PECKIANA • Volume 4 (2005) • 57 – 66

ISSN 1618-1735

Mass occurrence and migration of *Ommatoiulus sabulosus* (Linnaeus, 1758) (Diplopoda, Julida: Julidae) in Poland

GRZEGORZ KANIA & HENRYK TRACZ

Abstract

The striped millipede *Ommatoiulus sabulosus* (Linnaeus, 1758) occurs throughout Europe. The mass occurrence and migration of *O. sabulosus* in Dąbrowa Górnicza, Jaworzno and Chrzanów in Poland in the years 2000 – 2004 are described. Possible reasons of mass-scale occurrence of millipedes are climatic factors, food abundance, development strategies and overwintering places. *O. sabulosus* is classified as a pest in Poland and has been studied because huge numbers invade houses in spring, causing a considerable nuisance to people.

1. Introduction

The striped millipede *Ommatoiulus sabulosus* (Linnaeus, 1758) was first described by Linnaeus as *Julus sabulosus* in the 10th edition of »Systema Naturae« (1758), and is considered a well-known and commonly occurring millipede in Europe, also known as *Archiulus sabulosus* Berlese, 1886. Jawłowski (1929) also uses the latter term. In publications from the late 19th century the species was referred to under a generic name of *Schizophyllum* Verhoeff, 1895. The name *Schizophyllum sabulosum* was used in monographs by Schubart (1934), Halkka (1958), Stojałowska (1961) and many other authors. Latzel (1884) proposed the genus name *Ommatoiulus.* The currently adopted combination and name is *Ommatoiulus sabulosus* (Linnaeus), introduced by Jeekel (1968).

Ommatoiulus sabulosus (L.) occurs throughout Europe. It shows a marked ecological adaptivity, as indicated by its wide horizontal and vertical distribution. It can live at altitudes as high as 2800 m in the alpine zone (Würmli 1972). *Ommatoiulus sabulosus* has also been observed on sandy soils (Schubart 1934, Barlow 1957, Fairhurst 1974, Blower 1985).

These millipedes are eurytopic, inhabit the open areas of fields, dry slopes and roadside edges as well as litter of various plant communities (Haacker 1968, Stojałowska 1950, 1961,1968). *O. sabulosus* is characteristic of pine forests (*Vaccinio-myrtilli-Pinetum*) (Wytwer 1992, Tracz 1996). *O. sabulosus* inhabits mixed pine and oak forests (*Pino-Quercetum*), oak-hornbeam forests (*Tilio-Carpinetum*), deciduous Carpathian forests with beech (*Dentario glandulosae-Fagetum*) as well as various types of meadows and xerothermic grasslands. *O. sabulosus* is also found in old, neglected gardens (Jędryczkowski 1992, 1994). This species is reported by Haacker (1968) to inhabit forests, bushes, and fields, but necessarily on sandy ground. According to Barlow (1957), sandy ground provides optimal conditions for *O. sabulosus* occurrence. *O. sabulosus* is found to be active from May to October (Schubart 1934, Stojałowska 1961) with maximum activity

in summer (Barlow 1957), which was confirmed by ecological studies of Haacker (1968) and Voigtländer (1996). The active season for *O. sabulosus* is usually May to July with daytime activity, as shown by Fairhurst (1969). *Ommatoiulus* has been found to climb bushes and tree trunks (Haacker 1968, Stojałowska & Staręga 1974). Barlow (1957) found *O. sabulosus* to inhabit sandy and dry places on sunny days, to be resistant to water loss and relatively unrestricted by high temperature. Females of *O. sabulosus* living in dry habitats demonstrate the reverse reaction in the period of migration undertaken to lay eggs choosing a humid habitat (Perttunen 1953, Barlow 1957). The xerophilous *O. sabulosus* prefers temperatures of 26 – 31 °C (Haacker 1968). From the review of literature (Schubart 1940, Cloudsley-Thompson 1949, Hopkin & Read 1992, Ćurčić & Makarov 1995, Korsos 1998), it is known that mass occurrences and migrations of millipedes have been frequently observed in Poland (Tab. 1), throughout Europe (Tab. 2) and in other regions of the world.

