FEEDING BY SLUGS ON SOME PASTURE PLANT SPECIES: LABORATORY EXPERIMENTS

G.M. BARKER, B.E. WILLOUGHBY and R.P. POTTINGER

Ruakura Soil and Plant Research Station, MAF, Private Bag, Hamilton

SUMMARY

Feeding by the grey field slug (*Deroceras reticulatum*) on various pasture plant species was studied in the laboratory. An acceptability index was calculated for 43 common pasture plants. In simple choice tests, slugs preferred white clover (*Trifolium repens*) to grasses. Juvenile slugs given white clover or single grass species diets showed marked differences in consumption, assimilation and growth rate. White clover was the preferred diet. Sexually mature slugs lost weight on all diets but exhibited differences in consumptions, assimilation and fecundity.

INTRODUCTION

The Holarctic slug *Deroceras reticulatum* Muller has become widely distributed in the temperate world. The species is common in New Zealand pastures and is frequently associated with plant damage, particularly in legumes. Little quantitative information is available concerning the ecology of slugs in grassland. Slugs are known to feed on a wide variety of foods in captivity and in the wild. Grey field slugs feed predominantly on higher plant material — dead and living (Runham and Hunter 1970). A basic requirement of ecological and pest management studies of slugs is information on food preferences and food assimilation. The present paper is concerned with laboratory studies on these aspects.

METHODS

Experiment 1: Acceptability of various plant foods

Mature slugs were collected from pasture on 1 May 1981. The slugs were held in moist rearing chambers for 2 days with sliced carrot food.

The slugs were then housed individually in petri dishes with filter paper carpets kept saturated with distilled water at 20°C. This maintained 95-99% humidity. Fresh leaves were collected from plants naturally established in the field in the case of weed species, and from sown plots in the case of various grasses and legumes. For each test plant, a 20 mm diameter leaf disc, or leaf fragments of near equivalent area, were offered to each of 15 slugs. The extent of feeding was estimated visually after 24 h, to give an acceptability index (AI). In the feeding scale used, AI3 represented considerable feeding with >60% of the leaf disc consumed; AI2 indicated 30-60% of disc consumed; AI1 indicated < 30% of disc consumed; while AI0 represented no feeding.

Experiment 2: Feeding preferences

Mature slugs collected on 1 May 1981 from pasture were weighed and held overnight without food. Fragments, of approximately equal weight, of 8 plant species (Table 2) were randomly arranged around the periphery of each of 22, 15 cm diameter glass tissue dishes. One slug was placed in each dish at 5 pm. Fourteen hours later, the incidence of feeding and the percentage consumed was visually assessed for each plant species.

Experiment 3: Ingestion and assimilation by juvenile slugs

Slugs were collected from pasture on 22 April, 1981. Within 2 h the collected specimens were transferred to petri dishes with moistened filter paper floors, and held overnight. Slugs were then weighed and randomly assigned to each of eight plant food treatments (Table 3), with 23 replications. Individual slugs were held in petri dishes

Proc. 36th N.Z. Weed and Pest Control Conf.

(without filter paper) suspended over water in sealed plastic boxes, which maintained relative humidity at 95-96%. The boxes were placed in a screenhouse with a diurnal temperature range of 10-22 °C. A weighed amount of fresh food was replaced every 2 days for the duration of the experiment (50 days). A subsample was oven dried to determine dry matter content. Remnant food and faeces were oven dried and weighed. The total dry weight of the introduced and remnant food was calculated. Percentage assimilation was calculated by: $A = \frac{C - F}{C} \times 100$

where C is the dry weight of food eaten and F is the dry weight of faeces produced. The slugs were weighed every 7 days.

TABLE 1: Acceptability indices of 43 plant species offered as leaf fragments to grey field slugs.

