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Studies on Oligochaeta taxocens in streams, interstitial and cave waters of southern Poland with remarks on Aphanoneura and Polychaeta distribution

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Abstract. A total of 59 oligochaete species were found in the studied materials*. The taxonomic notes on the following taxa are included: *Nais* with bifid needle setae, *C. tatrensis, C. parviseta,* and *E. dominicae*. The distribution of Aphanoneura (*Aeolosoma* spp.) and Polychaeta (*Troglochaetus beranecki*) in Polish underground waters is discussed. The composition and structure of the oligochaete taxocens from various kinds of water bodies (streams, springs, interstitial waters, and cave waters) in the mountains and uplands of southern Poland is presented. In montane streams four types of taxocen are distinguished: with predomination of Enchytraeidae, Naididae, Lumbriculidae, or *P. volki*. In interstitial waters taxocens similar to those living in the stream bottom are found, besides those streams, in which Naididae predominated in the benthic fauna. In stagnant, endogenous cave waters mainly Enchytraeidae and Lumbriculidae were noted, while in Sudeten Tubificidae (*Rhyacodrilus falciformis*) were also encountered. In caves with watercourses Naididae and *Propappus volki* were also found. The comparison with oligochaete fauna living in the same kind of water bodies in other geographic regions showed the similarity of taxocens living in the studied water bodies (mainly on the genera level).

Key words: Annelida, Oligochaeta, mountain streams, springs, interstitial waters, cave waters, Poland.

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I. INTRODUCTION

After geographical names the following abbreviations are used in the text:
C. – Cave,
I. B. – intermountain basin,
L. – Lake,
R. – River,
S. – Stream,
V – valley.

Stations located in each region are numbered starting with 1 while a letter indicating region preceding each number stands for:
T – Tatra Mts,
S – Sudeten Mts,
J – Olkuska Upland,
W – wells on Wysoczyzna Łaska Upland,
I – other stations, situated in various regions.

Taxocens of a few, most common, groups of benthic invertebrates living in the streams of various mountain ranges in Poland have been comprehensively described, e.g. Chironomidae from the High Tatra Mts (KOWNACKI 1971), Ephemeroptera (SOWA 1975), and Trichoptera from the Western Carpathian Mts (SZCZĘSNY 1986). However, so far there has been no such description of Oligochaeta dwelling at the bottom of montane streams. Likewise, there is no information on oligochaetes living in interstitial waters of montane streams, since the sole data from that habitat in Poland have been obtained from interstitial waters of submontane streams and rivers (KASPRZAK 1973a) and one lowland river (KASPRZAK 1975). In the earliest papers summarising the knowledge of troglo- and stygobiontic fauna of caves in Poland (SKALSKI & SKALSKA 1969), or of stygobionts from underground waters of various types (SKALSKI 1976, 1994), no information on oligochaetes has been provided or only a scant one. Occasional studies on these invertebrates in Polish caves did not start until the 70-ties (DUMNICKA 1977b, 1977c), while the first paper summarising the knowledge on their presence in caves of Southern Poland was published only a few years later (DUMNICKA 1981). Nevertheless, the present state of our knowledge on the Oligochaeta fauna of underground waters is not sufficient since certain karstic areas have not yet been studied and the area of Kłodzkie Sudeten was studied only once in the 30-ties (PAX & MASCHKE 1935), when Niedźwiedzia C. – the most interesting and longest cave of this region – was not known.

The present paper aims at summarising the knowledge on the distribution of oligochaetes in karstic areas of Poland. Taxocens of oligochaete present in the headwater streams of a few mountain ranges are compared; gradual changes in the composition and structure of oligochaete taxocens living in a benthic, interstitial, and cave environment are also investigated. Additional materials from the wells located on the Grabia R. terrace permitted comparison of the composition of underground water taxocens from karstic regions with those coming from areas of different geological structure. Moreover, an attempt to answer the question of how and when stygobiontic Oligochaeta species reached the underground waters of the studied areas of Poland has been made.

History of the oligochaete fauna investigations on the studied regions

Although the studies on aquatic fauna in the mountains (especially in the Tatra Mts) started as far back as at the end of XIX century, oligochaetes long remained one of less known groups. The first, very fragmentary, data on these invertebrates can be traced to the works of WIERZEJSKI (1881, 1883), who studied the fauna of High Tatra Mts lakes and found there merely three Oligochaeta species. Further elaborations, also particularly concerning lakes, were made by MINKIEWICZ (1914) and KOWALEWSKI (1914), who determined material collected by the first above author. 15 species were mentioned in these papers. Initial information on the occurrence of oligochaetes in the streams (*Nais variabilis* only) was given by ČERNOSVITOV (1930). He studied mainly the fauna of lakes and soil Enchytraeidae from Slovak High Tatra and Nižne Tatra Mts. Further information on oligochaetes from various lakes located at different altitudes can be found in papers by HRABĚ (1939, 1940, 1942). The first list of oligochaete species found in the streams of the High Tatra Mts was given by DUMNICKA (1976a). The first reports on oligochaete fauna from Western Tatra Mts streams were by KASPRZAK (1981a) and by KASPRZAK & ZAJONC (1980), who found five species. Thanks to the studies on the Kościeliski S. (DUMNICKA & WOJTAN 1989, DUMNICKA & GALAS 1997, GALAS & DUMNICKA 1998) the list was considerably enlarged. KOWALSKI (1955) was the first one to note the presence of the Oligochaeta in the Tatra Mts caves, followed by CHODOROWSKA & CHODOROWSKI (1960) who described the abundant presence of that group in certain types of cave water bodies, but without determination of those materials. In a few papers devoted to oligochaetes from caves (DUMNICKA 1977b, 1995b, 1996c) 22 species were listed, among them the majority being found in water bodies, but some also in cave terrestrial sediments, and one new species was described (GADZIŃSKA 1974).

The first faunistic studies in the Sudeten Mts (the Śnieżnik Massif) on a large scale were carried out in the third decade of the XX century by Prof. Pax's team from Wrocław. At the same time they studied aquatic fauna collected from various surface (swamps, springs, streams) and cave water bodies. The results of those studies were published in a series of papers (MASCHKE 1936, PAX & MASCHKE 1935, 1936, STAMMER 1936). In the underground waters stygobionts such as the polychaete *Troglochaetus beranecki* (in Radochowska C. and Na Rogóżce C.), not known from other mountain ranges in Poland, were found (STAMMER 1937). On the basis of materials collected during those studies MOSZYŃSKI (1936) described a new stygobiontic species (*Trichodrilus spelaeus*) found in an adit. Unfortunately, this adit was destroyed, and the species could not later be found. Parallel studies on aquatic fauna of the Śnieżnik Kłodzki Massif, mainly in the part now belonging to the Czech Republic, were carried out by HRABĚ (1937a), who found six species of oligochaetes in the caves, including one stygobiont, as well as seven species in the streams. 20 species from running waters of Kotlina Kłodzka I.B. were reported by KASPRZAK (1973b, 1973c), who carried out his studies primarily on parts of streams polluted by municipal sewage, so that the most numerous were species belonging to the families Naididae and Tubificidae.

The first information on oligochaetes from the Krakowsko-Wieluńska Upland (the Olkuska Upland is a part of it) concerned underground waters originates from a paper by JAWOROWSKI (1893) who found in wells in Kraków two species of Lumbricidae and three Enchytraeidae species (including one, now considered as *species dubiae*). Further information was provided by SZARSKI (1947), who collected material mainly from fish ponds near Kraków, but also from running waters (Vistula R. and Wilga R.) and a well (in which he found *Haplotaxis gordioides*). An abundant occurrence of aquatic Oligochaeta in the Sąspówka S. (a tributary of the Prądnik S.) was noted by SZCZĘSNY (1968), but that material was not determined. KASPRZAK (1976c) elaborated oligochaete fauna of the Prądnik S. (31 species, 2 species in the spring), while DUMNICKA (1994b) in the Sąspówka S. Untill the 70-ties the only Oligochaeta taxa known from cave sediments of the Olkuska Upland were: *Dendrobaena* sp. described by DEMEL (1918) from the Nietoperzowa C. as well as undetermined Enchytraeidae, found by the same author in the Łokietka C. Later on, materials from a few caves were worked out (DUMNICKA 1977c, DUMNICKA & WOJTAN 1990) and two new species have been found in that environment (DUMNICKA 1976b, 1977a).

From the Świętokrzyskie Mts the first list of oligochaetes present in running waters can be found in the paper by DUMNICKA (1978) concerning mainly the oligochaete fauna of the Nida R. and its main tributaries but also from the lower parts of this mountain range (Lubrzanka R. and Belnianka R.). More thorough studies of running waters in that area were carried out by KAHL (1983, 1986, 1991). In this last paper she described in detail the distribution of species in the streams flowing down the Łysogóry Mts, the main range of the Świętokrzyskie Mts, and neighbouring regions. Oligochaetes in stagnant waters of the Świętokrzyski region were studied only by BARTNICKA (1978, 1980).

Information on aquatic oligochaetes of the Niecka Nidziańska Basin can be found solely in papers by Dumnicka (1978), Kahl (1983), and by Dumnicka & Wojtan (1993).

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II. MATERIAL AND METHODS

In the present work materials collected in the period 1972–96, as well as some materials collected between 1965 and 1972 from the High Tatra Mts streams by Dr A. Kownacki are analysed. The frequency and periods of samplings varied considerably. In some High Tatra Mts streams (Czarny Potok S. and Sucha Woda S.), Sąspówka S., and also in Kryspinowska C. samples were taken monthly. Seasonally (minimally 4 times a year) samples were collected from the remaining streams, springs, interstitial waters, wells and Kłodzkie Sudeten caves, two caves located on the Olkuska Upland, the Chelosiowa Jama C. (Świętokrzyskie Mts), and two Tatra Mts caves (Kasprowa Niżnia C. and Wodna C.). In some caves and artificial cavities (called „souterrains") samples were collected only once or twice, and if more frequently this was in one season only – usually in winter. The smallest number of samples from one station was 10, but usually there were many more of them. The majority of materials collected in the Tatra Mountains, Olkuska Upland, Świętokrzyskie Mts, and Niecka Nidziańska Basin were already used in particular papers (Dumnicka 1976a, 1977b, 1977c, 1994b, 1995b, 1996b, 1996c, Dumnicka & Galas 1997, Dumnicka & Wojtan 1989, 1990, 1993, 1994, Galas et al. 1996a, Galas & Dumnicka 1998) but new data from various water bodies of these regions are also included. In the Tatra Mts new materials were collected from springs and interstitial waters close to the streams as well as additional benthic samples from two streams: the Sucha Woda S. (High Tatra Mts) and Kościeliski S. (Western Tatra Mts). Materials from caves were also complemented by materials from cave water bodies (Zimna C., Naciekowa C., Kasprowa Niżnia C.). As to the Olkuska Upland, material from springs located in the Sąspówka V. and additional benthic samples from Sąspówka S. were collected; in the Świętokrzyskie Mts – materials from the Raj C. and additionally from the Chelosiowa Jama C. were collected and worked out. Materials from the Sudeten Kłodzkie Mts (collected from streams, interstitial waters, springs, and caves), and also samples (collected by Dr A. Konopacka) from wells situated on the Grabia R. terrace (part of the Południowo-Wielkopolska Lowland) have not yet been published. In caves and souterrains (artificial cavities) samples have been collected from two kinds of water body. The first one was the underground watercourses of surface streams. These streams may inflow directly into the caves (e.g. the Skorocicki S.), or through a layer of sediments (the Kościeliski S.). The second type of water body – named endogenic water body – consisted of pools or lakelets originating from precipitation waters infiltrating the caves from the surface. Not all endogenic water bodies have direct contact with surface waters. Some of them are in contact with groundwaters, while others are isolated from thems owing to the impermeability of the cave floor.

The samples (mainly qualitative ones) were taken from various kinds of bottom (solid rock, boulders, sand, clay, mud, detritus) in springs, streams, and cave water bodies using a bottom scraper (a slightly modified Surber net with a 0.3 mm mesh). In order to collect samples from interstitial waters of the streams holes 40-50 cm deep were dug, and infiltrating water was trickled through a mesh (Karaman-Chappuis method). Samples from wells were collected using a Cvetkov net (one with a special plastic container preventing caught invertebrates from pulling back). Each time 20 hauls with a mesh were made. All samples were preserved with 4% formaline. After washing from the sediments the animals were sorted using a stereoscopic microscope, and whole specimens were mounted in Canada balsam. The density (number of individuals per m^2) was calculated, if this was possible. For all samples (qualitative and quantitative) the relative abundance of each species or higher taxon was calculated. The structure of taxocens was determined on the basis of these data. A taxocen, following the definition of CHODOROWSKI (1960), is a group of related species with defined and repeating dominance structure and living in the same environment. On the basis of the relative abundance, in the taxocen three groups of species were distinguished: dominants $10\% \le d \le 100\%$, subdominants $1\% \le d \le 9.9\%$, and remaining adominants $d < 1\%$. For a few populations of *Cernosvitoviella tatrensis* the length of setae was measured on selected segments and the importance of differences was tested using the Student t-test. The homogeneity of populations was tested on the basis of variation coefficient (CV) values (MAYR 1974):

$$CV = (SD x 100) : M$$

where SD – standard deviation, M – average.

The similarity of taxocens was defined on the basis of Sokal's method and cluster analysis.

For biometric studies of *C. tatrensis*, besides specimens collected from the studied streams, material from theTatra lakes collected during statutory studies of the Institute of Freshwater Biology PAS and grants* was also used.

III. DESCRIPTION OF THE STUDY AREA

Classification, names and areas of geographic regions are used after KONDRACKI (1994) and depicted in Fig. 1.

1 – The Tatra Mts

These Mountains, formed during the Alpine orogenesis, are the highest (2663 m) range of the Carpathian Mts, and lie between the Huciańska Pass on the West, and the Ździarska Pass on the

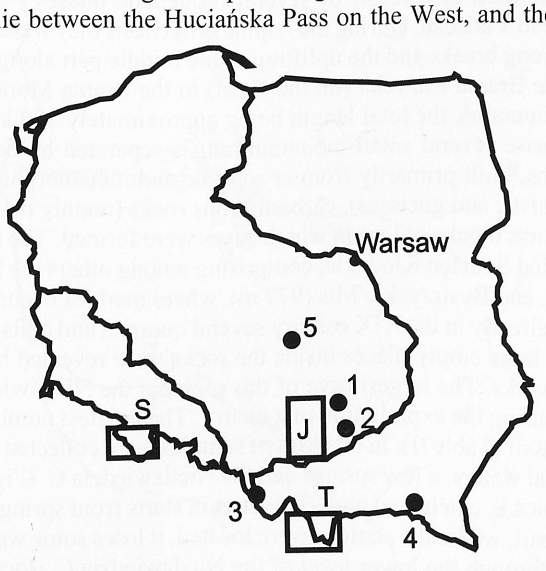

Fig. 1. Map of Poland showing the location of the studied regions. T – Tatra Mts, S – Kłodzkie Sudeten Mts, J – Olkuska Upland, 1 – Świętokrzyskie Mts, 2 – Niecka Nidziańska Basin, 3 – Beskid Śląski Mts, 4 – Beskid Niski Mts, 5 – Wysoczyzna Łaska Upland

East. In a straight line they are about 55 km long, about 15 km wide, and have an area of 785 km^2, of which only 175^2 km lies in Poland. The studied water bodies are situated both in the High Tatra Mts, built from granite rock, while in lower parts in places from schists and flysch rocks and in the Western Tatra Mts built mainly from limestone and dolomites.

The studied High Tatra Mts streams (Fig. 2) drain the northern slopes of that mountain range and the majority of them outflow from lakes: the stream from Czarny Staw under Rysy (1580 m), Rybi Potok S. – Morskie Oko L. (1395 m), Roztoka S. – Wielki Staw L. in Dolina Pięciu Stawów Polskich V. (1665 m), Czarny Potok S. (the upper part of Sucha Woda S.) – Czarny Staw Gąsienicowy L. (1620 m). Outflows from the mentioned lakes located at the highest altitude are situated in the alpine pasture zone, and the remaining ones in the upper alpine forest zone (Table I). These streams are characterised by high variability of flow rates, the highest values being attained during the snow melting season and after driving rains. Only some fragments of the Sucha Woda S. bed are dry through parts of the year since its waters run out by underground ways (GŁAZEK 1995). The Kościeliski S. (Western Tatra Mts) originates from the joining of two streams: Pyszniański and Tomanowy, which start from springs (altitude: 1325 m and about 1670 m). Although the Kościeliski S. runs through highly karstified terrains, periods of its complete drying out occur only in exceptionally dry years. Some of its waters run continuously through the Wodna pod Pisaną C. Also through the Chochołowska Szczelina C. (Chochołowska V.) runs a part of the Chochołowski S. waters. Among the remaining studied caves (Table I) only the Kasprowa Niżnia C. is at times almost completely flooded and its entrance then works as a vauclusian spring. Other caves fed by infiltration waters are drained by vauclusian springs situated on the valley bottom, mainly Kościeliska V. (Lodowe źródło S.) (GŁAZEK 1995).

Information on the hydrology, hydrochemistry, and on the zoocenoses of surface waters of the Polish Tatra Mts is collected in a book edited by MIREK et al. (1996), an unpublished elaboration by KOWNACKI & ŁAJCZAK (1997), and a detailed description of caves in the paper by KOWALSKI (1953) and subsequent volumes edited by GRODZICKI (1991, 1993a, 1993b, 1995).

2 – The Sudeten Kłodzkie Mts

The Sudeten were formed as a result of several orogenetic phases – from the Precambrian through early-Paleozoic to Variscan. During the Alpine orogenesis they were morphologically rejuvenated owing to the strong breaks and the uplifting of the middle part along the border faults. The Sudeten spread from the Brama Łużycka (on the West) to the Brama Morawska separating them from the Carpathian Mountains, the total length being approximately 280 km, and width up to 50 km. The Sudeten comprise several small mountain ranges separated by depressions of different sizes. In these mountains, built primarily from crystalline and metamorphic rocks of various age (bazalts, porphyries, schists, and gneisses), carboniferous rocks (mainly marbles) undergoing karstiphication processes form blocks or lens in which caves were formed. The studied region is a part of the East Sudeten, called Sudeten Kłodzkie, comprising among others the Śnieżnik Massif (1424 m), Złote Mts (1125 m), and Bystrzyckie Mts (977 m), where marbles occur especially frequently. This is why in this area already in the XIX century several quarries and adits were built. During the exploitation of quarries large empty places inside the rocks were revealed but some of them were destroyed during later works. The largest cave of this region – the Niedźwiedzia C., was found in 1966 also incidentally during the exploitation of a quarry. The greatest number of research stations were in the Śnieżnik Massif (Table II). In this Massif samples were collected from the bottom of the Kleśnica S., its interstitial waters, a few springs and the Niedźwiedzia C. (Fig. 3). All these stations are situated in the Kleśnica S. catchment area. This stream starts from springs located at an altitude of 1210 m. In its upper part, where the stations were located, it loses some water in several sinkhole systems; its waters run through the lower level of the Niedźwiedzia C., located at the level of the valley bottom and in some places even below it (CIĘŻKOWSKI 1989). A karstic area of that part of the valley is being formed until today, so great quantity of water runs through it and may shift in dif-

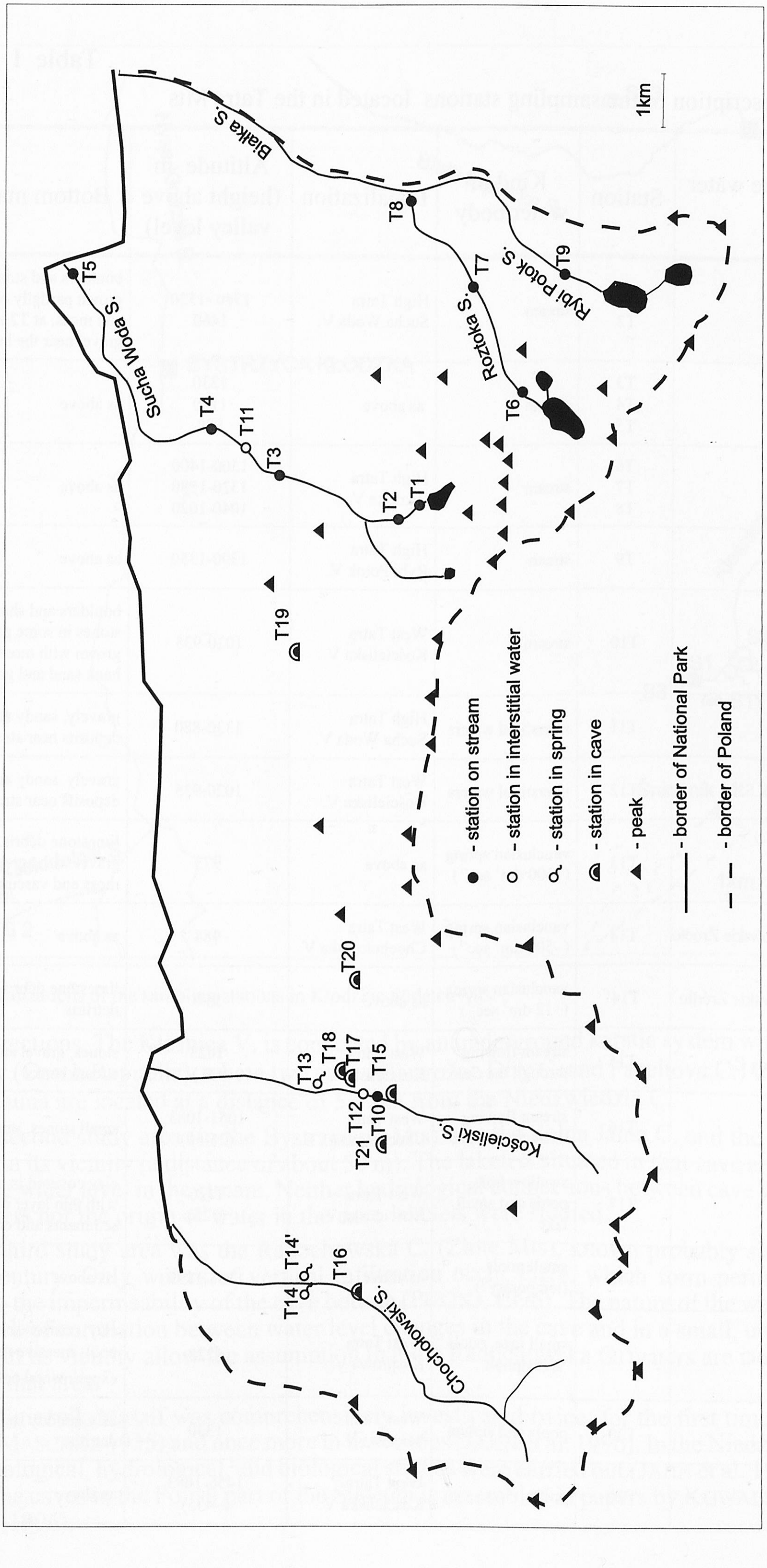

Fig. 2. Localizations of the sampling stations in Tatra Mts.

Table I

Description of the sampling stations located in the Tatra Mts

Name of the water body	Station	Kind of water body	Localization	Altitude m (height above valley level)	Bottom materials
Czarny Potok	T1 T2	stream	High Tatra Sucha Woda V.	1540 -1530 1460	boulders and stones over-grown partially with algae and moss; at T2 sand and gravel near the banks
Sucha Woda	T3 T4 T5	stream	as above	1330 1180 880	as above
Roztoka	T6 T7 T8	stream	High Tatra Roztoka V.	1500-1400 1320-1280 1040-1020	as above
Rybi Potok	T9	stream	High Tatra Rybi Potok V.	1390-1350	as above
Kościeliski Potok	T10	stream	West Tatra Kościeliska V.	1020-935	boulders and sharp-edged stones in some places over-grown with moss; at the bank sand and gravel
Sucha Woda S.	T11	interstitial waters	High Tatra Sucha Woda V.	1330-880	gravely, sandy and muddy deposits near stream bed
Kościeliski Potok S.	T12	interstitial waters	West Tatra Kościeliska V.	1020-935	gravely, sandy and muddy deposits near stream bed
Lodowe Źródło	T13	vauclusian spring ($\sim$500 dm^3 sec^{-1})	as above	973	limestone débris, sand and gravel with agregation of moss and vascular plants
Wielkie Chochołowskie Źródło	T14	vauclusian spring ($\sim$500 dm^3 sec^{-1})	West Tatra Chochołowska V.	988	as above
Małe Chochołowskie Źródło	T14'	vauclusian spring ($\sim$12 dm^3 sec^{-1})	as above	990	limestone débris, sand and detritus
Wodna pod Pisaną C.	T15	stream flowing through the cave	West Tatra Kościeliska V.	1023 (0)	stones, gravel and sand at the stream banks
Chochołowska Szczelina C.	T16	stream flowing through the cave	West Tatra Chochołowska V.	1051-1083 (26-50)	small stones, sand and clay
Zimna C.	T17	swallow hole, pools and small lake	West Tatra Kościeliska V.	1120 (125)	clay covered in some places with thin layer of muddy sediments and detritus
Naciekowa C.	T18	small pools (temporary?)	as above	1188-1199	as above
Kasprowa Niżnia C.	T19	small lake, pools and siphon	West Tatra Kasprowa V.	1228	clay, coarse sand, in some pools massive rock; experimental containers
Miętusia C.	T20	pools and siphon	West Tatra Miętusia V.	1330	clay, muddy sediments and detritus
Bandzioch C.	T21	pools	West Tatra Kościeliska V.	1456-1683 ($\sim$435)	as above

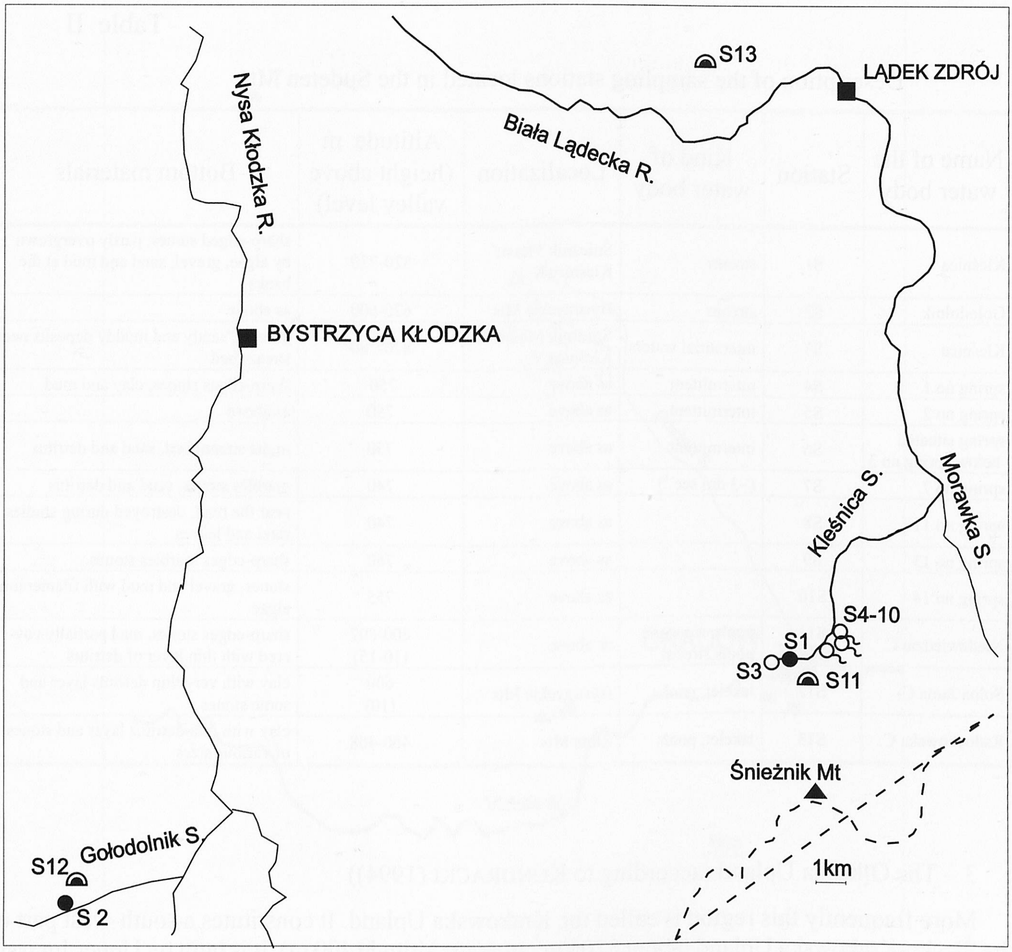

Fig. 3. Localizations of the sampling stations in Kłodzkie Sudeten Mts.

ferent directions. The Kleśnica V. is connected by an underground karstic system with the Morawa R. valley (Czech Republic), where two caves (Tvarožne Diry C. and Paceltova C.) with rich stygobiontic fauna are located at a distance of 5.5 km from the Niedźwiedzia C.

