JOURNAL OF PLANT PROTECTION RESEARCH
Vol. 44, No. 3 (2004)

FOOD PREFERENCES OF *DEROCERAS RETICULATUM*, *ARION LUSITANICUS* AND *ARION RUFUS* FOR VARIOUS MEDICINAL HERBS AND OILSEED RAPE

Jan Kozłowski[1], *Maria Kozłowska*[2]

[1]Institute of Plant Protection, Miczurina 20, 60-318 Poznań, Poland
e-mail: j.kozlowski@ior.poznan.pl

[2]Agricultural University, Department of Mathematical and Statistical Methods,
Wojska Polskiego 28, 60-638 Poznań, Poland
e-mail: markoz@owl.au.poznan.pl

Accepted: September 14, 2004

Abstract: Studies on palatability of some commom weed species, herbaceous plants and oilseed rape to *D. reticulatum*, *A. lusitanicus* and *A. rufus* slugs have been carried out under laboratory conditions. In food choice trials the rate and degree of damage to seedlings and leaf disks were determined for 20 plant species. The conducted experiments have also permitted to establish, which plant species were preferred or were not accepted by particular slug species. It was found that the studied slug species preferred seedlings and leaves of *Brassica napus* and *Papaver rhoeas*, but showed no preference for *Epilobium hirsutum*, *Geranium sanguineum* and *Saponaria officinalis* plants. As to the remaining plant species under study, the preferences exhibited by particular slug species were quite diverse.

Key words: slugs, *D. reticulatum*, *A. lusitanicus*, *A. rufus*, medicinal herbs, oilseed rape, feed preference

INTRODUCTION

Slug (*Gastropoda: Pulmonata*) damages to sown crops and frequently a low effectiveness of this pest control by granulated molluscicides have stimulated a search for other methods reducing the pest numbers and harmfulness. Alternative methods limiting slug feeding on cultivated plants consist in providing other food sources in the form of palatable plant species or in reducing plant species palatability by using antifeedants (Webbe and Lambert 1983; Molgaard 1986; Cook et al. 1997; Briner and Frank 1998; Barone and Frank 1999; Frank and Friedli 1999). Beside cultivated plants, the most accessible food on crop plantations are weeds and herbceous plants in the vicinity of plantations. Some of them are more palatable

than sown crops, whereas others are completely rejected by slugs (Dirzo 1980; Cook et al. 1997; Briner and Frank 1998; Kozłowski and Kozłowska 2000; 2003). Slugs directed by smell and taste, can make a choice between plants (Duval 1971; 1973; Cates and Orians 1975). Slugs intensively fed on the most attractive plants frequently caused significant damages.

The article describes results of the conducted food choice trials evaluating the palatability of different herbaceous species and oilseed rape to *D. reticulatum*, *A. lusitanicus* and *A. rufus* slugs.

MATERIAL AND METHODS

The food choice trials (with multiple choice and without choice) were carried out on 20 plant species under laboratory conditions (daily temp. 19°C, night temp. 16°C, RH 93%, day length 15 h).

Trials with multiple food choices were conducted in semi-transparent plastic containers (80 × 50 × 20 cm) 1/3 filled with soil and divided into 40 plots. The containers were closed and equipped with two holes covered with mill gauze. Nineteen plant species (weed or herbaceous plants) and winter oilseed rape were sown in each container. Ten seeds of each plant species were sown in each container on two plots (2 × 5 seeds). The time of sowing was chosen in accordance with the germination and developmental rate of each plant species to obtain as even plant material for the tests, as possible. After attaining by plants the stage of 1–3 leaves and the height of 5–8 cm, 10 starved (48 h without food) and immature slugs of one species were placed in each container. The mean weight of the slugs was 0.5 g for *D. reticulatum*, 2.4 g for *A. lusitanicus* and 2.7 g for *A. rufus*. Throughout 30 consecutive days, the percentage of plant area consumed by the slugs was estimated using a 5-degree scale (0% = no damage, 25%, 50%, 75% and 100% of consumed plant area). Five seedlings per each of the 20 studied species in 6 replicates were tested for each slug species.

Trials without choice were carried out in plastic and closed containers (22 × 18 × 13 cm) with small ventilate holes and filled with 5 cm-layer of soil. Five seeds of each plant species (totally 20 plant species examined) were sown in each container. When the plants reached the stage of 1–3 leaves and were 5–8 cm in height, a single starved slug (48 h without feed) was placed into a container. The mean weight of the slugs was 0.4 g and 1.3 g for *D. reticulatum* and *A. lusitanicus*, respectively. Throughout consecutive 15 days, the percentage of plant area consumed by the slugs was estimated, as in the similar previous experiment. Five seedlings were tested for each of the 20 studied plant species in 10 replicates.