Tab. 1 Records of mass occurrence and migrations of millipedes in Poland.

Date of occurrence	Place	Millipede species	Author and date of publication
1930	near Skierniewice	*Megaphyllum projectum kochi* (Verhoeff)	Jawłowski 1936
1934	Tuszyn near Łódź	*Strongylosoma stigmatosum* (Eichwald)	Jawłowski 1936
1949	Lublin	*Ommatoiulus sabulosus* (L.) *Strongylosoma stigmatosum* (Eichwald)	Stojałowska 1949 Stojałowska 1949
1958	near Lublin	*Glomeris hexasticha* (Brandt)	Stojałowska 1962
1958	near Warszawa	*Glomeris hexasticha* (Brandt)	Dziadosz 1966
1959	Lublin	*Strongylosoma stigmatosum* (Eichwald)	Stojałowska 1959
1959	Ojców near Kraków	*Strongylosoma stigmatosum* (Eichwald)	Dziadosz 1966
1963	Kruklin / Giżycko	*Ommatoiulus sabulosus* (L.)	Dziadosz 1966
1996	Kraków	*Ommatoiulus sabulosus* (L.)	new record by Pawłowski
1996	Stawska Góra near Chełm	*Ommatoiulus sabulosus* (L.)	new record by Kania
2000 – 2003	Dąbrowa Górnicza	*Ommatoiulus sabulosus* (L.)	new record
2002, 2003, 2004	Jaworzno, Chrzanów	*Ommatoiulus sabulosus* (L.)	new record

Tab. 2 Records of mass occurrence and migrations of millipedes in Europe.

Date of occurrence	Place	Millipede species	Author and date of publication
1900	Germany	*Ommatoiulus sabulosus* (L.)	Verhoeff 1900
1938	Germany	*Ommatoiulus sabulosus* (L.)	Verhoeff 1935/38
1953 – 1958	England	*Tachypodoiulus niger* (Leach)	Scott 1958 a, b
1960	France	*Ommatoiulus sabulosus* (L.)	Demange 1960
1961	Germany	*Ommatoiulus sabulosus* (L.)	Haacker 1968
1968	England	*Ommatoiulus sabulosus* (L.) *Tachypodoiulus niger* (Leach)	Fairhurst 1969
1977	Romania	*Strongylosoma stigmatosum* (Eichwald)	Ceuca 1982
1973	Germany	*Ommatoiulus sabulosus* (L.)	Helb 1975
1987, 1988	France	*Ommatoiulus sabulosus* (L.)	Sahli 1996
1980	Czech Republic	*Cylindroiulus caeruleocinctus* (Wood)	Samšinák 1981
1980	Norway	*Cylindroiulus londinensis* (Leach)	Meidell & Simonsen 1985
1993	Yugoslavia	*Megaphyllum unilineatum* (C. L. Koch)	Curcič & Makarov 1995
1995, 1996	Hungary	*Megaphyllum unilineatum* (C. L. Koch)	Korsós 1998
1999 – 2002	Germany	*Ommatoiulus sabulosus* (L.)	Ehrnsberger 2002

2. Materials and methods

Specimens of *O. sabulosus* were collected by hand from leaf litter in open areas around Dąbrowa Górnicza, Jaworzno and Chrzanów. Numerous millipedes were collected from meadows, fallows, fields as well as gardens and walls of residential buildings and warehouses. During the observation in the area measurements of soil pH were taken. Both sexes were differentiated under the stereomicroscope.

3. Results and discussion

Within the cities of Dąbrowa Górnicza and Jaworzno in the region of Upper Silesia as well as Chrzanów and the village of Balin (Małopolska), the millipede *Ommatoiulus sabulosus* occurred in masses. Millipedes were treated as pests, because they were invading agrocoenoses, gardens and houses.