The second study area (in the Bystrzyckie Mts) was the Solna Jama C. and the Gołodolnik S. running in its vicinity (a distance of about 50 m). The lakelets situated in that cave are a few metres above the water level in the stream. Neither hydrological connections between cave waters and surface waters nor the origin of water in the cave lakelets were studied.

The third study area was the Radochowska C. (Złote Mts), known probably since the end of XVIII century. Only waters of vertical infiltration occur there, which form permanent lakelets thanks to the impermeability of the cave bottom (PULINA 1996). The nature of the water supply and also a lack of correlation between water level changes in the cave and in a small, unnamed stream running in its vicinity allow the assumption that the Radochowska C. waters are isolated from the water of that area.

The Śnieżnik Massif was comprehensively investigated twice: for the first time in the 30-ties (PAX & MASCHKE 1935) and once more in the 90-ties (JAHN et al. 1996). In the Niedźwiedzia C. detailed geological, hydrological, and biological studies were carried out (JAHN et al. 1989). Information on the caves in the Polish part of the Sudeten is assembled in papers by KOWALSKI (1954) and PULINA (1996).

Table II

Description of the sampling stations located in the Sudeten Mts

Name of the water body	Station	Kind of water body	Localization	Altitude m (height above valley level)	Bottom materials
Kleśnica	S1	stream	Śnieżnik Massif Kleśnica V.	820-730	sharp-edged stones, partly overgrown by algae, gravel, sand and mud at the banks
Gołodolnik	S2	stream	Bystrzyckie Mts	620-600	as above
Kleśnica	S3	interstitial waters	Śnieżnik Massif Kleśnica V.	820-780	gravely, sandy and muddy deposits near stream bed
spring no 1	S4	intermittent	as above	750	sharp-edges stones, clay and mud
spring no 2	S5	intermittent	as above	750	as above
spring situated below spring no 3	S6	intermittent	as above	750	in the stream bed, sand and detritus
spring no 7	S7	(~3 dm sec^{-1})	as above	740	marbles stones, sand and detritus
spring no 11	S8		as above	740	near the road, destroyed during studies, sand and leaves
spring no 13	S9		as above	760	sharp-edges marbles stones
spring no 14	S10		as above	755	stones, gravel and mud with filamentous algae
Niedźwiedzia C.	S11 S11'	pools, rimstone pools,stream	as above	800-807 (10-15)	sharp-edges stones, mad partially covered with thin layer of detritus
Solna Jama C.	S12	lakelet, pool	Bystrzyckie Mts	600 (10)	clay with very thin detritus layer and some stones
Radochowska C.	S13	lakelet, pools	Złote Mts	460-468	clay with thin detritus layer and stones of various sizes

3 – The Olkuska Upland (according to KONDRACKI (1994))

More frequently this region is called the Krakowska Upland. It constitutes a south-west part of the Śląsko-Krakowska Upland (about 820 km^2, average altitude 400 m). It is built by Upper Jurassic limestone which forms a compact platform. The summit surface is hilly, in the southern part divided by the valleys of a few small streams, the Prądnik S. with its tributary Sąspówka S. among others (Fig. 4).

Two of the studied caves (the Smocza Jama C. and Kryspinowska C.) (Table III) are located in the Brama Krakowska area, a transitional region among neighbouring macroregions. Brama Krakowska is the area dissected by tectonic faults on several tectonic horsts filled with Miocene deposits. There is vast literature concerning the natural history of the Ojców National Park, located on the Olkuska Upland (PARTYKA 1976). The remaining parts of that Upland are much less known. Information on caves is contained in studies by KOWALSKI (1951), SZELEREWICZ & GÓRNY (1986).

4 – The Świętokrzyskie Mts

The Świętokrzyskie Mts constitute a part of the Kielecko-Sandomierska Upland, and consist of the Paleozoic core formed by sedimentary rocks from various geological periods, from Cambrian to lower Carboniferous. The Paleozoic core was formed during the Caledonian and Variscan orogeneses, and later on remodelled during the Alpine orogenesis. These mountains have several parallel ranges separated by river valleys, the highest range being called the Łysogóry Mts (611 m). In that area caves were formed principally in Devonian marbles. The studied caves, the Chelosiowa Jama C. and Raj C. (Table III), are also located in the Kielecki subregion. Inside these caves are a few per-

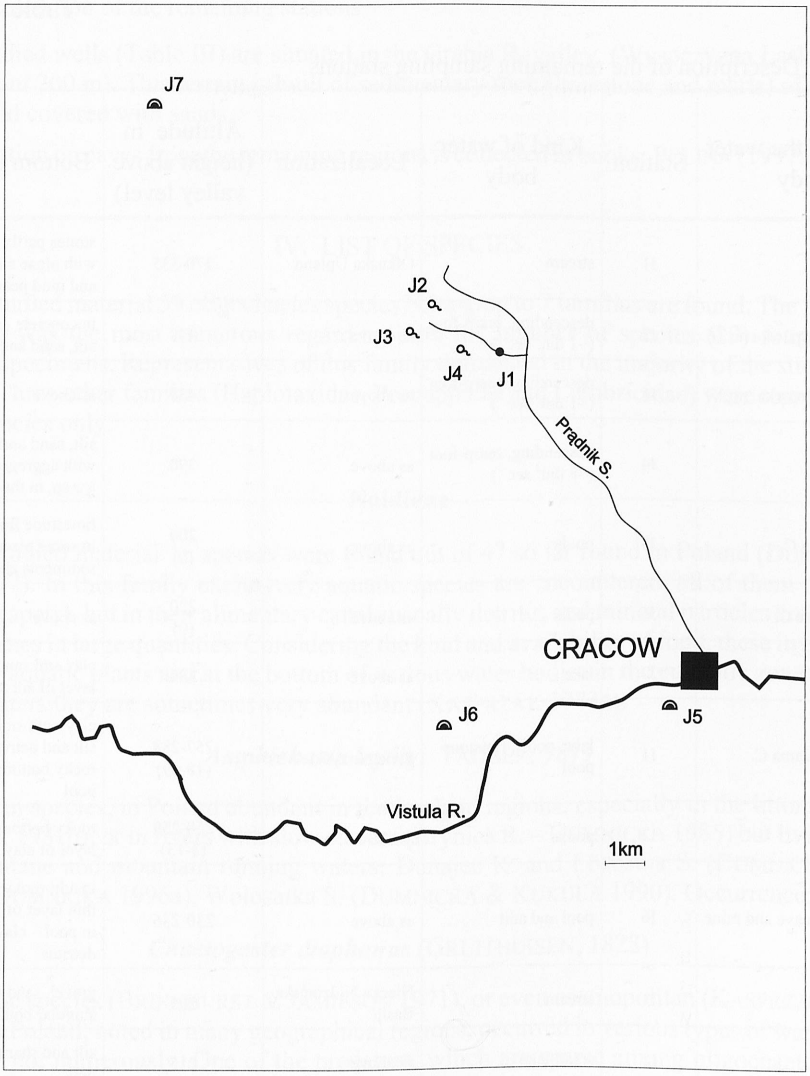

Fig. 4. Localizations of the sampling stations in Olkuska Upland.

manent and temporary pools, fed by infiltration waters. Moreover, in the lowest place of the Chelosiowa Jama C. there is a lakelet located at groundwater level. The characteristics of this region, and above all of its caves, can be found in the paper edited by URBAN (1996).

5 – The Niecka Nidziańska Basin

From the North it borders with the Świętokrzyski region. This is an upland area (altitude about 200-300 m) with a hilly surface, built of sedimentary rocks from various geological periods. Karstic phenomena occur here mainly in gypsum from the Tertiary which in places, e.g. in the studied Skorocicka V., are outcropped (GUBAŁA et al. 1998). The Skorocicki S. has both epigean and hypogean sectors, similarly to water bodies of other caves of that area, they are only partially located inside the caves. Characteristics of the caves of this region were published by WOŁOSZYN (1990) and GUBAŁA et al. (1998).

Table III

Description of the remaining sampling stations

Name of the water body	Station	Kind of water body	Localization	Altitude m (height above valley level)	Bottom materials
Sąspówka	J1	stream	Olkuska Upland	370-335	stones partly overgrown with algae and moss, sand and mud near the bank
spring of Sąspówka no 16	J2	descending, scarp-foot (~1 dm^3 sec^{-1})	as above	442	in concrete casing, clay, silt, sand and plant debris
spring of Sąspówka no 17	J3	descending, scarp-foot (~1 dm^3 sec^{-1})	as above	430	as above
spring no 20	J4	descending, scarp-foot (~8 dm^3 sec^{-1})	as above	390	silt, sand and small stones, with aggregation of *Veronica* sp. in the outlet
Smocza Jama C.	J5	pools	as above	206 (0)	limestone fragments, clay, in some places muddy sediments and detritus
Kryspinowska C.	J6	pools	as above	220 (0)	as above
Mąciwoda C.	J7	lake	as above	380	clay and sand with thin layer of silt and detritus
Chelosiowa Jama C.	I1	lake, pools, rimstone pool	Świętokrzyskie Mts	257-288 (18-49)	clay with small amount of silt and detritus rocky bottom in rimstone pool
Raj C.	I2	pools	as above	250-259 (3-13)	rocky bottom with thin layer of clay and silt
Miedzianka cave and mine	I6	pool and adit	as above	230-236	in adit rocky bottom with thin layer of silt in pool – clay and silt with detritus
Skorocicki S.	I3	stream	Niecka Nidziańska Basin	205	gravel, sand and silt with singular boulders
Siesławice C.	I4	small lake	as above	215	silt and sharp-edges boulders
Mokra C.	I5	pools	Beskid Śląski Mts	990	boulders and stones with thin clay layer
Sucha Góra I Quarry	I7	temporary pool	Beskid Niski Mts		sand and stones with thin layer of clay
Sucha Góra II Quarry	I8	small lake	as above		stones, at the bank sand and silt, wood pieces sunk in the water
well no 1	W1	420 m from river, 13 y	Wysoczyzna Łaska Upland	about 200	sand, calcareous rocks and marls
well no 3	W3	~ 25 m from river, 6 y	as above	as above	as above
well no 4	W4	~ 45 m from river, 10 y	as above	as above	as above
well no 5	W5	~ 420 m from river, 50 y	as above	as above	as above
well no 6	W6	~ 300 m from river, 4 y	as above	as above	as above
well no 7	W7	~ 300 m from river, 70 y	as above	as above	as above

6 – Localization of the remaining stations

The studied wells (Table III) are situated in the Grabia R. valley, (Wysoczyzna Łaska Upland, altitude about 200 m). This terrain is built of sedimentary rock (limestone and marls) of the Cretaceous period covered with sands.

Information on caves from the remaining regions is collected in books: PULINA (1997a, 1997b).

IV. LIST OF SPECIES

In the studied material 59 oligochaetes species belonging to 7 families are found. The family Enchytraeidae was the most numerous regarding both the number of species (29) found and the number of specimens. Representatives of this family dominated in the majority of the studied environments. Three other families (Haplotaxidae, Propappidae and Lumbricidae) were represented by singular species only.

Naididae

In the studied material 16 species were found out of 47 so far found in Poland (DUMNICKA & ROŻEN 1997). In this family exclusively aquatic species are encountered, all of them mainly algivores (scrapers), but in their alimentary canals usually detritus and mineral particles are also present, sometimes in large quantities. Considering the kind and availability of food, these invertebrates live among aquatic plants and at the bottom of various water bodies in the euphotic zone. In the interstitial waters they are sometimes very abundant (KASPRZAK 1973a).

Amphichaeta leydigi TAUBER, 1879

European species, in Poland abundant in the lowland regions, especially in the littoral of lakes (KASPRZAK 1981b), or in rivers with slow current (Brynica R. – DUMNICKA 1985) but living also in the submontane and mountain running waters: Dunajec R. and Łososina S. (DUMNICKA 1987), Raba R., (DUMNICKA 1996a), Wołosatka S. (DUMNICKA & KUKUŁA 1990). Occurrence: J1, I3.

Chaetogaster diaphanus (GRUITHUISEN, 1828)

Holarctic species (BRINKHURST & JAMIESON 1971), or even cosmopolitan (KASPRZAK 1981b), common in Poland; noted in many geographical regions, occurred in various types of water bodies, but usually not numerously. One of the predators, which are sparse among oligochaetes. Occurrence: I3; lakes in Tatra Mts (MINKIEWICZ 1914), ponds near Kraków (SZARSKI 1947), running waters in Świętokrzyskie Mts (KAHL 1983, 1986).

Chaetogaster diastrophus (GRUITHUISEN, 1828)

Cosmopolitan, ubiquitous species, common in Poland, most abundant in the peryphyton on various substrata and among filamentous algae (e.g. *Cladophora* sp. in the Raba R.) (DUMNICKA 1996a), among rotting plants and in colonies of sponges (KASPRZAK 1978a). Occurrence: T10, 16, S10, J1; lakes in Tatra Mts (MINKIEWICZ 1914), running waters in Świętokrzyskie Mts (KAHL 1983, 1986, 1991).

Pristinella amphibiotica LASTOCKIN, 1927

Up to now known from European, African, and Chinese waters (KASPRZAK 1981b), habitat requirements not well known; in Poland singular specimens were noted in a few places: Chechło-Nakło L. (Upper Silesia) (DUMNICKA 1985), Dunajec R. near Szczawnica (DUMNICKA 1995a). Occurrence: J1.

Pristinella menoni (AIYER, 1929)

Known from Europe, Asia and Africa, in Poland dwells mainly in mountain waters, e. g. can be found in interstitial water of streams and rivers of Southern Poland (KASPRZAK 1973a), where together with *P. aequiseta* form *foreli* constituted c. 60% of Oligochaeta fauna. Besides, found in lake littoral (Konin L. – KASPRZAK 1977) as well as on the bottom of rivers (Nida R. – DUMNICKA 1978, Lubrzanka R. – KAHL 1986), but in small numbers. Occurrence: S2, I3, streams in Kotlina Kłodzka I.B. (KASPRZAK 1973c), Prądnik S. (KASPRZAK 1976c) running waters in Świętokrzyskie Mts (KAHL 1983, 1986, 1991).

Pristinella idrensis SPERBER, 1948

European species, in Poland known only from submontane regions: Raba R. (KASPRZAK & SZCZĘSNY 1976), Biała Woda S. (DUMNICKA 1982), Dunajec R. and Łososina S. (DUMNICKA 1987). Occurrence: S1-2, J1.

Stylaria lacustris (L.)

Cosmpolitan species, lives numerously among submerged plants and filamentous algae in stagnant waters and slowly flowing rivers. In montane streams can be found in small numbers in pools and near – river waters, from where it can be transported to the main stream. Occurrence: J1; ponds near Kraków (SZARSKI 1947), Prądnik S. (KASPRZAK 1976c), running waters in Świętokrzyskie Mts (KAHL 1983, 1986, 1991).

Nais elinguis MÜLLER, 1774

Cosmopolitan species, common in Poland, lives numerously in polluted but oxygenated rivers, e.g. Nida R. (DUMNICKA 1978), Grajcarek S. in the Pieniny Mts (KASPRZAK 1979b) and Dunajec R. (DUMNICKA 1995a). KOWALEWSKI (1914) wrote about it as a very common species in the Tatra Mts, especially in the lakes, but HRABĚ (1939) questioned this identification. KOWALEWSKI (and after him MINKIEWICZ 1914), mistook it for *N. variabilis*, a species dominating in this kind of habitat. Occurrence: S1, J1, I3, streams in Kotlina Kłodzka I. B. (KASPRZAK 1973c), Wilga R. in Kraków (SZARSKI 1947), Prądnik S. (KASPRZAK 1976c), running waters in Świętokrzyskie Mts (KAHL 1983, 1986, 1991).

Nais bretscheri MICHAELSEN, 1899

Holarctic species, one of dominants in clean and slightly polluted rivers and submontane streams with fast current and stony or gravel bottom, e.g. Kryniczanka S. (SZCZĘSNY 1974), Biała Woda S. (DUMNICKA 1982), Raba R. (KASPRZAK & SZCZĘSNY 1976), found also not numerously from the Western Sudeten (Kwisa R. – KASPRZAK 1973b); in the Tatra Mts its presence was observed only below alt. one thousand metres and that was in the vauclusian spring (Lodowe Źródło) and the Orawsko – Nowotarska I. B. (Cichy Potok S. and Białka R. – altitude 850-620 m). Only in strongly polluted Rybi Potok S. was that species found in high altitudes (1380 m). Occurrence: T13, J1,3; Prądnik S. (KASPRZAK 1976c), Tatra Mts – streams of lower and upper subalpine forests (KASPRZAK & ZAJONC 1980), running waters of Świętokrzyskie Mts (KAHL 1983, 1986, 1991).

Nais pseudobtusa PIGUET, 1906

Vastly distributed species, most probably cosmopolitan, but usually not numerous. In Poland frequently found in various types of water body: both in the littoral of natural (MOSZYŃSKA 1962) and artificially heated lakes (Konin L. – KASPRZAK 1977), as well as in lowland (Wełna R., KASPRZAK 1976a), or submontane rivers (Dunajec R., DUMNICKA 1987). Occurrence: T9, 10, 14, S1, 2, 7, 10, J1, 3; Tatra Mts – Morskie Oko L. (MINKIEWICZ 1914), ponds near Kraków (SZARSKI 1947), Kotlina Kłodzka I.B. (KASPRZAK 1973c), Prądnik S. (KASPRZAK 1976c), running waters of Świętokrzyskie Mts (KAHL 1983, 1986, 1991).

Nais communis PIGUET, 1906

Cosmopolitan species, commonly present in various kinds of water body (MOSZYŃSKA 1962); in many springs it is the most numerous or even the sole representative of the Naididae family (springs of Raba R., KASPRZAK & SZCZĘSNY 1976, spring in the Biała Woda V., KASPRZAK 1979b). Occurrence: T1, 6-10, 12-14, 16, S3, 10, J1-3, I3, 4; ponds near Kraków (SZARSKI 1947), Prądnik S. (KASPRZAK 1976c), running waters of Świętokrzyskie Mts (KAHL 1983, 1986, 1991).

Nais pardalis PIGUET, 1906

Cosmopolitan species; in Poland frequently present in stagnant waters and lowland rivers but not numerously (MOSZYŃSKA 1962, KASPRZAK 1973b), in submontane streams and rivers more numerous, usually accompanies *N. bretscheri* or *N. alpina*, e.g. streams of the Pieniny Mts and the Małe Pieniny Mts (KASPRZAK 1979b), Kryniczanka S., (SZCZĘSNY 1974), Raba R. (KASPRZAK & SZCZĘSNY 1976). Occurrence: T14, J1; ponds near Kraków (SZARSKI 1947), Prądnik S. (KASPRZAK 1976c), streams of Tatra Mts (KASPRZAK 1981a) and Kotlina Kłodzka I.B. (KASPRZAK 1973c), running waters of Świętokrzyskie Mts (KAHL 1983, 1986, 1991).

Nais variabilis PIGUET, 1906

Holarctic species, noted from clean running and stagnant waters, even brackish: Puck Bay and seashore of Baltic (MOSZYŃSKA 1962, KASPRZAK 1973b), where it can appear in mass. This is a dominant species in some out of the already studied lakes situated in the Polish part of the Tatra Mts, e.g. in Zielony Staw Gąsienicowy L. (KOWNACKI et al. 2000), and also in streams (even temporary ones) outflowing many lakes; sometimes abundant in limnocrenes. Occurrence: T1-4, 6-11, 13, 14, S2, 10, J1, I3; ponds near Kraków (SZARSKI 1947), many lakes and shallow ponds in Slovak Tatra Mts situated on the timber line, stream starting from Lodowy Staw L. (ČERNOSVITOV 1930, HRABĚ 1939), running waters of Świętokrzyskie Mts (KAHL 1983, 1986).

N. variabilis appears in large number both in highly mineralised or brackish waters (coast of the Baltic Sea – KASPRZAK 1973b) and in waters with extremely low ion concentration such as waters of the Tatra Mts and the Karkonosze Mts (Łomnica S. below Mały Staw L. leg. J. KWANDRANS, Łomniczka S. below waterfalls, leg. B. SZCZĘSNY). In other types of water body it is usually not numerous. Populations living in such different environmental conditions do not show overt differences in the length of hair and needle setae, stated when comparing these lengths in specimens collected by KASPRZAK (1973b) from peryphyton growing on wooden poles at the beach in Darłówek and specimens living in Sucha Woda S. in Tatra Mts, and in Łomniczka S. The lengths of hairs in specimens from these populations are within the range established by SPERBER (1948) but do not reach their maximum values described by that author.

Among seven species from the genus *Nais* having bifid needle setae in the dorsal bundles and inhabiting Polish and neighbouring water bodies (Table IV) only two species: *N. christinae* and *N. elinguis* are relatively easy to distinguish. The former owing to very characteristic ventral setae: in larval segments thin with longer distal tooth, in other segments – stout, with teeth of the same length, but different thickness – the proximal tooth is clearly thicker (Fig. 5). These setae resemble ventral setae of *N. barbata*. HRABĚ (1981) thought that *N. christinae* was identical with *N. variabilis* „forme des grand lacs" described by PIGUET (1906) from Swiss lakes. According to RODRIGUEZ & ARMAS (1983) populations of *N. christinae* found in Spain appear to have features somewhat resembling *N. variabilis*. However, in the material collected from Polish rivers these species are clearly different, above all they have completely different ventral setae (Fig. 5A-D). Precise delineation of these two species and statement of variability range of *N. christinae* requires comparative studies conducted on large material.

Nais christinae, described from the heated Konin lakes (KASPRZAK 1973d), was quickly found in the Vistula R. in the Połaniec region (KOWNACKI 1999), in the Warta R. (BIESIADKA & KASPRZAK 1977) and in the Nida R. (DUMNICKA 1978), where it occurred in natural, not heated wa-

Table IV

Comparison of taxonomic characteristic of some *Nais* species with bifid needle setae

Species	Length of hair setae (µm)	Teeth of needle setae	Thickness of anterior & posterior ventral setae	Ratio distal: proximal teeth of ventral setae		Giant setae	Stomach dilatation	Swimming
				anterior	posterior			
Nais elinguis	150-305	long; distal longer[1,2] long; parallel[3-6]	similar	2 : 1	2 (1.8) : 1 distal tooth thinner	absent	slow	with lateral movement
Nais christinae	up to 330	short[3]; short divergent[4] finely bifid[5]	V: 2.6-2.9 VI-X: 4.4-4.9	1.5 : 1	1 : 1	absent	sudden	with spiral movements
Nais communis	125-268	short; divergent[1,2,4,6] fine; bifid[3,5]	similar, thin	1 : 1	1 : 1	absent	slow	no swimming
Nais variabilis	170-570	short[1,2]; fine divergent[3,4,6]; fine[5]	II-V: 1.5-2 VI-X:2.2-3	1.2 (1.4) :1	1.2 (1.4) : 1	absent	sudden	with spiral movements
Nais stolci	147-212	long[3]; long, parallel[6]	II-V: 1.7 X: 5	2 : 1	VIII-4:1 XV-2.5:1	?	slow	?
Nais pardalis	up to 120	fine, equal[1,2]; short parallel[4,6]; short[5]	II-V: 2 VI -3 VII-X: 3.4-4	(1.8) 2 : 1	2 : 1	sometimes present	sudden	with spiral movements
Nais bretscheri	up to 135	long[3]; short parallel[4,6]; quite long, parallel[5]	II-V: 1.6-1.9 VI-3.6-3.7 next – 4.5	2 : 1	2 :1 or 3 : 1 in giant setae	present sometimes absent	slow	no swimming

1 – according to SPERBER 1948; 2 – according to BRINKHURST & JAMIESON 1971;3 – according to HRABĚ 1981; 4 – according to KASPRZAK 1981b; 5 – according to TIMM 1999a; 6 – personal observation.

ters. Later on this species was found in the Dunajec R. (DUMNICKA 1987, 1995a) and Raba R. (DUMNICKA 1996a). During earlier thorough studies on oligochaetes of the Dunajec R. at the same stretch (DRATNAL et al. 1979) and the Raba R. (KASPRZAK & SZCZĘSNY 1976) *N. christinae* was not encountered. Outside Poland that species is known from a few water bodies in the Czech Republic, Slovakia (HRABĚ 1981), France (LAFONT & JUGET 1976, GIANI 1984), and Spain (RODRIGUEZ & ARMAS 1983). Sudden appearance of *N. christinae* in many places in Europe, including rivers, where oligochaetes fauna was described before can be explained by rapid spreading of that species

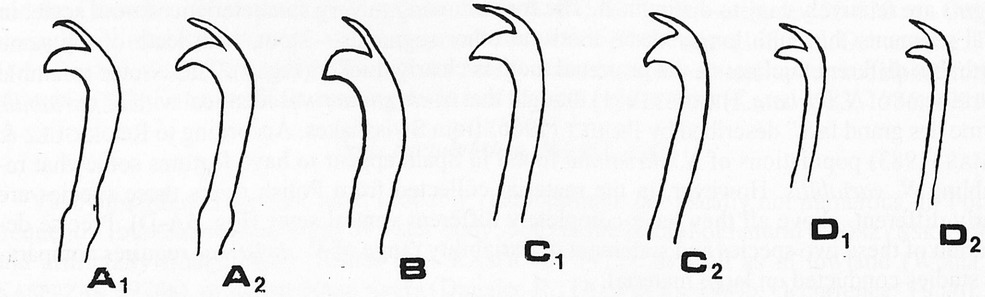

Fig. 5. *Nais christinae* (A-C) and *N. variabilis* (D) – shape of ventral setae. A_1, C_1, D_1 – from VI segment; A_2, C_2, D_2 – from X segment; B – from posterior segment. A_1, A_2 – after KASPRZAK 1973d, B – after TIMM 1999a, C_1, C_2 – from Dunajec R. D_1, D_2 – from Sucha Woda S.

brought or migrating from obscure regions. Perhaps under the name *N. christinae* we have at least two 'hidden' species, as evidenced by substantial differences in the structure of setae.