Investigations on the leaf acceptability (at the stage of 4–6 leaves) to the slugs were conducted in trials without choice. The experiments were performed under laboratory conditions in darkness at the temperature of 16°C. Disks of 346 mm^2 area or parts of leaves with the total area of 346 mm^2 were cut out from leaves of 20 plant species collected in the field. Three disks of each plant species were placed on moistened filter paper in tightly closed semi-translaminar plastic container (of 0.5 l capacity and 10 cm in diameter). The slugs were starved for 24 h before the tests. Prior to testing, each slug was weighed to make the total of their weights sim-

ilar for each plant species. The mean mass of the slugs was 0.5 g for *D. reticulatum*, 1.4 g for *A. lusitanicus* and 1.6 g for *A. rufus*. A single slug was placed in each container and after 12 h removed. The leaf area not consumed by the slug was measured with millimeter ruled paper. These data was transferred to percentage of the leaf area consumed by the slugs. Six replicates were performed for each slug and plant species.

The all obtained data in the trials were statistically analyzed using the analysis of variance and Tukey's test at $\alpha=0.05$.

RESULTS

Deroceras reticulatum

In the food choice trials on the first day of *D. reticulatum* feeding the slugs fed on the seedlings of six species, but the damage degree of all the plants under study was similar (Tab. 1). After two days of feeding, substantial differences were found in the degree of plant damage to particular species. Plants of *Brassica napus* L. var. *oleifera* L. were injured in 15.8%, 10 plant species were damaged by various degree, while the remaining plants were not damaged. The damage degree of *B. napus* seedling increased very quickly on the successive days of the slug feeding. On the 6th day, *B. napus* plants were injured by 70.8%, on day 11 – to 96.7% and on day 19 – to 100%. However, plants of *Bellis perennis* L., *Epilobium hirsutum* L., *Geranium pratense* L., *Geranium sanguineum* L., *Origanum vulgare* L. and *Ruta graveolens* L. after six days were not injured at all. After 10 days, *E. hirsutum* plants were not damaged, while

Table 1. Rate of seedling damage of different plant species by *Deroceras reticulatum* in food choice trials and results of Tukey's test at $\alpha=0.05$

Plant species	Day of feeding									
	1		2		6		14		25	
Bellis perennis	0.0	a	0.0	b	0.0	c	8.3	e	19.2	de
Brassica napus	8.3	a	15.8	a	70.8	a	96.7	a	100.0	a
Digitalis grandiflora	4.1	a	9.2	ab	13.3	bc	37.5	bcde	63.3	abcd
Epilobium hirsutum	0.0	a	0.0	b	0.0	c	4.2	e	10.0	e
Geranium pratense	0.0	a	0.0	b	0.0	c	23.3	cde	50.8	bcde
Geranium sanguineum	0.0	a	0.0	b	0.0	c	2.5	e	11.7	e
Glechoma hederacea	1.7	a	1.7	b	8.3	bc	29.2	cde	53.3	abcde
Holcus lanatus	0.0	a	2.5	ab	6.7	bc	18.3	cde	45.0	bcde
Hyssopus officinalis	0.8	a	6.7	ab	13.3	bc	55.0	abc	90.8	ab
Melissa officinalis	0.0	a	0.8	b	0.8	c	4.2	e	15.0	e
Origanum vulgare	0.0	a	0.0	b	0.0	c	14.2	cde	31.7	cde
Papaver rhoeas	0.0	a	0.0	b	11.7	bc	74.2	ab	100.0	a
Ranunculus repens	0.0	a	1.7	b	8.3	bc	40.0	bcde	52.5	bcde
Ruta graveolens	0.0	a	0.0	b	0.0	c	0.8	e	6.7	e
Saponaria officinalis	0.0	a	0.8	b	6.7	bc	15.8	cde	25.0	de
Symphytum officinale	0.0	a	0.0	b	0.8	c	10.0	de	31.7	cde
Thymus vulgaris	0.0	a	0.0	b	4.2	c	17.5	cde	63.3	abcd
Trifolium repens	0.0	a	0.8	b	3.3	c	15.8	cde	46.7	bcde
Urtica dioica	0.8	a	3.3	ab	3.3	c	12.5	de	19.2	de
Verbascum phlomoides	4.2	a	8.3	ab	24.2	b	51.7	bcd	73.3	abc

Values within each column, followed by the same letter are not significantly different

R. graveolens and *G. sanguineum* plants were injured by less than 1%. After 14 days, seedlings of *B. napus* were damaged the most seriously (97%). Plants of *Papaver rhoeas* L. were also significantly damaged (74.2%). A group of plant species damaged by less than 8% included: *R. graveolens* (0.8%), *G. sanguineum* (2.5%), *E. hirsutum* (4.2%), *Melisa officinalis* L. (4.2%) and *B. perennis* (8.3%). On 19th day of observations, beside *B. napus* plants injured to 100%, the most severely damaged plant species were *Papaver rhoeas* (97%) and *Hyssopus officinalis* L. (82%), whereas *E. hirsutum* and *G. sanguineum* were significantly injured in 5%, and *R. graveolens* only in 1.7%. After 25 days of slug feeding, plants of *B. napus* and *P. rhoeas* were damaged by 100% and plants of *H. officinalis* were damaged up to 90.8%, while *R. graveolens* plants were damaged by only 6.7%.

