

THE SPATIAL POPULATION DISTRIBUTION
OF *OMOPHRON LIMBATUM* FABRICIUS, 1777
(COLEOPTERA, CARABIDAE)
IN THE CONDITIONS OF REGULATED RIVERS

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Summary. The spatial population structure of *Omophron limbatum* F., 1777 was studied in the conditions of regulated river and influences of recreation and livestock along the part of Psel river (as a tributary of Dnieper river) in the north-east of Ukraine. This ground beetle is a specialised species inhabiting the exposed alluvial sediments of river banks in the conditions of natural rivers. Our study confirmed that the density and distribution of population of *O. limbatum* F. are dependent on a range of anthropogenic factors. Our results indicated that the regulation of the riverbed by dams, overgrowth of river bars by vegetations, and recreation and livestock pressure are the most important factors determining the spatial population pattern of this species. It was found that *O. limbatum* F. has a high sensitivity to environmental factors, which makes him a good indicator of the disturbance of natural environment.

Key words: Coleoptera, *Omophron limbatum*, population, spatial distribution, beach, riparian landscape, environment

INTRODUCTION

A problem of environmental consequences of over-regulation of rivers was actively discussed in the European countries during the 90s of the 20th century. It was indicated that the changes of hydrological regime of rivers in many countries have led to a high restructuring of hydrobiocenosis. Moreover, it was found that high transformation of rivers influenced the terrestrial communities of both vertebrates and invertebrate animals, especially in the biota

of the riparian zone [Plachter 1986, Zulka 1994, Manderbach and Reich 1995, Kirichenko 1998, 1999, Boscaini *et al.* 2000, Bonn *et al.* 2002].

Mass construction of hydroelectric power stations during the 50s of the last century on the river Dnieper and its tributaries in the Ukraine highly damaged and fragmented the streams and rivers. Thus the majority of rivers were transformed into riverbed reservoirs that changed the dynamics of their natural water regime. As a consequence of this intensive anthropogenic influence, various irreversible changes of the typical floodplain habitats caused the siltation and vegetation overgrowth of the river bars.

The population of ground beetle *O. limbatum* was selected as a model object and used for the purpose of identification of environmental changes of the studied area of the river Psel in the north-eastern part of the Ukraine. The goal of undertaken research was to ascertain the dependence of the spatial population distribution of *O. limbatum* F. on the activity of the power dam, the degree of overgrowth of bars, the level of recreation activities and heavy cattle trampling.

MATERIAL AND METHODS

Studied species. *Omophron limbatum* Fabricius, 1777 belongs to the genus *Omophron* Latreille, 1802 which is widely distributed at the Palearctic region with the exception of South-East Asia. In Europe *O. limbatum* is distributed throughout mainland Europe, excluding Finland, Norway and most of Sweden, and it occurs also in North Africa and Asia. This ground beetle is a typical riparian species, inhabiting sandy bars along large and middle-size rivers. The period of its activity is at dusk and at the night time [Drees *et al.* 2008]; this species is able to fly [Günter *et al.* 2004].

Study area. The investigation was conducted in north-eastern Ukraine, in the middle part of the river Psel that is a left tributary of the river Dnieper. The research was carried out from July to August, 2008. Open river banks were studied along the distance of about 70 km of modified section of river that is located above the power dam at the village of Nyzy (Sumy district). The power dam was built in that area in 1953.

Sampling and habitat survey. Beetles were collected using dry pitfall traps and simply by „washing out” of the substrate from their daytime resting places. That made it possible to identify the spatial population structure of *O. limbatum*. Pitfall traps (numbered 5 to 15) were arranged in 3–5 rows across the river's bars starting from the water edge level. Traps were functioning from dusk to the morning time.

19 sandy bars and 6 abrupt banks of the river Psel on the distance of 70 km section along the riverbed above the dam of the hydroelectric power station were used as research sites where the population density of *O. limbatum* was examined. The characteristics of each investigated alluvial bank are indicated in Table 1.

