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ANALYSIS OF A SHEEP PASTURE ECOSYSTEM IN THE PIENINY MOUNTAINS (THE CARPATHIANS)

XV. THE EFFECT OF PASTURE MANAGEMENT ON ANT POPULATION*

ABSTRACT: The number of ant species and the size of their colonies decrease in the areas where sheep were penned-up. The foraging activity of ants of the genus *Myrmica* is higher in these areas, which results in a higher colony biomass production and in a more rapid development of young generation. The foraging activity of *Lasius niger* L. decreases in the area of a sheep-fold, which is followed by a decrease in the production of the colony and comparatively slow development of young generation. The dominant species consume in the sheep-fold about 150 mg per m^2 of dry organic matter of plant and animal origin, while in the grazed pasture 1200 mg. These values correspond to 0.01 and 0.11% of primary production, respectively.

Contents

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1. INTRODUCTION

The present paper contains a part of the results of complex studies on the structure and functioning of a mountain pasture heavily grazed and manured by sheep.

In the pasture ecosystem energy mainly flows through plant production and sheep production (the major consumer) to the processes of sheep faeces decomposition accompanied by the changes in soil processes.

The role of ants in this ecosystem is significant as they are general predators with high consumption rate, occurring in great numbers and being relatively resistant to the environmental disturbances.

2. STUDY AREA

The studies were carried out in a mountain pasture near Jaworki village in 1969–1971. It is located at an altitude of 600 m. The climatic conditions of this region are presented in Table I. The soil is formed of deluvial materials as a result of sandstone and slatestone weathering. It belongs to the class of brown pseudogley podsolic soils (Czerwiński and Tatur 1974a). This pasture is covered by a *Lolio-Cynosuretum* association dominated by *Festuca rubra* L., *Carex panicea* L., *Agrostis vulgaris* With. and *Leontodon autumnalis* L. (Traczyk and Kochev 1974).

The pastures grazed by sheep occupy an area of about 100 ha. About 800 sheep live there from mid-May to mid-September. The pastures are used in the way characteristic of this region. Sheep graze from dawn till dusk, except a two-hour break at noon. They are penned-up at night in a fold of 0.125 ha. The sheep-fold is moved every 2–3 days, so the total area of penning-up sheep is about 9.4 ha per season. The area of sheep-folds is grazed some months later. The same area is generally used as a sheep-fold every three years. Grazing and penning-up sheep is associated with biocenotic changes of different kinds.

Grazing mainly results in the reduction of standing crop of plant biomass; it can amount to 80% of the total primary production. As the result of penning-up sheep vegetation is destructed and the whole area is covered with an almost uniform layer of manure, the amount of which can reach about 500 g/m^2. This accounts for a considerable concentration of N/NH_3 in soil, which approximates to 200 ppm in the top layer of 5 cm for about 30 days. Simultaneously, there occurs a decrease in soil reaction (pH in KCl = 5.5), and it remains low throughout the growing season (Czerwiński and Tatur 1974b). This results in the destruction of many groups of organisms inhabiting this area. Microbiological activity, however, increases and many groups of those animals which decompose faeces can develop. Due to this fact plant production in the following year is more than twice as high (Czerwiński et al. 1974).

The effect of grazing is a decrease in the number of herbivorous invertebrates; their biomass reaches several tens of mg/m^2 and it is about 100 times lower than in the mown meadows (Andrzejewska 1971). This is accompanied by a decrease in the number of predators. The biomass of ants and spiders approximates to 64 g/m^2 and it is about 5 times lower than in the mown meadows (Kajak, Breymeyer and Pętal 1971).

Tab. I. General climatic conditions
A – mean monthly temperature of the air (°C), *B* – monthly precipitation (mm)

Years		Months											
		J	F	M	A	M	J	J	A	S	O	N	D
A	1969	–6.2	2.5	2.4	5.1	13.9	13.8	15.6	14.2	11.8	7.1	4.2	–7.2
	1970	–4.0	5.1	0.3	5.5	9.7	14.5	15.4	14.9	10.0	–	–	–
	1971	–	–	–	6.3	12.0	14.1	15.8	17.0	11.0	–	–	–
B	1969	–	–	–	–	65.5	151.8	66.2	182.0	8.8	46.3	–	–
	1970	–	–	–	–	103.0	183.5	306.7	97.9	51.3	72.2	75.9	–
	1971	–	–	–	29.4	48.4	115.8	124.0	68.9	43.2	–	–	–

Both in the grazed pasture and the pasture used as a sheep-fold there occurs an increase in the number of saprophages and soil herbivores, the biomass of which varies between 4,000 and 26,000 mg/m^2, while in the mown meadows between 6,000 and 13,000 mg/m^2 (N o w a k 1971 and in press, K a j a k 1974).

