SELECTION OF WILD HOSTS FOR FEEDING BY PASSION VINE HOPPER, *SCOLYPOPA AUSTRALIS* (WALKER) (HEMIPTERA: RICANIIDAE) IN THE BAY OF PLENTY

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ABSTRACT

Passion vine hopper, *Scolypopa australis* (Walker) (Hemiptera: Ricaniidae), a pest of kiwifruit, occurs on a wide range of native and introduced plants that are probably not equally preferred as hosts. First-instar nymphs and adults were observed on 69% and 53% respectively, of 42 plant species found at varying frequency in a survey of gullies adjacent to kiwifruit orchards in the Bay of Plenty. In choice tests with four plant species common in gullies, first-instar nymphs and adults preferred the native species mahoe (*Melicytus ramiflorus*). Under no-choice conditions, survival from first to late instar was also best on mahoe. Of 10 plant species in a no-choice test, adults survived best and laid most eggs on the native species wineberry (*Aristotelia serrata*).

Keywords: passion vine hopper, host plants, preference

INTRODUCTION

The passion vine hopper, *Scolypopa australis* (Walker), is an introduced pest of kiwifruit in New Zealand (Steven 1990). Adults and nymphs feed on phloem and excrete honeydew. Sooty mould growing on the honeydew reduces the marketability of kiwifruit. Dead plant stems and leaf petioles approximately 2 mm in diameter are common sites for oviposition. Eggs are laid in late summer and autumn and hatch in the following spring. Nymphs develop through five instars and become adults in summer, completing a single generation in one year.

Passion vine hopper has been recorded from a large range of plants in New Zealand and in Australia, which is its site of origin (Siew 1960; Fletcher 1978; Spiller & Wise 1982). In the Bay of Plenty, passion vine hopper occurs on native and introduced plants in gullies. From mid-summer to autumn adults may disperse from gullies into adjacent kiwifruit orchards. Few passion vine hoppers complete their lifecycle in kiwifruit orchards as relatively few eggs are laid there (Steven 1990) and these are often removed when vines are pruned during winter. Thus, plants in gullies are likely to be important in the population dynamics of passion vine hopper.

This work was initiated to further understand the behaviour of passion vine hopper. Host selection for feeding and oviposition, and the effect of different hosts on survival and development were investigated for native and introduced host plants present in gullies.

MATERIALS AND METHODS

Field survey

A survey of the presence of passion vine hopper on wild plants was conducted in the Tauranga district, Bay of Plenty during 2001/02. Plants were identified in a 1 m wide transect from the top to the base of 10 gullies bordering kiwifruit orchards and the density of each plant species recorded as plants/m^2. Transects were 36 to 130 m long. Plants in and near transects were checked for the presence of first-instar nymphs in October and for adults in the following February.

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General methods for experiments

All experiments to study host choice except one were carried out in cages in a shade house. The no-choice experiment with adults was carried out in three controlled-temperature rooms at 18°C. This temperature is approximately the average hourly temperature from January to April at Te Puke when passion vine hoppers occur as adults. Selection of plant species for experiments was determined by availability and plant size suitable for insect cages. Native species, except for bracken (*Pteridium esculentum*), were purchased from a plant nursery. Introduced species and bracken were propagated. Plants were of approximately equivalent height (500 mm) at the start of experiments and were watered each evening. First-instar nymphs and adults were collected from wild hosts in gullies and introduced evenly to the cage floor on the same day or on the following day. At assessment first-instar nymphs, which are often difficult to see, were counted after first enclosing individual plants in a box above a tray with a dark base and applying an aerosol insecticide spray. The plant was then shaken 10 minutes later to remove any surviving nymphs that had not been killed by the insecticide. Adults are relatively large and easy to see and were counted on plants in cages. Tufts of fibres projecting from plant stems, each associated with the site of an implanted egg, were counted as egg-laying scars. Data were analysed by ANOVA after transformation by log $(x + 0.5)$ to remove variance heterogeneity. Alternatively, where variance heterogeneity could not be removed by transformation, data were analysed by Friedman's non-parametric test (Zar 1996). Means were separated using the Least Significant Difference (LSD) at $P<0.05$.

No-choice experiment for nymphs

Groups of 30 first-instar nymphs were introduced to five groups of five cages (480 mm wide, 480 mm long and 730 mm high) with a single plant of mahoe (*Melicytus ramiflorus*), pepper tree (*Macropiper excelsum*), blackberry (*Rubus fruticosus*), Japanese honeysuckle (*Lonicera japonica*) or pigeonwood (*Hedycarya arborea*). Cages were arranged in a randomised block design. The number of individuals on each plant and their stage of development were determined after 35 days. Nymphs were collected into 70% ethanol by aspirator and separated into different instars using a key by Fletcher (1978) with the aid of a binocular dissecting microscope. The experiment was carried out between late November 2001 and early January 2002 when ambient air temperatures were 8.8 to 28.5°C.

