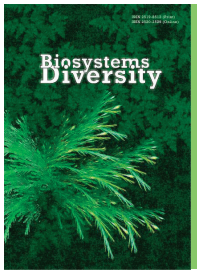

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Ecological-faunistic analysis of ground beetles and tiger beetles (Coleoptera: Carabidae, Cicindelidae) of metropolises of Ukraine

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Ground beetles and tiger beetles are the most noticible representatives of predatory invertebrates often used in bioidentificational studies. This article provides quantitative and ecological characteristics of Caraboidea in five metroplises of Ukraine (Dnipro, Donetsk, Kharkiv, Kyiv, and Lviv). In total, in these cities, 237 species of Caraboidea were recorded, belonging to 63 genera and two families – Carabidae (231 species, 61 genera) and Cicindelidae (6 species, 2 genera). By abundance of Carabidae in megapolises, 33 species were identified to abundant. Eudominants were represented by three species: *Harpalus rufipes*, *Pterostichus melanarius* and *P. oblongopunctatus*, dominants – five: *Amara aenea*, *Anchomenus dorsalis*, *Calathus fuscipes*, *Harpalus distinguendus* and *Poecilus versicolor*. Subdominants were 25 species: *Amara similata*, *Asaphidion flavipes*, *Badister bullatus*, *Bembidion lampros*, *B. properans*, *Broscus cephalotes*, *Calathus ambiguus*, *C. melanocephalus*, *Carabus cancellatus*, *C. coriaceus*, *C. granulatus*, *Cylindera germanica*, *Harpalus affinis*, *H. anxius*, *H. griseus*, *H. latus*, *H. tardus*, *Limodromus assimilis*, *Microlestes minutulus*, *Nebria brevicollis*, *Notiophilus palustris*, *Poecilus cupreus*, *Pterostichus niger*, *P. ovoideus* and *P. strenuus*. In the studied cities, 53 species are rare, 151 species were identified to the group of accidental species. For separate cities, number of eudominants ranged from 4 (Donetsk, Kyiv) to 6–8 (Kharkiv, Lviv). Ten species discovered: *Amara famelica*, *A. majuscula*, *Anisodactylus nemorivagus*, *Asaphidion pallipes*, *Badister lacertosus*, *Blemus discus*, *Harpalus laeviceps*, *Limodromus krynickii*, *Pterostichus minor* and *Tachyta nana* were new for the Steppe zone of Ukraine. *Chlaenius aeneocephalus* and *Brachinus brevicollis* were recorded for the first time in the Right Bank of the northern subzone of the steppe zone, and *Stenolophus abdominalis* mentioned earlier for the far south of Ukraine was for the first time reported for the northern Steppe. *Microlestes negrita* was new for the Forest Steppe, and *Masoreus wetterhalli* and *Syntomus foveatus*, known earlier for the forest zone and the south of the steppe zone, were for the first time reported for its northern subzone. The levels of faunistic similarity of Caraboidea for different metropolises ranged within 0.20–0.60 for all species and 0.32–0.90 for abundant species. Most similar were carabidofaunas of Kharkiv and Dnipro (similarity index of Jaccard equaled 0.58–0.87), slightly lower in Dnipro and Kyiv (0.50–0.72). Lowest parameters were seen for Lviv compared with the other cities (0.20–0.32). According to the species composition, the most numerous were meadow (119) and forest elements (59 species). To the polytopic group, 25 species are identified, 23 to the steppe group, and 11 species to the litoral group. In numbers in all the metropolises, the polytopic group dominated, among which abundant species comprised almost half. Within the forest group in Dnipro, Donetsk and Kharkiv, 4–6 abundant species were recorded, whereas in Kyiv and Lviv their number was 14–17 species. Within the meadow group, common species were represented by 4–11 species, and in the steppe and litoral groups such species were absent. In relation to moisture, eudominants were mesophiles (165 species), including 31 abundant species. According to the trophic specialization, zoophages dominated (146 species), including 24 abundant species. Among zoophytophages, 60 species (seven abundant) were recorded. Phytozoophages were represented by 30 species (two abundant). According to mechanical composition of soil, the more diverse groups were observed to be made up species preferring loamy and clay-loamy soils (85 species each), but to the abundant species from these groups, 6 and 10 species respectively were identified. The group of ground beetles with non-manifested preferences to mechanical composition of soil was represented by 41 species, though by number of abundant (17 species), the group was dominant. To inhabitants of heavy loamy, sandy and sabulous soils, 4, 6 and 16 species correspondingly were identified, and no abundant species were observed. At the level of abundant species, the ecological structure was more similar than shown by the analysis of all the species of ground beetles. Hypothetically, typical representatives of carabid beetles of Ukrainian metropolises could be considered polytopic or meadow (to a lesser extent forest) mesophile zoophages or zoophytophages which prefer loam-clayey soils without preference to one or the other type of soil.

Keywords: Caraboidea; species composition; ecological structure; urban cenoses; cities.

Introduction

Cities, especially large ones (metropolises) are a quite specific environment for many insects which inhabit original anthropogenic habitats – urbocenoses, which according to a number of parameters significantly differ from natural biotopes. The survey of the entomofauna of urbocenoses allows us to understand the peculiarities of its formation, role and adaptive abilities of insects in the conditions of an urban environment, and also perform their ecological and bioidentificational evaluation (Sustek, 1987; Magura et al., 2008; Komlyk & Brygadyrenko, 2019, 2020). Among insects, within the largest order of beetles (Coleoptera), one of the dominating groups in the terrestrial ecosystems is caraboid beetles (ground beetles – Carabidae and tiger beetles – Cicindelidae). Ground beetles as inhabitants of almost all natural and transformed ecosystems in the conditions of urban landscapes were the objective of numerous publications. They included analyses of a number of aspects of the ecological-faunistic structure of the communities, distribution of species of Carabidae in different types of urban landscapes in many cities of a

number of European countries: Poland (Czechowski, 1981; Kosewska et al., 2013), Germany (Klausnitzer, 1983, 1990; Franzen, 1992); Slovakia (Šustek, 1987), Czech Republic (Hurka & Jedlickova, 1990), Belarus (Aleksandrowicz, 1997, 2014; Ryzhaya, 2005; Halinovski & Krytskaya, 2016), Hungary (Magura et al., 2004), Bulgaria (Penev et al., 2008), Finland (Niemelä & Kotze, 2009) and Spain (Šustek, 2012). These studies resulted in revealing interesting faunistic data and evaluating the role and possibilities of maintaining the representatives of Caraboidea in the conditions of cities (but mostly in city parks). Only some studies focused on comparative analysis of ground beetles in urbocenoses of various geographically remote cities (Balkenhol et al., 1991; Avtaeva et al., 2019).

In Ukraine, such faunistic studies (to different extents) were also sporadically conducted in a number of metropolises – Kyiv (Putchkov et al., 2003; Kirichenko & Danylkiv, 2011), Kharkiv (Putchkov et al., 2016, 2017b; Komaromi et al., 2018; Nikolenko, 2018), Dnipro (Brygadyrenko, 2015a, 2015b, 2016; Brygadyrenko & Korolev, 2015) and Lviv (Rizun & Khrapov, 2001; Rizun & Dedus', 2016). At the same time, ground beetles were found to be the most studied group, unlike some other families of beetles less studied in transformed biocenoses, for example scarabs Scarabaeidae (Putchkov et al., 2017a), staphilinids Staphilinidae (Putchkov et al., 2020) clown beetles Histeridae (Putchkov & Komaromi, 2018) and snout beetles Curculionidae (Komaromi et al., 2019; Nazarenko et al., 2020).

However, in each of the abovementioned studies, there are individual data on Carabidae regarding one particular city or even its separate territories (for example, only green plantations). At the same time, to understand the peculiarities of the formation of urban carabidofauna (similarly to other groups of insects) more fully, generalized comparative analysis of its structure should be performed in different, similar by parameters, but geographically remote, metropolises. Such analysis would allow us to obtain more detailed information about the patterns of the reaction of insects to different conditions of their habitat. For ground beetles, such comparisons were performed only on the example of tribes Carabini and Pterostichini (Putchkov et al., 2016, 2017b), whereas for other coleopterans (Scarabaeidae, Staphilinidae, and Curculionidae) only preliminary comparative data for separate cities were obtained (Putchkov et al., 2017, 2020; Nazarenko et al., 2020). The available data suggest greater differences regarding the compositions of species than ecological structure of the community of one or the other group of beetles in metropolises located in different geographic zones.

The objective of this study was to compare the taxonomic composition, abundance of species and the main indicators of the ecological structure of the communities of ground beetles in five metropolises of Ukraine. On the basis of these data, ecological-faunistic analysis should be performed in order to determine the peculiarities of the formation of the communities of Caraboidea in metropolises located in different geographical zones.

Material and methods

The beetles were counted during more than 20 years – in 1998–2019 (with separate breaks for some years) in the main urbocenoses of four metropolises of Ukraine: Dnipro, Donetsk, Kharkiv and Kyiv. Moreover, additionally, we used all the available literature on ground beetles in Kyiv (Kirichenko & Danylkiv, 2011; Kirichenko et al., 2019) and Kharkiv (Dekhtyareva, 2002, 2004). The materials on Donetsk were kindly provided to the authors by V. V. Martynov (Donetsk). The data for Lviv (exclusively the parks) are given on the basis of the literature data (Rizun & Khrapov, 2001; Rizun & Dedus', 2016).

In Dnipro, the studies were undertaken in 1998–2019 in urbocenoses, among which the main were also the recreation zones in the Right Bank (Lazar Globa Park, Taras Shevchenko Park, Monastyrsky Island, Sevastopolsky Park, Yury Gagarin Park, Botanical Garden of Dnipro University, Volodia Dubinin Park, Park of the 40th Anniversary of the Liberation of Dnipropetrovsk, Tonnelna Ravine Tract, forest communities of the Zaporizke Highway, river bank communities on the Pobeda Enbankment, Kliuev Garden Square, forest plantations west of the Kievskaia Street, Memory and Reconciliation Park, forest plantations in the areas of Parus residential zone and Diivka), and the areas on the Left Bank of the Dnipro River (Forest-Park of Friendship of Nations, bank communities of the Kuriache Lake, forest plantations west of the Donetske Highway). Except for the recreation zones, pit-fall traps were installed in the yards of private households, alongside highways, near large industrial enterprises (Brygadyrenko & Reshetniak, 2014a, 2014b, 2016; Korolev & Brygadyrenko, 2014; Reshetniak et al., 2017).

