#### . POLSKA AKADEMIA NAUK ZAKŁAD ZOOLOGII SYSTEMATYCZNEJ

# A C T A Z O O L O G I C A C R A C O V I E N S I A

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The Distribution and Abundance of Ground-Surface-Inhabiting Arthropods above the Timber Line in the Region of Zólta Turnia in the Tatra Mts.

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Размещение и численность наземных членистоногих над верхней границей леса на территории Жулта Турня в Татрах

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#### PROBLEM

The study of the alpine flora and fauna suggests a number of problems, which result from specific environmental alpine conditions and from the accumulation of many ecologically very various environments within a comparatively small area. In the Tatra Mts., just as in any other mountains, this diversity is the resultant of such factors as altitude, aspect and inclination of slopes, site on the slope, and geological substratum, which all together make up a complex of ecological conditions and thus exert an influence upon the nature of the plant cover as well as upon the composition and abundance of the fauna of a given place. For this reason the Tatras constitute a peculiarly interesting region for various ecological studies, and their area may be regarded as comparatively well known in so far as its fauna and flora are concerned. Out of the numerous naturalistic studies carried out in the Tatras, those on plant associations made by SZAFER and his co-workers in the third decade of this century deserve special attention (Szafer, Pawłowski, Kulczyński, 1923, Pawłowski, Sokołowski, Wallisch, 1928). The studies concerning the zoology of the region have so far been confined chiefly to faunistic and autecological works. There are a few synecological studies dealing with the fauna of waters (GAJL, 1926) and that of caves (KOWALSKI, 1955), while synecological studies on the ground-surface-inhabiting fauna have been lacking hitherto.

The faunistic studies have undoubtedly contributed much to the knowledge of the ecology of the species living in the Tatra Mts. and to the characterization of various Tatra environments from the ecological point of view. However, in some respects the methods of faunistic studies are by far less sensitive and precise than the ecological methods. This is due to two facts: firstly, no standard methods of catching are as a rule used for faunistic studies and so the data obtained are hardly comparable; secondly, only the presence of a given species in a given place or its absence from this place is generally taken into account without considering detailed quantitative data.

The ideas and methods of community ecology applied for this study of ground-surface-inhabiting arthropods above the timber line have been derived from the ideas and methods used in phytosociology.

The general principles and conceptions of community ecology and the results obtained in this field of researches are collected in a series of textbooks on animal ecology (Elton, 1927; Allee et al., 1949; Dice, 1955; Odum, 1959; Balogh, 1958), while the criticisms on these conceptions are to be found in the work by Andrewarthy and Birch (1954) and that by Bodenheimer (1958). The fundamental method of community ecology consists in determining the specific and the quantitative composition of the fauna in a certain definite area and in utilizing these data for the recognition of the nature of the biocenosis, its relation to physical circumstances, and the phenomena taking place within it.

Natural biocenoses being too complicated units, their parts, i. e. communities or assemblages of animals, are generally studied. By help of qualitative and quantitative studies it is possible to distinguish particular animal communities, characterized by their definite species composition and abundance, in the field as well as during phytosociological researches (Macfadyen, 1947; Renkonen, 1949), to find out relations between the occurrence of animal communities and that of plant associations (Macfadyen, 1954; Mikulska, 1955), and to describe the succession of animal communities against the background of the succession of plant associations (Janetschek, 1949; Barnes, 1953; Grodziński, 1958) as well as seasonal changes within communities (Smith, 1928; Łuczak, 1953) and the effect of human activity upon their state (Downy, 1944; Kajak, 1960). Moreover, qualitative and quantitative collections of the fauna in an area render theoretical considerations on the mechanisms operating within natural communities and their relations to the whole biocenosis possible (Elton, 1946; Tarwid, 1952).

There are many various conceptions and definitions of the term "animal community" in animal ecology (Macfadyen, 1957; Chodorowski, 1960). Therefore, in order to avoid misunderstanding the term "community" will be used to denominate all arthropods taken in traps in the study area in accordance with the definition framed by Petrusewicz (1937), who applies it for any group of animals chosen from any ecological point of view.

The method of study adopted for this work is in general outlines as follows: Standardized traps were laid out in a chosen place for a strictly determined period of time to catch all animals moving on the surface of the ground. As a result a picture was obtained which included the species composition, the abundance of particular species and other data concerning the specimens taken in the traps. This picture was the resultant of two factors: the species composition and abundance of the fauna in the given place and the method of sampling applied. The method of sampling being standard, it was possible to grasp the differences between the animal communities inhabiting various habitats, whereas the dynamics of seasonal changes in the species composition and abundance of a community could be traced by taking samples at different times. A series of data referring to the fauna of the study area and to diverse ecological phenomena connected with the existence of this fauna were thus obtained.

In the study of the communities of ground-surface-inhabiting arthropods above the timber line presented in this paper efforts were made to collect the data concerning the following problems:

- 1. the influence of physical factors of environment, namely those connected with altitude and slope aspect, upon the composition and abundance of the fauna trapped,
- 2. the influence of plant cover upon the composition and abundance of the fauna trapped,

- 3. the dynamics of seasonal changes in the abundance of particular species and in the composition and abundance of the whole community, and
- 4. the community of ground-surface inhabiting arthropods as a component of the biocenosis of the region above the timber line.

Apart from the foregoing, this study provided a kind of inventory of the fauna of ground-surface-inhabiting arthropods in the region above the timber line, the state of which fauna is conditioned by the specific configuration of the ecological environment. If any changes connected with a rise or drop in human interference occurred in the region under study, it would be possible to determine the effect of these changes upon the species composition and abundance of the fauna of ground-surface-inhabiting arthropods by repeating the study observing the same methods.

One of the important difficulties encountered during biocenotic studies is the abundance and diversity of animal forms included in a biocenosis. Animal communities constitute very complicated systems and, as Elton (1927) has already remarked, it is most proper to pick out as simple communities as possible, with a very small number of species for synecological studies. Then it is much easier to find out which factors account for the qualitative and quantitative composition of the community. The postulate of studying simplest communities has to some extent been fulfilled in the present study. In the Tatra Mts., as in other mountains, the number of species decreases with altitude and consequently the biocenoses become simpler. Moreover, most careful attention has been given in this work to the fauna inhabiting stone debris, completely devoid of seed plants. This animal environment is the poorest in species in the Tatra Mts. The flora of stone debris consists only of lichens, mainly crustose, and there being a lack of suitable shelter and sufficient amount of food available for animals in debris, only appropriately adapted species are able to live steadily in it.

I owe the idea and encouragement to carry out the studies on animal communities in the Tatra Mts. to Prof. W. Szafer. The work was done under the direction of Dozent B. Ferens and Prof. R. J. Wojtusiak. I received many valuable suggestions from C. S. Elton, Director of the Bureau of Animal Population of the Oxford University, and other workers of this Bureau before I undertook my study, and from Dr S. Myczkowski, Dr W. Grodziński and Dr Z. Bocheński in the course of the study.

Mgr A. Rajwa of the Meteorological Observatory of the P. I. H. M. on Kasprowy Wierch gave me instructions and help with the elaboration of the topography, geology and climate of Zółta Turnia. I worked out the plant cover of the mountain with the aid of Dr S. Myczkowski (seed plants) and Dr J. Nowak (lichens). The insects collected were identified for the most part by Dr W. Szymczakowski and Dr B. Burakowski (Carabidae), Dr A. Szujecki (Staphylinidae), Prof. J. Nast (Homoptera) and Dr Pisarski (Formicidae). Centipedes (Chilopoda) were identified by Dr J. Kaczmarek.

The correctness of some identifications of the *Arachnidae* was checked by Prof. J. Rafalski and Mgr J. Prószyński.

During my field work I availed myself of the hospitality of Mr L. DZIĘ-DZIELEWICZ of the Meteorological Station of the P. I. H. M. on Hala Gąsienicowa.

I wish to express my hearty thanks to all these persons for their disinterested labour and for help given me during my work.

#### METHOD

A well-defined and standardized method of catching specimens must be used for all the studies aimed at determining the abundance of animals existing in a given area. Catches are to provide population samples available for further studies. As for the studies of plant communities, the matter is comparatively simple; one marks out an area and calculates quantitative relations for it. Analogically, when communities of soil-inhabiting animals are to be studied, a portion of soil together with animals present in it is taken from a definite area and to a definite depth. Nets can be used for animals living on the surface of the ground and on vegetation so as to isolate a definite area in some way and collect all the animals occurring within it. Unfortunately, the case gets complicated here, because part of fast-moving animals escape before the net comes into contact with the ground. It is therefore selective sampling. Other methods, such as sweeping with nets, shaking down animals from trees and shrubs, looking out for specimens, and setting traps of any kind are also selective.

There is no soil fauna in stone debris and no biocenotic nets can be used, for the debris surface is uneven and nothing can prevent animals from running away between stones. Sweeping and shaking down can be applied only where there is vegetation. The method of spotting animals and catching them by the spotter has too many defects and is unfit for quantitative studies, because its results are hard to compare not to mention other things. For these reasons the only method that can be used in stone debris is the trapping method.

Attention should be given to two features of the trapping method:

- 1. the trap is kept in the field for twenty-four hours so that the species active at various times of the day, not only those whose activity coincides with the stay of the investigator in the field, fall into it,
- 2. most animals found in a trap are those most abundant at the trapping site, most mobile and prone to fall into this very type of traps. Thus the number of animals taken in traps is the function of three factors: the abundance of the animals, their mobility, and the selectivity of the traps.

The trapping that provided the data for this study was made above the timber line in stone debris as well as in areas, covered by mountain pines and grass, adjacent to the debris.

The traps used for catching were Barber traps (Tretzel, 1955). They were 1-litre glass jars with a diameter of 86 mm. and a height of 135 mm. The jars were somewhat distended just below the top so as to make it impossible for the specimens caught to escape. In order to stop the animals from eating one another and from drying the jars were half-filled with water. A teaspoonful of salt was put in each jar to prevent rotting processes.

The jar was placed among debris stones, which were arranged so that the top of the jar was at the level of the debris surface and the stones either touched the edge of the jar opening or projected beyond the edge and hung over the opening. The size and shape of the stones were chosen so that they encompassed the jar opening uninterruptedly. Structurally, they did not differ from the other stones of the debris, but formed a straight track to the pitfall trap. An animal, moving fast over the stones towards the opening, fell into the jar, and when inside it could not get out of it in any way. In mountain pine areas the jar was placed in litter under branches so that its opening was at the level of the litter surface. The traps were laid out in a similar way in places covered with grass.

In addition to the collections of the epigeal fauna made by means of the Barber traps, as described above, extra collections of small insect flying over the debris areas were carried out. The traps used for this purpose were standardized as well. They were round jar lids, 95 mm. in diameter, coated with a resinous compound used to band fruit-trees. The lids were placed horizontally on debris stones and replaced every time the Barber traps were emptied out. The relative abundance of the insects flying over the debris areas could be calculated from these catches without identifying the species they represented.

Web-spinning spiders occurring in the debris were also taken during the study.

The data on the temperature, humidity and mean daily sums of sunshine duration on Hala Gasienicowa and Kasprowy Wierch were obtained from the State Institute of Hydrology and Meteorology.

# Organization of Trapping

Trapping was made on the slopes of Mount Zółta Turnia in the years 1959 and 1960. In 1959 collections were made at six localities selected at altitudes of 1500, 1600, 1700, 1800, 1900 and 2000 m. above sea-level. For the sake of simplicity these localities were denoted by the figures: 15, 16, 17, 18, 19 and 20 respectively. The symbols thus show the altitudes of the localities in hundreds of metres. Where it was possible, attempts were made to choose the localities so that they were similar to each other and differed only in altitude. In practice, it was impossible to execute this postulate exactly, and consequently the localities differed not only in altitude but also in the aspect and inclination of the slopes, site on the slope, characteristic features of the

close neighourhood, structure of the debris etc. These differences will be later discussed in detail. At each locality six pitfall traps were laid in the debris area and one in the adjacent patch of grass or mountain pines. The traps were set among mountain pines at localities 15, 16 and 17 and in grassland at localities 16, 18, 19 and 20. In 1959 collections were begun as soon as the snow cover had vanished, in May, and continued until it reappeared and water got frozen in the jars so that it was impossible to do any more trapping, i. e., until September.

In 1960 the sampling localities were changed so that they might be all on the slopes just facing the north. Three such localities were found at altitudes of 1600, 1800 and 2000 m. above sea-level and they were denoted by N. 16, N. 18 and N. 20. At each of these localities, as in the previous year, six traps were laid in stone debris, no collections being made among mountain pines and in grassland in their close vicinity. In addition, in order to find out the difference in abundance dependent upon the slope aspect, parallel collections were made at two localities lying close to each other at the same altitude but on slopes with various aspects in 1960. These localities were denoted by SW and NE. Eight traps were placed out at either of them but only in stone debris. In 1960 collections were carried out for two months only, in August and September. The precise number of all the traps used is given in Table I.

Table I Number of traps at particular sampling localities

				19	59						1960		
Samplin	g localities	15	16	17	18	19	20	N.	16 N	. 18	N. 20	sw	NE
Number of	Debris Mountain	6	6	6	6	6	6		6	6	6	8	8
traps	pines Grass	1	1 1	1	1	1	1	-		_	_	_	_

Animals were taken out of the traps on the average every two weeks. This prevented the putrefaction of the animals caught and produced a clear picture of changes in the abundance and composition of the fauna in the course of time. The specimens taken out of the traps were placed in 75% ethyl alcohol and carefully examined in the laboratory.

Since it took a fairly long time to collect animals in all the traps on account of the hard field and weather conditions, it was not always possible to empty the traps out exactly at two week intervals. The dates at which the traps were emptied are presented in Table II. The first column of Table II shows the periods in which animals got into the traps. The periods are marked by symbols, which will be used next in the discussion of the results.

Table II

The exact dates at which the traps were emptied out

			1959	9			
Locality	15	16	1'	7	18	19	20
	24. V	23. V	23.	V	23. V	23. V	23. V
V/VI	9. VI	9. VI	11.	VI	10. VI	10. VI	10. VI
VI	24. VI	23. VI	23.	VI	24. VI	24. VI	24. VI
VI/VII	13. VII	13. VII	13.	VII	19. VII	14. VII	14. VII
VII	24. VII	24. VII	24.	VII	25. VII	25. VII	25. VII
VII/VIII	6. VIII	6. VIII	6.	VIII	7. VII	I 7. VIII	7. VIII
VIII	22. VIII	22. VIII	22.	VIII	23. VII	I 23. VIII	23. VIII
VIII/IX	6. IX	5. IX	5. ]	IX	6. IX	6. IX	6. IX
IX	15. IX	15. IX	15. IX		16. IX	16. IX	16. IX
			196	0			
Local	N. 16	N.	18	N	7. 20	sw	NE
	5. VI	11 4.	VIII	4.	VIII	5. VIII	5. VIII
VIII	17. VI	II 18.	VIII	18.	VIII	18. VIII	18. VIII
VIII/IX	2. IX	2.	IX	2.	IX	2. IX	2. IX
IX	15. IX	15.	IX	15.	IX	15. IX	15. IX

#### DESCRIPTION OF STUDY AREA

The study presented in this paper was made in the Polish Tatras, on the slopes of Zólta Turnia. This mountain is a suitable area for studies of this kind, because (1) it lies near Zakopane in the vicinity of Hala Gasienicowa and its slopes are comparatively easy of access all the year round, (2) places covered by stone debris are to be found on its slopes at various altitudes from the timber line (1400 m. above sea-level) up to the top (2086 m.), and (3) this region is rarely visited by tourists, who might disturb the course of work.

# Topography and Localities

Zółta Turnia (see the topographic map, Fig. 1), with its peak reaching an altitude of 2086 m., lies in the northern branch of the Granaty ridge, separating the Pańszczyca Valley from the Valley of Czarny Staw Gasienicowy.

On the south the peak of Żółta Turnia borders on the Żółta Pass (2044 m.), which next passes into Wierch Pod Fajki joined in turn with the group of Granaty. The western slopes of Żółta Turnia fall steeply to the Valley of Czarny Staw Gąsienicowy and are cut by many gullies. On the north-east the slopes fall down equally steeply towards the Czerwony Stawek in the Pańszczyca Valley, while on the east they are somewhat less steep.

The northern slope, on which the traps were disposed, is a plane inclined towards the north and distinctly separated from the eastern and western slopes.