Choice experiments for nymphs and adults

Approximately 80 first-instar nymphs or 30 adults were introduced to cages (480 mm wide, 730 mm long and 730 mm high) with four plants, one each of mahoe, pepper tree, blackberry and honeysuckle. There were 10 replicate cages for both first-instar nymphs and adults. Plants were placed in one of four positions in cages according to a random sequence of 1-4 generated by computer. The number of first-instar nymphs on each plant was counted after 10 days, and the number of adults after 7 and 32 days. The number of scars from egg laying was counted after 32 days. Choice experiments were carried out in November 2001 (nymphs) and in February and March 2002 (adults) when ambient air temperatures were 7.6 to 23.7°C and 8.9 to 25.7°C, respectively.

No-choice experiment for adults

Late-instar nymphs were collected from gullies and reared in cages (480 mm wide and long, 730 mm high) on a mixture of privet (*Ligustrum vulgare*), mahoe, bracken and wineberry (*Aristotelia serrata*). Newly formed adults were removed each day and introduced to cages (480 mm wide, 480 mm long and 730 mm high) with one of 10 different plant species (Table 3) such that each cage contained a cohort of 15 adults less than 24 h old. Six replicates of each plant species were established in late January and early February 2000. Thin pieces of balsa wood (1.5 mm thick, 30 mm wide and 230 mm long) were added to each cage to provide egg-laying sites. Dead passion vine hoppers were removed from cages each day, counted and sexed until no adults remained, and average longevity was determined for adults in each cage. Scars from egg laying in balsa wood sections and in plants were counted and divided by the number of females to estimate average fecundity per female. No attempt was made to account for the contribution of individual females to egg laying.

RESULTS

Field survey

We identified 31 native and 11 introduced plant species of which two species, pepper tree and mahoe, were present in all gullies (Table 1). The most common introduced

TABLE 1: The frequency and density (no./m^2) of plants in transects of gullies in the Bay of Plenty and presence of first-instar nymphs (N) and adults (A) of passion vine hopper (PVH).

Plant species	Common name	Freq.[1]	Mean plant density±SD	PVH present
Native species				
Macropiper excelsum	Pepper tree	10	0.356±0.178	N, A
Melicytus ramiflorus	Mahoe	10	0.245±0.266	N, A
Cyathea dealbata	Silver fern	9	0.055±0.054	N, A
Cyathea medullaris	Black tree fern	8	0.116±0.110	N, A
Geniostoma rupestre	Hangehange	8	0.086±0.114	N, A
Blechnum capense	Ground fern	7	0.018±0.016	N, A
Aristotelia serrata	Wineberry	6	0.031±0.033	N, A
Hedycarya arborea	Pigeonwood	5	0.061±0.108	N, A
Coprosma robusta	Karamu	5	0.015±0.017	N, A
Blechnum chambersii	Fern	4	0.064±0.160	N
Knightia excelsa	Rewarewa	4	0.022±0.032	N
Coprosma grandifolia	Kanono	4	0.019±0.029	N, A
Brachyglottis repanda	Rangiora	4	0.016±0.024	N, A
Pneumatopteris pennigera	Gully fern	4	0.015±0.022	N, A
Pseudopanax arboreus	Five-finger	4	0.014±0.022	N, A
Fuschia excorticata	Native fuschia	3	0.015±0.029	N, A
Dysoxylum spectabile	Kohekohe	2	0.014±0.042	N, A
Leptospermum ericoides	Kanuka	2	0.011±0.024	
Weinmannia racemosa	Kamahi	2	0.010±0.022	
Litsea calicaris	Mangeao	2	0.006±0.013	
Coprosma lucida	Karamu	2	0.004±0.008	N
Myrsine australis	Mapau	2	0.003±0.007	N, A
Dryopteris filix-mas	Male fern	1	0.006±0.018	N, A
Dicksonia squarrosa	Tree fern	1	0.003±0.009	
Podocarpus totara	Totara	1	0.002±0.005	
Phyllocladus trichomanoides	Celery pine	1	0.002±0.005	
Schefflera excelsa	Pate	1	0.002±0.005	
Pteridium esculentum	Bracken	1	0.002±0.013	N, A
Olearia sp.		1	0.001±0.004	
Beilschmiedia tawa	Tawa	1	0.001±0.003	
Leucopogon fasciculatus	Mingimingi	1	0.001±0.004	
Introduced species				
Rubus fruticosus	Blackberry	4	0.030±0.041	N, A
Tradescantia albiflora	Wandering jew	3	0.051±0.086	N
Rubus fruticosus	Bramble	3	0.013±0.022	A
Berberis vulgaris	Barberry	3	0.012±0.024	N, A
Eucalyptus sp.	Gum	3	0.008±0.015	N, A
Ulex europaeus	Gorse	2	0.006±0.013	
Lonicera japonica	Japanese honeysuckle	1	0.016±0.052	N, A
Verbena sp.	Verbena	1	0.004±0.012	N
Acer sp.	Japanese maple	1	0.004±0.005	N
Prunus sp.	Taiwan cherry	1	0.002±0.002	N
Persea americana	Avocado	1	0.001±0.004	A