The role of ants in this ecosystem was estimated on the basis of population numbers, production and consumption. Also the response of ants to penning-up sheep was studied, including the rate of restoration of dominant species population, their production and the changes in seasonal activity. The studies were mainly conducted in three types of environments: (1) on the sheep track, i.e., on the part of the pasture (*P*) grazed during the passage of sheep four times a day; this is destroyed less than are the other parts of the pasture, (2) in the area of the previous-year's sheep-fold; in 1970 this area was designated by the symbol *F*V69, and in 1971 by the symbol *F*V70, (3) in the areas used as sheep--folds in May of the current year of study; they were designated as *F*V69 in 1969 and *F*V71 in 1971.

3. METHODS

The methods used for the studies on the role of ants in the environment have been described in previous papers (P ę t a l and P i s a r s k i 1966, P ę t a l et al. 1971, P ę t a l 1972).

The studies were carried out from May to October. The density of ant population was estimated on the basis of the number of nests per unit area and the number of individuals per nest. Net production was calculated as the sum of increases in the number and biomass of young individuals throughout the growing season. For this purpose 2-3 nests were excavated each week from each environment.

Penetration of ants was estimated on the basis of the number of foragers leaving and returning to the nest. They were observed at 3–5 nests for 5 minutes each week. In addition, the penetration of the area was determined using 20 pitfall traps located at a distance of 1.5 m, in two rows. Trapping was conducted for two days a week.

4. RESULTS

4.1. Ant populations in differently used areas of the pasture

The ecosystem under study is penetrated by 14 species of ants. The number of species is lower in the sheep-folds than in the grazed pasture (Tab. II), which can be explained by the different sensitivity of ants to destruction of the environment by sheep. The index of penetration, calculated as the sum of the average number of individuals caught per month, is 3.11 in the grazed pasture, while in the area of the previous-year's sheep-fold it drops to 1.75 and in the area of the current-year's sheep-fold it increases to 3.51.

These differences result from the fact that the penetration in the previous-year's

Tab. II. Percentage contribution of different species to the total population of ants in the study area (on the basis of pitfall traps in 1970)

Species	Habitats		
	P	*FV*69	FV70
Myrmica rugulosa Nyl.	47.90	24.72	27.92
M. sulcinodis Nyl.	16.72	6.18	3.13
M. laevinodis Nyl.	10.28	16.36	29.91
Lasius niger L.	12.21	11.64	28.49
L. affinis Schenck	2.89	5.81	0.57
L. flavus F.	2.57	24.36	0.57
Formica rufibarbis F.	2.57	2.91	4.56
F. cunicularia Latr.	2.57	1.45	2.56
Myrmica sabuleti Mein.	0.96	2.54	0.85
M. ruginodis Nyl.	<0.40	0	0
M. scabrinodis Nyl.	<0.40	2.54	0.85
Tetramorium caespitum L.	<0.40	0	0
Formica fusca L.	<0.40	0	0
F. pressilabris Nyl.	<0.40	<0.40	0

sheep-fold is more difficult because of the rich development of vegetation, and in the current-year's sheep-fold the activity of ants related to the restoration of destructed nests and colonies is greater.

All environments are dominated by *Myrmica laevinodis*, *M. rugulosa*, *M. sulcinodis* and *Lasius niger*. These species represent more than 50% of all foraging ants.

Species of the genus *Myrmica* construct the nests of earth, generally without mounds and they move to another place twice a year. Their colonies consist of 200–300 individuals. Eggs are deposited almost the whole season; young imagines appear from July to September; the maximum occurs in July.

The colonies of *Lasius niger* are much greater; they may consist of 1000 individuals generally occupying the nests of earth with mounds, and they live in them for more than a season. The maximum of the development of young generation occurs in June; lower numbers of pupae and very few larvae can still be found in July and September.

There are differences between these species in their resistance and adaptability to the habitat destruction caused by penning-up sheep. These differences are related to their biology and the way they build their nests. The production and numbers of *Lasius niger*, which develop in the first half of summer, decrease after penning-up sheep at that period. The species of the genus *Myrmica*, the development of which is more prolonged, have an opportunity to compensate for the losses in production. Both the species of the genus *Myrmica* and *Lasius niger* are predators; they feed on small invertebrates such as larvae and imagines of *Diptera*, *Auchenorrhyncha*, *Coleoptera*, *Aphidae* and *Araneae*. They carry to the nest also plant material. The maximum of their foraging activity both in the grazed pasture and the sheep-fold occurs in July (Fig. 1). In August a considerable decrease is observed.