In food trials without choice, after the first day of feeding, *D. reticulatum* slugs essentialy damaged *B. napus* seedlings (29.5%, Tab. 2). Five plant species were not damaged at all. Two days after, plants of *B. napus* were injured up to 45%, and among the remaining species, plants of *Holcus lanatus* L. were injured at the most (12%). Slugs did not feed on the plants of *Epilobium hirsutum* and *Saponaria officinalis* L. species. After six days, plants of *B. napus* were injured up to 76%, while those of *Papaver rhoeas*, 58%. Interesingly, the least damaged (below 3%) were plants of: *Bellis perennis*, *Geranium sanguineum*, *Geranium pratense*, *Saponaria officinalis* and *Ruta graveolens*, whereas plants of *E. hirsutum* were not damaged at all. After 12 days, *P. rhoeas* was damaged by 100%, while *B. napus* to 95.5%. Seedlings of *E. hirsutum*

Table 2. Rate of seedling damage of different plant species by *Deroceras reticulatum* in food trials without choice and results of Tukey's test at $\alpha=0.05$

Plant species	Day of feeding							
	1		2		6		14	
Bellis perennis	0.0	b	1.0	b	2.0	ef	22.0	efghi
Brassica napus	29.5	a	45.0	a	76.0	a	97.0	a
Digitalis grandiflora	2.5	b	3.5	b	6.5	def	16.5	ghi
Epilobium hirsutum	0.0	b	0.0	b	0.0	f	4.5	i
Geranium pratense	1.0	b	1.0	b	3.0	ef	7.5	hi
Geranium sanguineum	1.0	b	2.0	b	3.0	ef	5.0	i
Glechoma hederacea	4.0	b	8.5	b	35.0	bc	58.5	bcd
Holcus lanatus	8.0	b	12.0	b	32.0	cd	62.0	bc
Hyssopus officinalis	2.0	b	9.5	b	25.5	cdef	47.5	bcdef
Melissa officinalis	4.5	b	6.0	b	14.5	cdef	38.0	cdefgh
Origanum vulgare	3.0	b	3.0	b	10.5	cdef	51.0	bcde
Papaver rhoeas	0.5	b	7.5	b	58.0	ab	100.0	a
Ranunculus repens	1.0	b	2.5	b	6.0	ef	19.5	fghi
Ruta graveolens	3.0	b	3.0	b	3.0	ef	10.0	hi
Saponaria officinalis	0.0	b	0.0	b	3.0	ef	11.5	hi
Symphytum officinale	1.5	b	3.5	b	9.0	def	28.0	defghi
Thymus vulgaris	0.0	b	2.0	b	21.5	cdef	58.5	bcd
Trifolium repens	4.5	b	7.0	b	26.0	cde	73.5	ab
Urtica dioica	4.0	b	5.5	b	18.5	cdef	43.5	bcdefg
Verbascum phlomoides	0.0	b	2.0	b	10.0	cdef	28.0	efghi

Explanation – see table 1

species were damaged the least. This tendency was observed until day 14. Beside *E. hirsutum*, considerably less injured were seedlings of *G. sanguineum*.

In the tests on leaf acceptability, *D. reticulatum* slugs ate *B. napus* leaves the most (13.7%, Tab. 3). Among the remaining plants the mostly eaten were, for example, leaves of *Urtica dioica* L. (8.7%), *Hyssopus officinalis* (8%) and *Glechoma hederacea* L. (6.9%). These slugs did not feed on the leaves of five plant species: *Geranium pratense*, *Epilobium hirsutum*, *Thymus vulgaris* L., *Verbascum phlomoides* L., *Holcus lanatus* L. Leaves of *Bellis perennis* were damaged only up to 0.2% and leaves of *Geranium sanguineum* and *Ruta graveolens* were damaged in 0.3%.

Table 3. Percentage of consumed area of leaves of different plant species during 12 h by three slug species and results of Tukey's test at α=0.05

Plant species	Slug species					
	D. reticulatum		*A. lusitanicus*		*A. rufus*	
Bellis perennis	0.2	b	4.2	efg	19.6	abc
Brassica napus	13.7	a	99.5	a	70.2	ab
Digitalis grandiflora	3.8	ab	30.5	cdefg	41.4	abc
Epilobium hirsutum	0.0	b	0.6	g	0.4	c
Geranium pratense	0.0	b	1.4	g	0.3	c
Geranium sanguineum	0.3	b	0.0	g	0.4	c
Glechoma hederacea	6.9	ab	0.6	g	16.5	abc
Holcus lanatus	0.0	b	6.9	efg	0.7	c
Hyssopus officinalis	8.0	ab	52.0	bcd	73.4	a
Melissa officinalis	0.5	b	19.5	cdefg	28.0	abc
Origanum vulgare	1.3	ab	3.7	fg	8.2	c
Papaver rhoeas	3.8	ab	83.6	ab	53.7	abc
Ranunculus repens	0.8	b	36.8	cdefg	15.9	bc
Ruta graveolens	0.3	b	18.4	cdefg	18.1	abc
Saponaria officinalis	1.1	ab	1.4	g	0.3	c
Symphytum officinale	3.5	ab	46.6	bcdef	23.9	abc
Thymus vulgaris	0.0	b	3.1	g	32.5	abc
Trifolium repens	5.4	ab	54.3	bc	10.3	c
Urtica dioica	8.7	ab	47.0	bcde	29.7	abc
Verbascum phlomoides	0.0	b	9.4	defg	2.5	c

