

Effects of adult feeding on longevity and fecundity of *Ctenopseustis obliquana* (Lepidoptera: Tortricidae)

PHILIPPA STEVENS

KARYN FROUD

LISA JAMIESON

The Horticulture and Food Research
Institute of New Zealand Ltd
Private Bag 92 169
Auckland, New Zealand
email: pstevens@hortresearch.co.nz

INTRODUCTION

Conservation biological control is the manipulation of the environment to enhance the survival, fecundity, longevity, and behaviour of natural enemies to increase their effectiveness (Landis et al. 2000). There has recently been much interest in enhancing the effectiveness of biological control agents in cropping environments through the provision of flowering plants. One of the premises underlying this approach is that nectar availability is limited within the monoculture environments typical of commercial horticulture, and that many adult parasitoids require nectar to reach their full reproductive potential. However, provision of flowering plants may also act as a nectar source for pest insects and if there is a similar positive effect on reproduction potential of pests the provision of flowering plants may not yield any net benefits.

Abstract *Ctenopseustis obliquana* (Walker) is one of the key pests of horticulture in New Zealand and there is interest in the provision of flowering plants within orchards to increase the effectiveness of biological control. A trial was carried out to evaluate the potential impact of providing nectar sources within orchards on the longevity and fecundity of this pest. Newly eclosed pairs of moths were set up in the laboratory and provided with a supply of either honey or water, or remained unfed. The age-specific reproduction of pairs was determined each day throughout their lives. Provision of both water and honey significantly increased longevity and numbers of eggs laid per female compared to moths that were not provided with a source of honey or water. Moths provided with honey had significantly greater longevity than moths provided water, but total egg production and number of days spent egg laying was not increased. Moths provided honey had a prolonged post-ovipositional period compared to moths only provided with water. It is concluded that the provision of nectar sources within orchards is not likely to increase the reproductive capacity of *C. obliquana* but the suitability of any new plants as hosts for larval *C. obliquana* needs to be evaluated.

Leafrollers are amongst the most serious pests of horticultural crops in New Zealand. One of the common pest species in kiwifruit and avocados in the northern part of the country is the endemic species *Ctenopseustis obliquana* (Walker) (Lepidoptera: Tortricidae). *C. obliquana* has several parasitoids including *Dolichogenidia tasmanica* (Cameron) (Hymenoptera: Braconidae), *Trichogramma* (*Trichogrammanza*) *funiculatum* Carver (Hymenoptera: Trichogrammatidae), and *Trigonospila brevifacies* (Hardy) (Diptera: Tachinidae) (Valentine & Walker 1991; van der Geest et al. 1991). Previous work has shown that *T. funiculatum* reproductive capacity can be significantly increased in the presence of honey solution, dandelion or buttercup flowers (Stevens 1997). A trial in Canterbury found that planting buckwheat in an apple orchard significantly enhanced leafroller parasitism within apple orchards, especially by *D. tasmanica* (Irwin et al. 2000). Some growers are now actively planting mixtures of flowering plants in orchards to improve biological control. However, provision of nectar plants has also been shown to increase populations of pest Lepidoptera (Zhao et al. 1992; Baggen & Gurr

Keywords *Ctenopseustis obliquana*; honey; leafroller feeding; habitat manipulation