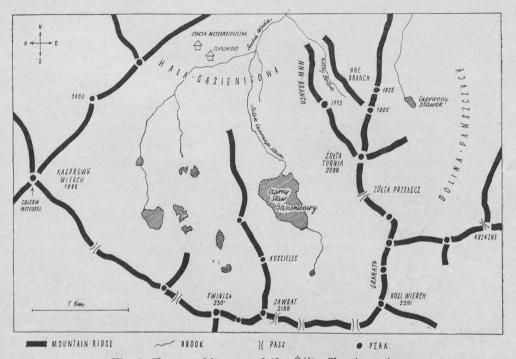


Fig. 1. Topographic map of the Żółta Turnia region

As a result the peak of the mountain from the altitude of about 1800 m. up to the top forms a pyramid with its gentlest slope turned to the north. The middle and the lower part of the northern slope are cut up by the Zółty Potok, which takes rise from a spring funnel below the level of 1800 m. At about 1700 m. the funnel passes into the erosional, deep-cut valley of the Zółty Potok. The valley separates two branches of Żółta Turnia, a NNE branch and a NNW branch, which extend towards the north-east and north-west respectively. The inlination of the branches is small and irregular with culminations, 1885 m. and 1825 m. in altitude in the NNE branch and 1773 m. in the NNW branch. The NNW branch slopes steeply towards the Valley of Czarny Staw Gąsienicowy and somewhat less steeply towards the Żółty Potok Valley. The ridge of this branch falls gently to the north and from 1500 m. more steeply to the Valley of the Sucha Woda. The NNE branch passes into a gently inclined plane on the north-east but falls steeply towards the Pańszczyca Valley

on the eastern side. The plane is called Dubrawiska and slopes gently down to an altitude of about 1500 m. Below this level it is undercut by the steep side of the Sucha Woda Valley.

The trapping localities on the slopes of Zólta Turnia are shown on the photograph (Phot. 1). Their detailed topographic situations are as follows:

- 15. At the foot of Żółta Turnia, on the western slope of the NNW branch over the Sucha Woda Valley; in a shallow depression formed by blocks of quartzitic sandstone.
- 16. On the eastern slope of the NNW branch, on a small sill over the Żółty Potok.
- N. 16. Also on the eastern slope of the NNW branch, north of locality 16, from which it is separated by a small, shallow gully.
- 17. Above localities 16 and N. 16, in the middle portion of the eastern slope of the NNW branch.
- 18. In the middle of the spring funnel of the valley of the Żółty Potok, where the plane of the northern slope is somewhat depressed, passing into the NNE and NNW branches.
  - N. 18. West of locality 18, also in the spring funnel.
- 19. By the north-eastern edge of the summit of Zólta Turnia but still on its northern slope.
- 20. Below the top of the mountain, also by the north-eastern edge of the summit but on the slope falling down to the Valley of Czarny Staw Gasienicowy.
- N. 20. East of locality 20, below the top of the mountain but not by the edge only in the middle of the north slope.

Localities SW and NE are situated by a culmination of an altitude of 1773 m. on the NNW branch, some dozen metres from the top of the culmination. SW lies on its southwestern slope and NE on the north-eastern slope.

The aspects and inclinations of the slopes are given for all these localities in Table III.

Table III
Aspect and inclination of the slopes on which the particular localities were situated

Loc	eality	15	16	17	18	19	20	N. 16	N. 18	N. 20	sw	NE
Aspect	Deviation from N	45°	27°	15°	18°	6°	70°	0°	0°	00	120°	15°
Aspect	Toward	W	E	E	W	W	w	-	_	-	W	E
Slope in	nclination	20°	27°	33°	28°	31°	30°	35°	30°	30°	36°	36°

# Geological Structure and Principal Features of Debris at Particular Localities

In the area of Zólta Turnia the aboriginal geological formations contact with the crystalline massif of the Tatra Mts. (Książkiewicz, 1951). The summit of the mountain is built of Tatra granite. On the northern slope the granite

is overlain directly by Lower Triassic quartitic sandstone, the outcrops of which are present in both mountain branches. The lower portions of the branches are of limestones and dolomites of the Middle Triassic. The bottom of the Sucha Woda Valley is covered by Pleistocene formations.

The whole northern slope of Zółta Turnia as we'll as its branches are covered by stone debris, which descends as low as 1450 m. above sea-level. The debris is the product of the weathering of granites and quartzites mostly in the Pleistocene period. The northern slope, from about 1800 m., up to the summit is covered all over by granitic blocks, which in the spring funnel of the Zółty Potok slip down to about 1700 m. Below this level the branches of the mountain are covered by debris of quartzitic sandstone, which on the western slope of the NNW branch stretches down to the timber line at an altitude od 1450 m.

The granitic blocks of debris have rounded edges and rough surfaces. They are not so resistant to the action of destructive agents as quartzitic blocks. The rough surface of granite results from uneven weathering of its mineral components. The quartzitic sandstone blocks have sharp edges and their surfaces are smoother than those of the granitic blocks. They are very resistant to the action of destructive agents.

The principal features of debris at the particular localities are as follows:

- 15. The debris consists of large blocks of quartzitic sandstone, forming an uneven surface among patches of mountain pines. The blocks undergo no evident displacement owing to the small inclination of the slope. It is difficult to estimate the thickness of the debris; probably it amounts to several metres
- 16. and N. 16. The debris is also composed of sandstone, but the blocks are smaller. It is mobile, the stones move when trodden on and roll down towards the Zółty Potok.
- 17. The debris of a structure similar to that at locality 16, somewhat less mobile, consists of quartzitic sandstone fragments.
- 18. and N. 18. The debris is made up of large-sized round-edged granitic blocks. The depth of the gaps between the stones indicates that the thickness of the debris is considerable. The debris is formed of weathering granite falling down from the summit and its northern slope. The blocks of the debris undergo no evident displacement at present.
- 19. The stones of the debris are a little smaller but they little differ from those at locality 18. The debris is rather shallow, its stones do not undergo any evident displacement.
  - 20. The structure of the debris like that at locality 19.
- N. 20. The debris resembles that at locality 19 but it consists of somewhat smaller blocks.

SW and NE. The structure of the debris like that at locality 17.

The structure of stone debris in several selected places is shown in the photographs (Phot. 2).

### Remarks on the Climatic Conditions of the Study Area

The climate of the Tatra Mts. is affected by many various factors such as altitude, topographical features, geological structure, plant cover and other things, which result in a very great diversity and in the occurrence of a large number of local climates and microclimates in a relatively small area (MICHALCZEWSKI, 1955). The same is true of the region of Zółta Turnia.

Unfortunately, for technical reasons it was impossible to carry out systematic meteorological studies in this area. Owing to this only a short description of the climate, based on the observations made in the neighbouring regions will be given at this place.

Generally speaking, the climate of the Tatras is a mountain climate characterized by a lowered temperature, abundant rainfall, great intensity of insolation and short vegetative period. A general idea of the climatic conditions on the slopes of Zółta Turnia may be given by the data obtained from the meteorological stations on Hala Gąsienicowa (1500 m.) and on Kasprowy Wierch (2000 m.). These data for the year 1959 are summarized in Table IV.

Table IV

Average temperature, humidity and mean daily sums of sunshine duration on Hala Gasienicowa and Kasprowy Wierch in the periods of trapping in 1959

		Temp	erature, in	°C				
	V/VI	VI	VI/VII	VII	VII/VIII	VIII	VIII/IX	IX
Hala Gąsienicowa	6.4	7.6	11.2	12.5	10.9	11.3	7.0	6.4
Kasprowy Wierch	3.0	5.3	7.9	9.7	7.4	8.5	3.9	3.0
	Re	lative	humidity,	in %				
	V/VI	VI	VI/VII	VII	VII/VIII	VIII	VIII/IX	IX
Hala Gąsienicowa	76	80	75	88	83	78	82	78
Kasprowy Wierch	86	87	84	94	92	88	90	88
Mean	daily sums	of suns	shine dura	tion, in	n hours pe	er day		
	V/VI	VI	VI/VII	VII	VII/VIII	VIII	VIII/IX	IX
Hala Gąsienicowa	4.5	4.7	5.2	1.4	3.7	5.8	3.2	3.7
Kasprowy Wierch	4.6	5.4	5.2	1.1	3.4	4.4	3.9	3.9

It will be seen from Table IV that the average temperatures were about 10°C on Hala Gąsienicowa and 7°C on Kasprowy Wierch during the vegetative period of 1959, the temperatures on the latter being, therefore, lower on the average by about 3°C than those on the former. This difference reflects the characteristic decrease in air temperature with altitude. It should be supposed

that similar differences occur between the temperatures of Hala Gasienicowa and the summit of Żółta Turnia.

The vegetative period in the Tatras lasts very short. The areas above the timber line are still covered by a thick layer of snow in April. The snow subsists also in May but only in patches. In June nearly the whole area is free from snow, nevertheless there occur occasional small falls of snow, which thaws soon, in June, July and August. A thin layer of snow is present as early as the end of October and in November, but the thick snow cover appears only in December and January.

The highest annual temperatures occur in July and August. There are great contrasts in temperatures between fine days and nights in the Tatra Mts. owing to intense insolation in the daytime.

Temperature inversions occur in the Tatra region during anticyclonic weather, when masses of cold air lie in the valleys while it is warmer on the mountain slopes above (ORLICZ, ORLICZOWA, 1955).

Owing to the heavy rainfall and high cloud amount the relative humidity of the Tatra region is great. The humidity of a given place is to a high degree dependent upon the slope aspect and the nature of the plant cover. As may be seen from the data presented in Table IV, the mean relative humidity in the vegetative period on Hala Gasienicowa is by 4—6% smaller than the humidity recorded on Kasprowy Wierch. It is usually dry in the stone debris area of Zółta Turnia, because water flows here down without being stopped by stone blocks. It keeps much longer in places covered by grass and mountain pines.

It is a notorious fact that the sunshine in mountains is intenser and rich in ultra-violet rays. This is not without an influence on the thermic balance of cold-blooded invertebrates. The effect of radiation being dependent upon the aspect and inclination of slopes, the mean temperature is always higher on the southern slopes than on those facing the north.

The frequent and strong winds, of which the "halny" wind blowing from the south may reach a speed of 50 m. per second, have a great influence upon the fauna of small animals of the Tatra Mts. They play an important role in the dispersal of small invertebrates and may also destroy the webs of spiders.

#### Plant Cover

Two main factors determining the differentiation of the composition and character of the plant cover over the study area are the altitude and geological substratum. The influence of the human activity is relatively small, though Zólta Turnia has been used as a sheep pasture up to now.

The slopes of the mountain extend between 1420 m. above sea-level (the bottom of the Sucha Woda Valley) and 2086 m. (the top of the mountain). In the Tatras this range includes three vegetation zones: the upper forest zone,

the subalpine mountain pine zone, and the alpine meadows zone (PAWŁOWSKI, 1959). All these zones are represented on the northern slope of Żółta Turnia.

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Quartzitic sandstone and granite, which constitute the geological substratum of the mountain, are parent rocks for very poor, acid soils with a small calcium content. On such a substratum the vegetation is poor and comprises the species characteristic of it.

The upper-zone spruce forest covers the bottom of the Sucha Woda Valley and extends over the northern slopes of Zółta Turnia up to the timber line, which penetrates into the compact fields of mountain pines. Within the range of the timber line there occur single specimens of stone pines (*Pinus cembra* L.). The timber line, which in the Valley of Czarny Staw Gąsienicowy runs at an altitude of 1500 m., at the foot of the NNW branch comes down toward the Sucha Woda Valley below locality 15, where the forest comes into direct contact with the stone debris area. On the NNE branch the timber line ascends the gently inclined face of Dubrowiska to reach an altitude of 1560 m. Its lowering to 1420 m. on the NNW branch is due to the kind of the substratum (quartzitic sandstone), the barrenness of the soil derived from it, and the mechanical action of the debris, the blocks of which reach some dozen metres in length in this place (Sokołowski, 1928).

Above the timber line the slopes of Zółta Turnia are covered by fields of compact mountain pine bushes and by stone debris. Mountain pines form the Mughetum carpaticum silicicolum subassociation (PAWŁOWSKI, SOKOŁOWSKI, WALLISCH, 1928) here. The slopes of both the NNE and the NNW branch are covered by mountain pines and by stone debris devoid of any higher forms of plants. On these slopes there also occur other seed-plant associations, whose range and differentiation are rather limited on account of the poor substratum. The Tritido-Distichetum association (Szafer, Pawłowski, Kulczyński, 1923), the Calamagrostetum tatricum, appearing among the fields of mountain pines. and the Luzuletum spadiceae, covering wet small gullies, may be encountered here. Beginning from the contact line of quartzitic sandstone and granite up, the area of mountain pines decreases, and they do not occur in compact fields any more but in somewhat smaller groups, while single patches reach as high as 1900 m. Most part of the area is here occupied by the Trifido-Distichetum association and stone debris. At 1800 m. stone debris holds mainly the spring funnel of the Zólty Potok, whereas the Trifido-Distichetum and Mughetum carpaticum associations extend over the mountain branches. The summit of Zółta Turnia, from 1900 m. up, is covered only by stone debris and the Trifido-Distichetum. The plant associations occurring on the remaining slopes facing the Zółta Pass, the Valley of Czarny Staw Gasienicowy, and the Pańszczyca Valley have not been taken into account in this description.

In general, it may be stated that the northern slopes of Zólta Turnia are covered by stone debris encroached on by the *Mughetum carpaticum* and *Tri-fido-Distichetum* associations. The mountain pine prevails on the substratum of quartzitic sandstone, on which there are only few patches of the *Trifido-*

Distichetum. On the border of the debris areas with the Mughetum carpaticum either the encroachment of mountain pines on the debris (Phot. 3) was observed or on the contrary some areas of Mughetum carpaticum were seen to be buried by more mobile debris. Nevertheless the boundary between the Mughetum carpaticum and the debris was well and distinctly defined. However poor in plant species, the mountain pine association provides very good shelter for many members of the animal kingdom. The animals take shelter not only among the dense branches of mountain pines but also in the thick layer of litter made up of fallen needles, which undergo a very slow decomposition.

Where a debris area is surrounded by grassland, the initial colonization of the debris by this plant association is apparent. For this reason it is difficult to mark out the distinct boundary between these two habitats. Within the patches of Trifido-Distichetum there are numerous granitic blocks, single or in groups, covered only by lichens, while the debris is overgrown by particular components of grassland (Phot. 4). An important role in such an initial colonization is played by the species Juncus trifidus L., growing in shallow depressions and cracks of stones as well as between stones. The Trifido-Distichetum association is the chief plant element of the alpine meadows zone on a substratum poor in calcium. In the region of Zólta Turnia this association occupies nearly the whole area uncovered by debris and Mughetum carpaticum, the share of the remaining associations, Calamagrostetum tatricum and Luzuletum spadiceae, being only slight.

The floral conditions at the particular sampling localities are as follows: 15. Debris surrounded by the *Mughetum carpaticum*. No other seed-plant associations in the close vicinity. The mountain pines are not very high here (0·5—1·0 m.). In addition to *Pinus mughus* Scop. the *Mughetum carpaticum* association includes the following species: *Vaccinium myrtillus* L., *Cetraria islandica* (L.), *Lycopodium selago* L., *Empetrum hermaphroditum* HAGERUP. The pitfall traps disposed over the debris were about 10 m. away from the mountain pine association.

16. Debris bordered from above and on both sides by the Mughetum carpaticum and from the side of the gully of the Zółty Potok by a patch of the Trifido-Distichetum association. Some dozens of metres north of the site there is a patch of Luzuletum spadiceae, and on the west, in the upper portion of the eastern slope of the NNW branch there are a few patches of Calamagrostetum tatricum. The pitfall traps in the debris were about 10 m. away from the Mughetum carpaticum and about 15 m. from grassland. The mountain pine bushes were not very high (0.5—1.0 m.) in this place and the following species occurred within their area: Pinus mughus Scop., Deschampsia flexuosa (L.), Cetraria islandica (L.), Cladonia sp., Dicranum scoparium (L.), Sphagnum Girgensohnii Russ. The Trifido-Distichetum included the following species: Sphagnum Girgensohnii Russ. (in patches up to 1 sq. m.), Juncus trifidus L., Deschampsia flexuosa (L.), Oreochloa disticha (Wulf.), Festuca supina Schur, Agrostis rupestris All., Festuca picta Kit., Vaccinium myrtillus L., Homogyne

alpina (L.), Luzula spadicea (All.), Polytrichum sp., Calluna vulgaris (L.), Primula minima L., Hieracium alpinum L., Solidago virga-aurea ssp. alpestris (W. K.), Geum montanum L., Picea excelsa (LAM.) (dwarf form), Cystopteris regia (L.), Lycopodium selago L., Doronicum Clusii All., Calamagrostis villosa

(CHAIX), Mutellina purpurea (Poir.).

N. 16. Debris adjacent to a shallow, small gully, which is covered by a patch of Luzuletum spadiceae in the lower portion, and somewhat higher by the Trifido-Distichetum association. Moreover, the debris area borders on the Mughetum carpaticum. At locality N. 16 and in its close neighbourhood there occur the same species as have been recorded for locality 16. The pitfall traps in the debris area were about 5 m. from the Mughetum carpaticum and about 10 m. from the Trifido-Distichetum.

17. Debris surrounded by the Mughetum carpaticum, which includes Pinus mughus Scop., Vaccinium myrtillus L., Empetrum hermaphroditum Hagerup, Deschampsia flexuosa (L.), Cetraria islandica (L.) and Sphagnum Girgensohnii Russ. The pitfall traps in the debris were about 10 m. from the mountain pine association. Some scores of metres below this site there was the Calamagrostetum tatricum association separated by fields of mountain pines.

