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GROUND BEETLE COMMUNITIES FOUND IN THE SUBURBS OF OIL WELLS OF OIL FIELDS IN KHOINIKI DISTRICT (REPUBLIC OF BELARUS)

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Abstract

Ground beetle communities found in the suburbs of wells of three oil fields of Khoiniki district (Republic of Belarus) were studied in the research carried out. These deposits are in the forest area. This research drew out that there is a growth in the number of species composition and abundance of ground beetles (Carabidae) in the exclusion zone due to the anthropogenic transformation of forest ecosystems. At the same time there is a reduction in representation in ground beetle communities of forest species in favor of meadow and field species to their total disappearance. The reduction occurs together with the growth of species abundance and number.

Key words: Coleoptera, Carabidae, oil wells, species abundance, hygropreferendum, biopreferendum, life forms

INTRODUCTION

On the territory of Gomel region, the only region in the Republic of Belarus, oil is actively explored and produced under natural ecosystems of different types. It cannot help but influence the condition of zoobiota inhabiting ecosystems related to oil production. As the previous research in Sudovitsa oil field (Halinouski 2017) as well as in South Ostashkovichi oil field (Halinouski 2020) showed, the key factors of influence are the anthropogenic transformation of natural areas. This transformation is accompanied by the reduction of projective vegetation cover, sand off area, change of biota species composition, and the number of certain species of invertebrate and vertebrate animals. Studying the influence of oil exploration on the condition of natural ecosystems, primary and secondary distortions can be distinguished (Soromotin 2006). So, A. V. Soromotin regards terrain transformations and snow accumulation settings, change of intensification of geological processes, and deforestation as the primary distortions. He calls the secondary distortions the formation of a process chain that modifies ecosystems in time and space.

Ground beetles are the most favorable object under study among herpetobion Coleoptera because they are the most diverse and widespread group of insects inhabiting the soil surface (Thiele 1977). Ground beetles are also a very good object for bioindication of anthropogenic influence on ecosystems. This influence is related to affecting the soil surface (Koivula 2011).

Whereas oil has been produced and oil fields have been onstreamed on the territory of Gomel region for quite a long time, and there has not been made the detailed and overall assessment of consequences of oil production affecting on zoobiota condition, so the research for this topic will be of highness of scientific novelty and large practical importance.

METHODS

Khoiniki district of Gomel region is situated in the southeast of the Republic of Belarus. The investigations were carried out on three oil fields and the control plot:

1) Station 1: Wells № 32 of Malodusha oil field are open sites against clear cutting on the fringe of forest area (52°09′02.286″ N 30°12′04.734″ E);
2) Station 2: Well № 14 of Kartashov oil field is represented by forest site after clear cutting with a wide exclusion zone with sandy soil and rare grassland vegetation (52°05′44.2356″ N 30°07′23.9412″ E);
3) Station 3: Well № 1 of East-Izbyn' oil area is represented by forest site – clearcutting in the midst of forest area (52°05′13.9452″ N 30°07′35.2884″ E);
4) Station 4: the control plot, which is not exposed to man-caused influence – forest site (52°22′52.1220″ N; 29°50′17.9052″ E).

Ground beetles were collected with the help of pitfall traps in May-September 2021. Polystyrol glasses of a volume of 0.5 l were used as pitfall traps. The glasses were filled

with formalin by one-third. The pitfall traps were set out at a rate of 20 pieces for one station in 2-times repetitive (2,400 trap-days were handled).
Calc electronic tables of LibreOffice package (www.libreoffice.org) were used to make a primary base of ground beetles. The base includes the data about taxonomic affiliation, biopreferendum, hygropreferendum, life forms of imago and number. RStudio package (www.rstudio.com) and PAST 4.0.3 (www.nhm.uio.no) were applied to analyze distribution, mean values, errors, and verification of hypotheses about their differences and ties (relations). Alpha-diversity indexes in communities, as well as cluster analysis, were made using BioDiversity Pro software package (biodiversity-pro.software.informer.com). The natural logarithm base was used to calculate the Shannon diversity index and distribution models. Clustering was based on the Jaccard similarity coefficient. Dominance in communities was determined with the help of the Renkonen scale (Renkonen 1938). Life forms of ground beetles were estimated by I. Kh. Sharova (Sharova 1981).