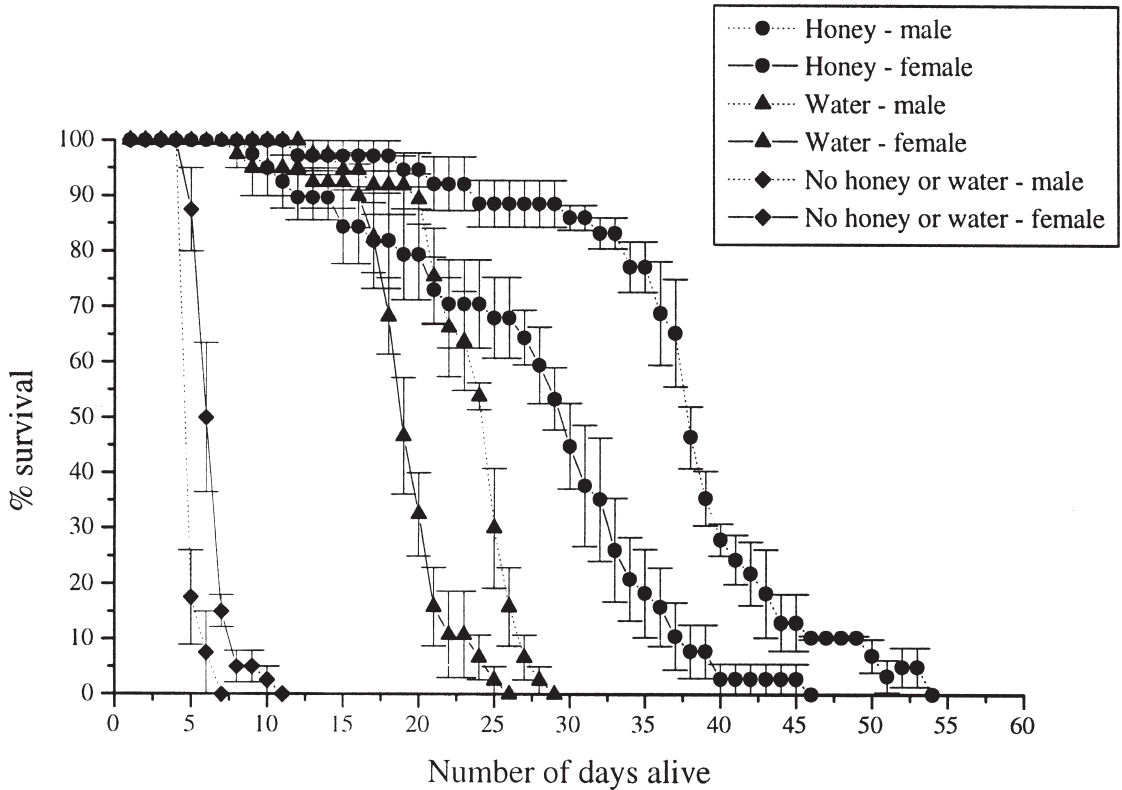


Fig. 1 Survivorship curves for male and female *Ctenopseustis obliquana* provided with either honey solution, water, or provided no honey or water (mean \pm SEM).

1998). There has been little detailed evaluation of the potential impact of nectar producing plants on *C. obliquana* populations. Most adult Tortricidae require only water for normal longevity and fecundity, but some species need sugar to produce any eggs or to realise their full egg potential (Benz 1991). Before recommending the establishment of a flowering plant ground cover in orchards to improve biological control of *C. obliquana*, it would be pertinent to assess the possible impact on the pest species as well.

MATERIALS AND METHODS

Ctenopseustis obliquana was obtained from a laboratory colony maintained at HortResearch, Mt Albert, New Zealand (Clare & Singh 1988). The moths had been reared for 81 generations in the laboratory. Newly eclosed adults (<24 h old) of *C.*

obliquana were set up as individual male and female pairs within a transparent perspex tube (15 cm long and 4 cm diam.). The tube was lined with a 13 \times 13 cm polythene square rolled into a sleeve to provide a removable oviposition site. Each end of the perspex tube was sealed with a plug of absorbent cotton wool. Ten pairs of moths were set up for each treatment with four replicates.

Moths and any resulting eggs were held at 18°C with a 16:8 light:dark photoperiod during the experiments.

Pairs were provided with either water, 10% w/v honey solution, or no honey or water. The honey and water was provided by dipping the cotton wool plugs in the water or honey solutions every 3 days. The longevity of the male and female moths was determined by daily inspections. Each polythene sleeve was checked daily and was removed and replaced if any eggs were present. Eggs were stored within Petri dishes lined with tissue at 18°C. The

number of egg batches, total number of eggs, and number of viable eggs in each batch were counted 6–9 days after oviposition using a stereo microscope. Viable eggs were distinguished from unfertilised eggs by the presence of the larval head capsule within the chorion. The egg batches were rechecked c. 21 days after oviposition, by which time larvae had hatched, and the number of hatched eggs determined by counting the remaining unhatched eggs. The number of egg batches, total number of eggs, and number of fertile eggs laid per female were determined daily for the lifetime of each female.

