GROWTH, DEVELOPMENT AND SURVIVAL OF PORINA (*WISEANA* SPECIES) ON SELECTED NATIVE AND EXOTIC GRASS SPECIES IN NEW ZEALAND

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Abstract

Porina (*Wiseana* spp.), are endemic insects that are major insect pests of pasture in New Zealand. Despite their impact on exotic pastures, porina are not known to cause significant damage in their native habitats. To improve management of porina in pastures it is important to determine why porina cause considerable damage in exotic pastures but not in their native habitats, and requires an understanding of their growth, survival and preference for native or exotic plant species. To date, the feeding behaviour of porina have not been studied in detail on native grasses, and there are also questions about porina larval development on native plant species. The growth rate and feeding behaviour of porina larvae were studied when supplied with foliage from several native and exotic plant species: *Festuca actae, Acyphylla squarrosa*, *Poa cita*, *Chionochloa rubra*, *Phormium tenax*, *Lolium perenne* × *Lolium multiflorum* and mixed grass species (which consist of fescue, ryegrass and weeds). Mortality, larval survival time, percent growth rate and the relative growth rate of larvae ranged from 12.5–75%, 96–177 days, 57–225% and 0.0057–0.0083 (gm/gm/day) respectively. This study confirmed the differential success of porina larval growth and development on native and exotic plant hosts that will have implications for individual fitness, population dynamics and potential management.

Introduction

Pasture is a major component of livestock and dairy production in New Zealand. New Zealand pastoral agriculture is based on a composition of introduced grasses and clovers that has been both profitable and resilient but is particularly susceptible to pest outbreaks (Jackson et al., 2012). In 2015, white clover and ryegrass contributed about NZ$19 billion to the New Zealand economy. These high-quality pastures are being threatened by two major insect pests. One of these pests is the *Wiseana* complex (Lepidoptera: Hepialidae) of seven recognised endemic species, commonly known as porina. Several of these species are major pests in pastures particularly in the southern North Island and many parts of the South Island of New Zealand (Popay et al., 2012). Porina moths are univoltine and fly during spring and summer with a mean flight peak date and periods which vary with locality and year (Carpenter et al., 1980). Porina larvae feed mainly on pasture plants and show rather unusual behaviour because the larvae live underground in burrows, emerging only at night to feed on the pasture. The larvae remove all herbage nearest the tunnel entrance by severing tillers, leaves and stems near ground level and dragging foliage into their tunnels where they are eaten (French and Pearson, 1981). During this period they remain in the soil for about 4–9 months feeding before pupation. It is these subterranean larvae which cause pasture damage during autumn, winter and spring, depending on the locality and year. It is hypothesized that porina development is more successful on exotic pasture species than on native plant species.

Some authors have recorded porina feeding on a broad range of native plants (see various authors in Spiller et al., 1982; White, 2002). However, none of the supposedly native plants have been specifically studied as hosts of porina, and there are questions about the larval development on these plants. Knowledge of porina larval development is essential because it will help to explain how some porina species have adapted to exotic pastures. This study examines the development success of porina larvae on native and exotic plant hosts. Such knowledge could provide useful information for the management of porina in pastures.

Methods

Insects and plant material

Porina larvae of mixed ages were collected from porina infested paddocks. The larvae were placed into individual 120 ml plastic containers half to three quarters filled with 3–4 months old potting mix and with a hole drilled in the cap for air flow. The larvae were kept in a constant temperature (CT) cabinet at 15°C reverse daylight (12 L: 12 D), and fed mixed grass species (containing fescue, ryegrass and weeds) every 2–3 days for one month to check for disease symptoms. Only healthy larvae that survived this initial screening were used for the experiment.

Young native plants of spear grass, *Aciphylla squarrosa* (Apiaceae); red tussock, *Chionochloa rubra* (Poaceae); Banks Peninsula blue tussock, *Festuca actae* (Poaceae); New Zealand flax, *Phormium tenax* (Xanthorrhoeaceae) and silver tussock, *Poa cita* (Poaceae) were purchased from Plantlife Propagators Ltd (Ashhurst, New Zealand). Seedlings of the exotic ryegrass (nil endophyte), a hybrid of *Lolium perenne* × *Lolium multiflorum* (Poaceae), were obtained from AgResearch Ltd (Lincoln, New Zealand). Mixed grass species comprising fescue, ryegrass and weeds were sourced from a lawn. Each plant was carefully transferred from its original pot to a 200 ml pot of 3–4 month-old potting mix comprising 80% bark, 20%, Osmocote Exact fertilizer (16-3.5-10), horticultural lime, hydroflo, pumice and allowed to grow in a glass house for two months before use in experiments.

