

# ZOOGEOGRAPHY AND HABITAT DISTRIBUTION OF EARTHWORMS (LUMBRICIDAE) AND ENCHYTRAEIDS (ENCHYTRAEIDAE) OF THE CARPATHIAN MOUNTAINS (POLAND)

K. KASPRZAK

Kasprzak, K., 1989. Zoogeography and habitat distribution of earthworms (Lumbricidae) and enchytraeids (Enchytraeidae) of the Carpathian Mountains (Poland). *Misc. Zool.*, 13: 37-44.

*Zoogeography and habitat distribution of earthworms (Lumbricidae) and enchytraeids (Enchytraeidae) of the Carpathian Mountains (Poland).*— Among earthworms living in the Carpathian Mountains numerous species are megaporectic and peregrine and of the Alpine-Dinaro-Carpathian type distribution. Four zoogeographical groups of enchytraeids can be distinguished: European, North-European, cosmopolitan and Palaearctic species. Most species of enchytraeids are eurytopic or polytopic, and only few are associated with definite habitat types. Specific fauna of earthworms live in Carpathian beech woods. The most abundant species are soil dwellers (geophagous) and those living above soil surface (litter species).

Key words: Lumbricidae, Enchytraeidae, Zoogeography, Distribution, Mountains.

(Rebut: 6 VI 89)

K. Kasprzak, Osiedle Zwycięstwa 8/109, 61-645 Poznań, Poland.

## INTRODUCTION

The earthworms of the Polish Carpathian Mountains were first studied during the nineties of the past century; NUSBAUM (1895, 1896) reports different species from Tatra Mountains. However, investigations on earthworms in other region of Polish Carpathians are fragmentary. A great deal of novel knowledge about earthworms in Pieniny Mountains was gained by NOWAK (1975) and KASPRZAK (1979b), and in Western Bieszczady Mountains by PLISKO (1971). Data on the distribution of enchytraeids in the Carpathian Mountains are also fragmentary and undefined. Detailed studies of enchytraeids were only carried out in Pieniny Mountains by KASPRZAK (1979a), and partially in Tatra Mountains by KASPRZAK & ZAJONC (1980).

The present work is a short report of the zoogeography and ecology of earthworms and enchytraeids living in different environments in the Polish part of the Carpathian Mountains.

## MATERIAL AND METHODS

Data have been selected among the results of the studies carried out between 1968 and 1975 on the distribution of earthworms and enchytraeids in the Polish Carpathians (specially in Pieniny Mountains and Bieszczady Mountains but also in Beskidy Mountains and Tatra Mountains) (fig. 1).

Given the site conditions it was expected that most earthworms lived close to the surface in the litter layer. Thus, the earthworms were collected specially by digging and by hand, sorting the mould and the soil. Rotten logs, bark of dead trees and cattle droppings were checked. Muddy soil and sandy-gravel initial soils along the streams were also inspected. Earthworms were sampled also by the Raw's formalin (0.3-0.5%) expulsion method (5-10 dm<sup>3</sup> of the solution were applied to the area of 0.5 m<sup>2</sup> for each extraction). After extraction they were immediately put into polythene bags together with some of the soil moistened with water, brought to the labora-

tory, counted, narcotised and preserved in 75 % ethanol or AFG solution (75 % ethanol - 750 ml, 4 % formalin - 200 ml, glycerine - 50 ml). All juveniles were classified.

Enchytraeids were sampled with a cylindrical steel corer (8 cm  $\phi$ ) to a depth of 10 cm. Each sample contained the litter and humus layers, down to the surface of the mineral soil. These samples were stored in separate plastic bags and transported to the laboratory. The enchytraeids were extracted with the wet funnel technique of O'CONNOR (1955) method. Enchytraeids were also extracted by hand and microscopic sorting the soil and the litter layer (qualitative method). Individuals were mounted as glycerol microscopical slides with a dash 25 % of acetic acid according to NIELSEN & CHRISTENSEN (1959) method with the KASPRZAK (1986a) modification. Alive and prepared individuals were examined for maturity and identified.