Data from moths provided with different types of food or water resources were compared with analysis of variance (ANOVA). Least significant differences (LSDs) were calculated to separate treatments if the ANOVA resulted in a $P < 0.05$. Percentages were angular transformed before analysis but untransformed percentages are shown in tables. The analysis was performed using SAS (Release 6.12).

Table 1 Mean longevity (days) of moths provided with either honey solution, water, or no honey or water source (mean \pm SEM). Numbers in the same column followed by the same letter are not significantly different by ANOVA and LSD tests ($P < 0.05$).

	Male (days)	Female (days)
Honey	36.5 \pm 1.5a	26.5 \pm 1.6a
Water	22.7 \pm 0.6b	18.2 \pm 0.6b
No honey or water	4.3 \pm 0.1c	5.9 \pm 0.2c
<i>P</i>	0.001	0.001

RESULTS

Both males and females provided with honey lived significantly longer than moths provided with water only. Likewise, moths provided with water lived significantly longer than moths provided with no honey or water source (Table 1). Survivorship curves are shown in Fig. 1. Male and female moths provided with honey survived for up to 53 and 45 days respectively whereas the maximum survival of male and female moths provided with no honey or water was 6 and 10 days respectively. The maximum survival of male and female moths provided with water was intermediate (28 and 25 days respectively).

Female moths provided with honey or water laid significantly more egg batches and produced c. 40 times the total number of eggs over their lifetime than females not provided any honey or water (Table 2). The number of egg batches produced per female and the total number of eggs were not significantly different between females provided with water or honey solution. Females provided with honey solution or water had comparable numbers of days where oviposition occurred during their lives. Females provided with either honey or water had a 1–2-day pre-oviposition period followed by a very similar pattern of egg laying (Fig. 2). Oviposition peaked when female moths were 5 days old for moths provided with honey or water. Females provided with honey and water ceased to lay any eggs after a maximum of 28 and 19 days respectively. The provision of honey and water to adults did not have a significant effect on the percentage of eggs that were viable or the percentage of eggs that hatched. The mean percentage of viable eggs ranged from 56.2 to 75.9% for moths provided with honey and no honey or water respectively.

Table 2 Number egg batches, total number of eggs laid, and mean number eggs/female per day of female *Ctenopseustis obliquana* provided with either honey solution, water, or no honey or water (mean \pm SEM). Numbers in the same column followed by the same letter are not significantly different by ANOVA and LSD tests ($P < 0.05$).

Treatment	No. egg batches/female	Total no. of eggs/female	Mean no. eggs/female per day	Mean no. of egg laying days during lifetime
Honey solution	21.1 \pm 3.3a	593.0 \pm 80.8a	24.89 \pm 4.03a	9.6 \pm 1.1a
Water	16.9 \pm 1.8a	571.2 \pm 41.8a	31.81 \pm 2.11a	9.1 \pm 0.6a
No honey or water	0.2 \pm 0.1b	13.4 \pm 6.3b	2.34 \pm 1.10b	0.2 \pm 0.6b
<i>P</i>	0.0001	0.0001	0.0001	0.0001

