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ZONAL AND ZOOGEOGRAPHIC CHARACTERISTIC OF THE ANT FAUNA (HYMENOPTERA, FORMICIDAE) OF UKRAINE

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Zonal and Zoogeographic Characteristic of the Ant Fauna (Hymenoptera, Formicidae) of Ukraine. Radchenko A. G. — One hundred forty ant species belonging to 38 genera of 5 subfamilies are known to occur in Ukraine nowadays. All the species are attributed to 16 zoogeographic complexes that are grouped into three faunogenetic classes. Comparative zonal and zoogeographical analysis of the fauna of different geographical regions of Ukraine has revealed their essential heterogeneity. The ant fauna of the Forest-Steppe zone is not original. At the same time, it is not transitive between the faunas of the Forest and Steppe zones. Ant fauna of the Forest-Steppe is related to those not the Steppe but the Forests zones, and the Forest-Steppe can be included in the southern subzone of a Forest zone of t Europe.

Key words: ants, Formicidae, fauna, zoogeography, Ukraine, Europe.

Зональная и зоогеографическая характеристика мирмекофауны (Hymenoptera, Formicidae) Украины. Радченко А. Г. — В Украине известно 140 видов муравьев из 38 родов 5 подсемейств. Выделены 16 зоогеографических комплексов, отнесенных к трем фауногенетическим классам. Сравнительный зональный и зоогеографический анализ фаун различных физико-географических регионов Украины выявил их существенную разнородность. Показано, что фауна муравьев Лесостепи не является самобытной. В то же время, она не является переходной между фаунами лесов и степной зоны. По происхождению мирмекофауна Лесостепи связана с таковой не степной, а лесных зон, и, на основании данных о распространении муравьев, Лесостепь может быть включена в состав южной подзоны лесной зоны Европы.

Ключевые слова: муравьи, Formicidae, фауна, зоогеография, Украина, Европа.

Introduction

In Ukraine 140 species of ants from 38 genera of 5 subfamilies are known at present. Among them, 5 occasionally introduced species (*Hypoponera punctatissima* (Roger), *Linepithema humile* (Mayr), *Brachymyrmex heeri* Forel, *Paratrechina vividula* (Nylander) and *Monomorium pharaonis* (Linnaeus)) are indoor species, living in houses, greenhouses, etc. All of the above mentioned species are not included in the following zonal and zoogeographical analysis. Thus, the ant fauna of Ukraine includes 135 native species.

Zonal-geographical analysis of the fauna

The richness of ant fauna of Ukraine is emphasized by comparing it with the faunas of adjacent regions. For example, 62 species are known in Belarus, 103 in Poland, 108 in Slovakia, 104 in Czech Republic, 120 in Hungary, and 105 in Romania ant species. Even in the vast and diverse territory of European Russia (excluding the Northern Caucasus, bordering between Europe and Asia along the Kuma-Manych Depression) only 131 ant species are found (Arnoldi, Dlussky, 1978; Blinov, 1984, 1985; Czechowski et al., 2002; Radchenko et al., 2003, 2004, 2005; Markó et al., 2006; Werner, Wiezik, 2007; Csósz et al., 2011; see also Radchenko, 2007 b).

