# FEEDING, FLIGHT AND DISPERSAL IN THRIPS

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## Introduction

The aim of this paper is to amplify some of the general points made in my introductory paper on the order Thysanoptera (Lewis 1990, this proceedings), with particular reference to feeding, flight and dispersal. These aspects of thrips behaviour are clearly of great relevance to the spread and effects of infestations of *Taeniothrips inconsequens* in New England, and although most of the work described has concentrated on another species, *Limothrips cerealium* (Haliday) (Lewis 1973, Chisholm & Lewis 1984) much of the information is probably applicable to terebrantian species of similar phytophagous habits and size such as the pear thrips.

## Feeding

During feeding on stem, leaf or flower sap, adult and larval thrips adopt a characteristic stance with the tip of the mouthcone pressed on to the substrate surface with which close contact is maintained by means of the labial pad (see p. 5, Fig. 1). The maxillary and labial palps are spread out on each side and just touch the substrate, presumably to provide sensory information (Fig. 1). Other hairs and sensillae on the front of the head and paraglossae, respectively, probably have a tactile and chemosensory function. When the insect is not feeding, the labral pad is withdrawn and covered by the paraglossa. As the thrips explores a feeding site these move aside to expose the horseshoe-shaped labral pad which rapidly unfolds to its full size as it is pressed against the substrate.

Figure 1. Side view of mouthcone of feeding *Limothrips*; maxillary palps (left) and labial palps (right) sense the leaf surface; the labral pad and paraglossal sensilla are pressed closely against it (x250).

The mandible is stout with a broad base apparently fused to the internal ridge marking the junction between frons and clypeus. In fact, it is articulated to this thickening at one point only, so as to make an initial opening in plant tissue. The whole head capsule, with the mouthcone serving as pivot, is thrust downwards and slightly backwards, then the mouthcone shortens, forcing the mandible to protrude about 20 $\mu$ and rupture the epidermis of the plant tissue. The final penetrative stab is usually preceded by a series of less powerful exploratory thrusts.

Once the plant epidermis is pierced the mandible is largely withdrawn and the two styliform maxillae are inserted as a unit up to 60 $\mu$ into the underlying cells. The two stylets can move independently, but because ridges on the right stylet fit into grooves bordering the left stylet they function jointly as an efficient tube through which cell contents are imbibed.

Cinematographic pictures of feeding (Chisholm & Doncaster 1982) show inflow confined to the end of the tube, but liquid can be taken through a sub-terminal orifice even when one stylet is extended a shorter distance than the other.

Muscular pulsations at 2-6/sec are visible through the pale head capsule of larvae, and the resulting pumping action draws in liquid and chloroplasts from the plant. The internal diameter of the maxillary tube in *L. cerealium* is only about 1 $\mu$m, far smaller than wheat protoplasts. However, the thrips easily pierce the plasmalemma enclosing each protoplast with their maxillae, gaining access to the chloroplasts. Even when these greatly exceed the diameter of the maxillary tube, the suction created by the muscular pumping is sufficient to distort them enough to allow their passage up the tube. This species appears able to ingest about $8.5 \times 10^{-5}$ $\mu$l/min which equates to about 12.5% of its body weight per hour.

By contrast Day & Irzykiewicz (1954) estimated that *Thrips tabaci* Lindeman, a smaller species than either *L. cerealium* or *Taeniothrips inconsequens* imbibed about 17% of its body weight per hour; 10-20% would seem a likely average consumption for phytophagous Terebrantia.

The effects of stylet penetration by *Limothrips* are easily detectable microscopically on the surface and within leaves. Externally, probing sites are visible because the presence of the labral pad removes surface wax, and the leaf cuticle so exposed often wrinkles, indicating plasmolysis in the epidermal cells. Sometimes a "silvered" patch develops under an area of concentrated punctures as air penetrates the emptied plant cells. Many of the holes remaining after the stylets have pierced the leaf are approximately "figure-of-8"-shaped, presumably produced by the mandible and maxillae, though the extent to which this shape is attributable to probing or subsequent wrinkling of the substrate is uncertain (see p. 13, Fig. 2).

Within leaves, there is little sign of seepage of cell contents after feeding, indicating that the cells below the puncture are completely emptied. These empty cells are clearly visible, even where feeding has been light and where no surface silvering is visible. Emptied cells usually lie beneath a collapsed epidermal cell, and their appearance is the same whether the upper or lower epidermis has been pierced.

After more extensive feeding, when the plant tissue shows obvious external signs of damage, including widespread silvering, the internal cell structure is completely disrupted, the epidermal cells, especially the bulliform cells become shrivelled and distorted, a sign of extreme desiccation (Esau 1961). Many of the mesophyll cells disappear completely, others retain no cytoplasm or cell contents, and those that do show extreme plasmolysis with the cytoplasm contracting from the cell walls and deformed chloroplasts. The epidermal cells often collapse completely, with visible wrinkling of the outer cuticle. Cytoplasm contracts away from mesophyll cell walls which become flaccid. These effects are not directly attributable to feeding but flow from desiccation of the pierced and surrounding cells.