Larval development and survival of porina on native and exotic hosts

For the no-choice bioassay, the surviving porina larvae (n = 53) were weighed, the potting mix changed and the larvae arranged in descending order by weight. Larvae were allocated randomly to one of the seven different treatments: *A. squarrosa, C. rubra, F. actae, P. tenax, P. cita, L. perenne* × *L. multiflorum* and mixed grass spp. (n = 8 for all food sources except the mixed grass treatment, n = 5). Containers with larvae were placed randomly within the CT cabinet. Larvae were fed *ad libitum* with fresh foliage of the selected host plant every 3–4 days for six months. Larvae were checked daily for mortality and weighed monthly with the potting mix replaced in each container at weighing.

To determine the growth rate of the porina larvae on each host, the relative growth rate (RGR) was calculated and measured in grams of tissue gained per gram of caterpillar per day (Waldbauer, 1968).

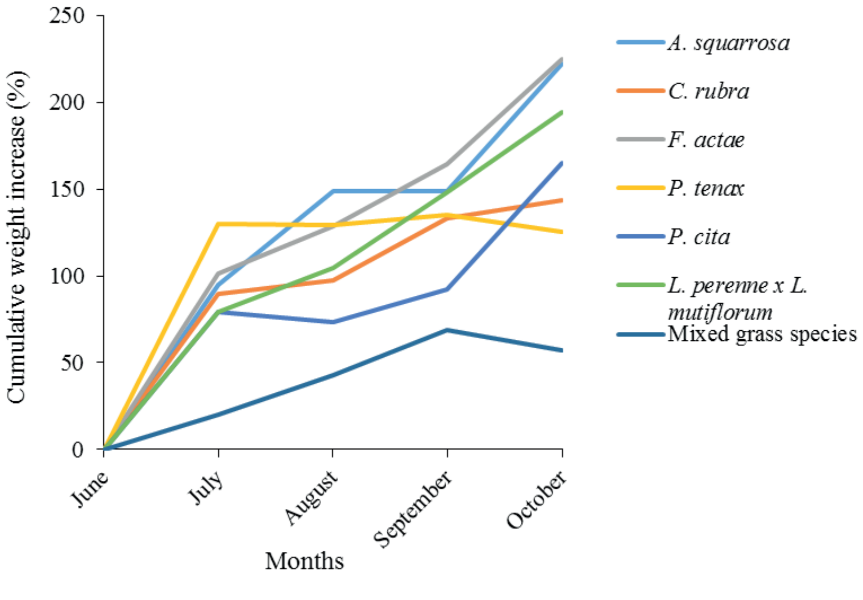
$$RGR = \frac{\textit{larval weight gain during feeding period}}{\textit{(mean larval weight during feeding trial)} * \textit{(duration of feeding trial)}}$$

The effect of host diet on growth data (i.e. monthly weight gain of the larvae from initial weight) were analysed by ANOVA, while larval survival was evaluated using survival analysis. Statistical tests were conducted with GenStat® 18 and SigmaPlot 13.0.

Results and Discussion

Larvae grew rapidly on the foliage of *F. actae*, *A. squarrosa* and *L. perenne* × *L. multiflorum*, but grew more slowly on *P. cita*, *C. rubra*, *P. tenax*, and mixed grass spp. A net increase in percentage larval weight was observed for all seven treatments after four months of feeding (Figure 1), with *F. actae* and *A. squarrosa* having the highest cumulative weight increases of 225% and 222% respectively, while mixed grass species had the least with 57%.

Figure 1.
Effect of diet on weight increase of porina larvae.