RESULTS AND DISCUSSION

As a result of the research carried out 778 specimens of ground beetles of 30 species from 11 genera were gathered (Table 1). Ground beetle communities of Malodusha and Kartashov oil fields were characterized by the largest species abundance and number. This could be linked with the fact that these sites have a rather wide exclusion zone from the border of the forest. This zone contains rare grassland vegetation and a display of edge effect, i.e. an ecotone.
There were detected 2 species of ground beetles that were distinguished on all investigated areas. They are *Amara aenea* and *Harpalus rubripes* – the species tend to open biotopes with grassland vegetation. At the same time, each of the investigated sites near the oil wells had many species which could be found only there. There were most such species (11) in Malodusha deposit: *Amara majuscula*, *Anisodactylus binotatus*, *Calathus fuscipes*, *Carabus granulatus*, *Harpalus distinguendus*, *H. griseus*, *H. latus*, *H. smaragdinus*, *Oodes helopioides*, *Poecilus cupreus* and *Pterostichus niger.* There were 1 such species in Izbyn' deposit (*Carabus arvensis*) and 2 such species in the control plot (*Panagaeus bipustulatus* and *Pterostichus oblongopunctatus*) accordingly.
The number of dominant species was inhomogeneous and it varied from 3 species near the oil well of Izbyn' deposit to 6 species in Kartashov deposit. Though it's impossible to say in general that the investigated sites differed much by the number of dominant species, there were significant variations by species composition. The ground beetles which would dominate in all examined Ground beetle communities were not detected, but *Harpalus rubripes* dominated by number in three of them, and it was subdominant in the fourth one (Izbyn' deposit) (Table 1). Except for this species *Calathus erratus*, *C. fuscipes*, *Harpalus affini*, and *H. flavescens* dominated in Malodusha oil field.
Typically forest species *Calathus micropterus*, *Carabus arvensis* and *C. glabratus* were distinguished in the number of dominants in Izbyn' deposit. At the same time, almost half of all the detected specimens of ground beetles account for the last deposit (Table 1).

Table 1

Ground beetles species composition and abundance (%) in ground beetle communities of the investigated oil fields

