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ANNUAL MONITORING POPULATION OF EARTHWORMS (CLITELLATA: LUMBRICIDAE) IN MAN-AFFECTED ECOSYSTEMS AROUND ARTIFICIAL GRUŽA RESERVOIR

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ABSTRACT. The present study investigates the earthworm communities in man-affected ecosystems around artificial Gruža reservoir. The study took place during 2023 and 2024, during the three seasons: summer, autumn and spring. Surrounding Gruža reservoir earthworms were collected from various habitats which included natural (reservoir banks, meadows, forest community), and cultivated biotopes. Field research was conducted in accordance with ISO 2361 standards. Our results show that earthworm communities are poor and uniform. During our research, recorded four eregrine and one Trans-Aegean species. The main threats to earthworm populations identified in this research are habitat degradation due to waste, agricultural activities, and increased tourism and recreational activity. In this regard, the measures that the competent authorities would implement could be beneficial to ecosystems and, consequently, to earthworm communities. Based on the results presented in this paper, it is necessary to continue the intensive research to preserve the biological diversity of the area.

Keywords: earthworms, Lumbricidae, Gruža reservoir, soil degradation, terrestrial ecosystem.

INTRODUCTION

In the Republic of Serbia, there are about 150 artificial reservoirs, and the one of the larger is Gruža reservoir belongs to Central Serbia (MARKOVIĆ *et al*., 2017). Physio-chemical parameters, as well as the living world of the accumulation, have been well studied (RANKOVIĆ and SIMIĆ, 2005; OSTOJIĆ *et al*., 2007; PEŠIĆ, 2012; MILINČIĆ *et al*., 2013; TOPUZOVIĆ *et al*., 2015; ČAĐO *et al*., 2016; MARKOVIĆ *et al*., 2017). Botanical researches

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around Gruža reservoir were organized even before the formation of the reservoir, and are still ongoing. Insect surveys were carried out sporadically (PEŠIĆ, 2012). But, there is no permanent soil monitoring in this area, so the risk assessment can only be done based on the distribution of potential pollutants. The Institute for public health from Kragujevac monitors soil quality in the immediate vicinity of the Gruža reservoir at two locations in and at two depths (surface and 50 cm below the surface). In the past ten years at these locations, none of the basic parameters (presence of heavy metals, organochlorine pesticides, polycyclic hydrocarbons and polychlorinated biphenyls) exceeded the defined limit values at any depth. However, in addition to the usual chemical and physical indicators, it is recommended to include soil biodiversity as an indicator of health soil. Also, the functioning of soil ecosystems is highly dependent on soil biodiversity as it supports a wide range of ecosystem processes, functions and services, and the importance of soil biodiversity is largely ignored or underestimated (ANONYMOUS, 2010).

The quality of the soil is influenced by all factors related to the quality of water, as well as the way the soil is used. Different ecosystems surround Gruža reservoir, but agricultural fields dominate. Modern agricultural practices can modify the physical and chemical properties of soil (SEKULIĆ *et al*., 2020). Also, water from the reservoir is used uncontrolled for irrigation. On this reservoir, the destruction of the vegetation belt on the banks are also evident, due to the construction of retaining walls and various buildings, and an additional threat is the intensive tourist activity (VUJADINOVIĆ *et al*., 2017).

The characteristics that are common to all types of soil degradation are the significant drop in organic reserves, degradation of soil structure and severe impoverishment of soil by invertebrate communities, especially earthworms. Earthworms from the Lumbricidae family are a relatively small but ecologically very important group of invertebrates. In terrestrial ecosystems, they dominate their biomass and role in soil processes and are the indicators of soil quality (BERTRAND *et al*., 2015; BARTZ *et al*., 2023). They are also considered ecosystem engineers because they indirectly or directly modify the availability of resources for other species, such as plants and microorganisms (HACKENBERGER *et al*., 2018). On the other hands, the earthworm fauna of Serbia is quite well-known. STOJANOVIĆ-PETROVIĆ *et al*. (2020) recorded the presence of 77 lumbricid taxa in the country. It is worth noting that there have been no research expeditions on earthworm fauna in the Gruža reservoir area.

The present study investigates the earthworm communities in man-affected ecosystems around artificial Gruža reservoir. The study also explores the structure of lumbricid communities by season.

