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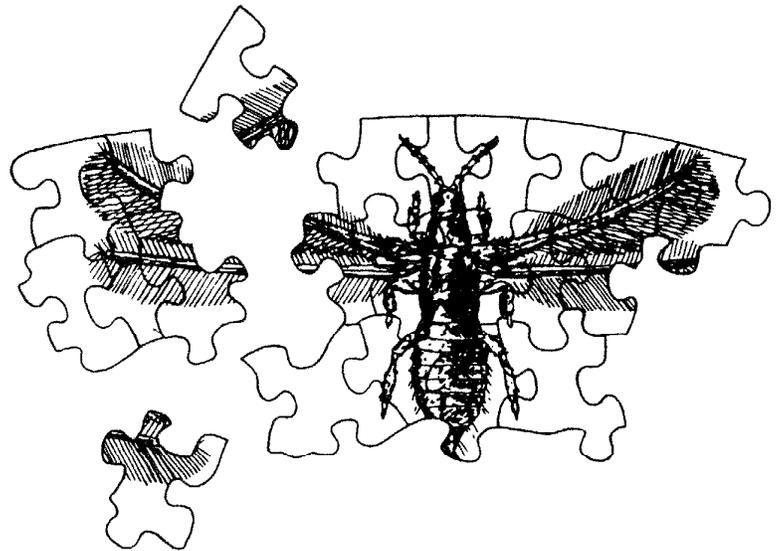
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University of Vermont

General Technical Report NE-147

# Towards Understanding Thysanoptera



**Editors:**

**Bruce L. Parker  
Margaret Skinner  
Trevor Lewis**

## **ACKNOWLEDGMENTS**

This conference would not have been possible without the dedicated efforts of many people, only a few of whom can be mentioned here. We thank Steve LaRosa for organization of special events and Eva Noronha-Doane for facilitating registration. Recording of the conference was expertly supervised by Luke Curtis; transcriptions were prepared by Peggy Verville and Nancy Burgess from the University of Vermont, Department of Plant and Soil Science; and layout of the proceedings was prepared by Frances Birdsall. Thanks also to the numerous personnel from the Vermont Department of Forests, Parks and Recreation who helped with transportation and many other technical details.

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## TOWARDS UNDERSTANDING THYSANOPTERA

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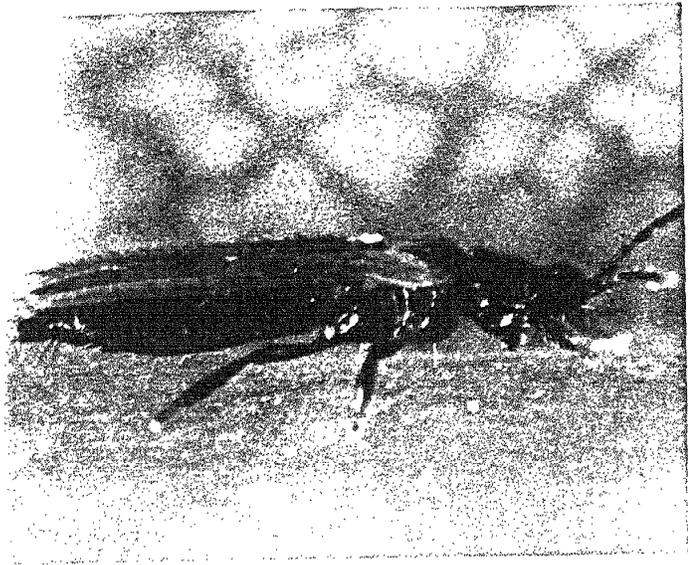
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**CLOSING REMARKS**

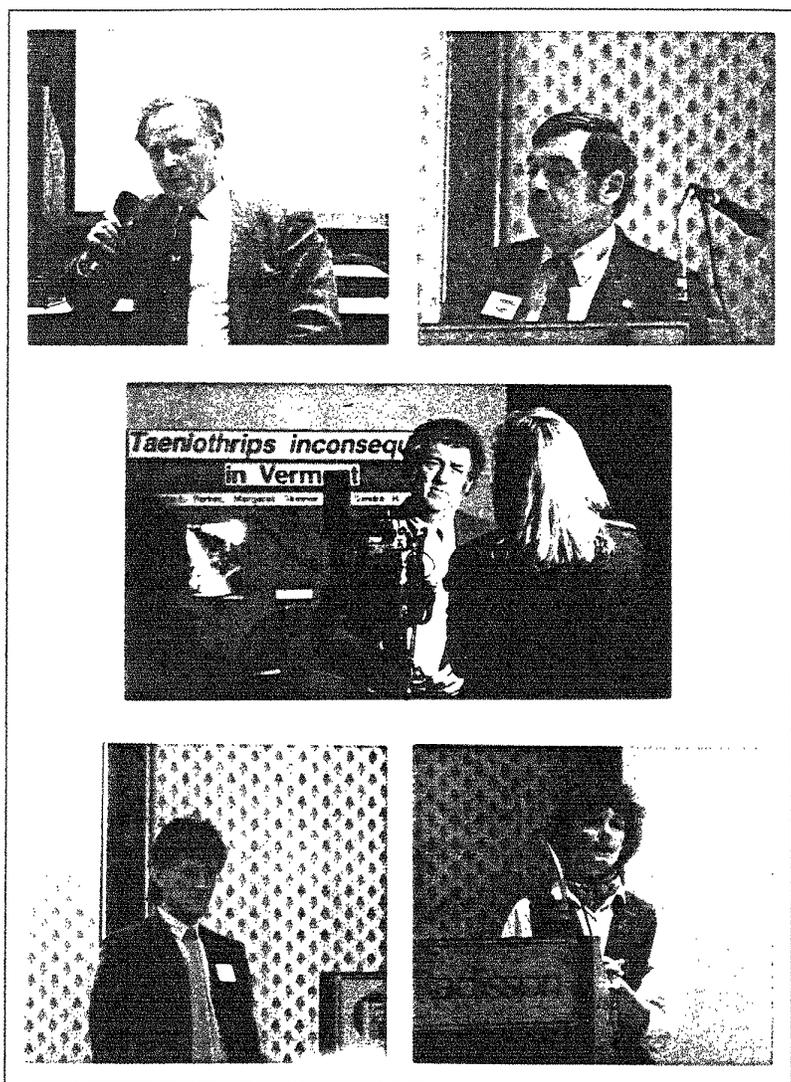
Donald L. McLean, Dean and Director  
College of Agriculture and Life Sciences  
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List of conference participants



PEAR THRIPS, *Taeniothrips inconsequens* (Uzel)  
(photo by T. E. Downer)



A few of the conference participants (from top left to bottom right): Trevor Lewis, Institute of Arable Crops Research; Conrad Motyka, VT Department of Forests, Parks and Recreation; Bruce L. Parker, The University of Vermont; Nick J. Mills, Commonwealth Institute of Biological Control; Margaret Skinner, The University of Vermont.