The density of nests of these species in the grazed pasture and sheep-folds of different age is given in Table III. Also the amounts of organic matter collected from the habitat to

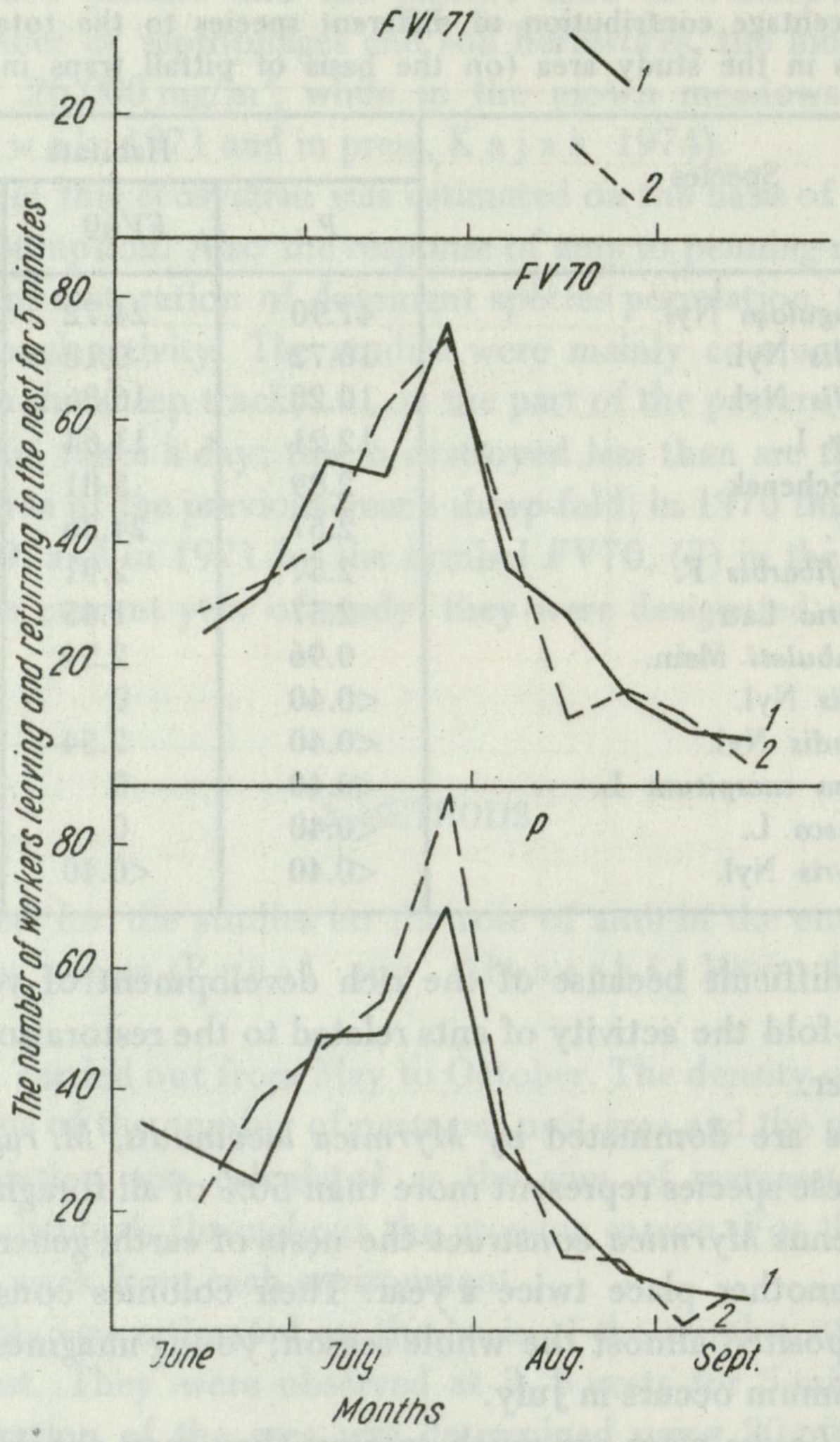

Fig. 1. Comparison of the foraging activity of ants in different habitats in 1971

1 – Myrmica rugulosa, 2 – Lasius niger

the end of August is indicated. It has been calculated on the basis of production, assuming that production is the equivalent to about 2% of the food collected (P ę t a l 1967 and in press, K a j a k B r e y m e y e r and P ę t a l 1971). These data indicate that the role of the species of the genus *Myrmica* in the energy flow through the ecosystem is greater in the sheep-folds than in the grazed pasture, while *Lasius niger* is more important in the grazed pasture. The amount of organic matter taken by ants roughly corresponds to 0.1% of primary production in the grazed pasture and 0.01% in the sheep-fold.