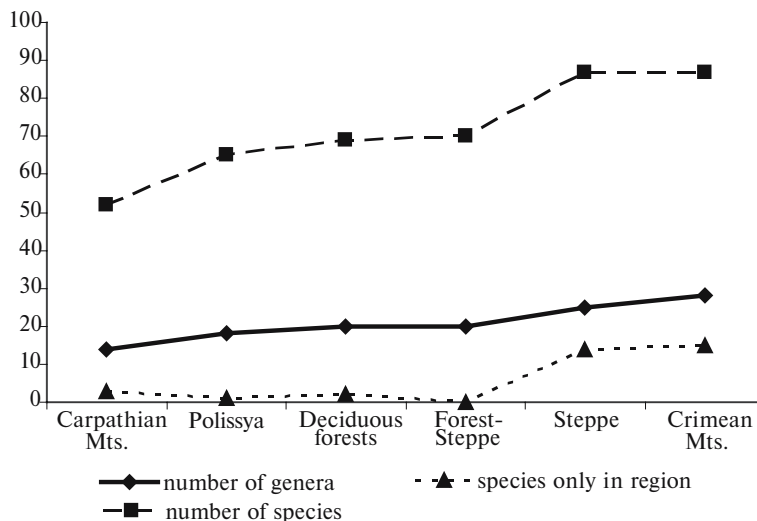


Fig. 1. Number of species and genera of ants in different natural zones of Ukraine.

Рис. 1. Количество видов и родов муравьев в различных природных зонах Украины.

Ukraine is located within different physiographic zones: the East European Plain, which includes zones of mixed forests (Polissya), deciduous forests (including the Carpathian lowland), Wood-and-Steppe and Steppe zones, the Carpathian mountain country and the Crimean Mountains, including subtropics of the southern coast of the Crimea. Earlier authors (Marinich et al., 1982) did not separate a zone of deciduous forests, but now there are more and more evidences for such zoning, proposed by Marinich (2003). Such a variety of conditions led to the richness of the ant fauna and also to the significant differences in allocation of species and faunistic complexes.

Species richness of different natural zones generally corresponds to the generic one: 14 genera and 52 (3) species (number of species found only in the discussed region are in brackets) are found in the Carpathian Mts., 18 genera and 65 (1) species in Polissya, 20 genera and 69 (2) species in Deciduous Forest zone, 20 genera and 70 (0) species in Forest-Steppe, 25 genera and 87 (14) species in Steppe, and 28 genera and 87 (15) species in the Crimean Mts. (see also fig. 1). As can be seen, the species and generic richness increases from the mountain forests of Carpathians to the south and reaches its maximum in the Steppe and Crimean Mts.

At the same time, comparison of ant fauna of different natural zones shows its high heterogeneity. The highest similarity, which is not surprising, is observed between the adjacent forest regions — Polissya and Deciduous Forests (Jaccard index¹ = 0.836). Similar, although somewhat lower performance of the index is observed between Polissya and Carpathians, Polissya and Forest-Steppe, Steppe and Deciduous Forests. It is important to stress that the fauna of the Forest-Steppe zone is much more similar to those of the adjacent forest zones than to the Steppe one (table 1, fig. 2). It is quite naturally that the similarity of the faunae of forest areas with those of the steppes and the Crimean Mts. is the lowest. It is noteworthy that the similarity of the Forest-Steppe ant fauna with that of the Steppe significantly lower than with Polissya and Deciduous Forests zones.

Such difference can be easily explained: many of the major and widely distributed genera, such as *Formica*, *Myrmica* and *Camponotus* include both mesophilic and xerophilic representatives whose distribution is limited to one or other natural zones. For example, genera found in all regions, account for more than 45% of their total number and species — less than 30%.

¹ Jaccard's index = $c / (a + b - c)$, where a and b are the number of species in two centres compared and c is the number of species in common.

Table 1. Comparison of the ant faunas in different regions of Ukraine (at the species level)*
Таблица 1. Сравнение фаун муравьев различных регионов Украины (на уровне видов)*

Regions	Polissya	Carpathian Mts.	Deciduous Forests	Forest-Steppe	Steppe	Crimean Mts.
Polissya	65	0.696	0.836	0.688	0.382	0.382
Carpathian Mts.	48	52	0.613	0.525	0.264	0.264
Deciduous Forests	61	46	69	0.805	0.405	0.356
Forest-Steppe	55	42	62	70	0.554	0.481
Steppe	42	29	45	56	87	0.554
Crimean Mts.	42	29	41	51	62	87

* Diagonal indicate the number of species in the region; in the lower left side of the table — number of species common to the compared regions; in the upper right side Jaccard index values.