## PREFACE

Pear thrips, *Taeniothrips inconsequens* (Uzel), first surfaced as a pest of sugar maple, *Acer saccharum* Marsh, in Pennsylvania in the late 1970s. Though similar damage was observed in Vermont in the early 1980s, it was probably misdiagnosed as frost damage until 1985, when finally thrips were positively confirmed as the causal agent. Pear thrips damage to sugar maple fluctuated greatly from year to year, raising only slight concern among sugarmakers and forest managers. However, the situation changed dramatically in the spring of 1988, when pear thrips caused widespread, severe foliage damage to sugar maple in southern Vermont (over 200 thousand hectares) and other New England States. Recognized as a potential threat to forest health, pear thrips received tremendous media coverage, including the front page of the New York Times and the CBS Evening News!

The response in Vermont to this crisis was swift. With support from the Vermont legislature and the Department of Agriculture, a major research effort was launched, coordinated jointly by the University of Vermont and the VT Department of Forests, Parks and Recreation. This pest presented unique research and management challenges. Pear thrips on sugar maple represented a known pest on a new host in a new habitat. As of 1988 almost no information existed on this insect in a sugar maple forest. In addition thrips in general were virtually unknown as a northern hardwood forest pest, and forest managers knew little about how to handle such an insect. Finally, because thrips are such small insects, new and specialized methods were needed for survey and study of this pest.

As Vermont's research efforts got underway, it became clear that much could be learned from scientists familiar with other thrips species. The goal of this conference was to gather these specialists together to present their ideas on thrips survey and management methodology, particularly as it related to pear thrips in a forest setting. Participants came from across the United States, Canada and the United Kingdom to share their expertise. Though many didn't know that a "sugarbush" was not a shrub, but a natural stand of mature 30-m-tall sugar maple trees (100 ft), they all knew what maple syrup was! Certainly by the end of the conference all of the participants recognized the unique value of the sugar maple to the heritage and economy of Vermont and the Northeast, and shared our concern for its future in light of the threat of pear thrips.

We thank all of the conference participants who freely and enthusiastically shared their knowledge. Without their expertise and continued technical support, our pear thrips research would not have progressed as far or as fast as it has. We thank all those attending the conference for helping to make it a productive event. Though the pear thrips problem is far from being "solved," this conference started the research process on a solid footing.

**EVOLUTION AND SYSTEMATICS**

SPACE, TIME AND THRIPS:  
BIOGEOGRAPHIC ISSUES IN THE  
EVOLUTIONARY ECOLOGY OF THYSANOPTERA

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**Introduction**

Most participants of this symposium will be concerned with understanding thrips ecology primarily in order to develop practical and effective control strategies. Questions dealing with historical aspects (evolution) may seem of only isolated "theoretical" interest with little significance for everyday pragmatic concerns. Evolutionary theory is widely presented, however, as a cornerstone of modern biology and this position implies that evolutionary considerations can and do provide a direct input into our understanding of both ecosystems and individual organisms. Most evolutionary perspectives on living organisms are derived from specialist studies such as ecological, genetic or developmental systems. Data from these studies are extrapolated to represent evolutionary processes in reference to some general theoretical or metaphorical framework (e.g., natural selection) that also has its source in the same kind of observations.

In evolutionary ecology the course of evolution is often separated out from the living present so that the historical "past" and the ecological "present" of evolution never seem to quite come together (Gray 1990). This arbitrary division between past and present may provide an implicit, and little recognized, barrier to effective synthesis between evolution and ecology in the study of modern-day organisms. I will address this problem with respect to the general biogeographic problem of incorporating space into evolution and the potential significance for future work on thysanopteran ecology.

## Evolutionary Characters

An important component of evolutionary approaches to natural processes is the construction of a comparative framework for identifying information content. Comparative information is expressed by the establishment of a particular taxonomy representing what we understand of the real natural world through systematic analysis of characters (Nelson & Platnick 1981). There is unfortunately a dearth of comprehensive comparative phylogenetic and evolutionary information on the Thysanoptera (cf. Lewis this proceedings, Nakahara this proceedings) although the range of contributions in this symposium referring to many different situations suggests that this information could develop. However, systematics/taxonomy remains one of the most threatened of disciplines in the natural sciences suffering continuing attrition in funding, diminished emphasis in university courses and uncertainty about its scope and content from both systematists and non-systematists in the natural sciences (Whitehead 1990).

Understanding the role of systematics may represent the weakest link in establishing the discipline as a relevant component of general biological studies (Whitehead 1990). The systematic component most familiar to non-systematists is the taxonomy that provides an ordering of information within which organisms may be compared and specific issues identified. There is the danger, however, that this familiarity may degrade taxonomy as being nothing more than a convenient labelling system for the indifferent use of ecologists, environment managers etc. This perception overlooks the theoretical content of taxonomy that concerns the question of genealogy as shared evolutionary history (Fig. 1). Taxonomy is a direct representation of a natural process (evolution) and provides a summary, a statement about the current knowledge of that process (Nelson & Platnick 1981). It is through the process of evolution that systematics may be recognized as an indispensable component for any meaningful biological study whether phylogeny or ecology.

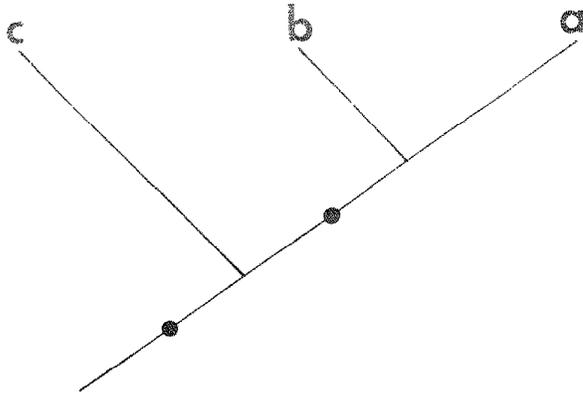


Figure 1. Simplified conceptual relationship between taxonomic category (taxa a, b, c) and phylogenetic evolution. Taxa are positioned according to inferred historical relationship. Taxa "a" and "b" are more closely related to each other than either taxon is to "c". Solid circles represent unique shared characters defining taxonomic and phylogenetic relationships (modified from Nelson & Platnick 1981).

At present there are insufficient detailed comparative studies on the ecology and phylogeny of Thysanoptera to establish an analytical approach for a narrative on thrips evolution. In optimistic anticipation of this future development I will briefly consider the important issue of space/time arising from systematic and biogeographic studies of evolution and examine the implication for understanding the evolutionary relationship between ecology and history.