18. Debris covering a large area surrounded by the Trifido-Distichetum, which includes Juncus trifidus L., Oreochloa disticha (Wulf.), Vaccinium myrtillus L., Vaccinium vitis-idaea L., Chrysanthemum alpinum L., Deschampsia flexuosa (L.), Festuca picta Kit., Agrostis rupestris All., Cetraria islandica (L.), Lycopodium selago L., Soldanella montana Willd., Cladonia sp., Homogyne alpina (L.), Mutellina purpurea (Poir.), Doronicum Clusii All., Luzula spadicea (All.), Campanula alpina Jacq., Sphagnum Girgensohnii Russ., Primula minima L., Carex sempervirens Vill., Vaccinium uliginosum L., Empetrum hermaphrodium Hagerup, Calluna vulgaris (L.), and Gnaphalium supinum L. The pitfall traps in the debris area were about 20 m. away from the grassland association. At a distance of some tens of metres there were single clumps of mountain pines. This association was made up of Pinus mughus Scop., Deschampsia flexuosa (L.), Gentiana punctata L., Calamagrostis villosa (Chaix) and Luzula spadicea (All.).

N. 18. The floral composition of the close vicinity the same as that for locality 18. Initial colonization of the debris and the gaps among its stones by the *Trifido-Distichetum* may be seen at this locality. The pitfall traps were 15 m. away from the grassland and about 20 m. from the nearest patch of

Mughetum carpaticum.

19. Debris surrounded by the Trifido-Distichetum association composed of Juncus trifidus L., Oreochloa disticha (WULF.), Vaccinium vitis-idaea L., Cladonia sp., Carex sempervirens VILL., Carex atrata L., Primula minima L., Lycopodium selago L., Chrysanthemum alpinum L., Luzula spadicea (ALL.), Festuca supina Schur, Cetraria islandica (L.), Vaccinium uliginosum L., Campanula alpina Jacq., Doronicum Clusii All., Salix retusa L., Homogyne alpina (L.), Ranunculus montanus WILLD., Polygonum viviparum L., Salix herbacea L.,

and *Sphagnum Girgensohnii* Russ. Small patches of low mountain pines were still encountered at this altitude, but they did not occur in the neighbourhood of the trapping locality. The pitfall traps in the debris area were 5 m. from the grassland association.

20. Debris surrounded by the Trifido-Distichetum. Among the patches of grassland there occur single granitic blocks and bare faces of rocks. The composition of the Trifido-Distichetum association is as follows: Juncus trifidus L., Cetraria islandica (L.), Oreochloa disticha (Wulf.), Doronicum Clusii All., Polytrichum sp., Primula minima L., Vaccinium vitis-idea L., Chrysanthemum alpinum L., Luzula spadicea (All.), Homogyne alpina (L.), Carex atrata L., Geum reptans L., Pedicularis verticillata L., Ranunculus thora L., Campanula polymorpha Witasek, Festuca supina Schur, Poa violacea Bell., Lycopodium selago L., Soldanella montana Willd, and Poa laxa Haenke. The pitfall traps disposed in the debris area were about 5 m. from the Trifido-Distichetum. There were no other seed-plant associations in the close neighbourhood of the debris.

N. 20. Very extensive area of debris bordered by the *Trifido-Distichetum* association with the same floral composition as given for locality 20.

SW — Debris surrounded by the Mughetum carpaticum on all sides but the north, where it comes into contact with patches of grassland. The Mughetum carpaticum includes Pinus mughus Scop., Sphagnum Girgensohnii Russ., Deschampsia flexuosa (L.), and Cetraria islandica (L.). The Trifido-Distichetum is composed of Juncus trifidus L., Deschampsia flexuosa (L.), Cetraria islandica (L.), Cladonia sp., Dicranum scoparium (L.), Vaccinium myrtillus L., Homogyne alpina (L.), Gentiana punctata L., Vaccinium vitis-idaea L., Oreochloa disticha (Wulf.), and Carex sempervirens Vill. The pitfall traps placed out in the debris were 3 m. away from the mountain pine association and 5 m. from the grassland.

NE — Extensive debris bordered on all sides by the *Mughetum carpaticum*, which on the south formed a narrow strip (1—2 m.) directly adjoining the large fields of grassland. The floral composition was the same as at locality SW. The pitfall traps in the debris were 5 m. away from the *Mughetum carpaticum* area and about 10 m. from the *Tritido-Distichetum*.

The data concerning the distribution of the seed-plant associations in relation to the particular localities are summarized in Table V.

Table V
The occurrence of seed-plant associations at the sampling localities or in their close neighbourhood

	15	16	17	18	19	20	N. 16	N. 18	N. 20	sw	NE
Mughetum carpaticum	+	+	+	_	_	_	+	_		+	+
Trifido — Distichetum		+	_	+	+	+	+	+	+	+	+

On the surface of the sheer debris there were no seed plants, the stones being covered by lichens. The lichens were chiefly saxicolous ones with crustose thalli, though other species with foliose and fructicose thalli were also encountered as well as a few species growing on the soil surface, in our case, between the stones.

The degree to which the debris was covered by lichens was very variable and difficult to establish, because there was no continuous debris surface only an accumulation of rock fragments with their faces lying in many different planes. The stone faces, which at the same time formed the surface of the debris, were generally covered by lichens in 100% in the places where the debris stones did not undergo any displacement. However, looking on the debris surface from above one could notice bare stone faces free from lichens. This was due to the displacement of stones and consequent uncovering of new stone surfaces and stones which had been lying in the depth up to then. The more mobile the debris, the smaller was the area covered by lichens.

The lichen cover and its species composition at the particular sampling localities were as follows:

- 15. Lichen cover of about 95%. More than the half of the area covered by lichens was under *Rhizocarpon alpicola* (Hepp.), next came *Umbilicaria cylindrica* (L.), *Rhizocarpon tinei* (Tornab.), *Parmelia stygia* (L.). *Buellia atrata* (Sm.), *Lecidea confluens* Fr., *Umbilicaria polyphylla* (L.), *Umbilicaria erosa* (Ach.), and the soil-surface species *Stereocaulon denudatum* Flk.
- 16. Lichen cover of about 70%. Most part of the area was occupied by *Rhizocarpon alpicola* (Hepp.), *Buellia atrata* (Sm.) and *Lecidea* sp. The remaining species were *Rhizocarpon tinei* (Tornab.), *Umbilicaria cylindrica* (L.) and the soil-surface species *Sphaerophorus fragilis* (L.).
- N. 16. Lichen cover of 60%. Rhizocarpon alpicola (Hepp.) was the most abundant, Rhizocarpon tinei (Tornab.) and Lecidea sp. came next. The remaining species were Lecidea confluens Fr., Lecanora intricata (Schrad.) and the soil-surface lichen Stereocaulon denudatum Flk.
- 17. Lichen cover of 85%. More than the half of the area was covered by Rhizocarpon alpicola (HEPP.). The remaining species were Buellia atrata (SM.), Rhizocarpon tinei (TORNAB.) and Lecidea confluens Fr. Soil-surface lichens were lacking.
- 18. Lichen cover of 90%. The most numerous species: Rhizocarpon alpicola (Hepp.) and Rhizocarpon tinei (Tornab.). The remaining species were Umbilicaria cylindrica (L.), Lecanora badia (Hoffm.), Buellia atrata (Sm.), Lecidea confluens Fr., Lecidea aenea Duf., Lecidea sp., Parmelia stygia (L.), Parmelia pubescens (L.), Umbilicaria polyphylla (L.), Lecanora intricata (Schrad.), Lecanora cinerea (L.), and of soil-surface lichens, Stereocaulon denudatum Flk., Sphaerophorus fragilis (L.) and Cetraria islandica (L.).
- N. 18. Lichen cover of 80%. As in locality 18, the most numerous species was *Rhizocarpon alpicola* (Hepp.). It was followed by *Rhizocarpon tinei* (Tornal), *Umbilicaria cylindrica* (L.), *Lecanora badia* (Hoffm.), *Lecidea lapicida*

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ACH., Buellia atrata (SM.), Lecidea sp., Lecidea confluens Fr., Lecidea aenea Duf., Parmelia pubescens (L.), Umbilicaria polyphylla (L.), Lecanora intricata (SCHRAD.), Lecanora cinerea (L.), and the soil-surface lichens Stereocaulon denudatum Flk. and Cetraria islandica (L.).

- 19. Lichen cover of 95%. More than the half of the area was occupied by Rhizocarpon alpicola (Hepp.). The remaining species were Buellia atrata (Sm.), Lecidea aenea Duf., Lecanora badia (Hoffm.), Umbilicaria cylindrica (L.), Parmelia stygia (L.), Parmelia pubescens (L.), Umbilicaria polyphylla (L.), Lecidea lapicida Ach., Umbilicaria erosa (Ach.), Parmelia encausta (Sm.), Hematomma ventosum (L.), and the soil-surface species Stereocaulon denudatum Flk., Sphaerophorus fragilis (L.), Alectoria ochroleuca (Eheh.) and Cetraria islandica (L.).
- 20. Lichen cover of 95%. The most numerous species were Rhizocarpon alpicola (Hepp.) and Lecidea sp. The remaining species: Buellia atrata (Sm.), Umbilicaria cylindrica (L.), Rhizocarpon tinei (Tornab.), Lecidea confluens Fr., Lecidea aenea Duf., Lecidea lapicida Ach., Parmelia stygia (L.), Parmelia pubescens (L.), Lecanora cinerea (L.), Parmelia encausta (Sm.), Pertusaria corallina (L.), Lecidea mosigii (Hepp.), Lecidea aglaea Smrft., Crocinia neglecta (Nyl.), and the soil-surface species Stereocaulon denudatum Flk., Sterophorus fragilis (L.), Cladonia gracilis elongata (Jacq.), Lecidea demissa (Rustr.), and Ochrolechia frigida (Sw.).
- N. 20. Lichen cover of 80%. Rhizocarpon alpicola was the most numerous. The remaining species: Buellia atrata (SM.), Umbilicaria cylindrica (L.), Lecidea lapicida Ach., Lecidea sp., Lecidea confluens Fr., and of the soil-surface lichens, Alectoria ochroleuca (Ehrh.), Stereocaulon denudatum Flk., Thamnolia vermicularis (Sw.), Bacidia flavovirescens Dicks., and Cladonia pleurota (Flk.).
- SW Lichen cover of 90%. The most numerous species was Rhizocarpon tinei (Tornab.) followed by Rhizocarpon alpicola (Hepp.), Buellia atrata (Sm.), Umbilicaria cylindrica (L.). The remaining species: Lecidea sp., Lecidea kochiana Hepp., Lecidea confluens Fr., Parmelia stygia (L.), Lecanora badia (Hoffm.), Umbilicaria erosa (Ach.), Pertusaria corallina (L.), Lecidea mosigii (Hepp.), Lecidea aglaea Smrft., Lecanora campestris (Schraer.), Sporostatia cinerea (Schraer.), Lecidea pantherina Ach., and the soil-surface lichen Sphaerophorus fragilis (L.).

NE — Lichen cover of 90%. More than the half of the area was covered by Buellia atrata (Sm.). The remaining species were Lecidea sp., Lecidea kochiana Hepp., Rhizocarpon tinei (Tornab.), Rhizocarpon alpicola (Hepp.), Umbilicaria deusta (L.), Umbilicaria cylindrica (L.) and Lecanora atra (Huds.). No soil-surface lichens were found.

Generally speaking, the lichen flora was very alike at all localities. There were somewhat more species on the granite debris than on quartzitic sandstones. The same goes for soil-surface lichens, especially at localities 19, 20 and N. 20, where the debris layers were relatively shallow.

#### RESULTS

During the study 3468 individuals of 61 species were taken in the pitfall traps. The list of these species is given in Table VI.

Table VI

List of arthropod species taken in the pitfall traps on the slopes of Zólta Turnia in the years 1959 and 1960. Numbers of individuals collected in stone debris (D), Mughetum carpaticum (P), and Tritido-Distichetum (G) are given for each species

	D	P	G	Total
Arachnoidea				Tames a
Araneida				
Coelotes atrops (Walckenaer)		2	_	2
Coelotes sp.		1	_	1
Cryphoeca silvicola (С. L. Косн)	9	4	1	14
Cybaeus angustiarum L. Koch		1	_	1
Aleopecosa aculeata (CL.)	_		1	1
Pardosa nigra (C. L. Koch)	518	4	21	543
Pardosa saltuaria (L. Koch)	_		2	2
Pardosa sp.			2	2
Pachygnata degeeri (Sundevall)		1 .	1	2
Bolyphantes luteolus (Blackwall)		2		2
Taranucnus setosus (Cambridge)	9	2		9
fam. Linyphidae indet.	4	3		7
Centromerus pabulator (Cambridge)	4	1	1	2
Cornicularia cuspidata (Blackwall)			1	6
	5	1		1
Wideria antica (Wider)	1	_	 1	1
Drassodes pubescens (THORELL)		_		
Clubiona terrestris Westring	41	3	1	45
Philodromus sp.	1	1	_	2
Xysticus bifasciatus C. L. Koch	_		2	2
Xysticus cristatus (Cl.)	1			1
Araneida indet.	1	_		1
Opilionidea				
Mitosoma chrysomelas (Herm.)	1		5	6
Ischyropsalis dacica Roewer	1	25		26
Mitopus morio (F.)	183	38	727	948
Platybunus bucephalus C. L. Koch	396	174	733	1303
Pseudoscorpionidea				
Neobisium simoni (L. Koch)		1	_	1
Chilopoda				
Lithobius cyrtopus Latzel	1	1	1	3
Lithobius mutabilis Koch	2		_	2
Lithobius muticus Koch	2	_	1	3
Lithobius nigrifrons Latzel	1	_		1
Lithobius pelidnus Haase	3		2	5
Lithobius sp.		1	3	4

Table VI (cont.)

	D	P	G	Total
Insecta				
Coleoptera				
fam. Carabidae				
Calathus metallescens Dej.		2	14	16
Carabus auronitens F.	_	1		1
Carabus silvestris transsylvanicus Dej.	1	2	4.7	50
Carabus sp. (larva)	1			1
Cychrus caraboides L.		1	_	1
Deltomerus tatricus Mill.	34		7	41
Leistus montanus Steph.	4			4
Leistus piceus Fröl.		2	1	3
Leistus sp.	1			1
Nebria tatrica Mill.	254	11	6	271
Pterostichus fossulatus Quens.	2	1	1	4
Pterostichus foveolatus Duft.	1			1
Pterostichus morio Duft.	14		37	51
Trechus sp.		1	4	5
Carabidae indet.		1	_	1
fam. Curculionidae				
Hylobius piceus De Geer		2		2
Otiorrhynchus arcticus O. F.			2	2
Otiorrhynchus dubius Ström.			1	1
Otiorrhynchus niger F.	2			2
Pissodes pini L.		2		2
Sitona crinitus Hbst.	1	-	_	. 1
fam. Byrrhidae				
Byrrus glabratus Heer	_	1		1
Carpathobyrrulus tatricus Mroczkowski	1		1	2
fam. Coccinellidae				
Coccinella quinquepunctata L.	1	_	_	1
Coccinella septempunctata L.	2	-		2
6 01 1				-
fam. Catopidae			,	10
Catops tristis (Panz.)	3	6	1	10
fam. Chrysomelidae				
Minota obesa Waltl.		-	4	4
fam. Staphylinidae				
Philonthus montivagus Heer	-	-	1	1
Quedius obscuripennis Beruh.		1	_	1
Quedius cincticollis Kr.	_	3	-	3
Tachinus rufipennis Gyll.	1	1	_	2

Table VI (cont.)

	D	Р	G	Total
fam. Elateridae				
Corymbites cupreus aeruginous F.	1	_		1
Hypnoides consobrinus Muls.	1	_		1
Prosternon tesselatum L.	-	_	1	1
Hymenoptera				
fam. Formicidae				
Camponotus herculeanus (L.)	1	2	_	3
Myrmica ruginodis Nylander	_	11	_	11
Homoptera				
Homo provide				
Errhomenellus brachypterus (FIEB.)	3	9	_	12
Heteroptera				
Lygus montanus (Schill.)	2		_	2

As may be seen from the list (Table VI), eight species were trapped in large numbers. They were two spiders, Pardosa nigra (C. L. Koch) and Clubiona terrestris Westring, two harvestmen, Platybunus bucephalus C. L. Koch and Mitopus morio (F.), and four ground beetles, Nebria tatrica Mill., Deltomerus tatricus Mill., Carabus silvestris transsylvanicus Dej., and Pterostichus morio Duft. Most of the data I managed to obtain refer to these species and they constitute the material for pointing out some regular features of the populations of these species in the field. They are all predators feeding on small invertebrates, mainly insects, and it is this way of life that determines their great mobility accounting for the big catches in pitfall traps.

The sex and age of the specimens were also taken into consideration in the discussion of spatial and seasonal changes within the populations of spiders and harvestmen. For the spiders *Pardosa nigra* C. L. Koch and *Clubiona terrestris* Westring the age categories were established on the basis of the following criteria:

A — Mature individuals: well-developed copulatory organs both in males and in females.

B — Submature individuals: copulatory organs still incompletely developed, thickenings on the tarsi of the palpi in males and signs promising the future epigyne in females.

C — Immature individuals: these are only slightly smaller than the mature individuals. No signs of copulatory organs on the palpi and on the ventral side of the abdomen make it impossible to identify the sex of an individual.

