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The enchytraeid assemblage (Annelida: Clitellata: Enchytraeidae) of a Sandhill prairie site in Nebraska, USA

Jiří Schlaghamerský

Masaryk University, Faculty of Science, Department of Botany and Zoology, Kotlářská 2, 611 37 Brno, Czech Republic
E-mail: jiris@sci.muni.cz

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Abstract

Hitherto the enchytraeid fauna of North American prairie and other types of grassland remains unknown. In March 2011 soil samples were taken in a Sandhill prairie habitat used as rangeland, close to Grand Island, Nebraska. Enchytraeids were extracted by the wet funnel method and identified alive. The total enchytraeid density was 3400 ± 800 individuals/m^2 (± SE); 70 % of the individuals were present in the upper 3 cm of soil (sampling depth: 12 cm). The assemblage consisted of at least six species, the identity of four could be ascertained. *Bryodrilus librus* (Nielsen & Christensen, 1959) was predominant, followed by *Fridericia bulboides* Nielsen & Christensen, 1959. For *B. librus* this is the southern-most reported locality within its known range. Also present was *Enchytraeus dichaetus* Schmelz & Collado, 2010, the occurrence of which in North America had been published once before from Canada without any details on its locality. The rather poor assemblage might be the result of a harsh climate and drought-sensitive sandy soil.

Keywords Enchytraeidae | community structure | grassland | North America soil | soil fauna

1. Introduction

At the time of European settlement, North America was rich in mesic and semiarid grasslands; since then mesic grasslands, i.e. true pairie, have been largely transformed to intensive agriculture (Whitcomb 1989). Strangely enough, there is not a single publication on the enchytraeid fauna of natural or at least semi-natural grasslands of North America. Literature on North American enchytraeids or potworms is generally scarce (see Schlaghamerský 2013, this volume) and only one single study provides information on the composition of entire enchytraeid assemblages of well-defined sites, albeit lacking data on the percentage representation of the species based on abundance data (Dash & Cragg 1972). However, this study covers only two forest types and a fen in the Canadian Rocky Mountains. Nurminen (1973) collected *Fridericia bulboides* Nielsen & Christensen, 1959, *F. ratzeli* (Eisen, 1872) and *Enchytraeus christenseni* Dózsa-Farkas, 1992 (as *E. minutus* Nielsen & Christensen, 1961) in meadows close to Montreal, Canada, but presented only faunistic data. Healy (1989, 1996) reported on qualitative collections made in West Florida, however, although various terrestrial and aquatic habitats were covered, grasslands were only marginally represented and the published data do not allow any assessment of their enchytraeid fauna. Bird (1930) published a quantitative study on biotic communities of the Aspen Parkland in Manitoba, Canada, which also included a virgin tallgrass prairie site. He reported the occurrence of enchytraeid individuals without any discrimination to species. Unfortunately, even the quantitative data are of no use as the extraction method used at that time was inappropriate for this group.

In March 2011, visiting the Platte River valley in Nebraska, I took the opportunity to take soil samples at an apparently near-natural site within rangeland near the town of Grand Island. To my knowledge these data on the encountered enchytraeid assemblage are the first of their kind and thus present a significant, although modest,

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contribution to the exploration of the North American enchytraeid fauna and the soil fauna, and biodiversity in general, of prairies.

2. Materials and methods

2.1. Study site

A small area of rangeland (41°0'13.669"N, 98°28'49.595"W, ca. 587 m a.s.l.) along a dirt road on Taylor Ranch, situated ca 25 km north of the Platte River and ca 10 km north-west of the town of Grand Island, Nebraska (USA), was sampled (Fig. 1). According to cattle dung present, this area had been grazed rather recently. It was close to a reported lek site of the Greater Prairie Chicken (*Tympanuchus cupido pinnatus*), which is considered an indicator of well-preserved native prairie (Johnsguard 2007). Thus the land can be considered to be a fairly natural prairie despite its use as rangeland. However, this might not necessarily fully apply to the sampled piece of land close to the road. The area is situated some distance south-east from the Nebraska Sand Hills, the core area of Sandhill prairie (Whitcomb 1989), which is a type of mixed grass prairie typical of stabilized sand dunes. Nevertheless the land of Taylor Ranch includes stabilized sand dunes and is referred to as Sandhill prairie (e.g., Johnsguard 2007). In general, the wider area around Grand Island represents a transition zone between tallgrass prairie in the east (penetrating along the Platte River to the west) and mixed grass and Sandhill prairie in the west (and in the uplands).