Of course, the quantity of different species vary greatly both in Ukraine as a whole and in the separate regions. For example, red wood ants from the *Formica rufa*-group, many members of the genera *Lasius* F., *Myrmica*, *Camponotus* and some others form the basis of ant fauna in different ecosystems not only in our country but also in the whole Palaearctic. At the same time, many species and even genera are extremely rare. To some extent this may be associated with a cryptic style of life of some of them, however rigorous studies in many areas has confirmed the true rarity of at least about 20 species. For example, *Cryptopone ochracea* (Mayr), *Proceratium melinum* (Roger), *Liometopum microcephalum* (Panzer), *Bothriomyrmex communistus* Santschi, *Formica cinereofusca* Karawajew, *Myrmica stangeana* Ruzsky, *Aphaenogaster splendida* (Roger), *Temnothorax semenovi* (Ruzsky), *T. recedens* (Nylander) and some other species are known only by a single or at most by a few rare finds.

There are also endemic ant species in Ukraine: *Strongylognathus arnoldii* Radchenko, *S. chelififer* Radchenko, *Solenopsis ilinei* Santschi, *Plagiolepis karawajewi* Radchenko, *Chalepoxenus tauricus* Radchenko. *Tapinoma kinburni* Karawajew was known only from Ukraine until recently, but some years ago it had been recorded from the Belgorod region of Russia (Prisny, 2003). It is characteristic that all of them distributed either in the Steppe zone, or at the southern coast of Crimea.

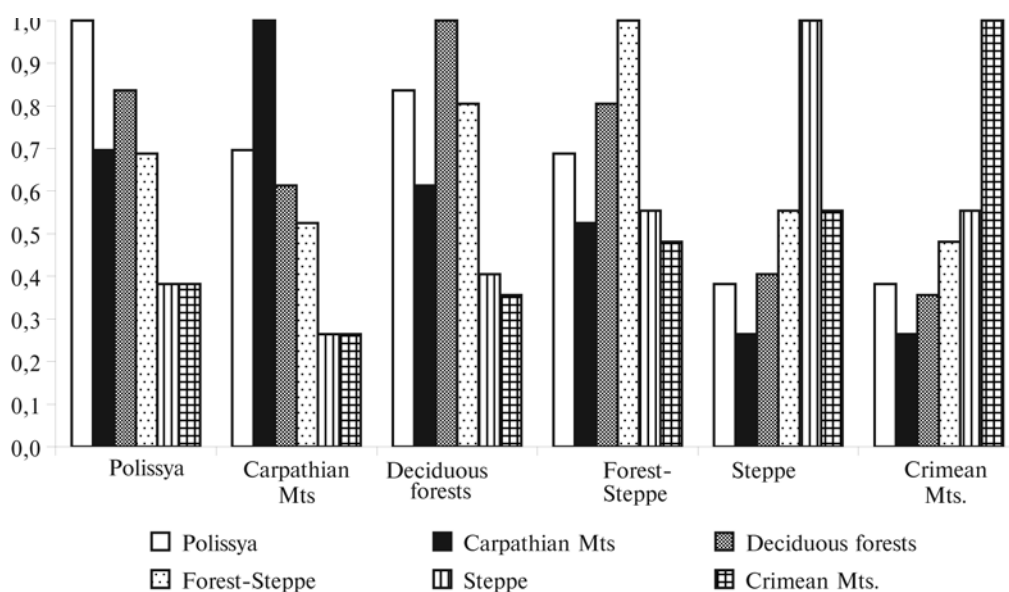


Fig. 2. The similarity of ant fauna in different regions of Ukraine at the species level (Jaccard index).

Рис. 2. Сходство мирмекофаун различных регионов Украины на видовом уровне (индекс Жаккара).