This millipede was first reported in Dąbrowa Górnicza in 2000. Millipedes appeared in huge numbers in 2002, causing panic among the inhabitants. Specimens of *Ommatoiulus sabulosus* were wandering along streets and pavements, entering homes, warehouses a school and a church. In mid-May 2003 the invasion was less intense.

It is noteworthy that the infested districts of Dąbrowa G. are separated by approx. 4.5 km of arable areas, uncultivated for many years. Fallows, mostly degraded, constitute a convenient biotope for millipedes. In Jaworzno in the years 2002, 2003 and 2004 millipedes appeared on a massive scale in April and May, whereas numerous populations were present until the end of June. Thousands of specimens of the species were wandering across meadows, fields, fallows, and entering gardens. The studies on the collected specimens demonstrated the domination of adult forms (average length of males: 1.5 – 2.8 cm, females: 2.1 – 4.7 cm), with an average of 46 segments and a total number of approx. 700 specimens in the sample populations. The sex ratio was 1 : 1.4 with a prevalence of females. Adult specimens and fewer juvenile forms were occurring on a massive scale in the vicinity of housing, frequently entering cellars. The millipedes were climbing walls of buildings (up to 2 – 3 metres high) and the most of the specimens concentrated around front doors and balconies, entering houses. In May certain residential buildings in the vicinity of fallows were covered with a few thousand millipedes, almost all over the surface of walls. The largest numbers of *O. sabulosus* were noticed in the morning hours and around noon, in sunny weather. After a rainfall period, there appeared to be a considerable limitation in the population. In Jaworzno the millipedes were migrating across meadows and fallows on sandy ground. This is ecotone with *Pinus silvestris*, with such plant species occurring there as e.g. *Achillea millefolium*, *Artemisia vulgaris, Euphorbia esula, Solidago serotina, Prunus spinosa, Robinia pseudoacacia* as well as numerous grass species, e.g. *Calamagrostis epigeios*. During the observation period, soil pH values of 6.2 – 6.8 were measured in the vicinity. Mainly meadows and fallows cover the area, since cultivation of soil has been abandoned due to the creation of a new municipal landfill site. Houses and farm buildings with gardens are situated within 2 km. The village of Balin near Chrzanów has been infested with hordes of millipedes since 2002. The millipedes proved difficult to eliminate. In the vicinity, fallows are dominant (90 %), whereas meadows and fields (covering 10 %) border the pine forest on sandy ground. In a dozen home gardens millipedes were observed in such great numbers that they caused panic among the local village population.

For example, in June 2004, in one well-kept garden 505 specimens of millipedes (246 females, 249 males, 10 juveniles) were found on a single day. In wandering groups of millipedes adult males and females can be found with females prevailing due to their migrating to wet sites to lay eggs. A new house situated directly on the edge of field, meadow and fallow was covered with millipedes in great numbers in the spring. In June adult millipedes of both sexes were found in wet hiding places by and on the walls of houses. In the district of Chrzanów located on the pine forest fringe, the population density of *Ommatoiulus sabulosus* expanded at the most in April and May, with their numbers decreasing in June. All the inhabitants found the major problem in the secretion of odorous substances and migration of a huge number of millipedes, impossible to control in the period of springtime occurrence.

Reasons for mass-scale occurrence of *Ommatoiulus sabulosus* are:

1. Climatic factors may easily limit or shift the range of extent of the species. In the years 2002 and 2003 the average temperature in spring and summer was 25 °C, and winter temperatures ranged from –5 to +6 °C. Spring of 2002 and 2003 was characterised by high temperatures, with dry spells and rapid thunderstorms, and the winters of these

years were mild, with a small number of freezing days – mean monthly and annual temperatures were above average.