According to data listed for Taylor Ranch by the Natural Resources Conservation Service (http://soils.usda.gov, accessed on May 7, 2011), the vegetation consists of sand bluestem (*Andropogon hallii,* 25%), prairie sandreed (20%), little bluestem (*Calamovilfa longifolia*, 20%), switchgrass (*Panicum virgatum*, 10%), needleandthread (*Hesperostipa comata*, 5%), miscellaneous perennial grasses (5%), and miscellaneous perennial forbs (5%); the soil is Valentine fine sand with a moist bulk density of 1.40–1.60 g/cm^3, an organic matter content of 0.5–1% and a soil pH of 5.6–7.3 (all values for the upper 5 inches ≈ 13 cm of soil). However, the sampled plot was at the foothill of a stabilized sand dune and the sampled soil probably had a higher percentage of silt and clay than given for typical Valentine fine sand – it was extremely fine-grained and of high cohesion when dry. Several types of loess-derived silt and clay loams have been mapped in the area south of the 'sand hills' (Veatch & Seabury 1918). A composite soil sample of the upper 12 cm of soil taken by the present author had a pH (H_2O) of 7.5.

The area is situated in the east-central part of the Great Plains and its climate is transitional between that of the north-central Mississippi Valley and the semiarid climate of the High Plains. Rainfall is moderate and frequently low, humidity relatively low and the rate of evaporation relatively high; there is a wide range between high and low temperatures (Veatch & Seabury 1918). According to the Natural Resources Conservation Service (http://soils.usda.gov, accessed on May 7, 2011), Taylor Ranch has a mean annual precipitation of ca 640 mm, mean annual temperature of 10–12°C and a frost free period of 150–170 days. During the cold winter months, the soil in the area 'freezes to a depth of several feet', summers are usually very warm, temperatures frequently rising above 38°C (Hearn & Burgess 1903). After a very cold winter (from November 2010 temperatures remained most of the time below 0°C, e.g. from January 8 to January 14 without interruption), the area had experienced a warm spell from February 11 to February 20, 2011, at the beginning

Figure 1. Location of the Sandhill prairie sampling site (dot) on Taylor Ranch near Grand Island, Nebraska.

of which the snow cover melted. Another cold spell was interrupted around mid-March, but by the time of sampling low temperatures and snow-fall had returned (http://weatherspark.com/history/, accessed on March 27, 2013).

2.2. Sampling and sample processing

On March 26, 2011 six soil cores were taken at random positions within an area of ca 10 m × 10 m, using a split soil corer of 4.8 cm in diameter (18 cm^2 surface area). The sampling depth was 12 cm, in two cases the sample could be taken only down to 9 and 11 cm, respectively, due to high soil density (or frozen soil). Enchytraeids were extracted from these layers by a modified O'Connor wet funnel extraction as developed for the quantitative extraction of enchytraeids (24 h without heating with subsequent heating of the soil surface up to 44°C within 4 h; for a comparison of extraction efficiency of the original O'Connor method and some modifications see Kobetičová & Schlaghamerský 2003). Prior to extraction the soil was kept cool during transportation and stored in a refrigerator at ca. 4°C. Extracted enchytraeids were kept in water-filled Petri dishes at the same temperature. Enchytraeids were identified under a light microscope to species or at least to genus level (the latter in particular in cases of juveniles, injured or dead specimens), except for a few specimens already decomposing at the time of examination.