[1]Number of transects out of a total of 10 where species occurred.

species were creepers or trailing plants, which tended to be at the top of gullies where there was little canopy cover. Nymphs and adult passion vine hopper were observed in all gullies and were present on 69% and 53% of all plant species respectively (Table 1). Aggregations of first-instar nymphs and adults occurred at the tip of growing shoots on plants, particularly mahoe, wineberry, karamu (*Coprosma* spp.) and pigeonwood. First-instar nymphs and nymphal exuviae also tended to be clustered under leaves of many plant species.

No-choice experiment for nymphs

In the absence of choice, the number of nymphs surviving after 35 days was significantly affected by host plant (P<0.001). More nymphs survived on mahoe than on other plants (Table 2). More nymphs occurred on pigeonwood and honeysuckle than pepper tree; infestation on blackberry was intermediate between these plants (Table 2). Most passion vine hoppers were third instars (62%) after 35 days and mean development stage of surviving nymphs did not differ between plant species (Friedman Statistic = 8.2, P>0.05) (Table 2).

TABLE 2: Number (out of 30) and development stage of passion vine hopper nymphs after 35 days in a no-choice test of host plants (mean ± SD). Within each column, values followed by the same letter are not significantly different at P<0.05.

Host plant	Number of nymphs	Instar
Mahoe	14.8±7.2 a	3.4±0.1 a
Pigeonwood	6.6±4.3 b	2.8±0.4 a
Japanese honeysuckle	3.4±1.7 bc	2.4±0.3 a
Blackberry	1.6±0.5 cd	2.8±0.3 a
Pepper tree	1.2±0.4 d	3.0±1.0 a

Choice experiments for nymphs and adults

First-instar nymphs were not distributed equally amongst host plants after 10 days (P<0.01). More nymphs occurred on mahoe and blackberry than on pepper tree (Table 3). Adults were unequally distributed amongst host plants after 7 days (Friedman Statistic = 20.3, P<0.001) and after 32 days (Friedman Statistic = 9.8, P<0.05), and preferred mahoe to pepper tree (Table 3). Fewer adults were found on blackberry and honeysuckle than on mahoe after 7 days. The number of adults surviving after 32 days was relatively low and varied widely between cages; more adults occurred on mahoe than on pepper tree with numbers on blackberry and honeysuckle intermediate (Table 3). Numbers of egg-laying scars differed between plant species (P<0.001) with pepper tree having fewer than mahoe, blackberry and honeysuckle (Table 3).

TABLE 3: Number of first-instar nymphs, adults and egg scars on host plants in choice tests (mean ± SD). Within each column, values followed by the same letter are not significantly different at P<0.05.

Host plant	Nymphs after 10 days	Adults After 7 days	Adults After 32 days	Scars from egg-laying after 32 days
Mahoe	20.0±13.0 a	14.1±6.4 a	3.9±3.6 a	38.2±26.5 a
Blackberry	23.5±17.1 a	0.5±0.7 c	0.8±1.6 ab	53.3±30.6 a
Japanese honeysuckle	9.4±8.1 ab	0.8±0.8 bc	0.5±0.7 ab	36.4±19.2 a
Pepper tree	4.1±3.7 b	2.0±2.2 b	0.1±0.3 b	9.0±16.7 b

No-choice experiment for adults

Host plant significantly affected longevity (Friedman Statistic = 41.0, P<0.001) and fecundity (Friedman Statistic = 26.1, P<0.01). Average longevity of adults was greatest on wineberry, fleabane and mahoe (Table 4). Egg-laying scars occurred on strips of balsa wood and on plant stems, but only in eight of 60 cages. Wineberry had more egg-laying scars than other plants (Table 4). There were no egg-laying scars present on six host plant species.