Associations of species in similar ecosystems may differ widely in their taxonomic re-

lationships, but may reflect a close resemblance in its functional relationship with the environment (LEE, 1987). The three morphoecological groups proposed for lumbricids by BOUCHÉ (1972, 1977) are used to group up species:

- a) Epigeous or litter species, live in surface litter or other above-ground habitats.
- b) Topsoil species, live in borrows but come to the surface to gather food.
- c) Endogenous or subsoil species, live in mineral soil horizons, feeding on soil that is more or less enriched with organic matter.

## RESULTS AND DISCUSSION

### Zoogeography

#### Lumbricidae

The zoogeographical analysis of earthworms start from OMODEO's classification of types of occurrence of the earthworms in Europe (1952,

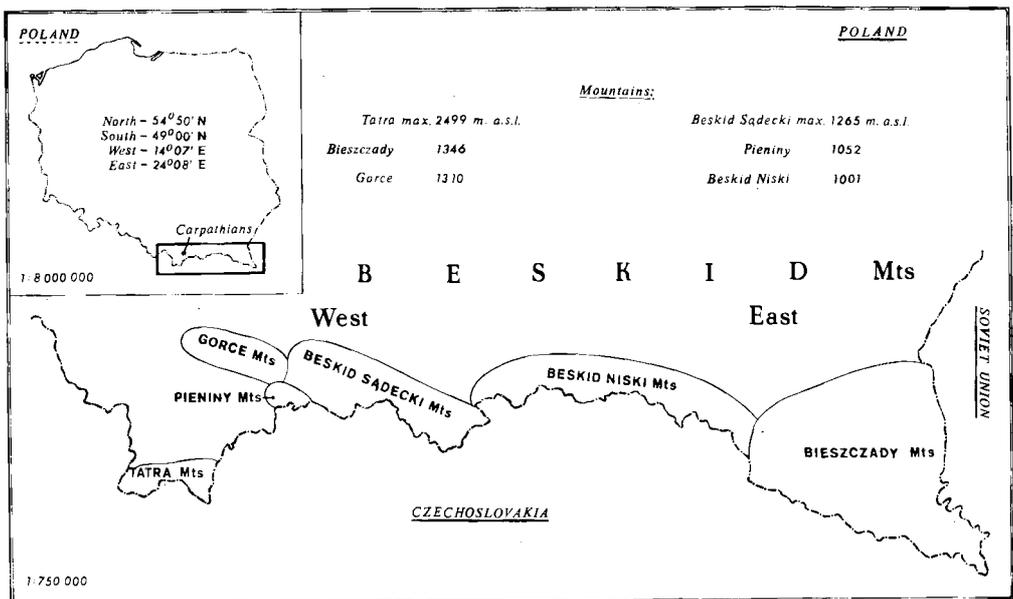


Fig. 1. Map of the Polish part of Carpathian Mountains.  
 Mapa de los Montes Cárpatos polacos.

1961). Many species of earthworms recorded in Poland are megaporeutic and peregrine (table 1) (KASPRZAK, 1986b). These are species which resettled post-glacial terrains and were brought by man from different conti-

nents. The oligoporeutic species can be classified into two groups: one involves the species which in fact did not colonize the regions subjected to the Pleistocene glaciation, they occur in southern Poland and in the Carpathian

Table 1. Megaporeutic and oligoporeutic earthworm species of Poland.  
*Especies megaporéuticas y oligoporéuticas de lombrices de tierra de Polonia.*

