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Book Review

LEWIS, T. 1973. Thrips. Their Biology, Ecology and Economic Importance. Academic Press Inc., London and New York. xv + 349 pp., 82 text-figures, 32 tables, 16 plates + front piece, 6 appendices, author and subject indices. Cloth \$24.20 (U.S.).

The title of this new book on Thysanoptera accurately reflects its contents. Its author, Dr. Trevor Lewis of the Rothamstead Experimental Station, England, is a productive contributor to the literature of the field covered and is well qualified to write it.

The book consists of an Introduction (Chapter 1) and 11 chapters arranged into 4 sections: Biology (3 chapters), Techniques (2), Ecology (4) and Economic Importance (2). The Introduction on historical background, structure and classification is only six pages long and is rather too brief, even considering the emphasis of the book. It adequately characterizes the order but there is no discussion of the phylogenetic relationship of thrips to other hemipteroids. Such information is useful when one is considering the comparisons Lewis makes with these insects in later chapters.

Chapter 2 is an up-to-date review of reproduction and development in Thysanoptera. Discussed are sexual differences, sex ratios, mating, eggs and oviposition, immature stages and annual cycles. Unfortunately, this chapter contains some lapses in fact and some unsupported generalizations, all indicating that many of the references cited remain unread. For example, there is no evidence that gynandromorphs in thrips “develop due to aberrant distribution of sex chromosomes” (p. 9) as Lewis says they do, since sex chromosomes have not been identified with certainty in any species of the order. That female thrips have panoistic ovarioles is not indicated even though their presence is probably one reason that individual females bear relatively few offspring (see Mahowald, A. P. 1972. Vol. 1 Developmental Systems: Insects). The “tube” leading to the “vas deferens” in males (p. 10) is the vas deferens. The structure to which Lewis gives this name is the seminal vesicle. Male thrips do not have a “spermatheca” in spite of his statement to the contrary (p. 11) – in fact no male insects do. In his discussion of mating behaviour, Lewis makes no mention of spermatophores even though such structures were shown to occur in several thripids by Bournier in 1956. Also, I know of no experimental studies that support his statement (p. 13) that “the sexes find each other by means of sense cones on the antennae” even though this is probably what happens.

In his discussion of immature stages, Lewis points out (p. 23) that “there are various ob-

jections” to the “larva-pupa” vs. the “nymph” terminology. He indicates only that “some aspects of the unique development of thrips resemble the development of typical hemimetabolous insects whose young are called nymphs, more than holometabolous ones whose young are called larvae”. In fact, all studies to date of metamorphosis in the order indicate that thrips are truly holometabolous – at least as much so as some of the less derived Endopterygota.

Plant interrelationships are the subject of Chapter 3. An accurate description of thrips mouthparts and how they are used is included. Interstitial dwellers, those species living in flower heads or grass sheaths, are particularly diverse. The grasses provide an abundance of suitable habitats of this type and Lewis suggests that this is why the Gramineae hosts more species of Thysanoptera than does any other plant family. These thrips are all strongly thigmotropic, each preferring crevices with walls opposed at varying angles from less than 0.5° to $> 1.5^\circ$.

Of some 5,000 described species of Thysanoptera, about 140 are gall formers with most of these being tropical or subtropical members of the Phlaeothripidae. Such galls, like those of cecidomyiid midges and cynipid wasps, can comprise a miniature ecosystem containing many interacting species, some of which are inquilines or predators and only one of which actually forms the gall.

The habits of some phytophagous species are bizarre. *Organothrips bianchi*, the taro thrips, develops in algal slime within the leaf axils of the host plant. Specimens of this species introduced into Germany have been able to adapt to living completely submerged on *Cryptocoryne* plants in aquaria.

Chapter 4 treats interrelationships of thrips with other animals and pathogens. Some of these relationships also are peculiar. The cacao thrips, *Selenothrips rubrocinctus* is an important, pantropical pest. In Malaya, a eucharitid wasp of the genus *Psilogaster* is frequently found in its company. Members of this genus parasitize ants. The female deposits 50 to 100 eggs in a circle around a single egg of *Selenothrips*. When the thrips hatches, it tries to escape through this surrounding palisade, thus stimulating some of the wasp eggs to hatch. The emerging planidia attach themselves to the larval thrips. Since ants are often observed carrying *Selenothrips* larvae in their jaws, this might provide an opportunity for the planidia of *Psilogaster* to transfer to the ant and to be carried back to the ant’s nest. The only error in this chapter is in Figure 28. C and D are propupae not larvae as is indicated in the legend.

That portion of the book that will be the most use to the majority of readers is section II. In Chapter 5 are detailed directions for rearing, for virus transmission studies and for long-distance transport of species with biological control potential. Also included are methods for measuring the response of thrips to physical variables of various kinds.

Sampling of thrips from a variety of habitats is discussed in Chapter 6 from the point of view of a field ecologist (Dr. Lewis is the author, with L. R. Taylor of *Introduction to Experimental Ecology* (1967) – a book dealing in detail with this and other aspects of ecological investigation). Sampling and extraction techniques are described for populations in soil and litter, on vegetation and flying. The sorting of such catches and experimental design are also treated.

