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THRIPS POLLINATION IN THE LOWLAND FOREST OF NEW ZEALAND

Summary: Thrips, in particular *Thrips obscuratus*, were collected from the flowers of 13 species of trees common in the lowland forest of New Zealand. Many New Zealand trees have flowers which are small, shallow, clustered, and lack bright colours. This un-specialized floral form is suitable for pollination by small insects, such as flies and thrips. *Thrips obscuratus* is among the most frequent visitors to the flowers of some trees. The pollen loads of the thrips and the breeding system of the plants indicate thrips may function as effective pollinators.

Keywords: Thrips; *Thrips obscuratus*; Thysanoptera; pollination; New Zealand.

Introduction

Thrips (Thysanoptera) are common visitors of flowers but their presence is generally regarded as pestilent, or at best inconsequential, and their potential as pollinators is often overlooked. On the Faeroes, where there is a paucity of flower-visiting insects, Hagerup (1950, 1951) found that heather (*Calluna*) was pollinated by a thrips, *Taeniothrips ericae*. On the European mainland, heather is typically pollinated by butterflies and long-tongued bees which are absent on the Faeroes. Stimulated by these observations, Faegri and van der Pijl (1966) remarked: "there is every reason to presume that [thrips] and other small and insignificant, unobtrusive animals may prove to be of much greater importance than hitherto suspected." Since then thrips have been discovered to pollinate the flowers of other plant species which are often capable of self-pollination or are adapted to pollination by other orders of insects (Mathur and Mohan Ram, 1978). Three New Caledonian species of *Belliolum* are reported as dependent on thrips for pollination, but this too may be a derived relationship (Thien, 1980).

It is well known that New Zealand, like the Faeroes, has a disharmonic insect fauna, with few butterflies and no native long-tongued social bees. Of the indigenous plants whose pollinators have been collected, the most frequent insect visitors are flies, a group with considerable diversity in New Zealand (Heine, 1937; Primack, 1983). In a survey of plant-pollinator relationships, Heine (1937) recorded 16 native plant species on whose flowers thrips were found. Primack (1983) reported that South Island montane plants generally have unspecialized pollination systems and that flies were the most abundant floral visitors. Primack neither collected thrips nor investigated their significance as pollinators.

A study of the reproductive ecology of lowland horopito (*Pseudowintera axillaris*) recorded *Thrips obscuratus* as a common insect visitor to

its flowers (Norton, 1980). *Pseudowintera* is endemic to New Zealand and is the only genus of the Winteraceae found there. Because lowland horopito is in the same family as *Belliolum*, it may be that pollination by thrips is common in the Winteraceae. On the other hand, it is possible that other members of the New Zealand flora with unspecialized flowers are pollinated frequently by thrips as well as flies. Consequently a survey of the flowers of tree species growing in association with lowland horopito was undertaken to determine the role of thrips as possible pollinators.

Study Location and Methods

Observations and collections of flowers and insects were made on wild plants in three field sites and on cultivated plants in Kelburn, Wellington.

- (1) During October 1978 - May 1979, fieldwork was conducted in the Akatarawa region at the southern end of T ararua Forest Park (40°58'S, 175°10'E) in a low montane forest (c. 500m) dominated by hinau-kamahi-rimu (*Elaeocarpus dentatus* - *Weinmannia racemosa* - *Dacrydium cupressinum*) with lowland horopito as a prominent under-storey tree. The area is subject to high rainfall (c. 3100 mm/yr) and strong northwesterly winds (Park, 1971).
- (2) During August 1979 - January 1980, fieldwork was conducted in Orongorongo Valley (41°21'S, 174°58'E) near the DSIR Ecology Division Field Station. Observations were made in their intensive study area (elevation 100m), a rimu-miro- northern rata (*Dacrydium cupressinum* - *Podocarpus ferrugineus* - *Metrosideros robusta*) forest with frequent pigeon wood (*Hedycarya arborea*) and hinau. Orongorongo Valley, also subject to strong winds, receives about

- 2500 mm/yr rain, and has mean summer and winter temperatures of 15.5°C and 6.7°C respectively (Fitzgerald, 1976).
- (3) Further observations were made at Trentham Memorial Park, Upper Hutt, in December 1979. This is a tawa-kahikatea (*Beilschmiedia tawa* - *Dacrycarpus dacrydioides*) forest with abundant mahoe (*Melicytus ramiflorus*) in the understory.