Analysis of the distribution of ants and of the peculiarities of structure of the faunistic complexes can shed light on the rather controversial question: is the Forest-Steppe zone original, distinctive zone, or it is a transitional region between the Forests and Steppe zones? Famous Russian myrmecologist K. V. Arnoldi stood for the first point of view and pointed out the uniqueness of the ant fauna of the Forest-Steppe zone (Arnoldi, 1956, 1965, 1968). However, my data contradict this view.

First of all, there are no ant species unique to the Ukrainian Forest-Steppe zone. There are two main types of zonal ecosystems in this region: mainly deciduous, rarely mixed island forest of valleys and beam type, as well as moderately dry upland meadows and meadow-steppes. Correspondingly, the Forest-Steppe ants can be clearly divided into mesophilous forest and more xerophilous grassland inhabitants. Simultaneously, fauna and structure of multi-species associations of ants of forest ecosystems in the Forest-Steppe are almost identical to that of the forests of the southern part of Polissya and of the zone of Deciduous forests.

The ant fauna of meadow ecosystems is also more similar to those of forests than of steppes what supported by a lower value of the Jaccard index between Forest-Steppe and Steppe zones (0.357). The absence or extreme rarity of the steppe edicator species, such as *Cataglyphis aenescens* (Fürster), *Proformica epinotalis* (Ruzsky), several species of *Temnothorax* Mayr, *Bothriomyrmex* Emery, etc., is also important. Many species common to the Forest-Steppe and Steppe fauna, in fact, are not typical steppe dwellers, but also live in xerothermal habitats in the Central Europe and partly in the Mediterranean region, i. e., are not interrelated with the origin and further development of the steppe ecosystems.

Thus, based on the study of ants, I can make the following conclusions: — the forest dwellers are dominated in the Forest-Steppe zone, and virtually no true steppe species here;— the Forest-Steppe ant fauna genetically related to the forest fauna, but not to the steppe one;— the Forest-Steppe is not a substantive natural zone nor a transitional region between the forest and steppe zones;— the Forest-Steppe is likely to be included in the southern sub-zone of the European forests.

Zoogeographical analysis of the fauna

The basic postulate of my zoogeographic studies was and remains a well-known fact: the modern character of the area of any taxon is the result of historical development of the latter, woven into the overall picture of phylogeneis, phylocenogenesis and faunogenesis (Chernov, 1984, Radchenko, 1998, 2003). Therefore, in the zoogeographical analysis I used not only chorological approach, but also take into account peculiarities of the ecology and biology of species, their phylogenetic relationships, the history of the formation of species and faunistic complexes. In addition, the data of systematic, paleontology, paleogeography, florogenetic, physical geography, and other related sciences are widely used. The classification of areas proposed below are based on the zonal-provincial approach (Emelyanov, 1974; Kryzhanovsky, 1987, 2002; Czechowski et al., 2002; Radchenko, 2007 a), it has a hierarchical structure and takes into account not only the present distribution of species, but the history of the formation their areas.

All native ant species of Ukraine are assigned to 16 **zoogeographical complexes**, which are grouped into three **faunogenetic classes**: class of the zone of coniferous forest (taiga), zones of mixed and deciduous forests, and class of semi-arid and arid zones of Eurasia. Such an association is based on the characters of areas, as well as on the ecological features of species, included in the different classes, and also reflected the common history of faunogenesis in these three vast regions.

Thus, the origin and subsequent evolution of the fauna of the semi-arid and arid zones of Eurasia is closely related to the development of xerophytic landscape and vegetation

in the region of the drying Tethys Ocean starting in the Late Oligocene. Flora and fauna of the zone of Deciduous and Mixed Forests of the Western Palaearctics, in essence, is a derivative of the ancient Turgay flora (Krishtofovich, 1946), and fauna of the Taiga zone is the youngest in the Palaearctic Region, it was the most exposed to the catastrophic effects of the Pleistocene glaciations. A brief characteristic of the zoogeographical complexes, discussed in this article is as follows.