Explanation – see table 1

Arion lusitanicus

In the food choice trials, plants of the most species (16 species) were injuried already after the first day of *A. lusitanicus* feeding (Tab. 4). Plants of *Digitalis grandiflora* Mill. were injured in the highest degree (68.3%). Heavily damaged were also plants of the species *Papaver rhoeas* (50.8%) and *B. napus* (46.7%). After two days, plant damage of these species increased to 86.7, 68.3 and 64.2%, respectively. The slugs did not feed on the plants of *Ruta graveolens*, *Saponaria officinalis* and *Geranium sanguineum*. On 4th day of the observations, *B. napus*, *D. grandifolia* and *P. rhoeas* were damaged in over 91%, while *Symphytum officinale* L., *Thymus vulgaris* and *Verbascum phlomoides* – over 65%. However, the damage of *Epilobium hirsutum* and *Glechoma hederacea* constituted only 3%, while plants of *Ruta graveolens*, *Saponaria officinalis*

Table 4. Rate of seedling damage of different plant species by *Arion lusitanicus* in food choice trials and results of Tukey's test at α=0.05

Plant species	Day of feeding									
	1		2		6		14		25	
Bellis perennis	1.7	d	5.0	ef	43.3	defg	81.7	a	99.2	a
Brassica napus	46.7	abc	64.2	ab	97.5	a	99.2	a	100.0	a
Digitalis grandiflora	68.3	a	86.7	a	95.8	a	97.5	a	98.3	a
Epilobium hirsutum	1.7	d	1.7	f	5.0	hi	15.0	bc	56.7	bc
Geranium pratense	5.0	d	12.5	def	30.8	efghi	34.2	b	75.0	ab
Geranium sanguineum	0.0	d	0.0	f	0.0	i	0.0	c	0.0	d
Glechoma hederacea	1.7	d	2.5	f	9.2	ghi	23.3	bc	43.3	bc
Holcus lanatus	4.2	d	11.7	def	18.3	fghi	25.0	bc	33.3	c
Hyssopus officinalis	4.2	d	16.7	def	80.0	abc	100.0	a	100.0	a
Melissa officinalis	3.3	d	10.2	def	50.8	bcdef	90.8	a	100.0	a
Origanum vulgare	0.0	d	5.8	ef	49.2	cdef	90.8	a	99.2	a
Papaver rhoeas	50.8	ab	68.3	a	99.2	a	100.0	a	100.0	a
Ranunculus repens	5.8	d	13.3	def	40.0	defgh	93.3	a	100.0	a
Ruta graveolens	0.0	d	0.0	f	3.3	i	19.2	bc	46.7	bc
Saponaria officinalis	0.0	d	0.0	f	0.0	i	1.7	c	30.0	cd
Symphytum officinale	19.2	cd	36.7	bcd	85.8	ab	96.7	a	100.0	a
Thymus vulgaris	13.3	d	31.7	cde	91.7	a	100.0	a	100.0	a
Trifolium repens	7.5	d	19.2	cdef	55.0	bcde	93.3	a	100.0	a
Urtica dioica	8.3	d	11.7	def	17.5	fghi	36.7	b	90.0	a
Verbascum phlomoides	26.7	bcd	45.0	bc	70.8	abcd	89.2	a	100.0	a

Explanation – see table 1

and *Geranium sanguineum* were not damaged at all. The tested slugs did not feed on *G. sanguineum* plants until the last day of observations. After 6 days of the slug feeding, the most severely damaged were plants of the species: *P. rhoeas* (99.2%), *B. napus* (97.5%), *D. grandiflora* (95.8%) and *T. vulgaris* (91.7%). However, plants of *S. officinalis* and *G. sanguineum* remained undamaged. After 14 days, plants of twelve species became damaged in 82–100%. Two plant species – *Urtica dioica* and *G. pratense* were injured up to 36.7% and 34.2%, respectively. The remaining plants were injured in less than 25%. After 25 days, twelve plant species were damaged to 100% or below 100%, whereas plants of *G. sanguineum* were not damaged at all.