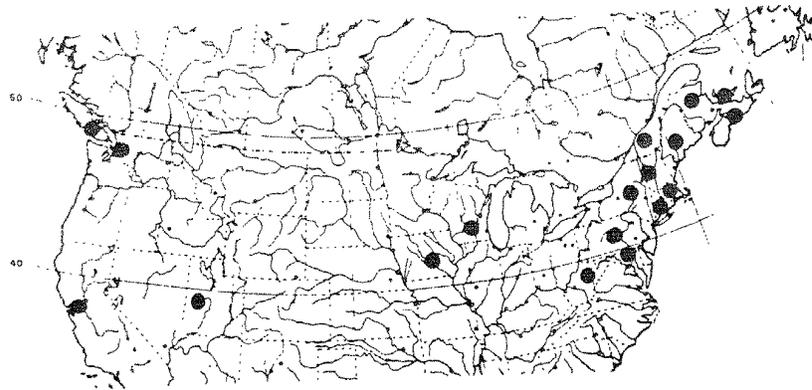
#### **Spatiotemporal Characters**

The study of space/time in evolutionary biology is nominally the field of biogeography - the investigation of animal and plant distributions. Biological or evolutionary studies often give only tacit or implicit recognition to the existence of "space" and "time" and rarely does this concern receive critical appraisal outside biogeography. The implicit acceptance of space and time "as read" assumes a separate, discrete existence for each - a separate time (like an arrow of time) and

a separate space (such as a defined area). While this "common sense" appreciation is based on an original separation, in practice we conceive of space in a temporal sense--a particular moment in time (this moment being the present, the "now" in which we think). Conversely time is thought in relation to a sequence or spacing of particular moments (Derrida 1982). Each, therefore, becomes a necessary counterpart to the other, and instead of referring to space *and* time in evolution it is more appropriate to think of space/time (Craw 1988). This joining is significant for how we approach ecology and history which traditionally separates and isolates past (time) from present (place).

Distributions are explicitly spatiotemporal and show that organisms do not evolve only in their physical form, but have a real geographic existence with their evolutionary boundaries (ecological and historical limits) being determined or "defined" by space/time (Fig. 2). Biogeography has often assumed space and time to represent a separate stage or container that provided the environment in which organisms actively migrate and evolve so that organisms evolve, environments do not (Craw & Page 1988, Gray 1988). Migration stories were constructed largely on the belief that individual attributes of organisms (e.g., flying, walking, rafting etc.) are responsible for their different distributions (Darwin 1859, Wallace 1876). This evolutionary framework effectively exiled organic distributions from having any real existence in evolution. Instead of forming a data base in their own right, distributions were treated as an ephemeral manifestation of differing migratory abilities between of organisms. Without an explicit space/time dimension biogeography could not contribute anything much to evolution or ecology in general.

d.



b.

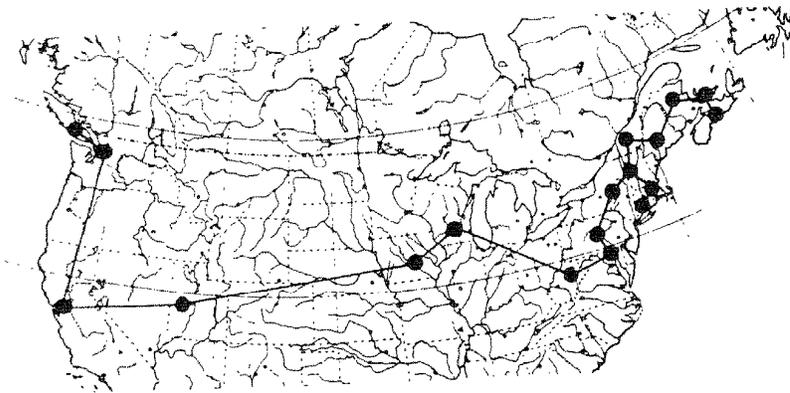


Figure 2. The biogeographic (space/time) evolution of organisms as represented in the range of the pear thrips (*Taeniothrips inconsequens*) in North America. (a) The range of pear thrips as a distribution emphasizing the general localities based on records of the insect. (b) The geographic localities represented as a biogeographic map of the space/time coordinates of the distribution filled in by lines. The lines connect the localities in the form of a minimal spanning tree. (distributional information from M. Skinner).

The treatment of space/time in evolutionary biogeography changed substantially in the 1950s through the establishment of panbiogeography (Croizat 1952, 1958). This form of biogeography examined distributions as providing a space/time data base - literally the "records of life" (Croizat 1964). Panbiogeography was concerned with developing an analytical framework for comparing the spatiotemporal characteristics of distribution patterns and deriving an understanding of the evolutionary relationship between historical events and the ecology of organisms with respect to present location. This geographic treatment of space/time provided an explicit role for evolutionary systematics by treating geographic information as characters amenable to analysis and interpretation (cf. Page 1987).

An important early finding in panbiogeography was that specific attributes of organisms, such as local means of survival (flying, walking, swimming, rafting etc.), were not general predictors of their present location on the globe. Just because an organism had the ability to fly did not mean that it was any more widely distributed than flightless beetle or worm. Croizat (1952, 1958) found that organisms with different migratory abilities could have the same pattern of distribution and suggested, therefore, that historical events were an important determinant of geographic range and the local ecology of organisms. Some organisms may appear to have greater freedom of movement and more expansive range than localized endemics, but their evolution in space/time was regarded as being fundamentally no different (Croizat 1964, Craw 1988). The common element of evolution for organisms with a "weedy" ecology (such as the pear thrips *Taeniothrips inconsequens* (Uzel)) and more specialized or localized forms concerns the role of actively changing ecological circumstances and their relationships with earth history. It is this interrelationship that concerns biogeography as a science investigating the space/time events that contribute to the evolutionary ecology of organisms.

## Biogeographic Events

How may these very general biogeographic considerations bear on specific approaches to thrips ecology and "management?" With pear thrips, for example, the present ecology involves two major developments: (1) the presumed human mediated introduction of pear thrips into North America (Bailey 1944) and (2) the association of pear thrips with, and recent prevalence on, sugar maple (*Acer saccharum* Marsh.). Both events involve changing spatial and temporal boundaries in thrips evolution. Comparative inferences on the evolution of pear thrips host-plant relationships are limited by the lack of detailed information on host-plant relationships of pear thrips in the European range (see Mills, this proceedings) although it is known to feed on members of *Acer* and the sugar maple does not necessarily represent a major host-plant "departure." The host-range expansion has involved host plants that could not be previously exploited (because of their absence) in the Eurasian range of pear thrips. These geographic changes, occurring within the present historical record, could be visualized as an active "colonization" by an aggressive or assertive organism making use of new environmental opportunities. This view would assume space and time to be separate from the organism and it could, therefore, be argued that the thrips has actively entered a "new" passive environment.

In a static space and time model of evolution the pear thrips entry onto sugar maple may be treated as an "invasion" or "colonization" and in a *de facto* sense this appears to be true. It requires, however, the underlying assumption of discrete separateness between the insect and host-plant - that the thrips alone defines the host while the host has no active role through its own spatiotemporal characters. This one-sided dichotomy in favor of thrips presents the thrips as the sole "active" evolutionary partner establishing initial contact. The separation of insect (organism) and host-plant (environment) has been modelled by Janzen (1968) in terms of "island biogeography" formalized by McArthur & Wilson (1967). Janzen (1968) argues that a species of plant is an island in evolutionary time to the insect species that feeds on it, but the individual plant may also be

analyzed in space and contemporary time to the individual insects that feed on it. The island concept presented by Janzen is explicitly based on space and time as containers (Fig. 3) and emphasized by the reference to McArthur & Wilson (1967) who view spatiotemporal evolution in the tradition of Darwin (1859) and Wallace (1876) where specific attributes of organisms are responsible for differential migration and colonization. Janzen (1968) extends this model to limit the plants role as the passive recipient to insect migration and affecting only the opportunity for establishment by character differences such as size, distance and chemical and structural composition.