Observations were made during day and night, those at night under artificial red light. Thrips were captured in small (20 ml) glass vials, killed in standard killing jars with ethyl acetate, and stored dry. Pollen loads were determined under a dissecting microscope. Identifications were made after the thrips were treated in 60% ethanol for several weeks followed by a 10% NaOH bath. Examinations were made under a Cambridge Stereoscan 600 SEM after dried insects had been sputter-coated with gold. Collections are deposited with Entomology Division, DSIR, Auckland.

Results

Thrips, primarily *Thrips obscuratus*, were observed on the flowers of 13 species of trees common in the lowland forest of New Zealand. The trees were lowland horopito, tawa, pigeonwood, mahoe, lemonwood (*Pittosporum eugenioides*), hinau, kamahi, putaputaweta (*Carpodetus serratus*), kaikomako (*Pennantia corymbosa*), pate (*Schefflera digitata*), five-finger

(*Pseudopanax arboreus*), kapuka (*Griselinia littoralis*), and ngaio (*Myoporum laetum*). Flies or beetles were found on the flowers of most of these but only *Thrips obscuratus* were observed on tawa and kapuka, and an unidentified thrips on kaikomako. The trees represent several forms of sex expression (Table 1).

Lowland horopito

Thomson (1881), Sampson (1963), and Godley and Smith (1981) suggested that the small, inconspicuous greenish-white flowers of this plant are wind pollinated. My research (Norton, 1980) showed that lowland horopito has a labile pollination system, relying on *Thrips obscuratus* and small flies to transfer pollen as well as some pollen being disseminated by wind.

The flowers of lowland horopito remain on the tree for an average of 7-11 days (Norton, 1980). The stigmatic crests are receptive during early anthesis, secreting a minute amount of nectar. The anthers shed pollen in permanent tetrahedral tetrads during the latter half of flowering. On young flowers where the sole reward is the stigmatic exudate, *Thrips obscuratus* were found carrying tetrads which suggests previous visits to flowers in late anthesis. By the time of dehiscence, stamens have lengthened and separated, creating interstices into which the pollen falls. It is in the crevices between stamens, not at the apical pollen sacs, that the thrips consume the pollen. As a thrips feeds it follows the circular gap between

Table 1: Trees of the New Zealand lowland forest on whose flowers thrips were captured. Locations are 1. Akatarawa region, southern Tararua Forest Park; 2. DSIR Ecology Division Field "Station, Orongorongo Valley; 3. Trentham Memorial Park, Upper Hutt; 4. Observations by B. F. Shore; 5. Wellington Botanical Gardens. Sex expression data from Allan (1961), Moore and Irwin (1978), and Godley (1979).

Tree species	Location	Sex expression	Sex(es) of plants on which thrips were found	Species of thrips	Sex of thrips
<i>Pseudowintera axillaris</i>	1	hermaphroditic	M,F	<i>Thrips obscuratus</i>	F,M
<i>Beilschmiedia tawa</i>	3	hermaphroditic	M,F	<i>T. obscuratus</i>	F
<i>Hedycarya arborea</i>	2	dioecious	M	not identified	-
<i>Melicytus ramiflorus</i>	1,2,3	dioecious	M,F	<i>T. obscuratus</i>	F,M
<i>Pittosporum eugenioides</i>	2	variable	M,F	not identified	-
<i>Elaeocarpus dentatus</i>	1,2	hermaphroditic	M,F	<i>T. obscuratus</i>	F
<i>Weinmannia racemosa</i>	1	hermaphroditic	M,F	not identified	-
<i>Carpodetus serratus</i>	4	gynodioecious	not recorded	not identified	-
<i>Pennantia corymbosa</i>	1,2	dioecious	M,F	not identified	-
<i>Schefflera digitata</i>	2	variable	M	not identified	-
<i>Pseudopanax arboreus</i>	5	dioecious	M,F	<i>T. obscuratus</i>	F
<i>Griselinia littoralis</i>	1	dioecious	F	<i>T. obscuratus</i>	F
<i>Myoporum laetum</i>	2	hermaphroditic	M,F	<i>T. obscuratus</i>	F

the whorls of stamens. Consequently tetrads in its path that are not eaten are often trapped by the setae (hairs) on the thrips's legs, wings, abdomen, thorax, head, or antennae. The pollen load is greatest on the ventral edges of the abdomen and on the thorax around the mouth parts. After feeding in one flower a thrips crawls to another, usually in the same inflorescence or on the same branch. In this manner, flowers in early anthesis containing nectar and those in late anthesis offering pollen are visited.