In food trials without choice, after the first day of feeding, *A. lusitanicus* slugs damaged the most seriously (21.5%) *Verbascum phlomoides* (Tab. 5). Heavily damaged were also: *Papaver rhoeas* (18%) and *Hyssopus officinalis* (17.5%). Plants of *B. napus* were injured in 14%. The slugs did not feed on the seedlings of *Saponaria officinalis* and *Glechoma hederacea*. Considerably the least damaged (0.4%–1.5%) were plants of the species: *Epilobium hirsutum*, *Geranium pratense*, *G. sanguineum* and *Ruta graveolens*. After two days, the most seriously damaged were plants of: *P. rhoeas* (39%) as well as *H. officinalis* (32.5%) and *V. phlomoides* (30%). Still undamaged were the plant species *G. hederacea* and *S. officinalis*. After six days of slug feeding, plants of *P. rhoeas* were damaged in 86.5%, while those of *H. officinalis* and *V. phlomoides* up to 62.5% and 53.5%, respectively. The slugs still did not feed on the plants of *S. officinalis*. The least damaged (from 0.5% to 3%) were the species *G. he-*

Table 5. Rate of seedling damage of different plant species by *Arion lusitanicus* in food trials without choice and results of Tukey's test at $\alpha=0.05$

Plant species	Day of feeding							
	1		2		6		14	
Bellis perennis	6.5	abcd	10.5	cde	22.5	defg	47.0	defg
Brassica napus	14.0	abcd	22.0	abcd	31.5	cde	67.5	bcd
Digitalis grandiflora	10.0	abcd	16.0	bcde	25.5	defg	51.0	def
Epilobium hirsutum	0.4	d	2.0	de	6.0	efg	13.0	i
Geranium pratense	0.5	d	1.0	de	3.0	fg	4.0	i
Geranium sanguineum	1.0	d	1.5	de	2.0	fg	5.0	i
Glechoma hederacea	0.0	d	0.0	e	0.5	fg	6.5	i
Holcus lanatus	10.0	abcd	13.0	bcde	26.0	cdefg	45.0	defg
Hyssopus officinalis	17.5	abc	32.5	ab	62.5	ab	95.5	a
Melissa officinalis	7.0	abcd	10.0	cde	15.0	defg	24.5	ghi
Origanum vulgare	6.5	abcd	6.5	de	20.5	defg	42.0	efg
Papaver rhoeas	18.0	ab	39.0	a	86.5	a	100.0	a
Ranunculus repens	8.5	abcd	11.5	bcde	20.5	defg	39.5	fgh
Ruta graveolens	1.5	cd	3.5	de	8.0	efg	16.0	hi
Saponaria officinalis	0.0	d	0.0	e	0.0	g	3.5	i
Symphytum officinale	7.0	abcd	13.0	bcde	32.5	cde	65.5	cde
Thymus vulgaris	8.5	abcd	19.5	abcde	40.5	bcd	85.5	abc
Trifolium repens	13.5	abcd	20.0	abcde	37.0	bcd	67.5	bcd
Urtica dioica	4.5	bcd	10.0	cde	28.0	cdef	42.0	efg
Verbascum phlomoides	21.5	a	30.0	abc	53.5	bc	91.0	ab

Explanation – see table 1

deracea, *G. sanguineum* and *G. pratense*. Slightly damaged (6%–8%) were also plants of the species *E. hirsutum* and *R. graveolens*. After 14 days, plants of *P. rhoeas* were damaged in 100%, plants of *H. officinalis*, *V. phlomoides* and *T. vulgaris*, up to 96, 91 and 86%, respectively. Significantly the least damaged were plants of *S. officinalis*, *G. pratense*, *G. sanguineum* and *G. hederacea*. Plant damages of these species amounted from 3.5 to 6.5%.

In the tests on leaf acceptability to *A. lusitanicus*, leaves of *B.napus* were eaten the most (99.5%), while leaves of *Papaver rhoeas* were consumed a little less (83.6%) (Tab. 3). The slugs did not feed on the leaves of *Geranium sanguineum*, whereas leaves of *Epilobium hirsutum* and *Glechoma hederacea* were eaten only to 0.6%. Leaves of *Saponaria officinalis* and *Geranium pratense* were also little consumed (ca. 1.4%).

Arion rufus

In trials without feed choice, after the first day of *A. rufus* feeding, most of the studied plant species were damaged (Tab. 6). Plants of *Digitalis grandiflora* were damaged in 85%, while seedling damage of *B. napus*, *Hyssopus officinalis* and *Papaver rhoeas* averaged to 65.8, 64.2 and 62.5%, respectively. The slugs did not feed on the seedlings of *Geranium sanguineum*, *Glechoma hederacea* and *Holcus lanatus*. After two days of slug feeding, plants of *H. officinalis*, *B. napus* and *P. rhoeas* were damaged to over 90%, and after three days their damage amounted up to 100%. Plants of *Saponaria officinalis* and *Geranium sanguineum* were not damaged at all. On the 6th day, two groups of plants significantly differing in damage degree could be distin-

Table 6. Rate of seedling damage of different plant species by the slug *Arion rufus* in food choice trials and results of Tukey's test at $\alpha=0.05$