Table 1. Characteristics of the investigated alluvial banks and hydrological parameters

Stations	Code of sampling banks	Area of beaches, m ²	Vegetation cover, %	Anthropogenic factors	Velocity of flow, m/s	Water lucidity, m
Above vil. Big Rybycia	R-0	15	0	2	0.44	4
Below vil. Big Rybycia	R-1	45	50	2	0.44	3
	R-2	22.5	50	2	0.44	3
	R-3	9	0	1	0.44	3
Above vil. Mogrycia	R-4	20	0	-	0.5	3.5
	R-5	25	95	-	0.5	3.5
Below vil. Grunivka	R-6	180	75	1	0.44	3.5
	R-7	13.6	0	1	0.44	3.5
	R-8	140	70	2	0.44	3.5
	R-9	277.8	65	2	0.44	3.5
	R-10	94.8	95	-	0.44	3.5
	R-11	6.3	0	-	0.44	3.5
Near vil. Vilshanka	R-12	72	20	-	0.2	3.4
	R-13	9	0	1	0.2	3.4
Above vil. Big Chernetchyna	R-14	43.2	33.3	1	0.275	3.4
Below vil. Big Chernetchyna	R-15	30	0	-	0.275	3.4
	R-16	6	0	1	0.275	3.4
	R-17	8.5	50	-	0.275	3.4
	R-18	14.28	0	-	0.275	3.4
vil. Homene	R-19	17.25	0	1	0.26	3.4
vil. Chervone	R-20	15	0	2	0.055	1.1
Nyzy, above HPS*	R-21	24	100	-	0.055	0.5
Nyzy, below HPS	R-22	50	0	1	0.085	1
	R-23	45	0	1	0.085	1

*HPS – hydroelectric power station; anthropogenic factors: 1 – recreation, 2 – livestock trampling

These sites were grouped in three types according to their environmental changes: with absence of direct or significant impact of human beings, with certain impact of human recreation, and with livestock trampling (Tab. 1). The authors counted the percentage of coverage by overgrowth vegetation on studied sandy bars for the evaluation of environmental changes of the areas. The evaluation of influence of vegetation overgrowth on the population density of several other species of ground beetles was studied by one of the authors in her previous publication [Kirichenko 1999]. The water lucidity and flow velocity on the each section of the river Psel were also measured.

More than 5000 specimens of *O. limbatum* were found in 59 collection samples. The population density of *O. limbatum* was determined on the basis of two methods: by calculation of average density of species per one trap and per one square meter (Tab. 1). The number of collected specimens was counted for each trap and average density was identified for each studied site. The density of

species per one square meter was measured by counting of number of specimens on that surface area in each studied site. The final analysis of quantitative data was performed using the statistical program PAST [Hammer *et al.* 2001] and CANOCO 4.5 software package [ter Braak and Smilauer 2002].

RESULTS AND DISCUSSION

The population of *Omophron limbatum* is localised on riverbanks with alluvial sediments (Fig. 1A, B). Beetles are found on the sandy bars and on the abrupt banks, but densities of specimens were low on the abrupt banks (R-3, 10,