In Donetsk, ground beetles were collected in 1999–2004 in three city parks: Shcherbakov Park, Lenin Komsomol Park, Putilovsky Park, and also in the Rakovska Ravine (outskirts of the city). In the territory of Kharkiv, the counts were made in 2015–2019 in three parks (Pobeda, Karpovsky Sad, Mashynostroitelei); outskirts of Kharkiv Forest Park in the territory of the city; territories of G. N. Vysotsky Ukrainian Research Institute of Forestry and Forest Melioration (center of the city) and separate yards of the suburban zone (Oleksiivka). A complete characteristic of these urbocenoses was provided in a number of studies on insects of Kharkiv (Komaromi et al., 2018). In Kyiv (the period of 1998–1999, 2002, 2009, 2013), sporadic studies were performed in the main park plantations of city: Lysa Hora Tract (Right Bank of the Lybid River, near the place where it falls into the Dnipro River); Pobeda Park (Left Bank, Darnytsia), Rylsky Park (Right Bank, Holosiivo) and Saint Volodymyr Hill (center), and also separate plantations in Darnytsky and Dniprovsky Districts (Left Bank). The data on tracts of Teremky, Feofaniya and limited territory of Holosiivsky National Park adjacent to the city outskirts (west and south-west part of the city) is taken from the literature sources (see above). The data on Lviv are given exclusively on the basis of the literature sources for two city parks: Sykhivskyi Park and Vinnikovsky (Rizun & Khrapov, 2001; Rizun & Diedus, 2016), studies on which lasted for only two years – 2001 and 2015.

Thus, the main studies (and analysis of the literature sources) in urbocenoses were conducted in different tree, shrub and decorative plantations of the abovementioned cities. Due to this fact, during the analysis of the material, we did not take into account the carabid fauna of the aquatic and semiaquatic biotopes (in order to prevent confusion with the structure of the communities of ground beetles) which is well represented (and quite specific due to the large amount of water bodies) in Dnipro and Kyiv, but less in Kharkiv and almost absent in Lviv and Donetsk.

During the studies, we used mainly Barber pitfall traps (plastic cups filled with 10% solution of acetic acid or the so-called live traps without fixator). In each biotope, we installed 10–20 traps in line. The extraction of beetles was made with the intervals of 5–10 days from late April to early October, but sometimes only from May to mid July. In addition, the beetles were recorded and collected on the itineraries in the city, both in the abovementioned areas and others (on lawns and pavements).

In total, in urbocenoses of all the metropolises, over 70,000 specimens of ground beetles were recorded (around 3,500 for Kharkiv, 4,000 for Kyiv, 25,500 for Donetsk, 35,000 for Dnipro, around 2,800 specimens for Lviv). Based on the total number of the selection of no less than 2,500 specimens, according to level of the abundance, five groups were distinguished and presented using a points scale (Table 1): 1 – occasional species or subrecedents (scattered individuals were seen in separate years numbering from one to five specimens for the entire period of the collections, and their share usually equaled less than 0.15%); 2 – rare species or recedents (occured sporadically in small numbers, 0.15–0.65% of total collections); 3 – infrequent species or subdominants (often and continuously occurred in the most biotopes, 0.65–2.49% of overall collections); 4 – common species or dominants (quite often recorded in most habitats, 2.50–9.99% of the overall collections), 5 – abundant species (eudominants), recorded in large numbers in all urbocenoses (over 10% of the overall collections in a metropolis).

In smaller selections (for separate urbocenoses where the total number of the beetles caught was 200–1,000 specimens), the species the share of which exceeded 15% of the total number of beetles on the plot were identified to eudominants, 5.0–14.9% to dominant, 1.0–4.9% to subdominants, 0.30–0.99 to rare, and less than 0.30% to occasional species (Putchkov, 2018).

According to the general number scale, we distinguished species the abundance of which is expressed as the ratio of the total of points for all of the metropolises where the species was recorded to the total num-

ber of cities. Thus, the species identified to eudominants were characterized by the average value of abundance equaling 4.0–5.0, dominants – 3.0–3.9, subdominants – 1.8–2.9, recedents – 1.0–1.7, subrecedents – 0.2–0.9 points. The first three groups (regardless of the amount of the selection) are considered in the study as abundant species for one or the other metropolis. It has to be noted that the data on abundance presented in this article to a sufficient degree reflect the level of overall number of abundant species for the whole period of the surveys taking into consideration most of the urbocenoses. During further studies, some changes may occur in the taxonomic composition and ratio of their number, especially due to recording other rare and occasional species.

To evaluate the similarity of the species composition of separate cities, we used Jaccard coefficients of species similarity. The classification of ecological groups (taking into account the characteristics of imagoes and larvae) is given based on our observations and using the literature data (Sharova, 1981; Putchkov, 2018; Brygadyrenko, 2015a, 2015b, 2015c, 2016). Such divisions into groups are partly subjective, but are provided corresponding to the conditions and pattern of one or the other plot, confinement of species (both imago and larva) to the natural biotopes taking into account the peculiarities of change of the habitat of species in different geographic regions of Ukraine. Some more accurate determinations of biotopic confinement of abundant species of the transitional groups (for example forest- or meadow-marsh, meadow-steppe, forest-shrub and other) are absent, but are briefly considered in the text in the discussion of results. According to preferendum to soils with different mechanical composition, the groups were distinguished with consideration of abundance of larvae, and in case of absence of such data – according to the quantitative characteristics of imago in the areas with different edaphic conditions.

Classification of taxa is given according to the catalogue of beetles of Adephaga suborder of Palearctic (Catalogue of Palearctic Coleoptera…, 2017), and alphabetically within genera and the text (Table 1). Statistical analysis of the data was performed in Statistica 8.0 software (Statsoft Inc., USA).

Results

In total, in the urbocenoses of the metropolises (according to our observations and the literature), 237 species of Caraboidea have been recorded (Table 1), belonging to 63 genera and two families – Carabidae (231 species, 61 genera) and Cicindelidae (6 species, 2 genera), which is almost one third of all taxonomic composition of the Caraboidea superfamily in Ukraine. We can confidently presume that the list of ground beetles of urbocenoses (especially for the most poorly studied carabidofauna of Lviv), and other cities of Ukraine, where such studies have not been conducted, will increase to 250–260 species (mainly due to rare species).

Taxonomically the richest genera were *Harpalus* (34), *Amara* (26) and *Carabus* (22 species). Quite diverse were genera *Pterostichus* (16), *Bembidion* (9), *Ophonus* (8), *Poecilus* (7), *Badister* (6), *Agonum*, *Calathus*, *Notiophilus* and *Stenolophus* (5 species each). The remaining 50 genera were represented by 1–4 species (Table 1).

Taxonomic diversity of ground beetles to one extent or the other is specific. In urbocenoses of Dnipro, 156 species have been recorded, 119 in Donetsk, 125 in Kharkiv, 137 in Kyiv, and only 66 in Lviv. The latter circumstance is due to the short period of the studies (only two years) and the lowest number of urbocenoses taken into consideration (only two parks). At the same time, the number of species and the ratio of quantitatively different groups of ground beetles (abundant, rare, and occasional) differed to different extent. For some cities (except Lviv), the number of species of the abundant groups ranged from 19 (Donetsk) to 33 species (Kyiv), in percentage accounting for 14.1% (Dnipro) to 24.1% (Kyiv). The number of recedent species and subrecedents did not differ much for most of the cities (Table 1).

Table 1
Faunistic and ecological characteristics of beetles of Cicindelidae and Carabidae families in metropolises of Ukraine

No	Species	Dnipro	Donetsk	Kharkiv	Kyiv	Lviv	Total for five cities	Biotopic preferred range	Humidification preferred range	Trophic characterization	Soil texture preferred range
	Cicindelidae										
1	*Cicindela campestris* Linnaeus, 1758	2	1	1	2	0	1.2	md	mz	zo	cm
2	*C. hybrida* Linnaeus, 1758	0	0	1	2	0	0.6	pt	mz	zo	sd
3	*C. maritima kirgisica* Mandl, 1936	2	0	0	0	0	0.4	lt	mh	zo	sd
4	*C. soluta* Dejean, 1822	2	0	0	1	0	0.6	fr	mz	zo	sd
5	*Cylindera arenaria viennensis* (Schrank, 1781)	1	0	0	1	0	0.4	md	mz	zo	sd
6	*C. germanica* (Linnaeus, 1758)	2	2	3	2	1	2.0	md	mz	zo	cm
	Carabidae										
7	*Leistus ferrugineus* (Linnaeus, 1758)	1	3	1	1	0	1.2	fr	mz	zo	lm
8	*L. piceus* (Frölich, 1799)	0	0	0	0	3	0.6	fr	mz	zo	lm
9	*L. rufomarginatus* (Duftschmid, 1812)	0	0	0	0	1	0.2	fr	mh	zo	lm
10	*Nebria brevicollis* (Fabricius, 1792)	0	0	0	4	5	1.8	fr	mh	zo	lm
11	*Notiophilus aquaticus* (Linnaeus, 1758)	0	0	1	0	0	0.2	md	mh	zo	cm
12	*N. biguttatus* (Fabricius, 1779)	1	2	2	2	1	1.6	fr	mz	zo	cm
13	*N. germinyi* (Fauvel in: Grenier, 1863)*	0	0	2	1	0	0.6	md	mh	zo	cm
14	*N. laticollis* Chaudoir, 1850	3	1	3	1	0	1.6	md	mz	zo	cm
15	*N. palustris* (Duftschmid, 1812)	1	4	1	2	1	1.8	fr	mz	zo	cm
16	*Calosoma auropunctatum* (Herbst, 1784)	2	1	2	0	0	1.0	md	mz	zo	cm
17	*C. denticolle* Gebler, 1833	1	1	0	0	0	0.4	md	mz	zo	cm
18	*C. inquisitor* (Linnaeus, 1758)	1	3	3	1	0	1.6	fr	mz	zo	df
19	*Carabus arvensis* Herbst, 1784	0	0	0	3	4	1.4	fr	mz	zo	cm
20	*C. besseri* (Fischer von Waldheim, 1822	1	0	0	0	0	0.2	md	mz	zo	cl
21	*C. cancellatus* Illiger, 1798	1	1	3	4	0	1.8	pt	mz	zo	df
22	*C. clathratus* Linnaeus, 1761	1	0	1	0	0	0.4	md	mh	zo	cm
23	*C. convexus* Fabricius, 1775	1	3	0	4	0	1.6	fr	mz	zo	cm
24	*C. coriaceus* Linnaeus, 1758	0	0	0	4	5	1.8	fr	mz	zo	cm
25	*C. estreicheri* Fischer von Waldheim, 1822	1	1	1	0	0	0.6	md	mz	zo	cm
26	*C. excellens* Fabricius, 1798	1	0	0	4	0	1.0	md	mz	zo	lm
27	*C. glabratus* Paykull, 1790	0	0	1	2	5	1.6	fr	mz	zo	cm
28	*C. granulatus* Linnaeus, 1758	2	2	3	4	1	2.4	pt	mz	zo	df
29	*C. hortensis* Linnaeus, 1758	0	0	0	1	0	0.2	fr	mz	zo	cm
30	*C. hungaricus scythus* Motschulsky, 1847	1	1	0	0	0	0.4	st	mx	zo	cl
31	*C. intricatus* Linnaeus, 1761	0	0	0	0	1	0.2	fr	mz	zo	cm
32	*C. linnaei* Panzer, 1810	0	0	0	0	2	0.4	fr	mz	zo	cm