D — Young individuals: much smaller than the mature (A) and immature (C) ones. They were specifically identified on the basis of the fact that they occurred on the dorsal side of the abdomens of females and got into traps together with their bearers. They were not included in the totals of specimens caught in the pitfalls, because they fell into them together with females and not by ones. There were generally some scores of young individuals on one female.

Only two age categories have been established for the harvestmen *Platy-bunus bucephalus* C. L. Koch and *Mitopus morio* (F.):

- A Mature individuals: well-developed copulatory organs, genital operculum rigid and can be easily swung off showing the well-developed penis or ovipositor under it.
- B Immature individuals: these include all the remaining individuals taken in the traps. Their genital operculum was not rigid but it was grown into one with the skin on all sides. Copulatory organs still incompletely developed under the genital operculum.

In the discussion the populations of these eight most abundant species will be dealt with first and followed by the phenomena concerning the whole community.

# The Distribution and Abundance of Ground-Surface-Inhabiting Arthropods in Particular Habitats and Localities

Two problems will be considered in this section: (1) the differences in the species composition and abundance of animals from three different habitats: stone debris, mountain pine association and grassland; (2) the differences in the species composition and abundance of animals between particular sampling localities. The exact situation and characteristics of all these localities have been given in the description of the study area, and now it remains to discuss the trap catches at these localities.

A comparison of the numbers of individuals of several species most abundant in various habitats taken at each locality is presented in the graph of Fig. 2. The graph shows the numbers of specimens caught in one trap for each habitat at each locality in the year 1959.

Fig. 3 shows the density and frequency of several abundant species in stone debris. The graph is based on the data concerning the catches in the debris areas in the last three trapping periods (VIII, VIII/IX, IX) in 1959 (localities 15, 16, 17, 18, 19, and 20) and in 1960 (localities N. 16, N. 18, and N. 20). The density and frequency were calculated by the BARNES method (BARNES 1953) using the following formulae:

 $\begin{aligned} \text{Density} &= \frac{\text{total number of individuals of given species taken in traps}}{\text{total number of traps}} \\ &= \frac{\text{number of traps in which given species were present}}{\text{total number of traps}} \end{aligned}$ 

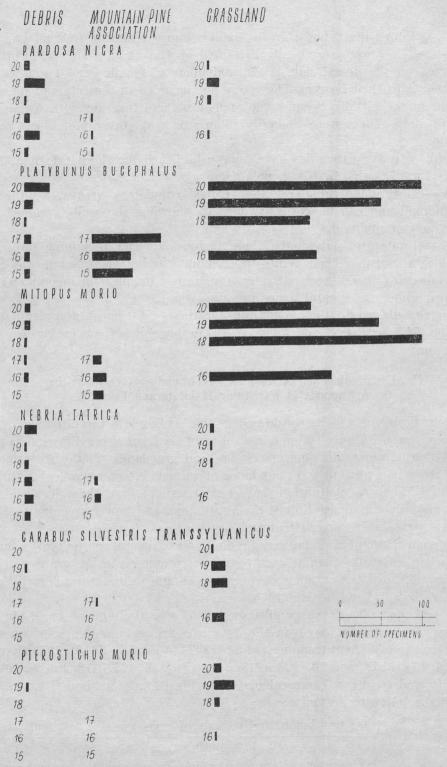


Fig. 2. Numbers of six most numerous species caught in one trap in each habitat at each locality over the year 1959

A similar graph of density and frequency (Fig. 4) has been made up on the basis of the catches in the last three periods (VIII, VIII/IX and IX) in 1960

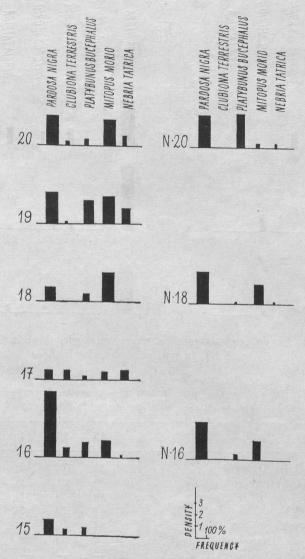


Fig. 3. Density and frequency of several most numerous species taken in the traps in stone debris during the last three trapping periods of 1959 (localities 15, 16, 17, 18, 19, and 20) and 1960 (localities N. 16, N. 18, and N. 20)

for two localities, SW and NE, to illustrate the differences in the occurrence and abundance of animals in relation to the aspect of the slopes.

Table VII presents the numbers of individuals collected in the debris habitat at particular localities.

On the basis of these graphs and tables it is possible to analyse the abundance of several abundant species in different habitats and localities.

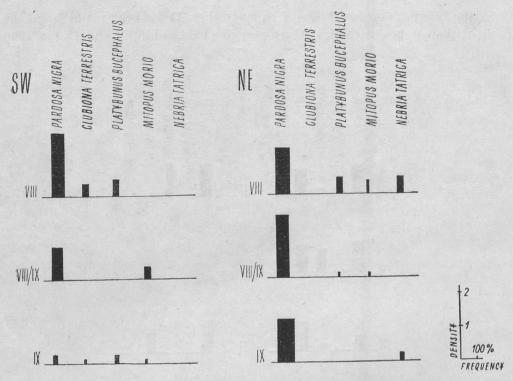


Fig. 4. Density and frequency of several most numerous species taken in the traps at localites SW and NE in particular trapping periods

Table VII
The number of individuals of several abundant species taken in all traps in the debris habitat
at particular localities in 1959

	15	16	17	18	19	20
Pardosa nigra (С. L. Косн)	28	162	45	28	87	67
Clubiona terrestris Westring	9	10	12	_	1	5
Platybunus bucephalus C. L. Koch	50	24	34	37	81	131
Mitopus morio (F.)	1	34	7	29	37	45
Nebria tatrica Mill.	24	26	45	66	19	65
Deltomerus tatricus MILL.	3	1	2	6	6	16
Carabus silvestris transylvanicus Dej.	_	_		-	1	-
Pterostichus morio Duft.	-	-	_	-	9	5

# Pardosa nigra (C. L. Koch)

The highest catches of this spider were obtained in the debris areas (Fig. 2) and the smallest in the mountain pine association. The traps laid out in grassland took mainly immature individuals (C), which formed 71% of the total number of all individuals caught, while those collected in the debris amounted to as little as 11%. On the basis of these data the spider Pardosa

nigra may be regarded as a species associated with debris, which refers at least to mature (A) and submature (B) individuals. Immature individuals probably find better living conditions in grassland than in debris.

Some differences may also be noted between the numbers of specimens taken only in debris at particular localities (Table VII, Fig. 2 and 3). However, it is difficult to find a common factor responsible for these differences. At any rate, there is nothing to suggest the fact that the abundance of this species at altitudes ranging from 1500 m. above sea-level to 2000 m. was connected with the altitude. The frequent occurrences of the spider in question at locality 16 should rather be ascribed to a high humidity of this debris area with a relatively shallow debris layer and situated a short way from a brook. On the contrary, the debris at localities 15 and 18, made up of big rock fragments, had such a great thickness that its surface lay high above the water table. At the last localities the catches of *Pardosa nigra* (C. L. Koch) were the poorest.

It can hardly be inferred from the available data (Fig. 4) whether this spider occurs in larger numbers on the northern slopes or on the southern. No great differences in the numbers of the members of this species were found between localities SW and NE except that considerably more individuals were caught at locality NE in the first half of September (IX). It is likely that there is no direct relation between the abundance of this species and the slope aspect.

Generally speaking, in spite of some differences, the species *Pardosa nigra* (C. L. Koch) was encountered in large numbers in all debris areas and in somewhat smaller numbers all over the remaining area above the timber line.

#### Clubiona terrestris Westring

This species was caught in small numbers in stone debris and *Mughetum carpaticum*, but only one specimen was trapped in grassland, at locality 16, situated a short way from debris and mountain pine areas. In debris this spider was found only on the bottom faces of stones in the day-time. As other members of the family *Clubionidae*, it probably belongs to the group of night species.

In the debris habitat Clubiona terrestris Westring was taken at all localities but locality 18 (Table VII), the catches at localities 19 and 20 being remarkably smaller than those at localities 15, 16, and 17, which adjoin the fields of mountain pines. It might be supposed that the number of individuals of this species decreases with altitude. However, it was not affected directly by the altitude but by the presence or lack of the mountain pine association, with which this species is associated and which governs its abundance, in the close vicinity of the debris.

There may be some relationship between the abundance of this species and the slope aspect (Fig. 4), because some members of the species were taken at locality SW and none at all at locality NE.

# Platybunus bucephalus C. L. Koch

The size of the catches of this harvestman varies markedly from one habitat to another (Fig. 2). The catches were abundant in the grassland habitat, smaller in the *Mughetum carpaticum*, and relatively poor in debris. This harvestman, similarly to the spider *Pardosa nigra* (C. L. KOCH), showed varying proportions of mature (A) and immature (B) individuals in different habitats (Table VIII).

Table VIII

Number of mature (A) and immature (B) individuals of the species *Platybunus bucephalus* C. L. Koch taken in one pitfall trap in each habitat at each locality during the whole period of trapping in 1959

		15	16	17	18	19	20	% of total
Debris	A	2	2	2	1	10	29	78
DOMIS	В	, 3	3	5	1		1	22
W 7.1	A	4	11	45		\ \ \		34
Mughetum carpaticum	В	43	34	37	X	×	×	66
	A		80		116	217	236	89
Trifido-Distichetum	В	X	49	×	5	10	20	11

Immature individuals (B) form 66% of the total number taken in the Mughetum carpaticum and hardly 11% of that in the grassland habitat. This results from the fact that immature individuals keep the Mughetum carpaticum, while mature ones leave its floor for the mating season. This matter will be discussed in detail in the section on seasonal changes in abundance. The Mughetum carpaticum is therefore a habitat fit for immature (B) and the Trifido-Distichetum for mature individuals (A).

A relatively small number of members of this species was, as has been mentioned above, caught in debris, namely a thirtieth of that taken in the *Trifido-Distichetum*. Thus, this harvestman is not associated with debris as the spider *Pardosa nigra* (C. L. Koch) is, though it is only slightly less abundant in this habitat than the other. Its occurrence in debris might be ascribed to its great mobility and consequently to tendency to penetrate all habitats surrounding the *Trifido-Distichetum* and *Mughetum carpaticum*. However, it may well be that the harvestman Platybunus bucephalus finds food and shelter in the debris area.

The number of individuals of this species collected in the debris habitat at different localities is very variable (Table VII), which is, however, independent of altitude. It is difficult to establish the factor answerable for the differences. No relation was also noted between the abundance of these harvestmen and the slope aspect (Fig. 4).

### Mitopus morio (F.)

The association of this species with grassland is evident (Fig. 2). Immature individuals do not occur in large numbers in other habitats as those of the foregoing species do. The number of specimens collected in the mountain pine habitat is a fifteenth and that in debris a fortieth of the number of individuals trapped in grassland. The fact that in debris more members of this species were taken at localities 16, 18, 19, and 20 than at localities 15 and 17 (Table VII) may be explained by the position of the former localities within a short distance of the grassland association. Localities 15 and 17 were surrounded only by mountain pines and so the catches of this harvestman were considerably smaller at them. No effect of slope aspect upon the abundance of this species was observed (Fig. 4).

#### Nebria tatrica MILL.

This is another species, next to *Pardosa nigra* (C. L. KOCH), associated with debris. The numbers of this insect obtained from the mountain pine and grass areas do not exceed the numbers of specimens taken in debris (Fig. 2). It may be thus assumed that this species is associated with debris and adapted to live in it. *Nebria tatrica* MILL. is probably more abundant on slopes facing the north, since no specimens were collected at locality SW (Fig. 4).

#### Deltomerus tatricus MILL.

This species was caught in the traps disposed over the debris and grass areas. No specimens were taken in the *Mughetum carpaticum* habitat.

#### Carabus silvestris transsylvanicus Dej.

A beetle apparently associated with grassland (Fig. 2); only one specimen taken in debris and one in a mountain pine area.

#### Pterostichus morio Duft.

This beetle is associated with the grassland habitat, where it occurred in the largest numbers (Fig. 2). The catches in debris were relatively poor and no specimen was trapped in the *Mughetum carpaticum*.

In grassland it was taken in all traps at all localities, most numerously at locality 19. In debris it was collected only at localities 19 and 20 (Table VII). These data suggest a dependence of the occurrence and abundance of the

species upon the altitude. The dependence is manifested by the fact that *Pterostichus morio* was most numerous in the alpine meadow zone, and even there at the upper localities.

The occurrence and abundance of this species may be explained in another way as well. A very small catch in grassland at locality 16 may have been due to the fact that the grassland patch was there very small, situated just on a brook and somewhat differing in floral composition from those at higher-situated localities. The occurrence of this beetle in the debris at localities 19 and 20 may be explained by that the debris areas at these localities were small and the traps lay within a short distance (about 5 m.) of the grassland association. The areas of debris at localities 18 and 16 were larger and the traps in the debris a long way from grassland, while localities 15 and 17 were surrounded only by fields of mountain pines, in which this species did not occur.

It should be stated with regard to the whole study area above the timber line that there are several species that occurred in all habitats and all localities ranging from  $1500~\mathrm{m}$ . to  $2000~\mathrm{m}$ .

The harvestman Platybunus bucephalus C. L. Koch should first of all be mentioned as one of these species. In the mountain pine habitat it outnumbered all the remaining species, in grassland proved as abundant as Mitopus morio (F.), and in debris its number was slightly exceeded by that of Pardosa nigra (C. L. Koch). This is the case, if the data for the whole year have been taken into account. However, as the number of individuals of particular species caught in the traps changed in the course of time, there were periods in which the harvestman Platybunus bucephalus C. L. Koch outnumbered all the remaining species, and other periods when its number fell short of those of other species. Only in the mountain pine habitat it constantly held its position of a dominant species. Two other species standing next to Platybunus bucephalus C. L. Koch and occurring in large numbers in each of the habitats were Mitopus morio (F.) and Pardosa nigra (C. L. Koch). Although associated with definite habitats, in which they were trapped in the largest numbers, they were also fairly numerous over the whole remaining area. Nebria tatrica MILL. was the last of the species that were abundant in all the three habitats.

There is still a whole series of species which were caught in the traps in each of the three habitats, but they may not be regarded as dominant species of the area above the timber line, because the number of their members taken in the traps was too small.

There were several common dominant species, but the abundance of each particular species varied from one habitat to another. In debris the catches of the spider *Pardosa nigra* (C. L. Koch) were the highest, with the two harvestmen, *Platybunus bucephalus* C. L. Koch and *Mitopus morio* (F.), coming in second, while the beetle *Nebria tatrica*, the spider *Clubiona terrestris* and the beetle *Deltomerus tatricus* were taken in somewhat smaller numbers. In

the mountain pine habitat *Platybunus bucephalus* was the most numerous, followed by a little smaller numbers of *Mitopus morio* (F.), *Nebria tatrica* Mill, and *Pardosa nigra* (C. L. Koch). In grassland the harvestmen *Platybunus bucephalus* C. L. Koch and *Mitopus morio* (F.) were unchallenged dominant species coming before *Carabus silvestris transsylvanicus* Dej, *Pardosa nigra* C. L. Koch), *Deltomerus tatricus* Mill, and *Nebria tatrica* Mill.

This is how the matter stands as regads the abundance and distribution of several common species in each habitat over particular localities. However, to complete the picture presented above, all the arthropod species collected in the course of the study should be taken into consideration. The catches of these species were too small to permit the determination of habitat preference for each species on the basis of the number of individuals caught.

The number of arthropod species and that of individuals taken in one trap in each habitat at each locality in 1959 are shown in Table IX.

 ${\it Table\ IX}$  Number of arthropod species and individuals taken in one trap in each habitat at each locality in 1959

		15	16	17	18	19	20
Debris	4	8	6	4	8	6	
Number of species	Mughcarp.	18	14	12	×	×	×
	TrifDist.	×	13	×	12	17	9
	Debris	19	42	25	9	48	61
Number of individuals	Mughcarp.	98	97	116	×	×	×
	TrifDist.	×	310	×	420	509	397

The traps placed in debris took the smallest number of species. It is only natural, as the debris habitat is the poorest and least differentiated. Nearly twice as many species were trapped in each, the mountain pine and the grassland habitat. In all probability, the mountain pine habitat, being more differentiated than grassland, has more species, but since the traps took only animals moving on the surface of litter, the number of species trapped in the former habitat did not exceed that from the latter.

The differences between the habitats become clear, if the total number of individuals of all species collected is taken into account. Then it becomes apparent that as far as the fauna of arthropods moving on the surface of the ground is concerned debris is the poorest habitat, while they are most abundant in the grassland association. The catches in the mountain pine areas, though considerably higher than those in debris, were several times smaller than the catches in grassland, for most animals inhabiting the mountain pine habitat reside among branches or in litter and only few move on the surface of litter.