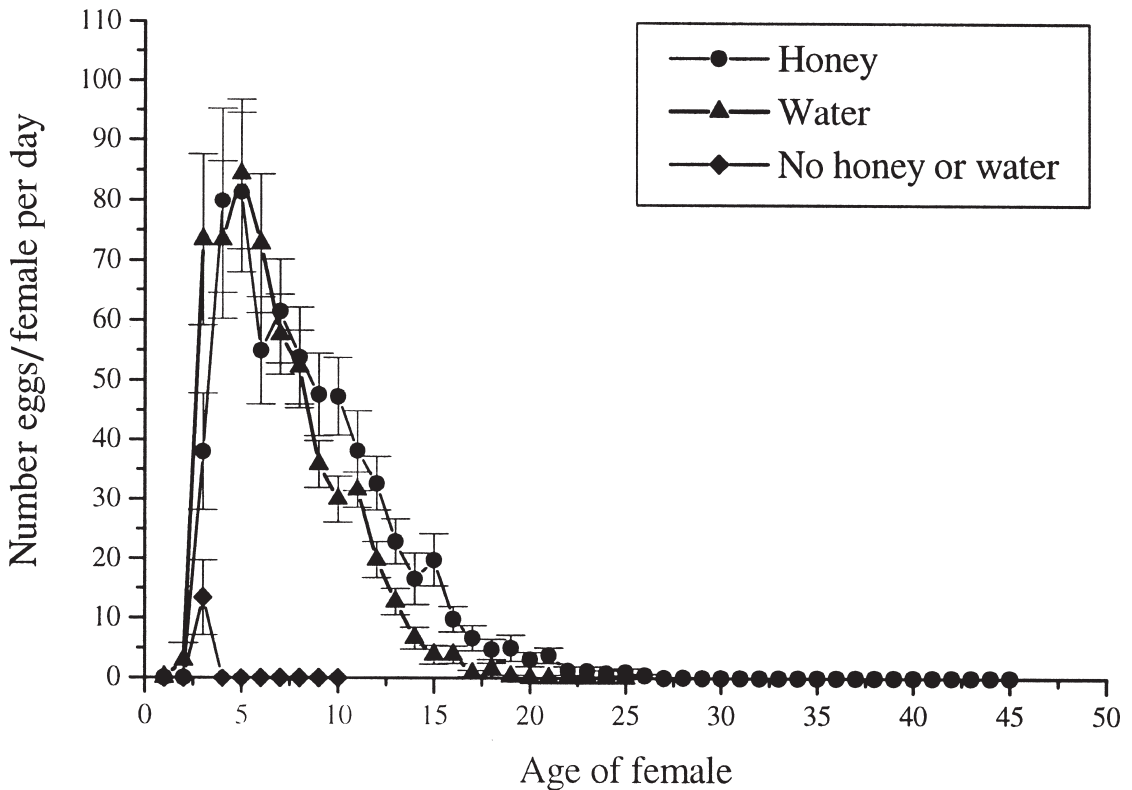


Fig. 2 Daily production of eggs by female *Ctenopseustis obliquana* provided with either honey solution, water, or provided no honey or water (mean \pm SEM).

The mean percentage of eggs that hatched ranged from 26.7 to 46.9% for moths provided with honey and no honey or water respectively.

DISCUSSION

This is the first detailed report of the age-specific fecundity of *C. obliquana*. A distinct age-related pattern of oviposition was observed for females that were provided with either honey solution or water. A previous study that evaluated some age-related changes in egg laying in *C. obliquana* reported that age of first mating had a significant effect on the number of egg masses laid by females over 3 days following mating (Foster et al. 1995). Though the moths in this current study were presumably able to mate at any age, the previous study allowed mating to occur only with females that were 1, 3, 5, or 7–11 days old. The numbers of eggs and egg masses laid

by females that were mated at 7–11 days was significantly less than for female moths mated at a younger age. The result of the current experiments suggests that the decrease in egg laying observed by Foster et al. (1995) may have been a direct result of female age rather than a result of the delayed age at which mating occurred.

The lifetime fecundity of females in the current experiment was significantly higher than in previous reports. For example, Clare & Singh (1990) reported that laboratory reared *C. obliquana* laid a mean of 132 eggs at 18°C. The moths in Clare & Singh (1990) had been fed 10% honey solution as adults however, larvae had fed on a different diet from that used here. Larval diet has previously been shown to be an important factor influencing fecundity of *C. obliquana*. *C. obliquana* reared on artificial diet containing powder made from dried leaves of different tree species produced between 10 and 453 eggs/female depending on which leaf powder was

used (Barrington et al. 1993). The moths used in this study had been reared in optimal conditions on an artificial diet known to maximise fecundity. However, it may be possible that wild adult moths, which can be smaller and with less fat reserves, would benefit from nectar sources. Further investigations to determine the impact of larval diet on adult nutritional requirements would be beneficial.