4.2. M o d i f i c a t i o n s i n p r o d u c t i o n p r o c e s s e s

The colonies of ants in the sheep-folds are smaller than in the grazed pasture and the number of their nests is generally lower (Tab. III). In August the standing crop of biomass

Tab. III. Population characteristics of dominant species of ants

Species		Habitats							
		P			*FV*69		*FV*70		*FV*71
		1969	1970	1971	1969	1970	1970	1971	1971
		Number of specimens in the nest							
Myrmica ssp.	$\bar{x}$	342.8	390.0	251.2	344.5	333.8	224.1	309.5	165.9
	$S\bar{x}$	±57.0	±138.9	±57.9	±55.8	±52.1	±75.0	±79.5	±37.3
Lasius niger	$\bar{x}$	1246.6	712.3	414.4	898.8	–	–	214.3	52.0
	$S\bar{x}$	±516.2	±65.6	±185.3	±197.4			±146.2	±17.4
		Number of specimens produced by society							
Myrmica ssp.	$\bar{x}$	138.7	160.8	160.3	155.0	97.6	94.6	244.0	118.5
	$S\bar{x}$	±40.01	±56.3	±32.8	±38.7	±19.8	±42.2	±79.2	±36.8
Lasius niger	$\bar{x}$	614.4	191.0	325.9	571.2	–	–	148.0	21.6
	$S\bar{x}$	±237.3	±56.3	±163.9	±183.3			±113.9	±13.1
		Density of the nests/m^2							
Myrmica ssp.		0.01			0.05		0.04		0.19
Lasius niger		0.07			0.01		0.02		0.07
		Density of specimens/m^2							
Myrmica ssp.		3.42	3.90	2.51	17.2	16.69	8.96	12.38	31.52
Lasius niger		87.29	49.86	29.00	9.0	–	–	4.28	3.64
		Amount of organic matter removed till September in mg dry weight/m^2							
Myrmica ssp.		67.5	51.0	64.5	427.5	190.0	153.0	483.4	86.0
Lasius niger		1100.5	426.5	570.5	238.0	–	–	117.5	56.0

of all individuals staying in the nest and also the standing crop of production were lower in the sheep-folds than in the grazed pasture. This decrease was particularly significant in *Lasius niger* (Fig. 2). During that period the most of biomass was already produced. The biomass of the colony could be still increased due to the foragers penetrating the area. Their number depends on the actual climatic conditions and food supply in the habitat.

The response of ants to the changes in the habitat, which results from penning-up sheep, can be determined by the index of the age structure of individuals remaining in the nest, which is calculated as the ratio of the number of young to adult individuals (Ny/N_o), and by the index of the growth rate of young generation, which is calculated as the ratio