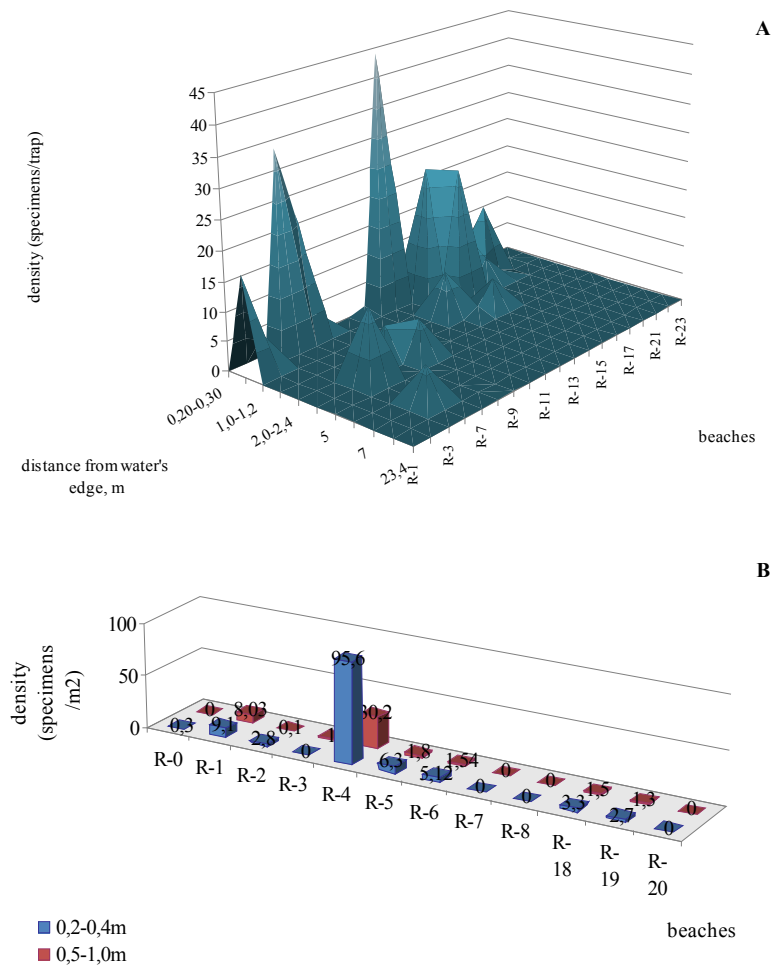


Fig. 1. Spatial distribution of the population of *O. limbatum* on sandy beaches (numbered R-0 – R-23) at different distances from water edge: A – data collected by traps, B – data collected by the method of washing

16 and 22). Beetles are not active during the daytime when they hide and dig inside a wet sandy bar. The population of *O. limbatum* becomes active at night time. During that time the major part of population are concentrated at the distance of 0.2–1.0 m from the water edge (Fig. 1A).

Our results reveal that the population density remains independent from the surface area of beaches (Fig. 2).

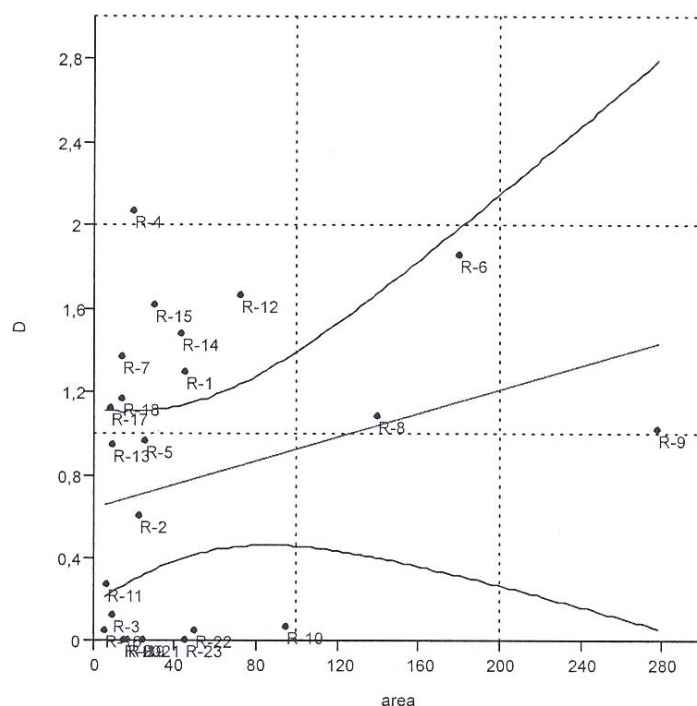


Fig. 2. Dependence of population density (D) of *O. limbatum* on the area (m^2) of sandy beaches ($N = 24$, $r = 0.264$, N – number of sites, r – coefficient of correlation)

Expansion of vegetation on the sandy beaches was observed as a result of increase in the trophy of water and disturbance of the hydrological regime of the river. The results of analysis (done by model regression GLM) show that the population density of *O. limbatum* reduces in the conditions of vegetation expansion on sandy bars (Fig. 3).

Undertaken study showed a certain correlation between the velocity of the current and water transparency in the river (Fig. 4), while there is no correlation between these hydrological parameters and population density of *O. limbatum*. Probably, the hydrological parameters have an indirect influence on the population of this species.

