Biology and rearing of *Pseudocoremia suavis*, an endemic looper (Lepidoptera: Geometridae) with a history of outbreaks on exotic conifers

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Abstract

The life cycle and seasonal phenology of the endemic geometrid *Pseudocoremia suavis* (Butler) is described, as well as a method for rearing the species continuously in the laboratory on cut foliage of radiata pine (*Pinus radiata* D.Don). Both males and females demonstrated developmental polymorphism, having either five (Type I) or six (Type II) larval instars. These two larval types did not differ significantly in the total development time (from egg hatch to adult) of around 60 days in either case. The development time and head capsule widths of the penultimate and ultimate instars of each type suggest that these two instars are equivalent in both Type I and Type II larvae. In the field, most instars were present throughout the sampling period from mid-November to mid-March, and no clear peaks in activity were observed for adult males caught on female-baited sticky traps. These results support the findings of others that this species does not have clearly synchronised generations. Catch data from female-baited traps revealed that calling peaked in one-day old females, with a mean of c. 27% of catches, and declined steadily with age. About 99% of cumulative catches occurred by the time females were 12 days old.

Keywords: life history, developmental polymorphism, rearing, phenology, head capsule width, calling phenology

Introduction

The endemic common forest looper, *Pseudocoremia suavis* (Butler) (Lepidoptera: Geometridae), is common throughout New Zealand, feeding on a wide range of trees and shrubs, including southern beech (*Nothofagus* spp.), podocarps, and kanuka (*Kunzea ericoides*) (Zondag 1956, Dugdale 1958). It is not known as a significant pest of native species but it has caused serious defoliation in exotic plantation forests (White 1974, Kay 1982). Several outbreaks occurred in pine plantations (*Pinus* spp., mainly *P. radiata* D. Don) in Canterbury in the 1950s and early 1960s (White 1974), and in North Island Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) plantations in the 1970s (Kay 1982, 1983b). These outbreaks are the only known cases in New Zealand where large areas of exotic conifer forest were defoliated by an insect. In the northern hemisphere a wide range of Lepidoptera defoliators, including some Geometridae, can cause significant defoliation of conifers (Berryman 1996, Speer *et al.* 2001).

The biology and ecology of *P. suavis* is of interest because of the potential risk of renewed outbreaks and because this species is an indigenous defoliator that has colonised an introduced forest tree. Considerable work was done on the biology and rearing of *P. suavis* during and after the outbreaks, although the majority of this is in unpublished reports which give limited detail of methods or analysis of results (e.g., Zondag 1956, Alma 1975). Zondag (1956) described aspects of the taxonomy, morphology, life history and mortality factors of *P. suavis* based on observations made during an outbreak in Canterbury in 1951-52. The structural characteristics of the larvae were described by Dugdale (1958). During 1970 and 1971, Alma (1975) used a light-trap to monitor *P. suavis* populations in Rotorua. Kay (1983a) conducted host plant preference experiments to investigate resistance in Douglas-fir.

Knowledge of the biology of both outbreak and non-outbreak *P. suavis* populations would help us to understand outbreaks of this pest, and how to monitor and manage these events when they occur. In this paper we describe aspects of the life history, rearing methods and development of *P. suavis* based on new data gathered during the course of recent experiments, complemented with information from previous reports. We also describe the period of female calling in the field along with a method to

monitor populations using sticky traps baited with live female moths. We focus on *P. suavis* from Eyrewell Forest pine plantation in North Canterbury, where major outbreaks have occurred in the past.

