loyolaia indica* on different hosts during different seasons, revealed that dispersal is facultative being triggered by abiotic factors. Movements by species like *Loyolaia indica*, *Priesneriana kabandha* and *Elaphrothrips denticollis* could be categorised under dispersive movements, since they lack the behavioural patterns typical of migrants. In other words, it is a movement that occurs when the requirements of thrips change due to differences in feeding and microclimate (Southwood 1962).

4. Discussion

In phytophagous insects, the favoured host plant is something 'lived on' with the whole community as such being selected, so that the interaction between the host and the insect is direct and preference by the insect being towards survival, food and the community as a whole (Dethier 1954). In mycophagous thrips, the situation is further complicated in that the interaction is triangular, involving the insect species, the preferred microhabitat where the insect 'lives' and the fungal species that is fed upon. Hence, the preferred microhabitat by harbouring the needed specific fungal species as well as by providing the needed ideal microclimate, may directly/indirectly influence the survival of the thrips. Observations on feeding range and host preferences of six species of mycophagous thrips indicated diversity of patterns so that the trends in feeding and host preferences assume distinct advantageous adaptations for the survival of these thrips. A major observation that emerged from the analysis of food range and host preferences relates to the various categories of food range diversity among mycophagous thrips studied here *i.e.*, (a) highly restricted food range and niche diversity (*e.g.*, *Dinothrips sumatrensis*), (b) restricted food range and niche variability (*e.g.*, *Priesneriana kabandha* and *Elaphrothrips denticollis*) (c) diversity in food range and restricted niche variability (*Tiarothrips subramanii*) and (d) diversity in food range and niche variability (*e.g.*, *Loyolaia indica*). The observations also revealed that restricted food range and/or relative preference of food in different niches is generally coupled with niche-diversity, while diversity in food range is coupled with restricted niche variability. The restriction or relative preferences in fungal food may necessitate mycophagous thrips dispersing to various hosts which might harbour the preferred fungal species, while for the thrips having diverse food range and occupying an ideal microhabitat (which harbours the needed fungal species), dispersal to different sites appear unwarranted. Further, the nature of the microhabitat coupled with the tolerance/resistance of the host to the growth of specific species of fungi might exert a tremendous influence on the host preferences by mycophagous thrips. Nutritional factors as the basis for restriction/diversity in feeding preferences may be explained in thrips species showing a narrow or wide feeding range. The preference of spores to mycelia, the restricted preferences towards higher fungi and the preferential feeding of Coelomycetes and Hyphomycetes by some sporophagous thrips (having restricted feeding range) may have to be ultimately explained on the basis of nutrition, a factor which has to involve considerable amount of experimental evidence.

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References

Ananthakrishnan T N, Dhileepan K and Padmanaban B 1983a Reproductive strategies and behavioural attributes in some sporophagus idolothripinae (Tubulifera : Thysanoptera); *Proc. Indian Acad. Sci.* (*Anim. Sci.*) **92** 95-108

Ananthakrishnan T N, Padmanaban B and Dhileepan K 1983b Gut spore composition and influence of fungal hosts on the rate of mortality and post-embryonic development in *Tiarothrips subramanii* (Ramk.); *Proc. Indian Acad. Sci.* (*Anim. Sci.*) **92** 11-17

Ananthakrishnan T N and William James P 1983 Studies on Thrips-Fungal association — I. Feeding preferences in some sporophagous idolothripinae (Tubulifera : Thysanoptera); *Proc. Indian Natl. Sci. Acad.* **49** 86-92

Dethier V G 1954 Evolution of feeding preferences in phytophagous insects; *Evolution* **8** 35-54

Graves R C and Graves A C F 1970 The insects and other inhabitants of Shelf fungi in the southern blue Ridge region of Western North Corolina. IV. The Thysanoptera; *Ann. Entomol. Soc. Am.* **63** 96-98

Joshi G P 1974 The biology of *Stictothrips fimbriata* (Anan.) a mycohagous Thysanoptera on different meals; *Z. ang. Entomol.* **76** 146-149

Southwood T R E 1962 Migration of terrestrial arthropods in relation to habitat; *Biol. Rev.* **37** 171-204