An analysis of the numbers of species and individuals taken in the same habitats but at different localities, i. e. at different altitudes, shows that the differences between the localities are smaller than those between the debris, mountain pine and grassland habitats. No correlation between the altitude and the number of arthropods or their species collected in the traps has been observed here. The number of species trapped in the debris area at an altitude of 1500 m., within a short distance of the timber line, is no larger than the number of species derived from similar debris areas at 2000 m.

Another method may be used for analysing the differences between particular habitats and those between localities, namely, the method worked out by Czekanowski and Kulczyński (Kulczyński, 1940) for distinguishing plant associations. The data used with this method are those obtained from the catches in one trap for each habitat at each locality during the whole trapping period of 1959.

The coefficient of similarity (P) was calculated for each trap in relation to any other trap by the formula

$$P = \frac{100}{2} \left( \frac{c}{a} + \frac{c}{b} \right)$$

where a — number of species in one trap

b — number of species in the other trap

c — number of species common to both traps

Then the coefficients were tabulated and presented graphically by means of a suitable scale of shaded squares. In this way it is possible to find out which traps were the most similar to each other and to realize whether any groups of traps distinguished themselves by similar species compositions.

It will be seen from the trellis diagrams of similarity coefficients (Figs. 5 and 6) that no groups of traps differing distinctly from the remaining ones in having similar species compositions of animals caught in them may be distinguished in the material obtained by trapping. The same is true in the case of any other arrangement of traps in the trellis diagram. Therefore, the application of the method of CZEKANOWSKI and KULCZYŃSKI renders it possible to state that there was one and not several animal communities in the study area.

The trellis diagram of similarity coefficients may be made up so that the traps from the same habitats (debris, mountain pines, grassland) lie side by side, and then it is possible to find out whether such traps are conspicuous for similar species compositions of animals taken in them. The diagram of Fig. 5 shows that the coefficient between the traps from the same habitat was frequently lower than that between the traps from different habitats. For instance, traps D. 19 and G. 20 have more species in common than trap D. 19 has with other traps from debris and trap G. 20 with other traps from grassland.

The highest similarity coefficients are encountered between the traps within debris and between the traps from debris and grassland. Hence it may be inferred that the grassland and debris habitats differed least from each other. The coefficients expressing similarity between the four traps disposed over grassland and between those from debris and mountain pine habbitats are somewhat lower. The similarity coefficients between the three traps in

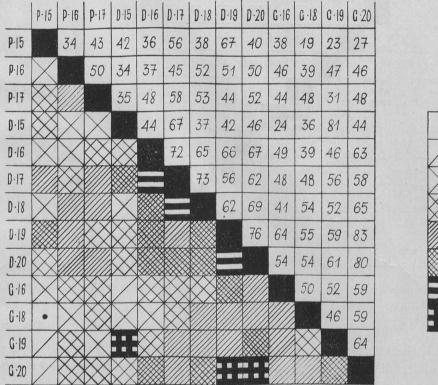




Fig. 5. Similarity coefficients calculated from the catches in one trap in each habitat at each locality during the year 1959. The values for particular traps are arranged according to habitats (debris, mountain pine association and grassland)

the mountain pine habitat are relatively low, while the grassland and mountain pine habitats have the fewest species in common.

The trellis diagram of similarity coefficients may be rearranged so that the traps from the same locality are placed side by side and the localities are set in the order of their altitudes. (Fig. 6). This arrangement permits the apprehension of the relation between the altitude and the species composition of a catch. If any such relation existed, the squares with the darkest shade should group along the diagonal of the diagram and those with the lightest shade in the left-hand bottom corner. As may be seen from the diagram, this is not the case, and therefore the species likeness between the catches in the traps laid out at the same locality or at localities situated near to each other is no

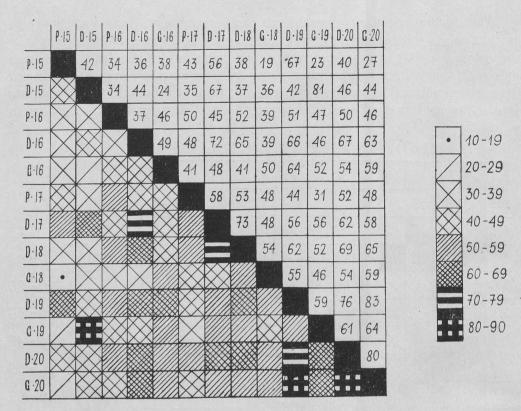


Fig. 6. Similarity coefficients calculated from the catches in one trap in each habitat at each locality during the year 1959. The values for particular traps are arranged according to altitude

greater than that between the catches at localities lying far from each other. It is difficult to distinguish any animal communities associated with the subalpine mountain pine zone or the alpine meadows zone.

# Seasonal Changes in the Composition and Abundance of Ground-Surface-Inhabiting Arthropods

Pardosa nigra (C. L. Koch)

The seasonal changes in the abundance of this species are illustrated in the graph (Fig. 7). The number of specimens caught in the debris habitat at all localities in 1959 varied considerably with time. The catch of the period including the end of May and the beginning of June (V/VI) was the smallest, only 14 individuals were taken jointly in all localities. In the next two weeks (VI) the catch amounted to 198 specimens, this being the peak of abundance. Then the number of these spiders in the traps decreased reaching the other

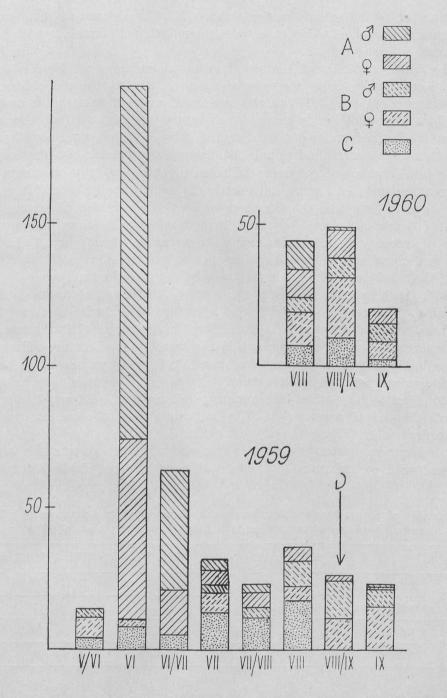


Fig. 7. Catches of Pardosa nigra (C. L. Koch) in debris at all localities taken together in particular trapping periods of 1959 and 1960. The histogram shows the numbers of mature (A), submature (B), and immature (C) individuals as well as those of males and females. The arrow indicates the time when a female with young individuals (D) was trapped

minimum of 26 individuals in September (IX). The decrease is not regular, which may be ascribed to the changes in the mobility of animals resulting from the weather changes.

The graph in Fig. 7 shows also the abundance of Pardosa nigra (C. L. Koch) in particular age categories (cf. p. 204). At the end of May and the beginning of June (V/VI) there was a small group of immature individuals (C) and a somewhat larger group of submature individuals (B) in the trans. In June (VI) the number of immature individuals (C) increased considerably. while that of submature individuals (B) dropped also remarkably. The increase in the total number of specimens collected at this time may be assigned to the great quantity of mature individuals (A), which appeared in this period. At the end of June and the beginning of July (VI/VII) the submature individuals (B) vanished completely, and in the traps there occurred only a small group of category C and a remarkably larger group of category A. In July (VII) the submature individuals (B) reappeared and from July (VII) to August (VIII) the specimens collected in the traps belonged to the three age categories (A. B. C), with category A being on the wane. At the end of August and the beginning of September (VIII/IX) the immature individuals (C) disappeared and females with their young (D) turned up. In September (IX) the members of categories A and B were present in the traps, the submature individuals (B) predominating over the mature ones (A). The abundance of particular age categories presented itself similarly in the last two months of trapping in 1960 (Fig. 7) except that the immature individuals (C) did not disappeared towards the end of August (VIII/IX) but subsisted to the end of trapping, i. e. to September (IX).

In order to complete the picture offered above the periods in which females appeared with cocoons must be taken into consideration (Table X).

Table X

Total number of mature females (A) and number of females with cocoons from all habitats and all localities taken together in particular trapping periods of 1959

		V/VI	VI	VI/VII	VII	VII/VIII	VIII	VIII/IX	IX
1959	total	_	63	16	5	5	5	4	3
	with cocoons			2 .	3	4	4	3	1
1960	total	×	×	×	×	×	10	10	2
	with cocoons	×	×	×	×	×	5	9	1

As will be seen from Table X, the females with cocoons appeared at the passage from June to July (VI/VII) and starting from July (VII) outnumbered the females without cocoons. In June and July the cocoons were light green in colour, at the end of August and in September they lost this coloration and became more grey.

 ${\bf Table~XI} \\ {\bf Seasonal~changes~in~the~abundance~of~\it Pardosa~\it nigra~(C.~L.~Koch)~trapped~in~stone~debris.} \\ {\bf The~table~shows~numbers~of~specimens~taken~at~each~locality~according~to~age~and~sex~categories} \\ {\bf Table~XI} \\ {\bf Table~XI} \\ {\bf Table~shows~numbers~of~specimens~taken~at~each~locality~according~to~age~and~sex~categories} \\ {\bf Table~XI} \\ {\bf Ta$ 

					19	959					1960		
Locality			15	16	17	18	19	20	N. 16	N. 18	N. 20	sw	NE
V/VI	A B C	70 07 FO 07	—   —   —   1	$egin{array}{c c} - & - \ 2 & 1 \ 1 & 1 \end{array}$			1 3 2	—   —   . 1   1	×	×	×	×	×
VI	A B C	4004 4004	3 1 — 1	58 28 - 1 2	14 10 —	6 6 - 1	26 12 — 1 3	17 6 — 2	×	×	×	×	×
VI/VII	A B C	70 04 70 04 04 70 04	2 2 - 1	18 4 —	9 2	1 3 - 1	6 2 - 2	6 3 - 1	×	×	×	×	×
VII	A B C	40 04 40 04	3 1 —	$\begin{array}{ c c }\hline 1\\1\\-\\2\\2\\\end{array}$			2 - 1 1 5	1 1 1 4 3	×	×	×	×	×
VII/VIII	A B C	10 07 10 07 10 07 10 07	2 2 1	1 1 1 - 5	1 1 -		1 1 - 2		×	×	×	×	×
VIII	A B C	1001 1007 ·	2 1 - 1	$\begin{array}{ c c }\hline 1\\3\\2\\9\end{array}$		1 2 -	1 2	1 2 - 7	1 - 1 3 -	2 4 — 1	1 — 1 3 1	5 · 3 · 2 · 3 · 2	1 3 1 3 - 3
VIII/IX	A B C	80000		1 5 7		1 1 1	4 2	2 1	2 6 2	2 1 1 2	1 - - 5 4	4 2 1 1	4 2 8 1
IX	A B C	40 04 40 04		2 4	1 - 1		1 1 5	—   1   1	2 2 2	1 1 1 —	——————————————————————————————————————	1 4 1	$\begin{bmatrix} -2 \\ -3 \\ 1 \end{bmatrix}$

The foregoing changes in the abundance of particular age categories were based on the trap catches from the debris habitat in all localities held in the given year. The changes in abundance are given separately for sex and age categories as well as for each locality in Table XI, which shows that these seasonal changes are alike for each locality. Locality 15, which in June (VI) did not show any increase in the number of mature specimens (A), this increase being characteristic of all the other localities, was an exception. As the number of specimens was very small, it was impossible to realize whether this happened by accident or owing to an actual cause.

Fig. 7 and Table XI do not include the data regarding the catches in the mountain pine and grassland habitats, these being presented in Table XII.

Table XII
Seasonal changes in the abundance of Pardosa nigra (C. L. Koch) collected in the mountain pine (P) and grassland (G) habitats, at all localities taken together, according to age and sex categories

			V/VI	VI	VI/VII	VII	VII/VIII	VIII	VIII/IX	IX
		3		1	1				_	
	A	9	_	_	_		-		1	_
P		3					1			<u></u>
	В	9	_	_		_	_	_	_	_
	C		_	_	- X			_		
		13		_	. 1	_				
	A	9	_	_	_	_	-		1	2
G	D	3	_	_	_		-		_	_
	В	9	1	_	1	_	_	-		. —
	C		2	3	2	1	2	, 1	3	1

The number of specimens caught in the mountain pine and grassland habitats was small, but even so it is apparent that these data agree with those obtained from debris except for the number of immature individuals (C) taken from grassland. In this habitat the individuals of category C form 71% of the total population, whereas in all the debris areas taken together they form hardly 11% (data for 1959). Moreover, immature individuals (C) subsisted in grassland up to the end of the study in September 1959, while in debris no specimen was caught in the last month of trapping.

It is difficult to establish the numerical relation of the sexes in particular developmental stages. The catches of submature individuals (B) were too small to permit any statement concerning this subject, the sex ratio fluctuated, and there was no distinct predominance of one sex over the other. As regards mature individuals (A), males prevailed evidently at all localities during the mating season. This prevalence was expressed by the ratios of 124:63 (approx.

2:1) in June (VI) and 42:16 (approx.  $2\cdot5:1$ ) towards the end of June and at the beginning of July (VI/VII), which was probably due to a greater agility of males and not to their larger number.

### Clubiona terrestris Westring

The seasonal changes in the abundance of this species in the debris, mountain pine, and grassland habitats are given in Table XIII.

Table XIII

Seasonal changes in the abundance of *Clubiona terrestris* Westring trapped in the debris (D), mountain pine (P), and grassland (G) habitats, at all localities taken together, according to age and sex categories

			V/VI	VI VI	VI/VII	VII	VII/VIII	VIII	VIII/IX	IX
						1959				
	A	<b>3</b> 9	3	2 1	1	6	1 1	8	3	1 2
D	В	300		_ -	_	_	2	<u> </u>	1	_:
	С					1	2	-	-	
	A	<b>7</b> 0 9	=	_	<u> </u>	_	1		1	— —
Р	В	₹ 2		_	_		_	1	_	_
	C				_	_				
	A	800	<u> </u>	_ _		_	1	_		_
G	В	<b>7</b> 0 9				_	_	_ 	_	_
	C				_	_				_
						1960				
	A	3 9	×	×	×	×	×	1		1
D	В	3 9	×	×	×	×	×	1		_
	C		×	×	. ×	×	×	1	-	_

The small number of individuals trapped makes it impossible to determine the variations of the number and age structure of *Clubiona terrestris* Westring with time. It may be stated on the basis of the data included in Table XIII

that immature individuals (C) were taken in July and August (VII, VIII/VIII, VIII), submature individuals (B) from the end of July to the beginning of September (VII/VIII, VIII, VIII/IX), and mature ones (A) all through the trapping period. However, it does not evidence that in the other periods there were no immature or submature individuals in the population.

Apart from the trap catches the females of *Clubiona terrestris* Westring together with their young ones, which might be reckoned in category D, were collected under stones. The young individuals were in cocoons attached to the lower parts of the debris stones. In all probability, they hatched from eggs not long before.

### Platybunus bucephalus C. L. Koch

The seasonal changes in the abundance of *Platybunus bucephalus* C. L. Koch are illustrated graphically in Fig. 8. In the traps disposed in debris these changes presented themselves as follows:

At the beginning of trapping, at the passage from May to June (V/VI), the traps took only immature individuals (B), which reached their numerical maximum just at that time. Then their number dropped gradually until they disappeared completely in July (VII). The mature individuals (A) turned up in the traps in small numbers at the end of June and the beginning of July (VI/VII), with their maximum in July (VII). In this period 195 mature individuals (A) were caught in the traps in the debris areas. The highest number of mature individuals was nearly five times as large as the maximum value for immature individuals. From July the abundance of mature individuals collected in the traps dwindled gradually to reach a minimum in the last trapping period, in September (IX). The second generation of immature individuals (B) appeared in a small number in the traps at the end of August and the beginning of September (VIII/IX) and subsisted to the end of trapping.

The data from 1960 indicate that the seasonal changes in that year do not differ much from those in the previous year. Thus, in the last months of trapping there was a gradual decrease in the number of mature individuals in the traps. No immature individuals of the second generation were taken, which may be ascribed either to their somewhat delayed appearance in this year or to their accidental avoiding of the traps.

The seasonal changes in the abundance of specimens in the traps exposed in the grassland association were like those in debris.

The problem of the considerably higher catches of this species in the mountain pine and grassland habitats in relation to the catches in the debris will not be discussed in this place. *Platybunus bucephalus* C. L. Koch had two abundance peaks in grassland, just as it had in debris, followed by a drop in the number of specimens trapped. And again as in debris, the maximum number of mature individuals (A) was nearly five times as large as the maximum number of immature ones (B).