Tawa

The paniced flowers of tawa are small (2-3 mm diameter), green, inconspicuous, and scentless. Although the flowers are unattractive and appear poorly adapted for insect pollination, they are even less suited for wind pollination. Neither stigmas nor stamens are exerted but always remain partly enclosed by the perianth segments. The anthers are covered by flaps which are hinged distally, characteristic of the laurel family.

During anthesis, the flaps open to expose the pollen to insect visitors. Agile *Thrips obscuratus* easily manoeuvre about the flower, becoming well laden with pollen in the process (Fig. 1).

Ngaio

Ngaio differs from many New Zealand trees in that its flowers are borne singly and have a marked spatial separation of anthers and stigma. The shallow corolla tube is sub-zygomorphic and has purple honey guides, characters uncommon in the lowlands. Members of this predominantly Australian genus attract a generalized assemblage of visitors (Chinnock, 1979). Indeed Heine (1937) reported flies, moths, bees, beetles, and thrips from ngaio's flowers. *Thrips obscuratus* was the most numerous visitor which I recorded although the average pollen load was only one grain (Norton, 1980). The separation of anthers and stigma presents no obstacle to pollen transfer, as thrips were observed to feed on pollen from an anther, move to the base of the ovary to consume



Figure 1: Leg of thrips with tawa pollen, 825X.

nectar, and then crawl up the style for the exudate at the stigma. The scattered hairs on the corolla did not impede the thrips' movements.

Mahoe

Mahoe flowers of both sexes are nectariferous and have a strong sweet odour. Male flowers secrete nectar from the distal end of the filament, abaxial to the anthers. The nectar begins to exude prior to dehiscence, enabling insects to feed without acquiring a pollen load. Once the anthers open, pollen adheres liberally to the nectar-coated thrips, as well as to the flies and beetles which also pollinate mahoe. Three of eight thrips captured on female flowers had mahoe pollen present, indicating previous visits to male mahoe flowers.

Five-finger

On male flowers of five-finger, *Thrips obscuratus* do not feed on the pollen directly from the

anthers. Instead the insects remain on the central disc where the pollen, once shed, collects with the nectar. Pollen grains are grasped by, or adhere to, the thrips's front legs as it crawls through the food mixture (Fig. 2). The thrips stands vertically at the base of the petals and, clutching the pollen with its palps and front legs, draws the grain to its mouthparts. Presumably, the contents of the pollen are either squeezed or sucked out.

Kaikomako

Kaikomako has conspicuous pure-white flowers with a thoroughly entomophilous appearance. Thomson (1927) regards these as "evidently entirely dependent on insects for pollination" but fails to mention what insects, if any, were observed. During daytime observations, I noted only unidentified thrips on kaikomako flowers. The sole thrips collected from a female flower had three grains of kaikomako pollen adhering. The flowers resemble the form typical of plants