The second from relatively easily distinguishable species – *N. elinguis*, has exceptionally long and almost parallel teeth in the needle setae and all ventral setae with distal tooth twice as long as the proximal ones. Moreover, in *N. elinguis* specimens preserved in formalin the eyes are yellowish, orange, or pale-beige, whereas in other species from genus *Nais* fixed in that preservative, the eyes are pinkish violet, violet, to dark-violet.

The remaining species from that group can be put in the following order: *N. communis* – *N. variabilis* – *N. pardalis* – *N. stolci* – *Nais bretscheri.* In that line consecutive species resemble neighbouring ones while at the same time each one shows high variability of taxonomic features which hinder their right determination. In this situation the largest possible number of various features – morphological, anatomical, and behavioural should be applied for determination of each species from that group of resembling species.

The main feature is the shape of the ventral setae, described and depicted in keys for each mentioned species. The identification of *N. communis* and *N. variabilis* is based mainly on the structure of these setae. In *N. communis* setae both in anterior and posterior segments have the same thickness and equal teeth, whereas in *N. variabilis* ventral setae in posterior segments are thicker than in anterior ones, moreover in all ventral setae distal teeth are longer than the proximal one. The shape and thickness of ventral setae also allows distinction of *N. variabilis* from the related *N. pardalis* (especially specimens without giant setae). The setae of posterior segments in *N. pardalis* are thicker and the difference between distal and proximal teeth more distinct (Table IV). According to SPERBER (1948) and KASPRZAK (1973b), a useful method in distinguishing the two species is to compare the length of the hair and needle setae and their ratio. LODEN & HARMAN (1980) cultivated the two species together and after 30 days of culture (which equals 7-15 generations formed by asexual reproduction) setae of that species remained distinctive. HRABĚ (1981) takes into account also the angle between teeth in ventral setae of larval segments as a feature helpful in distinguishing these similar species. It is believed to be acute in *N. pardalis, N. stolci* and *N. bretscheri,* while right-angled in *N. variabilis*. According to drawings in keys, original papers, and the present author's observations, the angle is very similar in all species from that group except for *N. communis* and *N. variabilis* where it is slightly less acute. Taking into account the shape of ventral setae, the only feature allowing distinction of *N. bretscheri* from *N. stolci* is the presence of giant setae in the former. However, in various environmental conditions giant setae may disappear, which was observed in, e.g., *Pristina aequiseta* where its presence or absence depends on physico-chemical conditions of the environment (LODEN & HARMAN 1980). Also in these species from the genus *Nais* (*N. pardalis, N. bretscheri*), which most often possess giant setae, specimens without them are also known. Therefore, it is impossible to distinguish *N. bretscheri* from *N. stolci* definitely on the basis of the structure of ventral setae.

The shape of the needle setae, mainly the shape and length of teeth, is the next feature most frequently used in keys to the Naididae family (SPERBER 1948, CHEKANOVSKAYA 1962, BRINKHURST & JAMIESON 1971, KASPRZAK 1981b, TIMM 1999a). Unfortunately, for a few of the discussed species there are no drawings depicting the shape of the needle setae, while there are substantial differences in the descriptions, e.g., in the case of *N. pardalis* or *N. bretscheri* (Table IV). The comparison of shapes of the needle setae in available drawings from keys, paper of HRABĚ (1981), and the author's own observations allow the statement that in *N. communis, N. variabilis*, and *N. christinae* the teeth of needle setae are very short and more or less divergent (Fig.6A-J). According to TIMM (1999a), in the last species the teeth are poorly seen. In *N. pardalis* and *N. bretscheri* these teeth are parallel, on some pictures of *N. bretscheri* – a little longer (Fig. 6K-P), while in *N. stolci* they are parallel and have almost the same length as in *N. elinguis* (Fig. 6R-W). Therefore the shape of needle setae teeth allows distinction of *N. stolci* from *N. bretscheri*. It was thought that one of the useful diagnostic feature allowing distinction of similar species from that group is the kind of transition of the oesophagus into stomach dilatation – abrupt in *N. pardalis* and *N. variabilis*, while slow in *N.*

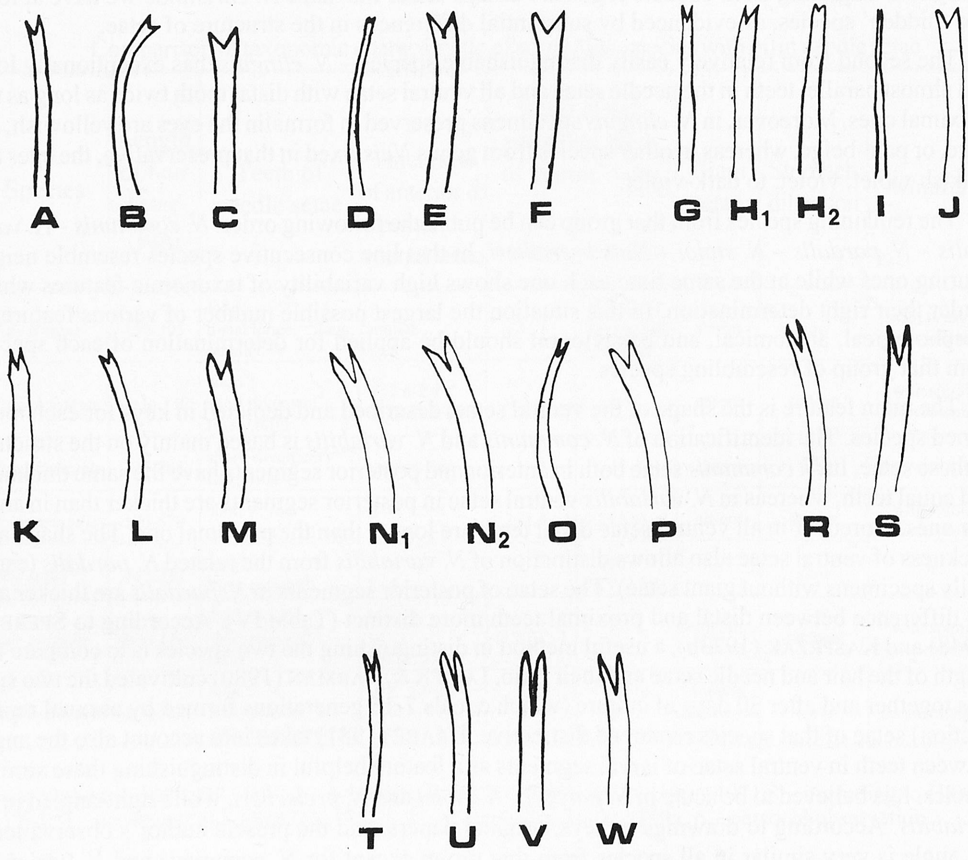

Fig. 6. Distal end of bifid needle setae in some species of the genus *Nais*. A-C – *N. communis*; D-F – *N. variabilis*, E – normal shape, F – teeth anormally divergent G-J – *N. christinae*; K-M – *N. pardalis*; N-P – *N. bretscheri*; N_1 – young specimen, N_2 – fully developed specimen; R-S – *N. stolci*; T-W – *N. Elinguis*. A – after SOKOLSKAYA 1962; B, D, I, L, O, V – after TIMM 1999a; G – after KASPRZAK 1973d; H_1, H_2, K, N_1, N_2, R, U – after HRABĚ 1981; S – from Valča S. leg. det. F. ŠPORKA; T – after SPERBER 1948; C – from spring; E, F – from Sucha Woda S.; J, W – from Dunajec R.; M, P – from Raba R.

communis, N. bretscheri, and *N. stolci*. Sometimes in the preserved material the kind of stomach dilatation is not clearly visible, which may result from the shrinkage of tissue caused by formalin.

The next accessory diagnostic feature may be the way in which these species move in water. Some species do not swim, while some of them swim with spiral or lateral movements (Table IV); unfortunately for *N. stolci* the way of movement is not known.

With such small differences among species it is possible to classify them correctly only when large material is available. In cases where only single specimens are collected, especially in atypical environment, it is better to limit classification to species complex.

Nais alpina SPERBER, 1948

European species, frequently found in large numbers in clean streams and submontane rivers where it may be one of the dominants in the oligochaetes taxocen, e.g. Czarny Potok S. near Krynica (SZCZĘSNY 1974), Biała Woda S. (DUMNICKA 1982). Occurrence: T10, 12, S1-3, 10, J1; Prądnik S. (KASPRZAK 1976c).

Homochaeta naidina BRETSCHER, 1896

Species known from Europe and Japan, in Poland rare, found in Lednickie L. (MOSZYŃSKA 1962) and numerously in the Vistula R. near Kraków (SZARSKI 1947). Habitat requirements not known. Occurrence: J1.

Vejdovskyella intermedia (BRETSCHER, 1896)

European species, in Poland common in river bottoms, e.g. in Wełna R. (KASPRZAK 1976a), Nida R. (DUMNICKA 1978) or Raba R. (KASPRZAK & SZCZĘSNY 1976); found also in the lake littoral (Konin L., Pomorski Lake District (KASPRZAK 1981b). Occurrence: J5.

Tubificidae

Exclusively aquatic species, detritivorous – in Poland 35 species have been found so far (including a few characteristic of brackish waters) (DUMNICKA & ROŻEN 1997), in the studied material 4 species only. They inhabit all kinds of water body, but most abundantly occur on the muddy bottom in rivers and lakes (also montane) where frequently they are the dominant taxa of the benthic macrofauna. In montane streams usually not present or extremely sparse.

Rhyacodrilus falciformis BRETSCHER, 1901

European species, thought to be stygophile, may be considered as a bioindicator of the presence or proximity of springs (JUGET 1987). Known from various kinds of natural water bodies rich in organic matter, such as overgrown small ponds near Świecie (MOSZYŃSKI 1934), swamp on Cybina R. (KASPRZAK 1972a), marsh (KASPRZAK 1979b), springs of different types and karstic streams (HRABĚ 1981). Occurrence: S11, 12, J1, 4; streams of Niżne Tatra (ČERNOSVITOV 1930) and Tatra Mts (KASPRZAK & ZAJONC 1980).

Epirodrilus pygmaeus (HRABĚ, 1935)

European species, described and most often found in the Czech Republic, known also from Yugoslavia (HRABĚ 1981). In Poland single specimens were collected mainly in the southern part of the country: Dunajec R. (DUMNICKA 1987), Brynica R. (DUMNICKA 1985), but also in the harbour basin on the Wolin Island (LEGEŻYŃSKI 1971). Occurrence: J1; streams of Kotlina Kłodzka I.B. (KASPRZAK 1973c).

Tubifex tubifex (MÜLLER, 1774)

Cosmopolitan species, common in stagnant and slow-running waters with muddy bottom; one of dominant species in polluted waters. Occurrence: J1,3, I3. Śnieżnik Massif (HRABĚ 1937a), streams of Kotlina Kłodzka I.B. (KASPRZAK 1973c), ponds and Vistula R. near Kraków (SZARSKI 1947), Prądnik S. (KASPRZAK 1976c), running waters of Świętokrzyskie Mts (KAHL 1983, 1986, 1991). MINKIEWICZ (1914) reported the presence of this species from a few lakes on the Polish side of the Tatra Mts from Zmarzły Staw L. under Zawrat P. (alt. 1787 m) and Zielony Staw L. in Gąsienicowa V., from lakes in Pięć Stawów Polskich V. to Toporowy Staw Zadni L. (1089 m). In Slovak High Tatra Mts reported by ČERNOSVITOV (1930) and HRABĚ (1981) who found this species in 15 lakes situated in the alpine zone out of 20 studied. In the studied mountain streams (Tatra Mts, Śnieżnik Kłodzki M.) occurred only scarce juvenile specimens of Tubificidae with hair setae, probably belonging to that species.

Tubifex ignotus (ŠTOLC, 1886)

Probably cosmopolitan species, in Poland common, reported from streams in the Małe Pieniny Mts (DUMNICKA 1982) and submontane rivers – Dunajec R. (DUMNICKA 1987), to lakes in Pomorskie Lake District (MOSZYŃSKA 1962). Usually not numerous, only in Lubrzanka R. close to the mouth it was the dominant species on the muddy bottom (KAHL 1986). Occurrence: I3; Prądnik S. (KASPRZAK 1976c), running waters of Świętokrzyskie Mts (KAHL 1983, 1991), Tatra Mts – stream in Niżny Smokowiec (ČERNOSVITOV 1930), Śtrbske pleso (HRABĚ 1939). KASPRZAK & ZAJONC (1980) report that this species is characteristic for Tatra Mts lakes situated in the upper alpine forests zone, but they did not give actual localizations.

Lumbriculidae

A relatively small family with exclusively aquatic species, the majority of them occurring on the bottom of mountain streams and lakes as well as in subterranean waters. Frequent endemites, especially among stygobionts. The distribution of stygobiontic species is inadequately known, owing to the lack of studies (mainly on interstitial waters) in some geographical regions, scant occurrence of these species, and also taxonomic problems. Therefore attribution of a given species to endemic ones may result from poor knowledge of its distribution. In Poland only 9 species have been found so far, including 4 stygobionts (DUMNICKA & ROŻEN 1997). In the studied material 7 species were found, including 3 stygobionts. The last stygobiont found in Poland, *Trichodrilus spelaeus species inquirenda,* described on the basis of one specimen (MOSZYŃSKI 1936) from locus typicus (a nonexistant adit in Klecienko village at the foot of the Śnieżnik massif). It is usually considered as an abnormal specimen, having one male pore on IX segment and the other on X. In spite of a search carried out in this region this species was not retrieved.

Lumbriculus variegatus (MÜLLER, 1774)

Holarctic species, in waters with low pH is frequently the dominant: Karkonosze Mts, Kamienna R. (KASPRZAK 1976b), Świętokrzyskie Mts – spring sector of Lubrzanka R. (KAHL 1986), in other habitats found frequently but in small numbers (KASPRZAK 1981b). Occurrence: T2, 3, 6-8, 15, 16, J1; Toporowy Zadni pond (MINKIEWICZ 1914), lakes in Slovak Tatra Mts (ČERNOSVITOV 1930, HRABĚ 1939), streams in Tatra Mts (KASPRZAK & ZAJONC 1980), ponds near Kraków (SZARSKI 1947), Prądnik S. (KASPRZAK 1976c), Kotlina Kłodzka I.B. – drainage ditch and streams (KASPRZAK 1973b), running waters of Świętokrzyskie Mts (KAHL 1983, 1991).

Stylodrilus heringianus CLAPAREDE, 1862

Holarctic species, in Poland frequently found in mountain or karstic streams and rivers with cold water: Karkonosze Mts, Izerskie Mts (KASPRZAK 1976b), Kryniczanka S. (SZCZĘSNY 1974). It lives on sandy-gravel or stony bottom and coastal alluvial sediments. Well tolerates low water pH (KAHL 1986), but is also frequent in slightly alkaline sediments (pH 7.0-8.0) (KASPRZAK 1973c). Occurrence: T2, 15, 16, J2; Śnieżnik Massif (HRABĚ 1937a), Kotlina Kłodzka I.B. (KASPRZAK 1973b), Tatra Mts lakes from Wahlenbergowy Wyżni Staw (2154 m) to Toporowy Staw (1089 m) (MINKIEWICZ 1914, ČERNOSVITOV 1930, HRABĚ 1939), streams of Niżnie Tatra Mts (ČERNOSVITOV 1930) and Tatra Mts (KASPRZAK & ZAJONC 1980), Prądnik S. (KASPRZAK 1976c), Świętokrzyskie Mts streams where in sectors close to the springs and upper ones, was frequently the dominant species (KAHL 1983, 1991).

Stylodrilus parvus (HRABĚ & ČERNOSVITOV, 1927)

Holarctic species, known from a few places with highly different ecological conditions. In Poland found in the Bieszczady Mts (Wołosatka S., Terebowiec S.), where it was the dominant species (DUMNICKA & KUKUŁA 1990), frequent in the Eastern Carpathians and in Yugoslavian mountains (HRABĚ 1981). It may occur also in sea – and brackish waters (Caspian Sea – CHEKANOVSKAYA 1962), while in Poland – a small brook ending in Pucka Bay (LEGEŻYŃSKI 1976). Occurrence: S2; Śnieżnik Massif (HRABĚ 1937a), streams of Niżne Tatra Mts (ČERNOSVITOV 1930) and of Tatra Mts (KASPRZAK & ZAJONC 1980).

Stylodrilus brachystylus HRABĚ, 1929

Species known till now from a few European countries: Czech Republic (HRABĚ 1981), France (GIANI 1979a) and Spain (GIANI 1984), Estonia (TIMM 1999a) and from southern Poland where it was found in stony-gravel sediments and at the bottom of Kwisa R. and Nysa R. (Western Sudetes Mts), Poroniec S. (Orawsko-Nowotarska I.B.) (KASPRZAK 1973b, c), streams in Bieszczady Mts (KASPRZAK 1981a) and in a well in Warta V. (KASPRZAK 1973c). Occurrence: T2, Śnieżnik Massif (KASPRZAK 1973c).

Trichodrilus pragensis VEJDOVSKÝ, 1875

Stygobiont, described from a well in Prague; this description was revised by HRABĚ (1971), on the basis of material collected also from wells in Prague, and also from wells at Oslavany (Moravia). HRABĚ had two specimens (from the collection of Prof. PIGUET) captured in a well in Basel (Switzerland) and determined as *T. pragensis*, but after studying their anatomy Hrabě ascertained that these specimens represented a new family (Dorydrilidae) and subsequently described it as *Dorydrilus mirabilis*. Hence, the demonstration of the presence of *T. pragensis* in Switzerland on the basis of Prof. PIGUET's materials is unfounded, while the report of its presence at the Baltic Sea coastline (MENGE 1845, after MOSZYŃSKA 1962) needs confirmation. This species was found in the interstitial environments of some running waters in Rumania (BOTEA 1963), hyporeic waters of mountain streams of Eastern Hesse (SCHWANK 1981), and in Pozo del Inferno (Cantabria, Spain), (RODRIGUEZ & GIANI 1994). Occurrence: S11, 12.

Trichodrilus cernosvitovi HRABĚ,1937

Stygobiont, a rare species known so far from the place where it was originally described (springs of the Waha R. – Belgium, HRABĚ 1937b) and from interstitial waters in a few places in Europe: Rhône R. (JUGET & DUMNICKA 1986), Grajcarek S. in Pieniny Mts (KASPRZAK 1979b). Occurrence: T12; Ku Dziurze S., Strążyski S. and Olczyski S. (near a large vauclusian spring) – in at least one of the listed streams (KASPRZAK 1981a), (the author did not provide exact localization).

Trichodrilus moravicus HRABĚ, 1938

Stygobiont, rare species, known from bottom and alluvial sediments of streams in Małe Pieniny Mts (KASPRZAK 1979b), also found in profundal of a lake in Niżne Tatra Mts (HRABĚ 1981). Occurrence: T19, S11, 12; streams flowing out from caves on Morawy, Śnieżnik Kłodzki Massif (HRABĚ 1937a).

Haplotaxidae

Haplotaxis gordioides (HARTMANN, 1821)

Holarctic species, in Poland exclusive representative of that family, known only from the southern part of the country. Species characteristic of cold mountain and upland waters, lives even in polluted water currents of that type, e.g. Kamienna R. in Szklarska Poręba (Karkonosze Mts) (KASPRZAK 1976b), Prądnik S. (DRATNAL 1976, KASPRZAK 1976c). Occurrence: T8-10, 15, J5, W6; Czarny Staw pod Rysami L. (MINKIEWICZ 1914), lakes in Slovak part of Tatra and Niżne Tatra Mts (ČERNOSVITOV 1930, HRABĚ 1939), Śnieżnik Massif (HRABĚ 1937a, KASPRZAK 1973c), Kotlina Kłodzka I.B. (KASPRZAK 1973c).

Propappidae

Propappus volki MICHAELSEN, 1916

Palearctic species, dominant in non-polluted running waters with sandy and gravel bottom in Poland, e.g. in clean sectors of rivers: Nida R. (DUMNICKA 1978), Brynica R. (DUMNICKA 1985) or Wełna R. (KASPRZAK 1976a); less numerous on sandy-muddy bottom (KAHL 1983). Occurrence: T1, 5, 7, 10, 13-16, S7, J1, 4; Tatra Mts streams (KASPRZAK 1981a, KASPRZAK & ZAJONC 1980), streams in Śnieżnik Massif (HRABĚ 1937a, KASPRZAK 1973c), and in Kotlina Kłodzka I.B. (KASPRZAK 1973c), running waters of Świętokrzyskie Mts (KAHL 1983, 1986).

Enchytraeidae

To this family, represented in Poland by 89 species (DUMNICKA & ROŻEN 1997), belong mainly forms living in the soil, although some genera (*Mesenchytraeus, Cognettia),* and also single species from other genera (e.g. *Marionina argentea, M. riparia* or *Enchytraeus buchholzi*) are very common on the bottom of various water bodies. Only genus *Cernosvitoviella* is known mainly from the aquatic environment. In the studied material 29 species of enchytraeid were found, including many typically soil species. Data concerning the occurrence of Enchytraeidae in the water bodies are very fragmentary, since in hydrobiological studies enchytraeids were usually not determined and treated only summarily. In the case of enchytraeids, the distribution of individual species and even of genera is not sufficiently known. New species are being described and many geographical regions have not yet been studied in this respect. Perhaps the majority of enchytraeid genera will turn out to be cosmopolitan ones, with species of much smaller ranges. The ease of accidental, passive transport, especially of soil enchytraeid species by humans, as well as high adaptability of many species from this family may lead to the disappearance of diversification of enchytraeids fauna of even distant terrains.

Mesenchytraeus armatus (LEVINSEN, 1884)

Species known from Europe and North America, amphibious form, in Poland known mainly from the southern part of the country: Raba R. (KASPRZAK & SZCZĘSNY 1976), Karkonosze Mts, Izerskie Mts (KASPRZAK 1976b), but also noted on the Baltic coastline and on the Wielkopolsko-Kujawska Lowland (MOSZYŃSKA 1962). In mountain streams it may be a dominant taxon, e.g. in small streams of Pieniny Mts (KASPRZAK 1979a). Occurrence: T1, 3, 6-13, 16, S 1-7, J2; Prądnik S. (KASPRZAK 1976c), Tatra lakes (ČERNOSVITOV 1930), Tatra streams (KASPRZAK 1981a), cave sediment in Dziura C. (KASPRZAK & ZAJONC 1980), running waters of Świętokrzyskie Mts (KAHL 1986, 1991).

Cernosvitoviella atrata (BRETSCHER, 1903)

Holarctic species, amphibious, in Poland common, but usually not numerous, known from various habitats: springs, lowland and submontane rivers, lake littoral, soil of swamps and peat bogs (KASPRZAK 1986a), wells (KASPRZAK 1973c). Occurrence: T1, 4, 10-13, 16, 17, 21, S1-3, 11-13, J1, 4; lakes in Slovak Tatra Mts (ČERNOSVITOV 1930), Kotlina Kłodzka I.B. (KASPRZAK 1973c), streams of Świętokrzyskie Mts (KAHL 1991).

Cernosvitoviella tatrensis (KOWALEWSKI, 1914)

Species mentioned from High Tatra Mts lakes (KOWALEWSKI 1914, MINKIEWICZ 1914), and fully described 3 years later (KOWALEWSKI 1917). Found in many lakes: from Teryański Wyżni L. (2124 m) to Toporowy Zadni L. (1089 m). On the Polish side of the Tatra Mts the highest location is in Zmarzły Staw L. below Zawrat Pass. Species characteristic of muddy bottoms of Tatra lakes where it is a dominant form among Oligochaeta, e.g. in Długi Staw L. (GALAS et al. 1996b), Dwoiste Stawki L. (KOWNACKI et al. 2000). Single specimens were also collected in the Raba R. (KASPRZAK & SZCZĘSNY 1974, KASPRZAK 1978b). Occurrence: T9-11, 13-17, S1, 3, 13; streams in Śnieżnik Massif (HRABĚ 1937a).

It was the author of the original description (KOWALEWSKI 1917), who first noted the variation of specimen size depending on the altitude of lakes and especially on water temperature (the lower the temperature the larger the specimens). However, he did not publish specific data. Although the preserved material was available the length of the body was not measured, but length of the setae in selected segments in 50 completely mature specimens allowed comparison of populations.