Section III on Ecology provides, in one place, a great mass of information of use to entomologists studying thrips life histories. Locomotion, particularly flight, is the subject of Chapter 7. On being blown over a windbreak, flying thrips have a tendency to accumulate in large numbers under its lee in the same way that snow flakes or sand grains do. Numbers of thrips can be 2-to-14-fold higher in this location than elsewhere in a field. An applied entomologist, knowing this, can sample for pest species behind such obstacles, thereby recognizing invasions before the species multiply to economic threshold densities. Insecticides, applied to

fields only in areas adjacent to fences, hedgerows and windbreaks, would probably prevent outbreaks. (Practically all of the information in this very detailed chapter is the work of Lewis and his co-workers.)

Survival of Thysanoptera in unfavourable weather conditions is fully treated in Chapter 8. Both winter and dry-season survival is discussed including sites, mortality, ovarian diapause, flight inhibition and emergence from hibernation. Most thrips avoid adverse weather as adults under bark or in the soil.

Natural regulation of field populations of thrips is analyzed thoroughly in Chapter 9. (One is reminded, in this chapter, that some of the earliest, quantitative studies of animal population dynamics were carried out by Andrewartha on *Thrips imaginis* in Australia.) The numbers that single species can reach under ideal conditions can be impressive, especially in those species that are crop pests. *Limothrips cerealium*, the corn thrips, and Lewis' principal research animal, can build up to densities of 6-7 million/acre.

Chapter 10 considers species diversity and spatial distribution of Thysanoptera in different habitats. Numbers of species occurring in different habitats throughout the world range from 0 (Truelove Lowland, Devon Island, N. W. T., Canada) to more than 40 (dry steppe, N. Khazakhstan, U.S.S.R.). In temperate latitudes, grassland seems to support richer communities; in tropical areas, rainforests do. As would be expected, managed habitats contain fewer species in larger numbers than natural ones in similar climatic zones. In the latter there are usually several do-dominant species; in the former only one. Where the two habitats meet there is usually a transition zone which contains more species than either of the parent habitats.

Pests are specifically treated in Chapter 11. Only a few hundred species of thrips are pests and a relatively small number of these are of major importance. Most species are in the family Thripidae. The same crop grown in different parts of the world is usually infested by different species in each place. Only a few species are cosmopolitan (e.g. *Thrips tabaci*, the onion thrips). The sections on cultural, biological and chemical control of thrips add little not already fully covered in most recent textbooks of applied entomology.

The last chapter is short and summarizes what little use has been made of thrips in biological control programs. All evidence suggests that predacious thrips are unlikely to be key factors in any control program. *Liothrips urichi* on the other hand, was introduced into Fiji from Trinidad in 1930 to control Koster's curse (*Clidemia hirta*). This weed grows lushly to the exclusion of all other vegetation. Once established, the thrips so inhibited the growth of the weed that it was unable to compete with surrounding vegetation, and has since been no problem.

Fifty black and white photographs are gathered into 16 plates at the end of the book. These are well reproduced and illustrate various subjects treated elsewhere in the text. Included are habitats, mouthparts (stereoscan micrographs), crop damage, galls, phlaeothripid polymorphism (much more fully covered in Ananthakrishnan's recent (1969) book on Indian Thysanoptera), parasites, and two intriguing stereoscan micrographs of a corn thrips crushed between the growing "cheeks" of a wheat grain (such entrapped beasts are a significant source of contamination in milling flour.)

The bibliography contains about 685 titles of papers published throughout the world in most major languages. Some of these are monographic in scope and Lewis has provided yeoman service in bringing them together and discussing them thoroughly between one set of covers.

The six appendices are an unusual and valuable part of the book. The first is a list of faunal works listing thrips occurring in defined parts of the world. Some cover limited areas (e.g. Mound, L. A., 1970. Thysanoptera from the Solomon Islands); others the whole world (e.g. Jacot-Guillarmod's catalogue of the World Thysanoptera – reviewed earlier in this

journal (Quaest. ent. 8 (2): 123)). The third appendix is the longest and is in three parts. Part 1 is a list of thrips species, their parasites, and the place where the relationship was discovered. Part 2 is a similar list of their predators and Part 3 of predatory thrips species and their prey. Appendix 4 lists species associated with different habitats from different parts of the world. Appendix 5 lists insecticides, formulations, and dosages used against pest species and 6 is an alphabetically-arranged list of all generic and specific taxa mentioned in the text together with synonyms and common names. (Of 265 species mentioned from throughout the world, 39 occur in Alberta, Canada.)

The book is clearly written, well produced and is free of typographical errors. Many of the graphs have been reinterpreted and redrawn from older references in the light of recent research. In spite of the weaknesses mentioned in the second chapter, this is an important new work on Thysanoptera. It is essential reading for anyone beginning a study of Thysanoptera and should aid in improving the quality of applied research on thrips – much of which is now second-rate. On the dust jacket the publishers observe that “as a reference work *Thrips* is likely to be unchallenged for many years”. It is a pleasure to agree with this appraisal.

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