2. Food abundance of the environment, searching for new sources of foodstuff, competition of other species populations. The population of *O. sabulosus* was increasing until the specimens used all available food in the environment. Due to the rapid increase in reproduction, the population of *O. sabulosus* reached its climax in spring. The growth of millipede population ended with the mass occurrence.
3. The search for places to lay eggs. Females search for wet places rich in nutritional substances to lay their eggs.
4. Overwintering in dwellings, millipedes enter deep holes and underground corridors to find protection against cold, or they dig caverns where they stay for winter in adult stages or as juveniles. Overwintering inactivity differs in duration, depending on climatic factors. Observations of *O. sabulosus* occurrence indicate that the animals search for suitable overwintering places.

Stojałowska (1949) described a mass occurrence of *Ommatoiulus sabulosus* in Wólka Abramowicka near Lublin. Numerous specimens of *O. sabulosus* climbed trees and bushes in such numbers that branches were covered with them. In the mixed forest with pine and oak, specimens of *O. sabulosus* occurred in an area 2 km long and 0.5 km wide, on bilberries, moss and tree saplings, on the bark and leaves. As an example, 14 juvenile specimens of different age and 5 adults were found on the trunk of a oak-tree sapling, up to 1.5 metres above the ground. Adult and juvenile *O. sabulosus* specimens were found up to 2.5 m above the ground, but only on oak (*Quercus robur*) and aspen (*Populus tremula*) saplings. In warm, sunny weather conditions the animals did not avoid the sunlit side of trees, though there were fewer of them found there. Stojałowska (1968) mentioned that the ratio of the number of males and females was changing in the period of several months, from July to October males were found individually in »status medius«. In the whole number studied, females prevailed (sex ratio 3 : 1).

The mass occurrence of *Ommatoiulus sabulosus* in Kruklin, near Giżycko in Mazury, in June 1963 observed by Jabłoński and Salska, was described by Dziadosz (1966), based on a sample comprising 186 specimens: 125 females, 40 males, 1 »status medius« and 20 juveniles. The millipedes were wandering along the sunlit road in great numbers. The fact that a significant number of males were carried on females' backs indicates the occurrence of a mating march. Dziadosz (1966) claimed that the phenomenon of mass occurrence of millipedes was connected with their migration. This is caused by a mass migration with courtship and mating behaviour of adult specimens and migration of individuals of different age without courtship and mating behaviour. According to Dziadosz, the millipede migration may be attributed to atmospheric conditions as well.

The mass occurrence and vertical migration of *O. sabulosus* was observed in the reserve shrub steppe Stawska Góra near Chełm, east Poland, in May 1996. This is a shrub steppe and xerothermic grassland, where the largest number of specimens of *O. sabulosus* occurred on *Prunus spinosa*. The branches were covered with specimens of *O. sabulosus*, both adults and juveniles, in uncountable quantities (new record by Kania). According to Pawłowski, from Institute of Evolution and Systematic of Animals in Kraków, a mass occurrence of *O. sabulosus* was observed in Tyniec, part of Kraków, May 1996.

Mass occurrence of *Ommatoiulus sabulosus* in Germany and in France

Verhoeff (1900) described a mass migration of *Ommatoiulus sabulosus* on sunny days, which stopped a train in Sennheim, Alsace. Specimens of *O. sabulosus* were crossing the railway track over a length of 1 km. Crushed by the train, they caused lack of friction and stopped the train. The fact that almost all the observed specimens of female *O. sabulosus* were sexually mature may indicate the purpose of migration to be the search for place to lay eggs. Verhoeff claimed the millipede migration may have been caused by sexual impulse, though the explanation of the phenomenon does not seem sufficient. Verhoeff (1938) also described mass occurrence of *Ommatoiulus sabulosus* in the sandy region of Brandenburg in Germany. The millipedes were migrating before noon in sunny weather in May/June 1938.

Haacker (1968) described the migration of a few thousand specimens of *O. sabulosus* in a pine forest of Heidenheim (Rheinhessen, Germany) in April, 1961. On a forest road he found a 100 metre-long row of millipedes moving south-eastwards. Haacker claimed the appearance of *O. sabulosus* was not directly connected with soil pH (4.6 – 8.2).