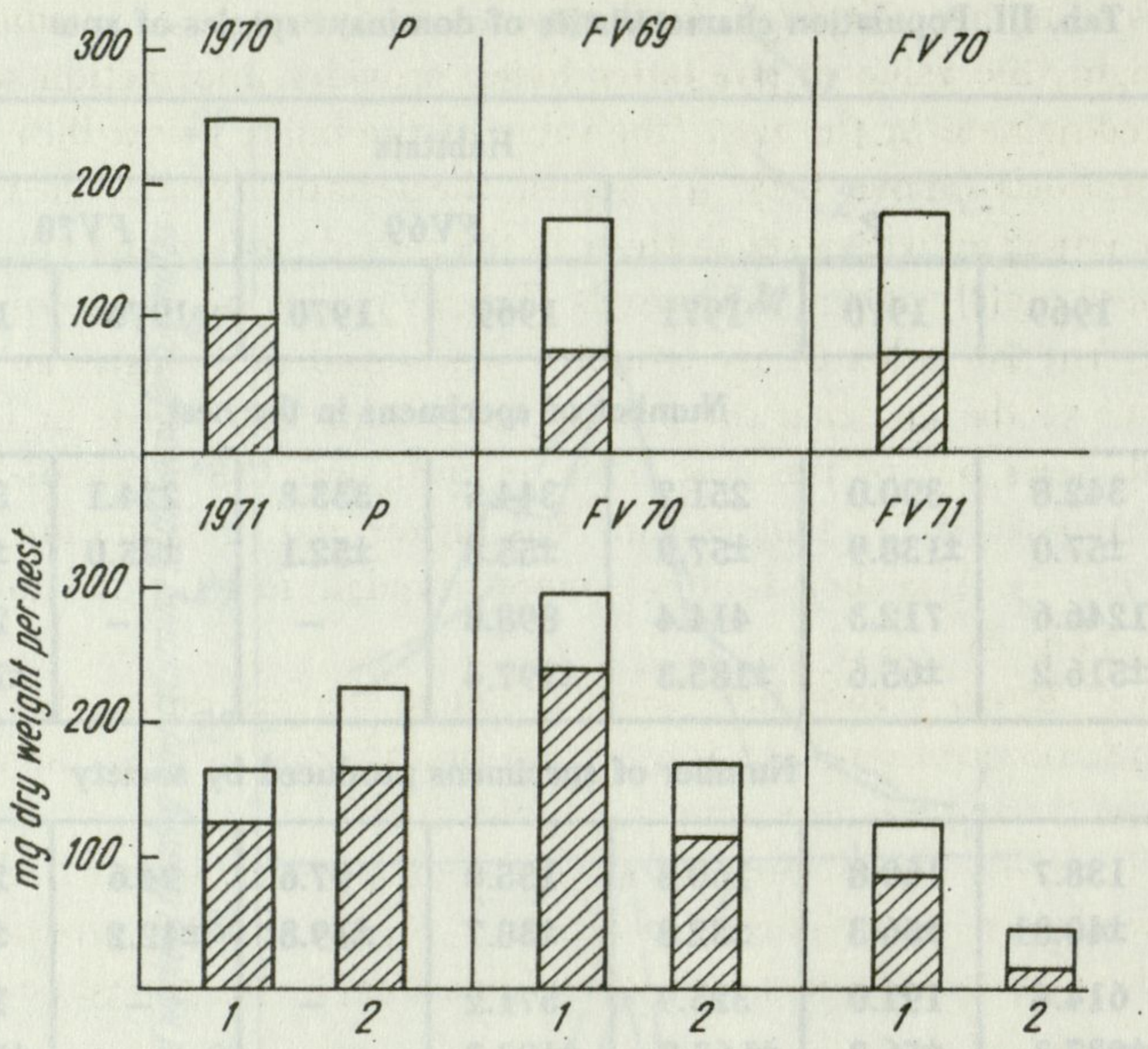

Fig. 2. Standing crop (including production – shaded part of the bar) of an average ant colony in different habitats in August

1 – Myrmica ssp., *2 – Lasius niger*

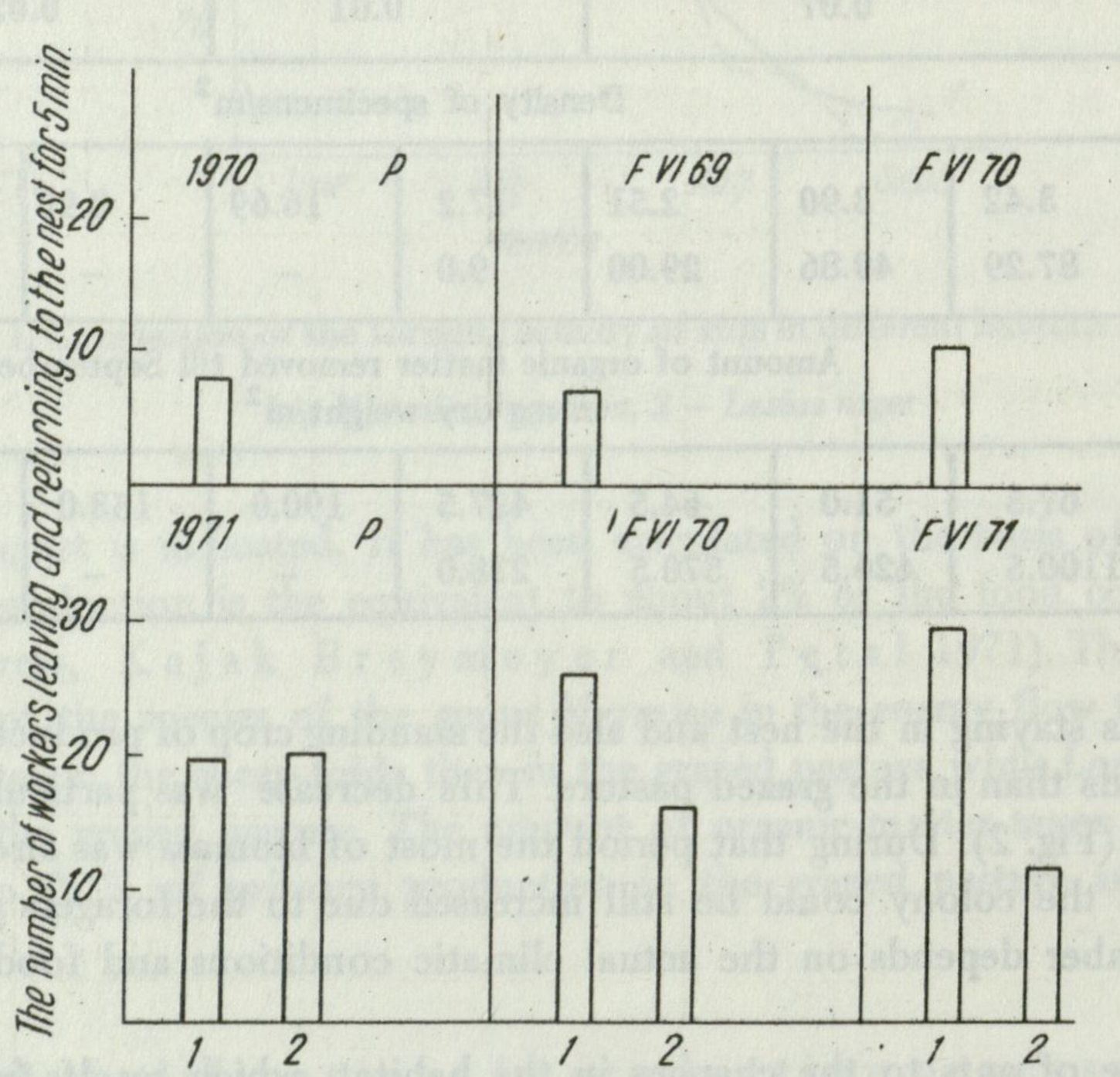

Fig. 3. Comparison of the foraging activity of ants in the grazed pasture and in the sheep-folds at different ages in August