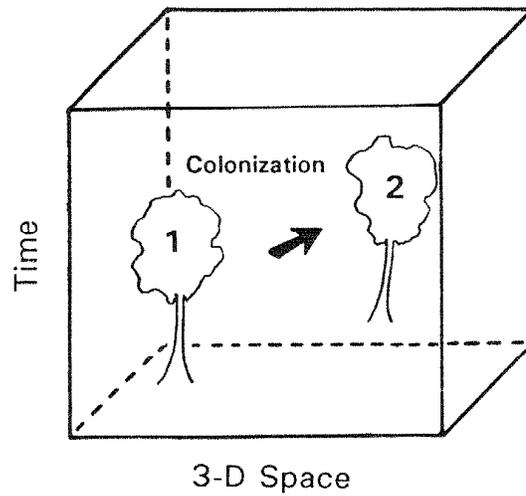
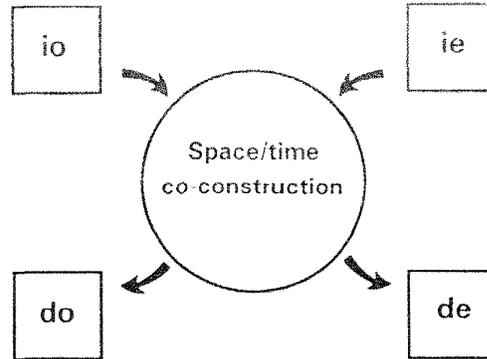


Figure 3. Host-plant relationships conceptualized for an organism/environment whereby evolution takes place within a container of absolute space and time. New host-plant relationships occur through the organism actively migrating from one environment location (1) to another (2) (modified from Craw & Page 1988).

If space/time is already present in the very existence of an organism (i.e., its ecological and developmental existence) the traditional division drawn between organism and environment is no more than an idealistic abstraction. Just as time may be thought of as space and

space as time, a particular "ecology" has no meaningful existence without reference to "organism" and organisms do not come into existence without an ecology (i.e., environmental relations) (Gray 1988). If organisms and environments (ecology) are seen as having a reciprocal character, their individual boundaries are mutually contingent. When interpreting ecological changes such as that of the pear thrips, the evolutionary process involves reorganization of space/time boundaries (the North American extension) that includes both the thrips as an organism and the thrips as an ecology. Thus, it is not the pear thrips alone as a separate "organism" that has entered North America, but an evolving pear thrips ecology (since the thrips organism did not travel at any stage without an environment). In this perspective it is possible to look at the evolutionary history of thrips as a co-construction of organism and environment (cf. Gray 1988). This differs from some traditions in evolutionary ecology that look at organisms and environments as closely interacting, but only as separate, distinct entities. Here they have no prior separate existence. In a co-construction context the evolution of thrips could be seen to involve a process of development in a particular place/time where inheritance involves "organism" and "environment" components as the raw materials in each thrips generation (Fig. 4). Rather than treating either or both of the inherited characters as the determinants of thrips ecology, it is the process of mutual construction that takes place during development that defines the apparently distinct thrips "organism" as we see it, and the separate ecology that we associate with the insect. Neither of these aspects have come into existence pre-formed, they were involved in developmental (or successional) processes and these processes of co-construction are contingent upon the place/time in which they occur (cf. Gray 1990, Grehan 1988, Oyama 1982).

a.



b.

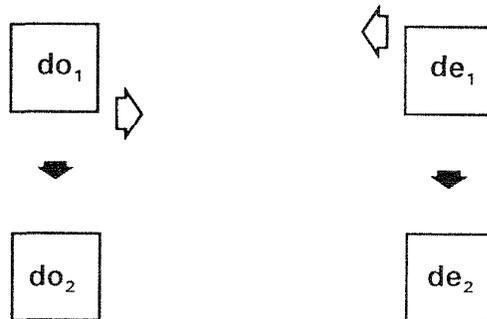


Figure 4. (a) A co-construction model of host-plant relationships. Evolution is contingent upon the interrelationship between space/time events (biogeography) and the initial "raw material" of inheritance in both its organism and environmental aspects (io = initial organic inheritance; ie = initial environmental inheritance). Through development there is a co-construction that results in the defined "organism" (do) and defined environment (de) which now may have the appearance of separate distinct entities. This can be contrasted to host-plant models (b) where evolution occurs through the interaction of separate organism (do1) and environment (de1) entities (here the host-plant is being treated as an environment with respect to a particular insect). The interaction may result in modification of either or both components (do2, de2).

The co-construction perspective has been recently formalized by Gray (1987, 1988, 1990) to help synthesize history and ecology in evolutionary studies. Co construction is an important consideration because it places the historical context of evolution as being historically contingent upon when and where organisms and environments interact. Evolutionary systematics, through biogeography, is concerned with the spatiotemporal characters of evolution which may become important if not critical for understanding the present evolutionary ecology of organisms and how this may change in relation to the evolution of environments. Evolution in space/time may, therefore, be thought of as a process whereby ecology has history and history is mediated ecologically (Gray 1990).

In panbiogeography the incorporation of space/time in organism-environment relations leads to rejection of organisms as being representations of some kind of inner ideal that can be defined for all places/times (as in most approaches to species definitions). Instead organisms or natural taxa are seen as having a spatiotemporal existence whereby their individuality is diagnosable only with respect to particular places/times (Craw 1988). This contingency is developed as a general evolutionary framework whereby "earth" and "life" are seen to evolve together (Croizat 1964, Heads 1990) and biogeographic research is involved in the analytical and statistical ramifications (e.g., Craw & Page 1988, Craw 1988, Page 1987, Henderson 1990). The conceptual linking of space/time with the form of an organism allows the potential for interlocking the findings of different disciplines in evolutionary biology (Fig. 5) where ecology has for its immediate focus present spatial relations of an organism. These relations are, however, contingent upon spatiotemporal studies (biogeography), and developmental processes (which mediate organism-environment transactions). The conceptual model provides possibility for reciprocal insights to be developed between the disciplines.

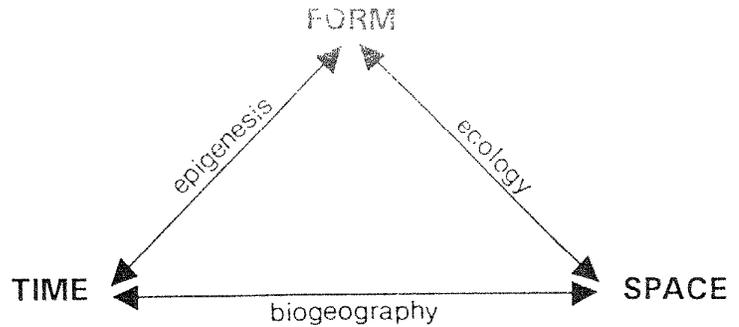


Figure 5. Model of the reciprocal relations between different evolutionary disciplines with respect to the contingent relationship of space/time with form. Biogeography may be regarded as having its primary focus with relative space/time and have a reciprocal relationship with ecology and developmental sciences (from Craw & Page 1988).