It was found that populations of *C. tatrensis* living in various water bodies differ in the length of setae. Specimens living in the Kościeliski S. had the shortest ones with a comparatively high variance of their length (Table V), which was confirmed by a high coefficient of variation CV – from 7.2 to 9.4. That population differs distinctly from all the remaining ones ($p>0.001$). Only for the population from the Kleśnica S. the differences were smaller – at the level 0.05 (for setae of III and V segment). The population found in the Sudeten Mts in the Kleśnica S. characterized by the length of setae close to that found in specimens living in the Tatra lakes, only the third segment setae being considerably shorter. The length of setae in populations of *C. tatrensis* from all the Tatra lakes is similar. Especially populations living in Długi Staw L. and Dwoiste Stawy L. have an almost identical length of setae, differing only in the III segment ($p<0.05$). The lowest values of CV (from 4.5 to 5.6) were observed for specimens living in Dwoiste Stawy L. which indicates a relatively high homogeneity of that population. Apart from the absolute length of setae, populations from the studied water bodies differ in the dimensions of setae in particular segments. The population of *C. tatrensis* from Siwe Stawki L. is characterized by the presence of distinctly shorter setae on the third segment, while in the remaining ones the differences in their lengths were not statistically important. Most often the setae of the third III segment are the shortest of all those measured but in the population living in Długi Staw L. these setae are more or less of the same length as those of segments V and XV. As a rule the longest setae were encountered on the XII segment, but only for the Kleśnica S. population were the differences between lengths of the setae of that segment and the neighbouring ones measured (VIII and XV) were statistically important ($p<0.05$). The measurements carried out confirmed that the size of setae in populations living in different water bodies depends on the environmental conditions, mainly altitude, whereas differences in setae length on particular segments in various populations suggest differences among populations.

In the fundamental systematic review of the European species from the family Enchytraeidae (NIELSEN & CHRISTENSEN 1959) *C. tatrensis* was not taken into account, since its original description (KOWALEWSKI 1917) as well as a reference to its occurrence in the Sudeten Mts (HRABĚ 1937a) were not easily accessible. Untill the 70-ties no new materials were collected since there were no studies conducted in the area of its presence. It was only when KASPRZAK (1978b) on the basis of

Table V

Cernosvitoviella tatrensis – characteristic of the populations living in various water bodies

Length of setae (μm) in segment:	Kleśnica S. Sudeten	Kościeliski S. Tatra Mts	Siwe Stawki L. Tatra Mts	Długi Staw L. Tatra Mts	Dwoiste Stawy L. Tatra Mts
III	41,2	44,8	53,3	55,1	51,5
sd	2,7	3,6	3,8	301	2,9
cv	6,5	8,0	7,1	5,6	5,6
V	54,0	48,1	59,6	56,7	56,2
sd	4,3	4,5	2,9	2,9	2,9
cv	5,0	9,3	4,9	5,1	5,2
VIII	54,9	49,9	58,5	58,5	58,0
sd	3,1	3,6	3,4	4,0	2,7
cv	5,6	7,2	5,8	6,8	4,6
XII	57,1	51,7	59,4	58,9	57,8
sd	2,7	3,8	2,9	3,4	3,1
cv	4,7	7,3	4,9	5,8	5, 4
XV	55,8	47,9	58,7	55,8	55,8
sd	2,7	4,5	2,7	3,1	2,5
cv	4,8	9,4	4,6	5,5	4,5

material collected from the Raba R. (KASPRZAK & SZCZĘSNY 1976), published a comparison between this species and other similar *Cernosvitoviella* species with a drawing of the spermathecae, which is reproduced in the literature (e.g. HEALY 1979). Specimens described by KASPRZAK were not fully mature, since they had not the final distension of the ampullae (Fig. 7B), which could be seen in KOWALEWSKI's and other materials (Fig. 7A, C, D). A supplement to the diagnosis of this species and the appearance of fully developed spermathecae was published by MARTINEZ-ANSEMIL & COLLADO (1996) on the basis of the material from Długi Staw L.

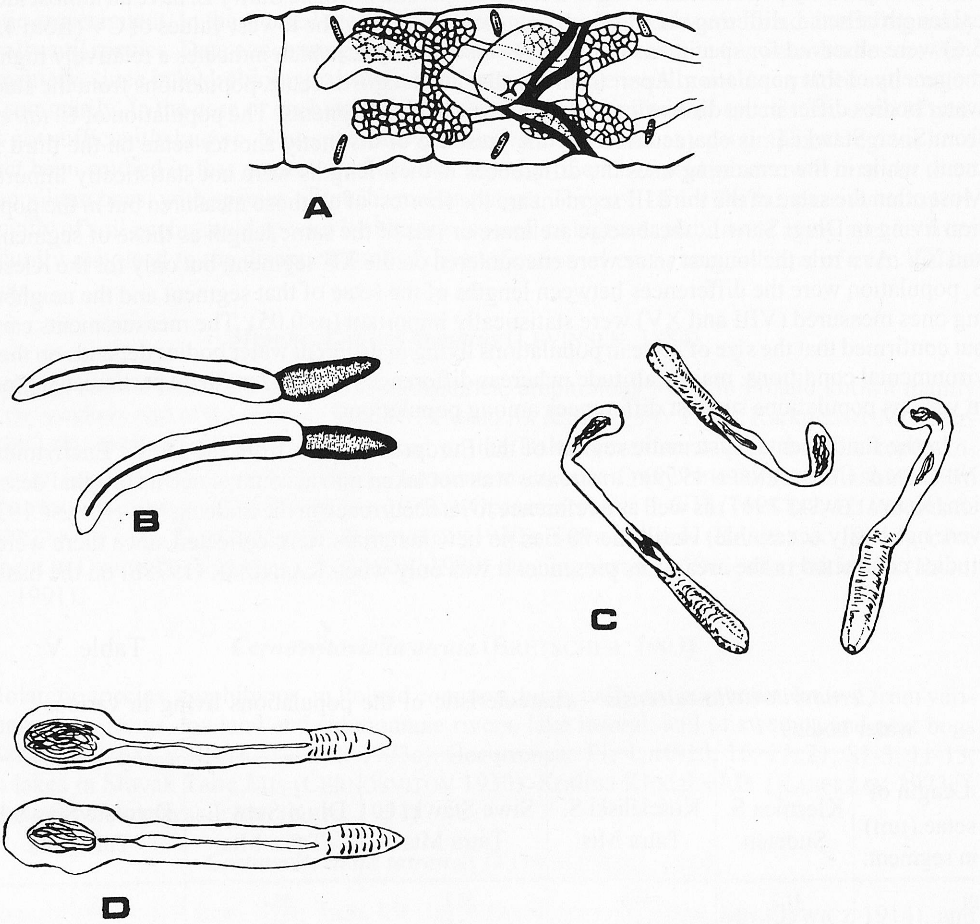

Fig. 7. *Cernosvitoviella tatrensis* – shape of the spermatheca. A – after KOWALEWSKI 1917; B – after KASPRZAK 1978b; C – after MARTINEZ-ANSEMIL & COLLADO 1996; D – from Siwe Stawki L.

Cernosvitoviella carpatica NIELSEN & CHRISTENSEN, 1959

European species, in Poland known mainly from the southern part of the country: sector of the Nida R. close to the mouth (DUMNICKA 1978), Raba R. (KASPRZAK & SZCZĘSNY 1976), Biała Woda S. in Małe Pieniny Mts (DUMNICKA 1982), and a spring in that valley (KASPRZAK 1979a), but found also on Wielkopolsko-Kujawska Lowland in swamp and peat soil (KASPRZAK 1978a). Occurrence: T1,4,7-9, 15, J1, 4.

Cernosvitoviella parviseta GADZIŃSKA, 1974

Stygobiont, a very rare species, described from the swallow hole of the Zimna C. (GADZIŃSKA 1974). The only numerous appearance was in the place of description where 67 mature specimens were captured once. This material was collected when the outflow from the swallow hole was blocked, resulting in the formation of a small pool there. A species found also in other caves in the Tatra Mts, in caves in the Sudeten Mts and in the material from wells located on Wysoczyzna Łaska Upland, probably it has occur also in underground waters in Italy (*C. c.f. parviseta*, after GIANI et al. 1995). Occurrence: T15, 17, S13, W3, 6.

On the basis of specimens found in the caves and wells the description of *C. parviseta* was completed: length of setae 15-22 μm (in the original description about 15 μm.), primary pharyngeal glands united dorsally, secondary glands nearly globular (Fig. 8A). Lymphocytes of two types: spindle-shaped and oval, the latter less numerous. Dorsal vessel originating in XIII or XIV. Spermathecal ampullae cylindrical, well separated from the ectal duct (Fig. 8B). Efferent duct at half-length widened, narrowing before the male pore, but this narrowing is sometimes invisible owing to the concentration of glandular cells (Fig. 8C). The population from the wells differs slightly from that from the Tatra Mts mainly in the dimensions of specimens and length of their setae.

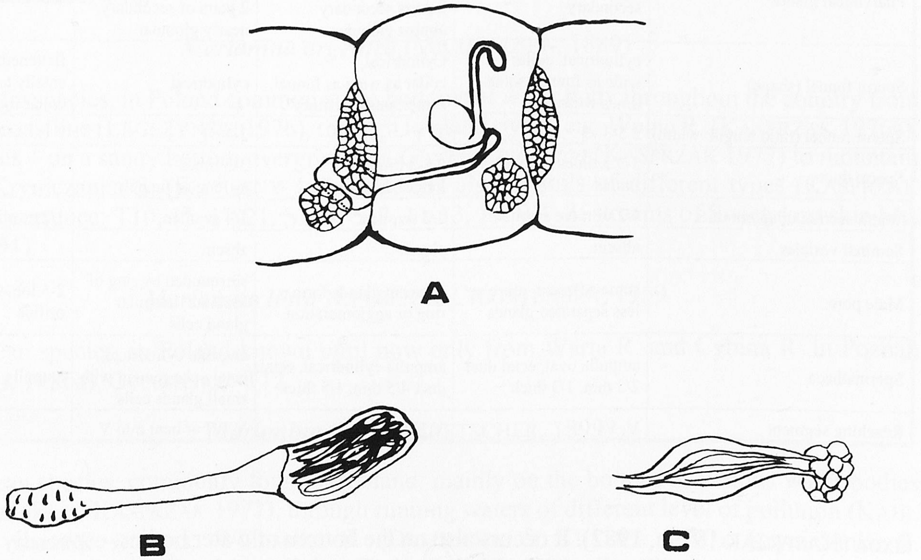

Fig. 8. *Cernosvitoviella parviseta* : A – arrangement of the pharyngeal glands and spermathecae; B – spermatheca; C – distal end of the efferent duct

C. parviseta together with *C. aggtelekiensis* (DÓZSA-FARKAS 1970) and *C. goodhui* (HEALY 1975) form a species complex (Table VI). *C. parviseta* is the only one species from that complex found in Poland. It is highly probable that the species included in that complex were separated relatively not long ago and two of them (*C. aggtelekiensis* and *C. parviseta*) colonized underground waters. Differences occurring among these species are small but seem to be sufficient to retain their distinctiveness. Moreover, *C. c.f. goodhui* described by ROTA (1995), which in a few important details differs from *C. goodhui*, seems to be one more species belonging to the discussed complex. In the case of such resembling species their separation requires additional studies, as was done for *Enchytraeus buchholzi/christenseni* complex (SCHMELZ et al. 1999).

Buchholzia appendiculata (BUCHHOLTZ, 1862)

Holarctic species, connected mainly with the terrestrial environment: soils of meadows and forests, and also peat and muck soils – in these habitats *B. appendiculata* is frequently the dominant

Table VI

Comparison of taxonomic characteristic of *Cernosvitoviella aggtelekiensis* / species complex

Feature / Species	*C. aggtelekiensis* DÓZSA-FARKAS 1970	*C. parviseta* GADZIŃSKA 1974	*C. goodhui* HEALY 1975	*C. c.f. goodhui* ROTA 1995
No of segment	21-23	21-24	20-22	19-20
Setal formula	3,4,6-2÷4 : 4÷9-3,4,6	5÷7-4,5:5÷8-4,5	3÷7-2÷6 : 3÷9-3÷7	2÷5-2÷4:3÷6-3÷5
Lymphocytes	spindle-shaped	spindle-shaped and oval, scarce	spindle-shaped	spindle-shaped
Dorsal vessel	XIV-XV	XIII-XIV	XIII	IX-XII
Pharyngeal glands	2 pairs of primary and secondary	2 pairs primary united dorsally 2 pairs secondary almost globular	2 pairs primary, united dorsally 2 pairs of secondary, nearly globular	lack of description
Sperm funnel (shape)	cylindrical, collar as wide as funnel, sometimes wider	Cylindrical, collar as wide as funnel, sometimes indistinct	cylindrical	flattened, tapering entally to ectally, collar indistinct
Sperm funnel (ratio length: width)	2.5-3 : 1	3 : 1	2-3 : 1	?
Sperm duct	3-3.5 times as long as funnel	2.5-3 times longer than funnel	3-5 times as long as funnel	
Width section of sperm duct	1/2 or more swollen	1/2 swollen	1/4 swollen	1/2 swollen
Seminal vesicles	absent	absent	absent	
Male pore	some adjacent, more or less separated glands	adjacent glands form a ring or agglomeration	surrounded by ring of separate, irregular gland cells	2-5 lobes at the ectal orifice
Spermatheca	ampulla oval, ectal duct 2/3 thin, 1/3 thick	ampulla cylindrical, ectal duct 4/5 thin, 1/5 thick	ampulla cylindrical, ectal enlargement with small glands cells	ampulla oval
Reaching segment	V, VI	V, VI or V only	V, VI or bent into V	

taxon (KASPRZAK 1979a, 1982). It occurs also on the bottom of water bodies, especially small ones (KASPRZAK 1978a). Occurrence: T21, S4, 5, J4, 6; Slovak Tatra Mts (ČERNOSVITOV 1930), soil in the spruce and beech forest (KASPRZAK 1981a).

Bryodrilus ehlersi (UDE, 1892)

Holarctic, soil species, in Poland common, but usually present in small numbers (KASPRZAK 1986a). Found also at the bottom of small water bodies and marsh (KASPRZAK 1979a). Occurrence: S13; Tatra Mts (MOSZYŃSKI & MOSZYŃSKA 1957), Dziura C. (KASPRZAK & ZAJONC 1980).

Cognettia sphagnetorum (VEJDOVSKÝ, 1877)

Holarctic species common in Poland, in the aquatic environment most numerously present at the bottom of mountain streams where it can be one of the dominants, e.g. in Wołosatka S. in Bieszczady Mts (DUMNICKA & KUKUŁA 1990) and in shore sediments (Pieniny Mts streams – KASPRZAK 1979a). Very frequent also in soils of different types (KASPRZAK 1986a) and in the litter of coniferous forests e.g. in pine forests formed from 67 to 99.7% of Enchytraeidae fauna (PILIPIUK 1993). Occurrence: T6, 7, 10-12, 15, S1, 3, 5, W5; Tatra Mts, Stawy Gąsienicowe V. (MINKIEWICZ 1914), Slovak Tatra Mts (ČERNOSVITOV 1930), soil in the spruce forest (KASPRZAK 1981a), streams and Tvarožne Diry C. in the Śnieżnik Massif (HRABĚ 1937a).

Cognettia glandulosa (MICHAELSEN, 1888)

Holarctic species, in Poland known mainly from the southern part of the country: Karkonosze Mts, Izerskie Mts (KASPRZAK 1976b), Bieszczady Mts (DUMNICKA & KUKUŁA 1990), but known also from Wielkopolsko-Kujawska Lowland (MOSZYŃSKA 1962). Habitat requirements similar to these of *C. sphagnetorum*. Occurrence: T9, 11, 12, 19, S4; Tatra Mts, Dolina Stawów Gąsienicowych V. (MINKIEWICZ 1914), Slovak Tatra Mts including Bystra R. (ČERNOSVITOV 1930), stream in Śnieżnik Massif (HRABĚ 1937a).

Cognettia anomala (ČERNOSVITOV, 1928)

European species till now known from only a few places: described from Eastern Carpathians Mts (ČERNOSVITOV 1928), also found in Bieszczady Mts (Wołosatka S., Terebowiec S.) (DUMNICKA & KUKUŁA 1990) and in the soil of pine forests in Bory Tucholskie Forest (PILIPIUK 1993). Occurrence: T10.

Marionina argentea (MICHAELSEN, 1889)

Holarctic species, in Poland common at the bottoms of water body throughout the country from the Baltic coastline (LEGEŻYŃSKI 1976), through lowland rivers, e.g. Wełna R. (KASPRZAK 1976a), heated lakes – on a sandy bottom overgrown by *Glyceria aquatica* (KASPRZAK 1977) to mountain streams: Kryniczanka S. (SZCZĘSNY 1974). Dwells also in soils of different types (KASPRZAK 1986a). Occurrence: T10, 15, 17-21, S1, 3, 5, 7, 11-13, J6, W1, 3; streams of Świętokrzyskie Mts (KAHL 1991).

Marionina libra NIELSEN & CHRISTENSEN, 1959

European species, in Poland known until now only from Warta R. and Cybina R. in Poznań (KASPRZAK 1986a). Occurrence: T12.

Marionina riparia BRETSCHER, 1899

European species, commonly found in Poland, mainly on the bottom of various water bodies from heated lakes (KASPRZAK 1977), through running waters of different level of pollution (KAHL 1983) to montane streams: Wołosatka S. (DUMNICKA & KUKUŁA 1990), Kryniczanka S. (SZCZĘSNY 1974), present however also on the border of water bodies (Pieniny Mts – KASPRZAK 1979a) and in the terrestrial environment (pine woods – PILIPIUK 1993). Occurrence: T15-17, 20, S11-13, J1, 3, Kotlina Kłodzka I.B. (KASPRZAK 1973c), Prądnik S. (KASPRZAK 1976c), running waters of Świętokrzyskie Mts (KAHL 1983, 1986, 1991).

Enchytraeus buchholzi VEJDOVSKÝ, 1879

Cosmopolitan species, in Poland common both in aquatic and terrestrial environment (KASPRZAK 1986a). It is a species with a very wide ecological range (NIELSEN & CHRISTENSEN 1959). Occurrence: T10 -12, 14, 15, 17, 20, 21, S4 -6, 11, 13, J1, 6, I1, 6, W5-7. Śnieżnik Massif: adit (STAMMER 1936), Patzeltova C. (HRABĚ 1937a), Tatra Mts: Dziura C. (KASPRZAK & ZAJONC 1980), soil in beech forest (KASPRZAK 1981a).

Enchytraeus lacteus NIELSEN & CHRISTENSEN, 1961

European species, in Poland known from a few localities: Pieniny Mts, soil in the Carpathian beech forest (KASPRZAK 1979a), Wielkopolsko-Kujawska Lowland (KASPRZAK 1986a). Occurrence: I1, 2, W3, 5, 7.

Enchytraeus dominicae DUMNICKA, 1976

Stygobiont, described from Nietoperzowa C. (DUMNICKA 1976b), till now known mainly from underground waters of Poland, probably found also in Italy (after GIANI et al. 1995, data presented in a poster). Lives at the bottom of cave water bodies and also in wet sediments. Mature specimens can be encountered throughout the year, e.g. in Nietoperzowa C., where thit species is present in large numbers (DUMNICKA 1981). Developmental cycle at a temperature of 7-9° C is short (cocoon incubation period – about 30 days, maturation period – about 90 days), comparable to that of other *Enchytraeus* species of the same size kept in low temperatures (DUMNICKA 1984). Lack of prolongation of life stages, which is characteristic for stygobionts, testifies that *E. dominicae* is a recent migrant to the underground environment. Occurrence: T12, 17, 20, 21, S6, 8, 11-13, J6-8, I1, 2, W3, 5-7.

E. dominicae closely related to *E. buchholzi,* seems to be the next species belonging to the species complex *E. buchholzi/ E. christenseni* (SCHMELZ et al. 1999). The combination of anatomical features, both somatic (shape of coelomocytes, shape and number of pharyngeal glands) as well as details of the structure of reproductive organs (especially the shape of spermathecae) permit separation of these species. However, these species have high variability of distinguishing characters and interspecific differences are small. To decide on attribution to a given species within that species complex more profound studies are necessary, such as protein patterns and crossbreeding experiments, which will allow statement of their distinctiveness. The first steps in order to clarify taxonomic problems with *E. buchholzi* and related species were undertaken by SCHMELZ and co-workers (1999). However, their studies did not provide clear answers and need to be continued.

Fridericia galba (HOFFMEISTER, 1843)

European species, in Poland occurring mainly in soils of various types, but known also from shores of small water body and streams (Pieniny Mts – KASPRZAK 1979a). Occurence: T10, S1; Niżne Tatra Mts (ČERNOSVITOV 1930), Western Tatra Mts, soil in beech forest (KASPRZAK 1981a), Śnieżnik Massif, adit (STAMMER 1936).

Fridericia bisetosa (LEVINSEN, 1884)

European species, common in Poland, is frequently the dominant taxon in the soils of fields and meadows (KASPRZAK 1986a). In the aquatic environment rather rare. Occurence: T10; Niżne Tatra Mts, soils (ČERNOSVITOV 1930).

Fridericia bulbosa (ROSA, 1887)

Cosmopolitan species, lives mainly in the soil but also found on the bottom of various water body, mainly rivers: Raba R. (KASPRZAK & SZCZĘSNY 1974), Nida R. (DUMNICKA 1978). Occurence: T10, 11, 21; Tatra Mts – Zakopane (MOSZYŃSKI & MOSZYŃSKA 1957), soil in beech forest (KASPRZAK 1981a).

Fridericia alata NIELSEN & CHRISTENSEN, 1959

European species, in Poland found till now in terrestrial environment both in lowland places (Wielkopolska Lowland – KASPRZAK 1986a) and in the mountains (Pieniny Mts – KASPRZAK 1979a). Occurrence: S1, 6.

Fridericia semisetosa DÓZSA-FARKAS, 1970

European species, till now known from a few locations. Described from Baradla C. (Hungary), where it was found in the decaying pieces of a wooden bridge (DÓZSA-FARKAS 1970). Found also in the litter of deciduous forest near Budapest (DÓZSA-FARKAS 1970) and in the soil of fir forest and grassland in Pieniny Mts (KASPRZAK 1979a). Occurrence: S4.

Fridericia tridiverticula KASPRZAK, 1972

Species described from the soil of the park in the Zoological Garden in Poznań and known from locus typicus only (KASPRZAK 1972c) until it was found in the stream bottom in Śnieżnik Massif. Occurrence: S1.

Fridericia dissimilis DUMNICKA, 1998

Species described from a periodic spring no 2 (according to CIĘŻKOWSKI 1989) (DUMNICKA 1998) and till now known only from locus typicus. Mature specimens were collected in May and September.

In a few specimens 2 small appendages were found in the VI segment (Photo. 1), which feature was not included in the diagnosis of that species. Occurrence: S5.

Photo 1. *Fridericia dissimilis*. – *S – spermathecae; G – pharyngeal glands; A – appendages*

Henlea nasuta (EISEN, 1878)

Holarctic species, common in Poland in the soils of forests and meadows, lives also in marsh soils and alluvial clays (KASPRZAK 1986a) as well as on the bottom of small rivers: Wełna R. (KASPRZAK 1976a), Brynica R. (DUMNICKA 1985), Lubrzanka R. (DUMNICKA 1978). Occurrence: T8, 17, S4; Niżne Tatra Mts (ČERNOSVITOV 1930).

Henlea perpusilla FRIEND, 1911

Holarctic species, found as often in terrestrial habitats as in aquatic ones, in Poland known from many stations (KASPRZAK 1986a, DUMNICKA & KUKUŁA 1990). Occurrence: T17, 20, 21, S1, 4, 5, 7.

Achaeta eiseni (VEJDOVSKÝ, 1877)

Holarctic species, known almost exclusively from terrestrial habitats (soil of forests, meadows and fields) common in Poland (KASPRZAK 1986a). Occurrence J6; Niżne Tatra Mts (ČERNOSVITOV 1930).

Achaeta bohemica (VEJDOVSKÝ, 1879) *sensu* NIELSEN & CHRISTENSEN 1959

Species known from Europe and North Africa (ROTA & HEALY 1994) present mainly in the soils of deciduous and coniferous forests but noted also from the bottom of brooks and lake shores (KASPRZAK 1986a). Occurrence: S4, Śnieżnik Massif, Tvarožne Diry C. (HRABĚ 1937a).

Achaeta seminalis KASPRZAK, 1972

Species originally described from the soil in the Zoological Garden in Poznań (KASPRZAK 1972b), found also in Pieniny Mts (KASPRZAK 1979a), Gorce Mts, and Beskid Sądecki Mts (KASPRZAK 1986a), where it occurred in terrestrial habitats and on the borders of water bodies. Occurrence: S3.

Lumbricidae

Eiseniella tetraedra (SAVIGNY, 1826)

Cosmopolitan species, common in Poland, present mainly on the borders of various water bodies and in wet soils (KASPRZAK 1986b). Occurrence: T10, S2, 4; a spring in Śnieżnik Massif (PAX & MASCHKE 1936), Tatra Mts – lower and upper alpine forest (KASPRZAK & ZAJONC 1980), Niżne Tatra Mts (ČERNOSVITOV 1930), ponds near Kraków (SZARSKI 1947), Prądnik S. (KASPRZAK 1976c), running waters of Świętokrzyskie Mts (KAHL 1983, 1986, 1991).

V. OLIGOCHAETE TAXOCENS OF THE STUDIED REGIONS

1 – Tatra Mts

In the studied water bodies of this region 35 oligochaete species belonging to 7 families were found. Only in the benthos of High Tatra Mts streams the first dominant was the family Naididae (75.6% of taxocen) (Table VII), represented mainly by *Nais variabilis.* The second dominant was the representative of the Enchytraeidae family – *Mesenchytraeus armatus*, while the remaining taxa, among which there were both aquatic and soil species, were not numerous. In the studied springs the Naididae family was also important, constituting more than 22% of taxocen.

In the majority of the studied waters Enchytraeidae were the most numerous, dominating both in the stream benthos (in Western Tatra Mts – 61.5% of taxocen while 22% in High Tatra Mts) and in underground waters. This family was especially numerously encountered in waters of the studied caves and in the interstitial waters of High Tatra Mts streams, where it accounted for 95.6% and 91% of taxocen, respectively. In this last mentioned habitat the most numerous species was *M. armatus,* accompanied by *Cernosvitoviella* spp and *Cognettia* spp. On the limestone substratum in all the studied habitats, except for endogenic waters in the caves, *P. volki* (family Propappidae) was one of the important dominants (from 25% to 80% of taxocen). The family Lumbriculidae was more numerous in the interstitial waters of streams both in the High Tatra and in Western Tatra Mts (8%-10.6% of taxocen respectively). These were mainly juvenile forms from *Trichodrilus* genus while in the benthos of streams genera typical of epigean waters (*Stylodrilus* and *Lumbriculus*) were present. The remaining families (Haplotaxidae, Tubificidae and Lumbricidae) were represented by single taxa and a small number of specimens. The density of oligochaetes in the stream benthos ranged from several dozen specimens to a few thousand on m^2, while locally (in fine sediments) it could reach nearly 20 thou. specimens on $m.^{-2}$. For some part of thecollected samples it was impossible to state the density because of the methodology applied (KOWNACKI 1971).