1 – Myrmica ssp., *2 – Lasius niger*

of their biomass to number (B_y/N_y). As the average body weight of an adult individual is 0.8 mg dry weight, the value of the latter index provides information whether young larval forms predominate in the nest (the value of the index below 0.8) or large forms before metamorphosis (above 0.8). In August the nests of *Myrmica* in the sheep-folds contained more young individuals than those in the grazed pasture and young reached the adult weight more rapidly in the sheep-folds (Tab. IV). This trend was observed both in 1970 and 1971, but the index of age structure was considerably higher in all the areas in 1971. This is due to the fact that the production of ants was higher in 1971 and more adult individuals were out of the nest. This, in turn, was the effect of better climatic conditions; in August, 1971, temperature was higher and precipitation lower than in August, 1970 (Tab. I). Also their food was more abundant in 1971 and ants could forage more intensively (Fig. 3).

The number of foraging ants, thus being absent in the nest during its excavation, was estimated through observations, and it was three times higher in 1971 than in 1970. Ants carried to the nest 2–3 times more animal material in 1971.

The foraging activity of the genus *Myrmica* was considerably higher in the sheep-folds. The situation was reversed in the case of *Lasius niger;* the number proportion of young individuals in the nest was lower in the sheep-folds than in the grazed pasture, being the

Tab. IV. Age structure of ant societies (N_y/N_o) and an index of young generation growth (B_y/N_y) for different habitats in August

Species	1970		1971	
	N_y/N_o	B_y/N_y	N_y/N_o	B_y/N_y
	P			
Myrmica ssp.	0.70	0.79	3.63	0.74
Lasius niger			2.70	0.80
	FV69			
Myrmica ssp.	0.87	0.72		
	FV70			
Myrmica ssp.	0.73	0.81	4.59	0.80
Lasius niger			0.17	0.73
	FV71			
Myrmica ssp.			2.49	0.81
Lasius niger			0.60	0.80

lowest in the current-year's sheep-fold (Tab. IV). Their foraging activity decreased in the sheep-folds of the later months of the season (Fig. 3).

4.3. Modifications in the ways of habitat penetration

The effect of the changes in the energy requirements by ants during the growing season are the changes in the number of foraging ants and in the range of their penetration for food. The penetrated area is larger when the denisty of potential food items is insufficient (Pętal and Pisarski 1966). Foraging activity and the range of penetration can be found by the pitfall trap method (Fig. 4). Traps were located at a distance approximating the average range of penetration from the nest. More ants were caught not only when greater number of them penetrated the area but also when they go