I. Class of the coniferous forest zone (taiga) (23 species)

1) the *boreo-montane* complex (**BM**) — species distributed mainly in the northernmost part of the Palaearctic Region (the Taiga zone), usually having a very wide range from the Atlantic to Pacific Ocean. In the European plains, their southern limit as a rule does not reach 50°N, often at most 55°N, but at the same time they occur in the mountains of Europe and Caucasus; some species may penetrate by intrazonal habitats (e. g. forests in valleys of large rivers) far to the south up to the Steppe zone. In Ukraine **11** species.

2) the *montane* complex (**M**) — species occurring only in the mountains of Europe and Caucasus. Most probably, they are Tertiary relics. Two species are known in Ukraine: *Manica rubida* (Latreille) (Carpathian and Crimean Mts.) and *Formica cinereofusca* Karawajew (Carpathian Mts.).

3) the *North-Palaearctic* complex (**Pn**) — generally trans-Palaearctic forms whose ranges cover the taiga zone together with the northern part of the mixed and deciduous forest zones. Ecologically, they are mesophilous species living mostly in forests and in mountain meadows. In Ukraine **10** species.

II. Class of the mixed and deciduous forest zones (52 species)

4) the *European forests* complex (**EF**) — mesophilous and partly thermophilous species, distributed mainly in the zones of deciduous and mixed forests and Wood-and-Steppe of Europe; inhabit both forests and open areas. In Ukraine **9** species.

5) the *Euro-West-Siberian* complex (**EWS**) — species, widespread in Europe (usually also in the Caucasus) and in West Siberia, reaching to the east the Altai, rarely — the Lake Baikal. Their range can cover several natural zones, but they are absent or extremely rare in the Mediterranean region and in the Taiga. Ecologically, they are quite diverse and found both in forests and in open grasslands. In Ukraine **14** species.

6) the *Euro-Caucasian* complex (**EC**) — species distributed mainly in the zone of deciduous forests and partly in mixed forests in Europe and the Caucasus. They may also reach Asia Minor and the Near East. Many species are arboreal, but there are also polytopic representatives both in forests and in open areas. In Ukraine **15** species.

7) the *South-Palaearctic* complex (**Ps**) — generally trans-Palaearctic forms, often distributed from the Atlantic to Pacific Oceans, whose ranges cover mainly the southern part of the forest zones and the Forest-Steppe zone; ecologically associated with dry light forests or dry grasslands; in southern Europe live mainly in mountains. They are associated mainly with moderately dry and light forests or with mesoxerophilous grasslands. In Ukraine **14** species.

III. Class of the semi-arid and arid zones (60 species)

8) the *South-European* complex (**SE**) — species occurring mainly in dry light forests and xerothermal associations of southern Europe and partly Central Europe, they usually do not reach beyond 50° N northwards; at the same time they are quite rare in or absent from the Mediterranean region. In Ukraine **10** species.

9) the *Mediterranean* complex (**MD**) — species distributed in the Mediterranean region, i.e., in the Iberian and Apennine Peninsulas, southern France, the Balkans, Greece, the southwestern part of North Africa, and in Asia Minor (or in a significant part of this area). They occasionally occur also in the Near and Middle East, reaching in the east the Kopet-Dagh Mts., but are absent in deserts of the Middle Asian plains; they can also

reach Central Europe and the southern part of East Europe. Most typical habitats of these species are those of the Mediterranean type (dry forests, macchia scrub, xerothermal plant associations, often on stony mountain slopes). In Ukraine **16** species.

10) the **Crimean-Caucasian** complex (CC) — species occurring only in Crimean Mts. and the Caucasus. Ecologically, they are similar to the species of previous complex; in fact, this complex (as well as several ones below) can be considered as a particular case of the wider Mediterranean complex. In Ukraine 2 species found in Crimea: *Temnothorax jajlensis* (Arnoldi) and *Strongylognathus karawajewi* Pisarski.