Table VII

Percentage composition of oligochaete taxa in various water bodies in theTatra Mts

Taxon	High Tatra streams	High Tatra interst. w.	Koście-liski S.	Koście-liski interst. w.	Springs	Caves with running w.	Caves with stagnant w.
Lumbriculidae gen. spp. juv.	0.5	7.5		10.2	2.0	0.9	4.0
Stylodrilus spp. juv.	0.5	0.5					
– *heringianus*	0.5					0.3	
Lumbriculus variegatus	0.3					0.1	
Stylodrilus brachystylus	0.1						
Trichodrilus cernosvitovi				0.4			
– *moravicus*							0.4
Enchytraeidae gen. spp. juv.	2.0	46.0	22.9	20.1	12.7	4.3	33.7
Cernosvitoviella spp. juv.	1.1	7	21.2	18.1	3.9	5.8	7.7
– *tatrensis*	0.1	2.0	1.6	0.7	2.9	1.3	0.4
– *atrata*	0.1	2.0	1.7	3.5	2.9		1.5
Cognettia spp. juv.	4.5	1.0	0.9	1.8		0.3	
– *glandulosa*	0.4	2.0	0.6	2.1			0.4
– *sphagnetorum*	0.1	4.5	1.9	3.5		0.6	
Mesenchytraeus armatus	12.9	25.0	2.4	9.6	1.0		
– spp. juv.	0.3					0.1	
Cernosvitoviella carpatica	0.2					0.3	
Henlea nasuta	0.1						0.4
– spp. juv.	0.4						
Enchytraeus buchholzi		0.5	0.6	0.4	1	0.1	4.8
Fridericia bulbosa		1	0.3				0.7
Marionina spp. juv.			2.8	0.4		0.7	
– *argentea*			1.1			2.4	13.2
Buchholzia spp. juv.			1.9				2.9
Fridericia bisetosa			0.8				
– *galba*			0.6				
Cognettia anomala			0.2				
Enchytraeus dominicae				0.4			6.2
Buchholzia appendiculata				0.4			0.7
Marionina libra				0.4			
Cernosvitoviella parviseta						0.6	8.4
Marionina riparia						0.3	11.3
Henlea perpusilla							1.1
Fridericia spp. juv							1.5
– *maculata*							0.7
Propappus volki	0.1		35.4	25.4	51	80.3	
Tubificidae gen. spp. juv.			0.1			0.1	
Nais variabilis	70.7	1	0.2		15.7		
– *communis*	4.8		0.4	0.7	2.9	0.1	
– *pseudobtusa*	0.1		0.2		1		
– *alpina*			0.7	0.4			
Chaetogaster distrophus			0.2				
– sp.						0.1	
Nais bretscheri					2		
– *pardalis*					1		
Haplotaxis gordioides	0.2		0.7	1.1		1.3	
Lumbricidae gen. spp. juv.			0.4				
Eiseniella tetraedra			0.2	0.4			
APHANONEURA							
Aeolosoma spp.					p.		

In the caves with watercourses, apart from dominant *P. volki* and Enchytraeidae, the species from the family Naididae were present. They were not encountered in other types of cave waters. The composition of taxocens found in endogenous waters of Tatra Mts caves differs quite considerably among them (Table VIII). In Bandzioch C. soil forms had a high share (*Buchholzia* sp., *Fridericia* sp.), which most probably resulted from the localization of sampling sites in the upper parts of the cave, close to the earth surface. In the main gallery of Kasprowa Niżnia C. oligochaetes were not found although samples were collected several times from various water bodies, while in lower parts Lumbriculidae dominated (40%). In the Zimna C. almost exclusively enchytraeids were present. Besides great differences in the composition of cave water taxocens, species widely distributed in this habitat were also found. One of them – *M. argentea*, was found in all caves. In almost all the studied caves representatives of two closely related species (*E. buchholzi* and *E. dominicae*) were found. In Tatra Mts waters 4 stygobionts: *E. dominicae, C. parviseta*, and *T. moravicus* were found in caves and *T. cernosvitovi* in the interstitial waters.

In the studied caves the yield of oligochaetes was usually very small – from 1 (Kasprowa Niżnia C.) to 8 (Zimna C.) specimens in a sample (mean for all samples), and some 40% of collected samples were devoid of oligochaetes.

There are some difficulties in precise statement of the number of species found in the Tatra Mts. Some species, found only in the Niżnie Tatra Mts by ČERNOSVITOV (1930) (e.g. *Limnodrilus udekemianus*), in subsequent papers were listed as Tatra Mts species. Including soil species from the family Enchytraeidae, whose presence was described also in the aquatic habitat, it may be stated that so far in Tatra Mts waters 56 species of oligochaetes have been found (ČERNOSVITOV 1930, DUMNICKA 1976a, 1996c, DUMNICKA & WOJTAN 1989, HRABĚ 1939, 1940, 1942, KASPRZAK 1981a, KASPRZAK & ZAJONC 1980, KOWALEWSKI 1914, 1917, KOWNACKI et al. 1997, MINKIEWICZ 1914, VRANOVSKÝ et al. 1944, WIERZEJSKI 1881, 1883). Some of them were not found in the Polish part of the Tatra Mts (*Tatriella slovenica, T. tatrensis, M. gaudens, A. limnobius* and *T. ignotus*). The presence of some species is connected with an anthropogenic increase in water trophy or even pollution, such as *N. elinguis* or *N. simplex* in the Rybi Potok S. below Morskie Oko mountain – shelter (DUMNICKA 1976a). It seems that the list of species is not yet complete since some aquatic habitats (springs, marshes, streams of Western Tatra Mts, and some cave waters) have not been studied at all, or studied only at random.

Table VIII

Percentage composition of oligochaete taxa in the Tatra Mts caves

Taxon	Zimna C.	Kasprowa C.	Bandzioch C.	Miętusia C.	other caves
Lumbriculidae gen. spp. juv.	1.3	35.0			6.2
Trichodrilus moravicus		5.0			
Enchytraeidae gen. spp. juv.	24.0	25.0	52.8	52.5	63.8
Marionina argentea	11.0	5.0	10.9	27.5	17.5
Enchytraeus dominicae	9.2		3.6	2.5	12.5
– *buchholzi*	5.3		1.9	10.0	
Henlea perpusilla	0.6		1.9	2.5	
Marionina riparia	18.9			5.0	
Cernosvitoviella spp. juv.	11.0	20.0			
– *atrata*	1.3		3.6		
– *tatrensis*	0.6	5.0			
– *parviseta*	14.9				
Fridericia spp. juv.	1.3				
Henlea nasuta	0.6				
Cognettia glandulosa		5.0			
Buchholzia sp. juv.			14.5		
– *appendiculata*			3.6		
Fridericia maculata			3.6		
– *bulbosa*			3.6		

2 – Kłodzkie Sudeten Mts

In the water bodies of this area a total of 35 species were found. In the benthos of the studied streams 20 species were found, Enchytraeidae predominating there (57%) (Table IX). Among benthic Naididae (39.4% in total) the most numerous were *N. alpina* and *N. variabilis*. This last-mentioned species dominated strongly in one of the studied springs (S10 – limnocrene called Pax's spring), where it formed 78.2% of the taxocen. It was accompanied by *N. pseudobtusa*, less numer-

Table IX

Percentage composition of oligochaete taxa in various water bodies in Kłodzkie Sudeten

Taxon	Streams	Interst. w.	Pax Spring	Springs	Caves
Stylodrilus spp. juv.	2.5				0.2
– *parvus*	0.7				
Lumbriculidae gen. spp. juv.		0.6			15.5
Trichodrilus moravicus					2.0
– *pragensis*					2.2
Enchytraeidae gen. spp. juv.	13.7	24.5	0.5	58.6	40.9
Cernosvitoviella spp. juv.	19.8	18.0		1.2	2.4
– *atrata*	8.8	10.0			1.4
Marionina argentea	0.6	30.0		3.1	14.0
Cernosvitoviella tatrensis	3.8	10.0			1.0
Mesenchytraeus armatus	4.3	0.6		5.0	
Cognettia sphagnetorum	1.4	3.0		2.2	
Fridericia alata	2.1			1.7	
– *tridiverticula*	0.7				
– *galba*	0.7				
Henlea perpusilla	0.4			4.5	
Cognettia spp. juv.	0.7			1.2	
Achaeta seminalis		0.6			
– spp.		0.6			
Enchytraeus dominicae				2.8	3.8
- *buchholzi*				1.7	1.4
Henlea nasuta				0.5	
Buchholzia appendiculata				8.8	
Achaeta bohemica				0.5	
Cognettia glandulosa				1.2	
Fridericia semisetosa				0.5	
– *dissimilis*				4.5	
Henlea spp. juv.				0.5	
Marionina riparia					6.5
– sp.					0.2
Cernosvitoviella parviseta					0.2
Bryodrilus ehlersi					1.4
Propappus volki				0.5	
Rhyacodrilus falciformis					5.1
Tubificidae gen. spp. juv.					1.8
Nais alpina	14.4	1.5	1.5		
– *variabilis*	11.3		78.2		
– *pseudobtusa*	9.8		16.8	0.5	
Pristina idrensis	2.1				
– *menoni*	1.4				
Nais elinguis	0.4				
– *communis*		0.6	2.5		
Chaetogaster diastrophus			0.5		
Eiseniella tetraedra	0.4			0.5	
APHANONEURA					
Aeolosoma spp.	p.	p.			

ously found in the benthos of streams. In the interstitial waters of the studied streams and remaining springs (no S4-S9) Enchytraeidae occurred almost exclusively, amounting to more than 97% of taxocens found in these environments. These taxocens differed in the structure of dominance. In the interstitial waters the first dominant was *M. argentea*, a species scarce in the benthos. In the springs the only dominants were juvenile Enchytraeidae, also more frequent were species having different habitat requirements, such as *B. appendiculata* and *M. armatus*. In cave waters, besides juvenile Enchytraeidae, juvenile Lumbriculidae, and *M. argentea* occurred numerously.

The mean density of oligochaetes in the benthos of streams (during the studied period) was low and ranged from 660 specimens m^{-2} in Kleśnica S. to 1100 specimens m^{-2} in Gołodolnik S.

Table X

Percentage composition of oligochaete taxa in Kłodzkie Sudeten caves

Taxon	Radochowska C.	Niedźwiedzia C.	Solna Jama C.
Lumbriculidae gen. spp, juv.	1.1	20.9	25.2
Trichodrilus moravicus		6.6	1.8
– *pragensis*		4.4	3.3
Stylodrilus sp. juv.			0.4
Enchytraeidae gen. spp. juv.	60.4	26.4	30.3
Marionina riparia	11.9	5.5	2.3
Enchytraeus dominicae	8.1	1.1	1.4
Marionina argentea	4.9	15.3	21.5
Cernosvitoviella spp. juv.	2.2	2.2	2.8
– *atrata*	2.2	2.2	0.4
Enchytraeus buchholzi	2.2	3.3	
Cernosvitoviella tatrensis	2.7		
Bryodrilus ehlersi	3.8		
Cernosvitoviella parviseta	0.5		
Tubificidae gen. spp. juv.		9.9	
Rhacodrilus falciformis		2.2	10.6

In two of the studied caves, i.e. Niedźwiedzia C. and Solna Jama C., the structure of taxocens was highly diversified (Table X). In both these caves representatives of theTubificidae family were found – in Solna Jama C. – *Rhyacodrilus falciformis,* while in Niedźwiedzia C. except for that species, juvenile specimens with a different setal formula were found. In the last of the studied caves – Radochowska C., Enchytraeidae amounted to almost 99% of the taxocen, besides which only the presence of a few juvenile Lumbriculidae was found. Out of the four stygobionts *E. dominicae* occurred in all the caves, while *T. moravicus* and *T. pragensis* in the two first ones, and *C. parviseta* in Radochowska C. only.

In samples collected from the caves there were (on average) from 4 (Niedźwiedzia C.) to 18 (Solna Jama C.) specimens of oligochaetes; the highest percentage of empty samples was found in Niedźwiedzia C. (39%), distinctly smaller in Radochowska C. (10%), while in all samples collected from Solna Jama C. the studied animals were present.

Altogether 18 species of oligochaetes were known from Śnieżnik Massif waters (including 2 *species dubiae* from the family Enchytraeidae) (HRABĚ 1937a, MASCHKE 1936, MOSZYŃSKI 1936, PAX & MASCHKE 1935, 1936, STAMMER 1936). The present author's own studies enlarged that list by 26 species, thus in waters of that Massif 44 oligochaete species were found, while taking into account the fauna of Kotlina Kłodzka I.B. streams (KASPRZAK 1973c) that number risess to 50. Only in the upper course of the streams did Enchytraeidae dominate and also Naididae, characteristic of clean waters (*N. alpina, N. variabilis*). On the other hand, in the Kotlina Kłodzka I.B. streams, enriched with biogens from municipal and agricultural sewage, and also in the running waters of Western Sudeten, the most numerous were ubiquitous and well – tolerating water pollution species, although in that habitat Lumbriculidae (*Lumbriculus* and *Stylodrilus*) were also present (KASPRZAK 1973b, c), and sometimes even numerously.

3 – Olkuska Upland

In the studied water bodies of this region 31 species of oligochaetes were found. In the benthos of the Sąspówka S. Naididae dominated strongly, forming 60% of taxocen among which the most numerous was *Nais bretscheri* (Table XI). The share of the two families, i.e. Tubificidae and Enchytraeidae (represented mainly by juvenile specimens), was similar (21.6 and 16.5%). In the Prądnik

Table XI

Percentage composition of oligochaete taxa in various water bodies of Olkuska Upland

Taxon	Streams	Springs	Caves
Lumbriculidae gen. spp. juv.	0.6		2.7
Stylodrilus spp. juv.	0.9	1.0	
Lumbriculus variegatus	0.2		
Enchytraeidae gen. spp. juv.	7.3	13.1	62.8
Cernosvitoviella spp. juv.	5.5	17.2	
– *atrata*	3.2	4.1	
– *carpatica*	0.2	1.0	
Marionina riparia	0.2	2.0	
Enchytraeus buchholzi	0.1		0.9
Mesenchytraeus armatus		1.0	
Fridericia spp. juv.		1.0	
Buchholzia appendiculata		1.0	0.9
– spp. juv.			2.7
Marionina argentea			9.2
Enchytraeus dominicae			9.2
Achaeta spp. juv.			5.3
– *eiseni*			2.6
Fridericia bulbosa			0.1
Propappus volki	0.1	2.0	
Tubificidae gen. sp. juv.	19.4	48.6	
Rhyacodrilus falciformis	1.6	1.0	
Tubifex tubifex	0.5	1.0	
Epirodrilus pygmaeus	0.1		
Nais bretscheri	41.9	1.0	
– *communis*	1.6	3.0	
– *pseudoptusa*	0.6	2.0	
– *pardalis*	8.2		
– *variabilis*	3.0		
– *alpina*	2.2		
– *elinguis*	0.8		
Chaetogaster diastrophus	1.2		
Homochaeta naidina	0.1		
Amphichaeta leydigi	0.1		
Stylaria lacustris	0.1		
Pristina idrensis	0.1		
– *amphibiotica*	0.1		
– spp.	0.1		
Vejdovskyella intermedia			0.9
Haplotaxis gordioides			2.7

S., even in its non-polluted stretches, Tubificidae dominated in the oligochaete taxocen (mainly *T. tubifex* and *L. hoffmeisteri*) (KASPRZAK 1976c). In the studied springs that family also dominated. Enchytraeidae (40%) were the second dominant, the share of Naididae being small (6%). In cave waters Enchytraeidae formed 94% of taxocen, being represented by juvenile specimens (about 63%); among mature specimens the most numerous were: *E. dominicae* (found in all the studied caves) and *M. argentea* (found only in the Kryspinowska C.).

The mean density of oligochaetes in the benthos of the Sąspówka S. ranged from a few hundred specimens on m^{-2} in the upper course of the stream to about 2 thous. spec. m^{-2} in the middle course, while in the springs (where it was possible to take quantitative samples) it amounted to about 1 thous. spec. m^{-2}.

Table XII

Percentage composition of oligochaete taxa in Olkuska Upland caves

Taxon	Smocza Jama C.	Kryspinowska C.	Mąciwoda C.
Lumbriculidae gen. spp. juv.	14.3		33.3
Enchytraeidae gen. spp. juv.	50	65.6	33.3
Enchytraeus dominicae	7.1	8.6	33.3
– *buchholzi*		1.1	
Marionina argentea		10.7	
Achaeta spp. juv.		6.5	
– *eiseni*		3.2	
Buchholzia sp. juv.		3.2	
– *appendiculata*		1.1	
Vejdovskyella intermedia	7.1		
Haplotaxis gordioides	21.5		

Only a few species formed oligochaete fauna of the three analysed caves (Table XII). In all of them juvenile specimens of Enchytraeidae dominated, in the Smocza Jama C. a large share in the taxocen belonging to typically aquatic species, i.e. *Haplotaxis gordioides* (over 20%) and *V. intermedia*, not found in other caves of the Upland. The presence of Lumbriculidae (juvenile specimens with single pointed setae, probably *Trichodrilus*) was noted in two caves only (Smocza Jama C., Mąciwody C.). In all the sudied caves *E. dominicae* was present, the only stygobiont on the Olkuska Upland. In the Kryspinowska C. soil taxa (*Buchholzia, Achaeta)* were present on the pool bottom.

So far 57 oligochaete species (JAWOROWSKI 1893, SZARSKI 1947, KASPRZAK 1976c, DUMNICKA 1977a, 1977c, 1994b, DUMNICKA & KOWNACKI 1988, DUMNICKA & WOJTAN 1990) found in various water bodies (springs, streams, large river, fish ponds, underground waters) and with various levels of pollution were described from that area. This is why on such a small area species with distinctly different ecological needs were found. There is no doubt that the list of oligochaetes living in this region is incomplete, because the remaining parts of the Kraków-Wieluń Upland have not yet been studied.

4 – Świętokrzyskie Mts

In the studied caves of the Świętokrzyskie Mts only the representatives of the Enchytraeidae family were found, juvenile specimens forming 74.4% of taxocen (Table XIII). In Chelosiowa Jama C. the number of collected specimens was very small (on the average 1.3 per sample), percentage of empty samples being relatively high (35%). In the Raj C. the presence of oligochaetes was found in almost all samples, their number being on the average 4 specimens per sample.

Table XIII

Percentage composition of oligochaete taxa in various subterranean waters in Świętokrzyskie Mts, Wysoczyzna Łaska Upland and Niecka Nidziańska Basin

Taxon	Święto-krzyskie Mts – caves	Wells near Grabia River	Souterrains	Skorocice epigean	Skorocice hypogean	Siesławice lakelet
Lumbriculidae gen. spp. juv.			9.1		5	
Stylodrilus sp. juv.		2.8				
Enchytraeidae gen. spp. juv.	74.4	71.2	54.5		2.6	20
Cernosvitoviella spp. juv.	9.3	1.3				
Enchytraeus buchholzi	2.3	2.7	27.3			
– *dominicae*	4.7	12.4				
– *lacteus*	9.3	3.5				
– *mariae*			9.1			
Marionina argentea		3.8				
Cernosvitoviella parviseta		1.5				
Achaeta sp. juv.		0.2				
Cognettia sphagnetorum		0.2				
Tubificidae gen. spp. juv.		0.2		90.2	70.4	70
Tubifex tubifex				3.8		
- *ignotus*				0.4		
Nais elinguis				2.8	18.5	
Pristina menoni				1	1.9	
Chaetogaster diaphanus				0.2	0.8	
Amphichaeta leydigi				0.2	0.8	
Nais communis				1		10
- *variabilis*				0.4		
Haplotaxis gordioides		0.2				
APHANONEURA						
Aeolosoma spp.	p.	p.	p.			

Taxocen with the predominance of Enchytraeidae and Lumbriculidae (mainly *S. heringianus*), was present only in the spring and forest parts of the Świętokrzyskie Mts streams (Kahl 1991, Szczęsny 1990), while in their parts running through meadows, even with the absence of pollutants, Tubificidae took over dominancy, but not Naididae, as in streams and rivers of other mountain ranges. In the middle course of two rivers studied in the 70ties: Belnianka R. and Lubrzanka R. (Dumnicka 1978) *P. volki* positively dominated forming about 42 and 56% of oligochaete taxocen there, respectively. The second dominant were juvenile Tubificidae (mainly *Limnodrilus* sp.). Family Naididae, although represented by the greatest number of species (27) formed only a few percent of taxocen.

According to Kahl (1991), the list of species of oligochaetes from the Świętokrzyski region comprised 58 species (not taking into account 4 species from *Aeolosoma* genus, transferred to the newly established class Aphanoneura, and also 5 taxa of ectoparasits of crayfish (Kahl & Wojtas 1974) from the old family Branchiobdellidae, separated from Oligochaeta into the distinct order Branchiobdellida). Studies on underground waters added to that list 3 species from the family Enchytraeidae (*E. lacteus, E. mariae* and *E. dominicae*) (Dumnicka & Wojtan 1994, Dumnicka 1996b).

5 – Niecka Nidziańska Basin

In the gypsum karst waters the presence of poorly diversified oligochaete taxocens was found (Table XIII). In both surface and underground parts of the Skorocicki S. and in stagnant waters in Siesławice the first and frequently only dominant were juvenile specimens from the family Tubificidae (with hair setae), most probably *T. tubifex*. In the underground part of the Skorocicki S. *N. elinguis* also dominated and in Siesławice pools – juvenile Enchytraeidae. Near the spring of Skorocice S., besides Tubificidae juv. only a single taxon – *N. communis* occurred in the superficial sector and Lumbriculidae juv. inside the cave. Starting with 2 km of watercourse, the oligochaete taxocen became more diversified, 4-5 species from the family Naididae being noted. The densities of oligochaetes were distinctly lower in the underground parts of the stream (60 and 365 specimens per m^{-2}) when compared with neighbouring surface stations (530 and 2070 specimens per m^{-2}).

In the Niecka Nidziańska Basin studies on oligochaete fauna were carried out in the Biała Nida R. and Nida R. only. Even in the spring stretch of the Biała Nida R. the dominance of Tubificidae was observed (KAHL 1983), persisting on almost all the studied stations of both rivers (DUMNICKA 1978, KAHL 1983). Naididae, represented mainly by *N. elinguis*, were most numerous only periodically.

From running waters of this region 50 oligochaete species have been known (DUMNICKA 1978, KAHL 1983); in the studied material only one new species for the area was found – *N. variabilis* (DUMNICKA & WOJTAN 1993).

6 – Others – souterrains and non-karstic caves

In the Mokra C. (Beskid Śląski Mts), although samples were taken several times in various seasons, no representatives of Oligochaeta were found. In the underground small quarries in the Beskid Niski Mts only juvenile specimens of two oligochaetes families: Enchytraeidae (about 91% of taxocen), and Lumbriculidae (the remainder) were found (Table XIII). Besides, the presence of Aphanoneura (*Aeolosoma* sp. probably *A. niveum*) was noted there.

In the old copper mine, Miedzianka (Świętokrzyskie Mts), only enchytaeids were present, among which only 2 species from *Enchytraeus* genus were determined, not characteristic of caves.

In the wells of the Grabia R. valley also Enchytraeidae strongly dominated. The stygobiontic species *C. parviseta* was also found there. Apart from enchytraeids, *H. gordioides*, *Stylodrilus* sp., and not numerous juvenile Tubificidae were found in these waters. These typically aquatic taxa were present in the wells located closest to the riverbed. The mean number of specimens per sample was 16, but differences among wells were great. The largest number of oligochaetes was collected from the oldest wells (W5 and W7), indicating that they found favourable living conditions there. It is likely that in non-scoured wells sometimes the amount of organic matter deposited on the bottom increases and at the same time competition for food is small, since the presence of Crustacea was found in the 4 youngest wells only, these being located closest to the Grabia R. (KONOPACKA & JAŻDŻEWSKI 1996) while in these wells the number of Oligochaeta was the smallest.

7 – The similarity of taxocens of various water types in the studied areas

In the Tatra Mts the greatest similarity (Fig. 9) was found among taxocens inhabiting the bottom of streams in the Western Tatra Mts (D) and neighbouring interstitial waters (E), since taxa numerous in benthos (*Cernosvitoviella, Propappus*) dominated also in the interstitial waters. To that group of stations belongs also the remaining stations localized in the Western Tatra Mts: springs (G) and caves (H), as well as from the High Tatra Mts – stations on interstitial waters (C) (Fig. 9-I). Taxocens present in caves with flowing waters (F) and on the bottom of High Tatra Mts streams (B) differ considerably from all the remaining ones. In the High Tatra Mts the lack of similarity between oligochaete fauna of stream bottoms and their interstitial waters results from the dominance of

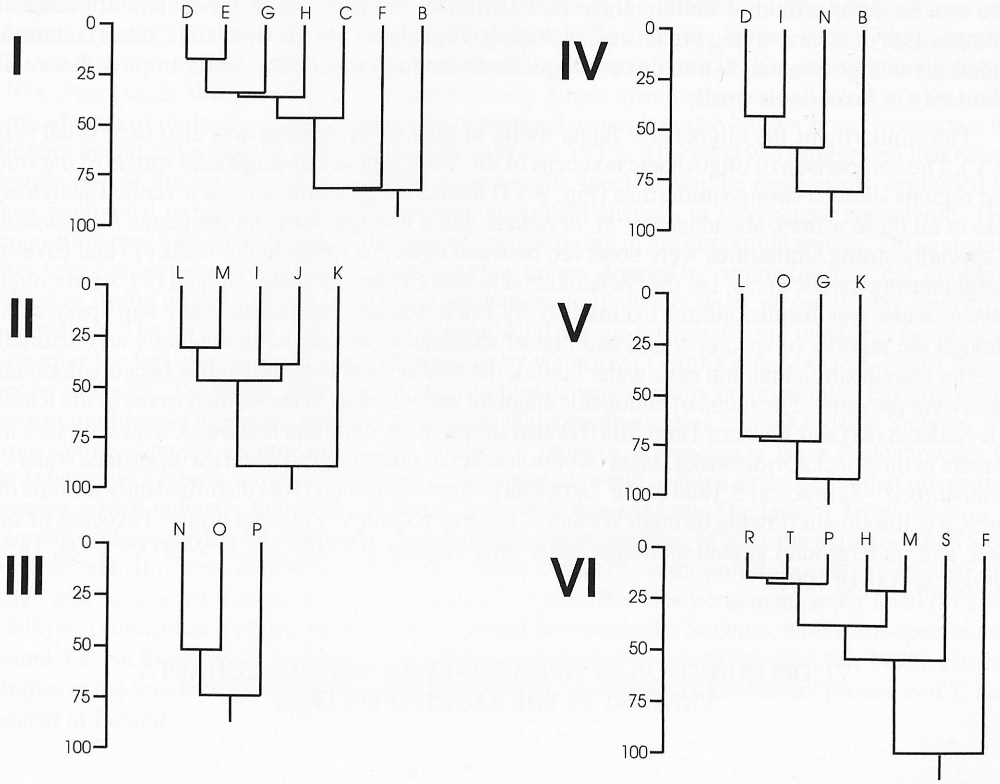

Fig. 9. Similarities of the studied water bodies. I – in Tatra Mts; II – in Kłodzkie Sudeten; III – in Olkuska Upland; IV – in streams of various regions; V – in springs of various regions; VI – in cave water bodies of various regions. High Tatra Mts: B – streams; C – interstitial waters; Western Tatra Mts: D – streams; E – interstitial waters; F – caves with stagnant waters; G – springs; H – caves with watercourses. Kłodzkie Sudeten Mts: I – streams; J – interstitial waters; K – Pax' spring; L – other springs; M – caves. Olkuska Upland: N – streams; O – springs; P. – Caves. Underground waters: R – caves of Świętokrzyskie Mts; S – souterrains; T – wells.