The *de facto* appearance of insects (or other animals) establishing relationships on plants and either maintaining a presence or not is not questioned here. The biogeographic problem concerns the metaphor of "island" which evokes a simplistic model of isolation and separation between entities that may be ecologically integrated. The establishment of pear thrips need not be interpreted as a lack or conquest of a barrier in the host-plant, but as a new ecological event contingent upon the mutual co-construction of evolutionary and ecological characters. In this sense the evolutionary "inheritance" of an insect concerns not just its genes or developmental characters, but also the environment characters. Each generation these characters do not appear already present and fully formed, but must be constructed in relation with each other through the development of the organism concerned. This interpretation involves a concept of space/time that is not only fluid, but totally contingent, a place where what is "organism" and what is "environment" is no longer quite as distinct as we might prefer from a pragmatic managerial standpoint.

### Conclusion

Specialists may respond to this deconstruction approach of organism-environment relations by asking, "What practical difference does this make to my work?" My response is that it makes a difference only if a specialist is prepared to explore the foundations and implications that become apparent. Thus, it is not my purpose or intention to impose co-construction, but contribute an appreciation of space/time concerning concepts taken for granted in ecological studies that do have a bearing on our interpretation of the real, natural world and the solutions we construct for reaching practical solutions to ecological problems.

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## SYSTEMATICS OF THYSANOPTERA, PEAR THRIPS AND OTHER ECONOMIC SPECIES

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### Abstract

The systematics of the Thysanoptera, and several economic species in the United States and Canada (North America) are discussed briefly. Morphological characters to distinguish the six families in North America and the following economic species, pear thrips (*Taeniothrips inconsequens* (Uzel)), basswood thrips (*Thrips calcaratus* Uzel), western flower thrips (*Frankliniella occidentalis* (Pergande)), flower thrips (*Frankliniella tritici* (Fitch)), tobacco thrips (*Frankliniella fusca* (Hinds)), and onion thrips (*Thrips tabaci* Lindeman) are discussed.

### Introduction

The common name for the order Thysanoptera is thrips. Other common names that have been used are bladderfeet and woodlouse. There is also a genus *Thrips*, which is the oldest name in the order. In the United States and Canada (North America), there are about 700 described species of thrips. Mound & Houston (1987) estimate about 4,500 known species worldwide and probably another 4,500, mainly in the tropics, that have not been described.

Most thrips are tiny and barely visible. They usually are 1-2 mm long, the smallest are about 0.5 mm and the largest found in the tropics are about 14 mm (Lewis 1973). They are found in flowers and various parts of the plants, and often pupate or spend part of their life cycle in soil or ground litter. Thrips have elongate bodies, which are often slightly to strongly flatten dorso-ventrally (Figs. 1-2). Antennae are 4- to 9-segmented. The right mandible is vestigial and the left mandible is developed. Two pairs of elongate wings are fringed with long cilia. A bladder is located at the apex of each leg (Fig. 3). The abdomen is 10-segmented.

Currently, there are eight families of thrips in two suborders worldwide. The suborder Tubulifera consists of only one family, Phlaeothripidae, which includes about 350 species in North America. Members of this family (Fig. 1) can be recognized by the tubelike last or tenth abdominal segment, which has terminal setae; the female lacks an ovipositor. Also, the forewings, which lie crossed on the abdomen when at rest, lack veins and setae except at the base, and their surfaces are bare. Foretarsi are always one-segmented. The maxillary stylets are long and inserted inside the head (Fig. 4). Only a few species in this family are of agricultural importance. Many species feed on fungi or fungal spores and several species are predators. The life cycle includes the egg, two larval stages, three pupal stages and adult. The antennae of the larvae are not annulated and the last abdominal segment is tubelike and often sclerotized, and the antennae of the pupae lie along the sides of the head.

In the suborder Terebrantia, there are five families in North America. They differ from the phlaeothripids by having an ovipositor. Also, the forewings, which lie parallel over the abdomen when at rest, have veins with setae, and their surfaces are covered with microtrichia (Fig. 2). Maxillary stylets are short. The life cycle includes the egg, two larval stages, two pupal stages and the adult. The antennae of the larvae are annulated, and the last abdominal segment is variously shaped. Antennae of the prepupa project anteriorly but lie over the head in the pupal stage.

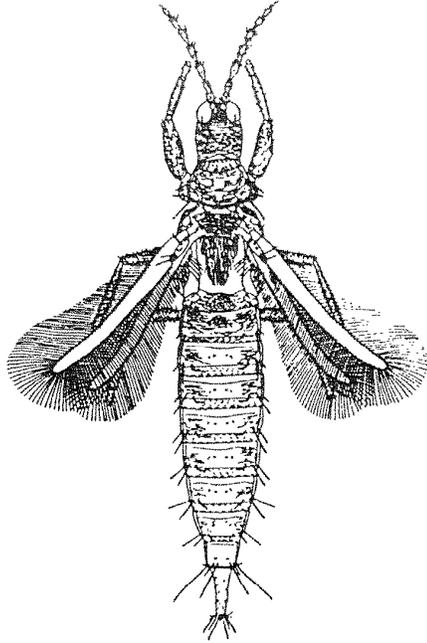


Figure 1. Phlaeothripidae adult (from Stannard 1968).

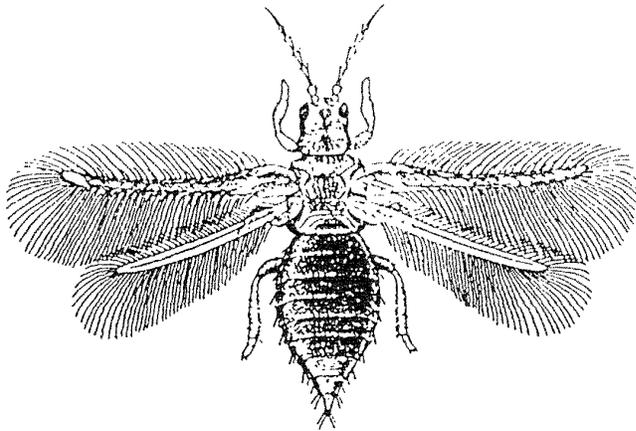


Figure 2. Thripidae adult (from Bailey 1938).

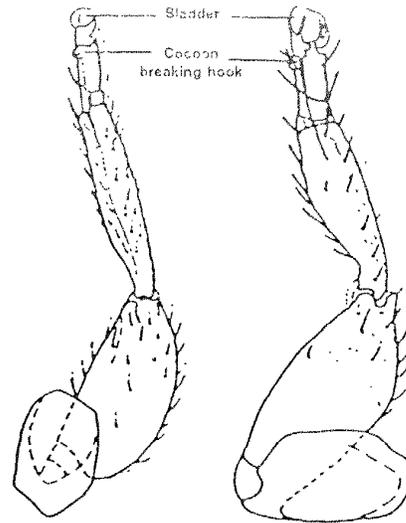


Figure 3. Bladder on the forelegs of Aeolothripidae (from Stannard 1968).

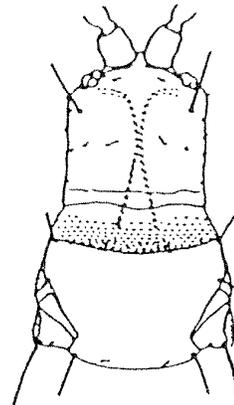


Figure 4. Maxillary stylets in head of Phlaeothripidae adult (from Stannard 1968).