Plant species	Day of feeding									
	1		2		6		14		25	
Bellis perennis	10.8	bcd	33.3	cdef	77.5	a	95.0	a	100.0	a
Brassica napus	65.8	ab	92.5	a	100.0	a	100.0	a	100.0	a
Digitalis grandiflora	85.0	a	88.3	a	100.0	a	100.0	a	100.0	a
Epilobium hirsutum	3.3	bcd	5.0	f	10.8	b	30.0	bcd	59.2	b
Geranium pratense	6.7	bcd	16.7	def	19.2	b	34.2	bc	50.8	b
Geranium sanguineum	0.0	d	0.0	f	0.0	b	0.0	d	0.0	c
Glechoma hederacea	0.0	d	1.7	f	10.0	b	33.3	bc	65.8	b
Holcus lanatus	0.0	d	9.2	ef	15.8	b	25.8	bcd	45.8	b
Hyssopus officinalis	64.2	ab	92.5	a	100.0	a	100.0	a	100.0	a
Melissa officinalis	14.2	bcd	46.7	bcde	88.3	a	100.0	a	100.0	a
Origanum vulgare	25.0	bcd	53.3	abcd	96.7	a	100.0	a	100.0	a
Papaver rhoeas	62.5	ab	90.8	a	100.0	a	100.0	a	100.0	a
Ranunculus repens	5.0	bcd	13.3	ef	76.7	a	95.8	a	100.0	a
Ruta graveolens	0.8	cd	0.8	f	2.5	b	20.0	bcd	48.3	b
Saponaria officinalis	0.0	d	0.0	f	0.0	b	3.3	cd	10.0	c
Symphytum officinale	10.8	bcd	66.7	abc	97.5	a	100.0	a	100.0	a
Thymus vulgaris	44.2	abc	80.0	ab	100.0	a	100.0	a	100.0	a
Trifolium repens	2.5	bcd	25.0	cdef	91.7	a	99.2	a	100.0	a
Urtica dioica	8.3	bcd	10.0	ef	21.7	b	48.3	b	100.0	a
Verbascum phlomoides	41.7	abcd	65.0	abc	90.8	a	100.0	a	100.0	a

Explanation – see table 1

guished. Plant damage in the first group of twelve species amounted from 76 to 100%. Plants of the remaining eight species were damaged in less than 22%, whereas plants of *S. officinalis* and *G. sanguineum* were still undamaged. After 14 days, plants of nine species were damaged to 100%, whereas plants of three species were injured to 95%. Plants of *G. sanguineum* continued to be undamaged, whereas damage of *S. officinalis* constituted only 3.3%. The distribution of plant species into three groups significantly differing in their damage degree lasted from day 22 to the last day of observations. The first group consisted of thirteen plant species damaged up to 100% or nearly, five species damaged in at least 41% (from 41 to 63%) constituted the second group and plants of two species – *S. officinalis* damaged a few percent and *G. sanguineum*, not damaged at all, represented the third group.

In tests on leaf acceptability to the slug *A. rufus*, leaves of *Hyssopus officinalis* were consumed the most – up to 73.4%, whereas leaves of *B. napus* were consumed a little less – in 70.2% (Tab. 3). The plant species mostly consumed by the slug were, for instance, *Papaver rhoeas* (53.7%) and *Digitalis grandiflora* (41.4%). The slugs fed the least on the leaves of *Epilobium hirsutum*, *Geranium pratense*, *Geranium sanguineum*, *Holcus lanatus* and *Saponaria officinalis*. Leaves of these species of during 12 hours feeding were consumed only from 0.3 to 0.7%.

DISCUSSION

As a result of our experiments, the slugs *D. reticulatum*, *A. lusitanicus* and *A. rufus* have clearly showed similar preferences for particular plant species among 20 species offered. Seedlings and leaves of *Brassica napus* and *Papaver rhoeas* were definitely preferred as a feed. The plant species *Epilobium hirsutum*, *Geranium sanguineum* and *Saponaria officinalis* were unacceptable or slightly acceptable to all slug species. As to the remaining plant species, preferences showed by particular slug species were diverse.

The slug *Deroceras reticulatum* mostly preferred plants of *B. napus*. Beside of the three plant species mentioned above, there were two more species, namely, *Ruta graveolens* and *Melissa officinalis*, which also belonged to plants slightly accepted by this slug.

Arion lusitanicus preferred mostly *Papaver rhoeas* and a little less *B. napus*. Highly palatable to this slug were also seedlings and leaves of *Hyssopus officinalis* as well as seedlings of *Thymus vulgaris* and *Digitalis grandiflora*.

The slug *Arion rufus*, besides the mentioned plant species, preferred or rejected by all slugs, readily ate seedlings and leaves of *Hyssopus officinalis* and *Digitalis grandiflora* and fed slightly on *Geranium pratense* plants.

It has been observed that attractiveness of plants to some slug species changed with the plant age. Some plants preferred at the seedling stage were poorly accepted at the mature stage. An example was the degree of acceptability of *Verbascum phlomoides*, *Digitalis grandiflora* and *Thymus vulgaris* seedlings and leaves to the slug *A. lusitanicus*. Leaves of these plants contrary to seedlings, were poorly consumed by the slug (Tabs 3, 4, 5). Similar results of observations concerning the influence of the host plant age on the degree of their acceptability to slugs, were obtained in studies on the attractiveness of plants from group I of plant species (Kozłowski and Kozłowska 2003). The reason of the decline in plant attractiveness at later developmental stages in some species could be an increase of leaf hardness making slug feeding difficult. Another, more probable reason could be a change in plant biochemical composition. It might be that in some plant species, simultaneously with their aging, the content of allelocompounds undergoes a change, which had a significant effect on the intensity of slug feeding.