Naididae in the benthos and their almost complete absence in the interstitial waters. In Kłodzkie Sudeten the closest, however, with not a great similarity index, are taxocens inhabiting cave (M) and spring waters (L), as well as the bottom (I) and interstitial waters (J) of the streams. All the listed taxocens form a common group, whereas taxocen found in Pax spring (K) differs from them distinctly (Fig. 9-II).

The oligochaete taxocens inhabiting the studied waters of the Olkuska Upland differ considerably, this being shown using cluster analysis (the smallest distance 52.9 for stations in a stream (N) and in springs (O)) (Fig. 9-III).

The studied streams differ among them in many features: they flow on various substrata (granite, limestone), at different heights (from alt. 1540 m to 335 m), and their waters have different trophy levels – from extremely poor (High Tatra Mts) to eutrophic (Olkuska Upland). Therefore, recorded similarities among Oligochaeta taxocens are few (Fig. 9-IV). Proportionally the greatest number of common features are shown by taxocens of mountain streams flowing on carboniferous bedrock (D, I), which may be joined by Sąspówka S. (N) flowing through limestones of the Olkuska Upland. On the other hand, the greatest distance was found between taxocens of the High Tatra Mts (B) streams and the remaining ones. The type of substratum was revealed to be the most important factor controlling the composition and structure of oligochaete taxocens, for the arrangement of similarities of taxocens depended on its kind. The kind of substratum, affecting water chemistry and the species composition of bottom algae (KWANDRANS 1993) is one of the factors affecting the composition of stream-living organisms, including Oligochaeta. At the same time, other factors decided the composition and structure of Oligochaeta fauna (temperature, water trophy), hence the similarity of taxocens is small.

The similarity of the oligochaete fauna living in the studied springs was also very small (Fig. 9-V). The comparison of oligochaete taxocens of the listed types of underground waters of the studied regions showed strong similarities (Fig. 9-VI) thanks to the dominance of juvenile Enchytraeidae in all these waters, abundance of *M. argentea*, and a few species from the genus *Enchytraeus*. Especially strong similarities were observed between taxocens found in the wells (T) and caves of neighbouring karstic areas, i.e. the Świętokrzyskie Mts (R) and Olkuska Upland (P), where oligochaete fauna was formed almost exclusively by Enchytraeidae, including many soil species. Although the number of species found and that of specimens per sample in the wells was distinctly greater than in similar natural cave water bodies, the similarity was considerable, because dominant taxa were the same. The fauna of endogenic stagnant water bodies in the studied caves of the Kłodzkie Sudeten (M) and Western Tatra Mts (H) also shows many common features. Caves with flowing waters in the Niecka Nidziańska Basin (where contact of underground waters with surface waters is undisturbed – Skorocicki S.) and in the Tatra Mts (where this contact was disturbed only to some degree, e.g. the stream flowing through Wodna C.) form a completely distinct group. Taxocens of surface and underground stream stretches differ only slightly (DUMNICKA & WOJTAN 1993, DUMNICKA & GALAS 1997).

VI. DISTRIBUTION OF APHANONEURA AND POLYCHAETA PRESENT IN THE STUDIED WATERS

1 – Aphanoneura

In the studied surface waters Aphanoneura were found only in one spring in the Tatra Mts and in the Śnieżnik Kłodzki Massif, where they occurred sparsely in the benthos of the Kleśnica S. Although among Aphanoneura there are genera and species living almost exclusively in the interstitial waters (JUGET & DUMNICKA 1986) and one species was described from cave waters in France (JUGET 1959), in the underground waters of Poland these invertebrates are relatively rarely encountered. Among studied underground water bodies only in the Świętokrzyskie Mts caves and in one of the quarries in the Beskid Niski Mts (Station I7) a temporal, massive appearance of Aphanoneura from the genus *Aeolosoma* was observed. Only *A. tenebrarum* and *A. niveum* were determined – species occurring mainly in stagnant surface waters (KASPRZAK 1981b). Besides, single specimens of *Aeolosoma* sp. were found in the wells near the Grabia R. and in interstitial waters of a stream in the Śnieżnik Massif. It is not easy to explain how these strictly aquatic species could find their way into cave waters of the Świętokrzyskie Mts and underground waters of a quarry in the Beskid Niski Mts. All these water bodies are located above groundwater level and are fed by percolating waters. Probably Aphanoneura must have been introduced there by people or animals visiting the caves – together with water for acetylene lamps and mud etcetera.

2 – Polychaeta

Troglochaetus beranecki DELACHAUX is the only stygobiontic inhabitant of the interstitial waters belonging to Polychaeta, family Nerillidae (earlier classified as Archiannelida), found in Poland exclusively in the waters of Na Rogóżce C. and in the Radochowska C. (STAMMER 1937). *Troglochaetus* is known from Western Europe, Middle Europe (HARTMANN-SCHRÖDER 1986), North America: Colorado (PENNAK & WARD 1986), New Hampshire, Ohio, and Pennsylvania

(STRAYER et al. 1995), and has recently been found in Italy (MORSELLI et al. 1995) and Northern Europe (Finland) (SÄRKKA & MÄKELÄ 1998). It occurs in the interstitial waters both of montane streams (Alps) (TILZER 1968) and large rivers (Upper Rhône, Rhine, Weser, Elbe, Oder, Danube) (HARTMANN-SCHRÖDER 1986). It may be one of the dominant taxa in that environment (TILZER 1973, PENNAK & WARD 1986) but frequently only single specimens are collected, e.g. in esker groundwater of Finland – 1 specimen per m^3 of pumped water. It is also known from cave waters including interstitial waters of cave water bodies (PLEŞA 1977). TILZER (1973) suggested that recent distribution of this species, and also other stygobiontic species, may be more easily explained by their ecological requirements than by paleogeographical changes in the regions considered. This suggestion may be especially apt in the case of species living in the interstitial waters. These species may very easily migrate within the catchment area, unless stopped by certain barriers, e.g. contamination or strong water pollution, and, using permanent groundwater level, probably may even cross watersheds. The survival of *T. beranecki* in subglacial refugia (especially in Finland) or reintroduction after the last glaciation period with wind or by waterfowl (SÄRKKA & MÄKELÄ 1998) should not be excluded. Therefore, their present distribution depends mainly on favourable environmental living conditions. During the author's studies on underground waters in the Kłodzkie Sudeten, despite taking samples several times, she could not retrieve *T. beranecki* from Radochowska C. STAMMER (1937) took samples five times in the same cave and in three cases found that interesting species, which indicates that in the 30-ies *T. beranecki* was not rare. The lack of *Troglochaetus* in samples collected in the 90-ties may reflect a decrease in its number, or even the extinction of a local population in this cave. Extinction might have been caused by water pollution or some another disaster, and because of isolation of Radochowska C. waters from the permanent water level (PULINA 1996) recolonization is highly unlikely. The second location in the Sudeten, where this species was found, i.e. Na Rogóżce C., was destroyed during exploitation of the quarry (PULINA 1996). Further studies in the Śnieżnik Massif are needed to confirm the possibility of the current presence of *T. beranecki* in Poland.

VII. DISCUSSION

Although oligochaetes are an important component of benthic communities in montane streams, this is a group rarely studied in waters of that type and their biogeographic patterns remain to be elucidated (WARD 1994). On the basis of personal materials and available literature, a comparison of oligochaete taxocens of montane and submontane streams of Poland was made and preliminary categorisation on 3 groups of streams was proposed (DUMNICKA 1994a). The elaboration of additional materials from the Śnieżnik Massif and Western Tatra Mts streams, besides the employment of a few papers dealing with oligochaete fauna from various mountain ranges in Europe, permitted complementation of this classification and the distinction of 4 groups of montane streams.

1 – Streams with dominance of Enchytraeidae

In the montane streams originating from springs of reo- and helocrene type starting at various altitudes (from 700 m to almost 2000 m), as a rule the most numerous are representatives of the family Enchytraeidae: Tatra Mts – Bela R. and its tributaries (ŠPORKA 1982), a stream from the Pod Chłopkiem Pass, Kościeliski S.; Sudeten – Kleśnica S., Gołodolnik S.; West Carpathian Mts – Raba R. (except for the station near the spring) (KASPRZAK & SZCZĘSNY 1976), some pyreneean streams (GIANI & LAVANDIER 1977), and also a small stream in the farthest – southeast of Russia (TIMM 1994). Among enchytraeids species, living in the discussed environment, a few ecological types can be identified. The first one is represented by genus *Cernosvitoviella*: almost exclusively living in aquatic environments, but present also in wet habitats such as acid bog and marsh (HEALY 1979, ROTA 1995). Species from that genus have an important share in oligochaete fauna present in montane waters of various regions where they may form even up to 40% of taxocen: e.g. in Kościeliski

S., or Far East Russian streams (TIMM 1999b). Their geographical distribution is varied: from species bound to one massif such as *C. estaragniensis* (GIANI 1979b) – Pyrenees, *C. pensau* – Sikhote-Alin Mts, East Asia (TIMM 1994, 1999b) to species with a far broader range – *C. bulboducta* – small streams and the upper courses of rivers in North Portugal and Galicia (MARTINEZ-ANSEMIL & COLLADO 1996), *C. tatrensis* – West Carpathian Mts and Sudeten. Only a few species are widely distributed and occur in waters of different types; here can be ascribed *C. atrata* and *C. carpatica*. Genus *Cernosvitoviella* is monophyletic, even young specimens being easily distinguished on the genus level (HEALY 1979); among all Enchytraeidae this genus is the most closely connected with the aquatic environment.

The second ecological type is represented by the semi-aquatic genera *Mesenchytraeus* and *Cognettia*. The most common species from the two genera (*M. armatus, C. sphagnetorum, C. glandulosa*) live mainly in acidified environments, both in soils and water bodies, but can be spotted also in habitats with neutral pH. Genera characteristic of cold and temperate regions of the northern hemisphere: genus *Mesenchytraeus* has its present centre of distribution in the northern region of the western Nearctic and eastern Paleartic, and genus *Cognettia* in the palearctic cold regions (HEALY 1996).

The third group of enchytraeids living in montane waters is formed by species from soil genera which most probably secondarily invaded the aquatic environment, or may sustain being periodically submerged, but are equally frequently encountered in the soil (especially a wet one). Here belong: *Marionina argentea, M. riparia* and *Enchytraeus buchholzi,* and also *Fridericia perrieri*, or *Henlea perpusilla,* which prefer wet soils (HEALY & BOLGER 1984), which is why they may be especially frequently spotted in small water bodies. As a rule, these species have a wide geographical range although one may presume that human activity contributed to their cosmopolitan distribution. Easy contact with surrounding soils and frequent changes in water level in the montane streams results in the abundant appearance of soil species in the aquatic environment. Accumulation of the organic matter in the border alluvia creates favourable conditions for many Enchytraeidae species.

2 – Streams with dominance of Lumbriculidae

In some streams rising from springs located at various altitudes: from 2370 m in the Pyrenees (GIANI & LAVANDIER 1977) to 350 m in the Świętokrzyskie Mts Lumbriculidae are the most numerous. Very often these are common species (*L. variegatus, S. heringianus*), characteristic of streams with low pH (KAHL 1983, 1986, KASPRZAK 1976b), but numerous occurrence of *S. brachystylus* was also found in the Western Sudeten (KASPRZAK 1976b), *S. parvus* in the Bieszczady Mts (DUMNICKA & KUKUŁA 1990), or *Trichodrilus macroporophorus* in the Pyrenees (GIANI & LAVANDIER 1977). In the majority of streams with the dominance of Lumbriculidae the bottom was formed by pebbles, gravel, and sand but *S. parvus* occurred numerously in a stream with stony bottom (DUMNICKA & KUKUŁA 1990). According to LAFONT et al. (1992), the latter species is characteristic of streams with active exchange of water between river and aquifer. Besides, Lumbriculidae usually constitute an important percentage of oligochaete taxocen in the streams with Enchytraeidae dominance, e.g. in the studied streams of the High and Western Tatra Mts and in the Bela R. (ŠPORKA 1982). Existing data on the distribution of Lumbriculidae species (except for the most common ones) in the montane streams are random and incomplete. Concomitantly, species usually found in streams may live in completely different habitats, e.g. *Stylodrilus parvus* – in the coastal area of the Caspian Sea (CHEKANOVSKAYA 1962). Without the knowledge concerning ecological requirements, present distribution, and history of that family it is hard to define factors decisively concerning the dominance of lumbriculids rather than enchytraeids in some high montane streams.

3 – Streams with dominance of Naididae

So far, numerous occurrence of species from the Naididae family have been described only in those high montane streams that originate from lakes in the High Tatra Mts and in the Karkonosze Mts (Łomnica S. leg. J. KWANDRANS) or from limnocrenes (e.g. in the Śnieżnik Massif and in the Gorce Mts), where in lakes and limnocrene springs the same Naididae species were dominants. Most frequently it was *Nais variabilis,* sometimes substituted by *N. communis* (KASPRZAK & SZCZĘSNY 1976). It seems that in the mountains of alpine type stagnant water bodies are the main site of their presence and from there Naididae are passively transported into the streams. Such a source of naidids may be inferred from their most numerous presence at stations located closest to the outflow (KASPRZAK & SZCZĘSNY 1976, KOWNACKI et al. 1997), and also by their small share in taxocens of streams starting from reocrenes. In submontane streams and rivers as well as in the karstic streams such as Sąspówka S., Naididae – represented manly by *N. alpina, N. bretscheri* and *N. pardalis* in clean waters and by *N. elinguis* and *N. barbata* in eutrophicated ones form the dominant oligochaete group (DRATNAL et al. 1979, KASPRZAK & SZCZĘSNY 1976, DUMNICKA 1982, 1987 and other papers).

4 – Streams with dominance of *Propappus volki*

The family Propappidae seldom dominates in the montane streams. Among those studied only in the Western Tatra Mts did *P. volki* amount to over 20% of taxocen. TIMM (1994) found numerous appearance of another species from that genus (*P. arhynchotus*) in an East Asian high mountain stream. *P. volki* is a species characteristic of streams and rivers of various size having a sandy or sandy-gravel bottom (FOMENKO 1972, BIRD 1982). It seems that water chemistry is also important – *P. volki* abounds in slightly alkaline waters with high calcium content (DUMNICKA & PASTERNAK 1978, BIRD 1982), which is why it was plentiful in the stream below the cave and also inside it (DUMNICKA & WOJTAN 1989, DUMNICKA & GALAS 1997).

5 – Springs

The oligochaete fauna of springs in Poland is insufficiently known. There are hardly any papers devoted exclusively to oligochaete taxocens of that environment. The spring zone was taken into account in studies only on a few running waters: Raba R. (KASPRZAK & SZCZĘSNY 1976), streams in the Małe Pieniny Mts (KASPRZAK 1979a, 1979b), and the Świętokrzyskie Mts (KAHL 1991). Materials collected in 13 springs in 3 geographical regions (Tables I, II, III) considerably enlarged the knowledge on the composition and structure of Oligochaeta taxocens of montane region springs and of Olkuska Upland. The composition of spring oligochaete fauna depends mainly on its type (reo- limno- or helocrene), and also from the altitude and water trophy.

In small montane springs of the reocrene type (Stations S4-S10, J2-J4) Enchytraeidae dominate, similarly as in helocrenes. The latter type of spring was little studied in Poland but on the basis of papers from other European regions (HEALY 1979, ROTA 1995) it may be stated that also in helocrenes Enchytraeidae are typical representatives of Oligochaeta. In montane limnocrenes Naididae (*N. variabilis* or *N. communis*) predominated (Station S10, springs of the Raba R. (KASPRZAK & SZCZĘSNY 1976) and Biały Potok S. (KASPRZAK 1979b)). In the Lodowe źródło spring in the Kościeliska V. (Western Tatra Mts) *P. volki* was abundant, similarly as in the Kościeliski S., which is fed by this spring. Temporarily *P. volki* was numerous also in the vicinity of outflows in one of the limnocrenes of Niebieskie źródła near Tomaszów Mazowiecki (KAHL 2000). In all the studied springs located on the Olkuska Upland, including the Jordan spring (Ściborzyce village, Dłubnia R. valley, in the same geographical region, leg. B. SZCZĘSNY) Tubificidae dominated, similarly as in the already-mentioned Niebieskie źródła springs (KAHL 2000). In the last study season in these springs *S. lacustris* was numerous. Collected data show that in limnocrenes the composition of taxocen largely depends on the character of the bottom deposit, altitude not being so important. When muddy deposits prevail Tubificidae are most numerous, among them *Pothamotrix hammoniensis, Rhyacodrilus coccineus*, as well as *Spirosperma ferox* and *Aulodrilus pluriseta* (Jordan spring, Ściborzyce), on sand – *P. volki,* and among filamentous algae – Naididae. In small springs of limnocrene type the share of Enchytraeidae is usually high (about 20-30%).

Applying the method of a net left for the night on reocrene outflows the presence of stygobiontic Amphipoda from the *Niphargus* genus (SKALSKI, personal inf. and author's studies) was found. On the other hand, so far stygobiontic Oligochaeta could not be caught with this method. High velocity of the water outflow frequently occurring in springs of this type leads to animals being carried away from underground waters. Amphipods live in larger crevices, where water flows faster hence they may be washed out more easily. Perhaps these animals may also actively migrate towards the surface, especially at night. The absence of Oligochaeta in the outflows of reocrenes does not mean that they are absent in the fissure water environment. Possibly oligochaetes live in places with slower water flow, since they actively avoid places where they could be prone to being washed out. In running surface waters they usually account for a far smaller percentage in drifting fauna when compared with their share in benthic fauna (ARMITAGE 1977, FLEITUCH 1985, DUMNICKA 1996a), this indicating that they actively protect themselves from being washed out from sediments.

6 – Interstitial waters

The notion 'interstitial fauna' refers to invertebrates inhabiting small spaces between sand and gravel particles. This is a broad notion since it encompasses not only fauna of waters in alluvial sediments and of hyporeic waters (under the stream bottom), but partially also truely phreatic water fauna. Samples from that environment can be collected using various techniques: the Karaman-Chappuis method (BOTEA 1963, KASPRZAK 1973a, TILZER 1968, applied in these studies), Bou-Rouch pump (JUGET 1984, PENNAK & WARD 1986), freeze-core pipes (BRETSCHKO & KLEMENS 1986, BRETSCHKO 1990) or artificial substratum (MATHIEU et al. 1991). Since such different methods are used and samples are collected from various habitats inhabited by interstitial fauna, caution is necessary when comparing results obtained by different authors, mainly those concerning fauna density in this habitat but also of species composition. In interstitial waters of the majority of studied Tatra Mts and Kłodzkie Sudeten streams a large share in the taxocen was composed of benthic species, hence the similarities of taxocens of these two habitats were usually high (especially in the Western Tatra Mts, slightly smaller in Sudeten streams). In the High Tatra Mts this rule was not valid, *N. variabilis,* dominating in the benthos, in the interstitial waters amounted to only 1% of taxocen. In hyporeic waters of alpine streams (TILZER 1968), Enchytraeidae dominated (unfortunately not classified), similarly as in the studied interstitial waters. In lower parts of alpine streams *P. volki* was numerous, Lumbriculidae (*Stylodrilus* and *Trichodrilus*) also had a large share. In interstitial waters of submontane streams and rivers of Southern Poland two species of Naididae dominated, i.e. *Pristinella menoni* and *Pristina aequiseta* form *foreli*, accompanied by Tubificidae juv. (KASPRZAK 1973a). These taxa constitute a modest percentage among benthic oligochaetes of these stretches of streams and submontane rivers, although locally, near the shore, they may be more numerous. The contribution of Enchytraeidae was distinctly smaller than in interstitial waters of high montane streams since that family formed only about 11% of taxocen. Among Lumbriculidae, similarly as in montane streams, juvenile specimens prevailed, which would involve *Trichodrilus* genus, rich in species characteristic of underground waters. The list of species comprises as many as 36 entries but these are summed up data from a few streams and rivers from the Sudeten Mts to the Bieszczady Mts (KASPRZAK 1973a). In a few papers concerning Oligochaeta from interstitial waters of submontane running waters of Rumania (BOTEA 1963, 1966, 1975) that author reported the dominance of Naididae in these waters, mainly from the genera *Pristina* and *Nais,* both represented by a few species. Enchytraeidae were also numerous and among Lumbriculidae he found a large number of *S. heringianus,* individual *Rhynchelmis* sp., and only one stygobiontic species – *Trichodrilus pragensis.* In the material collected in Colorado S. (alt. about 1800 m) from hyporeic and phreatic waters located near the stream bed and at some distance from it (PENNAK & WARD 1986) Oligochaeta (*Nais communis, Lumbricillus* sp. and Lumbriculidae juv. almost exclusively) were most numerous in hyporeic waters, in the remaining ones only 3 or 2 out of listed taxa being present, and not many specimens. Benthic and interstitial oligochaete fauna from the alluvial plain of the French Upper Rhône R. is very well known (JUGET 1984, 1987, JUGET & LAFONT 1994). Here the species diversity of this group of animals was high and rich stygobiontic fauna (from the families Tubificidae, Lumbriculidae and Dorydrilidae) were found. In the interstitial waters of the lowland Wełna R. Tubificidae, represented by common taxa, formed more than 99% of taxocen (KASPRZAK 1975), the rest belonging to Naididae and Enchytraeidae.

The number of species found in the interstitial waters is usually lower than that in the benthos of the same stream or river stretch and varies depending on the site and the depth from which samples were collected from over 20 (Rhône R., JUGET 1984) to only a few species (Colorado S., PENNAK & WARD 1986).

Interstitial waters are a zone of joint presence of oligochaete species from surface waters or soils and stygobionts (POP 1971). It was found that Oligochaeta are most numerous in the interstitial sediments with small particles – particle size 0.5-1 mm (TILZER 1968), 0.5-2 mm (BOTEA 1975). Taxa typical of surface waters are represented by the greatest number of species and specimens. The interstitial waters of the Wełna R. are an extreme example, since only species of this kind were present there. Some benthic species (stygophile ones) prefer interstitial waters since their share in taxocens of this environment is as a rule higher than in the benthos and they are characterised by a relatively high stability of presence in these waters. Among stygophile species two ecological types were distinguished – the first comprises species of small size, belonging to various families (from genera *Pristina, Pristinella, Nais*, *Cernosvitoviella, P. volki*, and *Marionina argentea*), which are most frequently encountered in small particle-sediments. From *Pristinella* and *Pristina* genera, in the interstitial waters, there are species characteristic of a given geographical region – *Pristinella menoni, P. aequiseta form foreli* and others (KASPRZAK 1973a, POP 1974) in Europe, while *P. jenkinae* in eastern USA (STRAYER & BANNON-O'DONNELL 1988). Some of the stygophile species (e.g. *P. volki*) are more numerous in the deeper zone in comparison with the surface of sediment in the stream bed (DUMNICKA & GALAS 1997), which facilitates their penetration into the interstitial waters. According to LAFONT et al. (1992), the occurrence of the majority of taxa mentioned above attests to active exchange between river waters and the aquifer. Exchange of water affects life conditions in the interstitial environment by increase in its oxygenation and also in food supply. Perhaps some of these ecological factors or others, such as smaller competition for place and food or an attempt to avoid predators, are decisive as to the preference of the mentioned taxa towards the environment of interstitial waters. Not all species can so easily move into interstitial waters – e.g. *N. variabilis,* a species dominating in the benthos of High Tatra Mts streams, did not colonize neighbouring interstitial waters. In this case probably coarse-grained interstitial sediment and low water temperature were factors limiting the inhabitation of these waters. Moreover, in a simple biocenosis, as that found in High Tatra Mts streams (KAWECKA et al. 1971), predator pressure may be slight and there is little competition for food, therefore *N. variabilis* is encountered almost exclusively in the benthos. To the second ecological type belong cold, stenothermic species, of relatively high dimensions (*Haplotaxis gordioides* and *Stylodrilus* spp.), which prefer the interstitial water environment because of more favourable temperature.

Stygobiontic Oligochaeta species found in interstitial waters belong to different families; their number in the waters of a given running water is not high and ranges from 0 (Wełna R.) to 5-6 (Rhône R.). In the interstitial waters of montane and submontane streams of Poland from 1 to 3 species belonging to the families Lumbriculidae and Enchytraeidae were found most frequently. The number of stygobionts mainly depends on the hydrological situation in the studied stretch of running waters, and most importantly on the kind of water flow – surface or subterranean (DOLE – OLIVIER & MARMONIER 1992), which changes according to the water level in the river. Through interstitial waters the flow of water is possible into three directions: infiltration from the river bed, exfiltration from subterranean waters into the river, and horizontal advection (BRUNKE & GONSER 1999). In the studied interstitial waters, as in the majority of natural riverbeds, the direction of flow changes throughout the year, therefore with low water levels in a river and underground feeding there are more stygobionts and stygophiles in the interstitial waters. In high water periods infiltration from river to alluvial plain occurs, and with the water benthic species reach interstitial waters, which can be treated as a refuge allowing many of them to survive. In cases of special configuration of the riverbed the flowpath is constant, e.g. in the studied stretch of the Töss R., Switzerland (BRUNKE & GONSER 1999) or the Rhône R. France (DOLE-OLIVIER & MARMONIER 1992), which promotes stabilization of the composition of invertebrate communities in the interstitial waters. The number and composition of stygobiontic oligochaete species of interstitial waters depends also on the geographical region and the kind of substratum on which the river flows: aquifer of karstic areas is as a rule richer in stygobionts than aquifer of other kinds of terrain (JUGET & DUMNICKA 1986).