Methods

The study was conducted over three summer seasons between October 2001 and March 2004. Rearing methods were developed over time, with separate colonies started in the 2001-02 season (Colony 1), and in the 2002-03 season (Colony 2). Previous workers have obtained live *P. suavis* by harvesting eggs from light trapped females (Faulds & Kay 1996), or by collecting larvae in the field. These methods are suitable when wild populations are sufficiently abundant to provide a reliable source of eggs, but this was not the case in Canterbury during this study. We established laboratory colonies that were started from light-trapped moths, and these light-trapping data were also used in an analysis of the phenology of wild adults in the field. Adult females from the colonies were used in female-baited sticky traps in the 2001-02, 2002-03 and 2003-04 seasons to provide additional data on the phenology of male moths. Data on larval phenology were collected from beating samples taken in the 2002-03 season. Life cycle information was obtained from observations made of the colonies, and from two no-choice host plant preference experiments and an additional experiment designed to determine the number of larval instars, all conducted in 2003 and 2004. All rearing and laboratory experiments were conducted at room temperature in Christchurch (approx. 23°C).

Rearing

P. suavis colony 1

The colony was initiated from female moths caught at Eyrewell Forest either by hand collecting on a white sheet spread out underneath a UV light, or using a Bioquip UV light trap. The former method was preferred as moths caught in the light trap were often in poor condition. This collection was taken within mature radiata pine stands between 22:00 h and 02:00 h, or throughout the night for the Bioquip trap, over 48 nights between 17 October and 22 December 2001. Captured females were placed in 35 mm film containers with drops of honey-water and strips of multi-layered cellulose wadding ('Cellosene') as an egg-laying substrate (Faulds & Kay 1996). The layering of the Cellosene mimics bark crevices into which eggs are laid in the wild (Zondag 1956). Cellosene strips containing eggs were then placed in 1-litre clear plastic jars with a fine mesh lid (mesh size 0.5 mm) containing fresh radiata pine foliage which was replaced weekly, or when all foliage was consumed. Mature larvae pupated in leaf litter in the container.

P. suavis colony 2

The second laboratory colony was started in the same manner as the first, by collecting live female moths over 12 nights between November 2002 and January 2003, but improvements were made to the rearing methods. For egg laying, captured female moths were placed individually in 400 ml clear plastic jars with fine mesh lids. Clear jars were used instead of film containers so egg development could be observed without opening the container. A dental wick soaked in 10% honey solution and a tissue-paper strip (an egg laying substrate made of four layers of two-ply facial tissue, stapled and cut into 10 mm by 20 mm rectangles) was added to each jar.

Tissue strips with eggs were placed in small pottles until eggs hatched. Neonate larvae were then transferred to a 1-litre jar and reared on new growth radiata pine needles at room temperature under fluorescent lights with a 12L:12D photoperiod. First and second instar larvae were reared in 1-litre jars. Fresh pine branch tips were provided as food, with the cut end of each branch tip wrapped in Parafilm® to reduce desiccation. Neonate larvae show a strong positive phototaxis and have a tendency to aggregate on the inside of the jar closest to the light source, where they can die of starvation. To ensure larvae remained on the pine foliage, two branch tips were curled around the base of the jar, with two more filling the rest of the jar. Jars were then laid on their side with the base facing the light. The pine foliage was replaced every third day for first and second instar larvae.

Once larvae were in the second instar and were less phototactic they were moved onto pine branches (changed every fifth day) in clear plastic boxes (320 x 310 x 80 mm, with mesh-covered ventilation holes in the lid). Larvae from two or three 1-litre jars were combined into these rearing boxes, giving

a total of c. 350 eggs from three different females in each box. A light mist of water was applied to the boxes every few days if needed, but care was taken not to let condensation form. Frass and pine needle debris were left in the boxes to provide a substrate for pupation.

Moth mating

Initial attempts to achieve mating by placing females and males together after they emerged had only limited success, apparently because successful mating in the laboratory requires pupae to be kept together so that males can mate with freshly-emerged females (J.S. Dugdale 2003, pers. comm.). Subsequently, pupae of both sexes were placed together in open Petri dishes on the floor of a large mesh cage (600 x 600 x 600 mm), with some shredded paper to simulate leaf litter. Honey water on cotton wool was also provided in the cage. Female moths, newly emerged and mated, were removed each morning and placed in plastic pottles, with a dental wick soaked in honey water and a tissue strip, for egg laying, as described above.