Of the five families, the Adiheterothripidae with one species and Merothripidae with four species are seldom found and are not discussed further. The Heterothripidae (Fig. 5) with 20 species have strongly sclerotized bodies. The sides of the abdomen are reticulated and microtrichia are usually present. Posterior margins of the abdominal segments have a fringe of longer microtrichia. Antennae are 9-segmented with segments III and IV having small sensoria in rows or bands encircling the segments near the apices. Species in this family are found in flowers and on leaves but are not known to be of economic importance. There are about 57 species in the family Aeolothripidae; many are predaceous. They can be recognized by their large size and broad forewings, which are usually banded and their apices are usually broadly rounded (Fig. 6). Further, the antennae are 9-segmented; segments III-V are elongate and parallel sided, and the sensoria on III and IV are flat, linear or oval. The ovipositor is upturned (Fig. 7). None of the other families have upturned ovipositors.

The family Thripidae (Fig. 2) is the largest family in the Terebrantia with about 280 described species in North America. It is recognized by the down-turned ovipositor (Fig. 8), forewings are usually slender with pointed apices, and the sensoria on the antennae III and IV project either as simple or forked (trichome) sense cones. Most of the economic species are found in this family and the morphological characters to identify several of the species are discussed.

#### Discussion of Adults

The following structures are some of the morphological characters used to identify thrips (Fig. 9). The antennae are located at the anterior part of the head. Between the compound eyes on the head are usually three ocelli (lens like organs) in a triangular arrangement. A crescent shaped coloration, the ocellar crescent, borders each ocellus. Normally, the crescents are orange to red. Also between the eyes are several setae, the ocellar setae. A pair of these setae in the ocellar area is known as the interocellar setae. The lateral margins of the head posterior to the eyes are referred to as the cheeks.

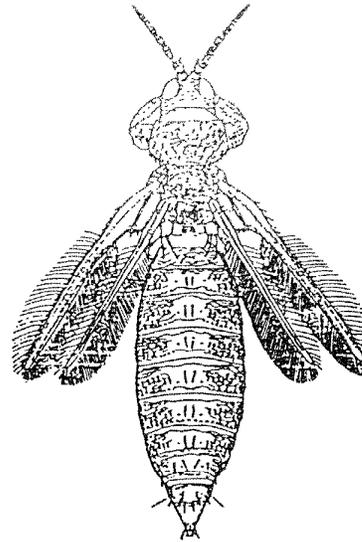


Figure 5. Heterothripidae adult (from Stannard 1968).

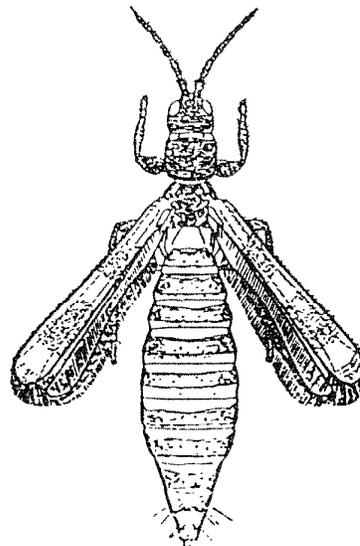


Figure 6. Aeolothripidae adult (from Stannard 1968).

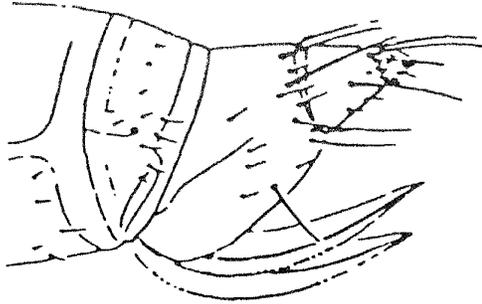


Figure 7. Ovipositor of female Aeolothripidae (from Kono & Papp 1977).

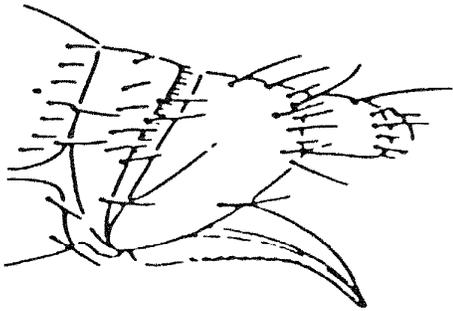


Figure 8. Ovipositor of female Thripidae (from Kono & Papp 1977).

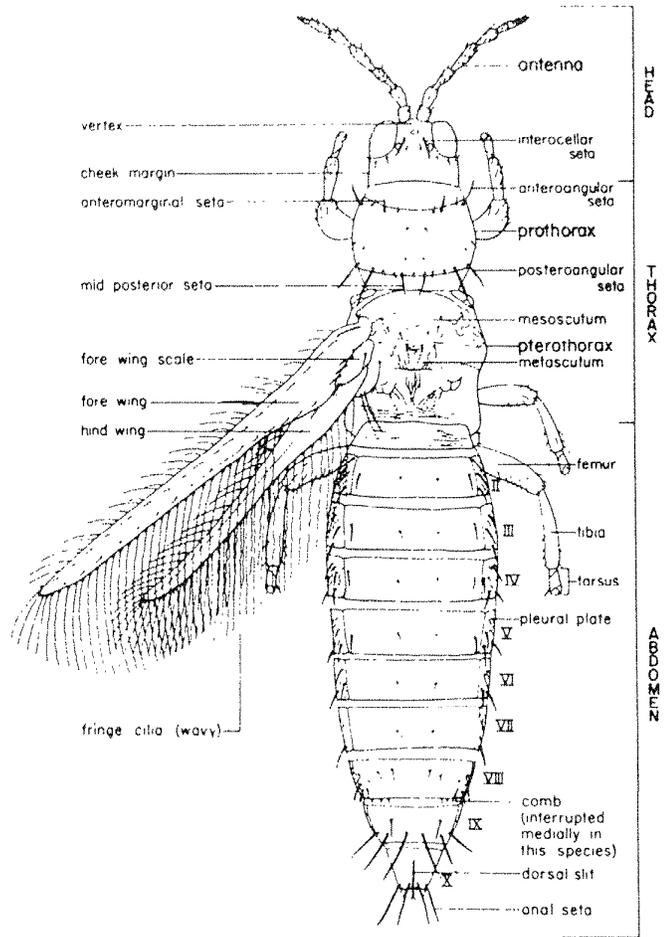


Figure 9. *Frankliniella tritici* (Fitch) (from Stannard 1968).

On the pronotum are various types of setae. One or two pairs of posteroangular setae, when present, are found on the posterior angular parts of the pronotum. Venal setae are present normally on two longitudinal veins on the forewings. The hind vein normally has a complete row of setae. On the forevein, the setae may be in a complete row or only a few irregularly spaced setae are found in the distal one-half. These setae are known as the distal setae. On the abdomen, the posteromarginal comb, which is a row of fine teeth, is found on the posterior margin of tergite VIII. A complete comb has a complete row of fine teeth, an incomplete comb lacks teeth from the median part, or the comb may be absent. Members of several genera such as *Frankliniella* and *Thrips* have a pair of submarginal ctenidia on abdominal tergites V-VIII. The ctenidium is a short row of fine teeth.

