EVALUATION OF METALLIC GREEN GROUND BEETLE AS A PREDATOR OF SLUGS

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ABSTRACT

The potential of the ground beetle, *Megadromus antarcticus* (Chaudoir) (Coleoptera: Carabidae) to prey upon slugs was investigated in laboratory and field experiments. This beetle preyed upon both *Deroceras panormitanum* (Lessona & Pollonera) and *D. reticulatum* (Müller) and consumed, on average, 0.55 slug per beetle per day. A positive linear relationship between slug density and slug consumption was observed. However, the biomass of slugs consumed remained relatively constant at 0.3 g slug per beetle per day. Slug numbers were reduced in small field plots of lettuce by beetle predation. However, this ground beetle is unlikely to be a useful biological control agent for slugs in intensive field crops because large innudative releases would be needed.

Keywords: carabid, slug, predation, *Megadromus antarcticus*

INTRODUCTION

Introduced terrestrial slug species have become widely established in New Zealand and some cause significant damage to agricultural and horticultural crops (Barker 1979). Two of the most commonly encountered species are grey field slug, *Deroceras reticulatum* (Müller), and brown field slug, *Deroceras panormitanum* (Lessona & Pollonera) (Scott 1984). In horticultural crops, control of slugs has traditionally been attempted by using various formulations of molluscicides, but the efficacy of these is often variable (Symondson 1989). Other preventative methods, such as barriers or traps, are either inefficient or impractical to use in commercial production areas.

Interest in using natural enemies to control slugs has increased in recent years particularly in some Northern Hemisphere countries (e.g. Symondson 1989; 1994; Asteraki 1993). Predatory ground-dwelling beetles from the family Carabidae appear to offer considerable promise as predators of slugs because they are often numerous in arable and intensive cropping areas and are very active foragers (Theile 1977). In the Canterbury region of the South Island of New Zealand, the metallic green ground beetle (MGGB), *Megadromus antarcticus* (Chaudoir)(Coleoptera: Carabidae), is common in bush remnants surrounding the Plains and Banks Peninsula; it is also encountered in suburban gardens and non-arable land where there is some shelter (Butcher and Emberson 1981).

The aim of this study was to determine the potential of MGGB as a predator of common pest slugs. Specific objectives were to determine: (1) whether this ground beetle would feed on slugs, (2) whether there was any preference for different slug species, (3) the rate at which slugs were consumed and, (4) the ability of this ground beetle to reduce slug numbers on lettuce plants in the field.

METHODS

MGGB adults (30-35 mm long) were collected at intervals from Banks Peninsula. No attempt was made to sex beetles and they were held in trays with leaf litter in the laboratory for several days to acclimatise before they were used in experiments. Grey field slug and brown field slug were collected from pasture and cropping areas near

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Lincoln University just before they were required for experiments. Both juveniles and adults were used in experiments, but very small or large slugs were excluded.

Predation of slugs

Shallow plastic trays (175x225x35 mm) partially filled with damp potting mix were used as experimental arenas. In each tray, a 125 mm diameter disc of fresh cabbage leaf was placed in the centre of each tray as a food source for the slugs. One MGGB adult was placed in each tray and one or three grey field slugs per tray, or one or three brown field slugs per tray were introduced. No trays were established with slugs only because previous observations had shown that natural mortality was negligible. There were five replicates of each slug density. Each tray was misted with water to maintain humidity and covered with a clear plastic lid. All trays were placed in a controlled environment room at 16°C and covered with several sheets of newspaper to reduce light penetration into the trays.

The trays were examined daily for 12 days and the number of slugs consumed (no sign of slugs, or only small remnants of slug bodies remaining) or killed (slug dead and largely intact) were recorded. Fresh slugs were added to the trays to replace those that were consumed or killed. The data were analysed by analysis of variance and an LSD test was used to separate the means.

Prey consumption rate

The results of the preceding experiment indicated that slug density influenced the number of slugs consumed by MGGB. Using an identical experimental procedure, brown field slugs were introduced at 1, 2, 3, 4 and 5 slugs per tray. There were 10 replicates of each slug density and observations on slug numbers were made daily for six days.

To determine the biomass of slugs consumed, the fresh weight of slugs was recorded before they were placed in the trays and the weight of remaining whole or partially eaten slugs was also recorded each day. The number of slugs consumed and the biomass of slugs consumed was regressed against slug density.

Predation of slugs on lettuce

As predation experiments in the laboratory may not accurately predict the ability of a predator in the field (Jervis and Kidd 1996), a simple field experiment was carried out involving the release of MGGB into small plots of lettuce plants artificially infested with slugs.

Ten 1x1 m plots were established on recently cultivated ground in the Biological Husbandry Unit at Lincoln University. Each plot was surrounded by 30 cm high sheet metal barriers; nine lettuce seedlings were planted in a regular pattern in each plot during late autumn. After two weeks, the plots were thoroughly searched and any slugs or arthropods found were removed. Fifteen brown field slugs were placed on the lettuce plants in each plot, and five MGGB were released into each of five randomly selected plots. All plots were searched daily for three days and the number of slugs missing from each plot was recorded. Slug count data were analysed by analysis of variance.

RESULTS

Predation of slugs

MGGB readily preys upon two common pest slug species (Table 1). Greater numbers of slugs were consumed or killed (not consumed) at higher densities (3 per tray). However, the difference between the two densities was only significant ($P<0.05$) for brown field slug. Most slugs were completely or almost completely consumed and, overall, only 12.6% of slugs were killed and not consumed.