Artificial diet

Pseudocoremia suavis F_3 generation larvae were reared from first instar on gypsy moth diet (recipe from United States Department of Agriculture, Massachusetts, USA). Diet was provided in 'fluted Sweetheart cups' with cardboard lids (95 mm diameter at top, 65 mm diameter at base, 55 mm deep; B&T International, PO Box 1243, Hixson, Tennessee, USA). Eighty to 160 mature eggs were put in each of eight cups for hatching in July 2003. Larvae were transferred to fresh diet as the old diet dried out.

Life cycle

Development time

The mean development time (laying to hatching) of *P. suavis* egg batches was recorded for the F_3 generation of Colony 2. The larval and pupal development time was recorded as part of three experiments (Table 1). Experiments A and C were no-choice host plant preference experiments, from which only the results for larvae reared on *P. radiata* are presented here. Experiment B was designed to examine the number of larval instars and was discontinued once larvae pupated. In all experiments each replicate consisted of a rearing pottle with a pine twig and a single *P. suavis* larva. Rearing pottles (M. Kay, Forest Research, Rotorua) were made of two stacked opaque plastic food cups (Lily brand) with an opening diameter of 92 mm and a clear plastic lid with puncture holes for ventilation. The external cup was 115 mm tall and acted as a water reservoir. The internal one was 80 mm tall with a 15 mm diameter hole in the base. The *P. radiata* twig stem was wrapped in a strip of paper towel to form a plug, which was inserted in the hole in the base, suspending the cut end of the twig in the water held in the outer cup below. Larvae were checked every 1-2 days, and twigs were replaced weekly. Larvae had access to water from the paper towel plug which was kept moist from the water reservoir.

Table 1. Details of experiments assessing development of *P. suavis* on pine.

Experiment	Dates	Number of replicates on *P. radiata*	HCW measured	Source of larvae
A	16/4 – 23/6/2003	10	Yes	Siblings, F_3, Colony 2
B	24/6 – 7/8/2003	20	No	Siblings, F_3, Colony 2
C	4/2 – 4/4/2004	15	Yes	Offspring of 3 wild-caught females

In Experiment A, larvae were reared communally on pine for 6 days before being separated into individual rearing pottles. In Experiments B and C, replicates were set up with newly hatched, unfed larvae. Experiments were conducted in the laboratory under fluorescent lights with a 12L: 12D photoperiod (Experiments A and B: 1 x Philips TLE 22W/33; Experiment C: 2 x Sylvania Gro-Lux F36W/GRO and 2 x Philips TLD 36W/865).
Changes in instar were recorded when the head capsule of a larva started to slip and the eyespots of the new head capsule were visible. Larvae remained in this state for approximately one day before fully shedding the old head capsule.

Head capsule width measurements
Head capsule widths (HCW) of live fifth and sixth instar *P. suavis* larvae were measured as part of Experiments A and C described above. In addition, the HCW of 317 F_3 and F_5 larvae of all sizes from a range of parents from Colony 2 were measured. These larvae were killed in boiling water and stored in 70% ethanol prior to measurement. All HCW measurements were taken at the widest point using a binocular microscope with an ocular micrometer calibrated using a stage micrometer.

Phenology

Larval phenology
The larval phenology of *P. suavis* was assessed by beating larvae from radiata pine, gorse (*Ulex europeaus*) and kanuka at Eyrewell Forest over 12 days between 28 November 2002 and 12 March 2003. Each sample was obtained by a single sharp blow with a stick to each of four branches on the same or adjacent trees (White 1975). A total of 1280 samples were taken on young pine, 243 on kanuka and 85 on gorse. In addition, 87 mature trees were sampled by cutting lower branches (6-8 m) with a pole pruner and dropping them onto a tarpaulin spread out on the forest floor below. These branches were then beaten by hand and the tarpaulin was checked for larvae. All larvae were returned to the laboratory, identified and assigned to one of five instars based on drawings and descriptions (Anon. 1959).

