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Soil fauna research in Poland: earthworms (Lumbricidae)

Abstract: Living organisms are the foundation of ecosystem services. Of particular notice is zoedaphone, often underestimated and basically unknown to the general public. The present review summarizes the current state of knowledge related to earthworms occurring in natural and anthropogenically altered habitats in Poland, in the context of the requirement for protection of soil biodiversity.

Keywords: earthworms, soil fauna, natural ecosystems, anthropogenic ecosystems

INTRODUCTION

Advancement of sustainable development and preservation of biological diversity are major tasks faced by the humanity in the 21st century. Announced and supervised by UNESCO, the Decade of Education for Sustainable Development lasted from 2005 to 2014 (Kostecka 2009). Another global environmental and educational operations are to be carried out between 2011 and 2020 in the framework of the Decade of Biodiversity (Strategic Plan... 2011–2020).

Biodiversity is a basis of ecosystem services used by people. All living organisms constitute a foundation of these services, so it is necessary to remember, among others, about soil zoedaphone, which is greatly underestimated, rarely acknowledged, and lacking public awareness (Kostecka 2004, Komisja Europejska... 2010).

Lumbricidae earthworms are a significant part of soil zoedaphone. Their role was recognized in ancient times by Cleopatra and in more contemporary period by Darwin. While making effort to preserve various species of terrestrial plants and animals, do we remember that organisms living in the soil also deserve to be protected? Notably, all soil organisms take part in key processes and changes, crucial for the life on Earth, therefore they constitute an inherent component of all categories of ecosystem services.

An example of multidimensional impacts on the soil and its services is provided e.g. by earthworms which are involved in developing soil structure, in circulation of nutrients and primary production. By improving soil fertility they also significantly impact the quality of crops. According to Blouin et al. (2013) they also play a role in climate regulation, reduction

of soil contamination and numerous cultural services. They are a source of nutritious food for animals and, in some cultures, for people. Currently they are also used in environmental biomonitoring. Highly conclusive findings for the needs of bioindicative measurements can be acquired e.g. by analyzing the number of Lumbricidae species and communities in relevant ecosystems.

The review conducted for the needs of this article focused on studies investigating qualitative and quantitative characteristics of this very significant group of soil inhabitants in the world and in Poland. This is important from the viewpoint of efforts designed to assess the quality and protect biodiversity of the soil – component of the natural environment.

METHODS

Analysis of the rate of worldwide research focusing on the selected issues (particularly related to Lumbricidae) was based on the data from Science Direct which is a full-text database created by Elsevier Science publishing company and comprising electronic versions of Elsevier scientific periodicals. Specific key words (soil biodiversity, soil fauna, Lumbricidae reclamation) were entered into the database search engine, and the result was counted, after retrieving the reports related to a given subject published in the last twenty years (2014 data included relevant information up until September of this year).

Source materials and a list of publications by Polish authors provided information for identifying the range of subjects investigated by studies focusing on earthworms in the domestic natural and anthropogenic ecosystems.

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STUDIES OF LUMBRICIDAE ACCORDING TO SCIENCE DIRECT DATA

Analysis of Science Direct database shows that, globally, since 1996 the number of publications related to earthworms has decreased and remains at a relatively low level (Fig. 1 and 2). In comparison to studies focusing on soil biodiversity (Fig. 1) or those containing a wide range of genetic analyses (Table 1), the number of publications related to Lumbricidae is very low and definitely insufficient.

STATE OF RESEARCH FOCUSING ON EARTHWORMS IN NATURAL AND ANTHROPOGENIC ECOSYSTEMS IN POLAND

The current state of knowledge related to earthworms in Poland is unsatisfactory for both natural and anthropogenic ecosystems. Studies of Lumbricidae are frequently of historical nature or focus on small parts of the territory of Poland. Knowledge of some species is based only on isolated sites, which may

FIGURE 1. Number of publications matching the phrases 'soil biodiversity' and 'Lumbricidae' according to Science Direct database

FIGURE 2. Number of publications matching the phrases 'soil biodiversity' and 'Lumbricidae reclamation' with reference to international environmental campaigns (Science Direct database)

TABLE 1. Number of publications matching the phrase Lumbricidae compared to genetic research (Science Direct database)

Year	Lumbricidae	Enchytraeidae	Collembola	Acarina	Soil Insecta	Soil Bacteria	Soil Fungi	Genetic
2014	114	60	260	139	208	8505	4884	71287
2013	142	47	260	147	196	8409	4893	76956
2012	107	57	234	125	181	7124	4223	69838
2011	134	45	195	118	154	6588	3808	65656
2010	107	48	219	128	146	5818	3540	62135
2009	115	48	228	104	164	5801	3405	61020
2008	113	57	230	89	146	5387	3325	57080
2007	128	43	190	97	135	4722	2892	53347
2006	116	49	235	100	142	4373	2787	50413
2005	78	42	164	96	106	4057	2510	45794
2004	78	40	195	82	106	3612	2259	42113
2003	113	49	148	90	93	3467	2134	38922
2002	62	42	170	93	78	2825	1814	33461
2001	76	35	160	73	90	2809	1839	33382
2000	50	25	128	66	70	2405	1542	30493
1999	56	22	104	91	56	2491	1493	25996
1998	68	26	88	53	54	2371	1527	27134
1997	90	19	87	63	37	2315	1410	27376
1996	46	16	63	98	35	2354	1369	24075
1995 and earlier	530	239	1057	1253	736	31142	22033	284965

result from the insufficient fauna-related data. Therefore, due to the changes occurring in the environment it is indispensable to both repeat and expand the previously conducted observations. It is also necessary to supplement findings by conducting research in areas in which *Lumbricidae* fauna has never been investigated before, e.g. areas of some national parks, nature reserves and habitats with varied wildlife (Kasprzak 1986, 2004).