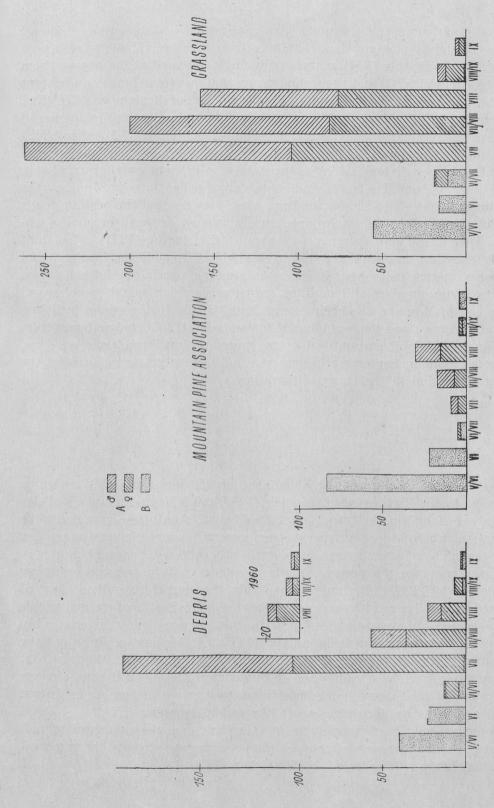


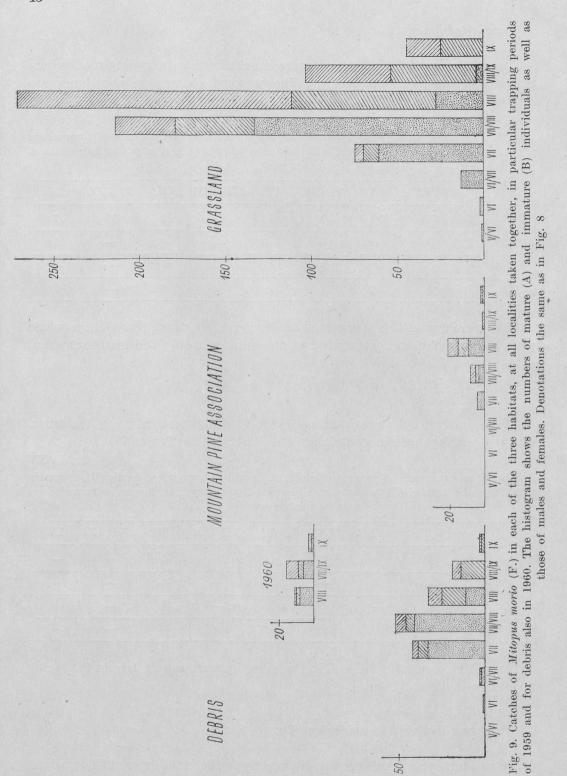
Fig. 8. Catches of Platybunus bucephalus C. L. Koch in each of the three haditats (debris, mountain pines, grassland), at all localities taken together, in particular trapping periods of 1959 and for debris also in 1960. The histogram shows the numbers of mature (A) and immature (B) individuals as well as those of males and females

The situation in the mountain pine association was somewhat different. As in the debris and grassland habitats, immature individuals were absent from the traps in July (VII), mature individuals appeared at the passage from June to July (VI/VII), and the second generation was to be found in the traps towards the end of August and at the beginning of September (VIII/IX). The immature individuals had an abundance peak also in the first period of trapping, at the end of May and the beginning of June (V/VI), after which their number dropped gradually. The seasonal changes in the abundance of mature individuals (A), however, took a different course from that in debris and grassland. The mature individuals appeared at the end of June and the beginning of July (VI/VII), but in July, when they reached the peak in debris and grassland, in the mountain pine association they occurred in small quantities. Then they were increasing in number till August (VIII), when (not in July) they had an abundance peak in this habitat. In addition, the maximum number of mature individuals in the mountain pine association did not exceed the maximum number of immature individuals, which might be observed at the end of May and the beginning of June (V/VI). In the period including the end of August and the beginning of September (VIII/IX) only a few mature individuals were still encountered in the traps in the Mughetum carpaticum, but none at all in September. There were only immature individuals of the second generation in the traps at that time.

## Mitopus morio (F.)

The seasonal changes in the abundance of *Mitopus morio* (F.) are given in Fig. 9. In the first period of trapping (V/VI and VI) small numbers of this species were found in the traps, none at all being taken in the mountain pine association, where also other species were generally caught in small numbers. Next the number of immature individuals (B) collected increased gradually reaching a peak in the period including the end of July and the beginning of August (VII/VIII). Beginning from July the immature individuals (B) matured gradually, passing over to category A. The first mature individuals (A) appeared at the passage from June to July, increased in number steadily and had an abundance peak in August (VIII). At the end of July and the beginning of August the immature individuals still prevailed in the traps but their number dwindled steadily and in September (IX) of 1959 none of them was caught at all. Mature individuals began to decrease in number in August (VIII) and went on decreasing up to the end of trapping (IX).

In the last months of trapping in 1960 the changes in the number of animals caught in the traps resembled those in the previous year except that immature individuals were still collected in September (IX).



### Nebria tatrica MILL.

Because only adult individuals were caught in traps, the data on the particular age categories are lacking. The seasonal changes in abundance are summarized in Table XIV.

Table XIV

Number of specimens of *Nebria tatrica* Mill. caught in traps in the debris (D), mountain pine (P) and grassland (G) habitats, at all localities taken together, in particular periods of trapping

	11	V/VI	VI	VI/VII	VII	VII/VIII	VIII	VIII/IX	IX
	D	27	55	9	114	21	2	10	7
1959	P	5	5	_			_		1
	G	2	1	1	1		1		
1960	D	×	×	l ×	×.	×	6		3

The members of this species were collected in the traps through the whole period of catching and occurred most numerously in July and least in autumn.

### Deltomerus tatricus MILL.

Analogously to the previous species only adults were taken in the traps. The seasonal changes in abundance are illustrated in Table XV.

Table XV

Number of specimens of *Deltomerus tatricus* MILL. caught in traps in the debris (D), mountain pine (P), and grassland (G) habitats, at all localities taken together, in particular periods of catching

		V/VI	VI	VI/VII	VII	VII/VIII	VIII	VIII/IX	IX
	D	4	15	1	14			-	_
1959	P		. —						
	G	4		1 .	. 1	1	1		
1960	D	×	×	×	×	×	_	<u>   - </u>	

As will be seen from Table XV, these beetles were caught late in the spring and early in the summer.

### Carabus silvestris transsylvanicus Dej.

Only adult specimens were caught, mainly in the traps exposed in grassland (Table XVI).

Table XVI

Number of specimens of *Carabus silvestris transsylvanicus* Dej. caught in traps in the debris (D), mountain pine (P), and grassland (G) habitats, at all localities taken together, in particular periods of catching

		V/VI	· VI	VI/VII	VII	VII/VIII	VIII	VIII/IX	IX
	D	_	1	_		-	_	_	_
1959	P	_	1.	_	_		_	_	
	G	7	14	7	3	9	4	2	1
1960	D	×	×	×	×	×		_	

The members of this species were taken in the traps through the whole period of catching and occurred most numerously in July (VII) and least in the autumn.

### Pterostichus morio Duft. .

Only adult specimens were trapped. The seasonal changes in abundance are presented in Table XVII.

Table XVII

Number of specimens of *Pterostichus morio* Duft. caught in traps in the debris (D), mountain pine (P), and grassland (G) habitats, at all localities taken together, in particular periods of trapping

		V/VI	VI	VI/VII	VII	VII/VIII	VIII	VIII/IX	IX
	D	1	4	3	2	1	3	_	_
1959	P		_		_		_		<u>.</u>
	G	3	3	3	4	3	13	8	_
1960	D	×	×	l ×	×	1 × 1	_	<u> </u>	

Table XVII shows that these beetles were found in the traps throughout the vegetation season except for September (IX).

The course of the seasonal changes in the abundance of all the species of ground-surface-inhabiting arthropods is illustrated in three graphs: one for stone debris (Fig. 10), one for mountain pine areas (Fig. 11) and one for grassland (Fig. 12).

It will be seen from the graphs that these changes in the abundance of all the ground-surface-inhabiting arthropods caught in the traps taken together varied from habitat to habitat. In debris most animals were taken early in the spring and late in the summer, while the catches at the end of June and the beginning of July (VI/VII) were comparatively small, which caused a deep indent in the curve. In grassland the most abundant catches were made in July and August, the number of specimens trapped in the re-

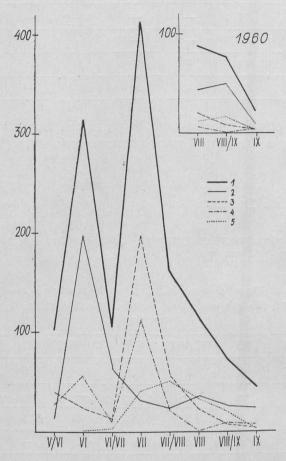


Fig. 10. Catches of all ground-surface-inhabiting arthropods in debris in particular trapping periods of 1959 and 1960. In addition to the number of all these arthropods taken together (1) the graph shows the numbers of the most numerous species: Pardosa nigra (C. L. Koch) (2), Platybunus bucephalus C. L. Koch (3), Nebria tatrica Mill. (4), and Mitopus morio (F.) (5)

maining periods being relatively small. In the places covered by mountain pines the seasonal fluctuations of abundance took an entirely different course: the largest catches were made in the spring, then the number of specimens dropped to rise again in August.

Table VI (p. 202) presents a list of all the species caught in the traps and consequently includes also those whose abundance has been shown in the graphs. The seasonal fluctuations of the numbers of several species most nu-

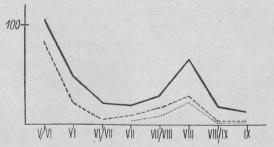


Fig. 11. Catches of all ground-surface-inhabiting arthropods in the mountain pine habitat in particular trapping periods of 1959. The graph shows also the numbers of two most numerous species: *Platybunus bucephalus* C. L. Koch (3) and *Mitopus morio* (F.) (5). Denotations the same as in Fig. 10

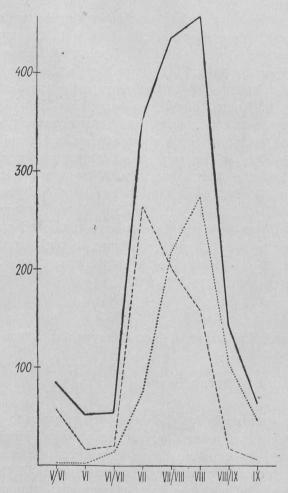


Fig. 12. Catches of all ground-surface-inhabiting arthropods in the grassland habitat in particular periods of 1959. The graph shows also the numbers of two most numerous species: Platybunus bucephalus C. L. Koch (3) and Mitopus morio (F.) (5). Denotations the same as in Fig. 10

merous in the given habitat are illustrated in the graphs as well. These data show evidently that the total number of animals caught in the traps in a given period depended for the most part upon the abundance of these most numerous species. The contribution of the remaining species was small.

The first abundance peak in debris was due to the high catches of the spider Pardosa nigra (C. L. Koch) in the mating season and relatively high catches of immature individuals of Platybunus bucephalus C. L. Koch. The other peak was connected with a rise in the number of mature specimens of Platybunus bucephalus C. L. Koch and Nebria tatrica Mill.

The abundance curve for the mountain pine association is governed by the changes in the population of the harvestman *Platybunus bucephalus* C. L. Koch, which was the most numerous species in this habitat. The other harvestman *Mitopus morio* (F.), increasing in number in August, also plays some role. Similarly, in the grassland association the fluctuation of the numbers of all animals caught depends upon the changes in the number of the two harvestmen, *Platybunus bucephalus* C. L. Koch and *Mitopus morio* (F.).

The graphs (Figs. 10, 11 and 12) show clearly that the abundance peaks, probably connected with the mating seasons in the three commonest species, Pardosa nigra (C. L. Koch), Platybunus bucephalus C. L. Koch and Mitopus morio (F.), did not occur at the same time but successively, one after another. June (VI) was the period of the highest catches of the spider Pardosa nigra (C. L. Koch), July (VII) of the harvestman Platybunus bucephalus C. L. Koch, and August (VIII) of the other harvestman Mitopus morio (F.). The abundance peak of the beetle Nebria tatrica Mill. fell in July (VII), the period in which Platybunus bucephalus (C. L. Koch) was also collected in large numbers. However, the beetle differs from the three above-mentioned species in its ways of life. Nebria tatrica Mill. probably belongs to night species; it was never observed on the surface of debris in the daytime, contrary to the three other species, which were seen there frequently.

# Results of Additional Catches and Observations on the Fauna of the Study Area

Trap Catches of Flying Insects

These catches were made for the most part in order to find out what the predatory invertebrates (spiders, harvestmen, beetles) inhabiting debris feed on. The traps used for catching flying insects have been already described in the section on the study methods. It remains to add that

1. the surface coated with the resinous compound amounted to 70 sq. cm. in each trap,

2. the compound used to coat the traps was green in colour, and so the trap surface did not differ from the stone faces of the debris in appearance,

- 3. the compound had no properties attracting small flying insects, and because of that it may be assumed that insects alighted over the whole area of the debris as frequently as on the surface coated with the compound,
- 4. the insects caught by means of the compound were generally spoiled and deformed so that it was impossible to identify them, and
- 5. the catches by means of this kind of traps were carried out from the end of June (VI/VII) to the first days of September (VIII/IX).

The great majority of the insects caught were *Diptera*. As a rule, all the insects trapped might be taken as food by spiders and other predatory invertebrates. The results of the catches are summarized in Table XVIII.

Table XVIII

Number of flying insects caught on one greased trap placed in debris at each locality in particular trapping periods

Locality	15	.16	17	18	19	20	Total
VI/VII	44	35	82	62	55	312	590
VII	32	40	22	34	26	119	273
VII/VIII	31	42	40	20	27	62	222
VIII	74	60	36	61	50	137	418
VIII/IX	21	43	38	22	51	98	273
Totals	202	220	218	199	209	728	1776

The number of insects caught in particular trapping periods was very variable, probably depending on the weather, while the numbers of specimens taken at particular localities were nearly the same except for locality 20, which all the time produced about three times as many individuals as any of the remaining localities. It may have been connected with the slope aspect, which was here most deviated from the north.

In general, the catches were fairly abundant at all localities, suggesting that flying insects often rest in debris and may well constitute food for spiders, harvestmen, and predatory beetles associated with debris.

# Web-Spinning Spiders in Debris

In addition to animals moving on the surface of debris caught in the Barbes traps and flying insects caught on the greased traps, web-spinning spider occurred occasionally in the debris. They were caught and identified.

In the course of two years' studies 14 individuals of web-spinning spiders were observed and caught on their webs spread among stones of debris. They were all caught in the debris areas adjacent to locality 15, whereas at the other localities no web-spinning spiders were found in spite of long searches.

All the spiders caught belonged to the species Araneus diadematus CL.: 8 of them were females, the remaining ones were immature without well-developed copulatory organs. The immature individuals were encountered in debris in May and in August, the mature ones in July and August.

The occurrence of the spider Araneus diadematus CL. only near locality 15 may be explained by that the debris in this place was composed of very big rock fragments suitable for spreading webs among them. This debris area was surrounded by fields of mountain pines and situated low, within a short distance of the timber line. It was thus protected against gusty winds, which might have destroyed the cobwebs. The remaining debris areas were of small, more mobile rock fragments or were situated considerably higher.

#### DISCUSSION

### Influence of Altitude upon the Distribution and Abundance of Animals

All the differences between the lowland and the mountain or high-mountain environments result from two principal factors: (1) altitude and (2) configuration of the region.

A rise in altitude is followed by a drop in atmospheric pressure and temperature (except for periods of temperature inversion), a rise in radiation intensity (especially within the range of ultra-violet rays), and an increase in air humidity as well as in wind force.

The configuration of an area includes first of all such elements as the inclination of slopes, the elevation of summits in relation to the mountain base, and the aspect of slopes. The inclination of slopes affects the intensity of denudation and, in consequence, the thickness of the soil layer. The wind force, cloudiness, and rainfall depend to a great extent upon the elevation, while the aspect of slopes influences the temperature and air humidity.

The species composition and abundance of animals in a given place may result both from a direct action of the physical factors of the environment and from the action of different physical and biotic factors accompanying the occurrence of specific plant associations in this place. The problems of the action of the physical factors of the environment dependent upon the configuration of the area and the influence of the plant cover on the abundance and distribution of animals will be omitted here in order to discuss the effect of the physical factors connected with altitude.

It is difficult to distinguish the direct action of the physical factors connected with altitude on the distribution and abundance of animals, because changes in altitude are followed by floral changes, and there are only few places in which the same plant associations occur at various altitudes. For this reason the present study was carried out in the region with an elevation range of 500 m. only. Nevertheless the study area included the whole mountain

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pine zone and more than the half of the alpine meadows zone. In the Tatra Mts. this elevation range renders it possible to observe great differences in floral composition and the degree in which the surface of the ground is covered by various plant species. These differences are clearly visible in the extent of the mountain pine cover on the northern slopes of Zółta Turnia.

It is well known from many faunistic studies on the Tatra region (Łomnicki, 1868; Kulczyński, 1881) how great the differences in the species composition and even in the number of species are between the particular vegetation zones. It is to some extent an open problem whether these differences should be attributed only to the occurrence of some definite plant associations, or whether they result from the action of the physical factors of environment connected with altitude upon the fauna.

However small were the differences in altitude between the trapping localities, had this direct action of the physical factors connected with altitude really influenced the abundance of animals, at least some changes in the number of species taken at various altitudes or those in the number of individuals of the most abundant species should have been visible.

The present study shows that the number of specimens neither increases nor decreases with altitude in any of the three habitats (debris, mountain pines, grassland) (Table IX, p. 213). For this reason the differences in the numbers of animal species encountered in particular vegetation zones should be ascribed to the influence of the plant cover and not to the physical factors associated with altitude.