Although this study aimed to evaluate the effect of adult diet on reproduction and survival of moths, it is possible that the different types of food sources resulted in changes to microclimate within the cages and that differences in results are not only related to ingestion. However, cages provided with honey and water would be expected to have similar microclimates (i.e., relative humidity) and the significantly greater longevity of moths provided with honey compared to moths provided with water indicates that treatment effects are not just related to microclimate. Moisture is clearly required for survival and reproduction since moths kept in a dry environment rarely laid eggs and lived only for a short time. In a natural situation moisture may be obtained from other sources apart from nectar, e.g., dew on leaves. Measures of leaf wetness in Pukekohe, Auckland, found that dew was present on leaves throughout the night and for at least 2 h after dawn even in the middle of summer (W. Henshall, HortResearch unpubl. data). Whether adult moths feed on flowers predominantly to gain moisture or to gain sugars is not known. However, the results of this experiment demonstrate that the longevity of adult *C. obliquana* may be affected by the provision of nectar producing plants.

Though longevity of moths may be extended, honey feeding by *C. obliquana* does not result in an increase in lifetime fecundity or an increase in the period over which oviposition occurs. Females provided with honey had a prolonged post-ovipositional period relative to females provided with water only. These results indicate that the presence of nectar sources in orchards would not necessarily be expected to increase the pest status of *C. obliquana*. The enhancement of adult longevity observed in this current study contrasts with results from another study on the effect of consumption of sucrose by adult Tortricidae. Provision of sugar water to *Cydia molesta* (Busck) did not increase longevity or fecundity in the laboratory (Benz 1991). However, the results of enzyme analysis showed that both larvae and adults of *Cy. molesta* can digest sucrose.

Though adult feeding on honey solution does not appear to confer direct reproductive advantages to female *C. obliquana*, other important characteristics related to reproductive success may be affected. The bioassay technique in this experiment did not allow consideration of the influence of adult nutrition on dispersal, flight, or mating success of males. Orientated flight of males to calling females is an important aspect of the behaviour of male moths that requires energy. Likewise, dispersal into suitable habitats for oviposition is an important part of the behaviour of female moths. Tomkins et al. (1991) found that related species of leafrollers, *Planotortrix excessana* (Walker) and *Epiphyas postvittana* (Walker), actively discriminated between different types of host plants for the purposes of oviposition. Benz (1991) considered that energy used for flight in most adult Tortricidae is derived from fat reserves, but noted that sucrose is utilised by some species. However, there does not appear to be a clear relationship between the relative role of lipids versus sugars as energy sources for flight and the propensity to feed on sugars as an adult moth.

As well as potentially providing a source of nectar for adult moths, the planting of additional ground cover plant species in an orchard could have impacts on other stages of the leafroller life cycle. For example, some of the ground cover species may be used for oviposition or may be hosts to larval *C. obliquana*. The importance of considering all the possible implications of introducing a greater diversity of plant species within a cropping environment has been clearly demonstrated with research on the potato moth *Phthorimaea operculella* (Zeller) (Baggen & Gurr 1998). *P. operculella* produced significantly more eggs in the presence of honey or flowers of buckwheat or coriander. However, the moth did not appear to derive any benefit from the presence of borage. The term “selective food plant” was used to describe a plant that provides benefits to natural enemies but does not confer any benefits to the pest (Baggen et al. 1999, 2000). As previously mentioned, the increased fecundity resulting from a favourable larval host plant is likely to be significantly greater than that resulting from sugar supply to the adult. As *C. obliquana* is very polyphagous, there must be a likelihood that the addition of other host plants to the orchard will increase leafroller natality. If this occurs, the impact of planting new groundcover species would be detrimental.

These results indicate that the planting of flowering plants in orchards would not be expected

to have a direct impact on populations of *C. obliquana* through provision of nectar and a corresponding increase in reproductive capacity. However, additional plant species introduced into a commercial cropping environment must not be hosts of the larval stages of *C. obliquana* or any other pest insects.

ACKNOWLEDGMENTS

We thank Anne Barrington for supplying the insects used in trials and John Charles and Garry Hill for comments on the manuscript. Warwick Henshall kindly provided leaf wetness data. The work was funded by the Foundation for Research, Science and Technology Grant no. CO6X0006.