7 – Water bodies in caves and souterrains

In cave water bodies, and also in cave sediments, the majority of oligochaete species found are common, ubiquitous forms which was noted even during initial cataloguing (ČERNOSVITOV 1939). These are mainly stygophile species, which usually form the prevailing part of the taxocen. Stygoxenic and stygobiontic species in cave waters form at most a few percent of oligochaete fauna, whereas among other systematic groups present there stygobionts prevail (SKALSKI 1994). An especially large number of stygophile and stygoxenic species has been found in caves with watercourses of surface streams. Among studied caves with this type of waters Tubificidae dominated only in the Skorocicki S. and in souterrains which had direct contact with the Wełtawa R. waters (DUMNICKA 1996b), like in the neighbouring surface stretches of these running waters. In all caves with watercourses, similarly as in interstitial waters, Naididae were found, this being the next proof of the possibility of their existence in the environment of underground waters. Lower densities of oligochaetes in underground parts of the stream in Skorocice as well as in the Tatra Mts seem to be correlated with a decreased amount of organic matter in stream deposits inside the caves, this having been observed in both these cases (DUMNICKA & WOJTAN 1993, GALAS & DUMNICKA 1998).

In endogenous cave water bodies stygophile species only from the family Enchytraeidae are present, most numerously the same as those found in interstitial waters: *Marionina argentea, M. riparia* and *Enchytraeus buchholzi.* In these waters there are neither Naididae nor *P. volki* – species characteristic of interstitial waters.

Oligochaetes may infiltrate from the river bottom not only into the interstitial waters but through them into the cave waters, this having been observed in Smocza Jama C. In this cave *Vejdovskyella intermedia* and *Haplotaxis gordioides* were found. In the benthos of the Vistula R. these species are currently absent owing to a too high pollution level (DUMNICKA & KOWNACKI 1988), therefore the cave waters, and most probably neighbouring interstitial waters, constitute a refuge, in which small populations of these species may survive. At the end of the XIX century the water level in the Vistula R. was higher than it is now and at that time groundwaters were almost completely stagnant, except for periods of flooding (KLECZKOWSKI 1967). At the beginning of the XX century the level of groundwaters started to decline, and at the same time pollution (including salt concentration) began to increase, especially in the second half of the century (BOMBÓWNA & WRÓBEL 1966, KASZA 1988). Oligochaetes in search of less polluted waters had actively to migrate from the river into the cave since the direction of water movement was reversed. In the cave there are no deposits of river origin, this indicating that there is and never was any direct connection with the river (GRADZIŃSKI M. et al. 1996). It is known that benthic Naididae species may actively move on the river bottom against the current (DUMNICKA 1996a) or using hyporeic waters (O' LEARY et al. 1992). In this case active migration in search of better environmental conditions seems to be the cause of populating cave waters by river bottom species. Migrations of inhabitants of interstitial waters through alluvial sediments occur also in other directions, e.g. away from the riverbed, but only a short distance e.g.

Nais communis was discovered some 20 m from the Colorado S. bed (PENNAK & WARD 1986). The furthest distance at which that species was found was in wells – up to 500 m from the Warta R. bed (KASPRZAK 1973c); in the case of Smocza Jama C. oligochaetes had to cross a distance of less than 70 m. On the other hand, in one of other caves of the Olkuska Upland – the Kryspinowska C. (situated near the Sanka R., a small tributary of the Vistula R.) no aquatic oligochaete species, neither benthic nor stygobiontic, have been found, this being connected with the geological structure of that area. This cave was formed in the Upper Jurassic limestone, within the tectonic horst of Kryspinów (GRADZIŃSKI R. 1972), which from the south and west borders with tectonic depression, which was filled with impermeable Miocene deposits. These deposits isolate limestone of the horst from ground- and surface waters of the Sanka R. valley. This is why water bodies in the Kryspinowska C. depend only on the local level of groundwaters of the already mentioned horst (prof. R. GRADZIŃSKI, personal information).

In Europe stygobiontic oligochaetes from many families (DUMNICKA & JUBERTHIE 1994), and of various origin are known: limnostygobionts – Lumbriculidae, certain Tubificidae, e.g. *Rhyacodrilus* (MARTINEZ-ANSEMIL et al. 1997), thalassostygobionts – Phallodrilinae (SAMBUGAR et al. 1999), and even species of soil origin (Enchytraeidae and Lumbricidae). Nevertheless, in Poland in underground waters representatives of only two families, Lumbriculidae and Enchytraeidae, have been found.

Stygobionts from the family Enchytraeidae are represented by two species only: *Cernosvitoviella parviseta* and *Enchytraeus dominicae.* They were found in the majority of the studied regions. As was already discussed in Chapter IV these two species have closely related ones in the surface waters and seem to be recent migrants to the underground environment. *E. polonicus*, found also in Polish caves, is a troglobiontic species, although it was found also in the sediments saturated by water (DUMNICKA 1977a).

The presence of stygobiontic Lumbriculidae was confirmed only in the area of the Tatra Mts and Kłodzkie Sudeten. Presumably, they occur also in two of the studied Olkuska Upland caves (Smocza Jama C. and Mąciwody C.) – determined as juvenile Lumbriculidae with simple pointed setae, hence not belonging to the epigean genera *Lumbriculus* and *Stylodrilus*. It may be assumed that the collected specimens belong to the *Trichodrilus* genus, from which in Poland only stygobionts have been found. Because of the extremely small numbers of stygobiontic oligochaetes, similarly as those of other stygobionts, it is frequently hard to be positive as to their presence. Until the beginning of the 80-ties no stygobiontic Lumbriculidae were found in the Tatra Mts, although the water bodies of a few caves were studied for several years (DUMNICKA 1977b, 1981). The first stygobiont from that family (*Trichodrilus cernosvitovi*) was found exceptionally in the interstitial waters of the Western Tatra Mts streams (KASPRZAK 1981a and author's own materials). This is a species most frequently spotted in that environment (JUGET & DUMNICKA 1986). The second stygobiontic lumbriculid – *T. moravicus* – occurred in the Kasprowa Niżnia C., located in the zone of oscillations of the karstic water table (GŁAZEK 1995). On the other hand, in the remaining studied caves of the Tatra Mts, stygobiontic Lumbriculidae have not so far been found, although in some of them their presence may be expected, especially in water bodies in contact with the phreatic zone (e.g. siphons in Miętusia or Zimna caves).

Among the studied caves of the Kłodzkie Sudeten the presence of stygobiontic Lumbriculidae has been found in two of them (Niedźwiedzia C. and Solna Jama C.), while they were absent in the Radochowska C. One of possible explanations of differences in the distribution of oligochaete fauna in these caves may be the history of glaciations in this area. During at least two glaciations – the South-Polish (San) and Middle-Polish (Odra), the glaciers entered Kotlina Kłodzka I.B., but they did not reach the studied caves (SROKA & KOWALSKA 1998). However, the glaciers blocked the outflow from the Kotlina Kłodzka I.B. to the North, this resulting in the formation of a new one directed to the South (areas of Czech Republic with caves: Paceltova, Tvarožne Diry). In the Solna Jama C. and Niedźwiedzia C. the flow of water was constant and probably at that time Lumbriculidae as well as Tubificidae (*Rhyacodrilus falciformis*) appeared in these caves. The underground connection of Niedźwiedzia C. waters with karstic waters of this region and the Czech Republic cave waters operates even today, hence stygobiontic Oligochaeta using that route could have migrated also in the post-glacial time. Hydrogeological processes in the region of Radochowska C. had a somewhat different course. During the glacial epoch the Biała Lądecka R. flow was blocked and in its valley terraces were formed; simultaneously a tributary of the Biała Lądecka R. in Radochów was filled up, isolating the surroundings of the cave from the remaining subterranean waters. In modern times, in that cave there are only waters of vertical infiltration (PULINA 1996), which prevents migration of stygobionts through interstitial waters, or from karstic flows.

The contemporary distribution of stygobiontic Lumbriculidae, like that of *Troglochaetus beranecki*, seems to depend mainly on the likelihood of their migration through underground waters of various types, especially along river valleys, and on the emergence of environmental conditions favourable for them. In some caves, as in Kryspinowska C. and Radochowska C., the water bodies of which for various reasons are isolated from groundwaters, the presence of stygobiontic Amphipoda (in both caves) (SKALSKI 1981) and of *Troglochaetus beranecki* (Radochowska C. only) was found. The listed stygobionts are considered to be Tertiary relicts and could have inhabited underground waters of the above-mentioned caves before they were isolated.

Underground waters are an environment more continuous even than that of surface waters enabling many species living in them to be widely distributed. Together with the progress in research on that environment, new localities of numerous species are being found. Unfortunately, in many regions even where underground waters are studied, e.g. alluvial floodplains of the Danube R. (DANIELOPOL 1976, 1989) or Rhine R. (after GIBERT et al. 1994), the knowledge of oligochaete fauna is very meagre. Therefore, with the current, very incomplete state of knowledge on the stygobiontic oligochaete species it would be premature to draw conclusions concerning their distribution and possible endemism.

REFERENCES

ARMITAGE P. D. 1977. Invertebrate drift in the regulated River Tees, and an unregulated tributary Maize Beck, below Cow Green dam. Freshwat. Biol., **7**: 167-183.

BARTNICKA H. 1978. Skąposzczety z rodziny Naididae w sadzawce parkowej w Kielcach. Studia Kieleckie, **2/18**: 71-77.

BARTNICKA H. 1980. Przestrzenne rozmieszczenie skąposzczetów (Oligochaeta) z rodzaju *Limnodrilus* i *Tubifex* w osadach dennych zbiornika zaporowego w Cedzynie koło Kielc. Studia Kieleckie, **3/27**: 37-44.

BIESIADKA E., KASPRZAK K. 1977. An investigation on the macrofauna of the River Warta within the city of Poznań. Acta Hydrobiol., **19**: 109-122.

BIRD G. J. 1982. Distribution, life cycle and population dynamics of the aquatic enchytraeid *Propappus volki* (Oligochaeta) in an English chalkstream. Holarctic Ecology, **5**: 67-75.

BOMBÓWNA M., WRÓBEL S. 1966. Badania chemiczne Wisły od ujścia Przemszy do Krakowa. Acta Hydrobiol., **8**, Suppl. 1: 321-343.

BOTEA F. 1963. Contributions to the study of Oligochaeta found in the phreatic water. Rev. de Biol., **8:** 335-343.

BOTEA F. 1966. Cercetări asupra faunei de oligochaete limicole din interstitialul bazinului Crişului Repede (valea Poicului). Lucr. Inst. de speol. „Emil Racoviţă", **5**: 75-80.

BOTEA F. 1975. Considérations sur l'écologie des oligochètes hyporhéophiles de la rivière Prahova. Trav. Inst. „Emile Racovitza", **14**: 45-49.

BRETSCHKO G. 1990. The effect of escape reactions on the quantitative sampling of gravel stream fauna. Arch. Hydrobiol.,**120**: 41-49.

BRETSCHKO G., KLEMENS W. E. 1986. Quantitative methods and aspects in the study of the interstitial fauna of running waters. Stygologia, **2 (4)**: 297-316.

BRINKHURST R. O., JAMIESON B. G. M. 1971. Aquatic Oligochaeta of the world. Oliver & Boyd, Edinburgh: 860 pp.

BRUNKE M., GONSER T. 1999. Hyporheic invertebrates – the clinal nature of interstitial communities structured by hydrological exchange and environmental gradients. J. N. Am. Benthol. Soc. **18**: 344-362.

CHEKANOVSKAYA O. V. 1962. Vodnye maloshchetinkovye chervi fauny SSSR. Zool. Inst. Akad. Nauk SSSR, Moskwa, Leningrad, **78**: 411 pp.

CHODOROWSKA W., CHODOROWSKI A. 1960. Ugrupowania fauny wodnej w jaskiniach tatrzańskich. Speleologia **II** (1): 57-62.

CHODOROWSKI A. 1960. Taxoceny wirków (Turbellaria) i metodyka ich badania. Ekol. Pol., ser. B, **6**: 95-114.

CIĘŻKOWSKI W. 1989. Badania hydrogeologiczne obszaru krasowego Masywu Śnieżnika. 180-201. In: Jaskinia Niedźwiedzia w Kletnie. Badania i udostępnianie. Jahn A., Kozłowski S., Wiszniowska T. (eds) Wyd. PAN, 369 pp.

ČERNOSVITOV L. 1928. Die Oligochaetefauna der Karpathen. Zool. Jahrb. **55**. Abt. f. Syst. 1- 28.

ČERNOSVITOV L. 1930. Přispévky k poznáni fauny tatranských Oligochaetů. Vést. Král. Čes. Spol. Nauk. Tř. **II.**: 1-8.

ČERNOSVITOV L. 1939. Catalogue des oligochaètes hypogés. Bull. Mus. Roy. Hist. Nat. Belgique. **15**: 1-47.

DANIELOPOL D. L. 1976. The distribution of the fauna in the interstitial habitats of riverine sediments of the Danube and the Piesting (Austria). Int. J. Speleol., **8**: 23-51.

DANIELOPOL D. L. 1989. Groundwater fauna associated with riverine aquifers. J. N. Am. Benthol. Soc., **8**: 18-35.

DEMEL K. 1918. Fauna jaskiń ojcowskich. Spraw. Posiedz. TN Warsz. Wydział Mat.-Przyr., **11**: 623-659.

DOLE-OLIVIER M. J., MARMONIER P. 1992. Patch distribution of interstitial communities: prevailing factors. Freshwater Biology, **27**: 177-191.

DÓZSA-FARKAS K. 1970. The description of three new species and some data to the enchytraeid fauna of the Baradla Cave, Hungary. Opusc. Zool., Budapest, **10**: 241-251.

DRATNAL E. 1976. Zgrupowania bezkręgowców bentosowych potoku Prądnik w Ojcowskim Parku Narodowym i na terenie przyległym. Ochr. Przyr., **41**: 281-321.

DRATNAL E., SOWA R., SZCZĘSNY B. 1979. Benthic invertebrates communities in the Dunajec River between Harklowa and Sromowce Niżne. Ochr. Przyr., **42**: 183-215.

DUMNICKA E. 1976a. Oligochaetes (Oligochaeta) of some streams of the High Tatra Mts and of the River Białka Tatrzańska. Acta Hydrobiol., **18**: 305-315.

DUMNICKA E. 1976b. *Enchytraeus dominicae* sp. n. – a new species of Enchytraeidae (Oligochaeta) from Poland. Acta Hydrobiol., **18**: 421-424.

DUMNICKA E. 1977a. *Enchytraeus polonicus* sp. n. – A new species of Enchytraeidae (Oligochaeta) from a cave in the Kraków-Częstochowa Upland. Bull. Acad. Pol. Sci., ser. Sci. Biol., Cl. II, **25:** 163-166.

DUMNICKA E. 1977b. Oligochaeta from caves in the Tatra Mts with references to anomalies in their structure. Proc. 7th Int. Speleol. Congress, Sheffield, England, 160-163.

DUMNICKA E. 1977c. Annual changes of oligochaete fauna in a cave of the Kraków-Częstochowa Upland. Proc. 7th Int. Speleol. Congress, Sheffield, England, 163-165.

DUMNICKA E. 1978. Communities of oligochaetes (Oligochaeta) of the River Nida and its tributaries. Acta Hydrobiol., **20**: 117-141.

DUMNICKA E. 1981. Skąposzczety (Oligochaeta) jaskiń Południowej Polski. V Rocz. Muz. Okr. w Częstochowie, Przyr., **2**: 15-22.

DUMNICKA E. 1982. Stream ecosystems in mountain grassland (West Carpathians). 9. Oligochaeta. Acta Hydrobiol., **24**: 391-398.

DUMNICKA E. 1984. Laboratory studies on biology of cave-dwelling Enchytraeidae: *Enchytraeus dominicae* DUMNICKA and *Fridericia bulbosa* (ROSA). Mém. Biospéol., **11**: 199-205.

DUMNICKA E. 1985. Ecology of some waters in the forest-agricultural basin of the River Brynica near the Upper Silesian Industrial Region. 9. Communities of oligochaetes. Acta Hydrobiol., **27**: 535-545.

DUMNICKA E. 1987. The effect of dam reservoirs on oligochaete communities in the river Dunajec (Southern Poland). Acta Hydrobiol., **29**: 25-34.

DUMNICKA E. 1994a. Communities of oligochaetes in mountain streams of Poland. Hydrobiologia, **278**: 107-110.

DUMNICKA E. 1994b. Habitat preferences of invertebrates (especially Oligochaeta) in a stream. Acta Hydrobiol., **36**: 91-101.

DUMNICKA E. 1995a. Degradation of the benthic invertebrate fauna of the Dunajec River in the neighbourhood of Pieniny National Park (Southern Poland). Oligochaetes Oligochaeta. SZCZĘSNY B. (ed). Ochr. Przyr., **52**: 208-216.

DUMNICKA E. 1995b. Fauna inhabiting water bodies and experimental containers used for plants decomposition study in a cave. Mém. Biospéol., **17**: 17-20.

DUMNICKA E. 1996a. Upstream-downstream movement of macrofauna (with special reference to oligochaetes) in the River Raba below a reservoir. Hydrobiologia, **334**: 193-198.

DUMNICKA E. 1996b. Aquatic Oligochaeta and Aphanoneura from the souterrains of Central Europe with description of a new *Enchytraeus* species. Mém. Biospéol., **23**: 167-171.

DUMNICKA E. 1996c. Oligochaetes from the subterranean waters of the Tatra National park. 118-120. In: Przyr. Tatrzańskiego Parku Narodowego a Człowiek, t. 2. Biologia, KOWNACKI A. (ed). Tatrzański Park Narodowy, Pol. Tow. Przyjaciół Nauk o Ziemi, Kraków-Zakopane, 124 pp.

DUMNICKA E. 1998. A new species of *Fridericia* (Oligochaeta: Enchytraeidae) found in a spring in the Sudety mountains (Poland). Annls Limnol., **34**: 155-158.

DUMNICKA E., GALAS J. 1997. The relationship between Oligochaeta, particulate organic matter and environmental conditions in epigean and hypogean parts of a mountain stream in Poland. Mém. Biospéol., **24**: 9-14.

DUMNICKA E., JUBERTHIE Ch. 1994. Aphanoneura et Oligocheta. 67-75. In: Encyclopaedia Biospeologica, t. I. Juberthie Ch., Decu V. (Eds), Société de Biospéologie, Moulis (C.N.R.S.), Bucarest, 834 pp.

DUMNICKA E., KOWNACKI A. 1988. A regulated river ecosystem in a polluted section of the Upper Vistula. 8. Macroinvertebrates. Acta Hydrobiol., **30**: 81-97.

DUMNICKA E., KUKUŁA K.1990. The communities of oligochaetes of the Wołosatka and Terebowiec streams (the Bieszczady National Park, southeastern Poland). Acta Hydrobiol., **32**: 423-435.

DUMNICKA E., PASTERNAK K. 1978. The influence of physico-chemical properties of water and bottom sediments in the River Nida on the distribution and numbers of Oligochaeta. Acta Hydrobiol., **20**: 215-232.

DUMNICKA E., ROŻEN A. 1997. XXIIIa. Oligochaeta – Skąposzczety. 130-137. In: Razowski J. (ed). Wykaz zwierząt Polski. T. IV. PAN, ISEZ, 303 pp.

DUMNICKA E., WOJTAN K. 1989. L'influence du milieu et des paramètres physico-chimiques de l'eau sur les peuplements des oligochètes et la variabilité des populations de *Propappus volki* (Enchytraeidae) dans la grotte Wodna (Tatras Montagnes, Pologne). Mém. Biospéol., **16**: 225-232.

DUMNICKA E., WOJTAN K. 1990. Differences between cave water ecological systems in the Kraków-Częstochowa Upland. Stygologia, **5**: 241-247.

DUMNICKA E., WOJTAN K. 1993. Invertebrates (with special regard to Oligochaeta) of the semi-underground water bodies in the gypsum caves. Mém. Biospéol., **20**: 63-67.

DUMNICKA E., WOJTAN K. 1994. Faune aquatique de la grotte Chelosiowa Jama (Montagnes Świętokrzyskie, Pologne Centrale). Mém. Biospéol., **21**: 53-56.

FLEITUCH T. Jr., 1985. Macroinvertebrate drift in the middle course of the River Dunajec (Southern Poland). Acta Hydrobiol., **27**: 49-61.

FOMENKO N. V. 1972. Ob ekologicheskich gruppach oligochet (Oligochaeta) r. Dniepra. 94-106. In: Vodnye Maloshchetinkovye Chervi, Akad. Nauk SSSR, Nauka, Moskwa, 191 pp.

GADZIŃSKA E. 1974. *Cernosvitoviella parviseta* sp. n. – a new species of Enchytraeidae (Oligochaeta) from the Polish Tatra Mountains. Bull. Acad. Pol. Sci., Ser. sci. biol., Cl. II, **22**: 403-406.

GALAS J., BEDNARZ T., DUMNICKA E., STARZECKA A., WOJTAN K. 1996a. Litter decomposition in a mountain cave water. Arch. Hydrobiol., **138**: 199-211.

GALAS J., DUMNICKA E., KAWECKA B., KOWNACKI A., JELONEK M., STÓS P., WOJTAN K., 1996b. Ekosystemy wybranych jezior tatrzańskich – polski udział w międzynarodowym programie AL.:PE2. 96-99. W:. Przyr. Tatrzańskiego Parku Narodowego a Człowiek, t. 2. Biologia, KOWNACKI A. (ed). Tatrzański Park Narodowy, Pol. Tow. Przyjaciół Nauk o Ziemi, Kraków-Zakopane, 124 pp.

GALAS J., DUMNICKA E. 1998. Seasonal changes of benthos and organic matter in a high mountain stream passing through a cave. 163-170. In: Advances in river bottom ecology. Bretschko G., Helešic J. (eds). Backhuys Publishers, Leiden, 344 pp.

GIANI N. 1979a. Les oligochètes aquatiques du Sud-Ouest de la France (2e note). Bull. Soc. Hist. nat. Toulouse, **115**: 347-358.

GIANI N. 1979b. Description de deux nouvelles espèces d'Enchytraeidae des Pyrénées. Annls Limnol. **15**: 107-112.

GIANI N. 1984. Contribution à l'étude de la faune d'eau douce et plus particulièrement des oligochètes. II. Les oligochètes aquatiques: taxinomie, répartition et écologie. Thèse, Université Toulouse, 196 pp.

GIANI N., LAVANDIER P. 1977. Les oligochètes du torrent d'Estaragne (Pyrénées Centrales). Bull. Soc. Hist. Nat., Toulouse, **113**: 234-243.

GIANI N., SAMBUGAR B., MARTINEZ-ANSEMIL E. 1995. Nouvelles données sur les oligochètes aquatiques des eaux souterraines du Sud de l'Europe. Res. du XII Col. Internat. Biospéol., Moulis, 28 aout – 2 sept. 1995: 50.

GIBERT J., DANIELOPOL D. L., STANFORD J. A. (eds) 1994. Groundwater Ecology. Academic Press. San Diego, New York, Boston, London, Sydney, Tokyo, Toronto, 571 pp.

GŁAZEK J. 1995. Hydrografia krasowa Tatr Polskich. 11-30. [In:] Jaskinie Tatrzańskiego Parku Narodowego. t. 4. Wielkie Jaskinie Doliny Kościeliskiej. Grodzicki J. (ed). Pol. Tow. Przyj. Nauk o Ziemi, Tatrzański Park Narodowy, Warszawa, 141 pp.

GRADZIŃSKI M., GÓRNY A., MOTYKA J. 1996. Wpływ ascenzyjnych przepływów na powstanie jaskini Smocza Jama. Mat. Symp., XXX Sympozjum Sekcji Speleologicznej Pol. Tow. Przyrod. im. Kopernika, Kielce-Bocheniec, 18-22.10.1996, p.16.

GRADZIŃSKI R. 1972. Przewodnik geologiczny po okolicach Krakowa. Wyd. Geol., Warszawa.

GRODZICKI J. (ed.) 1991. Jaskinie Tatrzańskiego Parku Narodowego. Jaskinie Doliny Chochołowskiej i dolinek reglowych. Pol. Tow. Przyj. Nauk o Ziemi, Warszawa, 200 pp.

GRODZICKI J. (ed.) 1993a. Jaskinie Tatrzańskiego Parku Narodowego. 2. Jaskinie zachodniego zbocza Doliny Kościeliskiej. Pol. Tow. Przyj. Nauk o Ziemi, Warszawa, 165 pp.

GRODZICKI J. (ed.) 1993b. Jaskinie Tatrzańskiego Parku Narodowego. 3. Jaskinie wschodniego zbocza Doliny Kościeliskiej. Pol. Tow. Przyj. Nauk o Ziemi, Tatrzański Park Narodowy, Warszawa, 194 pp.

GRODZICKI J. (ed.) 1995. Jaskinie Tatrzańskiego Parku Narodowego. 4. Wielkie jaskinie Doliny Kościeliskiej. Pol. Tow. Przyj. Nauk o Ziemi, Tatrzański Park Narodowy, Warszawa, 141 pp.

GUBAŁA J., KASZA A., URBAN J. 1998. Jaskinie Niecki Nidziańskiej. Pol. Tow. Przyj. Nauk o Ziemi, Warszawa, 173 pp.

HARTMANN-SCHRÖDER G. 1986. Polychaeta (incl. Archiannelida). 210-233. In: Stygofauna Mundi. A faunistic, distributional, and ecological synthesis of the world fauna inhabiting subterranean waters. Botosaneanu L. (ed.) Leiden – E.J. Brill/Dr W. Backhuys, 740 pp.

HEALY B. 1975. A description of five new species of Enchytraeidae (Oligochaeta) from Ireland. Zool. J. Linn. Soc., **56**: 315-326.

HEALY B. 1979. Three new species of Enchytraeidae (Oligochaeta) from Ireland. Zool. J. Linn. Soc., **67**: 87-95.