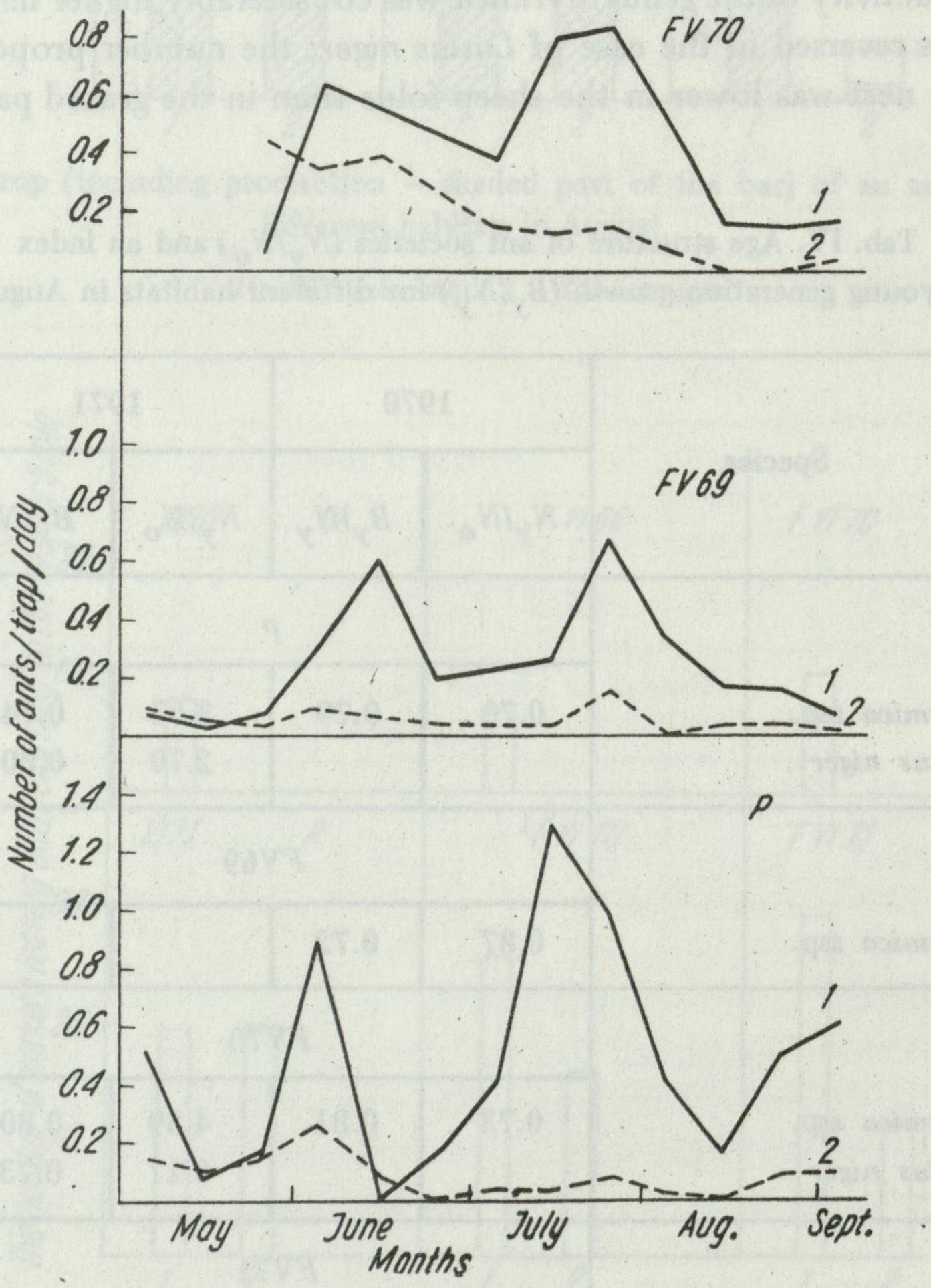

Fig. 4. Comparison of the penetration of different habitats by dominant ant species in 1970

1 – Myrmica ssp., *2 – Lasius niger*

farther from the nest. The value of the penetration index is expressed as the number of individuals captured by a trap per day. For the species of the genus *Myrmica* it has two peaks, in late May-early June and in July. The average values of this index throughout the growing season are: 2.33 in the grazed pasture (*P*), 1.30 in the previous-year's sheep-fold (*F*V69) and 2.14 in the current-year's sheep-fold (*F*V70). There are differences in the time of the occurrence of these peaks between the study areas. In the sheep-folds both of them are more prolonged and delayed by about 10 days as compared to the grazed pasture.

The penetration index of *Lasius niger* is considerably higher in the current-year's sheep-fold (1.0) than in the previous-year's sheep-fold (0.32) and in the grazed pasture (0.38). Particularly high activity of this species is observed in the current-year's sheep-fold in June, when there was still opportunity to raise new generation replacing that destructed in May by penning-up sheep.

In July, 1969, the penetration by ants was compared for the grazed pasture and sheep-folds at different age, i.e., for the previous and current year sheep-folds used in different months of the growing season (*F*V69, *F*VI69, *F*VII69) (Tab. V). The penetration index of the species of the genus *Myrmica* increased in the younger sheep-fold, while it rather decreased for *Lasius niger*.

Tab. V. Effects of the period of penning-up sheep on the penetration of the area by ants (July, 1969)

Habitats	Number of specimens/trap/day					
	Myrmica ssp.		*Lasius niger*		all ants	
	$\bar{x}$	$S\bar{x}$	$\bar{x}$	$S\bar{x}$	$\bar{x}$	$S\bar{x}$
P	0.29	± 0.11	0.14	± 0.07	0.65	± 0.30
*F*V68	0.13	± 0.03	0.06	± 0.01	0.27	± 0.02
*F*V69	0.34	± 0.18	0.04	± 0.01	0.42	± 0.17
*F*VI69	0.39	± 0.14	0.11	± 0.04	0.63	± 0.23
*F*VII69	1.10	± 0.21	0.05	± 0.03	1.20	± 0.17

The total index of penetration for all ants increased with a decrease in the age of the sheep-fold. Ants can actively adapt themselves to the disturbances in the habitat.

5. CONCLUSIONS

1. Ants perform a great role in the pasture ecosystems as consumers of large amounts of organic matter. Dominant species consume 150 mg/m^2 of plant and animal material per season in the sheep-folds and by 1200 mg/m^2 in the grazed pasture, or 0.01 and 0.11% of the primary production, respectively (A n d r z e j e w s k a 1974). The role of ants is increased due to their great resistance and adaptability to the environments destructed by penning-up sheep.