Species	Oil field			Control
	Malodusha	Izbyn’	Kartashov	
Amara aenea (De Geer, 1774)	1.83	2.38	5.01	6.00
Amara communis (Panzer, 1797)	0.31	0.00	4.18	4.00
Amara majuscula Chaudoir, 1850	0.61	0.00	0.00	0.00
Anisodactylus binotatus (Fabricius, 1787)	0.31	0.00	0.00	0.00
Broscus cephalotes (Linnaeus, 1758)	1.53	0.00	15.04	0.00
Calathus erratus (Sahlberg, 1827)	22.01	0.00	3.06	0.00
Calathus fuscipes (Goeze, 1777)	30.58	0.00	0.00	0.00
Calathus micropterus (Duftschmid, 1812)	0.00	16.67	0.00	16.00
Carabus arvensis Herbst, 1784	0.00	26.19	0.00	0.00
Carabus glabratus Paykull, 1790	0.00	42.86	0.00	42.00
Carabus granulatus Linnaeus, 1758	0.31	0.00	0.00	0.00
Carabus hortensis Linnaeus, 1758	0.61	0.00	0.00	12.00
Cychrus caraboides (Linnaeus, 1758)	0.00	2.38	0.00	4.00
Harpalus affinis (Schrank, 1781)	12.54	0.00	4.46	0.00
Harpalus anxius (Duftschmid, 1812)	0.31	0.00	1.39	0.00
Harpalus distinguendus (Duftschmid, 1812)	1.22	0.00	0.00	0.00
Harpalus flavescens (Piller et Mitterpacher, 1783)	7.03	0.00	20.89	0.00
Harpalus griseus (Duftschmid, 1812)	0.31	0.00	0.00	0.00
Harpalus latus (Linnaeus, 1758)	2.45	0.00	0.00	0.00
Harpalus rubripes (Duftschmid, 1812)	5.5	2.38	32.59	10.00
Harpalus rufipes (De Geer, 1774)	4.28	0.00	6.14	0.00
Harpalus smaragdinus (Duftschmid, 1812)	0.31	0.00	0.00	0.00
Harpalus tardus (Panzer, 1797)	1.53	4.76	7.24	0.00
Oodes helopioides (Fabricius, 1792)	0.92	0.00	0.00	0.00
Panagaeus bipustulatus (Fabricius, 1775)	0.00	0.00	0.00	2.00
Poecilus cupreus (Linnaeus, 1758)	0.31	0.00	0.00	0.00
Poecilus versicolor (Sturm, 1824)	2.75	0.00	0.00	2.00
Pterostichus melanarius (Illiger, 1798)	0.61	2.38	0.00	0.00
Pterostichus oblongopunctatus (Fabricius, 1787)	0.00	0.00	0.00	2.00
Pterostichus niger (Schaller, 1783)	1.83	0.00	0.00	0.00

Amara aenea, the philus of open sand spaces *Broscus cephalotes* as well as *Harpalus flavescens*, *H. rubripes*, *H. rufipes*, and *H. tardus* were determined as dominants in the ground beetle communities of Kartashov oil field. The large presence of such species as *Harpalus flavescens* can be regarded to a certain degree as an indicator of big areas of sand spaces. We also distinguished this species among the dominants at oil wells arrangement both on the floodplain of the river and in the forest (Halinouski 2017, 2020, Potapov 2021).

The mentioned above *Amara aenea*, *Harpalus rubripes* and *Calathus micropterus* as well as a big ground beetle *Carabus hortensis* dominated in the control plot by number.

We carried out one-way ANOVA analysis to estimate possible differences by the number of ground beetles in the studied ground beetle communities (Fig. 1). The analysis results show that there are differences by the number of ground beetles in ground beetle communities of Malodusha and Kartashov oil fields from Izbyn' deposit and the control plot (F = 3.21; p = 0.026).

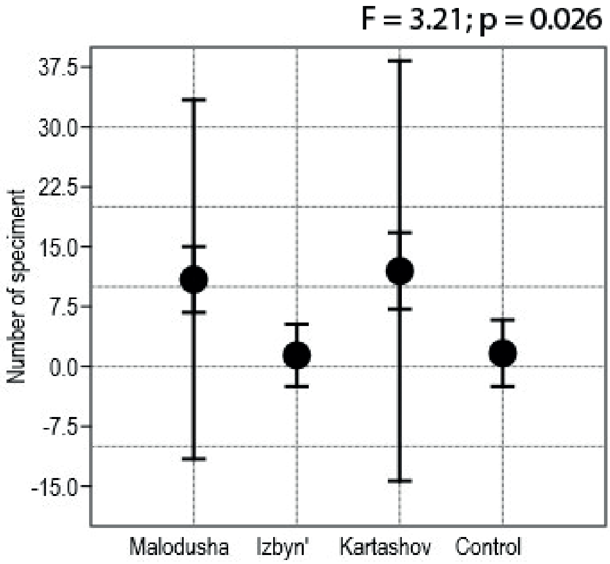

Fig. 1. The results of one-way ANOVA analysis of the number of ground beetles in ground beetle communities of the studied territories

We also made the cluster analysis of the species similarity in the studied ground beetles communities in the suburbs of oil wells (Fig. 2). Two clusters were revealed in the result of the analysis of the species similarity in ground beetle communities. These clusters were similar in number earlier: Malodusha and Kartashov oil fields as well as Izbyn' deposit and the controlled plot.