HEALY B. 1996. Records of Enchytraeidae (Annelida: Oligochaeta) from west Florida. 1. *Mesenchytraeus, Cognettia, Bryodrilus, Hemienchytraeus, Henlea* and *Buchholzia*. Proc. Biol. Soc. Washington, **109**: 118-137.

HEALY B., BOLGER T. 1984. The occurrence of species of semi-aquatic Enchytraeidae (Oligochaeta) in Ireland. Hydrobiologia **115**: 159-170.

HRABĚ S. 1937a. Beitrag zur Kenntnis der Fauna des Glatzer Schneeberges. Sb. Kl. Přir. v Brně. **20**: 1-10.

HRABĚ S. 1937b. Contribution à l'étude du genre *Trichodrilus* et description de deux espèces nouvelles. Bull. Mus. r. Hist. nat. Belg., **13** (32): 1-23.

HRABĚ S. 1939. Oligochètes aquatiques des Hautes Tatras. Věst. Česk. Zool. Spol., **6-7**: 209-236.

HRABĚ S. 1940. Bentická zviřena tatranských jezer. Sb. Kl. Prir. Brno, **22**: 1-13.

HRABĚ S. 1942. O bentické zviřené jezer ve Vysokých Tatrách. Physiographica Slovaca **I**: 124-177.

HRABĚ S. 1971. On *Trichodrilus pragensis* Vejd. (Oligochaeta, Lumbriculidae). Věst. Česk. Spol. Zool., **35**: 205-208.

HRABĚ S. 1981. Vodní Máloštětinatci (Oligochaeta) Československa. Acta Univ. Carolinae. Biologica, 1979, **1-2**, 167 pp.

JAHN A., KOZŁOWSKI S., PULINA M. (eds). 1996. Masyw Śnieżnika – zmiany w środowisku przyrodniczym. Wyd. Polskiej Agencji Ekologicznej S.A. 320 pp. + 16.

JAHN A., KOZŁOWSKI S., WISZNIOWSKA T. (eds) 1989. Jaskinia Niedźwiedzia w Kletnie. Badania i udostępnianie. Wyd. PAN, Zakład Narodowy im. Ossolińskich, 269 pp.

JAWOROWSKI A. 1893. Fauna studzienna miast Krakowa i Lwowa. Spraw. Kom. Fizyogr. AU, **28**: 29-48.

JUGET J. 1959. Recherches sur la faune aquatique de deux grottes du Jura méridional français: la grotte de la Balme (Isère) et la grotte de Corveissiat (Ain.) Ann. Spéléol., **14**: 391-401.

JUGET J. 1984. Oligochaeta of the epigean and underground fauna of the alluvial plain of the French upper Rhône (biotypological trial). Hydrobiologia, **115**: 175-182.

JUGET J. 1987. Contribution to the study of the Rhyacodrilinae (Tubificidae, Oligochaeta) with description of two new stygobiont species from the alluvial plain of the French upper Rhone, *Rhyacodrilus amphigenus*, sp. n. and *Rhizodriloides phreaticola*, g. n., sp. n. Hydrobiologia, **155**: 107-118.

JUGET J., DUMNICKA E. 1986. Oligochaeta (incl. Aphanoneura) des eaux souterraines continentales. 234-244. In: Stygofauna Mundi. A faunistic, distributional, and ecological synthesis of the world fauna inhabiting subterranean waters. Botosaneanu L. (ed.) Leiden – E.J. Brill/ dr W. Backhuys, 740 pp.

JUGET J., LAFONT M. 1994. Theoretical habitat templets, species traits, and species richness: aquatic oligochaetes in the Upper Rhône River and its floodplain. Freshwater Biology, **31**: 327-340.

KAHL K. 1983. Materials to the fauna of Oligochaeta of the Holy Cross Mountains (Góry Świętokrzyskie) and of the Nida Lowland (Niecka Nidziańska). Fragm. Faun., **28**: 23-37.

KAHL K. 1986. Skąposzczety (Oligochaeta) rzeki Lubrzanki w Górach Świętokrzyskich. Fragm. Faun., **30**: 35-43.

KAHL K. 1991. Skąposzczety (Oligochaeta) potoków i rzek Świętokrzyskiego Parku Narodowego wraz z otuliną. Fragm. Faun., **35**: 5-18.

KAHL K. 2000. Oligochaeta of the Niebieskie źródła nature reserve near Tomaszów Mazowiecki (Central Poland). Acta Univ. Lodziensis, Folia Limnologica, **7**: 19-37.

KAHL K., WOJTAS F. 1974. Przegląd krajowych gatunków z rodzaju *Branchiobdella*. Zesz. Nauk. Uniw. Łódzkiego, Nauki Mat.-Przyr., Ser. II, **56**: 3-12.

KASPRZAK K. 1972a. Materiały do znajomości skąposzczetów (Oligochaeta) Wielkopolski. Fragm. Faun., **18**: 99-119.

KASPRZAK K. 1972b. *Achaeta seminalis* sp. n., a new species of Enchytraeidae (Oligochaeta) from Poland and notes on other species of the genus *Achaeta* Vejdovsky, 1877. Bull. Acad. Pol. Sci., ser. Sci. Biol., **20**: 187-191.

KASPRZAK K. 1972c. *Fridericia tridiverticula* sp. n., a new species of Enchytraeidae (Oligochaeta) from Poland. Bull. Acad. Pol. Sci., ser. Sci. Biol., II, **20**: 411-413.

KASPRZAK K. 1973a. Oligochaeta in the interstitial waters. Przegl. Zool., **17**: 41-44.

KASPRZAK K. 1973b. Notatki o faunie skąposzczetów (Oligochaeta) Polski, I. Fragm. Faun., **18**: 405-434.

KASPRZAK K. 1973c. Notatki o faunie skąposzczetów (Oligochaeta) Polski, II. Fragm. Faun., **19**: 1-19.

KASPRZAK K. 1973d. *Nais christinae* sp. n., a new species of Naididae (Oligochaeta) found in Poland. Bull. Acad. Pol. Sci., ser. Sci. Biol., II, **21**: 535-539.

KASPRZAK K. 1975. Skąposzczety (Oligochaeta) osadów aluwialnych rzek. Prace Kom. Nauk. PTG, **3**: 173-185.

KASPRZAK K. 1976a. Badania nad skąposzczetami (Oligochaeta) dolnego biegu rzeki Wełny. Fragm. Faun., **20**: 425-467.

KASPRZAK K. 1976b. Materiały do znajomości fauny skąposzczetów (Oligochaeta) Karkonoszy i Gór Izerskich. Przegl. Zool., **20**: 323-325.

KASPRZAK K. 1976c. Materials to the fauna of Oligochaeta of the Ojców National Park and its vicinity – the Prądnik-Białucha stream. Acta Hydrobiol., **18**: 277-289.

KASPRZAK K. 1977. Bottom fauna of the heated Konin lakes. IV. Oligochaeta. Wróblewski A. (ed.) Monogr. Fauny Polski, **7**: 49-146.

KASPRZAK K. 1978a. Notatki o faunie skąposzczetów (Oligochaeta) Polski, IV. Materiały do znajomości fauny skąposzczetów Pobrzeża Bałtyku, Pojezierza Pomorskiego i Niziny Wielkopolsko-Kujawskiej. Bad. Fizjogr. Pol. Zach., ser. C – zoologia, **30**: 29-45.

KASPRZAK K. 1978b. Materiały do znajomości skąposzczetów (Oligochaeta) i ich morfologii. Bad. Fizjogr. Pol. Zach., ser. C – zoologia, **31**: 65-74.

KASPRZAK K. 1979a. Skąposzczety (Oligochaeta) of the Pieniny Mts. I. Wazonkowce (Enchytraeidae). Fragm. Faun., **24**: 7-56.

KASPRZAK K. 1979b. Skąposzczety (Oligochaeta) of the Pieniny Mountains. II. Naididae, Tubificidae, Haplotaxidae, Lumbriculidae, Branchiobdellidae. Fragm. Faun., **24**: 57-80.

KASPRZAK K. 1981a. Nowe dane o faunie skąposzczetów Oligochaeta w Tatrzańskim Parku Narodowym oraz w Bieszczadach. Chrońmy Przyr. Ojczystą. **37**: 72-75.

KASPRZAK K. 1981b. Skąposzczety wodne, I. Rodziny: Aeolosomatidae, Potamodrilidae, Naididae, Tubificidae, Dorydrilidae, Lumbriculidae, Haplotaxidae, Glossoscolecidae, Branchiobdellidae, Klucze do oznaczania bezkręgowców Polski, 4, PWN, Warszawa, 226 pp.

KASPRZAK K. 1982. Zgrupowanie Enchytraeidae (Oligochaeta) gleby murszowej nad jeziorem Zbęchy. Bad. Fizjogr. Pol. Zach., ser. C – zoologia, **33**: 165-167.

KASPRZAK K. 1986a. Skąposzczety wodne i glebowe, II. Rodzina: Wazonkowce (Enchytraeidae). Klucze do oznaczania bezkręgowców Polski, 5, PWN, Warszawa, 366 pp.

KASPRZAK K. 1986b. Skąposzczety glebowe, III. Rodzina: Dżdżownice (Lumbricidae). Klucze do oznaczania bezkręgowców Polski, 6, PWN, Warszawa, 187 pp.

KASPRZAK K., SZCZĘSNY B. 1976. Skąposzczety (Oligochaeta) rzeki Raby. Acta Hydrobiol., **18**: 75-87.

KASPRZAK K., ZAJONC I. 1980. Skąposzczety (Oligochaeta) Tatr. Przegl. Zool., **24**: 189-199.

KASZA H. 1988. A regulated river ecosystem in a polluted section of the Upper Vistula. 2. Hydrochemistry. Acta Hydrobiol., **30**: 15-22.

KAWECKA B., KOWNACKA M., KOWNACKI A. 1971. General characteristics of the biocoenosis in the streams of the Polish High Tatras. Acta Hydrobiol., **13**: 465-476.

KLECZKOWSKI A. S. 1967. Seasonal and secular variations in chemical composition of the ground waters within the Cracow City limits. Bull. Acad. Pol. Sci., Ser. Sci. Géol. et Géogr., **15**: 149-159.

KONDRACKI J. 1994. Geografia Polski. Mezoregiony fizyczno-geograficzne. PWN, Warszawa, 339 pp.

KONOPACKA A., JAŻDŻEWSKI K. 1996. Groundwater crustaceans of the wells in Grabia river system (Central Poland). Abstracts, 2nd European Crustacean Conference, Liege (Belgium), september 2-6, 1996: 47.

KOWALEWSKI M. 1914. Materyały do fauny polskich skąposzczetów wodnych (Oligochaeta aquatica). Część II. Spraw. Kom. Fizyogr. AU, **48**: 107-113.

KOWALEWSKI M. 1917. *Marionina tatrensis* M. KOWALEWSKI. (1914) 1916, nowy przedstawiciel rodziny Enchytraeidae. Rozpr. Wydz. Mat.-Przyr. AU. Ser. III, **16**: 1-8.

KOWALSKI K. 1951. Jaskinie Polski. I. Państ. Muz. Archeol., Warszawa, 466 pp.

KOWALSKI K. 1953. Jaskinie Polski. II. ibid. 186 pp.

KOWALSKI K. 1954. Jaskinie Polski. III. PWN, Warszawa, 192 pp.

KOWALSKI K. 1955. Fauna jaskiń Tatr Polskich. Ochr. Przyr., **23**: 283-333.

KOWNACKI A.1971. Taxocens of Chironomidae in streams of the Polish High Tatra Mts. Acta Hydrobiol., **13**: 439-464.

KOWNACKI A. 1999. Checklist of macroinvertebrates in the River Vistula. Acta Hydrobiol., **41**: 45-75.

KOWNACKI A., DUMNICKA E., GALAS J., KAWECKA B., WOJTAN K. 1997. Ecological characteristics of a high mountain lake-outlet stream (Tatra Mts, Poland). Arch. Hydrobiol., **139**: 113-128.

KOWNACKI A., GALAS J., DUMNICKA E., MIELEWCZYK S. 2000. Invertebrate communities in permanent and temporary high mountain lakes (Tatra Mts). Annls Limnol., **36**: 181-188.

KOWNACKI A., ŁAJCZAK A. (eds) 1997. Operat Ochrony Zasobów Wodnych Tatrzańskiego Parku Narodowego. Zakład Biologii Wód im. Karola Starmacha, PAN. unpublish.

KWANDRANS J. 1993. Diatom communities of acidic mountain streams in Poland. Hydrobiologia, **269/270**: 335-342.

LAFONT M., JUGET J. 1976. Les oligochètes du Rhône. I. Relevés faunistiques généraux. Annls Limnol., **12**: 253-268.

LAFONT M., DURBEC A., ILLE C. 1992. Oligochaete worms as biological describers of the interactions between surface and groundwaters: a first synthesis. Regul. Rivers: Res. & Manag., **7**: 65-73

LEGEŻYŃSKI P. 1971. Skąposzczety wodne (Oligochaeta limicola) wyspy Wolin. Bad. Fizjogr. Pol. Zach., ser. B, **24**: 83-106.

LEGEŻYŃSKI P. 1976. Contribution to the knowledge of aquatic Oligochaeta of North Poland. Bad. Fizjogr. Pol. Zach., ser. C, **29**: 129-138.

LODEN M.S., HARMAN W. J. 1980. Ecophenotypic variation in setae of Naididae (Oligochaeta). 33-39. In: Aquatic Oligochaete Biology. BRINKHURST R. O., Cook D. G. (Eds). Plenum Press, New York and London. pp: 529.

MARTINEZ-ANSEMIL E., COLLADO R. 1996. Two new species of freshwater Oligochaeta from the North-west Iberian Peninsula: *Krenedrilus realis* sp.nov. (Tubificidae) and *Cernosvitoviella bulboducta* sp. nov. (Enchytraeidae). J. Zool. Lond., **240**: 363-370.

MARTINEZ-ANSEMIL E., SAMBUGAR B., GIANI N. 1997. Groundwater oligochaetes from Southern-Europe. I. A new genus and three new species of Rhyacodrilinae (Tubificidae) with a redescription of *Tubifex pescei* (DUMNICKA) comb. n. Annls Limnol., **33**: 33-44.

MASCHKE K. 1936. Die Höhlenfauna des Glatzer Schneeberges. 5. Die Metazoenfauna der Bergwerke bei Mährisch-Altstadt. Beitr. Biol. Glatzer Schneeberges, **2**: 175-191.

MATHIEU J., MARMONIER P., LAURENT R., MARTIN D. 1991. Récolte du matériel biologique aquatique souterrain et stratégie d' échantillonnage. Hydrogéologie, **3**: 187-200.

MAYR E. 1974. Podstawy systematyki zwierząt. PWN, Warszawa, 452 pp.

MINKIEWICZ S. 1914. Przegląd fauny jezior tatrzańskich. Spraw. Kom. Fizjogr., **48**: 114-137 + 5 tabel.

MIREK Z., GŁOWACIŃSKI Z., KLIMEK K., PIĘKOŚ-MIRKOWA H. (eds) 1996. Przyroda Tatrzańskiego Parku Narodowego. Tatry i Podtatrze 3. Wyd. Tatrzański Park Narodowy, Zakopane-Kraków, 786 pp.

MORSELLI I., MARI M., SARTO M. 1995. First record of the stygobiont 'archiannelid' *Troglochaetus beranecki* DELACHAUX from Italy. Boll. zool., **62**: 287-290.

MOSZYŃSKA M. 1962. Katalog fauny Polski. Skąposzczety (Oligochaeta). XI, 2. PWN, 69 pp.

MOSZYŃSKI A. 1934. Skąposzczety (Oligochaeta) Pomorza. Pozn. Tow. Przyjaciół Nauk, Prace Kom. Mat.-Przyr.,Ser. B, Nauki Biol.,**7**: 1-18.

MOSZYŃSKI A. 1936. Die Höhlenfauna des Glatzer Schneeberges. 9. Ein neuer Vertreter der Gattung *Trichodrilus* Clap. (*Trichodrilus spelaeus* nov. spec.) aus dem Stollen in Neu-Klessengrund. Beitr. Biol. Glatzer Schneeberges, **2**: 214-216.

MOSZYŃSKI A., MOSZYŃSKA M. 1957. Skąposzczety (Oligochaeta) Polski i niektórych krajów sąsiednich. Pozn. Tow. Przyj. Nauk, Wydz. Mat.-Przyr., Prace Kom. Biol. **18**, 6, 204 pp.

NIELSEN C. O., CHRISTENSEN B. 1959. The Enchytraeidae critical revision and taxonomy of european species. Natura Jutlandica, **8-9**: 1-160.

O'LEARY P., LAKE P. S., MARCHANT R., DOEG T. J. 1992. Macroinvertebrate activity in the water column of backwaters in an upland stream in Victoria. Aust. J. mar. Freshwat. Res., **43**: 1403-1407.

PARTYKA J. 1976. Bibliografia Ojcowskiego Parku Narodowego (za okres do końca 1973 r.). Ojcowski Park Narodowy, Muz. im. Prof. W. Szafera, 228 pp.

PAX F., MASCHKE K. 1935. Die Höhlenfauna des Glatzer Schneeberges. I. Die rezente Metazoenfauna. Beitr. Biol. Glatzer Schneeberges, **1**: 4-72.

PAX F., MASCHKE K. 1936. Die Tierwelt der Quellen. 1. Die Metazoenfauna der Akratopegen. Beitr. Biol. Glatzer Schneeberges, **2**: 135-171.

PENNAK R. W., WARD J. V. 1986. Interstitial faunal communities of the hyporheic and adjacent groundwater biotopes of a Colorado mountain stream. Arch. Hydrobiol. Suppl. **74**, 3: 356-396.

PIGUET E. 1906. Observations sur les Naididées et révision systématique de quelques espèces de cette famille. Rev. Suisse Zool., **14**: 185-315.

PILIPIUK I. 1993. Enchytraeidae (Oligochaeta) of pine forests in Poland. Fragm. Faun., **36**: 75- 107.

PLEŞA C. 1977. Nouvelles données sur la répartition et l'écologie de *Troglochaetus beranecki* DELACHAUX (Archiannelida) en Roumanie. Trav. Inst. Spéol. „Emile Racovitza", **16**: 9-16.

POP V. 1971. Oligochètes (Annelida) limicoles des grottes et des eaux interstitielles de Suisse. Rev. Suisse de Zoologie, t. **78**, 47:821-827.

POP V. 1974. Faunistische Forschungen in den Grundwässern des Nahen Ostens. XII. Oligochaeta (Annelida). Arch. Hydrobiol., **73**: 108-121.

PULINA M. (ed.) 1996. Jaskinie Sudetów. Pol. Tow. Przyj Nauk o Ziemi, Warszawa, 202 pp.

PULINA M. (ed.) 1997a. Jaskinie Polskich Karpat fliszowych. T.1. Jaskinie Pogórza Śląskiego, Beskidu Śląskiego, Kotliny Żywieckiej, Beskidu Żywieckiego. Pol. Tow. Przyj Nauk o Ziemi, Warszawa, 250 pp.

PULINA M. (ed.) 1997b. Jaskinie Polskich Karpat fliszowych. T.2. Jaskinie Beskidu Małego, Beskidu Makowskiego, Pogórza Wiśnickiego, Beskidu Wyspowego, Gorców, Beskidu Sądeckiego, Pogórza Rożnowskiego, Pogórza Ciężkowickiego. Pol. Tow. Przyj Nauk o Ziemi, Warszawa, 228 pp.

RODRIGUEZ P., ARMAS J. C. 1983. Contribution à la connaissance de la faune d'Oligochètes aquatiques du pays basque et zones limitrophes. Annls Limnol., **19**: 93-100.

RODRIGUEZ P., GIANI N. 1994. A preliminary review of the taxonomic characters used for the systematics of the genus *Trichodrilus* CLAPAREDE (Oligochaeta, Lumbriculidae). Hydrobiologia, **278**: 35-51.

ROTA E. 1995. Italian Enchytraeidae (Oligochaeta). I. Boll. Zool., **62**: 183-231.

ROTA E., HEALY B. 1994. The enchytraeid fauna of North Africa. Hydrobiologia, **278**: 53-66.

SAMBUGAR B., GIANI N., MARTINEZ-ANSEMIL E. 1999. Groundwater oligochaetes from Southern Europe. – Tubificidae with marine phyletic affinities: new data with description of a new species, review and consideration on their origin. Mém. Biospéol., **26**: 107-116.

SÄRKKÄ J., MÄKELÄ J. 1998. *Troglochaetus beranecki* DELACHAUX (Polychaeta, Archiannelida) in esker groundwaters of Finland: a new class of limnic animals for northern Europe. Hydrobiologia, **379**: 17-21.

SCHMELZ R. M., COLLADO R., OESTREICH M. 1999. The *Enchytraeus buchholzi/ christenseni* species complex – outline of a problem and first steps towards a solution. Newsletter on Enchytraeidae, **6**: 31-39.

SCHWANK P. 1981. Turbellarien, Oligochaeten und Archianneliden des Breitenbachs und anderer oberhessischer Mittelgebirgsbäche. I. Lokalgeographische Verbreitung und die Verteilung der Arten in den einzelnen Gewässern in Abhängigkeit vom Substrat. Arch. Hydrobiol., Suppl. **62**: 1-85.

SKALSKI A. W., SKALSKA B. 1969. The recent fauna of the Polish caves. Actes IV^{e} CIS 4/5: 213-223.

SKALSKI A. W. 1976. Groundwater inhabitants in Poland. Int. J. Speleol., **8**: 217-228.

SKALSKI A. W. 1981. Podziemne obunogi (Amphipoda) Polski. V Rocz. Muz. Okr. W Częstochowie, Przyr., **2**: 61- 83.

SKALSKI A. W. 1994. Fauna wód podziemnych Polski. Przegl. Zool. **38**: 35-50.

SOWA R. 1975. Ecology and biogeography of mayflies (Ephemeroptera) of running waters in the Polish part of the Carpathians. 1. Distribution and quantitative analysis. Acta Hydrobiol., **17**: 223-297.

SPERBER Ch. 1948. A taxonomical study of the Naididae. Zool. Bidr. **28**: 1-296 with 21 Plates and 29 Figs).

SROKA W., KOWALSKA A. 1998. The preglacial fluvial deposits in the southern part of the Upper Nysa Depression, central Sudetes Mts, southwestern Poland. Geologia Sudetica, **31**: 157-170.

STAMMER H. J. 1936. Die Höhlenfauna des Glatzer Schneeberges. 8. Die Wasserfauna der Schneeberghöhlen. Beitr. Biol. Glatzer Schneeberges, **2**: 199-214.

STAMMER H. J. 1937. Der Höhlenarchannelide *Troglochaetus beranecki* in Schlesien. Zool. Anz., **118**: 265-268.

STRAYER D., BANNON-O'DONNELL E. 1988. Aquatic Microannelids (Oligochaeta and Aphanoneura) of underground waters of southeastern New York. The American Midland Naturalist, **119**: 327-335.

STRAYER D. L., MAY S. E., NIELSEN P., WOLLHEIM W., HAUSAM S. 1995. An endemic groundwater fauna in unglaciated eastern North America. Can. J. Zool., **73**: 502-508.

SZARSKI H. 1947. Skąposzczety wodne zebrane w okolicach Krakowa w r. 1942. Kosmos, Ser. A, Rozprawy, **65**: 150-158.

SZCZĘSNY B. 1968. Fauna denna potoku Sąspówka na terenie Ojcowskiego Parku Narodowego. Ochr. Przyr., **33**: 215-235.

SZCZĘSNY B. 1974. The effect of sewage from the town of Krynica on the bethic invertebrates communities of the Kryniczanka stream. Acta Hydrobiol., **16**: 1-29.

SZCZĘSNY B. 1986. Caddisflies (Trichoptera) of running waters in the Polish North Carpathians. Acta Zool. Cracov., **29**: 501-586.

SZCZĘSNY B. 1990. Benthic macroinvertebrates in acidified streams of the Świętokrzyski National Park (Central Poland). Acta Hydrobiol., **32**: 155-169.

SZELEREWICZ M., GÓRNY A. 1986. Jaskinie Wyżyny Krakowsko-Wieluńskiej. Wyd. PTTK „Kraj", Warszawa-Kraków, 200 pp.

ŠPORKA F. 1982. Máloštetinovce (Oligochaeta) rieky Belej. Zbornik Prac o Tatranskom Narodnom Parku, 181-185.

TILZER M. 1968. Zur Ökologie und Besiedlung des hochalpinen hyporheischen Interstitials im Arlberggebiet (Österreich). Arch. Hydrobiol., **65**: 253-308.

TILZER M. 1973. Zum Problem der Ausbreitungsfähigkeit von limnisch – interstitiellen Grundwassertieren, am Beispiel von *Troglochaetus beranecki* DELACHAUX (Polychaeta Archiannelida). Arch. Hydrobiol., **72**: 263-269.

TIMM T. 1994. Propappidae and aquatic Enchytraeidae (Oligochaeta) from the farthest southeast of Russia. Hydrobiologia, **278**: 67-78.

TIMM T. 1999a. A guide to the Estonian Annelida. Estonian Academy Publishers, Tartu-Tallinn. 208 pp.

TIMM T. 1999b. Oligochaeta of the Edinka Stream, Russian Far East. Species Diversity, **4**: 1-7.

URBAN J. (ed.) 1996. Jaskinie Regionu Świętokrzyskiego. Pol. Tow. Przyj Nauk o Ziemi, Warszawa, 321 pp.

VRANOVSKY M., KRNO I., ŠPORKA F., TOMAJKA J. 1994. The effect of anthropogenic acidification on the hydrofauna of the lakes of the West Tatra Mountains (Slovakia). Hydrobiologia, **274**: 163-170.

WARD J.V. 1994. Ecology of alpine streams. Freshwater Biology, **32**: 277-294.

WIERZEJSKI A. 1881. O faunie jezior tatrzańskich. Pam. Tow.Tatrzańskiego, **6**: 99-110.

WIERZEJSKI A. 1883. Zarys fauny stawów tatrzańskich. Pam. Tow. Tatrzańskiego, **8**: 95-123.

WOŁOSZYN B. W. 1990. Jaskinie Zespołu Parków Krajobrazowych Ponidzia. Studia Ośr. Dok. Fizjogr., **18**: 275-341.

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References. The list of references must be complete and prepared in the following method:

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Chapter: OSBORN J. W. 1978. Morphogenetic gradients: fields versus clones. In: P. M. BUTLER and K. A. JOYSEY (Eds.) – Development, function and evolution of teeth. Academic Press, London-New York-San Francisco. Pp: 171-201.

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