The effects of leaf-feeding by other terebrantian thrips on other crops can be much more obvious and serious. Heavily infested leaves of all ages shrivel, become discolored and brittle, and eventually fall, especially in hot, dry weather (Lewis 1973). To the extent that many of these harmful species, including *T. inconsequens*, are of a similar size to *L. cerealium* with mouthparts likely to penetrate to similar depths, the effects of feeding on leaves by thrips described above probably apply to most leaf-feeding species in the sub-order.

## Flight and Dispersal

Thrips are among the weakest flying insects, yet their finely fringed wings enable them to remain airborne long enough for the wind to blow them to great heights and for long distances. Indeed, migration by flight from breeding sites is a regular event in the life cycle of many species. Although it produces widespread scattering, resulting in the loss of millions of individuals, it nevertheless ensures that fresh food is found for breeding populations, and sheltered sites for protection during unfavorable seasons.

The upper limit to which thrips are carried is unknown but, in Louisiana, using sticky traps fitted to aircraft, Glick (1939) caught one *Frankliniella tritici* (Fitch) and one *Haplothrips graminis* Hood above 3,100 m (10,000 ft) and 89 specimens representing at least 16 species at lower altitudes above 6 m (20 ft). At Darango, Mexico, *Stomatothrips flavus* Hood and *Caliothrips phaseola* Hood were caught at 1,200 m (4,000 ft). An interesting and surprising feature of the data from Louisiana is the number of thrips caught at night, representing 35% of the total when catches from 150 m (500 ft) are included. Five out of the six night-flying individuals caught by Glick were at 150 m, but a *Sericothrips* sp. was caught at over 1,500 m (5,000 ft). Night flight can prolong the migration of other insects, for example aphids (Berry & Taylor 1968), and small insects may often fly at night in continental regions where warm, low-level jet streams develop above nocturnal inversions enabling individuals carried upwards earlier in the day to remain airborne during darkness.

There are a few indications that the migration of some thrips species over large continental land masses might be associated with frontal winds. In the United States *F. tritici* may be blown northwards every year. It has never been recorded hibernating in Illinois, yet large numbers of this species appear suddenly in spring (Stannard 1968), and similarly in Maryland it was suddenly abundant in June, 1957 (Henneberry et al. 1961). In view of the major displacements of leaf hoppers, bugs and aphids by large-scale weather systems in North America, it seems probable that flying thrips could likewise be carried by frontal winds.

Notwithstanding Glick's (1939) records, most flight usually occurs during the warmest period of the day (Lewis 1973) so the insects are airborne when ascending convective movement is greatest and many are blown upwards and away from their breeding or overwintering sites. Tree-dwelling species or those emerging from the ground beneath a tree canopy, as is the case with pear thrips in a sugarbush, may represent a special case in that the emerging population in spring is subject to less convective air movement than populations emerging in more exposed habitats. Nevertheless, it would be surprising if there were not some significant movement of such species over long distances, particularly of individuals from the edges of the stands, and trapping with suction and/or sticky traps (Lewis 1973) at different distances from sugarbushes should resolve this question. Important details of the design and placement of traps and interpretation of trap catches are given by Lewis (1973). White traps are known to be particularly attractive to several species of *Taeniothrips* (Lewis 1961). Vertical profiles of aerial density, corrected as appropriate for wind speed at different altitudes (Johnson 1957, Lewis 1959, 1964) would also indicate the propensity of pear thrips to disperse long distances. Concentrations of pear thrips populations around the edges of sugar maple stands may occur if individuals are widely distributed by aerial currents, as is the case with *Taeniothrips laricivorous* Kratochvil on the edges of larch stands (Zenther-Møller 1965).

Some species are renowned for "mass" flights, usually occurring when populations build up on host plants, then take off in response to favorable weather (Lewis 1964, 1965). In England some species of *Taeniothrips* behave in this way. A careful study of the effect of weather on mass flights of *L. cerealium* in southern England (Hurst 1964, Lewis 1964) showed that six meteorological criteria were likely to pertain. These were: no rain or drizzle during the day, maximum temperature at least 20°C, day mean temperature above that of the previous day, low dry adiabatic lapse rate with no convection above about 1,600 m (5,000 ft), at least 1 h of sunshine, and dew point between 5 and 15°C. However, *Taeniothrips* spp. were among those that did not always conform to these criteria, and they sometimes flew in more humid and cooler conditions. A study of the flight habits of *Taeniothrips inconsequens* in New England in relation to weather would therefore be a novel and probably rewarding exercise.

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