No	Species	Dnipro	Donetsk	Kharkiv	Kyiv	Lviv	Total for five cities	Biotopic preferred range	Humidification preferred range	Trophic characterization	Soil texture preferred range
33	*C. marginalis* Fabricius, 1794	1	2	3	0	0	1.2	fr	mz	zo	cm
34	*C. menetriesi* Hummel, 1827	0	0	0	1	0	0.2	fr	hm	zo	lm
35	*C. nemoralis* O.Müller, 1764)	0	0	5	3	0	1.6	fr	mz	zo	lm
36 a	*C. perrini* Dejean, 1831	0	1	0	0	0	0.2	st	mx	zo	cm
36 b	*C. scabriusculus* Olivier, 1795	2	0	0	2	0	0.8	md	mz	zo	cm
37	*C. sibiricus errans* Fischer von Waldheim, 1823	0	2	0	0	0	0.4	md	mz	zo	cl
38	*C. sibiricus fossularius* Obydov, 2007	1	0	0	0	0	0.2	md	mz	zo	cm
39	*C. variolosus* Fabricius, 1787	0	0	0	0	1	0.2	fr	hm	zo	lm
40	*C. violaceus* Linnaeus, 1758	0	0	0	1	1	0.4	fr	mz	zo	lm
41	*Cychrus caraboides* (Linnaeus, 1758)	0	0	0	1	3	0.8	fr	mz	zo	lm
42	*Blethisa multipunctata* (Linnaeus, 1758)	1	0	0	0	0	0.2	md	mh	zo	lm
43	*Elaphrus uliginosus* (Fabricius, 1775)*	1	0	0	0	0	0.2	lt	hm	zo	lm
44	*Loricera pilicornis* (Fabricius, 1775)	1	0	1	1	1	0.8	md	mh	zo	lm
45	*Scarites terricola* Bonelli, 1813*	1	0	0	0	0	0.2	st	mz	zo	cm
46	*Clivina collaris* (Herbst, 1784)*	0	1	1	1	1	0.8	md	mh	zo	cm
47	*C. fossor* (Linnaeus, 1758)*	2	1	2	1	0	1.2	pt	mz	zf	df
48	*Dyschiriodes globosus* Herbst, 1783	1	0	1	0	1	0.6	md	mz	zo	df
49	*Broscus cephalotes* (Linnaeus, 1758)	3	1	3	3	0	2.0	md	mz	zo	df
50	*B. semistriatus* (Dejean, 1828)	1	1	0	0	0	0.4	md	mz	zo	cm
51	*Blemus discus* (Fabricius, 1792)	1	0	0	0	1	0.4	md	mz	zo	cm
52	*Trechus quadristriatus* (Schrank, 1781)	1	0	1	2	1	1.0	pt	mz	zo	df
53	*T. secalis* (Paykull, 1790)	0	0	0	0	2	0.4	fr	mz	zo	lm
54	*Tachys scutellaris* (Stephens, 1829)	1	0	`0	0	0	0.2	lt	mh	zo	cl
55	*Tachyta nana* (Gyllenhal, 1810)	1	1	1	2	0	1.0	fr	mz	zo	df
56	*Asaphidion flavipes* (Linnaeus, 1761)	2	2	3	2	0	1.8	md	mz	zo	cm
57	*A. pallipes* (Duftschmid, 1812)	2	1	2	2	0	1.4	md	mh	zo	cm
58	*Bembidion assimile* Gyllenhal, 1810	0	1	1	0	0	0.4	md	mh	zo	cm
59	*B. biguttatum* (Fabricius, 1779)	2	0	1	1	1	1.0	md	mz	zo	cm
60	*B. lampros* (Herbst, 1784)	4	1	1	1	2	1.8	md	mz	zo	cm
61	*B. nerescheimeri* J. Müller, 1929	0	0	0	0	3	0.6	md	mh	zo	cm
62	*B. properans* (Stephens, 1829)	2	2	2	2	1	1.8	pt	mz	zo	df
63	*B. quadrimaculatus* (Linnaeus, 1761)	0	1	1	1	0	0.6	md	mz	zo	cm
64	*B. tetracolum* Say, 1823	0	0	0	1	1	0.4	md	mz	zo	sl
65	*B. stomoides* (Dejean, 1831)	0	0	0	0	3	0.6	fr	mz	zo	cm
66	*B. varium* (Olivier, 1795)	2	0	1	2	0	1.0	lt	mh	zo	sl
67	*Patrobus atrorufus* (Ström, 1768)	0	1	0	1	3	1.0	fr	mz	zo	cm
68	*Abax carinatus* (Duftschmid, 1812)	0	0	0	3	4	1.4	fr	mz	zo	cm
69	*A. parallelus* (Duftschmid, 1812)	0	0	0	5	3	1.6	fr	mz	zo	cm
70	*A. parallelepipedus* (Piller et Mitterpacher, 1783)	0	0	0	4	3	1.4	fr	mz	zo	cm
71	*Molops piceus* (Panzer, 1793)	0	0	0	2	2	0.8	fr	mz	zf	cm
72	*Poecilus crenuliger* Chaudoir, 1876	2	1	1	0	0	0.8	st	mx	zo	cm
73	*P. cupreus* (Linnaeus, 1912)	4	2	2	3	1	2.4	pt	mz	zo	df
74	*P. koyi* Germar, 1823 (=*sericeus* F.-W., 1824)	2	1	1	0	0	0.8	md	mz	zo	cm
75	*P. puncticollis* (Dejean, 1828)	1	0	0	0	0	0.2	st	mx	zo	cm
76	*P. lepidus* (Leske, 1787)	0	0	0	3	0	0.6	fr	mz	zo	cm
77	*P. punctulatus* (Schaller, 1783)	2	1	1	1	0	1.0	md	mz	zo	df
78	*P. versicolor* (Sturm, 1824)	4	4	4	3	1	3.2	md	mz	zo	cm
79	*Pterostichus anthracinus* (Illiger, 1798)	2	1	1	1	1	1.2	md	mh	zo	lm
80	*P. diligens* (Sturm, 1824)	0	0	0	1	0	0.2	fr	mh	zo	lm
81	*P. elongatus* (Duftschmid, 1812)	1	0	0	0	0	0.2	md	mh	zo	sl
82	*P. gracilis* (Dejean, 1828)	1	0	1	1	0	0.6	md	mh	zo	lm
83	*P. macer* Marsham, 1802	1	0	0	0	0	0.2	md	mz	zo	cm
84	*P. melanarius* (Illiger, 1798)	5	5	5	5	5	5.0	pt	mz	zo	df
85	*P. melas* (Creutzer, 1799)	1	1	0	2	0	0.8	md	mz	zo	lm
86	*P. minor* (Gyllenhal, 1827)	1	0	0	1	4	1.2	md	mh	zo	lm
87	*P. niger* (Schaller, 1783)	3	2	1	3	5	2.8	fr	mz	zo	lm
88	*P. nigrita* (Paykull, 1790)	2	1	0	1	4	1.6	md	mh	zo	lm
89	*P. oblongopunctatus* (Fabricius, 1787)	5	5	4	5	5	4.8	fr	mz	zo	lm
90	*P. ovoideus* (Sturm, 1824)	3	4	3	0	0	2.0	md	mz	zo	cm
91	*P. strenuus* (Panzer, 1797)	2	4	1	3	4	2.8	md	mz	zo	cm
92	*P. quadrifoveolatus* (Letzner, 1852)	0	0	0	0	3	0.6	fr	mz	zo	lm
93	*P. rhaeticus* Heer, 1837	0	0	0	0	2	0.4	fr	mz	zo	lm
94	*P. vernalis* (Panzer, 1796)	2	0	1	1	0	0.8	md	mh	zo	cm
95	*Stomis pumicatus* (Panzer, 1796)	1	1	0	1	1	0.8	fr	mz	zo	cm
96	*Calathus ambiguus* (Paykull, 1790)	3	2	4	3	0	2.4	pt	mz	zo	df
97	*C. distinguendus* Chaudoir, 1846	0	3	0	0	0	0.6	st	mx	zo	cm
98	*C. erratus* (C.R. Sahlberg, 1827)	2	1	2	1	0	1.2	md	mz	zo	lm
99	*C. fuscipes* (Goeze, 1777)	4	1	4	4	0	2.6	pt	mz	zo	df
100	*C. melanocephalus* (Linnaeus, 1758)	2	3	2	3	0	2.0	pt	mz	zo	df
101	*Dolichus halensis* (Schaller, 1783)	1	1	1	2	0	1.0	md	mz	zo	cm
102	*Laemostenus terricola* (Herbst, 1783)*	1	2	1	0	0	0.8	md	mz	zo	cm
103	*Taphoxenus gigas* (Fischer von Waldheim, 1823)	1	0	0	0	0	0.2	st	mx	zo	cm
104	*Agonum duftschmidi* J. Schmidt, 1994	0	1	1	1	1	0.8	md	mh	zo	lm
105	*A. gracilipes* (Duftschmid, 1812)	0	1	1	0	0	0.4	md	mh	zo	df