The expansion of the number of specimens of *O. sabulosus* was observed on a sandy terrace of alluvial origin near Eusdorf and Bous (Saarland, Germany) in the years 1970 and 1973. The culmination of the phenomenon took place in May 1973, when the mass migration was found troublesome by locals. The enormous reproduction of the population *O. sabulosus* occurred on grass and bush-grown areas uncultivated for 10 – 15 years. *Robinia pseudacacia* was a dominant tree species in the area. As possible reasons of the mass occurrence the author mentioned climatic conditions, food supply and population expansion, caused by undisturbed development of *O. sabulosus* (Helb 1975). In the years 1999 to 2002 another mass occurrence of *O. sabulosus* was observed in the community of Holdorf (Western Saxony, Germany). The animals covered terraces and walls of many buildings over a length of 300 metres from May to the end of June. The infested buildings were separated from uncultivated areas by only one street. Mainly adult specimens participated in migration (70 %). The fact of climbing saplings and trees a considerable height by specimens of *O. sabulosus* involved both adult individuals and juveniles, and was demonstrated during increased or mass occurrences of the millipedes (Ehrnsberger 2002).

In France, Demange (1960) described the occurrence of *O. sabulosus* in the village Greoux-les-Bains (Lower Alps). Around one home one could collect kilograms of millipedes within a few minutes. The millipedes could be found in holes in the soil, places hidden from sunlight as well as close to the soil surface. The phenomenon was gaining intensity in April and May. Two mass migrations of *O. sabulosus* in France in Val de Sibourg (Provence) 1987, and Peillon (Alpes-Maritimes) 1988 were described by Sahli (1996). Migrations of millipedes began in April. Millipedes wandered across roads and pavements, and climbed fences and walls of buildings. The population of millipedes consisting of thousands of millions of adult, post-adult and juvenile individuals was too large to be counted.

Tajovský (1993) described the occurrence of specimens of *O. sabulosus* in three biotopes: meadows, fields and fallows in the Czech Republic. Schmitt and Roth (1998) observed *O. sabulosus* in meadows and fallows on the area of agrocoenoses in north-eastern Germany. In such biotopes as fields, meadows, fallows *O. sabulosus* became synanthropic (Haacker 1968). It was proved by research results of Jędryczkowski (1982), who mentions the existence of *O. sabulosus* on town fringes. In the area of Dąbrowa G., Jaworzno and Chrzanów in Poland millipedes were wandering across fallows, fields, sandy dry meadows to gardens, climbing walls of buildings and entering houses. *O. sabulosus* shows preference for poor soil and sandy, dry meadows (Voigtländer 1996, Voigtländer & Düker 2001) which is consistent with studies in the area of Dąbrowa G., Jaworzno and Chrzanów. Verhoeff (1935/38) observed that periodomorphosis does not affect migrations of *O. sabulosus*. However, Fairhurst (1969) claimed that the male periodomorphosis are linked with the phenomenon of wandering of *Tachypodoiulus niger* and *O. sabulosus*. Sahli (1990) indicates the possibility of overwintering in »status medius« forms of *O. sabulosus* as protection from low temperatures, or aestivation as protection from drought. Hibernating specimens of *O. sabulosus* were found in humus (1 – 3 cm deep) and in organic remains in the humus layers 30 – 60 cm deep (Barlow 1957). According to Halkka (1958) millipedes *O. sabulosu*s died at –2.5 °C below a thin cap of snow in Finland. Nevertheless, Haacker (1968) claimed that *O. sabulosus* was resistant to cold down to –7 °C. This was about the average temperature in the winters of 2000/2004 in Dąbrowa G., Jaworzno and Chrzanów.