Species	Megaporeutic and peregrine	Oligoporeutic		
		Northern- Central- Eastern- European	Alpine- Dinaro- Carpathian	Transaegean
<i>Allolobophora georgii</i> Mich.		+		
<i>smaragdina</i> Rosa				+
<i>carpathica</i> Cog.			+	
<i>sturanyi</i> (Rosa)				+
<i>handlirschi</i> (Rosa)		+		
<i>jassyensis</i> Mich.				+
<i>rosea</i> (Sav.)	+			
<i>caliginosa</i> (Sav.)	+			
<i>longa</i> (Ude)	+			
<i>chlorotica</i> (Sav.)	+			
<i>leoni</i> (Mich.)		+		
<i>Dendrobaena auriculata</i> (Rosa)		+		
<i>octaedra</i> (Sav.)	+			
<i>veneta</i> (Rosa)				+
<i>alpina</i> (Rosa)				+
<i>Dendrodrilus subrubicundus</i> (Eis.)	+			
<i>rubidus rubidus</i> (Sav.)	+			
<i>rubidus tenuis</i> (Eis.)	+			
<i>Eisenia lucens</i> (Waga)			+	
<i>nordenskioldi</i> (Eis.)		+		
<i>spelea</i> (Rosa)			+	
<i>balatonica</i> (Pop)				+
<i>foetida</i> (Sav.)	+			
<i>Octolasion lacteum</i> (Oerley)	+			
<i>cyaneum</i> (Sav.)	+			
<i>Octodrilus argoviensis</i> (Bret.)			+	
<i>complanatus</i> (Dugés)			+	
<i>transpadanus</i> (Rosa)				+
<i>lissaensis</i> (Mich.)			+	
<i>Eiseniella tetraedra</i> (Sav.)	+			
<i>Lumbricus rubellus</i> Hoffm.	+			
<i>terrestris</i> L.	+			
<i>castaneus</i> (Sav.)	+			
<i>baicalensis</i> Mich.		+		
<i>polyphemus</i> (Fitz.)			+	
<i>Proctodrilus antipae antipae</i> (Mich.)		+		
<i>antipae tuberculatus</i> (Cerc.)		+		
<i>Bimastos parvus</i> (Eis.)	+			
<i>eiseni</i> (Lev.)	+			
<i>Fitzingeria platyura platyura</i> (Fitz.)			+	
<i>platyura montana</i> (Cér.)			+	
<i>platyura depressa</i> (Rosa)			+	

Mountains; the other group involves recessive, relict species such as *Lumbricus baicalensis*.

Among 42 earthworms species analyzed in Poland, 17 have cosmopolitan distribution (megaporeutic and peregrine), eight belong to the group of Northern-Central-Eastern-European type distribution, ten to the Alpine-Dinaro-Carpathian type distribution and seven to the Transaegean (=Caucasian-Alpine-Syrian-Aegean) type distribution (table 1). All species of earthworms found in the Polish part of the Carpathian Mountains (table 2) may be classified in the following geographical groups:

a) Megaporeutic species (14 species, 60.9%): *Allolobophora caliginosa*, *A. rosea*, *A. chlorotica*, *Eiseniella tetraedra*, *Octolasion lacteum*, *Bimastos parvus*, *Eisenia foetida*, *Lumbricus castaneus*, *L. rubellus*, *L. terrestris*, *Dendrobaena octaedra*, *Dendrodrilus rubidus rubidus*, *D. rubidus tenuis*, *D. subrubicundus*;

b) Alpine-Dinaro-Carpathian type distribution species (seven species, 30.4%): *Allolobophora carpathica*, *Octodrilus argoviensis*, *O. lissaensis*, *O. complanatus*, *Eisenia lucens*, *Lumbricus polyphemus*, *Fitzingeria platyura montana*;

c) Caucasian-Alpine-Syrian-Aegean type distribution species (two species, 8.7%): *Octodrilus transpadanus*, *Dendrobaena alpina*.

Another classification is based on the present occurrence of species rather than on historical data on their distribution. The zoogeographical classification of all species has been based on the analysis of their ranges and, if possible, on the frequency of their occurrence in a given area. In the Polish part of the Carpathian Mountains most numerous species are cosmopolitan (peregrine species). The remaining geographical groups have a minor participation (1-3 species) in the whole of the earthworms fauna of the Carpathian Mountains in Poland; they are as follows:

a) Palearctic: *Octodrilus transpadanus*

b) European: *Octodrilus lissaensis*

c) Central European: *Octodrilus argoviensis*

d) Southern European: *Octodrilus complanatus*, *Eisenia lucens*

e) Southern and Eastern European: *Lumbricus polyphemus*, *Dendrobaena alpina*, *Fitzingeria*

*platyura montana*

f) Endemic (Eastern Carpathian Mountains): *Allolobophora carpathica*.