2. The role of the species of the genus *Myrmica* is more important in the energy flow through the habitats used as sheep-folds, which are fertile and inhabited by a number of animal groups decomposing sheep faeces. The role of *Lasius niger* is more important in the grazed pastures as this species has lower tolerance to the destruction of habitat.

3. Penning-up sheep results in a decrease of the number of individuals in a colony, while the density of colonies increases in *Myrmica* ssp. and decreases in *Lasius niger* populations.

4. The occupation of sheep-fold habitats is possible due to the adaptation of production processes and the way of the area penetration.

These adaptations in *Myrmica* are realized in a different way than in *Lasius niger*. The species of the genus *Myrmica* increase the foraging activity in the sheep-folds, which is possible due the higher food resources in these habitats. As the result the production of the colony is higher and the development of young generation is more rapid than in the grazed pasture.

The foraging activity of *Lasius niger* decreases in the sheep-folds. This is accompanied by a decrease in the production of the colony and lower developmental rate of young generation.

5. Due to penning-up sheep not only the activity of foragers increases but also the range of the area penetration.

6. The maxima of penetration in the sheep-folds occur 10 days later than in the grazed pasture.

7. The more penning-up sheep is delayed in the season, the lower the penetration index of *Lasius niger* and the higher that of the species of the genus *Myrmica*.

6. SUMMARY

The purpose of the study was to estimate the role of ants as consumers in the pastures of the Małe Pieniny mountains. These pastures are grazed and heavily manured by sheep in the areas of sheep-folds, where they spend 2–3 successive nights. About 10% of the pasture area is used as sheep-folds each year. As a result it is covered with a layer of manure, the amount of which can reach 500 g/m^2, and the herbage is temporarily destructed.

In the sheep-folds the number of ant species is lower (Tab. II) and also the colonies are smaller (Tab. III) than in the grazed pasture. The occupation of the sheep-folds is achieved through the adaptation of production processes and by extensive exploration of the area (Figs. 1, 2, Tab. IV). The species of the genus *Myrmica* adapt themselves in a different way than *Lasius niger*. This is related to the differences in the biology between these groups. The species of the genus *Myrmica* have a higher foraging activity in the sheep-folds, which is possible due to the higher food supply in these habitats. This results in a higher production and a more rapid development of the young generation than in the grazed pasture. The foraging activity of *Lasius niger* decreases in the sheep-fold. This is accompanied by a considerable decrease in production and not so rapid development of young generation.

The later in the season penning-up sheep takes place, the lower the penetration index of *Lasius niger* and the higher one for the species of the genus *Myrmica* (Tab. V).

Dominant ant species consume 150 mg dry weight per m^2 of the organic matter of plant and animal origin in the sheep-folds and 1200 mg per m^2 in the grazed pasture, or 0.01 and 0.11% of the primary production, respectively.

7. POLISH SUMMARY (STRESZCZENIE)

Celem pracy było poznanie roli mrówek jako konsumentów na pastwiskach Małych Pienin. Pastwiska te są spasane przez owce i intensywnie przez nie nawożone na terenie koszarów, w których

spędzają 2–3 kolejne noce. Corocznie koszarzeniu podlega około 10% powierzchni pastwiska. Wynikiem tego jest pokrycie terenu warstwą nawozu (którego ilość dochodzi do 500 g/m^2) i czasowe wyniszczenie roślinności.

Na koszarach zmniejsza się liczba gatunków mrówek (tab. II) i zmniejsza się wielkość społeczeństw (tab. III). Opanowanie środowisk koszarzonych następuje poprzez przystosowania procesów produkcji oraz sposobu penetrowania terenu (fig. 1, 2, tab. IV). Odbywa się to inaczej u gatunków z rodzaju *Myrmica* i inaczej u *Lasius niger*. Jest to uwarunkowane odmiennością ich biologii. Gatunki z rodzaju *Myrmica* zwiększają na koszarach aktywność furażowania, na co pozwala wyższa zasobność pokarmowa tych środowisk. Wynikiem jest wyższa produkcja oraz szybsze, niż na pastwisku, dorastanie młodej generacji. *Lasius niger* wykazuje spadek aktywności furażowania na koszarach. Towarzyszy temu wyraźny spadek produkcji i wolniejsze dorastanie młodej generacji.

Im w późniejszym terminie sezonu odbywa się koszarzenie, tym niższy jest wskaźnik penetracji *Lasius niger* i tym wyższy gatunków rodzaju *Myrmica* (tab. V).

Dominujące gatunki mrówek pobierają na koszarach 150 a na pastwisku 1200 mg suchej masy materii organicznej, pochodzenia zwierzęcego i roślinnego, co globalnie odpowiada 0,01 i 0,11% produkcji pierwotnej.

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