Chemical control

In Jaworzno and Balin millipedes have been treated with pyrethroid insecticides, Alfasekt and Alfamor (Asplant – Skotniccy Sp. Jaworzno), which are only effective for one season. In Dąbrowa G., Basudin was applied to remove millipedes. The Institute of Plant Protection in Poznań allows the use of Basudin (toxic, 4th class) at a dosage of 8 – 120 kg per hectare, to control millipedes on arable areas and fallows. The mentioned chemicals are toxic for most living organisms, not only for pests. Basudin destroys e.g. *Elateridae*, whereas Alfamor is toxic for bees, and very toxic for fish and other water organisms. The applied chemicals are causing balance disturbance in biotopes within the vicinity of Dąbrowa G., Jaworzno and Balin, and are harmful to humans.

Biocontrol

Studies on the susceptibility of *O. sabulosus* to soil-dwelling nematodes and the entomopathogenic rhabditid nematodes *Heterorhabditis bacteriophora* Poinar, 1976 and *Steinernema carpocapsae* Weiser, 1955 have been conducted under laboratory conditions. Kania (2000) indicated that the death rate of *O. sabulosus* after 15 days of exposure to *Heterorhabditis bacteriophora* was 90 %. *Steinernema carpocapsae* caused 100 % cumulative mortality of millipedes in 15 days. The soil dwelling *Rhabditis strongyloides* caused no mortality after 15 days and encapsulated nematodes. The use of entomopathogenic nematodes to control millipedes at mass occurrence under field conditions would be reasonable instead of commonly used chemical substances. However, the lack of certification allowing the application of entomopathogenic nematodes excludes their practical use in the field.

4. Acknowledgements

We are very grateful to anonymous reviewers for useful comments on the manuscript. We extend our appreciation to Mr Pawel Staniewski for English translation. Thanks are also extended to Mrs Barbara Lubasz from the Municipality of Dąbrowa Górnicza, Mr Zbigniew Piatek from the Municipality of Jaworzno, Mr Tadeusz Mikłas – village administrator of Balin near Chrzanów.

5. References

Barlow, C. A. (1957): A factorial analysis of distribution in three species of diplopods. – Tijdschr. Entomol. **100**: 349 – 426

Blower, J. G. (1985): Millipedes. Keys and notes for the identification of the species. – Synopses of the British Fauna, (N. S.) **35**. – E. J. Brill, London, Leiden, 242 pp.

Ceuca, T. (1982): On the migrations at diplopods. – Nymphaea, Oradea **10**: 237 – 242

Cloudsley-Thompson, J. L. (1949): The significance of migration in Myriapods. – Ann. Mag. Nat. Hist. (London) **12** (2): 947 – 962

Ćurčić, B. P. M. & S. E. Makarov (1995): The occurrence of swarming in *Megaphyllum unilineatum* (C. L. Koch, 1838) (Diplopoda: Julidae), with observation on a case of pedal anomaly. – Arch. Biol. Sci., Belgrade **47** (1-2): 67 – 70

Demange, J. M. (1960): Sur un important rassemblement de *Schizophyllum sabulosum* L. (Myriapode-Diplopode). – Cahiers des Naturalistes Bull. Nat. Paris, n.s. **16**: 89 – 91

Dziadosz, C. (1966): Materiały do znajomości rozmieszczenia krocionogów (Diplopoda) w Polsce. – Fragm. Faun. **13**: 1 – 31

Ehrnsberger, R. (2002): Massenauftreten und Wanderung des Diplopoden *Ommatoiulus sabulosus* in Westniedersachsen. – Osnabrücker Naturw. Mitt. **28**: 199 – 203

Fairhurst, C. P. (1969): Activity and wandering in *Tachypodoiulus niger* (Leach) and *Schizophyllum sabulosum* (L.). – Bull. Mus. Natn. Hist. Nat. Paris **41**: 61 – 66

– (1974): The adaptive significance of variations in the life cycles of schizophylline millipedes. – Symp. Zool. Soc. London **32**: 575 – 587

Haacker, U. (1968): Deskriptive, experimentelle und vergleichende Untersuchungen zur Autökologie rhein-mainischer Diplopoden. – Oecologia **1**: 87 – 129

Halkka, R. (1958): Life history of *Schizophyllum sabulosum* (L.) (Diplopoda, Julidae). – Ann. Zool. Soc. Zool.-Bot. Fenn. »Vanamo« **19**: 1 – 72

Helb, H. W. (1975): Zum Massenauftreten des Schnurfüßlers *Schizophyllum sabulosum* im Saarland (Myriapoda: Diplopoda). – Entomol. Germanica **1**: 376 – 381

Hopkin, S. P. & H. J. Read (1992): The biology of millipedes. – Oxford University Press, Oxford, New York, Tokyo, 233 pp.