No	Species	Dnipro	Donetsk	Kharkiv	Kyiv	Lviv	Total for five cities	Biotopic preferred range	Humidification preferred range	Trophic characterization	Soil texture preferred range
106	*A. lugens* (Duftschmid, 1812)	2	0	0	1	0	0.6	md	mh	zo	lm
107	*A. versutum* (Sturm, 1824)	1	0	1	0	0	0.4	md	mh	zo	lm
108	*A. viduum* (Panzer, 1797)	1	0	0	1	0	0.4	md	mh	zo	lm
109	*Oxypselaphus obscurum* (Herbst, 1784)	2	0	0	0	5	1.4	fr	mh	zo	lm
110	*Anchomenus dorsalis* (Pontoppidan, 1763)	3	5	4	4	1	3.4	pt	mz	zo	df
111	*Limodromus assimilis* (Paykull, 1790)	0	2	1	4	5	2.4	fr	mz	zo	lm
112	*L. krynickii* Sperk, 1835	2	0	0	0	0	0.4	fr	mh	zo	lm
113	*Synuchus vivalis* (Illiger, 1798)	1	1	1	1	1	1.0	fr	mz	zo	lm
114	*Amara aenea* (De Geer, 1774)	5	2	2	5	1	3.0	pt	mz	fz	df
115	*A. apricaria* (Paykull, 1790)	2	1	3	2	0	1.6	pt	mz	fz	df
116	*A. aulica* (Panzer,1797)	1	2	1	1	0	1.0	md	mz	zf	cm
117	*A. bifrons* (Gyllenhal, 1810)	0	0	3	1	0	0.8	md	mz	fz	sl
118	*A. brunnea* (Gyllenhal, 1810)	0	0	0	1	0	0.2	fr	mz	fz	lm
119	*A. communis* (Panzer, 1797)	3	1	1	3	0	1.6	fr	mz	fz	lm
120	*A. consularis* (Duftschmid, 1812)	1	1	1	2	0	1.0	pt	mz	zf	df
121	*A. convexior* Stephens, 1828	0	4	2	2	0	1.6	md	mz	zf	lm
122	*A. convexiuscula* (Marsham, 1802)	1	0	0	1	0	0.2	md	mz	zf	cm
123	*A. crenata* (Dejean, 1828)	1	0	0	0	0	0.2	st	mx	fz	cm
124	*A. equestris* (Duftschmid, 1812)	1	1	1	0	0	0.6	md	mz	zf	cm
125	*A. eurynota* (Panzer, 1797)	2	2	0	1	0	1.0	md	mz	fz	df
126	*A. famelica* C. Zimmermann, 1832	1	0	0	1	0	0.4	md	mz	fz	lm
127	*A. familiaris* (Duftschmid, 1812)	2	1	2	3	0	1.6	md	mz	fz	df
128	*A. fulva* (O. Müller, 1776)	1	0	1	0	0	0.4	md	mz	fz	sd
129	*A. ingenua* (Duftschmid, 1812)	2	1	0	1	0	0.8	md	mz	fz	sl
130	*A. littorea* C.G. Thomson, 1857	0	0	1	1	0	0.4	md	mz	fz	lm
131	*A. lunicollis* Schiódte, 1837	1	0	0	1	0	0.4	md	mz	fz	lm
132	*A. majuscula* (Chaudoir, 1850)	1	0	0	1	0	0.4	md	mz	fz	sl
133	*A. municipalis* (Duftschmid, 1812)	1	1	0	0	0	0.4	md	mz	fz	lm
134	*A. ovata* (Fabricius, 1792)	2	2	2	2	0	1.6	md	mz	fz	df
135	*A. plebeja* (Gyllenhal, 1810)	0	0	0	2	0	0.4	fr	mz	fz	lm
136	*A. similata* (Gyllenhal, 1810)	3	3	3	3	0	2.4	pt	mz	fz	df
137	*A. spreta* Dejean, 1831	0	0	0	1	0	0.2	md	mz	fz	cm
138	*A. tibialis* (Paykull, 1798)	0	0	0	1	0	0.2	md	mz	fz	lm
139	*A. tricuspidata* Dejean, 1831	1	0	0	1	0	0.4	md	mz	fz	cm
140	*Zabrus spinipes steveni* (Fischer von Waldheim, 1817)	2	1	0	0	0	0.6	st	mx	fz	cm
141	*Z. tenebrioides* (Goeze, 1777)	2	1	1	0	0	0.8	st	mz	ff	cm
142	*Anisodactylus binotatus* (Fabricius, 1787)	2	1	2	1	1	1.4	md	mz	zf	lm
143	*A. nemorivagus* (Duftschmid, 1812)	1	0	0	1	0	0.4	fr	mz	zf	lm
144	*A. poeciloides pseudoaeneus* Dejean, 1829	1	0	0	0	0	0.2	st	mz	zf	sl
145	*A. signatus* (Panzer, 1797)	2	1	1	1	1	1.2	pt	mz	zf	df
146	*Acupalpus meridianus* (Linnaeus, 1767)	1	1	1	2	0	1.0	pt	mz	fz	df
147	*A. exiguus* (Dejean, 1829)	0	0	0	1	1	0.4	fr	mh	fz	lm
148	*Diachromus germanus* (Linnaeus, 1758)	1	0	0	0	0	0.2	md	mz	zf	cm
149	*Bradycellus verbasci* (Duftschmid, 1812)	0	0	0	1	0	0.2	fr	mz	fz	lm
150	*Dicheirotrichus ustulatus* (Dejean, 1829)	1	0	0	0	0	0.2	md	mh	zf	sl
151	*Stenolophus abdominalis persicus* (Mannerheim, 1844)	2	0	0	0	0	0.4	lt	mh	zf	sl
152	*S. discophorus* (Fischer von Waldheim, 1823)	1	0	0	0	0	0.2	lt	mh	fz	sl
153	*S. mixtus* (Herbst, 1784)	2	1	1	1	1	1.2	lt	mh	zf	sl
154	*S. proximus* (Dejean, 1829)	1	0	0	0	0	0.2	lt	mh	zf	sl
155	*S. teutonus* (Schrank, 1781)	2	0	1	1	0	0.8	lt	mh	zf	sl
156	*Harpalus affinis* (Schrank, 1781)	3	2	5	2	0	2.4	md	mz	zf	df
157	*H. amplicollis* Menetries, 1848	2	0	2	1	0	0.8	st	mx	zf	cm
158	*H. anxius* Duftschmid, 1812	2	2	2	3	0	1.8	pt	mz	zf	df
159	*H. atratus* (Latreille, 1804)	0	1	2	0	0	0.6	fr	mz	zf	lm
160	*H. autumnalis* (Duftschmid, 1812)	0	0	1	0	0	0.2	md	mz	fz	cm
161	*H. calceatus* (Duftschmid, 1812)	2	1	0	1	0	0.8	pt	mz	zf	cm
162	*H. caspius* (Steven, 1806)	1	1	1	1	0	0.8	md	mz	zf	lm
163	*H. distinguendus* (Duftschmid, 1812)	5	2	5	4	1	3.4	pt	mz	zf	df
164	*H. flavicornis* Dejean, 1829	0	1	0	0	0	0.2	md	mz	zf	lm
165	*H. froelichi* Sturm, 1818	1	1	1	1	0	0.8	pt	mz	zf	cm
166	*H. fuscipalpis* (Sturm, 1818)	2	0	0	0	0	0.4	st	mz	zf	cm
167	*H. griseus* (Panzer, 1797)	3	1	5	2	0	2.2	pt	mz	zf	cm
168	*H. hirtipes*(Panzer, 1796)	0	0	1	0	0	0.2	md	mz	zf	cm
169	*H. laeviceps* Zetterstedt, 1828 (=*quadripunctatus* Dej., 1829)	0	2	1	2	0	1.0	fr	mz	zf	lm
170	*H. latus* (Linnaeus, 1758)	3	4	3	2	0	2.4	fr	mz	zf	lm
171	*H. luteicornis* (Duftschmid, 1812)	0	0	1	1	1	0.6	fr	mz	zf	lm
172	*H. melancholicus* Dejean, 1829	1	0	0	0	0	0.2	st	mx	zf	lm
173	*H. modestus* Dejean, 1829	0	0	2	0	0	0.4	st	mx	fz	cm
174	*H. picipennis* Duftschmid, 1812	1	1	1	0	0	0.6	md	mx	zf	df
175	*H. politus* Dejean, 1829	0	0	1	0	0	0.2	md	mx	zf	cm
176	*H. progrediens* (Schauberger, 1922)	0	0	0	0	1	0.2	fr	mz	zf	cm
177	*H. pumilus* (Sturm, 1818)	0	1	2	2	0	1.0	md	mz	fz	cm
178	*H. pygmaeus* Dejean, 1829	0	0	1	0	0	0.2	fr	mz	zf	cm