Basic information about Lumbricidae communities in the Kampinos National Park (middle Poland) can be found in a publication by Plisko (1969). She also investigated the diversity of Lumbricidae in the isle of Wolin (Plisko 1962) and in the Bieszczady mountains (Plisko 1971, 1973). Another studies provided data about earthworms in the Pieniny mountains (Kasprzak 1979, 2000) and in the Polish part of the Carpathians (Kasprzak 1989). On the other hand, Rozen (1982, 1988) investigated Lumbricidae populations in the Niepołomice Forest (south Poland) and in the woods of the Beskid Śląski (Rozen et al. 2013). Studies focusing on various areas of Carpathian beech forests in the Bieszczady mountains were conducted by Kostecka (1992a, 1992b, 1998). Furthermore, comprehensive characteristics of the species inhabiting the Western Bieszczady mountains can be found in publication by Dumnicka and Kostecka (2004).

It is also necessary to conduct more comprehensive studies in areas affected by human activity (farming fields, meadows, wastelands, urban and post-industrial areas). Meanwhile, research focusing on farming areas may draw on previous studies carried out by e.g. Kasprzak and Ryl (1978), Kasprzak and Volender (1988),

Witkowski (1983, 1985), and Kostecka and Mazur (2009).

Earthworms inhabiting urban and suburban areas were investigated, among others, by Plisko (1959) and Pilipiuk (1981). Studies in the vicinity of Rzeszów city were conducted by Garczyńska and Kostecka (2002).

There are few publications focusing on earthworms in severely degraded and post-industrial areas (frequently encountered in Polish landscape). Such studies were conducted e.g. in Jeziórko in reclaimed areas formerly holding Machów sulphur plant (Kostecka et al. 2004), in the area previously occupied by Solvay sodium production plant in Kraków city (Pośpiech and Skalski 2006), in the area of Bolesław Zn-Pb steelworks (Łapiński and Rościszewska 2003), and in the areas contaminated with heavy metals near Olkusz (Tomsza et al. 2010).

In Europe there are a few centers specializing in Lumbricidae research. Their studies have a long history e.g. in Great Britain (Butt 2008; Butt and Lowe 2003; Carpenter et al. 2012). Lumbricofauna has been extensively investigated e.g. in Romania (Pop 1997; Pop and Pop 2006; Pop et al. 2007), France (Deacens et al. 2008; Richard et al. 2012), and in the Balkans (Stojanović and Karaman 2005; Stojanović et al. 2008; Stojanović et al. 2012).

PRESERVATION OF EARTHWORM DIVERSITY

Earthworm species protection and related issues have been rarely explored so far. In the Balkan

Peninsula a special Red List of endangered species was created for them, defining hazard categories (Stojanović et al. 2008). In Great Britain and Ireland distribution of Lumbricidae species has been presented in a form of maps (Carpenter et al. 2012). However, the study is incomplete due to numerous gaps in geographic distribution of some species. Therefore, even in England, where wide ranging attempts have been made to create an inventory, it is necessary to continue operations and monitor earthworm populations in the relevant areas.

In Poland, no earthworm species have been entered onto lists of endangered and protected animals. This is frequently linked with a lack of sufficient fauna-related data and the resulting inability to define hazards pertaining to these invertebrates. Hence it is impossible to classify specific Lumbricidae species in accordance with European Red List categories, defined e.g. by the International Union for Conservation of Nature (2001).

Notably, in Poland there are a few endemic species, encountered only in the Carpathians. Oligoporeutic earthworms constitute 48% of the 21 species identified in the Western Bieszczady mountains (Dumnicka and Kostecka 2004).

The existing evidence shows that hazards related to earthworm fauna result mainly from damage or loss of their natural habitats. This is a result of land development, intensive agrotechnical engineering, damage to plant litter, transformation of forests into farming fields and meadows, as well as land drainage (Kasprzak 2004).

CONCLUSIONS

1. The analysis of source materials shows that, although earthworms significantly contribute to the quality of ecosystem services, in Poland there are relatively few wide-ranging environmental studies focusing in this group of soil invertebrates.
2. Compared with efforts to preserve Lumbricidae taken in other countries, related operations carried out in Poland are insignificant.

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Badania fauny glebowej w Polsce – dżdżownice (Lumbricidae)

Streszczenie: Podstawę świadczeń pełnionych przez ekosystemy stanowią organizmy żywe. Na szczególną uwagę zasługuje zoedafon, często niedoceniany i nieobecny w świadomości społecznej. Opracowano zestawienie aktualnego stanu wiedzy nad dżdżownicami środowisk naturalnych i antropogenicznie zmienionych w warunkach Polski w kontekście potrzeby ochrony różnorodności biologicznej gleb.

Słowa kluczowe: dżdżownice, fauna glebowa, ekosystemy naturalne, ekosystemy antropogeniczne