It has been also observed that particular species of slugs have specific food preferences for plants offered. An example are *Melissa officinalis*, *Symphytum officinale* and *Bellis perennis* plants accepted by the slugs *A. lusitanicus* and *A. rufus* were not accepted by *D. reticulatum* (food choice trial, Tabs. 1, 4, 6). Species-specific food of slug species has been showed by several authors (Dirzo 1980; Briner and Frank 1998) in the studies on *Arion caruanae* and *Arion lusitanicus* feeding on different herbaceous plants.

The results obtained in the tests with and without choice suggest that the degree of attractiveness of particular plant species to slugs could be a predominant feature determined by species-specific properties of plants. They determine the smell and taste of food which were recognized and remembered by slugs (Whelan 1982; Clark et al. 1997; Cook et al. 1997). Owing to this mechanism, definite plant species in plant communities are preferred or rejected by the slugs. Studies on the slug feed-

ing behaviour have showed that plants differ in their palatability and acceptability to the slugs. The degree of plant acceptability and damage by slug is greatly influenced by plant structural properties, and first of all, their chemical composition, specific for particular plant species (Hunter 1968; Duval 1971; 1973; Cates and Orians 1975; Dirzo 1980; Molgaard 1986; Cook et al. 1996; Kozłowski and Kozłowska 2000).

The results of this paper allow for typify several plant species preferred and rejected by slugs. It should be mentioned that the plant species *Epilobium hirsutum*, *Geranium sanguineum*, *Saponaria officinalis*, which appeared to be unaccepted or slightly accepted by studied three slug species, have deserved special attention. Investigations on these plants will be continued for the purpose to explain the mechanism action of chemical compounds occurring in these plants.

CONCLUSIONS

1. Different slug species have similar food preferences for some species of host plants and highly diverse preferences for the others.
2. Attractiveness of some plant species to slugs can change depending on the plant developmental stage.
3. Among 20 plant species under study, the slugs *D. reticulatum*, *A. lusitanicus* and *A. rufus* preferred *Brassica napus* and *Papaver rhoeas* plants, but did not accepted *Epilobium hirsutum*, *Geranium sanguineum* and *Saponaria officinalis* plants.

ACKNOWLEDGEMENTS

The work was performed under research project No. 6 PO6B 030 20 of the State Committee for Scientific Research (KBN).

REFERENCES

Barone M., Frank T. 1999. Effects of plant extracts on the feeding behaviour of the slug *Arion lusitanicus*. Ann. Appl. Biol., 134: 341–345.

Briner T., Frank T. 1998. The palatability of 78 wildflower strip plants to the slug *Arion lusitanicus*. Ann. Appl. Biol., 133: 123–133.

Cates R.G., Orians G.H. 1975. Successional status and palatability of plants to generalized herbivores. Ecology 56: 410–418.

Clark S.J., Dodds C.J., Henderson I.F., Martin A.P. 1997. A bioassay for screening materials influencing feeding in the field slug *Deroceras reticulatum* (Müller) (*Mollusca: Pulmonata*). Ann. Appl. Biol., 130: 379–385.

Cook R.T., Bailey S.E.R., McCrohan C.R. 1996. Slug preferences for winter wheat cultivars and common agicultural weeds. J. Appl. Ecol., 33: 866–872.

Cook R.T., Bailey S.E.R., McCrohan C.R. 1997. The potential for common weeds to reduce slug damage to winter wheat: laboratory and field studies. J. Appl. Ecol., 34: 79–87.

Dirzo R. 1980. Experimental studies on slug-plant interactions. I. The acceptability of thirty plant species to the slug *Agriolimax caruanae*. J. Ecol., 68: 981–998.

Duval D.M. 1971. A note on the acceptability of various weeds as food for *Agriolimax reticulatus* (Müller). J. Conch., 27: 249–251.

Duval D.M. 1973. A note on the acceptability of various weeds as food for *Arion hortensis* Fèrrusac. J. Conch., 28: 37–39.

Frank T., Friedli J. 1999. Laboratory food choice trials to explore the potential of common weeds to reduce slug feeding on oilseed rape. Biol. Agr. Hort., 17: 19–29.
Hunter P.J. 1968. Studies on slugs of arable ground. III. Feeding habits. Malacol., 6: 391–399.
Kozłowski J., Kozłowska M. 2000. Weeds as a supplementary or alternative food for *Arion lusitanicus* Mabille (*Gastropoda: Stylommatophora*). J. Conch., 37 (1): 75–79.
Kozłowski J., Kozłowska M. 2003. Evaluation of food preferences and tolerance of slugs *Deroceras reticulatum*, *Arion lusitanicus* and *Arion rufus* (I group of plants) with preferences for various herbs. J. Plant Protection Res., 43 (4): 381–391.
Molgaard P. 1986. Food plant preferences by slugs and snails: a simple method to evaluate the relative palatability of the food plants. Bioch. Syst. Ecol., 14: 113–121.
Webbe G., Lambert J.D.H. 1983. Plants that kill snails and prospects for disease control. Nature 302, 754 pp.
Whelan R.J. 1982. Response of slugs to unacceptable food items. J. Appl. Ecol., 19: 79–87.