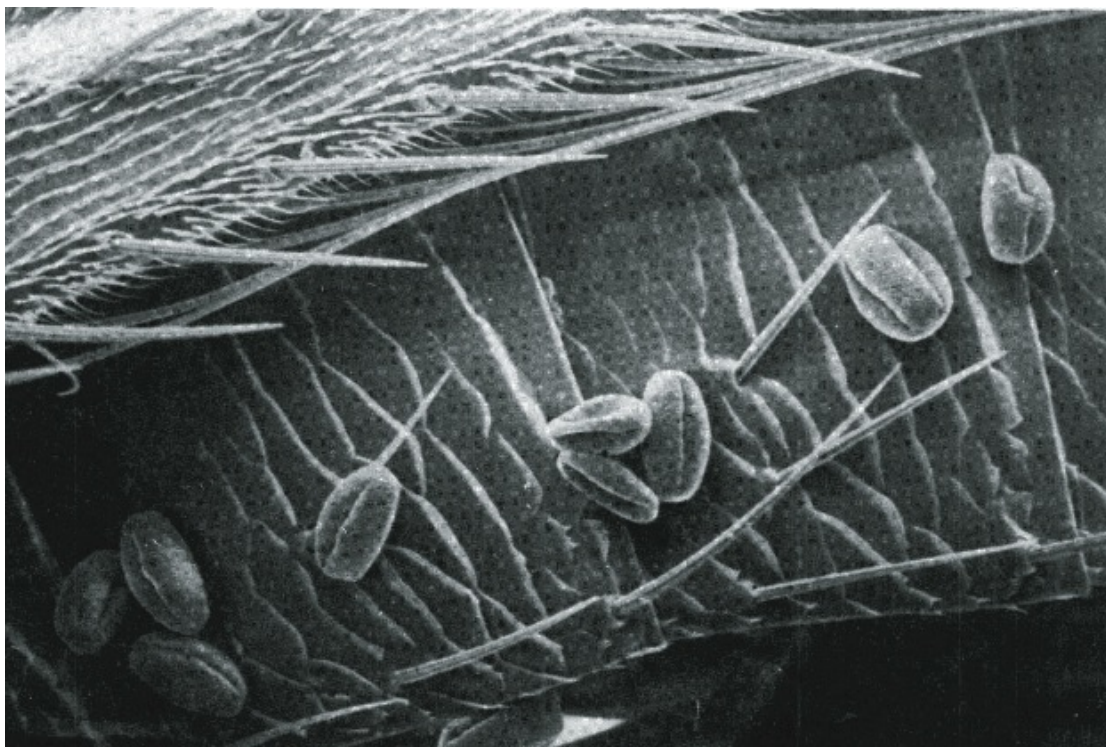


Figure 2: *Five-finger* pollen on abdomen of thrips. 925X.

pollinated by moths (Faegri and van der Pijl, 1966), yet no moths are known as visitors to kaikomako (J. S. Dugdale, pers. comm.). Three species of native bees, however, have been recorded to feed from kaikomako flowers (B. J. Donovan, pers. comm.).

Putaputeweta

B. F. Shore (pers. comm.) noticed unidentified thrips on the flowers of putaputeweta, a species which is morphologically gynodioecious but functionally sub-dioecious (Shore, 1978). The flowers form conspicuous white panicles which Thomson (1881) reported as being fragrant and nectariferous. The pollen is very sticky and Thomson considered the species "apparently dependent altogether on insects" for pollination, but later (1927) said, "I have not detected any insects on them." I also noticed no insect visitors during several observations, day and night, nor did I detect any scent or nectar. Thrips and an occasional fly or bee visit the flowers (B. F. Shore, pers. comm.) but to what extent any of these pollinate the flowers is not known. No moths are known to visit the flowers either (J. S. Dugdale, pers. comm.).

Thrips obscuratus responds to slight disturbances by flying or scurrying away or by taking refuge in natural crevices on the flower, making observations difficult. On pigeonwood, lemonwood, hinau, kamahi, pate, and kapuka, thrips were collected without detailed observations. *Thrips obscuratus* have also been collected from the flowers of other plants, native and cultivated (Table 2).

Discussion

Most of the thrips observed, captured, and identified were *Thrips obscuratus*. Little is known of the habits and food preferences of New Zealand thrips, but it is possible that the endemic *Thrips obscuratus*, being polyphagous, has become increasingly common since the introduction of exotic plants (Mount, 1978). *Thrips obscuratus* is known from native plants in 18 families, or 16% of the 112 families of spermatophytes in New Zealand. This range of hosts is relatively wider than that of thrips in Britain, where no species of thrips visits even 15% of the 136 families of spermatophytes found there (Pitkin, 1976).

The flowers of most plants on which *Thrips obscuratus* were captured are small, shallow, clustered, and lacking bright colours. Thomson (1881) suggested this convergent form, common in New Zealand, is an adaptation for fly pollination. Carlquist (1966) described this form, common on oceanic islands in general, as related to the small body size of insular insects. The flowers of tawa, for example, have a gap between stamen whorls and the ovary so small that *Thrips obscuratus* is among the few insects capable of feeding from and pollinating the flowers. Wind pollination of tawa is unlikely because of the unsuitable morphology of the flowers and the virtual absence of tawa pollen in fossil and modern pollen spectra (M. S. McGlone, pers. comm.). I observed no insects other than *Thrips obscuratus* on the flowers of tawa and suggest that the "minute insects, which had pollen grains adhering to their legs, thorax, and abdomen,"

Table 2: Other plants on which *Thrips obscuratus* have been collected. The records for *Celmisia* and *Gentiana* are from Mound (1978), the remainder personal observations. Sex expression data from Allan (1961); the disk-florets of *Celmisia* are hermaphroditic.