Adult phenology
The phenology of adults was assessed by light-trapping (described above) and by using sticky traps baited with newly-emerged female moths. The virgin females used in these traps were held in 35 ml plastic pottles, with wire mesh at both ends and containing a dental wick soaked in honey water, suspended beneath the ridge of a delta trap with a sticky base (HortResearch, Auckland). Trap bases were changed weekly, or when more than 10 moths had been caught, to prevent trap saturation.
In the 2001-02 season 265 female-baited sticky traps were set between 1 - 24 February 2002, staggered over 19 days as suitable F_1 female moths became available from Colony 1. Data from a subset of 46 traps were analysed to determine the relationship between the age of females and trap catch, as an indication of how long females release pheromone. An additional subset of 47 traps was used to determine longevity of female moths in the field. Temperature data used to examine the relationship between trap catch and ambient temperature were obtained from the Christchurch airport meteorological station, c. 10 km from the trapping area.
To assess the phenology of wild male *P. suavis*, data from the first six or seven nights of a subset of 98 female-baited traps from 2001-02 were used. Additional phenology data were obtained in subsequent seasons, with 18 traps set in March 2003, 30 in September 2003, 23 in October 2003, and 45 in December 2003. Females used in these traps were from Colony 2, and traps were set for six or seven nights.

Data analysis

Mann-Whitney U tests (SYSTAT 9, SPSS Inc. 1998) were used to examine the effect of differences in the number of instars observed (developmental polymorphism) and sex on development times and HCW. Linear regression was used to analyse the effect of ambient temperature on male moth catch, using temperature data from 22:00 - 2:00 hrs, when *P. suavis* moths were observed to be active in the forest. An exponential model was fitted using the SAS Non-linear modelling function (Statistical Analysis Software, SAS Institute Inc. 1999) to illustrate the effect of age of female moths on the daily catch rate of male moths. Daily catch raw data were transformed to the daily percentage of the total catch for each female. Trap catch data used to explore the relationship with ambient temperature were corrected for the age of females in sticky traps by transforming the data using the relationship shown in Fig. 5.

Results and Discussion

Rearing

At the peak of production, 120 F_2 females in Colony 2 produced c. 12,700 eggs resulting in 4,400 pupae, with 88% of females producing fertile eggs (Table 2). These rearing methods produced pupae at a similar rate to that from wild-collected females in Colony 1 (Table 2). Egg production by the F2 generation of Colony 2 (Table 2) was much greater than the mean of 36.7 eggs per wild-collected female in Rotorua by Faulds and Kay (1996), although lower than the range of 150-200 eggs per female found by Zondag (1956). No details are given that might explain why Zondag (1956) achieved such high egg production rates, although he does state that the number of eggs laid depended on the longevity of the female. Females in the present study were provided with honey water, which extends the life of many moth species (Stevens *et al.* 2002). Wild-collected moths could be expected to produce fewer eggs than those reared in the laboratory, as they may already have laid some of their egg load.

The development of a reliable means of achieving mating played a key part in the success of the rearing method. In the F_1 generation of Colony 2, egg production and the proportion of fertilised egg batches was much greater when male and female pupae emerged together in a large cage, than when they were paired after emergence (Table 2). The former method more closely mimics the behaviour of the moths in the wild, where males fly over the leaf litter seeking out recently emerged females that are drying their wings (J.S. Dugdale 2003, pers. comm.). Zondag (1956) observed that female *P. suavis* frequently mate with several males, although this was not investigated in the present study.

Pseudocoremia suavis was successfully reared from neonate larva to adult on gypsy moth diet, producing 78 pupae. Further work is needed to develop a suitable way of presenting the diet to these larvae as many died due to overcrowding and cannibalism. The use of diet does not seem worthwhile given the free access and ease of use of pine foliage. Kay (1995) found a 'neutral meridic'

Table 2. Productivity of the *P. suavis* colony, from wild females to the F_2 generation. Where no confidence interval is given, data were not recorded for individual females, only for the colony as a whole. In Colony 2, F_1, two different mating methods were used: 1) moths emerged in separate containers then put together for mating; 2) moths emerged together in the mating cage, giving males access to newly emerged females.