POLISH SUMMARY

PREFERENCJA POKARMOWA *DEROCERAS RETICULATUM*, *ARION LUSITANICUS* I *ARION RUFUS* W STOSUNKU DO RÓŻNYCH ZIÓŁ LECZNICZYCH I RZEPAKU OLEISTEGO

Ślimaki (*Gastropoda*: *Pulmonata*) powodują duże szkody w rzepaku ozimym, pszenicy ozimej i w warzywach. Zwalczanie tych szkodników moluskocydami jest często mało skuteczne. Dlatego poszukuje się innych metod ograniczania ich szkodliwości, między innymi przez wykorzystanie różnych gatunków roślin, zarówno chwastów jak i ziół leczniczych lub naturalnych związków roślinnych. Wymaga to poznania atrakcyjności poszczególnych gatunków roślin i określenia ich wrażliwości na żerowanie ślimaków. Badania nad smakowitością niektórych pospolitych gatunków chwastów, roślin zielarskich i rzepaku oleistego dla ślimaków *D. reticulatum*, *A. lusitanicus* i *A. rufus* przeprowadzono w warunkach laboratoryjnych. W testach z wyborem i bez wyboru określono tempo i stopień uszkodzenia siewek i krążków liści, 20 gatunków roślin. W wyniku przeprowadzonych eksperymentów wyznaczono gatunki roślin preferowane i nie akceptowane przez poszczególne gatunki ślimaków. Wykazano, że badane gatunki ślimaków preferowały siewki i liście roślin: *Brassica napus* i *Papaver rhoeas*. Do roślin nie akceptowanych należały: *Epilobium hirsutum*, *Geranium sanguineum* i *Saponaria officinalis*. W stosunku do pozostałych gatunków roślin preferencje poszczególnych gatunków ślimaków były zróżnicowane.

Book Review

Zakharenko, V. A. 2003. Tendetsii Izmeneniya Kompleksov, Vidovogo Raznoobraziya, Vnutripopulyatsionnykh Struktur i Dinamiki Vrednykh Organizmov.[Tendencies of Complex Changes Species Diversity, Interspecies Structures and Dynamics of Noxious Organisms]. Rossisjkaya Akademiya Selskokhozyaststvennykh Nauk – Otdelenie Zashchity Rastenii. Moskva, 76 pp., ISBN 5-85941-067-0. (In Russian).

This is a very interesting review and analysis of changes in the plant pests composition, their abundance, and their economic importance in Russia. These changes are due to climatic, agronomic and particularly due to economic reasons that took place in Russia during the last decades.

Chapter 1 "Development of agriculture, formation of agroecosystems and their phytosanitary status" (p. 3–9) provides good information on history of farming development in the World and on the territory of the Russian Federation. Special attention was given to analysis of origin of weedy plants. In Table 1 such information is provided in respect to 75 weed species of global significance pointing their origin and number geographic regions, countries and crops affected.

Chapter 2 "Trends in the development of agroecosystems in Russia and their phytosanitary conditions" (p. 9–23) provides many interesting information on phytosanitary situation of crops during three historical periods: Tschar Russia, Soviet Union and present market economy development. Of special interest in this chapter is information concerning: (1) mechanisms and processes which determine development of complexes of pests; (2) review of quarantine organisms present and absent on the territory of the Russian Federation.

Chapter 3 "General phytosanitary situation and formations of noxious organisms in agroecosystems in the Russian Federation at the end of the XX and the beginning of the XXI centuries" (p. 24–66) is of special interest to all plant protection specialists. In a descriptive form and in a number of tables very important information is provided on weed plants (p. 24–30), plant diseases (p. 31–42), and plant pests (p. 43–66) including species composition, crops and areas affected, pest economic thresholds.

Chapter 4 "Economic analysis of phytosanitary situation in agroecosystems" (p. 66–73) summarizes information on economic crop losses caused by 258 species of weeds, pests and pathogens. In several tables information on potential losses caused by noxious organisms to main crops in Russia are presented and discussed.

In „Conclusions" (p. 73) the author concludes that potential losses on the agronomically used area of 93.3 million hectares in the Russian Federation – estimated in the "grain units" – are equal to 101.6 million tons of cereal grain. In these total losses participate weeds (39.3 mil. tons), pathogenic microorganisms (34.9 mil. tons) and animal pests (27.4 mil. tons).

I recommend this book to plant protection specialists and persons concerned with economic problems in agriculture.

Jerzy J. Lipa
Institute of Plant Protection, Poznań, Poland