#### Enchytraeidae

Enchytraeids living in soils and inland waters are remarkable by the, generally, very large ranges of particular species. Data on geographical distribution of enchytraeids are little precise since only fragmentary studies have been carried out in the world. That is why it is difficult to classify particular species by zoogeographical groups, since their distribution is poorly known. The studies already conducted show that most of the enchytraeid species have large geographical ranges, which is related to their small ecological specialization. The general opinion is that enchytraeids are particularly abundant in the arctic zone and in northern parts of the temperate zone (O'CONNOR, 1971). Probably many species of enchytraeids occur circumpolarly, a deed that is indicated, among other things, by a large similarity between the enchytraeids of the Palaearctic region and of eastern parts of the Nearctic region (NURMINEN, 1973). For example, on the basis of data on the geographical distribution of enchytraeids, all species found in the Pieniny Mountains (KASPRZAK, 1979a) were classified in the following geographical groups:

a) European species (16 species, 44.4%): *Mesenchytraeus glandulosus* (Lev.), *M. pelicensis* Issel, *Cernosvitoviella carpathica*, *Achaeta camerani* (Cog.), *A. seminalis* Kasp., *Enchytronia parva* Niel. et Christ., *Fridericia perrieri*, *F. bisetosa* (Lev.), *F. connata* Bret., *F. maculata*, *F. alata* Niel. et Christ., *F. semisetosa* Dózsa-Farkas, *F. tubulosa* Dózsa-Farkas, *Enchytraeus lacteus* Niel. et Christ., *E. norvegicus* Abrah., *Marionina riparia*;

b) North-European species (also Spitsbergen and Iceland, sometimes Greenland and north regions of Canada) (twelve species, 33.3%): *Mesenchytraeus armatus*, *M. flavus* (Lev.), *Henlea nasuta*, *H. similis* Niel. et Christ., *H. perpusilla*, *F. leydigi* (Vejd.), *F. ratzeli*, *Cernosvitoviella atrata*, *Achaeta eiseni* Vejd, *Marionina argentea*, *Cognettia sphagne-*

*torum*, *Buchholzia appendiculata*;

c) Cosmopolitan species (five species, 13.9%): *Henlea ventriculosa* (d'Udek.), *Enchytraeus buchholzi*, *Fidericia galba* (Hoffm.), *F. bulbosa*, *F. bulboides* Niel. et Christ.;

d) Palearctic species (three species, 8.4%): *Bryodrilus ehlersi*, *Fridericia paroniana* Issel, *Enchytraeus minutus* Niel. et Christ. The observations carried out so far show that similar zoogeographical relations among enchytraeids occur over the whole central Europe. There are many works and papers which have helped in the definition of the ranges of the species of enchytraeids, and their membership to various zoogeographic regions and areas (KASPRZAK, 1986a).

#### Habitat distribution

##### Lumbricidae

Most of the earthworm species living in the Carpathian Mountains are largely eurytopic, i.e. they occurred in many different habitats

(beech forests, Carpathian alder-woods, xerothermic sward, meadows and pastures, sedge marsh and fields), only few species being associated with definite biotopes. The most specific earthworms of the Carpathian beech forest are: *Eisenia lucens* (feed under bark), *Dendrobaena octaedra*, *Lumbricus rubellus* (litter species), *Octolasion lacteum* and *Allolobophora caliginosa* (soil dwellers), *Octodrilus argoviensis* (litter species). The most abundant in the Carpathians (for example in Tatra, Pieniny, Bieszczady and Beskid Mountains) are soil dwellers (*A. caliginosa*, *A. rosea*, *O. lacteum*) and species living above soil surface (*L. rubellus*, *Eiseniella tetraedra*) (at 1600 m a.s.l., upper zone of the Regle Range). Large species—deep soil dwellers (*Lumbricus terrestris*, *Fitzingeria platyura montana*)—live mainly on the foothills and the lower zone of the Regle Range (at 1200-1300 m a.s.l.). A typical species in the soil of meadows of the lower montane zone (700-1250 m a.s.l.) in Tatra Mountains is *Dendrobaena alpina*—it lives in bu-

Table 2. Earthworm species of the Polish Carpathian Mountains: I. Tatra Mts; II. Pieniny Mts; III: Gorce and Beskid Sądecki Mts; IV. Eastern Beskid Mts; V. Bieszczady Mts.