Jawłowski, H. (1929): Krocionogi okolic Warszawy i niektóre gatunki z innych miejscowości Polski. – Spraw. Kom. Fizjogr. PAU, Kraków, **63**: 283 – 314

– (1936): Krocionogi poludniowo-wschodniej Polski. – Fragm. Faun. Mus. Zool. Pol. Warszawa **25**: 253 – 298

Jeekel, C. A. W. (1968): The generic and subgeneric names of the European Julidae generally referred to as *Schizophyllum* Verhoeff, 1895 (Diplopoda, Julida). – Entomol. Ber. Deel **28**: 49 – 51

Jędryczkowski, W. (1982): Millipedes (Diplopoda) of Warsaw and Mazovia. – Memorabilia Zool. **36**: 253 – 261

– (1992): The distribution and ecology of the millipedes in Poland. – Ber. Nat-med. Verein Innsbruck, Suppl. **10**: 385 – 391

– (1994): Krocionogi (Diplopoda) wybranych srodowisk Roztocza. – Fragm. Faun. **37**: 109 – 114

Kania, G. (2000): Susceptibility of the millipede *Ommatoiulus sabulosus* (Diplopoda, Julida: Julidae) to infection with nematodes. – Fragm. Faun. Suppl. **43**: 201 – 205

Korsós, Z. (1998): Ikerszelvényes-invázió Magyarországon. – Állattani Közl. **83**: 53 – 65

Latzel, R. (1884): Die Myriapoden der Österreichisch-Ungarischen Monarchie. Mit Bestimmungs-Tabellen aller bisher aufgestellten Myriopoden-Gattungen und zahlreichen, die morphologischen Verhältnisse dieser Tiere illustrierenden Abbildungen. Zweite Hälfte: Die Symphylen, Pauropoden und Diplopoden, nebst Bemerkungen über exotische und fossile Myriopoden-Genera und einem Verzeichnis der gesamten Myriopoden-Literatur. Wien, 414 pp.

Linnaeus, C. (1758): Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Holmiae, editio decima, reformata. Vol. 1, 824 pp.

Meidell, B. & A. Simonsen (1985): A mass occurrence of *Cylindroiulus londinensis* (Leach, 1815) in Norway. – Fauna norv. Ser. B **32** : 47 – 48

Perttunen, V. (1953): Reactions of Diplopods to the relative humidity of the air. Investigations on *Orthomorpha gracilis*, *Julus terrestris* and *Schizophyllum sabulosum*. – Ann. Zool. Soc. Zool.-Bot. Fenn. »Vanamo« **16** (1): 1 – 69

Sahli, F. (1990): On post-adult moults in Julida (Myriapoda, Diplopoda). Why do periodomorphosis and intercalaries occur in males? – In: Minelli, A. (ed.): Proceedings ot the 7th International Congress of Myriapodology. – Brill, Leiden: 135 – 156

– (1996): Déplacements en masse dans le sud-est de la France chez *Ommatoiulus sabulosus* (Myriapoda, Diplopoda, Julidae) avec invasions d´habitations. – In: Geoffroy, J. J., J. P. Mauries, M. Nguyen Duy-Jacquemin (eds): Acta Myriapodologica. Mem. Mus. Nat. Hist. Nat. **169**: 587 – 598

Samšinák, K. (1981): Über einige in Häusern lästige Arthropodenarten. – Anz. Schädl.kde. Pfl.schutz, Umweltschutz **54** : 120 – 122

Schmitt, G. & M. Roth (1998): Centipede and millipede communities in cultural landscapes of Northeast-Germany. Soil Zoology Problems in Central Europe. – In: Pižl, V. & K. Tajovsky (eds): Proc. 4th Central Europ. Workshop on Soil Zoology: 191 – 197

Schubart, O. (1934): Tausendfüßler oder Myriapoda. I: Diplopoda. – In: Dahl, F. (ed.): Die Tierwelt Deutschlands 28, Gustav Fischer Verlag, Jena, 318 pp.