An analysis of the abundance of the species occurring in the largest numbers in the traps indicates that there is some correlation between the number of animals caught and the altitude as regards the spider Clubiona terrestris WE-STRING, the harvestman Mitopus morio (F.), and the beetle Pterostichus morio DUFT. The catches of the spider Clubiona terrestris Westring in debris (Table VII, p. 208) were higher at localities 15, 16, and 17 than at localities 18, 19, and 20. This may be, however, explained by the lack of mountain pine fields, with which this spider is associated and in which it occurs in larger numbers than in any other habitats, at the higher localities. The harvestman Mitopus morio (F.) (Table VII, p. 208) was collected in large numbers in debris at localities 16, 17, 18, and 20, and in comparatively small numbers at localities 15 and 17. However, rich catches of this species were not connected with altitude but with occurrence of grassland in the close neighbourhood of the debris area. It remains to consider the problem whether altitude directly affects the distribution and abundance of the beetle Pterostichus morio DUFT. (Table VII, p. 208). Unluckily, the number of individuals of this beetle was too small to make any far-reaching conclusions possible and the facts so far observed may be dependent upon altitude as well as the influence of plant

The distribution of the garden spider Araneus diadematus CL. over the debris area offers another problem. This species occurred in debris only at

locality 15 and was never found in this habitat in any higher-situated place. Such a distribution was due to the small force of the wind and the small mobility of debris at locality 15 as compared with the higher localities. It might be supposed that in this case there existed a direct action of the physical factors connected with altitude (wind force) upon the distribution of the species. However, a close analysis shows that the wind force at locality 15 and the small mobility of debris resulted from the nearness of the timber line and the occurrence of exuberant fields of mountain pines in the close vicinity of the debris area. Therefore, even in this case the distribution of the garden spider must be attributed to the nature of the plant cover and not to the direct action of the physical factors connected with altitude.

Summing up these considerations I must state that no marked influence of the physical factors connected directly with altitude upon the distribution and abundance of ground-surface-inhabiting arthropods was found in the region above the timber line with an altitude range of 1500—2000 m. above sea-level.

# Influence of Slope Aspect upon the Distribution and Abundance of Animals

The following data obtained during the study are available for establishing the influence, if there was any, of the slope aspect upon the distribution and abundance of the fauna: (1) trap catches of 1959, when the particular localities differed more or less in the aspect of the slopes on which they were situated and (2) trap catches at localities NE and SW laid down especially for this purpose in 1960.

The only method that may be applied to establish this influence is to find out which localities differ most in slope aspect and next to compare the trap catches with these topographic features of the localities. The graphic presentation of the aspects and inclinations of slopes (Fig. 13) will greatly facilitate this action. As a rule, all the localities were on the northern slopes more or less deviating from the exact north direction. These deviations were the greatest at localities 15 and 20, and the smallest at locality 19 (Table III, p. 192, Fig. 17). Thus the greatest differences in the species composition and abundance of animals trapped should be found between these localities.

The number of species caught at the particular localities (Table IX, p. 213) is in no relation to the aspect of the locality. The same is true of the total number of individuals caught at each of the localities. In this case the number of individuals was really the largest at locality 20 most deviated from the north, but locality 19 with the smallest deviation came in second as far as the number of specimens was concerned. At an analysis of the number of individuals of the most abundant species trapped in debris (Table VII, p. 208) as well as in the other habitats (Fig. 2) it is difficult to discover any relations between the abundance of animals caught and the aspect of the slope.

It must be stated by way of recapitulation that the study carried out in 1959 did not provide any positive evidence of the influence of the physical factors connected with the slope aspect upon the composition and abundance of the fauna of ground-surface-inhabiting arthropods. But it must also be kept in mind that the localities differed very little in this respect, all of them being as a rule on the northern slope. However, it is possible that even these small differences had some bearing on the abundance and composition of the

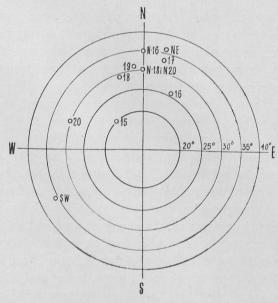


Fig. 13. Aspect and inclination of slopes at particular trapping localities

fauna, but the localities differed — in addition to the aspect of slopes — in altitude, nature of substratum, and a number of other features. The abundance and composition may be the resultants of all these factors and it is impossible to distinguish the influence of the aspect alone.

The catches in debris at localities SW and NE were somewhat different in character. These localities were about 100 m. away from each other, surrounded by the same plant associations, lying at the same altitude and characterized by the same type of debris. They differed only in slope aspect. Trapping was carried out here from August till September (VIII, VIII/IX, IX), but unhappily it did not produce very rich material. On the basis of the data obtained (Fig. 4) it may be ascertained that there were no marked differences between localities SW and NE. The species occurring in the largest numbers, Pardosa nigra (C. L. Koch), Platybunus bucephalus C. L. Koch, and Mitopus morio (F.), were trapped at both localities and their catches little differed in size. The only difference between the two localities was the occurrence of the beetle Nebria tatrica Mill. at locality NE and its lack at locality SW and, on the contrary, the occurrence of the spider Clubiona terrestris Westring

at locality SW, while it was lacking at the other locality. If the material were more abundant, it might be supposed that *Nebria tatrica Mill*. is associated with the northern slopes and *Clubiona terrestris Westring* with the southern. But the latter was collected at localities 19 and 17 (Fig. 7), which had the same aspect as locality NE, in the same period in 1959, and *Nebria tatrica Mill*. was caught at locality 20, considerably deviated from the north. Thus, there are no sufficient reasons to claim that the occurrence of these species is connected with the slope aspect.

It must be, however, noted that the aspect of small areas (up to 50 m.) was assumed to be the aspect of the whole slope, without taking into account the situation of this area within the whole of the slope and the aspect of the whole slope. It is clear that the environmental conditions on the northern slope of a small culmination, which itself lies on the southern slope of a mountain, are different from those on the northern slope of the mountain. The differences in slope aspect between the trapping localities did not result from their being situated on various slopes of a mountain or massif, because they all were on the northern slopes of Zółta Turnia. No great differences might be found between localities SW and NE, because they both lay a short distance from one another and undoubtedly there existed an exchange of air between them. The animals occurring at one locality might easily move over to the other. Owing to this the results of the study carried out at these localities are not conclusive enough to make the evaluation of the influence of the slope aspect upon the composition and abundance of the fauna possible.

To conclude these considerations it must be stated that the differences in slope aspect between particular localities did not refer to the whole slope but to its small sections. The material obtained by trapping presents no grounds to suppose that there is a dependence of the species composition and abundance of animals upon the aspect of the place in which the catches were made.

# Influence of Plant Cover Upon the Distribution and Abundance of Animals

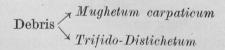
The foregoing considerations show that the altitude and slope aspect do not exert any marked influence upon the qualitative and quantitative composition of the fauna trapped at particular localities. The differences found between the localities were too small to suggest the existance of an influence exercised by the physical factors of environment connected with their situation. On the basis of the data obtained one can, however, find apparent differences between the trap catches in the debris, mountain pine, and grassland habitats, i. e., the differences resulting from the nature of the plant cover of the study area.

Phytosociologically, the mountain pines and grasses among which the traps were placed out formed the *Mughetum carpaticum* association and the

Trifido-Distichetum respectively. However, considering the animals inhabiting the areas covered by these associations, the differences between the Mughetum carpaticum and the Trifido-Distichetum are greater than, for instance, those between the Trifido-Distichetum and any other grassland association. For this reason the differences between the Mughetum carpaticum and the Trifido-Distichetum cannot be generalized as differences between plant associations treated as phytosociological units.

From the point of view of phytosociology debris cannot be compared with plant associations, because only lichens occur over its area and no seed plant associations. Nevertheless, in this study debris is compared with the mountain pine and grassland associations in the aspect of the influence exerted by the plant cover on the fauna, because the environment produced by debris just results from the lack of a plant cover.

Considering the plant cover of the study area one can distinguish two succession series coming from debris as their initial stage:



Comparing the animal communities of the three habitats one may observe the course of the succession of these communities on the ground of the succession of plant associations. The encroachment of the *Mughetum carpaticum* upon the debris areas was thus observed at localities 15, 16, and 17, while the *Trifido-Distichetum* was overgrowing them at localities 18, 19 and 20.

From the viewpoint of the requirements of the ground-surface-inhabiting arthropods living in the debris, *Mughetum carpaticum*, and *Trifido-Distichetum* habitats, these habitats may be characterized as follows:

The debris areas are devoid of seed plants constituting the basis for food chains and consequently the predatory arthropods feed on animals coming from adjacent territories covered by grass and mountain pines. Shelter is scarce in debris, the animals can hide only on the bottom faces of stones and in gaps between stones, but the mobility of stones creates an additional dange to small arthropods. The debris area being open, the animals are exposed to intense sun radiation, may be easily washed off the surface during heavy showers and are well visible to predators. In debris, stones keep by far less water than the soil layer in areas covered by vegetation. Air humidity is here low and diurnal range of air and stone temperatures wide. Also the action of winds is stronger on the surface of debris with no vegetation to protect it.

The conditions in the mountain pine bushes are entirely different. The populations of herbivorous animals inhabiting the litter as well as the branches of mountain pines are abundant enough to form the basis for food chains. The surface of litter is protected by the branches of mountain pines against predators, sun radiation, strong winds, etc. The fields of mountain pines retain large amounts of water, securing a considerably higher air humidity than in

debris areas and diminishing the amplitude of temperature fluctuations. It must be mentioned that in the study area mountain pines occurred in the subassocission of *Mughetum carpactium silcicolum*, which is composed of a small number of plant species. The ground surface under branches was covered mostly by fallen needles only, and therefore formed a habitat in some respect considerably poorer than the grassland association.

The grassland association differs from the *Mughetum carpaticum* in that its surface is remarkably more disclosed, its composition includes a larger number of plant species, and it lacks a thick layer of litter.

The data indicating the influence of the plant cover upon the abundance and distribution of ground-surface-inhabiting arthropods, obtained from the trap catches, are as follows:

- (1) the relatively small number of all arthropod species caught in stone debris as compared with the size of catches in the other habitats (p. 213),
- (2) the differences in the numbers of all arthropods trapped between the debris, mountain pine, and grassland habitats (p. 213),
- (3) the quantitative differences between the debris, mountain pine, and grassland habitats in the catches of the following species: Pardosa n gra (C. L. Koch), Clubiona terrestris Westring, Platybunus bucephalus C. L. Koch, Mitopus morio (F.), Nebria tatrica Mill., Deltomerus tatricus Mill., Carabus silvestris transsylvanicus Dej., and Pterostichus morio Duft., that is to say, of all species that were caught in sufficiently large numbers to show these differences (pp. 208—212),
- (4) the dependence of the number of individuals of the species *Mitopus* morio (F.) taken in debris upon the various plant associations (mountain pines, grassland) surrounding the debris area (p. 211),
- (5) the differences in the numbers of mature and immature individuals of the species *Platybunus bucephalus* С. L. Koch and *Pardosa nigra* (С. L. Koch) collected in various habitats (pp. 210 and 208),
- (6) the differences in seasonal changes in the abundance of all animals caught between the debris, mountain pines, and grassland habitats (pp. 227—228), and
- (7) the differences in changes in the abundance of the harvestman *Platybunus bucephalus* C. L. Koch with time between the mountain pine and grassland habitats (pp. 222—224).

All these data entitle us to state that the plant cover plays an essential role in the distribution and abundance of ground-surface-inhabiting arthropods above the timber line. Although the application of the CZEKANOWSKI-KUL-CZYŃSKI method (pp. 214—215) showed that it was impossible to distinguish three animal communities corresponding to the three habitats (debris, mountain pines, and grassland), and that the whole area above the timber line was occupied by one community, at a close analysis a number of differences connected with the existence of the three habitats could be found in the abundance of particular species and in the nature of the whole community.

As has been stated previously, there is no evidence of a relation between the distribution and abundance of animals and the altitude in the area between 1500 m and 2000 m. Consequently all these differences in the species composition and abundance of the fauna at various altitudes must be attributed, at least within such a narrow altitude range as that in the Tatra Mts., to vegetation zonation and not to physical factors directly connected with altitude.

### Seasonal Changes in the Community of Ground-Surface-Inhabiting Arthropods Above the Timber Line

Most of faunistic and ecological studies of various kinds coincide in the Tatra Mts. in July and August. As a result, there are only few data concerning the seasonal changes in the species composition and abundance of animals in the Tatra zoological literature. The purpose of this study, which covers the course of changes in the community of ground-surface-inhabiting arthropods through the whole vegetation period, is to fill this gap in part.

On the basis of the data obtained from the trap catches it is possible to establish the life-history as well as the causes of specific quantitative fluctuations of the catches in the course of time for three species, *Pardosa nigra* (C. L. Koch), *Platybunus bucephalus* C. L. Koch, and *Mitopus morio* (F.).

The young spiders (D) of the species Pardosa nigra (C. L. Koch) (pp. 216— 221) leave their cocoons in August or later. It is difficult to determine the time exactly, because one female with the young was trapped in the period including the end of August and the beginning of September (VIII/IX), while other females still with cocoons were encountered in September (IX). The further story of the young individuals (D) is unknown, as they did not fall into the pitfalls, unless together with females, and were not met on stones in the debris areas. On the other hand, it was difficult to distinguish them from many other spider species in the grassland and mountain pine habitats. Immature individuals (C) turned up in the traps in May. They were the last year's young (D), though they may as well have been the young from before two or more years. Therefore they were at least 7 months old. Starting from July up to the end of the trapping, in September; the members of this category (C) passed over to the category of submature individuals (B). That the submature individuals (B) taken in the traps in July were not of the same group as the analogous specimens caught in May and June was indicated by the differences in their developmental stages and the fact that the latter individuals vanished completely in the traps at the end of June and the beginning of July (VI/VII).

What is the further story of the spiders that in the period from July to the arrival of winter underwent development and passed from category C to category B as submature individuals? The available data show that they will winter as such to appear in the traps with young individuals (D), one year younger that they, in the period covering the end of May and the beginnine of June. They mature fully at the beginning of June. In June the percentagg of submature individuals (B) is very small, whereas the mature individuals form the vast majority of the population. The large amount of mature individuals caught in the traps in June (VI, VI/VII) was due, especially as regards males, to their great agility as compared with that of immature specimens, this being probably connected with the mating season. Then, the number of mature spiders dropped, which must be ascribed to a decline in their agility after the mating season and the gradual dying away of this category. As the absence of mature individuals (A) from the traps at the passage from May to June (V/VI) indicates, they do not last out the third winter.

The results of this analysis are presented in Fig. 14 illustrating the trap catches separately for the one-year- and two-year-old spiders of the species  $Pardosa\ nigra\ (C.\ L.\ Koch)$ . The data are the same as in Fig. 7.

Therefore, assuming that the immature individuals (C) occurring in the traps in May hatched from the cocoons in the preceding year, which is most probable, the life cycle of *Pardosa nigra* (C. L. Koch) lasts two years. The analysis is made difficult by the fact that the abundance of animals in the traps expresses not only the abundance of the population but also the agility of its members. Thus, for instance, the mature spiders (A) occurring in large numbers in the traps in June (VI) were the continuation of the group of submature individuals (B) trapped in considerably smaller numbers two weeks earlier.

Unluckily, the pattern of seasonal changes in the populations of Pardosa nigra (C. L. Koch) of other regions is not known. The variations of the abundance of this species with time can be compared with those of the related species Trochosa terricola Thorell collected in pine woods in the Częstochowa region (Łuczak, 1953). There this species was caught in Barber traps from April to December. Its life cycle is unknown; however, it was observed that the changes in the total numbers of individuals ran similarly to those in Pardosa nigra (C. L. Koch). The highest catches of Trochosa terricola Thorell were made in April, at the beginning of trapping. Then the number decreased to a half or a third of its value and finally no specimen was taken in November. The course of quantitative changes in Pardosa nigra (C. L. Koch) was similar except that the abundance peak was reached remarkably later, in June, and the first snow, occurring in the Tatra Mts. as early as the end of September or in October, rendered the continuation of trapping impossible, and so October must be assumed to be the period of the final disappearance of this spider in the traps.

• It will be seen from this comparison that the differences between the species *Pardosa nigra* (C. L. Koch) from the Tatras and the species *Trochosa terricola* Thorell from a lowland pine forest are due to climatic differences, i. e. to the duration of the vegetation period, which in the Tatras is for these spiders three months shorter.