No	Species	Dnipro	Donetsk	Kharkiv	Kyiv	Lviv	Total for five cities	Biotopic preferred range	Humidification preferred range	Trophic characterization	Soil texture preferred range
179	*H. rubripes* (Duftschmid, 1812)	0	1	1	3	0	1.0	md	mz	zf	df
180	*H. rufipes* (De Geer, 1774)	5	5	5	4	1	4.0	pt	mz	zf	df
181	*H. serripes* (Quensel, 1806)	1	1	1	1	0	0.8	md	mz	zf	df
182	*H. servus* (Duftschmid, 1812)	1	0	0	0	0	0.2	st	mx	fz	sl
183	*H. signaticornis* (Duftschmid, 1812)	0	0	1	0	0	0.2	md	mz	zf	lm
184	*H. smaragdinus* (Duftschmid, 1812)	3	1	3	1	0	1.6	md	mz	zf	df
185	*H. subcylindricus* Dejean, 1829	0	1	1	0	0	0.4	st	mx	zf	cm
186	*H. tardus* (Panzer, 1797)	2	3	4	3	0	2.4	md	mz	fz	cm
187	*H. tenebrosus* Dejean, 1829	0	0	1	0	0	0.2	st	mz	zf	cm
188	*H. xanthopus winkleri* Schauberger, 1923	2	1	3	1	0	1.4	md	mz	zf	lm
189	*H. zabroides* Dejean, 1829	1	1	0	0	0	0.4	md	mx	zf	cm
190	*Ophonus azureus* (Fabricius, 1775)	1	1	1	2	0	1.0	md	mz	zf	df
191	*O. cordatus* (Duftschmid, 1812)	0	0	1	0	0	0.2	md	mz	zf	lm
192	*O. diffinis* (Dejean, 1829)	0	0	1	0	0	0.2	md	mx	zf	lm
193	*O. laticollis* (Mannerheim, 1825)	1	2	0	1	0	0.8	md	mz	zf	df
194	*O. puncticollis* (Paykull, 1798)	0	1	0	2	0	0.6	md	mz	zf	lm
195	*O. rufibarbis* (Fabricius, 1792)	0	1	0	0	1	0.4	md	mz	zf	lm
196	*O. subquadratus* (Dejean, 1829)	0	1	0	0	0	0.2	st	mz	zf	lm
197	*O. shaubergerianus* Puel, 1937	0	0	0	1	0	0.2	md	mx	zf	lm
198	*O. rufibarbis* (Fabricius, 1792)	1	0	1	0	1	0.6	md	mz	zf	lm
199	*Trichotichnus laevicollis* (Duftschmid, 1812)	0	0	0	0	3	0.6	fr	mz	zf	lm
200	*Panagaeus bipustulatus* (Fabricius, 1775)	1	2	2	1	0	1.2	md	mz	zo	lm
201	*P. cruxmajor* (Linnaeus, 1758)	1	0	0	0	0	0.2	fr	mz	zo	lm
202	*Chlaenius aeneocephalus* (Dejean, 1826)	1	1	0	0	0	0.4	st	mz	zo	cl
203	*Ch. nitidulus* (Schrank, 1781)	0	0	0	1	1	0.4	lt	mh	zo	lm
204	*Ch. tristis* (Schaller, 1783)	1	1	1	0	0	0.6	md	mz	zo	df
205	*Ch. vestitus* (Paykull, 1790)	0	1	0	1	0	0.4	lt	hm	zo	sl
206	*Dinodes decipiens* (Dufour, 1820)	1	1	0	0	0	0.4	st	mx	zo	cm
207	*Oodes gracilis* (A. Villa et G.B. Villa, 1833)	1	0	0	0	0	0.2	md	mh	zf	lm
208	*O. helopioides* (Fabricius, 1792)	1	0	1	0	1	0.6	md	mh	zf	lm
209	*Badister bullatus* (Schrank, 1798)	2	3	2	2	0	1.8	md	mz	zo	lm
210	*B. dilatatus* (Chaudoir, 1837)	0	1	1	0	0	0.4	md	hm	zo	lm
211	*B. lacertosus* Sturm, 1815	1	0	0	0	1	0.4	fr	mh	zo	lm
212	*B. meridionalis* Puel, 1925	1	0	0	0	0	0.2	md	mh	zo	lm
213	*B. sodalis* (Duftschmid, 1812)	0	0	0	1	1	0.4	fr	hm	zo	lm
214	*B. unipustulatus* Bonelli, 1813	1	1	1	1	0	0.8	md	mh	zo	lm
215	*Licinus cassideus* (Fabricius, 1792)	1	0	1	0	0	0.4	md	mz	zo	cm
216	*L. depressus* (Paykull, 1790)	2	2	2	1	0	1.4	md	mz	zo	df
217	*L. silphoides* (P. Rossi, 1790)	0	1	0	0	0	0.2	st	mx	zo	lm
218	*Masoreus wetterhalli* (Gyllenhal, 1813)*	1	0	2	0	0	0.6	fr	mz	zf	lm
219	*Odacantha melanura* (Linnaeus, 1767)	1	0	0	0	0	0.2	md	mz	zo	lm
220	*Lebia cyanocephala* (Linnaeus, 1758)	0	1	0	1	0	0.4	md	mz	zo	df
221	*Demetrias monostigma* Samouelle, 1819	1	0	0	0	0	0.2	md	mz	zo	lm
222	*Dromius quadrimaculatus* (Linnaeus, 1758)	1	0	1	1	0	0.6	fr	mz	zo	lm
223	*Microlestes maurus* (Sturm, 1827)	0	1	1	0	0	0.4	md	mz	zf	lm
224	*M. minutulus* (Goeze, 1777)	3	3	2	2	0	2.0	pt	mz	zo	df
225	*M. negrita* (Wollaston, 1854)	0	1	1	0	0	0.4	st	mx	zo	cm
226	*M. plagiatus* (Duftschmid, 1812)	1	0	0	0	0	0.2	md	mx	zo	cm
227	*Syntomus foveatus* (Fourcroy, 1785)	1	0	0	0	0	0.2	md	mz	zo	cm
228	*S. obscuroguttatus* (Duftschmid, 1812)	1	1	0	0	0	0.4	md	mz	zo	cm
229	*S. pallipes* (Dejean, 1825)	0	0	1	1	0	0.4	md	mz	zo	lm
230	*S. truncatellus* (Linnaeus, 1761)	2	1	1	1	0	1.0	md	mz	zo	cm
231	*Cymindis cingulata* Dejean, 1825	0	0	0	0	1	0.2	fr	mz	zo	lm
232	*Drypta dentata* (Rossi, 1790)	1	0	1	1	0	0.6	md	mz	zo	lm
233	*Polystichus connexus* (Geoffroy, 1785)	0	1	0	0	0	0.2	st	mx	zo	sd
234	*Brachinus brevicollis* Motschulsky, 1844	1	0	0	0	0	0.2	st	mz	zo	sl
235	*B. crepitans* (Linnaeus, 1758)	2	2	1	1	0	1.2	md	mz	zo	df
236	*B. ejaculans* Fischer von Waldheim, 1829	1	0	0	0	0	0.2	md	mh	zo	lm
237	*B. elegans* Chaudoir, 1842	0	1	0	0	0	0.2	md	m	zo	lm
	Total number of species per city (number of species/their share in the number of all species) including:	156/ 100.0	119/ 100.0	125/ 100.0	137/ 100.0	66/ 100.0	237/ 100.0	–	–	–	–
	Eudominants	5/3.2	4/3.4	6/4.8	4/2.9	8/12.1	3/1.2	–	–	–	–
	Dominants	4/2.6	6/5.0	6/4.8	12/8.8	5/7.6	5/2.1	–	–	–	–
	Subdominants	13/8.3	9/7.6	15/12.0	17/12.4	9/13.6	25/10.5	–	–	–	–
	Recedents	47/30.2	24/20.2	24/19.2	31/22.6	5/7.6	53/22.4	–	–	–	–
	Occasional species (subrecedents)	87/55.7	76/63.8	74/59.2	73/53.3	39/59.1	151/63.8	–	–	–	–

Note: abundance for separate cities (explanation of the levels of abundance – see the section Material and Methods): 0 – species is absent from the collections, 1 – occasional species, 2 – rare species (recedent), 3 – subdominant species, 4 – common species (dominant), 5 – abundant species (eudominant); in general for all the metropolises (points): 4.0–5.0 – eudominants, 3.0–3.9 – dominants, 1.7–2.9 – subdominants, 1.0–1.6 – recedents, 0.2–0.8 – subrecedents; * – species is not reported for Ukraine in the catalogue of Palearctic (Catalogue of Palearctic Coleoptera, 2017); biotopic distribution: pt – polytopic, fr – forest, st – steppe, md – meadow, lt – littoral; hygropreferendum: mx – mesoxerophylous, mz – mesophylous, hm – hygromezophilous, mh – mesohygrophylous; trophic specialization: ff – phytophagous, zf – zoophytophagous, fz – phytozoophagous, zo – zoophagous; preferred mechanical composition of soils: df – different soil texture, sd – sandy, sl – sand loamy, lm – loam, cm – clay loamy, cl – clay.

Table 2
Number of species of ground beetles of different ecological groups for metropolises (species in total, in brackets – the number of common species)

Type of classification	Ecological groups	Dnipro	Donetsk	Kharkiv	Kyiv	Lviv	Total
Habitat preference	pt – polytopic	24 (11)	23 (6)	24 (11)	25 (13)	10 (1)	25 (16)
	fr – forest	21 (4)	17 (6)	20 (5)	39 (14)	35 (17)	59 (7)
	st – steppe	15 (0)	13 (1)	7 (1)	1 (0)	0 (0)	23 (10)
	md – meadow	87 (7)	64 (6)	71 (11)	67 (7)	19 (4)	119 (0)
	lt – littoral	9 (0)	2 (0)	3 (0)	5 (0)	2 (0)	11 (0)
Hydropreference	mx – mesoxerophylous	13 (0)	12 (1)	8 (0)	2 (0)	0 (0)	23 (0)
	mz – mesophylous	111 (22)	95 (16)	97 (27)	111 (33)	48 (17)	165 (31)
	hm – hygromesophylous	1 (0)	2 (0)	1 (0)	3 (0)	2 (0)	6 (0)
	mh – mesohygrophylous	31 (0)	10 (1)	19 (0)	21 (1)	16 (5)	43 (2)
Trophic specialisation	zo – zoophagous;	97 (13)	72 (13)	72 (15)	82 (25)	52 (21)	146 (24)
	fz – phytozoophagous	20 (3)	13 (2)	13 (4)	23 (5)	2 (0)	30 (2)
	zf – zoophytophagous	38 (6)	33 (3)	39 (10)	31 (4)	12 (1)	60 (7)
	ff – phytophagous	1 (0)	1 (0)	1 (0)	0 (0)	0 (0)	1 (0)
Soil texture preference	df – different soil texture	38 (13)	39 (7)	38 (14)	37 (16)	11 (1)	41 (17)
	sd – sand	4 (0)	1 (0)	2 (0)	3 (0)	0 (0)	6 (0)
	sl – sandy loamy	13 (0)	3 (0)	4 (1)	8 (1)	2 (0)	16 (0)
	lm – loam	44 (4)	30 (4)	36 (4)	49 (7)	30 (11)	85 (6)
	cm – clay loamy	53 (5)	43 (7)	45 (7)	40 (11)	23 (10)	85 (10)
	cl – clay	4 (0)	3 (0)	0 (0)	0 (0)	0 (0)	4 (0)

Among the studied communities of beetles, four types of ecological classification were distinguished: according to biotopic confinement, hygropreferendum, trophic characteristic and soil structure preference (Table 1, 2, Fig. 1). This division to some extent is conditional, but in general characterizes ecological peculiarities of carabidofauna of one or the other metropolises. Their analysis is presented in the discussion of the results (as well as the analysis of the taxonomic structure).