Our results showed that *O. limbatum* was negatively affected by the flood of riparian area and frequent fluctuation of the water level caused by the power

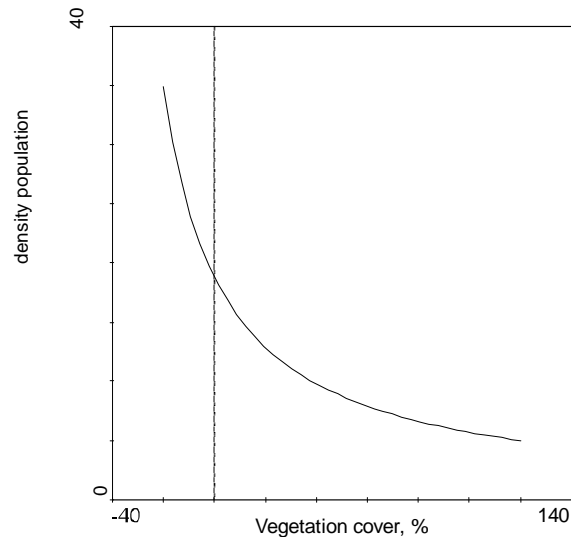


Fig. 3. Population density of *O. limbatum* depending on the vegetation overgrowth degree on studied sandy beaches

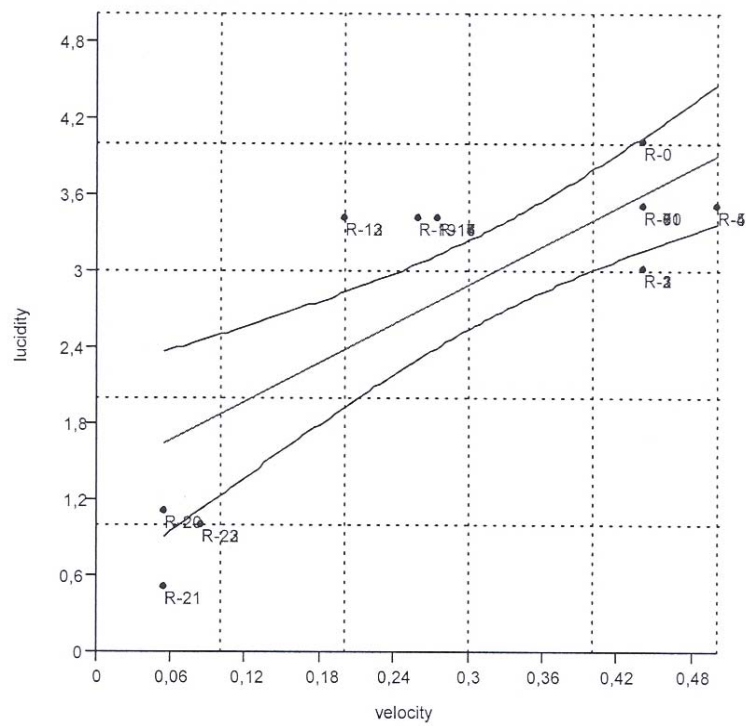


Fig. 4. Correlation of water lucidity and velocity of flow in the river Psel ($N = 24$, $r = 0.766$, N – number of sites, r – coefficient of correlation)

dam. It is possible to suggest that an indirect influence of the dam of the hydroelectric power station on the spatial distribution of population of *O. limbatum* reveals itself in decrease of the population density of this species when approaching to the dam (Fig. 5). This species was completely vanished on the riverbanks along the distance of more than 10 km above the dams of the hydroelectric station.

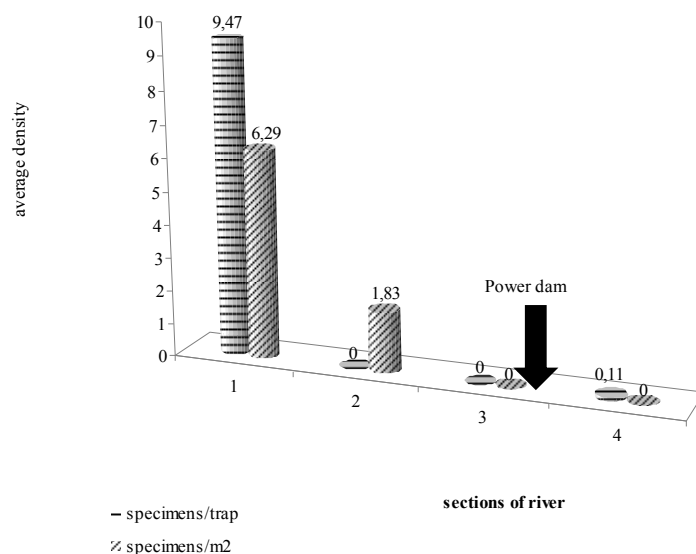


Fig. 5. Population density of *O. limbatum* along the riverbanks at the different sections of the river
 Psel: 1 – from vill. Big Rybycia to Sumy city, 2 – region of Sumy city, 3 – 1 km above the power dam, 4 – 0.5 km down from the power dam