	Parent generation	Number of females	% producing fertile eggs	Mean eggs/ female	Mean pupae/ female (± 95% CI)
Colony 1 (2001-02)	Wild	33	82%	Not recorded	32 ± 11.2
Colony 2 (2002-03)	Wild	17	100%	Not recorded	24 ± 12.1
	F_1 (moths emerged separately)	73	< 16%	9 (no CI)	2 (no CI)
	F_1 (moths emerged together)	28	46%	35 ± 14.8	13 ±10.4
	F_2	120	88%	106 ± 10.1	36 (no CI)

diet (HortResearch) unsatisfactory for rearing first instar *P. suavis*, but no other record of the rearing of this species on artificial diet has been found. Singh (1985) mentioned that the congeneric species Pseudocoremia rudisata (Walker) was partially reared on artificial diet (Singh 1983), but gave no further information.

Life cycle

Developmental polymorphism

Many Lepidoptera exhibit variation in the number of instars passed through during development, which has been termed 'developmental polymorphism' by Schmidt & Lauer (1977). This may be a consequence of poor nutrition, overcrowding, environmental conditions, or genetics (Wigglesworth 1972). Its incidence and contributing factors may differ between species (Zenner-Polania & Helgesen 1973) and between the sexes (Schmidt & Lauer 1977).

According to several authors (Dugdale 1958, Kay 1983a, Anon. 1959) *P. suavis* has only five instars, whereas Zondag (1956) reported the presence of either five or six instars. In the present study, all ten larvae reared on pine in Experiment A developed through six instars (hereafter called Type II larvae) (Fig. 1). In Experiment B, all 16 surviving larvae developed through five instars (hereafter called Type I larvae) (Fig. 1). In each of these experiments the larvae were siblings. In Experiment C, larvae were from three different mothers, and five larvae were Type I, and four were Type II (Fig. 1), suggesting a genetic basis for the different larval types. There may be geographical differences in developmental polymorphism, with Kay (1983a) finding only Type I larvae among *P. suavis* from Rotorua (North Island), and Zondag (1956) and our study finding both larval types in Canterbury (South Island) populations. Developmental polymorphism was observed in both males and females in Experiment C.

Rate of development

The mean development time for *P. suavis* eggs at room temperature was 12.8 ± 0.9 days (± 95% CI, n = 23) in Colony 1, and 14.2 ± 0.3 days (± 95% CI, n = 102) for F_3 eggs in Colony 2. These times fall within the range of 9-20 days reported by Zondag (1956).

The total development time for *P. suavis*, from egg hatch to adult emergence, did not differ significantly between larval types in Experiment C (Fig. 1, U = 2, $P = 0.273$). Only the fourth and fifth instars took longer to develop in Type I than Type II larvae (Fourth: U = 20, $P = 0.011$; Fifth: U = 20, $P = 0.012$). In all experiments the ultimate larval instar lasted approximately 12 days, regardless of whether it was the fifth or sixth instar