11) the **Balkan-Caucasian** complex (BC) — the areas are similar to the previous complex, but include the Balkans, the Crimea and the Caucasus. In Ukraine **3** species.

12) the **Crimean-Balkan** complex (CrB) — species distributed in the Crimea and the Balkans; in the Ukraine found a single species — *Bothriomyrmex communistus*.

13) the **Crimean** (Cr) — all **4** known species are endemics of the southern coast of Crimea.

14) the **Tethyan** complex (T) — species having a wide area that includes wholly or at least mostly the Mediterranean region, southern part of Central and East Europe, the Caucasus, Asia Minor, the Middle East, Iran, Kazakhstan, Middle Asia (i. e. so-called “Ancient Mediterranean” region *sensu* Semenov-Tian-Shansky, 1936). All **6** species, found in Ukraine, live in the steppes and dry meadows, and occasionally penetrate under the canopy of light, dry, warm and sparse forests.

15) the **Steppic** (a synonym of this name — *Scythian*) (ST) — species, widely distributed in the steppes of Eurasia; all of them are associated with grasslands and avoid forests, even dry and sparse ones. In Ukraine **12** species.

16) the **Turano-Steppic** (TST) — xerophilous and semi-xerophilous species living mainly in the steppes, but their areas also cover the Middle Asia, and some distributed in the Transcaucasia, Asia Minor and the Mediterranean. In Ukraine **6** species.

Ratio of the zoogeographical complexes of ants in Ukraine as a whole seems to be rather homogeneous, i.e., none of them is clearly dominant. Thus, 9 complexes that include from 7 to 12% of the species in total cover more than 80% of species diversity (fig. 4).

At the same time, if the distribution of the zoogeographical complexes is compared in the faunogenetic classes, the ratio of representatives of the “humid” (I and II) and “arid” (III) classes will be approximately equal (56 vs. 44%) (fig. 3). This situation is consistent with the natural environment in Ukraine, where semiarid regions occupy about half of its territory.

The compositions and distributions of both zoogeographical complexes and faunogenetic classes in different regions vary quite significantly (table 2, fig. 5, 6) and reflect, both the specificity of modern landscapes, and the history of the formation of ant fauna.

In zoogeographic respect, both by the composition of faunogenetic classes and of the zoogeographic complexes, the ant faunas of Polissya and Deciduous forests are the most similar among all the compared regions, although the first fauna is poorer and less diverse (tabl. 1, 2).

Zoogeographic analysis confirms the above mentioned character of the ant fauna of the Forest-Steppe zone that is much more similar to that of Forests than that of the Steppe zones. A different pattern is observed in the Steppe zone, where the richness and diversity of fauna not only increases, but very substantially increase the proportion of “arid” representatives. Finally, the richest and the most diverse is the ant fauna of the Crimean Mts., which includes representatives of all 16 zoogeographical complexes, and more than half of them belong to the class of semi-arid and arid zones of Eurasia, mainly due to the presence of the Mediterranean, Steppic, and Turano-Steppic elements (fig. 5, 6).

The above data show the richness and high diversity of the ant fauna of Ukraine, as well as its faunogenetic heterogeneity. Particularly clear these differences manifest themselves in the regional (both taxonomic and zoogeographic) analysis of ant fauna of dif-

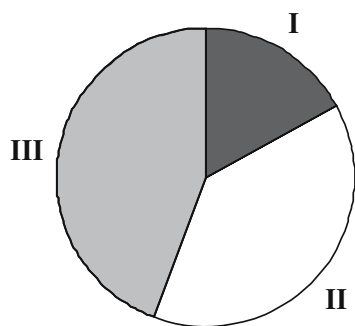
Table 2. Zoogeographic characteristic of ant fauna in different regions of Ukraine*

Таблица 2. Зоогеографическая характеристика мирмекофауны различных регионов Украины*