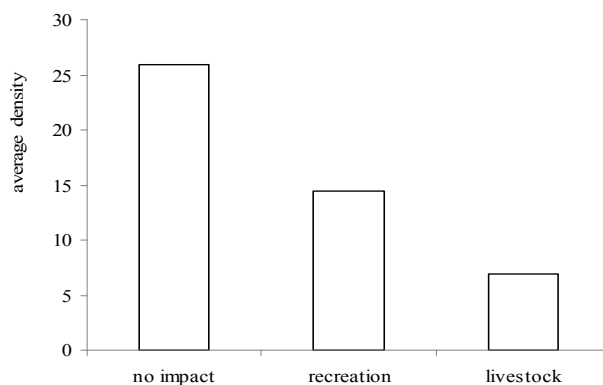


Fig. 6. Changes of population density of *O. limbatum* (average data) on the riverbanks with different anthropogenic factors

It was indicated that the recreation and livestock grazing and trampling became important biotic factors influencing the distribution of population of *O. limbatum*. The people and domesticated animals, regularly visiting the riverbanks, are causing the compaction of the substrate where this ground beetle lives. Our results show that the population density of *O. limbatum* reduces significantly under the conditions of high influence of these biotic factors (Fig. 6).

Thereby, undertaken research shows that the presence of river dams can dramatically change the habitats of *Omophron limbatum* through significant disturbance of the integrity of the biotope of this species.

CONCLUSION

It was found that the ground beetle *O. limbatum*, being a typical riparian species, can be effectively used as a model species for environmental investigations. This species was recognised as highly sensitive to environmental changes and to the influence of biotic and abiotic factors. Original authors' study revealed that the influence of the vegetation overgrowth, siltation of alluvial river bars, the level of recreation and livestock trampling, have led to significant changes of the natural habitats of *O. limbatum* and, as a consequence, to the decrease of its population density in the studied area. It is suggested that the over-regulation of the riverbed of Psel by hydroelectric power dam has had the most negative influence on the population distribution of the ground beetle *O. limbatum*.

The analysis indicates that *O. limbatum* has become a vulnerable and sensitive species because of global over-regulation and pollution of the rivers in the Ukraine. Eventually, *O. limbatum* has been recently designated as an endangered species in Great Britain [English Nature 2006]. It is proposed to undertake some conservation and restoration measures for the natural habitats of this species in the Ukraine.

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Acknowledgements. We are grateful to Dr Victor Fursov (Schmalhausen Institute of Zoology, Kiev, Ukraine) for useful comments and linguistic revision of the manuscript. The research has been supported by funding from the State administration of preservation of the environment in the Sumy district.

STRUKTURA POPULACJI *OMOPHRON LIMBATUM* FABRICIUS, 1777
(COLEOPTERA, CARABIDAE) W WARUNKACH RZEK UREGULOWANYCH TAMAMI

Streszczenie. Celem badań było wyjaśnienie rozmieszczenia przestrzennego populacji *Omophron limbatum* F., 1777, na aluwialnych plażach nizinnej rzeki Psel (lewobrzeżny dopływ Dniepru) uregulowanej tamami w zależności od stopnia pokrycia brzegów roślinnością i intensywności działań człowieka związanych z rekreacją i wypasaniem bydła. Spośród licznych gatunków biegaczy *O. limbatum* F. jest stenotopem piaszczystych plaż na brzegach rzek. Uzyskane wyniki wskazują, że zarastanie plaż roślinnością, rekreacja i wydeptanie substratu przez bydło, a również regulacja rzeki tamą negatywnie wpływają na zagęszczenie i rozmieszczenie populacji *O. limbatum* F.

Słowa kluczowe: Coleoptera, *Omophron limbatum*, populacja, przestrzenne rozmieszczenie, plaża, nadbrzeżny krajobraz, środowisko