While estimating the indexes of alpha diversity of communities, the biggest indicators of information diversity of ground beetles of Malodusha and Kartashov oil fields should be paid attention to against the background of low concentration of dominancy (Table 2). It can also tell about edge effect influence in oil wells separated from the forest border with a wide sand line of the exclusion zone that lacks tree vegetation. The high indicators of uniformity should also be noted especially in ground beetle communities of Kartashov oil field (Table 2).

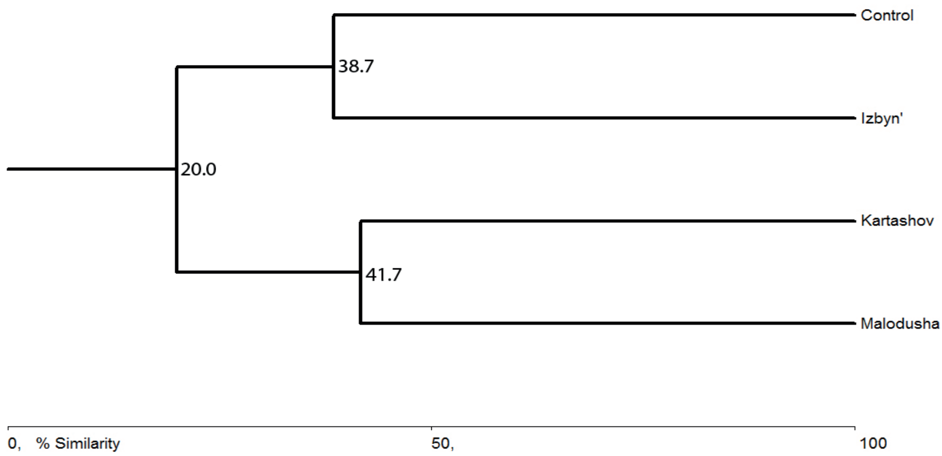

Fig. 2. The result of cluster analysis of the species similarity of ground beetles in carabidocomplexes of the studied territories

While considering the relation of ground beetles to humidity in ground beetle communities of the suburbs of oil wells of Khoiniki district, the sufficiently complete range of representatives – from hygrophilous to xerophilous species – were determined. Mesoxerophilous species as well as to some degree xerophilous species dominated in ground beetle communities of those wells which had wide exclusion zones between the well banking zone and the forest area border. At the same time, the overwhelming advantage of the mesophilous species is characteristic to the ground beetle communities of the forest border and the control plot. Although the mesoxerophilous species are highly presented, they give way to the mesophious ones all the same.

Ground beetle communities of forest sites (Izbyn' deposit and the control plot) are represented by mainly forest species of ground beetles which are dominated both by species abundance and number. Ground beetle communities of wells with a wide exclusion zone were characterized by a dramatic reduction of forest species representation in favor of meadow and field species (Table 2). Moreover, it should be noted that the original forest ground beetle communities of the well of Kartashov oil field lost its forest species overall. This well has a wide (about 50 m) exclusion line.

While analyzing the life forms of imago of ground beetles in the studied stations, it should be noted the predominance of large walking epigeobiontes as well as the significant presence of inhabiting soil litter stratobiontes, and somewhat less – geohortobiontes garpaloid in the stations which were subjected to little cutting or there was no cutting on them at all (Izbyn' oil field and the control plot). Inhabiting soil litter stratobiontes dominated by number and geohortobiontes garpaloid – by species abundance in ground beetle communities of the well with a rather narrow exclusion zone (the well of Malodusha oil field) that borders on the forest area (about 10 m) (Table 2). Geohortobiontes garpaloid and shifty-digging geobiontes are dominated both by species number and abundance while the width of the exclusion zone becomes larger (the well of Kartashov oil field).