Discussion

Caraboid beetles (Coleoptera, Caraboidea) recorded in urbocenoses in all the metropolises are one of the dominating groups of coleopterans. In the epigeal habitat, they exceeded the quantitative parameters of such large families such as Staphylinidae and Curculionidae (Nazarenko & Petrenko, 2008; Brygadyrenko, 2015b; Komaromi et al., 2018; Nazarenko et al., 2020; Putchkov et al., 2020). The number of species of caraboid beetles was almost twice the number of species of these families, and according to abundance they were also dominant (up to 60% of all beetles in the litter fauna of urbocenoses).

On the basis of abundance of species of Carabidae in general for all metropolises, only three species were identified to typical eudominants: *Harpalus rufipes*, *Pterostichus melanarius* and *P. oblongopunctatus*. Common (dominants) were five species: *Amara aenea*, *Anchomenus dorsalis*, *Calathus fuscipes*, *Harpalus distinguendus* and *Poecilus versicolor*. Subdominants were represented by 25 species (10.5% of species composition of ground beetles): *Amara similata*, *Asaphidion flavipes*, *Badister bullatus*, *Bembidion lampros*, *B. properans*, *Broscus cephalotes*, *Calathus ambiguus*, *C. melanocephalus*, *Carabus cancellatus*, *C. coriaceus*, *C. granulatus*, *Cylindera germanica*, *Harpalus affinis*, *H. anxius*, *H. griseus*, *H. latus*, *H. tardus*, *Limodromus assimilis*, *Microlestes minutulus*, *Nebria brevicollis*, *Notiophilus palustris*, *Poecilus cupreus*, *Pterostichus niger*, *P. ovoideus* and *P. strenuus*. That is, in general, 33 species could be identified (13.9% of total number of species of Carabidae) to common species of ground beetles (eudominant, dominant and subdominant species) recorded in urbocenoses of all the metropolises we surveyed. Rare species (recedents) were represented by 53 species (22.4%) and occasional (subrecedents) – 151 (63.7%) species (Tables 1, 2).

The situation for the cities varied. The number of eudominants was 4 (Donetsk, Kyiv) to 6–8 species (Kharkiv, Lviv). The highest (but practically equal) parameters were seen for dominant species and subdominants (Tables 1, 2). However, the number of rare and subrecedent species for separate cities varied more greatly. Their higher number was observed in Dnipro (47 and 87 species or respectively 30% and 55% of all the species of ground beetles). In Donetsk, Kharkiv and Kyiv, these groups included 24–31 rare and 73–76 occasional species (respectively 19–23% and 53–64% of all the species of ground beetles). In the carabidofauna of Lviv, the number and the share of rare and occasional species was minimum (respectively 5 rare and 39 occasional species). Moreover, in separate cities, sometimes the numerically dominant species were those which had a comparatively low average share in total for all metropolies taken as a whole. Apart from the abovementioned mass and common species same for the metropolises, one of the eudominants in the parks of Kharkiv was *Carabus nemoralis*, in Donetsk – *Amara convexior*, *Notiophilus palustris* and *Pterostichus strenuus*; Dnipro – *Poecilus cupreus* and *Bembidion lampros*, Kyiv – species of *Abax* genus and some of *Carabus* (*C. cancellatus*, *C. convexus*, *C. excellens*). Only in Lviv, the dominants were *Oxypselaphus obscurum*, *Carabus arcensis* and *C. glabratus*, absent in other metropolises. Moreover, in the latter two cities, the common species were also the ones not recorded in other metropolises (*Nebria brevicollis*, *Limodromus assimilis*). The species *Pterostichus minor* and *P. nigrita* also dominated only in Lviv, similarly to *Amara communis* in Dnipro and Kyiv.

The indicators of number we presented both for separate species and overall, indicate significant faunistic oligodominance of the carabidofaunas in different metropolises (especially at the level of abundant species), the specificity of their carabidofauna. In general, the total level of species diversity of Carabidae in urbocenoses was closer to that in agrocenoses of different regions of Ukraine according to the main parameters of biodiversity than to taxonomically more evenly natural ecosystems, especially in the comparative aspect of their faunas (Putchkov, 2018).

There were some faunistically interesting discoveries of some species of ground beetles. As many times mentioned earlier (Putchkov, 2018), seven species – *Clivina collaris*, *C. fossor*, *Elaphrus uliginosus*, *Laemostenus terricola*, *Masoreus wetterhalli*, *Notiophilus germinyi* and *Scarites terricola* were not reported for Ukraine in the latest Catalogue of Palearctic Coleoptera (2017). This does not mean that they were not indicated for the country earlier (Komaromi et al., 2018; Putchkov, 2018), but indicates insufficient familiarization of authors of the Catalogue with separate literature sources on carabidofauna of Ukraine. Many data on these findings were published in articles and reports in Ukrainian or Russian languages, complicating the research on them for foreign coleopterologists (mainly European).

However, regarding peculiarities of geographic distribution in Ukraine of a number of species of ground beetles (around 20), certain elaborations were made during the comparison with the latest check-list of Caraboidea of Ukraine (Putchkov, 2018). Therefore, discoveries of ten species (*Amara famelica*, *A. majuscula*, *Anisodactylus nemorivagus*, *Badister lacertosus*, *Blemus discus*, *Limodromus krynickii*, *Pterostichus minor*), recorded in urbocenoses of Dnipro, and also *Asaphidion pallipes*, *Tachyta nana* (Dnipro and Donetsk) and *Harpalus laeviceps* (Donetsk) were new for the steppe zone of Ukraine. Species *Chlaenius aeneocephalus* and *Brachinus brevicollis* were recorded for the first time in the Right Bank part of the northern subzone of Steppe Ukraine (Dnipro). Northward range extensions were confirmed for the typical

steppe species *Taphoxenus gigas* (south of Foresst Steppe), and *Stenolophus abdominalis*, indicated for the far south of Ukraine, was reported for the first time for the northern steppe subzone (both species in Dnipro). The species *Microlestes negrita* was found for the first time in the Forest Steppe (Kharkiv), and *Masoreus wetterhalli* (Kharkiv) and *Syntomus foveatus* (Dnipro), known earlier for the forest zone and the south of the Steppe, were for the first time recorded in the northern subzone and the Forest Steppe. Furthermore, discoveries of *Calathus distinguendus* (Donetsk), distribution of which in Ukraine is studied insuficiently, were confirmed in the northern steppe subzone (Putchkov & Aleksandrowicz, 2020). All the given information about new findings was quite predictable (taking into consideration the general ranges of these species), but indicates the insufficient degree of the research on the distribution of many species of ground beetles in Ukraine.