TABLE 4: Longevity and egg-laying scars of adult passion vine hopper (mean ± SD) caged on different host plants in a no-choice experiment. Within each column, values followed by the same letter are not significantly different at P<0.05.

Host	Adult longevity (days)	Egg scars per female
Wineberry	49.6±13.6 a	196.0±177.2 a
Fleabane[1]	18.0±6.5 a	0 b
Mahoe	13.9±4.2 a	0.4±0.9 b
Blackberry	10.7±9.3 b	15.4±37.6 b
Bracken	9.9±5.0 bc	8.7±15.4 b
Pepper tree	5.4±0.7 cd	0 b
Wandering jew	5.2± 1.1 d	0 b
Japanese honeysuckle	5.1±1.2 d	0 b
Rewarewa	4.9±1.1 d	0 b
Hen and chicken fern[2]	4.9±0.6 d	0 b

[1]*Conyza* sp.
[2] *Asplenium bulbiferum.*

DISCUSSION

Passion vine hoppers occurred on most plants in gullies, consistent with previous reports of its apparent polyphagy. Feeding by first-instar nymphs was difficult to observe due to their small size and some plants may have been incidental hosts. Exuviae of first and later instars have their stylet sheaths embedded in plant tissue and were observed to persist on plants long after nymphs had developed to adults. The presence of exuviae of different instars may be useful in further studies to indicate suitability of hosts for feeding and development by young passion vine hoppers.

Egg laying by passion vine hopper occurs in a wide range of plants and dead material (Cumber 1966; Fletcher 1978; Gerard 1985) and consequently newly-hatched first instars are likely to occur on a range of hosts. Studies here imply that first-instar nymphs are able to discriminate between plants and may disperse to find preferred hosts. When not given a choice of hosts, survival of first instars and newly emerged adults was reduced on some plants, although development rate from first to third instar was not affected. Distribution between hosts in choice tests was consistent with survival on hosts in no-choice tests. Pepper tree was not a preferred host, and was a relatively poor host for survival of young passion vine hopper. Mahoe was a preferred host for feeding by nymphs and adults, and was a relatively good host for survival.

In the no-choice trial, newly formed adults reared on mahoe did not survive for long enough to lay many eggs and this is anomalous compared with choice experiments and the no-choice test with nymphs. Whereas other experiments occurred in a shade house, the no-choice experiment with adults was conducted in temperature-controlled rooms. Temperature and relative humidity are likely to have differed between the shade house and temperature-controlled rooms, but it is not known if these differences contributed to our results. Clearly adults need to feed for some time before egg laying occurs. Siew (1960) found the first fully-grown oocytes present when females were 13 days old, but according to Fletcher (1978) egg laying may be delayed for two months after females reach adult stage. More eggs were laid on wineberry than on other plants. In the field, wineberry is often heavily infested with nymphs and adults. Wineberry and the more common mahoe probably contribute substantially to the abundance of passion vine hopper in gullies in the Bay of Plenty.

Feeding history may influence host choice by passion vine hopper. We tried to reduce any effect of feeding history by collecting nymphs and adults from a range of wild hosts. Further study of effects of feeding history on host choice by passion vine hopper is needed. Host choice by passion vine hopper may change over time due to changes in plant physiology. Blackberry appeared to be less attractive to adults than to first-instar nymphs in choice experiments reported here. However experiments with adults were completed later than those with nymphs by which time blackberry plants had flowered and set fruit. Gerard (1985) considered that nymphs moved from blackberry to bracken as blackberry produced flowers and stems became lignified. In the field, physiological changes in hosts may lead to dispersal of passion vine hopper in search of new hosts, including kiwifruit.

Host selection and acceptance in phloem-feeding insects is probably based on a variety of stimuli at the plant surface and on factors in phloem, and is mediated by host deprivation (Backus 1988; Bernays & Chapman 1994). Nymphs and adults of passion vine hopper did not completely avoid any plants in choice tests. This supports an hypothesis that host rejection by passion vine hopper may follow after feeding in the phloem, either due to inadequate nutrition or to the presence of intolerable chemicals. Further work on the response of passion vine hopper to different host plants is planned using electrical penetration graphs (EPG), a method first developed to study the probing behaviour of aphids (Tjallingii 1985). The use of EPG enables the quantification of invisible probing by sucking insects and may assist in defining factors that determine host suitability for passion vine hopper.

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