*Especies de lombrices de tierra de la parte polaca de los Montes Cárpatos.*

Species	I	II	III	IV	V
<i>Allolobophora caliginosa</i>	+	+	+	+	+
<i>carpathica</i>					+
<i>rosea</i>	+	+	+		+
<i>chlorotica</i>		+	+	+	
<i>Eiseniella tetraedra</i>	+	+	+	+	+
<i>Octolasion lacteum</i>	+	+	+	+	+
<i>Octodrilus lissaensis</i>					+
<i>transpadanus</i>					+
<i>complanatus</i>					+
<i>argoviensis</i>		+			
<i>Eisenia lucens</i>	+	+		+	+
<i>foetida</i>	+	+	+	+	+
<i>Bimastos parvus</i>					+
<i>Lumbricus castaneus</i>	+	+	+	+	+
<i>rubellus</i>	+	+	+	+	+
<i>terrestris</i>	+	+	+	+	+
<i>polyphemus</i>					+
<i>Dendrobaena octaedra</i>	+	+	+	+	+
<i>alpina</i>	+			+	+
<i>Dendrodrilus rubidus rubidus</i>	+	+		+	+
<i>rubidus tenuis</i>		+	+		
<i>subrubicundus</i>		+			
<i>Fitzingeria platyura montana</i>		+	+		+

rows, feeds on surface litter and it occurs at 1800 m a.s.l. (zone of the dwarf pine). In the soil of *Pinus mughus* Scop. there is a community of four species of earthworms: *D. octaedra*, *Dendrodrilus rubidus tenuis* (litter species), *D. alpina* (epiendogeus), *O. lacteum* (geophagous) (KASPRZAK & ZAJONC, 1980). In humid environments the most abundant species are *E. tetraedra*, *O. lacteum*, *D. octaedra* and *L. rubellus*.

The effect of man management on the earthworms fauna in the Pieniny Mountains has been analysed by KASPRZAK (1979b, 1980). The changes induced by man management are particularly pronounced in meadows and fields, thus modifying the species composition. On the Carpathian beech forest, which is a natural environment, forest species such as *Eisenia lucens* (feed under bark) and litter species (*Octodrilus argoviensis*, *Dendrodrilus rubidus tenuis*) are reduced. Instead, new spe-

cies such as *Eisenia foetida* (detritophagous and coprophagous) and *Dendrodrilus subrubicundus* living in litter, directly related to man management, appear.

Enchytraeidae

In the Carpathian Mountains most of the enchytraeid species live in different environments and only few of them are exclusive of a single biotope (for example *Propappus volki*, family Propappidae, which according to COATES, 1986, lives only in streams). The reasons of such a peculiarity of the enchytraeid fauna, are its high adaptability and possibly a great inner ecological differentiation of these environments composed by a big number of small microbiotops in which the same species are found. In the Polish part of the Carpathian Mountains 40 species of enchytraeids were found in different environments (initial warp soils, beech wood, beech and fir forests, spruce

Table 3. Enchytraeid species of the aquatic environments and caves of the Tatra Mountains (after KASPRZAK & ZAJONC, 1980): 1. Lakes; 2. Streams.