MATERIALS AND METHODS

In the central part of Šumadija, between Kragujevac and Čačak, in the territory of the municipality of Knić, the Gruža reservoir is disturbed (Fig. 1). By damming the middle course of the river Gruža, a reservoir was formed. The reservoir fills the Knić polje depression and is located between Gledić Mts. in the east and Kotlenik in the west. With the construction of the dam in 1984, water supply problems were solved, the risk of flooding was reduced, and the lake and its coastal area became recreational, sports and touristic (VUJADINOVIĆ *et al*., 2017). Our investigations were carried out surrounding the artificial Gruža reservoir. The study took place during 2023 and 2024, during the three seasons: summer, autumn and spring. Surrounding Gruža reservoir earthworms were collected from various habitats which included natural (reservoir banks, meadows, forest community), and cultivated biotopes. Field research was conducted in accordance with ISO 2361 standards. Classic taxonomic keys were used for identification to the species level (MRŠIĆ, 1991; CSUZDI and ZICSI, 2003; STOJANOVIĆ-PETROVIĆ *et al*., 2020). Since earthworms are not a homogeneous entity and include several functional groups, each of which is clearly different in terms of ecology and impact on the

environment, we have determined ecological forms, as well as zoogeographical types (BOUCHE, 1972; CSUZDI *et al*., 2011).

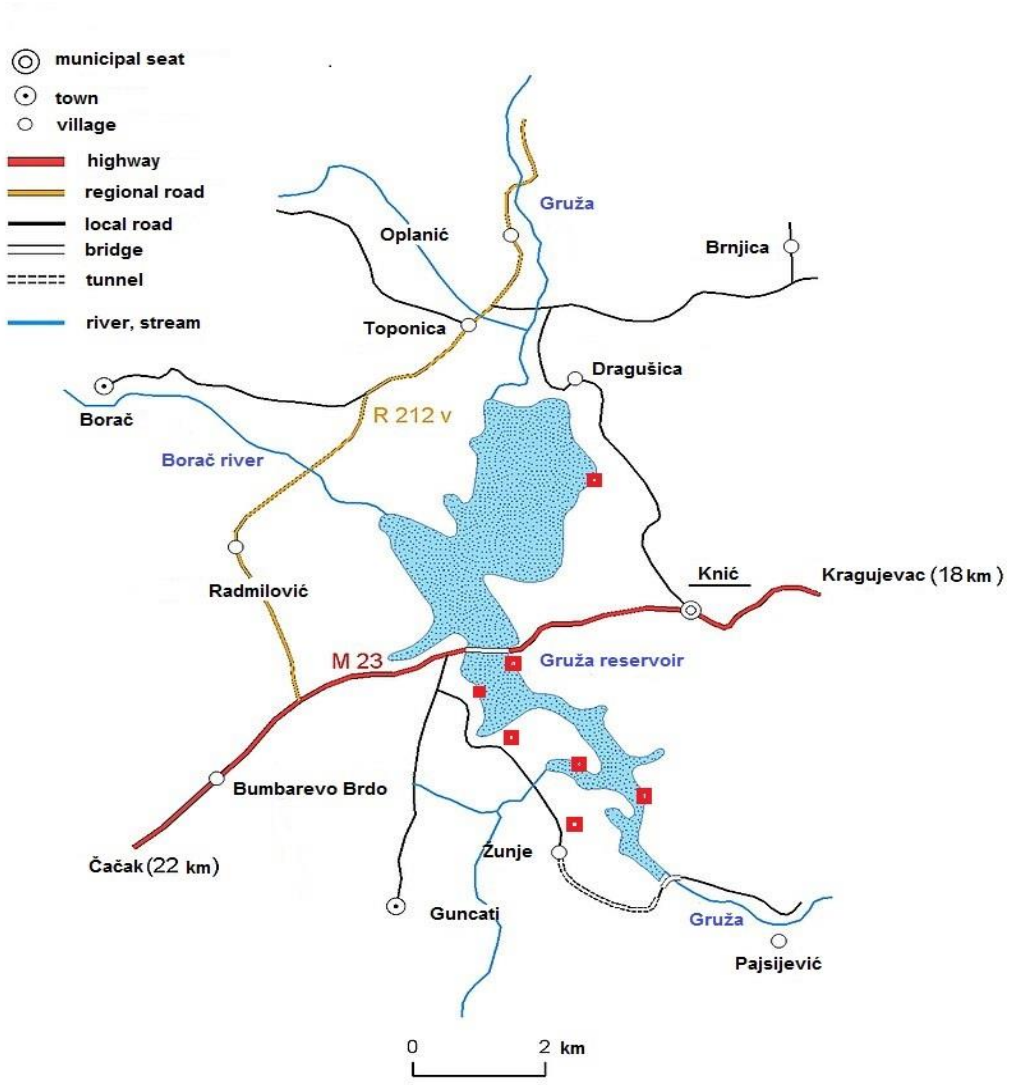

Figure 1. Map showing of the study area (Source: https://sr.wikipedia.org/wiki/Gruzansko.jpg) Red squares are the points where sampling were done