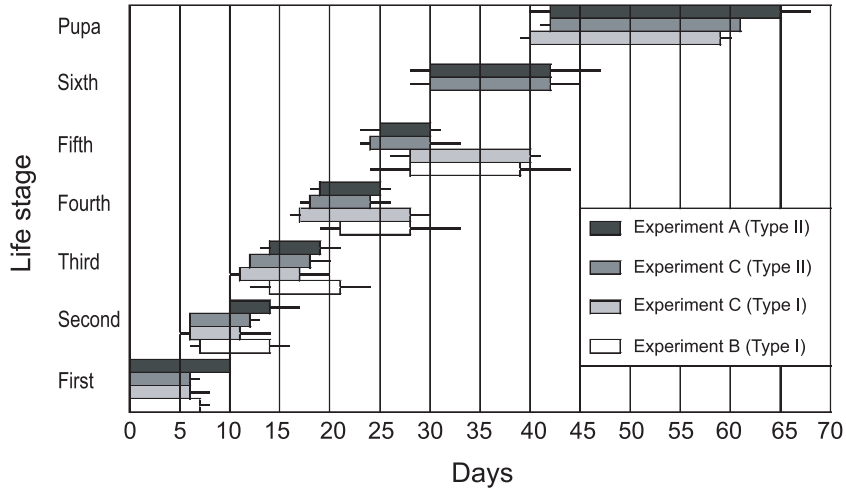

Fig. 1. Mean time (± max/min) spent in each life stage by larvae and pupae in Experiment A (Type II larvae), Experiment B (Type I larvae) and Experiment C (both Type I and Type II larvae). Note that pupal development times were not recorded for Experiment B.

(Fig. 1). The patterns of development of Type I *P. suavis* reared by Kay (1983a) were similar to those in the present study, with the first to the fourth instars lasting 5-6 days, and the fifth (ultimate) instar lasting 14 days on non-resistant, new-growth Douglas-fir.

Larval development times did not differ significantly between sexes in Experiment A (First: $U = 10.5$, $P = 1.000$; Second: $U = 6.0$, $P = 0.267$; Third: $U = 10.5$, $P = 1.000$; Fourth: $U = 10.5$, $P = 1.000$; Fifth: $U = 13.5$, $P = 0.434$; Sixth: $U = 13.5$, $P = 0.329$), but male *P. suavis* spent significantly more time in the pupal stage than females ($U = 0.0$, $P = 0.012$).

Head capsule widths

The head capsule widths (HCW) of larval Lepidoptera have frequently been used either as a means of determining the number of larval instars of a certain species, or as a way of assigning an individual to a particular instar (Beaver & Sanderson 1989, Godin *et al.* 2002). The HCW of the ultimate instar in Experiment C, whether the fifth or sixth instar, did not differ significantly ($U = 6$, $P = 0.559$, Table 3). Across Experiments A and C, the HCW of penultimate instars were similar, as was the HCW of ultimate instars (Table 3). The HCW of known fifth and sixth instar larvae in Experiments A and C are indicated on the frequency distribution of HCW of larvae taken from Colony 2 (Fig. 2). The first three peaks in Fig. 2 (0.40-0.50 mm; 0.60-0.75 mm; 0.85-1.30 mm) are likely to correspond to instars one to three. HCW between c. 1.35 mm and 2.05 mm probably represent a mix of fourth instar of Type I and fourth and fifth instars of Type II. The final peak, from 2.20 mm to 2.90 mm represents the ultimate instars (fifth or sixth) of Type I and II larvae. There were no differences between the sexes in HCW of fifth instar larvae in Experiment A ($U = 18.0$, $P = 0.067$), but the HCW of female sixth instar larvae were significantly larger than those of males ($U = 19.5$, $P = 0.033$).

Phenology

Larval seasonal phenology

A total of 133 *P. suavis* larvae were collected at Eyrewell Forest between November 2002 and March 2003. Most instars were present throughout the summer (Fig. 3), confirming Zondag's (1956) finding that generations overlap in Canterbury. Zondag (1956) reported that larvae were found throughout the year during a *P. suavis* outbreak in Canterbury pine plantations in 1951-52. In July 1952, early instar larvae were even observed to survive freezing, actively crawling again once the temperatures increased in the afternoon (Zondag 1956). White (1974) found two generations per year in Canterbury, with eggs hatching in June-September, and again in January-February. The present data do not support this pattern, as early instar larvae were collected throughout the summer sampling period (Fig. 3).

Table 3. Head capsule widths of fifth and sixth instar *P. suavis* larvae reared at room temperature on *P. radiata* in Experiments A and C.