Species tested	Mean Acceptability index	Species tested	Mean Acceptability index
Virtually rejected			
<i>Agrostis tenuis</i>	0.3	<i>Matricaria inodora</i>	0.1
<i>Anthoxanthum odoratum</i>	0.3	<i>Oxalis corniculata</i>	0.3
<i>Bellis perennis</i>	0.4	<i>Paspalum dilatatum</i>	0.1
<i>Bromus mollis</i>	0.3	<i>Phalaris tuberosa</i>	0.4
<i>Euphorbia pepus</i>	0.2	<i>Rumex acetosella</i>	0.2
<i>Galium aparine</i>	0.5	<i>Rumex crispus</i>	0.1
<i>Geranium molle</i>	0.4	<i>Senecio jacobaea</i>	0
<i>Holcus lanatus</i>	0.1	<i>Solanum nigrum</i>	0.1
<i>Lotus pedunculatus</i>	0.1		
Relatively acceptable			
<i>Agropyron repens</i>	1.7	<i>Hypochaeris radicata</i>	0.9
<i>Amaranthus powelli</i>	0.6	<i>Lolium perenne</i>	1.2
<i>Brassica napa</i>	1.5	<i>Plantago lanceolata</i>	1.9
<i>Bromus unioloides</i>	0.8	<i>Poa annua</i>	1.8
<i>Cirsium arvense</i>	1.1	<i>Senecio vulgaris</i>	1.4
<i>Cirsium vulgare</i>	0.7	<i>Stellaria media</i>	1.7
<i>Dactylis glomerata</i>	0.8	<i>Trifolium subterraneum</i>	1.3
<i>Erodium moschatum</i>	1.0	<i>Urtica dioica</i>	1.2
<i>Festuca arundinacea</i>	1.6	<i>Veronica persica</i>	1.9
Highly acceptable			
<i>Capsella bursa-pastoris</i>	2.5	<i>Rubus fruticosus</i>	2.2
<i>Chenopodium album</i>	2.4	<i>Taraxacum officinale</i>	2.5
<i>Polygonum aviculare</i>	2.4	<i>Trifolium pratense</i>	2.3
<i>Ranunculus repens</i>	2.6	<i>Trifolium repens</i>	2.7

SED 0.3

Experiment 4: Ingestion and assimilation by mature slugs

Slugs were collected from pasture in June 1981. Within 2 h the collected specimens were transferred to plastic petri dishes lined with damp filter paper to maintain 95-99% RH. Fresh sliced carrot was provided as food.

After 48 h each slug was weighed and 10 slugs of similar weight were randomly assigned to each of 12 plant food treatments (Table 4). The slugs were then returned to

new petri dishes with a known weight of fresh diet. The dishes were stored in a covered container at a temperature range of 15-22°C. A weighed amount of fresh food was replaced every 2 days for the duration of the experiment (20 days). Remnant food and faeces were oven dried and weighed. Total dry weight of the introduced and remnant food was calculated. Percentage assimilation was calculated as described above. The number of eggs laid was recorded.

RESULTS AND DISCUSSION

Laboratory acceptability studies showed that the grey field slug fed on most plant species occurring in pastures, though some were clearly more acceptable than others (Table 1). White clover and red clover (*T. pratense*) were highly favoured foods, as were some weeds, eg. *Ranunculus repens*, *Chenopodium album*, *Polygonum aviculare*, *Taraxacum officinale*. Grasses were generally less acceptable. Of the species tested, 40% were virtually rejected ($AI \leq 0.5$), 41% ($AI < 2.2$) were relatively acceptable, and 19% ($AI \geq 2.2$) were highly acceptable. The pattern of acceptability was similar to that obtained by Getz (1959) for three species of slug (*Arion circumscriptus*, *D. laevis* and *D. reticulatum*). The species of plants chosen by Getz for study were 45 common plants from abandoned fields in Michigan, USA. Of these 47% were rejected, 25% were relatively acceptable and 28% were highly acceptable. Dirzo (1980) tested the acceptability of 30 grassland and wasteland plants to *D. panormitanum*. He found 70% of species were rejected, 20% relatively acceptable, and 10% highly acceptable.

In choice experiments, white clover was preferred to grass species (Table 2).

TABLE 2: Occurrence and extent of feeding by the grey field slug when given a choice of eight plant species.

	Mean % occurrence of feeding	Mean % consumed
Browntop (<i>Agrostis tenuis</i>)	4.6	2.3
Tall fescue (<i>Festuca arundinacea</i>)	31.8	8.2
Phalaris (<i>Phalaris tuberosa</i>)	59.1	13.2
Cocksfoot (<i>Dactylis glomerata</i>)	4.6	1.0
Prairie grass (<i>Bromus unioloides</i>)	22.7	4.3
Ryegrass (<i>Lolium perenne</i>)	18.2	3.4
Paspalum (<i>Paspalum dilatatum</i>)	0	0
White clover (<i>Trifolium repens</i>)	81.8	26.1
SED	20.6	5.2

Three growth phases or stages can be distinguished during slug development. A logarithmic plot of body weight against time shows a series of straight lines corresponding to two juvenile growth phases and a mature phase. In mature slugs the weight and weight change are variable (Abeloos 1942; Runham and Hunter 1970; Wright 1973; Stern 1979).

The growth experiment (Table 3) showed that consumption, assimilation and liveweight gain of juvenile (phase II) slugs were highest on a white clover diet. Growth responses to a grass diet were varied. There was a nett gain in slug liveweight on prairie grass (*Bromus unioloides*) diet, but on the remaining grasses nett weight changes were negative, often with considerable weight loss. There was good agreement between acceptability and preference experiments and the growth experiment, namely, white clover was a preferred and more suitable food source than grasses.