*Enchytraeidos de los medios acuáticos y las cuevas de los montes Tatra: 1. Lagos; 2. Arroyos.*

Species	Zones						
	Lower montane		Upper montane		Dwarf pine	Alpine	Caves
	1	2	1	2	1	2	
<i>Propappus volki</i> Mich.		+		+			+
<i>Mesenchytraeus armatus</i> (Lev.)		+	+	+			+
<i>Cognettia sphagnetorum</i> (Vejd.)		+	+	+		+	
<i>glandulosa</i> (Mich.)	+	+		+		+	
<i>anomala</i> (Čer.)		+		+			
<i>Cernosvitoviella atrata</i> (Bret.)		+		+			+
<i>carpathica</i> Niel. & Christ.		+		+			
<i>parviseta</i> Gadz.							+
<i>tatrensis</i> (Kow.)	+	+			+	+	+
<i>Henlea nasuta</i> (Eis.)		+		+			
<i>perpusilla</i> Friend							+
<i>Fridericia bulbosa</i> (Rosa)							+
<i>perrieri</i> (Vejd.)		+					
<i>maculata</i> Issel							+
<i>ratzeli</i> (Eis.)				+			+
<i>Buchholzia appendiculata</i> (Buchh.)							+
<i>Bryodrilus ehlersi</i> Ude							+
<i>Enchytraeus buchholzi</i> Vejd.							+
<i>dominicæ</i> Dum.							+
<i>Marionina argentea</i> (Mich.)							+
<i>riparia</i> Bret.							+

forest, meadows, grass-lands and fields). The genus *Fidericia* Mich. was the most abundantly represented. *Buchholzia appendiculata* is most represented in the samples and by the highest numbers. Many species of enchytraeids live also in aquatic environments (lakes, streams) and caves (table 3) (caves: Szczelina Chochołowska, Dziura, Miętusia, Zimna, Kalacka, Goryczkowa, Bandzioch). In previous papers the human management influence on the enchytraeids in Pieniny Mountains is stressed (KASPRZAK, 1979a, 1980, 1982). The changes which can be connected with the human influence are especially visible in the anthropogenic environments, such as meadows and fields. The changes are expressed by a decrease in the number of species, a variation in the species composition, and by the restrained occurrence of species such as *Buchholzia appendiculata* and *Mesenchytraeus glandulosus*.

## CONCLUSIONS

1. Most earthworm species have cosmopolitan (megaporeutic and peregrine species) or Alpine-Dinaro-Carpathian distribution. Four zoogeographical groups of enchytraeids can be distinguished: European, North-European, cosmopolitan and Palearctic species.

2. Most species of enchytraeids are either eurytopic or polytopic, and only very few are associated with definite habitat types. Specific fauna of earthworms lives in Carpathian beech woods. The most abundant species in the Carpathian environments are soil dwellers (geophagous) and species living above soil surface (epigeous).

3. The agricultural activity of man in the Carpathian Mountains has caused a change of the whole species composition of earthworms in soils of seminatural and anthropogenic environments developed on primary forest. This change is a considerable reduction of the occurrence of specialized species connected with forest soils, as well as an increase of the number of eurytopic species of great adaptative abilities.

## RESUMEN

*Zoogeografía y distribución por hábitats de las lombrices de tierra (Lumbricidae) y de los enchytraeidos (Enchytraeidae) de los Montes Cárpatos (Polonia).*

Este trabajo es un breve informe sobre la zoogeografía general y la ecología característica de los enchytraeidos y las lombrices de tierra que habitan en diferentes medios de los Cárpatos polacos (fig. 1). En la fauna de lombrices la mayoría de especies posee una distribución cosmopolita (especies megaporeúticas y peregrinas) o bien tienen una distribución del tipo Alpino-Dinaro-Carpatiano (tabla 1). Se pueden distinguir 4 grupos zoogeográficos de enchytraeidos: especies Europeas, Noreuropeas, cosmopolitas y Paleárticas. La mayor parte de especies de enchytraeidos son euríticas y tan sólo unas pocas están asociadas a tipos definidos de hábitat. En los bosques de hayas de los Cárpatos habita una fauna específica de lombrices de tierra. Las más abundantes son pobladoras del suelo (geófagas) y especies que viven sobre la superficie de éste (epigeas). La actividad agrícola del hombre en los Montes Cárpatos ha causado cambios en la composición general de especies de lombrices en suelos seminaturales y entornos antropogénicos, provocando una considerable reducción en la presencia de especies especializadas asociadas a sustratos forestales, así como un aumento del número de especies euríticas con gran capacidad de adaptación.