Species	Location	Sex expression	Sex of plants on which Thrips were found	Sex of thrips
<i>Pseudowintera colorata</i>	Kakanui Ridge, Tararua Range	hennaphroditic	M&F	F
<i>Pseudowintera traversii</i>	Boulder Lake, NW Nelson	hermaphroditic	M&F	F
<i>Clematis paniculata</i>	Kakanui Ridge, Tararua Range	dioecious	M	
<i>Clematis hookeriana</i>	Orongorongo Valley	dioecious	M	
<i>Hoheria sexstylosa</i>	Botanical Gardens, Wellington	hennaphroditic	M&F	M&F
<i>Celmisia viscosa</i>	Cragieburn Forest, Canterbury	hennaphroditic	M&F	F
<i>Gentiana</i> sp.	Mt Hope, South Island	hennaphroditic	M&F	M
<i>Hebe speciosa</i>	cult. Wellington	hennaphroditic	M&F	F
<i>Phormium tenax</i>	Botanical Gardens, Wellington	hennaphroditic	M&F	F

noted by Roper (1967) were also *Thrips obscuratus*. No New Zealand plant is known to have a single species of insect as its pollinator. The only plants described as pollinated solely by thrips are members of *Shorea* (a Malaysian dipterocarp) and *Belliolium* in New Caledonia (Apaneh, 1981; Thein, 1980).

Not all plants whose flowers fit this convergent form attract thrips. Hangehange (*Geniostoma ligustrifolium*), for example, abundant in many lowland forests, bears flowers in prolific cymes. The flowers - pale green, nectariferous, and slightly foetid - attract weevils, syrphid flies, native bees, and introduced bees, but not thrips. The hairy corolla of a hangehange flower possibly denies a thrips access to the floral rewards. The flowers of mapou (*Myrsine australis*), also small and drab, are described by Pocknall (1978) as insect pollinated. My observations, day and night, of mapou flowers, wild and cultivated, revealed no thrips, nor any other insects. *Myrsine* pollen is generally over-represented in pollen spectra (M. S. McGlone, pers. comm.), and the flowers, lacking scent and nectar, are best regarded as wind pollinated.

Thomson (1881) says thrips may be found in flowers but to consider them pollinators is "erroneous" because they "would only bring about self-fertilization". Unlike honeybees and some butterflies, thrips are not known to forage by visiting many individuals of the same species, cross-pollinating en route. Nevertheless such adaptations for outcrossing are neither needed by nor found in many New Zealand plants. Of the partially or fully hermaphrodite species on which *Thrips obscuratus* were found, only one, lowland horopito, is known to be self-incompatible. Most native plants with bisexual flowers have breeding systems which favour pollination by an insect within a single flower or between flowers in the same inflorescence. Inconspicuous as single units, the flowers of many New Zealand trees are clustered, presumably to attract pollinators by the flag effect. Insect pollinators usually visit several to many flowers of an inflorescence during each forage. Therefore, unless every flower is synchronized, there will be flowers at various stages of anthesis in each inflorescence. Consequently any visitor to the flowers of a hermaphroditic, self-compatible species is a potential pollinator.

Bawa (1980) noted that many zoophilous dioecious species worldwide have small, pale, unspecialized flowers and are pollinated by small

opportunistic insects. This is generally true of New Zealand's dioecious trees (Godley, 1979). For an insect to pollinate a dioecious plant, not only must interplant visits be made, but visits to staminate flowers must precede those to pistillate flowers. Thrips in flight are difficult to observe, however thrips captured on female flowers of mahoe, kaikomako, and five-finger were found, upon examination under the SEM, to have the appropriate pollen adhering. Each female tree was within 10m of a flowering male of the same species. Successive visits by thrips to members of a dioecious species may be a function of the population structure (i.e. diversity and density) of the forest. Alternatively, such visits may indicate something less fortuitous but as yet undetermined, such as a preference for the plant as a food source or oviposition site.

The extent to which thrips contribute to the pollination dynamics of the lowland forest remains uncertain. Thrips feed primarily on plant tissues and their presence in flowers is common but opportunistic. Several of the species on which thrips were collected are pollinated by other mechanisms. For example, flax (*Phormium tenax*; Table 2) is bird-pollinated (Godley, 1979) and pigeonwood is wind-pollinated (Sampson, 1969). Other plants, such as kaikomako and ngaio, have floral structures which appear adapted for pollination by larger insects. Nevertheless it is probable that thrips are involved to a degree in the pollination of some self-compatible hermaphroditic species. It is also possible that thrips are involved in the pollination of some self-incompatible or dioecious species. The quantitation of the importance of thrips pollination, however, awaits further investigation.

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