	Date of experiment	Fifth instar HCW (mm) ± 95% CI	Sixth instar HCW (mm) ± 95% CI
Experiment A (Type II)	16 Apr – 23 Jun 2003	1.80 ± 0.04 (n=10)	2.45 ± 0.04 (n=10)
Experiment C (Type I)	4 Feb – 4 Apr 2004	2.34 ± 0.20 (n=4)	No 6th instar
Experiment C (Type II)	4 Feb – 4 Apr 2004	1.62 ± 0.04 (n=3)	2.39 ± 0.11 (n=4)

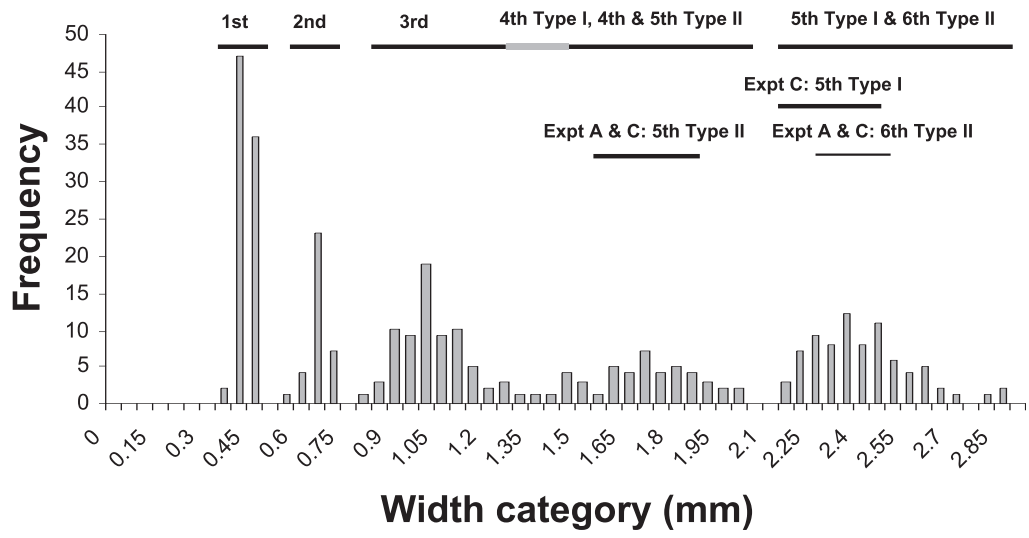

Fig. 2. Frequency histogram of head capsule widths of *P. suavis* from Colony 2. HCW ranges are also indicated for late instar Type I and Type II larvae reared in Experiments A and C.

Adult seasonal phenology

Pseudocoremia suavis males were active throughout the spring and summer trapping period, as shown by sticky trap and light trap data (Fig. 4). Light trap data gave some information on female activity, although this method is not directly comparable with the sticky trap results. There were no marked peak flight periods. Most females were caught in early summer (November and December, Fig. 4), but this may relate to the fact that this was the period when the most intensive light trapping was conducted.

During the 1951-52 *P. suavis* outbreak in Canterbury, Zondag (1956) recorded adult moths in late December and in January, and again between April and early September, giving a short summer generation and a long winter generation. In the present study, male moths were active at least from September to April, suggesting that generations in this non-outbreak population are less synchronised than those observed by Zondag (1956) and more similar to those found by Alma (1975) in Rotorua. In Alma's (1975) study, *P. suavis* adults were caught in light traps in every week of the year, but in greatest numbers over the summer months.

The lack of discrete generations shows that *P. suavis* can be active at any time during the year to make the most of periods of warm weather – a common characteristic among New Zealand insects (Dumbleton 1967, Watt 1975). All life stages are present year round (Zondag 1956), entering a state of quiescence or very slow growth during the winter. During periods of warmer winter weather some eggs and pupae complete development (Zondag 1956, J.S. Dugdale pers. comm.), leading to overlapping generations. Some synchronicity may occur therefore in years with consistently cold winters, particularly in more southern areas such as Canterbury, which may have been the case during Zondag's (1956) study.