REFERENCES

- Baggen, L. R.; Gurr, G. M. 1998: The influence of food on *Copidosoma koehleri* (Hymenoptera: Encyrtidae), and the use of flowering plants as a habitat management tool to enhance biological control of potato moth, *Phthorimaea operculella* (Lepidoptera: Gelechiidae). *Biological Control* 11: 9–17.
- Baggen L. R.; Gurr, G. M.; Meats, A. 1999: Flowers in tri-trophic systems: mechanisms allowing selective exploitation by insect natural enemies for conservation biological control. *Entomologia Experimentalis et Applicata* 91: 155–161.
- Baggen, L. R.; Gurr, G. M.; Meats, A. 2000: Field observations on selective food plants for biological control of potato moth by *Copidosoma koehleri* Blanchard (Hymenoptera: Encyrtidae). In: Austin, A. D.; Dowtin, M. ed. Hymenoptera: evolution, biodiversity and biological control. Collingwood, Australia, CSIRO Publishing. Pp. 388–395.
- Barrington, A.; Russell, G. B.; Lane, G. A. 1993: Effect of selected plants on the growth and development of leafrollers. Proceedings of the 46th New Zealand Plant Protection Conference. Pp. 187–190.
- Benz, G. 1991: Physiology, reproduction and ecology. In: van der Geest, L. P. S.; Evenhuis, H. H. ed. Tortricid pests, their biology, natural enemies and control: world crop pests vol. 5. Amsterdam, Elsevier Science Publishers. Pp. 89–147.
- Clare, G. K.; Singh, P. 1988: Laboratory rearing of *Ctenopseustis obliquana* (Walker) (Lepidoptera: Tortricidae) on an artificial diet. *New Zealand Journal of Zoology* 15: 435–438.
- Clare, G. K.; Singh, P. 1990: Use of day-degree estimates for rearing management of *Ctenopseustis obliquana* (Lepidoptera: Tortricidae) in the laboratory. *New Zealand Journal of Zoology* 17: 567–575.
- Foster, S. P.; Howard, A. J.; Ayers, R. H. 1995: Age-related changes in reproductive character of four species of tortricid moths. *New Zealand Journal of Zoology* 22: 271–280.
- Irwin, N. A.; Wratten, S. D.; Frampton, C. M. 2000: Understorey management for the enhancement of the leafroller parasitoid *Dolichogenidia tasmanica* (Cameron) in orchards at Canterbury, New Zealand. In: Austin, A. D.; Dowtin, M. ed. Hymenoptera: evolution, biodiversity and biological control. Collingwood, Australia, CSIRO Publishing. Pp. 396–403.
- Landis, D. A.; Wratten, S. D.; Gurr, G. M. 2000: Habitat management to conserve natural enemies of arthropod pests in agriculture. *Annual Review of Entomology* 45: 175–201.
- Stevens, P. S. 1997: The effect of floral feeding on a leafroller parasitoid. Proceedings of the 50th New Zealand Plant Protection Conference. P. 154.
- Tomkins, A. R.; Penman, D. R.; Chapman, R. B. 1991: Leafroller oviposition on larval host plants. *New Zealand Entomologist* 14: 37–41.
- Valentine, E. W.; Walker, A. K. 1991: Annotated catalogue of New Zealand Hymenoptera. Auckland, New Zealand, *DSIR Plant Protection report no. 4*. 84 p.
- van der Geest, L. P. S.; Wearing, C. H.; Dugdale, J. S. 1991: Tortricids in miscellaneous crops. In: van der Geest, L. P. S.; Evenhuis, H. H. ed. Tortricid pests, their biology, natural enemies and control: world crop pests vol. 5. Amsterdam, Elsevier Science Publishers. Pp. 563–577.
- Zhao, J. Z.; Ayers, G. S.; Grafius, E. J.; Stehr, F. W. 1992: Effects of neighbouring nectar-producing plants in populations of pest lepidoptera and their parasitoids in broccoli plantings. *The Great Lakes Entomologist* 25: 253–258.