#### **Pear Thrips**

The pear thrips, *Taeniothrips inconsequens* (Uzel) (Fig. 10), is known from Europe, Asia and in North America from British Columbia and Ontario in Canada and from Washington, Oregon, California, Utah, Maryland, Virginia, Pennsylvania, New York, Vermont, Connecticut, Massachusetts, New Hampshire and Maine in the United States. It has been reported from apple, pear, *Prunus* spp., maple and many other trees. This species has one generation per year, and lives most of its life in the soil.

The adult females have brown bodies. Antennae are 8-segmented, and the apical part of segment II and basal part of III are yellow or yellowish brown. Legs are generally brown; the tarsi and bases of tibiae and femora are yellow. Forewings are brown. The head has bulging eyes with the cheeks strongly arched, and two pairs of ocellar setae are present with the interocellar pair long and positioned between the posterior ocelli (Fig. 11). The distinctive feature of this thrips is the apical claw on the foretarsi (Fig. 12), which can be observed usually under the dissecting microscope. The pronotum has two pairs of long, well-developed posteroangular setae. Forewings have normally five to six setae on the distal one-half of the forevein.

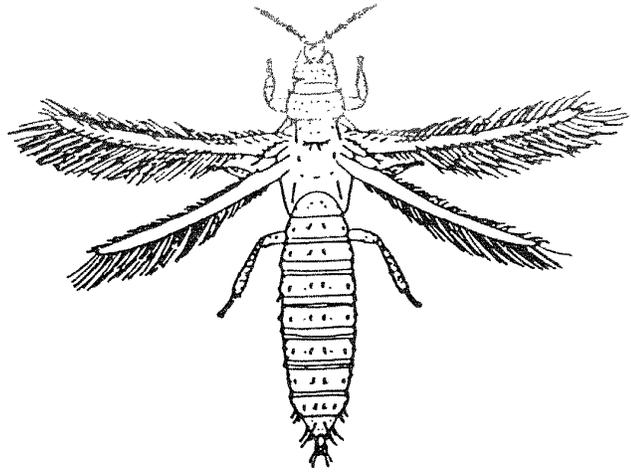


Figure 10. Pear thrips (from Bailey 1944).

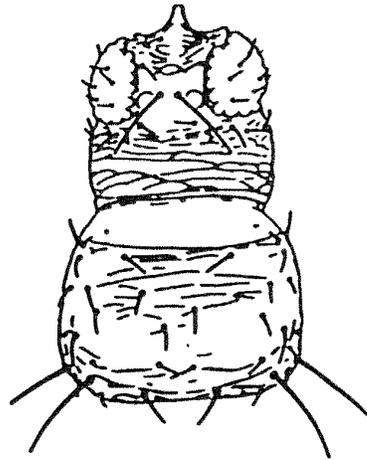


Figure 11. Head and pronotum of the pear thrips (from Mound et al. 1976).



Figure 12. Apical claw on foretarsus of pear thrips (from Mound et al. 1976).



Figure 13. Tooth on foretarsus of *Thrips calcaratus* Uzel (from Mound et al. 1976).

The abdomen lacks ctenidia, tergum VIII has a well-developed posteromarginal comb, and only the median pair of posteromarginal setae on abdominal sternum VII is anterior to the posterior margin. The male has not been found in North America.

*Taeniothrips orionis* Treherne, a native species found in western North America, closely resembles the pear thrips in color and most characters; however, it lacks the apical claw and has three distal setae on the forewings.

#### **Basswood Thrips**

*Thrips calcaratus* Uzel, the basswood thrips, was also introduced from Europe, and occurs in Ontario and Quebec in Canada and New York, Pennsylvania and Wisconsin in the United States. It infests various species of basswoods and other plants. Its life cycle is similar to that of the pear thrips.

The adult females have brown bodies. Antennae are 7-segmented; segment III, apices of II, and bases of IV and V are yellow. Legs have tarsi that are yellow and the tibiae are yellowish brown in the distal part. Forewings are grayish brown. The head has two pairs of ocellar setae, with the interocellar pair positioned between the anterior and posterior ocelli. The pronotum has two pairs of well-developed posteroangular setae. Instead of an apical claw, it has a distinctive thumb-like tooth on the distal tarsal segment (Fig. 13), which can be observed under the dissecting microscope. Forewings normally have three setae on the distal one-half of the forevein. The abdomen has ctenidia on tergites V-VIII, and tergum VIII has short, irregular spaced teeth on the posterior margin. Abdominal sternites III-VII have accessory setae. The male also has not been found in North America.

Some *Odontothrips* spp. have a small tooth on the foretarsi, but they also have one or two apical teeth or claws on the fore-tibiae, 8-segmented antennae, and lack accessory setae on the abdominal sternites. Most *Odontothrips* spp. feed on legumes.

#### Flower Thrips and Tobacco Thrips

The western flower thrips, *Frankliniella occidentalis* (Pergande), another species of economic importance, is a vector of the tomato spotted wilt virus (TSWV). It varies in coloration from completely yellow to completely brown. The usual color form is yellow with brown blotches or shading on the abdominal tergites, and pale yellow forewings. Antennae are 8-segmented, and the pedicel of segment III is not angulate. The head has three pairs of ocellar setae. The pronotum has a pair of well-developed anteromarginal setae, which are almost as long as the anteroangular setae, and two pairs of posteroangular setae. Forewings have two complete rows of venal setae. Ctenidia are present on abdominal tergites V-VIII, and tergite VIII has a complete posteromarginal comb, which is short and sparse. The flower thrips, *F. tritici*, and several other common *Frankliniella* spp. may be confused with it. The flower thrips (Fig. 9) has a distinctly angulate pedicel III; the anteromarginal setae are usually one-half to two-thirds as long as the anteroangular setae, and the posteromarginal comb on tergum VIII

is incomplete, i.e. teeth are absent medially. The tobacco thrips, *F. fusca* (Hinds), is also a vector of TSWV and has a brown body, pale brown forewings when the wings are developed, and the posteromarginal comb is absent from abdominal tergite VIII. The tobacco thrips has brachypterous and macropterous forms.

### Onion Thrips

The cosmopolitan onion thrips, *Thrips tabaci* (Fig. 14), is a well known pest and a vector of TSWV. This thrips also varies greatly in color from pale grayish yellow to dark brown. The grayish brown ocellar crescent, which can be observed under the dissecting microscope, will separate it from most species in Thripidae, which have orange to red ocellar crescents. Other diagnostic characters are the 7-segmented antennae, short posteroangular setae present on the pronotum, forewings usually with four to five setae on the distal one-half of the forewings, and the posteromarginal comb on abdominal segment VIII with long, close-set teeth.