RESULTS AND DISCUSSION

At the researched localities 24 samples were analyzed, and a total of 207 individuals, of which 52.7% were adults and 47.3% were juvenile individuals. Among the 109 adult individuals on which it could be performed identification, the presencee of only 5 species of earthworms from family Lumbricidae were determined (Tab. 1).

The most common species is *Lumbricus rubellus* Hoffmeister, 1843, it is a typical synanthropic species. The next most common species are: *Aporrectodea rosea* (Savigny, 1826), *Ap. caliginosa* (Savigny, 1826) and *Panoniona leoni* (Michaelsen, 1891). The species found with only one specimen is *Octolasion lacteum* (Örley, 1881) (Fig. 2). Our results are not suprising because they are species *Ap. caliginosa*, *Ap. rosea*, *L. rubellus, and O. lacteum* are the most common lumbricid species in Serbia (STOJANOVIĆ *et al*., 2018; STOJANOVIĆ-PETROVIĆ *et al*., 2020; POPOVIĆ *et al*., 2022). The mentioned species are peregrine (cosmopolitan) and high abundance in this group of species reflects their reproductive

capacityand width ecology valence. *Panoniona leoni* is a Trans-Aegean species, widely distributed in Europe from Italy to Ukraine (CSUZDI *et al*., 2011; STOJANOVIĆ-PETROVIĆ *et al*., 2020). The largest number of species was registered during summer (4 taxa), while only two taxa each were recorded during spring. *Aporrectodea caliginosa* and P. *leoni* were occurrenced only in summer, while *O. lacteum* was found only in autumn, and only one individual (Tab. 1; Fig. 2).

Table 1. The qualitative assemblage of earthworms around Gruža reservoir and seasonal dynamics.

	Ecological form	Zoogeographic type	summer	autumn	spring
Aporrectodea caliginosa (Savigny, 1826)	endogeic	peregrine	*	/	/
Aporrectodea rosea (Savigny, 1826)	endogeic	peregrine	*	*	*
Lumbricus rubellus Hoffmeister, 1843	epigeic	peregrine	*	*	*
Octolasion lacteum (Örley, 1881)	endogeic	peregrine	/	*	/
Panoniona leoni (Michaelsen, 1891)	endogeic	Trans-Aegean	*	/	/
juvenile			*	*	*
Total number of species in each season			4	3	2