Closer inspection of the pattern of predation over the 12-day experimental period revealed that 75% of beetles consumed one or more slugs during the first day, but by the sixth day only 25% of beetles consumed prey. When all data were pooled (both densities, both slug species), MGGB consumed, and consumed + killed, on average, 0.55 and 0.63 slugs per beetle, per day, respectively.

TABLE 1: Mean number (±SE) of grey and brown field slugs consumed, and consumed + killed by metallic green ground beetle over 12 days in laboratory arenas.

Number slugs provided	Slugs consumed		Slugs consumed + killed	
	Grey field slug	Brown field slug	Grey field slug	Brown field slug
1	5.6 ± 1.08	4.4 ± 0.87 ns	6.0 ± 1.00	4.8 ± 0.86 ns
3	7.0 ± 1.73	9.4 ± 1.56 ns	8.2 ± 2.15	11.0 ± 1.70 ns
$LSD_{0.05}$	ns	4.1	ns	4.4

ns = not significant, P>0.05

Prey consumption rate

When the density of slugs was increased, MGGB consumed greater numbers of slugs (Table 2). There was a highly significant (P<0.01) positive linear relationship with slug density (*x*) and daily slug consumption (*y*) ($y= 0.44 + 0.20x$, $r^2 = 0.99$). However, on a daily basis, the proportion of slugs consumed from those provided declined from 65% (1 slug per beetle, per day) to 28% (5 slugs per beetle, per day). When the biomass of slugs consumed was determined (Table 2), no significant difference between slug densities was detected. Overall, on average, individual beetles consumed 0.3 g slug per day.

TABLE 2: Mean number (±SE) and biomass (±SE) of slugs consumed per day by metallic green ground beetle when provided with different numbers of slugs per day in laboratory arenas.

Slugs provided /day	Slugs consumed / beetle / day	Slug mass (g) consumed / beetle per day
1	0.65 ± 0.10	0.33 ± 0.05
2	0.82 ± 0.10	0.27 ± 0.03
3	1.02 ± 0.05	0.24 ± 0.05
4	1.23 ± 0.07	0.29 ± 0.06
5	1.43 ± 0.08	0.36 ± 0.04

Predation of slugs on lettuce

On small field plots containing lettuce plants, MGGB was able to locate and destroy brown field slugs. When MGGB were present, 10.8±1.56 (x±SE) slugs per plot were missing after three days compared with 4.2±1.56 per plot from those plots with no beetles ($LSD_{0.05}$ 2.20). Overall, individual beetles consumed 0.24 slugs per day.

DISCUSSION

Although records of carabids feeding on molluscs extend back over many decades (Tod 1973), only in recent times has their potential as biological control agents for slugs in commercial crops been considered. Several Northern Hemisphere carabid species (e.g. *Abex parallelepipedus* Piller & Mitterpacher, *Pterostichus madidus* F.) have now been investigated. However, little equivalent research has been carried out in New Zealand. C.M. Ferguson (reported by Anon. 1990) found that two local South and Central Otago carabid species, *Mecodema rectolineatum* (Castelnau) and *Megadromus vagans* (Broun), fed actively on slugs. This study confirms that another local carabid, *Megadromus antarcticus,* will prey upon common pest slugs.

Carabids are generally polyphagous (Symondson 1994), although preference for prey type and size may be exhibited (Tod 1973). In this study, MGGB consumed similar numbers of both slug species (Table 1) even though the grey field slug (up to 50 mm extended) is larger than the brown field slug (up to 30 mm extended)(Barker 1979). By contrast, the Northern Hemisphere carabid, *A. parallelepipedus* (21 mm) is smaller than MGGB (22-34 mm) and is also able to readily consume grey field slug (Asteraki 1993). However, the number of slugs consumed per beetle per day by these two species differs; MGGB consumed on average 0.55 slugs per beetle per day in the first laboratory experiment whereas *A. parallelepipedus* consumed 0.26 slugs per day in a similar experiment (Symondson 1989).

Slug density also influenced the consumption rate by MGGB (Table 2), but the proportion of prey consumed declined with increasing density. This would strongly indicate that, on average, one or two slugs per beetle per day would likely be the maximum this species would consume. When the mass of slugs consumed was measured (Table 2), no significant difference between the treatments was indicated. This suggests partial consumption of prey is likely to increase as prey density increases and that gut capacity limits further prey consumption. This phenomenon has been demonstrated with the carabid *Notiophilus biguttatus* F. feeding on springtails (Ernsting and van der Werf 1988).

The field experiment further demonstrated the ability of MGGB to prey upon slugs, but the consumption rate (0.24 slugs /beetle / day) was approximately half that determined in the laboratory. This would not be unexpected because the slugs were released at a lower density in the field plots (15 /m^2) compared with the prey preference experiment (equivalent to 25-75 /m^2). The complexity of the habitat was also greater in the field than in the laboratory arenas and greater searching time by the beetles would probably be necessary to locate prey. Symondson (1993) also noted that crop characteristics may influence the ability of carabid beetles to locate slugs. This was not investigated in this study.

In conclusion, MGGB, like other carabids, will prey upon common pest slugs, but its potential as a biological control agent for use in horticultural crops is likely to be limited. MGGB has been collected from some horticultural crops, e.g. carrots, but only relatively low numbers have been encountered (Sivasubramaniam *et al.* 1997). Furthermore, is unlikely that sufficient slugs would be killed by this species unless large inundative releases of MGGB were made into a crop. This would require mass rearing, and this has only been achieved with one carabid (*A. parallelepipedus*) to date (Symondson 1994).

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