Sexually mature slugs fed *ad lib* on a single species of grass or clover lost weight over a 20 day period (Table 4). Considerable variation occurred with both consumption and assimilation efficiency of the various diets although these did not correlate with the negative liveweight changes. Variations in egg production did correlate with liveweight

changes ($r=0.7204$, $P<0.01$). There was no relationship, however, between initial liveweight and weight loss, consumption, assimilation or fecundity; slugs in the range 378-1024 mg lost weight and produced eggs. The slugs were apparently in the senile phase which follows sexual maturation. Much of the food consumed and assimilated went to maintenance of reproductive activity.

Assimilation efficiencies on white clover diet was higher in juvenile than in mature slugs. On grass diet assimilation efficiencies were similar for the two groups. Although not attempted in these experiments, in mixed diets certain foods may facilitate the use of others (Williamson and Cameron 1976).

TABLE 3: Body weights, weight change, consumption and assimilation efficiency of juvenile grey field slugs fed on various diets in the laboratory.

Plant species	Slug liveweight mg			Consumption mg DM/50 days	Assimilation %
	Initial	Final	%Change		
Browntop	270	172	-36.3	1935	89.9
Tall fescue	268	224	-16.4	1462	63.8
Phalaris	265	189	-28.6	1058	32.7
Cocksfoot	270	148	-45.2	1312	88.1
Prairie grass	270	298	10.4	2320	80.9
Ryegrass	268	236	-11.9	2300	90.0
Paspalum	263	91	-65.4	660	43.6
White clover	267	428	60.3	3017	97.6
SED	24	16	4.1	260	5.2

TABLE 4: Body weights, weight changes, consumption, assimilation efficiency and egg production of mature grey field slugs fed various diets in the laboratory.

Plant species	Slug liveweight mg			Consumption mg DM/20 days	Assimilation %	No. Eggs
	Initial	Final	%Change			
Browntop	672	490	-27.1	2620	90.5	30.2
Prairie grass	664	413	-37.8	3390	75.8	36.8
Tall fescue	632	438	-30.7	1570	64.3	40.6
Phalaris	694	435	-37.3	620	21.0	46.4
Cocksfoot	710	458	-35.5	1840	90.2	23.7
Red clover	486	433	-10.9	1540	60.4	0
Red clover seedling	430	375	-12.8	1890	67.7	0
White clover	735	560	-23.8	3100	62.2	32.6
White clover seedling	777	575	-26.0	2590	66.7	47.6
Lotus (<i>Lotus</i> sp)	668	511	-23.5	860	44.8	15.8
Lotus seedling	592	422	-28.7	350	47.6	18.1
Control (filter paper)	928	501	-46.0	3570	16.2	39.2
SED	276	52	6.3	316	4.8	10.5

The degree of damage suffered by a plant in the field will depend on characteristics of both the plant (e.g. relative abundance, acceptability) and the slug (e.g. searching ability, memory for unacceptable tastes, memory for location of acceptable plants). Our results suggest that slug damage in established pastures should be largely confined to white clover, and damage may be more severe where other acceptable plant foods are absent or rare.

ACKNOWLEDGEMENT

P.J. Addison for technical assistance.

REFERENCES

- Abeloos, M., 1942. Les etapes de la croissance chez la limace rouge (*Arion rufus* L.). *C.R. hebd. Seanc. Acad. Sci., Paris* 215: 38-29
- Dirzo, R., 1980. Experimental studies on slug-plant interactions. I. The acceptability of thirty plant species to the slug *Agriolimax caruanae*. *J. Ecology* 68: 981-998
- Getz, I.L., 1959. Notes on the ecology of slugs: *Arion circumscriptus*, *Deroceras reticulatus* and *D. laeve*. *American Midl. Nat.* 61: 985-998
- Runham, N.W. and Hunter, P.J., 1970. Terrestrial slugs. Hutchinson, London.
- Stern, G., 1979. Bilans ponderal et energetique de croissance et de reproduction chez *Agriolimax laevis* (Muller), Pulmonata, Limacidae. *Bull. Soc. Zool., France* 104: 147-160
- Williamson, P. and Cameron, R.A.D., 1976. Natural diet of the landsnail *Cepaea nemoralis*. *Oikos* 27: 493-500
- Wright, A.A., 1973. Evaluation of a synthetic diet for the rearing of the slug *Arion ater* L. *Comp. Biochem. Physiol.* 46A: 593-603