The life cycle of the harvestman *Platybunus bucephalus* C. L. Koch, established on the basis of the data obtained from the trap catches (pp. 222—224) is as follows:

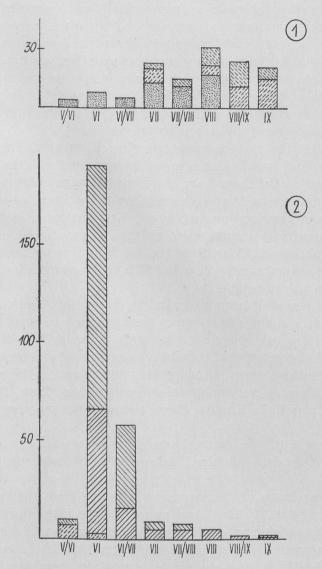


Fig. 14. Catches of Pardosa nigra (C. L. Koch) in debris in particular trapping periods of 1959 showing the division into one-year-old (1) and two-year-old (2) individuals. Data and denotations the same as in Fig. 7

Young individuals hatch in summer and appear in the traps at the end of August and the beginning of September (VIII/IX) as immature specimens (B). ŠELHAVÝ (1956) claims that they hatch from the eggs laid by females one month earlier. Their arrival may be delayed as indicated by the lack of immature spiders (B) in the debris area in September 1960. However, this is not

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quite certain, because only few specimens were trapped in debris late in the summer of 1959, and so their lack in the traps in the next year may have been by accident.

These harvestmen hibernate as immature (B) and appear in large numbers all over the three habitats in the next year, being most numerous in the *Mughetum carpaticum* association. There follows a gradual decrease in their number, which may be due to the reduction of their population, resulting from the high mortality rate and from a decline in their agility before maturation. The last takes place at the end of June and the beginning of July (VI/VII). At this time the harvestmen leave the mountain pine habitat and pass on to the more open areas covered by debris or grasses.

In July (VII) the mature harvestmen reach an abundance peak in the debris and grassland areas, which is probably connected with the mating season. The same reason makes them leave the mountain pine habitat for debris and grassland. From July to August the number of specimens taken in the traps in the debris and grassland areas falls off. It is distinctive that this decrease in number is much more rapid in debris than in grassland. After mating the harvestmen probably withdraw from the debris and partly from the grassland to return to the mountain pine areas. This fact accounts for a rise in their number in the last association.

In the final period of trapping including the end of August and September (VIII/IX, IX) the mature harvestmen were trapped in small numbers. This may have been due to a decline in their agility caused by a fall in the temperature and the completion of copulation, or to the high mortality rate. Since no mature individuals were encountered in the traps in the spring, it must be taken that they do not survive the second winter. Thus, the species *Platybunus bucephalus* C. L. Koch is characterized by a one-year developmental cycle.

The life cycle of the harvestman *Mitopus morio* (F.) established on the basis of the data obtained from the trap catches (p. 224) is as follows:

In the spring immature harvestmen (B) hatch from the eggs laid in the preceding year (Šilhavý, 1956) and appear in the traps towards the end of May and at the beginning of June (V/VI). Their quantitative fluctuations during the maturation period distinguish them from the species *Platybunus bucephalus* C. L. Koch. The maturation period is very short in *Platybunus bucephalus* C. L. Koch: all the immature individuals (B) passed over to the category of mature harvestmen (A) within two weeks. In *Mitopus morio* (F.) this period extends over three months, from July till September. This proves that the particular individuals of the population differ from each other in stage of development. As the members of category B mature, their number in the traps increases, which is contrary to what was observed in the case of *Platybunus bucephalus* C. L. Koch. They reach the peak abundance just before maturation. The number of mature individuals trapped does not differ greatly

from the number of immature ones from which they originated, which suggests that there are no differences in degree of agility between these two categories. The mating season directly follows the period of maturation and extends over August and the beginning of September (VIII, VIII/IX). Some specimens with exposed copulatory organs were caught at that time. It is mating that accounts for the great abundance of specimens trapped then.

The data concerning the life cycle of these two harvestmen reported by Šilhavý (1956) from Czechoslovakia and those presented for *Mitcpus morio* (F.) by Todd (1949) from England agree, as a rule, with the data obtained in the course of this study. There are, therefore, no grounds to suppose that the life cycle of the harvestmen above the timber line differs from that of the lowland populations of these species.

It is much more difficult to establish the life-history of the remaining species on the basis of the trap catches because of the scarcity of specimens caught or, in the case of insects, because no larvae were taken and the mature individuals could not be classified in the various age categories.

The following life cycle may be assumed for the spider Clubiona terrestris Westring (pp. 221—222), though with reserve, as the available data are unsufficient. Young individuals hatch from eggs in spring and are trapped in debris as immature specimens (C) as early as July. From the end of July to mid-August they develop and pass to the category of submature individuals (B). They mature fully late in the summer or in the autumn, and in the next year live as mature spiders (A). The time of mating could not be determined, there being no data on this subject. Generally speaking, this species has a two-year cycle of development similarly to Pardosa nigra (C. L. Koch).

Too scanty data have been gathered to establish the life cycle of the other arthropod species.

The causes producing specific variations of the total number of the community of ground-surface-inhabiting arthropods with time (pp. 227—230) must be looked for in the fluctuations of the numbers of several most numerous populations that make up this community. The changes in the abundance of the particular species may be explained to a great extent by the life cycle of these species, the ratio between the mature and the immature individuals, the course of copulation, etc.

The course of the life cycle is undoubtedly influenced by the physical factors of the environment occurring during the year, especially those connected with the duration of the vegetation season, the presence of snow cover, etc. Nevertheless, the life cycles of the species, and, consequently, the changes in their abundance and activity are relatively independent of the direct action of temperature, humidity and insolation.

The period when the fauna of ground-surface-inhabiting arthropods are active lasts above the timber line for five months at most. At the end of May the trap catches are still very scanty and in mid-September they already

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diminish considerably. The most intense activity of ground-surface-inhabiting arthropods takes place in June, July, and August. The mountain pine association, where the snow disappears somewhat earlier and the abundance peak is reached by the immature harvestmen of the species  $Platybunus\ bucephalus\ C.\ L.\ Koch in the period including the end of May and the beginning of June (V/VI), may be an exception.$ 

# The Community of Ground-Surface-Inhabiting Arthropods as a Component of the Biocenosis of the Region Above the Timber Line

It may be assumed that the world of living organisms inhabiting the region above the timber line forms a biocenosis, according to the definition put forward by Möbius (1877), or a community of Allee et al. (1949). Its range and the degree of its independence of the neighbouring biocenoses (communities) will not be discussed in this place owing to a lack of sufficiently numerous data. The biocenosis includes a large number of animal species living in the thin layer of soil, the litter of the mountain pine association, the turf of grassland, on the branches of mountain pines, among stones of debris, and flying in the air.

The method used (BARBER traps) determined which of the species were taken and put under study. They were arthropods moving on the surface of the ground, particularly those moving fairly fast, because only such species were trapped in large numbers. These conditions were fulfilled chiefly by predatory arthropods, which sweep all over the ground in search of a prey. The animals living in the litter of the mountain pine association, in the soil layer of grassland, and in the upper layers of vegetation, as well as the sluggish herbivores were not trapped at all or were taken in very small numbers. Since the animals caught in the traps were characterized by some common features concerning their manner of moving and hunting, they may be treated not only as a group distinguished by the method applied but also as an ecological group, which in this study has been called the community of ground-surface-inhabiting arthropods.

The community of ground-surface-inhabiting arthropods is bound to the biocenosis by many diverse relations. The dependence of the animal community upon plant cover has been already discussed. It is difficult to establish to what extent this dependence is direct (microclimate of plant associations, shelter for ground-surface-inhabiting arthropods) or indirect (trophic relations). Out of the herbivores that could serve as food for ground surface-inhabiting predatory arthropods the *Apterygota* and *Diptera* occurred in the greatest numbers above the timber line. Moreover, some species of predatory arthropods may be taken as food by other species; it may be therefore assumed that there are several feeding levels within the community of these arthropods. In addition, ground-surface-inhabiting arthropods themselves fall victims to screws (*Sorex* 

minutus L.) and insectivorous birds, appearing in large numbers above the timber line.

The mountain pine and grassland associations are probably self sufficing, while the debris areas are wanting in seed plants and no herbivores will be seen on lichens. This suggests that the fauna of predatory arthropods occurring in debris is dependent on the neighbouring territories covered by grass and fields of mountain pines. Of the ground-surface-inhabiting arthropods Pardosa nigra (C. L. Koch) and Nebria tatrica Mill. are associated with debris. The remaining species, occurring in debris in very small numbers as compared with the mountain pine and grassland habitats may be temporal migrants from other habitats. It may well be that some members of these species are associated with debris permanently. Though seed plants are wanting, the debris area may swarm with flying insects, mainly the Diptera, and a few of the Apterygota. They are migrants from the adjacent areas and form the basis of food chains for the fauna inhabiting the debris areas.

The ground-surface-inhabiting arthropods above the timber line form one community (pp. 214—216). The acknowledgement of this fact is a convention based on the application of the CZEKANOWSKI-KULCZYŃSKI method. If this method were used to distinguish plant associations, it would appear that at least three such associations may be made out within the study area and far more associations are recognizable in other similar areas. This is an evidence that the plant cover above the timber line is considerably more differentiated than the community of ground-surface-inhabiting arthropods of this region. This lack of differentiation characterizes also the vegetation zones, that is to say, no separate communities of ground-surface-inhabiting arthropods corresponding to the particular vegetation zones can be distinguished over the whole area above the timber line. The only differences to be noted are those in abundance of particular species. They are connected with the plant cover of the area and have been discussed above in details.

### SUMMARY

- 1. A total of 3468 arthropods of 61 species were caught in the traps within an altitude range of 1500—2000 m. a. s. l. on the northern slopes of Zółta Turnia (Tatra Mts.) during two successive years. The method applied determined that they were arthropods living on the surface of the ground.
- 2. One community of ground-surface-inhabiting arthropods was distinguished in this region by the CZEKANOWSKI-KULCZYŃSKI method. No differences in species composition allowing the distinction of any more communities were found between the trapping localities disposed at various altitudes and between three different habitats (stone debris, mountain pine association, and grassland).
- 3. Seasonal fluctuations in abundance of the whole community and of the populations of its most numerous species as well as the life cycles of the

species Pardosa nigra (C. L. Koch), Platybunus bucephalus C. L. Koch, and Mitopus morio (F.) were established.

- 4. No differences in the species composition and abundance of ground-surface-inhabiting arthropods which might be attributed to a direct influence of the physical factors of environment connected with altitude and slope aspect were found between the trapping localities at different altitudes.
- 5. It was established that the number of the species taken in the traps, the numerical abundance of individuals of these species, and the seasonal fluctuations within the community are dependent upon the nature of plant cover. Out of the numerous factors of the exterior environment the vegetation exerts the greatest influence upon the differentiation of the community.
- 6. It may be inferred from the available data that the faunal differences within the vegetation zones, at least as regards ground-surface-inhabiting arthropods, are due to specific plant associations and are independent of the direct action of the physical factors of environment connected with altitude. This, at any rate, concerns relatively low mountains, such as the Tatra Mts.

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STRESZCZENIE

Do pułapek umieszczonych na północnych stokach Żółtej Turni (Tatry Polskie) na wysokościach od 1500 do 2000 m n. p. m. odłowiono w ciągu dwóch lat 3468 stawonogów należących do 61 gatunków. Zastosowana metoda zde-

terminowała, że były to naziemne stawonogi, to znaczy poruszające się po powierzehni gruntu.

Przy użyciu metody Czekanowskiego-Kulczyńskiego wyróżniono jedno zgrupowanie naziemnych stawonogów. Między poszczególnymi stanowiskami pułapkowymi umieszczonymi na różnych wysokościach oraz między trzema różnymi środowiskami (usypiska kamienne, kosodrzewina, murawy) nie stwierdzono różnie w składzie gatunkowym, które przy użyciu tej metody upoważniałyby do wyróżnienia większej ilości zgrupowań.

Ustalono jak przebiegają zmiany sezonowe w liczebności całego zgrupowania i populacji kilku najliczniejszych gatunków, wchodzących w jego skład. Dla gatunków *Pardosa nigra* (C. L. Koch), *Platybunus bucephalus* C. L. Koch i *Mitopus morio* (F.) ustalono przebieg cyklu życiowego.

Między poszczególnymi stanowiskami pułapkowymi położonymi na różnych wysokościach nie stwierdzono różnic w składzie gatunkowym i liczebności naziemnych stawonogów, które można by przypisać bezpośredniemu wpływowi czynników fizycznych środowiska związanych ze wzrostem wysokości nad poziom morza.

Ustalono, że ilość odłowionych gatunków, liczebność osobników poszczególnych gatunków oraz przebieg zmian sezonowych w obrębie zgrupowania zależne są od charakteru szaty roślinnej. Wśród wielu czynników środowiska zewnętrznego największy wpływ na różnicowanie się zgrupowania wywiera szata roślinna.

Na podstawie zebranych danych przypuszcza się, że różnice faunistyczne w obrębie pięter roślinnych, przynajmniej w odniesieniu do naziemnych stawonogów, związane są z obecnością takich, a nie innych zbiorowisk roślinnych, nie zależą zaś od bezpośrednich wpływów czynników fizycznych środowiska, związanych ze wzrostem wysokości nad poziom morza. Odnosi się to w każdym razie do gór stosunkowo niskich, takich jak Tatry.

**РЕЗЮМЕ** 

При помощи специальных ловушек, расположенных на высоте от 1500 до 2000 м над уровнем моря, поймано на протяжении двух лет 3468 членистоногих, принадлежащих 61 виду. Этот метод ограничил нас к отлову только наземных членистоногих, т. е. передвигающиеся по поверхности земли.

При употреблении метода Чекановскего-Кульчиньскего выделено одно сообщество наземных членистоногих. Между отдельными пунктами расположения ловушек помещенными на разной высоте, а также в трех разных средах (каменные оползни, карликовые сосны, трава) не обнаружено разниц в видовом составе, которые, при использовании данного метода, давали бы, казалось, возможность отличия большего количества сообществ.

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Установлено, как протекают сезонные изменения в численности всего сообщества и популяции нескольких наиболее многочисленных видов, входящих в его состав. Для видов *Pardosa nigra* (С. L. Косп), *Platybunus bucephalus* С. L. Косп и *Mitopus morio* (F.) установлено развитие жизненного цикла.

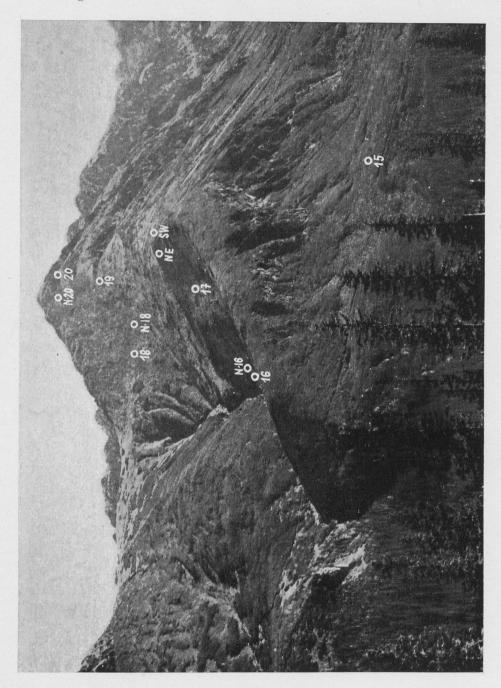
Между отдельными пунктами расположения ловушек, находящимися на разных высотах не обнаружено разниц в видовом составе и численности наземных членистоногих, которые были бы результатом непосредственного влияния физических факторов среды, связанных с увеличением высоты над уровнем моря.

Установлено, что количество отловленных видов, численность особей отдельных видов, а также развитие некоторых сезонных изменений в сообществе зависит от характера растительного покрова. Среди множества факторов внешней среды наибольшее влияние на дифференцировку сообщества оказывает растительный покров.

На основании собранных данных можно предполагать, что фаунистические разницы в границах растительных зон, по крайней мере в отношении наземных членистоногих, связаны с наличием тех, а не иных растительных сообществ, не зависят от непосредственного влияния физических факторов среды, связанных с возрастанием высоты над уровнем моря. Это, во всяком случае, относится к относительно низким горам, таким как Татры.

# Plate III

Phot. 1. Distribution of trapping localities over the northern slope of Zólta Turnia



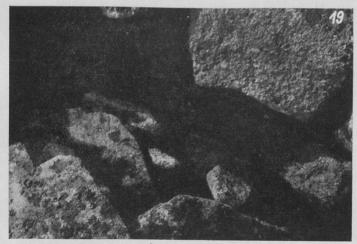
Phot. A. Lomnicki

# Plate IV

Phot. 2. Structures of debris at three selected localities. Ca 1/15 of normal size



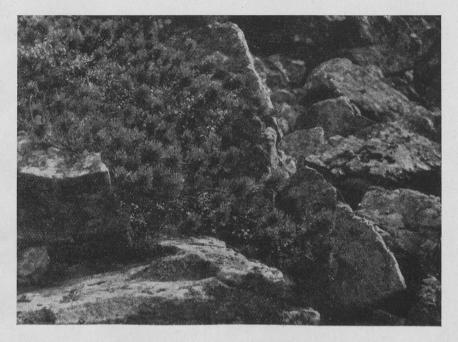




Phot. A. Lomnicki

### Plate V

Phot. 3. Encroachment of the mountain pine association on stone debris at locality 15 Phot. 4. The *Trifido-Distichetum* association overgrowing debris at locality 19



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Phot. A. Lomnicki

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