## REFERENCES

- BOUCHÉ, M.B., 1972. *Lombriciens de France. Ecologie et Systématique*. INRA Publ. Paris.
- 1977. Strategies lombriciennes. *Biol. Bull.*, 25: 122-132.
- COATES, K.A., 1986. Redescription of the oligochaete genus *Propappus*, and diagnosis of the new family *Propappidae* (Annelida: Oligochaeta). *Proc. Biol. Soc. Wash.*, 99 (3): 417-428.
- KASPRZAK, K., 1979a. *Oligochaeta* of the Pieniny Mts. I. *Enchytraeidae*. *Fragm. Faun.*, 24: 7-56. (In Polish).
- 1979b. *Oligochaeta* of the Pieniny Mts. III. Earthworms (Lumbricidae). *Fragm. Faun.*, 24: 81-95. (In Polish).
- 1980. *Oligochaeta* community structure and function in agricultural landscapes. In: *Aquatic Oligochaete Biology*: 411-431. (R.O. Brinkhurst & D.G. Cook, Eds.). Plenum Publishing Corporation, New York, London.
- 1982. Review of enchytraeid (*Oligochaeta, Enchytraeidae*) community structure and function in agricultural ecosystems. *Pedobiologia*, 23: 217-232.
- 1986a. *Aquatic and soil oligochaetes, II. Family: Enchytraeidae*. Klucze do oznaczania bezkręgowców Polski, 5. PWN, Warszawa. (In Polish).

- 1986b. *Soil oligochaetes, III. Family: Lumbricidae*. Klucze do oznaczania bezkręgowców Polski, 6. PWN, Warszawa. (In Polish).
- KASPRZAK, K. & ZAJONC, I., 1980. Oligochaetes of the Tatra Mts. *Przegl. Zool.*, 24: 189-199. (In Polish).
- 1981. Earthworms (*Oligochaeta, Lumbricidae*) of the Sudety Mts and Polish-Slovakian part of the Carpathians. *Przegl. Zool.*, 25: 495-512. (In Polish).
- LEE, K.E., 1987. Ecological strategies of earthworms. In: *On Earthworms. Selected Symposia and Monographs U.Z.I.*: 171-181 (A.M. Bonvicini Pagliali & P. Omodeo Eds.). Mucchi, Modena.
- NIELSEN, C.O. & CHRISTENSEN, N., 1959. The *Enchytraeidae*. Critical Revision and Taxonomy of European Species. *Natura Jutland.*, 8-9.
- NOWAK, E., 1975. Population densities of earthworms and some elements of their production in several grassland environments. *Ekol. Pol.*, 23: 459-491.
- NURMINEN, M., 1973. Distribution of northern Enchytraeids (*Oligochaeta*). *Ann. Zool. Fenn.*, 10: 483-486.
- NUSBAUM, J., 1895. Report on investigations of the vermes in summer 1893 year. *Spraw. Kom. Fizyogr.*, 30: 41-44. (In Polish).
- 1896. Materials to natural history of oligochaetes in Galicja region (Poland). *Spraw. Kom. Fizyogr.*, 31: 9-62. (In Polish).
- O'CONNOR, F.B., 1955. Extraction of Enchytraeid worms from a coniferous forest soil. *Nature*, 175: 815-816.
- 1971. Enchytraeids. In: *Soil Biology*: 215-257 (A. Burges & F. Raw Eds.). PWRiL, Warszawa. (In Polish).
- OMODEO, P., 1952. Particularity della zoogeografia dei Lombrichi. *Boll. Zool.*, 19: 349-369.
- 1961. Le peuplement des îles méditerranéennes et le probleme de l'insularite. *Col. int. du Centre nat. des Rech. sci.*, 94: 128-133.
- PLISKO, J.D., 1971. Earthworms (*Oligochaeta, Lumbricidae*) of the Bieszczady Mts. *Fragm. Faun.*, 17: 31-48. (In Polish).