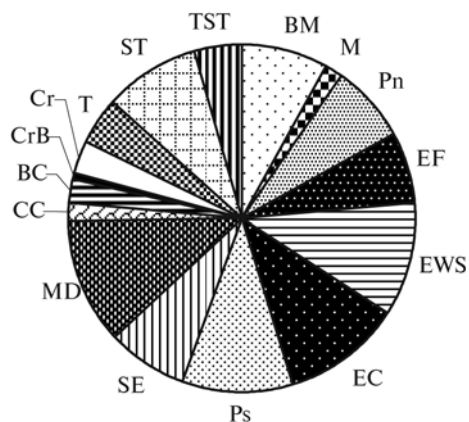
Zoogeographical complexes	Polissya	Carpathian Mts.	Deciduous Forests	Wood-and-Steppe	Steppe	Crimean Mts.	Total
BM	9	9	6	2	0	2	11
M	0	2	0	0	0	1	2
Pn	10	10	10	9	4	4	10
EF	5	3	6	5	5	3	9
EWS	12	9	12	13	12	11	14
EC	13	8	13	14	13	13	15
Ps	12	10	13	13	13	10	14
SE	1	0	4	2	8	6	10
MD	1	0	3	2	8	16	16
CC	0	0	0	0	0	2	2
BC	0	0	0	0	1	3	3
CrB	0	0	0	0	0	1	1
Cr	0	0	0	0	0	4	4
T	2	1	2	5	5	6	6
ST	0	0	0	3	12	1	12
TST	0	0	0	2	6	4	6
Total	65 (1)	52 (3)	69 (2)	70 (0)	87 (14)	87 (15)	
% of "endemics "	1.5	5.8	2.9	0	16.1	17.2	

* Abbreviations of the names of zoogeographical complexes see in the text above.

** in brackets: number of "endemics" for regions.



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Fig. 3. Assignment of the ant fauna of Ukraine to the faunogenetic classes: I — class of the Zone of Coniferous Forest (Taiga); II — class of the Zones of Mixed and Deciduous Forests; III — class of the Semi-Arid and Arid Zones of Eurasia.

Рис. 3. Распределение мирмекофауны Украины по фауногенетическим классам: I — класс зоны хвойных лесов; II — класс зоны смешанных и лиственных лесов; III — класс субаридной и аридной зон Евразии.

Fig. 4. Zoogeographical composition of the ant fauna of Ukraine as a whole (abbreviations are given in the text).

Рис. 4. Зоогеографический состав мирмекофауны Украины в целом (сокращения приведены в тексте).

ferent physiographic countries and natural zones of the country. This pattern reflects both the modern character of natural complex and the history of formation of the ant fauna of Ukraine.