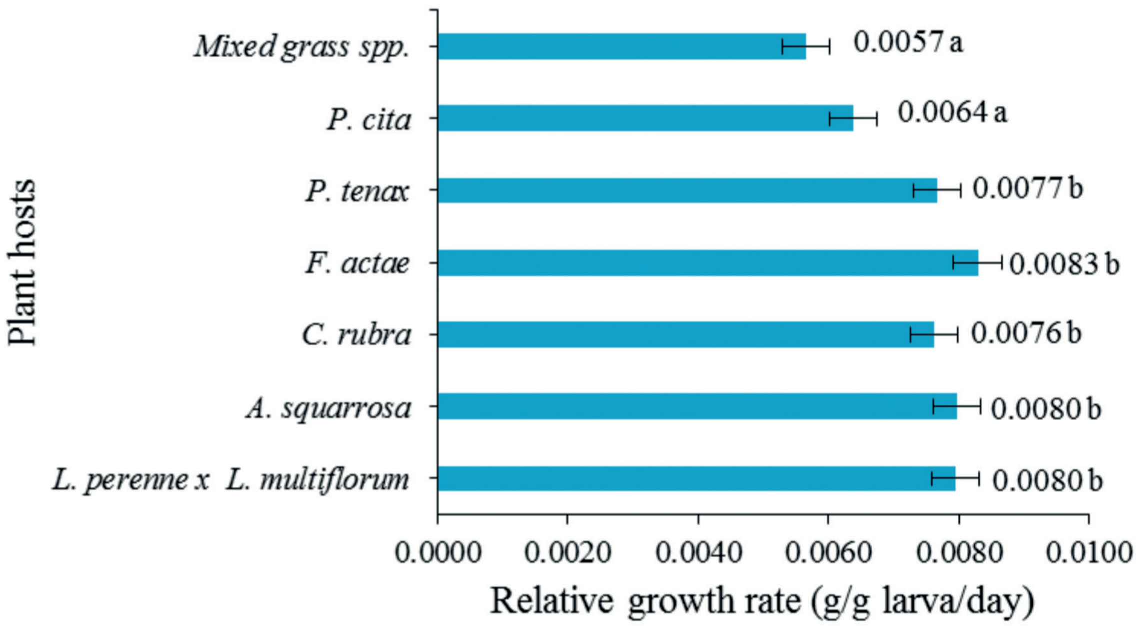


The largest average weight gain of 284 mg was on *L. perenne* × *L. multiflorum*, an exotic host, while the smallest average weight gain of 28.8 mg was on *P. tenax* (Table 1). There was a significant difference in weight gain between larvae fed with *L. perenne* × *L. multiflorum* and *P. tenax* (F (6, 18) = 3.46, p = 0.019). The difference in weight gain observed between ryegrass and flax in this study may be due to the relative toughness of flax leaves. Leaf toughness appears to be an essential defence mechanism against the European corn borer on maize with tougher leaves suffering less feeding damage (Bergvinson et al., 1994). In a review of neonate lepidopteran ability to establish themselves on host plants, Zalucki et al. (2002) concluded that their success is dependent on both external plant factors (e.g. plant architecture, leaf hairs and trichomes, leaf toughness and hardness, leaf micro-flora and microclimate) and internal plant factors (e.g. nutrition, chemical defences, sequestered metals, constitutive defence expression, induced defence expression, resins and latex, and changes in host quality and interactions) that also play significant roles.

Mortality was lowest on ryegrass (12.5%) with larvae surviving the longest, on average 177 days. The highest percentage mortality of 75% was recorded on *A. squarrosa*, *F. actae* and *P. cita*, which also recorded the lowest average survival time $\leq$ 96 days (Table 1); however, these differences were not statistically significant (F (6, 26) = 9.25, p = 0.160). A few larvae survived to pupation only from ryegrass (2 pupae), *C. rubra* (1 pupa), *P. tenax* (1 pupa) and mixed grass spp. (2 pupae). One adult moth emerged from ryegrass and one from mixed grass spp. The mortality observed on larvae fed on the native hosts could be as a result of the nutritional quality and plant defences of these native hosts. This study shows an inverse relationship between percentage mortality and average larval survival time (Atijegbe, 2016).

The lowest relative growth rate of 0.0057 (gm/gm larva/day) was recorded on larvae fed with mixed grass spp., while the highest was on *F. actae* although this was not significantly different from the RGR for *A. squarrosa* and *L. perenne* × *L. multiflorum* (Figure 2). While the larvae grew the fastest on *F. actae*, *A. squarrosa* and *L. perenne* × *L. multiflorum* and the slowest on mixed grass spp.

Figure 2.
Mean relative growth rate of porina (gm/gm caterpillar/day) on native and exotic host plants. Means followed by the same letter are not significantly different (P > 0.05).



Conclusions
This study was constrained by the variation in the age of the larvae used and the sample size. However, the results clearly show that porina larvae can feed and develop on some of the native hosts tested. A further study using a larger sample size and larvae of uniform age from several porina species is being conducted to validate this result. Additionally, the nutritional quality of the hosts plants is being analysed to determine the influence of primary metabolite on porina larval development on these hosts.

Table 1.
Effects of host plant on the weight gain*, mortality and survival

Plant species	Initial mean	Weight (mg): range	*N*	Mean weight gain (mg)	Std error	% mortality	Mean larval survival time (days)
L. perenne × *L. multiflorum*	414.6	298.0-551.4	8	284.0 [a]	40	12.5	177 [a]
A. squarrosa	427.4	334.6-635.0	8	91.0 [ab]	82	75.0	96 [a]
C. rubra	541.2	372.3-751.1	8	117.0 [ab]	39	37.5	161 [a]
F. actae	452.1	308.7-617.3	8	197.0 [ab]	115	75.0	96 [a]
P. tenax	563.6	389.9-971.0	8	28.8 [b]	42	37.5	154 [a]
P. cita	454.4	327.5-716.5	8	95.0 [ab]	78	75.0	77 [a]
Mixed grass spp.	413.2	327.6-524.5	5	150.0 [ab]	26	60.0	112 [a]

* weight gain = final weight – initial weight

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