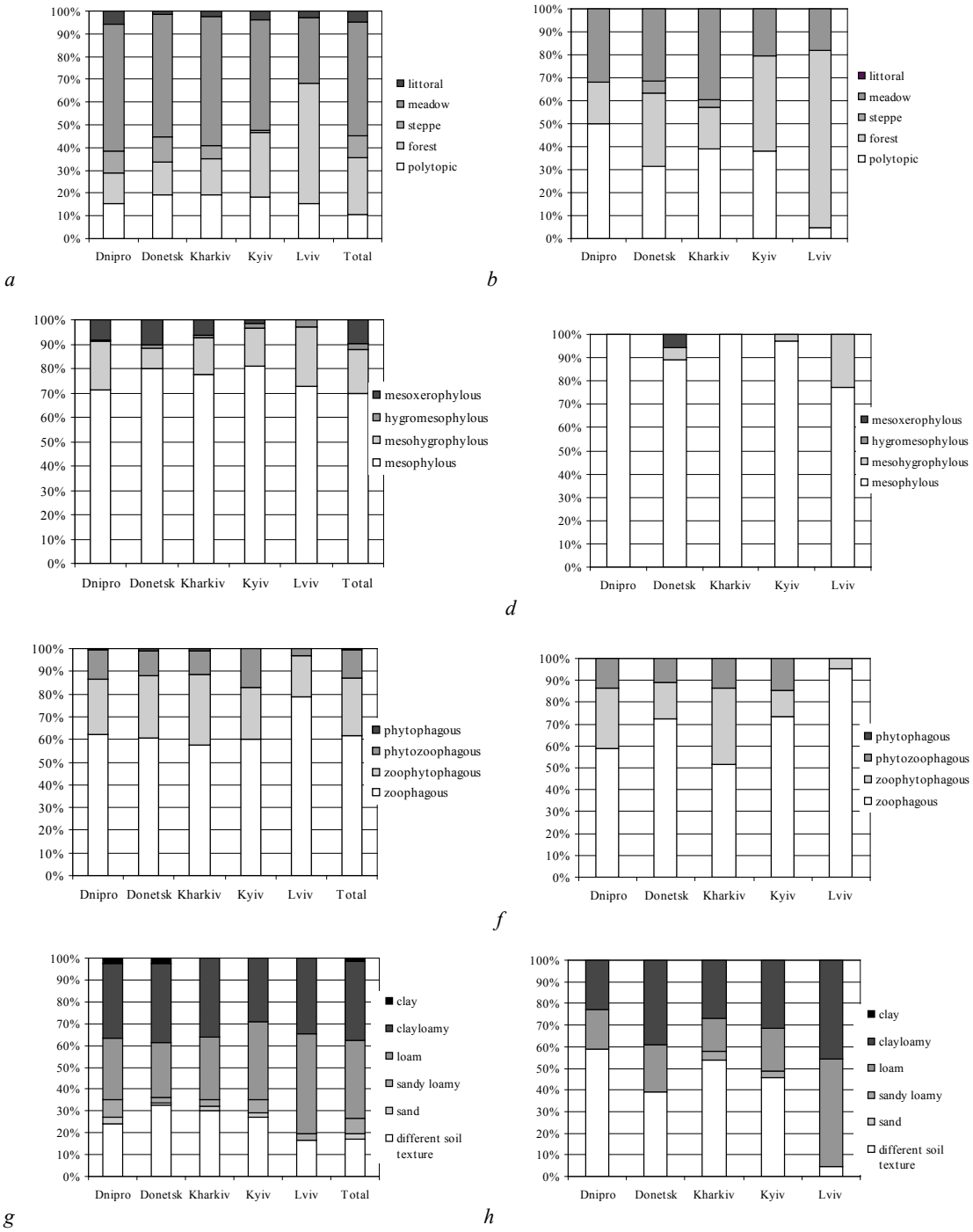

Fig. 1. Ratio (%) of the number of species of ground beetles and tiger beetles of different ecological groups in metropolises (*a*, *c*, *e*, *g*) and abundant species (*b*, *d*, *f*, *h*) in the cities of Ukraine

Differences in qualitative and quantitative parameters of the communities of Carabidoidea in the cities revealed significant differences in their faunistic similarity (Fig. 2*a*). In the comparison of all carabidofauna, the Jaccard coefficients ranged within 0.20–0.60. The lowest similarity was seen between Lviv and the other cities. More similar were the carabidofaunas of Kharkiv and Donetsk (around 0.60), these parameters were slightly lower between Dnipro and Kyiv (around 0.50). A similar situation was revealed also by comparing the abundant species of ground beetles (eudominant, dominant and subdominant species) in different metropolises, but with far higher indicators (Fig. 2*b*). Jaccard coefficient equaled 0.32–0.87. Similarity of Caraboidea of Kyiv and most cities was 0.72, and between Dnipro, Donetsk and Kharkiv reached over 0.83. The highest similarity was seen between Donetsk and Kharkiv (0.87), which is not surprising (considering the proximity of these

metropolises, especially according to longitude). Minimum indicators were seen for Lviv and other metropolises (0.32), but they were one and a half times higher than in the comparison of all the carabidofauna (Fig. 3*a*). Average value of the variation of the Jaccard coefficient accounted for 0.40–0.55, which could suggest sufficient similarity of Caraboidea of all the studied metropolises.

The levels of the indicators given above could indicate comparatively low differences in the main component of the carabidofauna of most cities as a result of comparatively close zonal conditions. Kyiv and Kharkiv are located in the forest steppe zone, and Dnipro and Donetsk – in the northern steppe subzone neighbouring with the Forest Steppe. Faunistic originality of carabidofauna of Lviv is due to its location in the subzone of broad-leaves forests, where the taxonomic composition of ground beetles is quite specific compared with other geographic regions of Ukraine. A certain role also belongs to the Carpathians, some specific representatives of whose fauna penetrate the western part of the forest zone of Ukraine.

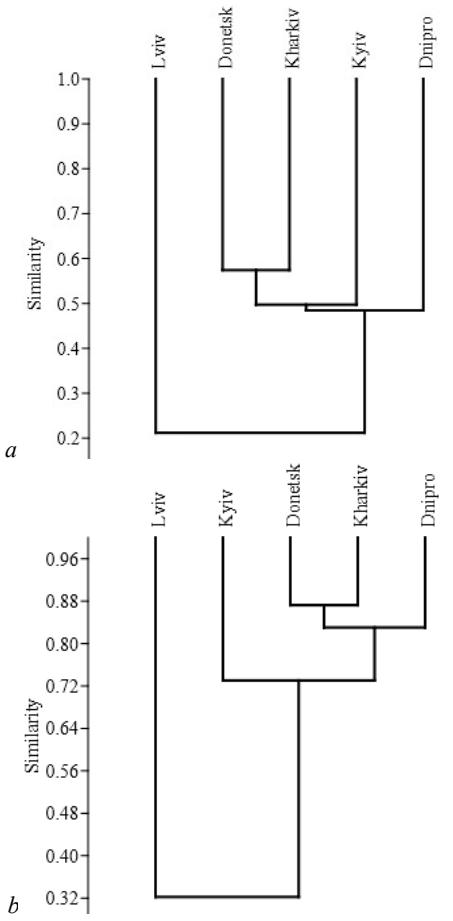

Fig. 2. Cluster analysis of similarity according to the Jacquard index of the entire carabidofauna of the megalopolises (*a*) and the abundant species (*b*)

A no less important aspect which underlies the differences in abundance and faunistic similarity is also the peculiarities of the ecological structure of the community of ground beetles in metropolises (Tables 1, 2). According to their lifestyle, peculiarities of diet and habitat distribution of species, all of the Caraboidea recorded in the urbocenoses could be divided according to several main ecological principals: biotopic distribution, hygropreferendum, trophic specialization and soil characteristics of their environments. To some extent, such approaches are subjective, and in some studies of the other researchers, the same species could be identified to different (but close) groups or subgroups (Brygadyrenko, 2015a, 2015c, 2016).

The structure of carabidofauna was quite diverse regarding biotopic preferendum, and therefore was considered only within four large groups: polytopic, meadow, forest and littoral. Based on the overall composition of the communities of ground beetles of the cities we studied, the faunistically most numerous were meadow (119) and forest elements (59 species, Fig. 1). Among the polytopic group, 25 species were noted, the steppe group was represented by 23 species, and among littoral (coastal), 11 species were recorded (Table 2, Fig. 1). However, in quantitative aspect, almost in all the metropolises we surveyed, the polytopic group dominated, in which common species formed almost the half (except Lviv). Among the forest complex in Dnipro, Donetsk and Kharkiv, 4–6 common species were recorded (13–16% of all carabidofauna), whereas in Kyiv and Lviv their number equaled almost third (14–17 species, 28–53%, Fig. 1). Despite the fact that meadow elements dominated in almost all cities (64–87 species), abundant elements of this group accounted for 8–15% (4–11 species). Most of the steppe species (13–15) were seen in Dnipro and Donetsk, fewer in Kharkiv (7) and only a couple in Kyiv (Fig. 1). Abundant species among this group were not found, though in southern cities, certain steppe elements could reach the level of subdominants (for example *Calathus distinguendus* in Donetsk or *Zabrus tenebrioides* in Dnipro). The number of littoral elements ranged from two (Donetsk, Lviv) to nine (Dnipro), but no abundant species were recorded among them (Table 2, Fig. 1).

According to the general (point) assessement of abundance of abundant species of ground beetles, in total in the studied cities, the basis for carabidofauna comprised polytopic (16 species) and meadow elements (10 species), less – forest inhabitants, represented by 7 species (Table 2; Fig. 1). At the same time, among eudominant and dominants, polytopic elements were represented by six species, whereas meadow and forest – one species each.

The data above in many aspects vary. The complexity of the analysis of biotopic structure among such large groups as forest and meadow species (less – among the litorral group) is due to the presence of some transitional groups (around 10), which (for facilitating the analysis) are intentionally not distinguished and discussed. Most species of these subgroups were recorded as recedents or subrecedents, but certain representatives sometimes were recorded as subdominants in separate cities. Therefore, among the forest group, forest-shrub groups (about 20 species) were recorded, many of which were sporadically subdominants (*Amara plebeja*, *Anisodactylus binotatus*, *Asaphidion pallipes*, *Calosoma inquisitor*, *Carabus violaceus*, *Harpalus xanthopus winkleri*, *Leistus ferrugineus*, *Masoreus wetterhalli*, *Odacantha melanura*, *Stomis pumicatus*). Among the flood plain-forest subgroup in urbocenoses, around 10 rare species were recorded (*Badister lacertosus*, *B. sodalis*, *Oxypselaphus obscurum* and others). There were also recorded forest-marsh elements (*Acupalpus exiguus*, *Carabus menetriesi*, *C. variolosus*). To the meadow group, almost 40 representatives of the subgroup of meadow-steppe species were identified, some of which were subdominants and also dominants in some cities (*Carabus excellens*, *C. scabriusculus*, *Harpalus caspius*, *H. pumilus*, *H. serripes*, *Licinus depressus*, *Poecilus koyi*, *P. punctulatus*, most species of the *Metophonus subgenus*), and also around 20 meadow-shrub species (*Amara communis*, *A. familiaris*, *A. ingenua*, *A. ovata*, *Brachinus crepitans*, *Calathus erratus*, *Harpalus rubripes*, *H. smaragdinus*, *H. tardus*, *Ophonus laticollis* many *Syntomus*). In the group of littoral species, not only typical elements were included (for example most of species of *Bembidion* and *Stenolophus* genera), but also inhabitants of humid flood-plain meadows – in total about 10 rare species (*Brachinus ejaculans*, *Chlaenius tristis*, most of the species of *Agonum*, *Badister* and *Oodes* genera). However, the diversity of littoral species in some cities (for example, Dnipro and Kyiv) is obviously higher due to the quite rich littoral carabidofauna, study of which was not included in the objectives of these researches.

According to other ecological characteristics, a handful of halophilic species of ground beetles were also recorded – *Anisodactylus poeciloides pseudoaeneus*, *Brachinus brevicollis*, *Dicheirotrichus ustulatus*, *Poecilus puncticollis*, *Tachys scutellaris*, mainly in separate urbocenoses of Dnipro.