– (1940): Myriapoda II. Die Wanderungen der Myriapoden. – Tabul. Biol. **18** (2/3): 216 – 229

Scott, H. (1958a): Migrant millipedes and centipedes entering houses 1953 – 1957. – Entomol. Mon. Mag. **94**: 73 – 77

– (1958b): Migrant millipedes entering houses 1958. – Entomol. Mon. Mag. **94**: 252 – 256

Stojałowska, W. (1949): Masowe pojawy krocionogów w okolicy Lublina. – Ann. UMCS Lublin **4**: 269 – 275

– (1950): Krocionogi okolic Lublina na tle fauny krocionogów Polski. – Ann. UMCS Lublin **5**: 217 – 244

– (1959): Analiza wedrówki *Strongylosoma pallipes* (Olivier) (Diplopoda). – Ann. UMCS Lublin **14**: 127 – 140

– (1961): Krocionogi (Diplopoda) Polski. – PWN, Warszawa, 216 pp.

– (1962): Sezonowe migracje *Glomeris hexasticha* Brandt (Diplopoda). – Abstract VII Congr. Pol. Soc. Zool. (3.09. – 5.09.1962) Toruń, Poland

– (1968): Materialy do poznania krocionogów (Diplopoda) Wyżyny Lubelskiej. – Fol. Soc. Scient. Lublin. B. **7/8**: 83 – 93

– & W. Staręga (1974): Krocionogi (Diplopoda). Katalog Fauny Polski. – PWN, Warszawa, 71 pp.

Tajovský, K. (1993): Diversity and structure of millipede communities (Diplopoda) in four different biotopes. – Ekologia (Bratislava) **12** (3): 277 – 283

Tracz, H. (1996): Spectrum of Diplopoda species in fresh pine stands of Poland. – Ann. Warsaw. Agricult. Univ. SGGW Forestry and Wood Techn. **47**: 39 – 46

Verhoeff, K. W. (1900): Wandernde Doppelfüßler, Eisenbahnzüge hemmend. – Zool. Anz. **23**: 465 – 473

– (1935/38): Diplopoden der Germania zoogeographica im Lichte der Eiszeiten. – Zoogeographica **3**: 494 – 547

Voigtländer, K. (1996): Diplopoden und Chilopoden von Trockenstandorten im Hallenser Raum (Ostdeutschland). – Hercynia N. F. Halle **30**: 109 – 126

– & C. Düker (2001): Distribution and species grouping of millipedes (Myriapoda, Diplopoda) in dry biotopes in Saxony-Anhalt/Eastern Germany. – Eur. J. Soil Biol. **37**: 123 – 126

Würmli, M., (1972): Zur vergleichenden Synökologie und Faunistik der kryptozoischen Makroarthropoden Mitteleuropas und Süditaliens. – Mitt. Schweiz. Entomol. Ges. **45**: 157 – 216

Wytwer, J. (1992): Diplopoda of pine forest in Poland. – Fragm. Faun. **36**: 109 – 126

Authors' addresses:

Dr Grzegorz Kania
Department of Biology & Parasitology, Medical University, ul. Radziwillowska 11
20-080 Lublin, Poland
e-mail: grzegorz.kania@am.lublin.pl

Prof. Dr hab. Henryk Tracz
Department of Forest Protection and Ecology, Agricultural University,
ul. Nowoursynowska 159
02-776 Warszawa, Poland
e-mail: tracz@wl.sggw.waw.pl