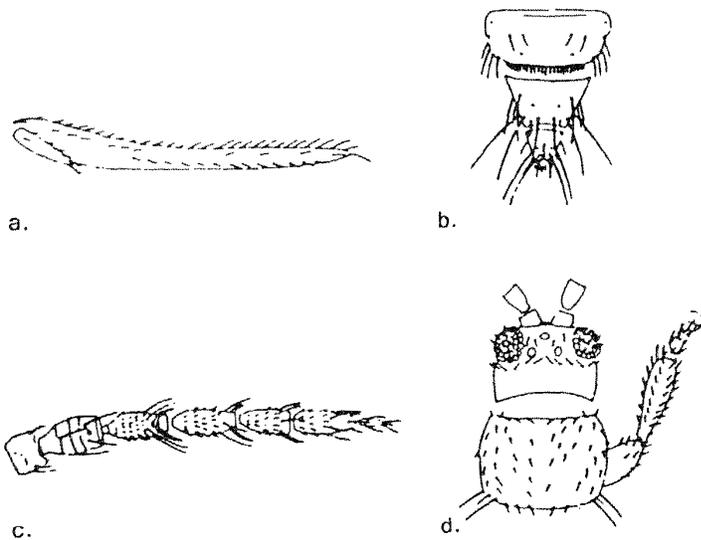


Figure 14. *Thrips tabaci* Lindeman (from Kono & Papp 1977); a. wing, b. abdomen, c. antenna, d. head and thorax.

#### Discussion of Immatures

At present, only a few first instars can be identified to species, and pupae can not be identified specifically. Several papers have been published on the second stage larvae and some can be identified to specific or generic level (Speyer & Parr 1941, Vance 1974, Miyazaki & Kudo 1986).

Larvae of the Thripidae have 7-segmented antennae on the head, three thoracic segments with three pairs of legs and a pair of spiracles on the mesothorax, and a 10-segmented abdomen with a pair of spiracles on the second and eighth abdominal segments (Fig. 15). The first stage larvae differ from the second stage larvae by having six pairs of setae on the pronotum and four pairs of setae on abdominal segments III-VII. The second stage larvae have seven pairs of setae on the pronotum and six pairs of setae on abdominal segments III-VII.

The head and body of pear thrips larvae are pale and lack sclerotization except on abdominal segments IX-X. Abdominal segment IX has seven-eight large dorso-lateral teeth on the posterior margin (Fig. 16). The two medial teeth are smaller than the lateral ones. A ventral row of small teeth is present on the posterior margin.

The basswood thrips larvae also do not have sclerotization on the head or body, except on abdominal segment IX and X. Abdominal segment IX has 17-18 large dorso-ventral teeth on the posterior margin. The lateral teeth are larger than those dorsally or ventrally. A ventral row of 8-10 small teeth is present.

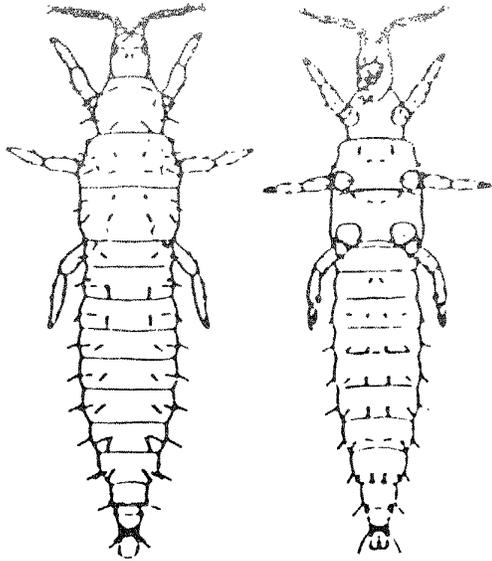


Figure 15. Second instar *Frankliniella intonsa* (Trybom) (from Speyer & Parr 1941).

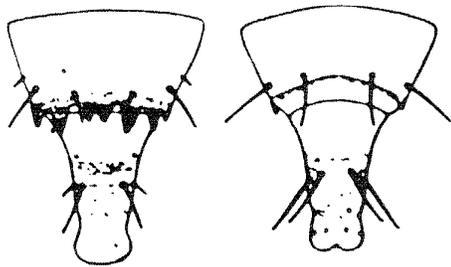


Figure 16. Abdominal segment IX-X of the second instar pear thrips (from Speyer & Parr 1941).

### Preserving and Mounting Specimens

Thrips may be collected and preserved in 60 or 70% ethanol. However, a better solution in which to collect and preserve thrips is AGA. This consists of eight parts of ethanol, five parts of distilled water, and one part each of glacial acetic acid and glycerine. This solution relaxes the wings and legs, which can be spread and aligned easily when the thrips are mounted on a slide. Specimens should not be kept over a year in AGA and should be transferred to 60% ethanol for longer storage.

When quick identifications are needed, temporary slide mounts prepared with Hoyer's or polyvinyl lactophenol may be used. These media will also clear the specimens. For permanent mounts, the specimens should be treated with sodium hydroxide and mounted in Canada balsam or other artificial media.

### Acknowledgment

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## Discussion Period

Question: How well is coloration maintained in preserved thrips specimens; is pigmentation retained for a long time?

Nakahara: Yes, color loss is not a problem; specimens do not fade after a year or more in solution. Thrips should be collected in AGA solution, but they will not hold up well for a long period of time and should be transferred to 60% ethanol after about a year.

Question: Is there an alternative to glacial acetic acid?

Nakahara: You can use vinegar, which is basically the same thing. One or two drops in a vial of alcohol is plenty. Acetic acid relaxes the thrips appendages which facilitates mounting, reducing the difficulties of spreading the wings.

Question: Is a typical thrips specimen obtained if collected directly from the soil as it emerges and mounted before it feeds on any plant tissue? Is the identifying color characteristics the same as those collected after they have fed on plant tissue?

Nakahara: Slight variation in coloration can occur among thrips. I have noticed colors ranging from yellow to reddish-orange among specimens of the same species. I don't know if this variation in color is a result of the plants they feed upon, but it may be. Thrips that have not yet fed often appear paler than those that have fed on plant tissue. However, the body pigments and basic distinguishing taxonomic features, such as the tarsal and abdominal structures will be present whether they have fed on plant tissue or not.

Question: What is the function of the sense cones, and the bladder on the foretarsi?

Nakahara: I haven't investigated the function of the sense cones, but I assume they are sense receptors of some sort. One theory is that the tarsal bladder is used to hold on to the host, which is a logical thought.

Question: Are you satisfied with the current state of thrips taxonomy, or do you believe that some groups need revision? Is there any work on thrips taxonomy underway presently?

Nakahara: I have just finished writing a manuscript on the Thripidae of North America. The last revision, which included 31 species, was done in 1968. Sixty species are included in my manuscript. It's a matter of the concept of what distinguishes a species. The taxonomy of thrips is evolving. For example, at one time the genus *Thrips* and *Taeniothrips* were only separated by the number of antennal segments, with eight segments in *Taeniothrips* and seven in *Thrips*. The problem that taxonomists faced was that you can get a specimen with seven segments on one antenna and eight segments on the other. Now what are you going to do in that case? Taxonomists now use other characters than the number of antennal segments to separate thrips genera. Therefore of the ten species originally in *Taeniothrips* only two now remain, and the rest have been put in different genera.

Question: Is anyone doing systematic work other than using morphology, such as DNA hybridization?

Nakahara: Not in the United States or Canada. Unfortunately I believe I'm the only person in this country doing systematic work on thrips. I'm glad to see so many people interested in thrips. It's been a long time since I've seen this many gathered together to talk about thrips.

Question: Are the drawings that you showed included in your manuscript, and when will it be published?

Nakahara: Probably in a couple of years, depending on funding. I work for a national agency, and therefore the availability of money is always a problem.