Table 2

Ecological groups and some indexes of ground beetles' diversity in the studied communities

Ecological groups	Oil field							
	Malodusha		Izbyn'		Kartashov		Control	
	N	A	N	A	N	A	N	A
Hygropreferendum								
hygrophilous	1	0.92	0	0.00	0	0.00	0	0
mesohygrophilous	2	0.61	1	2.38	0	0.00	1	4
mesophilous	10	44.34	3	61.91	2	10.30	6	78
mesoxerophilous	5	48.62	3	33.33	5	68.25	2	12
xerophilous	6	5.51	1	2.38	3	21.45	1	6
Biopreferendum								
riparian	1	0.31	0	0.00	0	0.00	0	0
peat bog	1	0.92	0	0.00	0	0.00	0	0
forest	4	5.19	4	88.10	0	0.00	5	76
meadow	9	46.79	3	9.52	4	64.90	3	16
field	9	46.79	1	2.38	6	35.10	2	8
Life-form of imago								
WE	2	0.92	3	71.43	0	0.00	3	58
S	1	4.28	0	0.00	1	6.13	0	0
SLS	1	0.92	0	0.00	0	0.00	1	2
ISLS	2	52.60	1	16.67	1	3.06	1	16
LSBS	4	5.50	1	2.38	0	0.00	2	4
S-DG	1	1.53	0	0.00	1	15.04	0	0
GG	13	34.25	3	9.52	7	75.77	3	20
Total specimens number	327		42		359		50	
Total species number	24		8		10		10	
Shannon's index, H'	2.22		1.51		1.93		1.80	
Simpson's index, D	0.17		2.85		0.19		0.23	
Margalef's index, M	3.97		1.87		1.53		2.30	
Uniformity by Pielou, e	0.70		0.73		0.84		0.78	

N o t e: N – number of species; A – species relative abundance, %; WE – walking epigeobiontes; S – stratohortobiontes; SLS – surface–litter stratobiontes; ISLS – inhabiting soil-litter stratobiontes; LSBS – litter and soil burying stratobiontes; S-DG – shifty-digging geobiontes; GG – geohortobiontes garpaloid

When we studied the condition of Coleoptera communities in the suburbs of wells of South Ostashkovichi oil field in Kalinkovichi district, we also observed similar features at extending the exclusion zone by cutting forest tree vegetation (Potapov 2021).

CONCLUSIONS

Thus, as the result of the research carried out for the species composition and ecological features of ground beetle communities in the suburbs of wells of oil fields in Khoiniki district which were formed as a result of anthropogenic transformations of forest ecosystems during oil wells arrangements, the following can be concluded:

1. Species composition of ground beetle communities of the studied territories represented by 30 species of ground beetles from 11 genera.
2. The number of ground beetle communities differs statistically and meaningfully ($F = 3.21$; $p = 0.026$), the studied ground beetle communities can be joined into two clusters by the species composition similarity, the distinctive feature of which is the presence of a wide sand space of the exclusion zone without tree vegetation.
3. Extending the exclusion zone leads to the significant restructuring of species composition and ecological features of ground beetle communities which is manifested in the sharp reduction of forest species in favor of meadow and field mesoxerophilous species of medium and small sizes.

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ZGRUPOWANIA BIEGACZOWATYCH W POBLIŻU SZYBÓW NAFTOWYCH W REJONIE CHOJNICKIM (BIAŁORUŚ)

Streszczenie

Przeprowadzono badania zbiorowisk biegaczowatych w sąsiedztwie odwiertów trzech pól naftowych, położonych w strefie leśnej. Ustalono, że w wyniku antropogenicznych przekształceń ekosystemów leśnych następuje wzrost liczebności i bogactwa gatunkowego biegaczowatych w pasie bezpieczeństwa. Jednocześnie wraz ze wzrostem bogactwa gatunkowego i liczebności zmniejsza się udział gatunków leśnych aż do ich całkowitego zaniku na rzecz gatunków łąkowych i polnych.