Regarding moisture, the eudominant species were typical mesophilous (165 species, i.e. over third of all the ground beetles). At the same time, there was an especially high number of mesophilous abundant species (16–33 species for different cities, around 94% of all carabidofauna (Table 2, Fig. 1). In general, the ratio of mesophilous for

different cities varied insignificantly. Mesoxerophilous and mesohygrophilous were represented by 23 and 43 species, almost all of which were recorded as rare or occasional (Fig. 1). Only three mesohygrophilous – *Nebria brevicollis*, *Oxypselaphus obscurum* and *Pterostichus minor* (some of dominants in Kyiv and Lviv) were sporadically recorded as subdominants (Table 1). The share of mesohygrophilous in Dnipro and Lviv was slightly higher than in Kharkiv and Kyiv, but nonetheless minimum in Donetsk. However, for mesoxerophilous, the reverse situation was seen: they were observed more often in Dnipro and Donetsk, more rarely – in Kyiv and Kharkiv and were absent in Lviv.

According to trophic specialization, four groups were distinguished, of which the dominant were zoophages of different specialization (146 species in total and over 60% of all the carabidofauna). Among abundant species, zoophagous were also eudominants (24 of 33 species, Table 2, Fig. 1). They all were represented both by obligatory predators (species of the tribes Bembidiini, Brachinini, Broscini, Carabini, Chlaenini, Cicindelini, Licinini, Lebiini, Nebriini and Notiophilini) and principal zoophages of the tribes Pterostichini, Platinini, Sphodrini and some others (Korolev & Brygadyrenko, 2014; Putchkov, 2018). The zoophages were also fairly diverse (60 species, over 25% of all the carabidofauna), including seven species identified to abundant (Fig. 1). The major share of this group comprised species of the Harpalini tribe. Among the phytozoohages, 30 species were seen (mostly of Zabrini tribe), including two species (*Amara aenea* and *A. similata*) identified to abundant (Table 2, Fig. 1).One species, *Zabrus tenebrioides*, was identified to phytophages; it was rarely recorded as subdominant in the urbocenoses of Dnipro. However, the closely related *Z. spinipes* was classified to phytozoophages and seen in the cities as rare or occasional. In general, proportion of the three main trophic groups in the cities differed insignificantly (Table 2, Fig. 1).

Most complicated and to a large degree conditional was the division of ground beetles into groups regarding the confinement to different types of soils and their mechanical composition. More accurate data could be obtained only as a result of studying the distribution and abundance of larvae of ground beetles, data on which are so far insufficient (we used the data on 82 species). In the absence of such material, the species were divided into soil groups provisionally, taking into consideration the peculiarities of quantitative distribution and abundance of imagoes both according to our observations and based on a number of literature sources generalized in some studies (Sharova, 1981; Brygadyrenko, 2015a, 2015c, 2016; Putchkov, 2018). In total, six groups of species of Carabidae were distinguished in terms of preference for one or the other mechanical composition of soil (Fig. 1). The most diverse groups comprised species which prefer loamy and clayey-loamy soils – 85 species in each, in total accounting for over 70% of species composition. However, abundant elements among these groups were only 6 of 10 species respectively (Table 2, Fig. 1). Quite richly represented was the group of ground beetles without clear preferences for mechanical composition of soil, to which 41 species were identified (17.3% of all the carabidofauna). However, by the number of common species, this group dominated and included 17 species – i.e. over the half of the abundant and common ground beetles. Six and sixteen species, among which no species were found abundant for the cities, were identified to the inhabitants of sandy and sabulous soils. The number of species which are associated with heavy clayey soils was minimum, most likely due to poor degree of study on such inhabitants (Table 2, Fig. 1).

In general, as well as according to taxonomic composition (Fig. 1), the ecological structure of the communities of ground beetles of most Ukrainian metropolises (based on the main characteristics) was more specific in the comparison of all carabidofauna (i.e. both abundant and rare species). However, comparison of only abundant species in the cities revealed quite close similarity of their carabidofaunas, especially by proportions of different ecological groups (differences for different metropolises equaled more than 10% – Table 2, Fig. 1). The only exception was Lviv, where the carabidofauna was the most original. This could be explained by specificity of local carabidocomplexes and the quite fragmented study on the fauna of ground beetles conducted in separate years in a minimum number of urbocenoses. More detailed studies on Carabidae in the cities of Western Ukraine, similarly to Southern regions (for example Odessa), would provide better understanding of the formation of the population of ground beetles of urban landscapes.

The above-mentioned peculiarities of taxonomic and ecological structures cause a number of differences in qualitative and quantitative structures of the Caraboidea community, originality of their fauna for some cities. In general, the range of ecological groups was minimum in Lviv, but maximum in Dnipro and Kyiv (Table 1, 2). Typical representative of caraboid beetles in urbocenoses of the main metropolises of Ukraine could be considered the polytopic and meadow mesophile zoophage (to a less extent forest), but also ecologically flexible species well adapted to living in urban plantations.

Conclusion

In total, in the urbocenoses, 237 species of Caraboidea were recorded (Table 1), belonging to 63 genera and two families – Carabidae (231 species, 61 genera) and Cicindelidae (6 species, 2 genera), which accounts for almost one third of taxonomic compound of Caraboidea superfamily in Ukraine. According to the abundance of Carabidae in all the metropolises we studied, 33 species were identified to abundant (about 25% of their total number). Eudominants were represented by three species: *Harpalus rufipes*, *Pterostichus melanarius* and *P. oblongopunctatus*. Five species were common: *Amara aenea*, *Anchomenus dorsalis*, *Calathus fuscipes*, *Harpalus distinguendus* and *Poecilus versicolor*. Subdominants were represented by 25 species: *Amara similata*, *Asaphidion flavipes*, *Badister bullatus*, *Bembidion lampros*, *B. properans*, *Broscus cephalotes*, *Calathus ambiguus*, *C. melanocephalus*, *Carabus cancellatus*, *C. coriaceus*, *C. granulatus*, *Cylindera germanica*, *Harpalus affinis*, *H. anxius*, *H. griseus*, *H. latus*, *H. tardus*, *Limodromus assimilis*, *Microlestes minutulus*, *Nebria brevicollis*, *Notiophilus palustris*, *Poecilus cupreus*, *Pterostichus niger*, *P. ovoideus* and *P. strenuus*. A total of 53 species (22.4%) were identified to rare (recendents), and 151 (63.7%) species to occasional (subrecendents). For separate cities, the number of eudominants was 4 (Donetsk, Kyiv) to 6–8 (Kharkiv, Lviv). In Dnipro, 47 and 48 rare and occasional species respectively were recorded, while in Donetsk, Kharkiv and Kyiv these groups included 24–31 rare and 73–76 occasional species.

Finds of ten species – *Amara famelica*, *A. majuscula*, *Anisodactylus nemorivagus*, *Badister lacertosus*, *Blemus discus*, *Limodromus krynickii*, *Pterostichus minor* (recorded in urbocenoses of Dnipro), and also *Asaphidion pallipes*, *Tachyta nana* (Dnipro and Donetsk) and *Harpalus laeviceps* (Donetsk) were new for the steppe zone of Ukraine. *Chlaenius aeneocephalus* and *Brachinus brevicollis* were for the first time recorded in the Right Bank part of the northern subzone of Steppe Ukraine, and *Stenolophus abdominalis* reported for the far south of Ukraine was for the first time reported for the Northern steppe subzone (Dnipro). *Microlestes negrita* was new for the Forest Steppe (Kharkiv). The species *Masoreus wetterhalli* (Kharkiv) and *Syntomus foveatus* (Dnipro) known earlier for the forest zone and south of the steppe zone were for the first time reported for the Northern subzone of the Steppe and Forest Steppe.

The levels of faunistic similarity of Caraboidea for different metropolises ranged within 0.20–0.60. Most similar (by coefficient of Jaccard) were the carabidofaunas of Kharkiv and Donetsk, slightly less in Dnipro and Kyiv (around 0.50). Minimum indicators were observed for Lviv and other cities (about 0.20). A similar situation was also revealed by the comparison of abundant species of ground beetles in different metroplises, but with much higher indicators (0.32–0.87).

According to species composition, the most numerous were meadow (119) and forest (59 species). A total of 25 species was identified to the polytopic group, 23 to steppe, and 11 to littoral. Almost in all metropolises, the polytopic group dominated, among which the abundant species formed almost half (except Lviv). Among the forest complex in Dnipro, Donetsk and Kharkiv, 4–6 abundant species were recorded, whereas in Kyiv and Lviv, their quantity equaled more than one third (14–17 species). Among the meadow group, 4–11 species were abundant (more of them in Dnipro and Donetsk). Abundant species among the steppe and littoral groups were absent. Regarding moisture, eudominants were mesophiles (165 species), among which 31 common species

were recorded. According to trophic specialization, zoophagous species dominated (146 species and over 60% of all carabidofauna, including 24 abundant species. Among zoophytophages, 60 species were recorded (more than 25% of all the carabidofauna), seven of which were abundant. Phytozoopages were represented by 30 species (two common). In relation to the mechanical composition of soil, the highest diversity was seen among the species which prefer loamy and clay-loamy soils – 85 species in each group. However, abundant elements among these groups were 6 and 10 species respectively. The group of ground beetles without clear preference to mechanical composition of soil was represented by 41 species, but by the number of abundant elements (17 species), it was the dominant group. Four, six and sixteen species were identified as inhabitants of heavy clayey, sandy and sabolous soils respectively, with no abundant elements. At the level of abundant species, in most metropolises, the ecological structure was more similar than shown by the analysis of all species of ground beetles.

The conducted studies allow us to analyze qualitative and quantitative characteristics of communities of Caraboidea in metropolises of Ukraine, evaluate their faunistic similarity, and in brief characterize the ecological structure. On the basis of the analyzed data, the typical representatives of caraboid beetles in metropolises of Ukraine could be considered the polytopic or meadow (less – forest) mesophile zoophages or zoophytophages which prefer loamy-clayey soils or without preference to one or the other mechanical composition of soil.

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