Female calling phenology

Trap catch declined logarithmically as the females aged (Fig. 5) with c. 27% of the mean total caught during the first night after emergence, and < 5% per night after the sixth night (Fig. 5). A cumulative mean total of 89% of the trap catch occurred during the first seven days and 99% of the catches occurred by the age of 12 days. The maximum age at which a male was caught was 23 days. Most females lived for several days after they had stopped attracting males and the oldest female lived for 37 days. Male moths were caught over a temperature range of 8 - 21°C (22:00-2:00 h), and catches increased little with increasing temperature (R^2 = 0.023, $P > 0.05$).

Concluding remark

Pseudocoremia suavis remains in moderate abundance throughout Eyrewell Forest and, despite the lack of major outbreaks since the late 1960's, warrants continued, occasional monitoring, particularly if a combination of droughts may again precipitate outbreaks (White 1974, Kay 1982) of this potentially serious defoliator.

Acknowledgments

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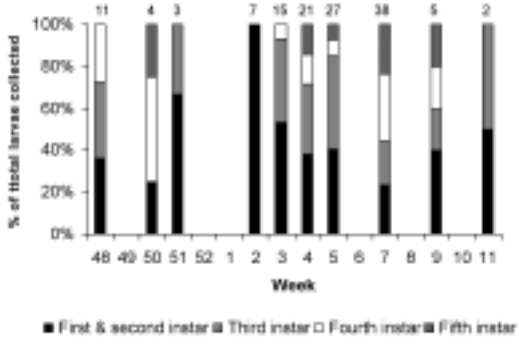

Fig. 3. Percent of *P. suavis* larvae in each instar collected off pine, gorse and kanuka at Eyrewell Forest between 25 November 2002 (week 48) and 11 March 2003 (week 11) (n = numbers above bars, no collections were made in weeks where no data is given). Note that *P. suavis* was thought to have five instars when this data was gathered: 'fifth instar' may actually have been a combination of fifth and sixth instar larvae, and 'fourth instar' a combination of fourth and fifth instar larvae.

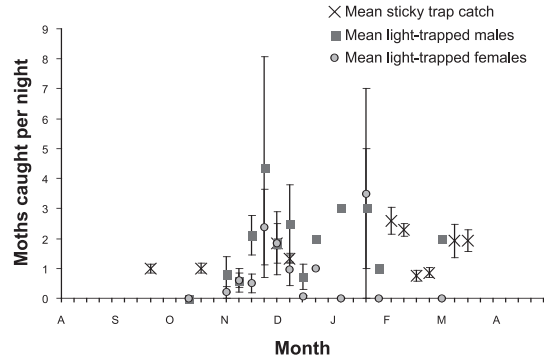

Fig. 4. Weekly mean of male *P. suavis* caught on female-baited sticky traps (traps active for 6 or 7 nights but converted to moths caught per night) and for light-trapped *P. suavis* (weekly mean of moths caught per night) at Eyrewell Forest. Data collected between 2001 and 2004 but pooled here into one generic year.

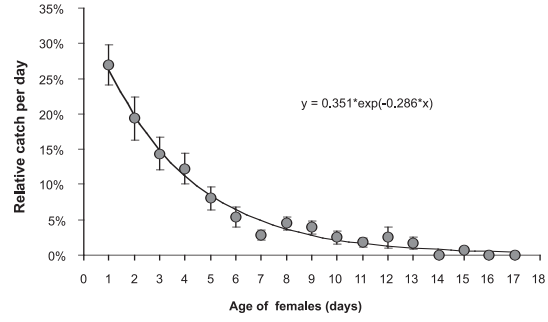

Fig. 5. Relationship between the age of female *P. suavis* used as bait in sticky traps and the mean percent (± SE) daily catch of males (total catch = 727 males, *n* = 46 female-baited traps). Note, only those traps were used for this analysis that were set up with newly emerged females and then checked daily.

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