* - species present; / - species absent

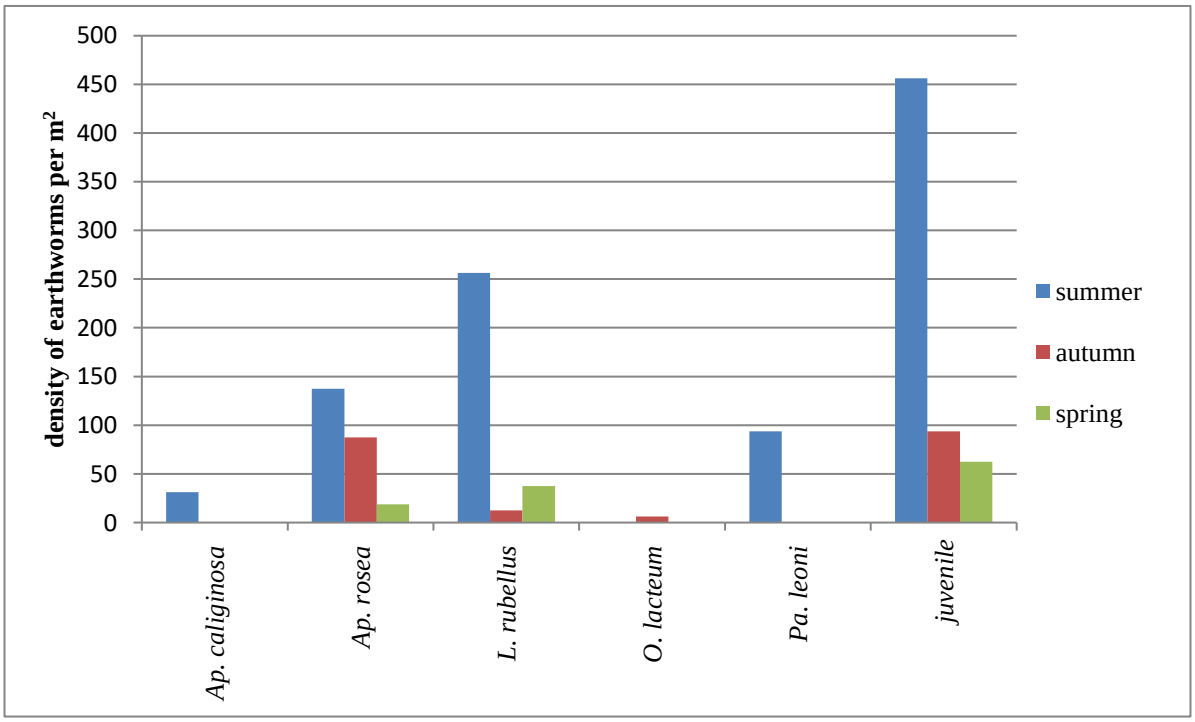

Figure 2. The quantitative assemblage of earthworms around Gruža reservoir and seasonal dynamics

Earthworms can be classified into three main ecological groups (BOUCHÉ, 1972). In addition, to morpho-anatomical-physiological characters, they are clearly different in terms of ecology and influence on soil processes. For example, epigeic earthworms have no impact on soil structure. Unlike them, anecic and endogeic affects the properties and structure of soil (ZICSI *et al*., 2011). Seasonal factors play an important role in the composition and size of the lumbricidae population, but they do not affect all ecological categories of lumbricidae equally. Since temperature and humidity are the two parameters that have the greatest influence on lumbricides, epigeic species are considered more sensitive than endogenous and anecic species (MONROY *et al*., 2006). These are also consistent with our results. According to HACKENBERGER KUTUZOVIĆ and HACKENBERGER KUTUZOVIĆ (2014), epigeic species are the most threatened category of earthworms in devastated environments, but that anecic species are also affected forms, even though they live at greater depths. In our research, anecic species are completely absent, only *L. rubelus* is epigeic species, while the others are endogeic (Tab. 1). These endogeic species inhabit almost all biotope and live and feed in the mineral layer of the soil. Endogeic species are favored because they can utilize resources of poorer quality through more efficient digestive processes related to mutualistic interactions with microflora introduced along with the soil (EDWARDS, 2004). These can be found in any type of substrate, even in the poorest sandy soil. In degraded soil, in a short period of time, the population of these species can be completely restored (STOJANOVIĆ-PETROVIĆ *et al*., 2020).

Anthropogenic influences can contaminate the soil and thus lead to an ecological imbalance in plant and animal communities, which can subsequently threaten the sustainability of the system. First, in the river valleys and around the Gruž reservoir, there are larger or smaller waste dumps containing waste of very different origins, which in a certain way at the local level leads to physical, chemical and biological soil pollution. Second, there is a large amount of waste on the banks of the reservoir as a result of various recreational activities. Third, perhaps the most important, in the narrow protection zone, there are large agricultural areas that are fertilized and treated with different chemical means, which further endangers the soil (MILOŠKOVIĆ *et al*., 2013).

In our research, the ratio of adult and juvenile individuals is almost equal, and the most juveniles were during the summer season, and the least during the spring. The low density and low number of offspring together with the current threats in the area may endanger the species' population in the future.

The detection of species and knowledge of their ecological characteristics provide an insight into the current state of the examined ecosystems. In our research, found species evidently proves that the degradation processes have progressed in the area Gruža reservoir. It is of the most importance to carry on with Lumbricidae investigations and follow them as indicators that are highly susceptible to environmental changes.

CONCLUSION

This study provides an insight into the structure of Lumbricidae communities in the area of Gruža Lake. Our results show that earthworm communities are poor and uniform. Only five species have been recorded. The main threats to earthworm populations identified in this research are habitat degradation due to waste, agricultural activities, and increased tourism and recreational activity. In this regard, the measures that the competent authorities would implement could be beneficial to ecosystems and, consequently, to earthworm communities.

Living organisms, as bioindicators, best reflect the real state of ecosystems and changes in them. Therefore, based on the results presented in this paper, it is necessary to continue the intensive research in order to preserve the biological diversity of the area.

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