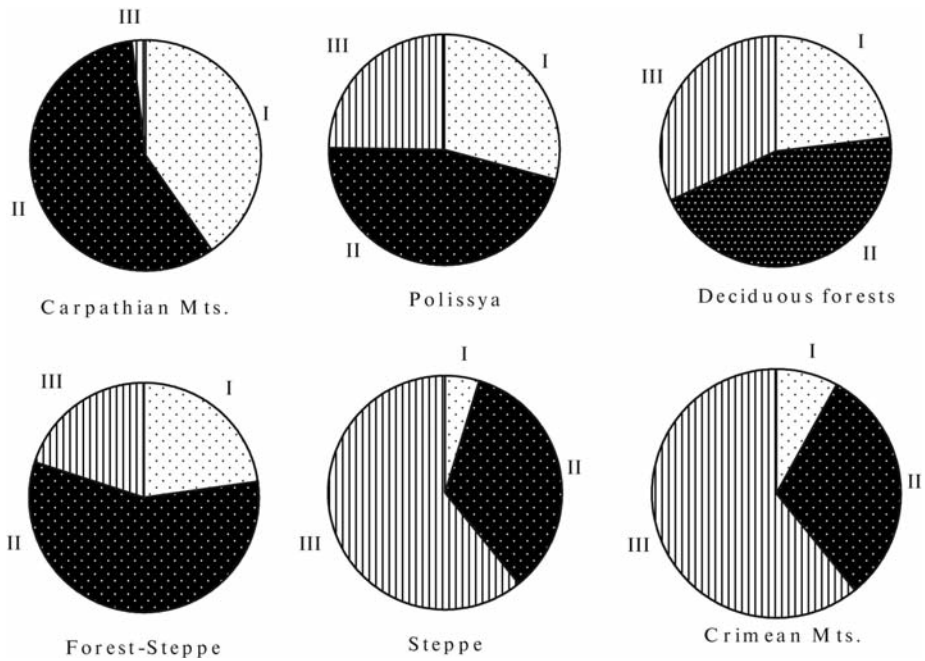


Fig. 5. Value of the faunogenetic classes of ants in different regions of Ukraine: I — class of the Zone of Coniferous Forest (Taiga); II — class of the Zones of Mixed and Deciduous Forests; III — class of the Semi-Arid and Arid Zones of Eurasia.

Рис. 5. Соотношение фауногенетических классов муравьев в различных регионах Украины: I — класс зоны хвойных лесов; II — класс зоны смешанных и лиственных лесов; III — класс субаридной и аридной зон Евразии.

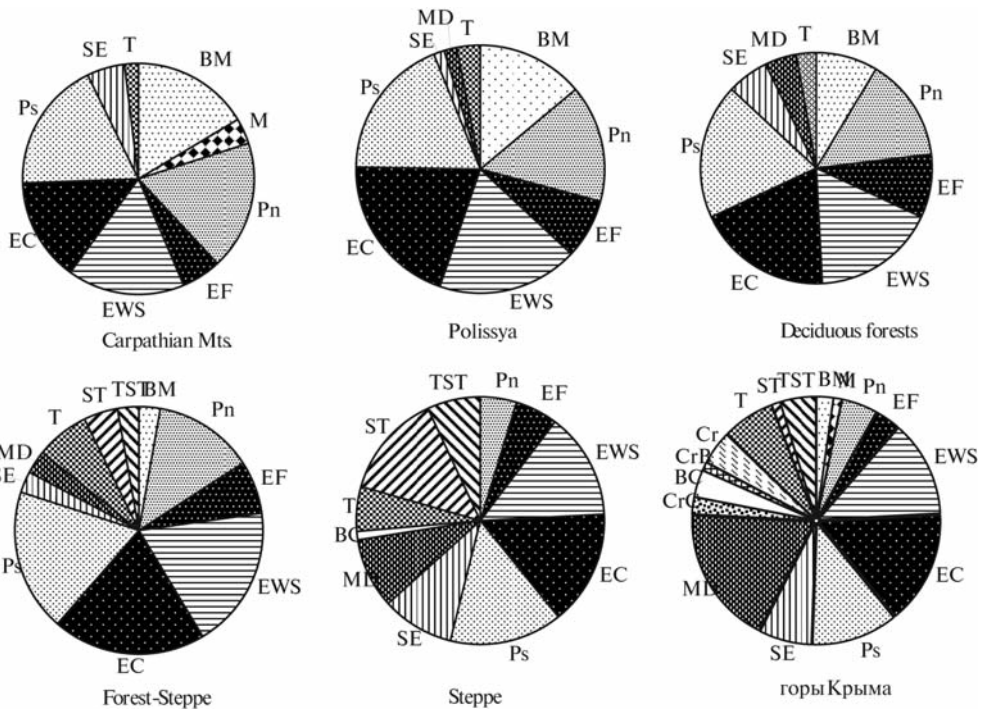


Fig. 6. Value of the zoogeographical complexes of the ant species in different regions of Ukraine (abbreviations are given in the text).

Рис. 6. Соотношение зоогеографических комплексов видов муравьев в различных регионах Украины (сокращения приведены в тексте).

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