3. Results

In total, 37 specimens of enchytraeids were extracted from the soil cores. Of these, five dead specimens could not be identified to genus. The total enchytraeid density was 3400 ± 800 individuals/m^2 (± SE, rounded to the nearest hundred). The vertical distribution was very uneven, with 70 % of individuals in the upper 3 cm of soil (including the grass litter) and 8–14 % in the following three 3-cm layers (Fig. 2). The assemblage consisted of at least six species, the identity of four could be ascertained. *Bryodrilus librus* (Nielsen & Christensen, 1959) was predominant, followed by *Fridericia bulboides* (Fig. 3). All the subadult and adult *Bryodrilus* specimens had spermathecae that were attached to the oesophagus and up to 5 chaetae per bundle. They had been originally identified as *B. parvus* Nurminen, 1970, synonymized with *B. librus* by Dózsa-Farkas et al. (2012). Three *Enchytraeus* specimens were present: a subadult *E. dichaetus* Schmelz & Collado, 2010, an adult individual of *E. buchholzi* s. l. Vejdovský, 1879 and a third, juvenile specimen that was tentatively assigned to *E. buchholzi* due to its chaetal formula: 2 – 2 : 3, 2 – 2 (thin body of 3 mm length, 18 segments, posterior part injured but complete; first nephridia at VI/VII; coelomocytes not visible due to prominent chloragogenous tissue with cells full of refractile droplets). Two specimens belonged to the genus *Achaeta*: one was juvenile (3.2 mm long), the other subadult (2 mm long, 22 segments, a short spermatheca in V and a small sperm funnel with attached spermatozoa were observed, both were probably not fully developed). In the subadult specimen, the dorsal vessel originated in VII, i.e. posterior to the third pair of pharyngeal glands. There were two pairs of preclitellar nephridia at VI/VII and VII/VIII, the brain posterior margin was rounded. No pyriform glands were present and neither lense-shaped nor other conspicuous cutaneous gland cells were visible. One subadult enchytraeid specimen was tentatively assigned to the genus *Oconnorella*: 3.7 mm long, 19 segments; chaetae straight, size within bundle approximately identical, formula: 2, 3 – 2, 3 : 3, 4 – 3; origin of dorsal vessel in XIII (XIV?); pale, oval coelomocytes (slightly smaller then length of chaetae), no oesophageal appendages observed, *Oconnorella*-type nephridia (Chen et al. 2006); seminal duct visible in XI/XII, other reproductive organs not observed.

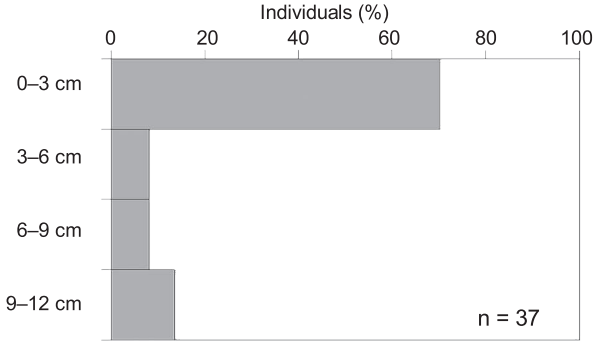

Figure 2. Vertical distribution of enchytraeids in the upper 12 cm of soil (four 3-cm layers extracted).

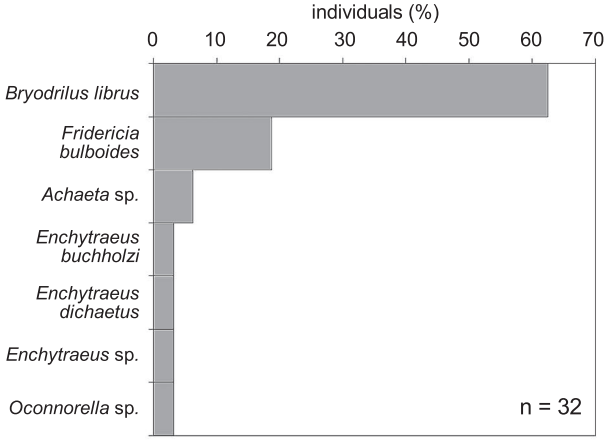

Figure 3. Dominance of enchytraeid taxa.

4. Discussion

The enchytraeid density found was low but not extreme, in particular as it represented a single sampling at the end of a harsh winter (cf. Didden 1993 – listing abundance data for a range of habitats based on year-round sampling); similar values for grasslands and individual sampling dates were found for instance by Schlaghamerský & Kobetičová (2006) and Schlaghamerský et al. (2007).

The enchytraeid assemblage of the study site was rather poor. This could have had several reasons. One might have been the low number of extracted soil cores. However, the dominant position of a single species, *Bryodrilus librus*, in almost all soil cores taken indicates that this was indeed the predominant species in the assemblage. Except one other species, *Fridericia bulboides*, all others were represented by very few specimens. Several scarce species might have gone unnoticed. Another reason might have been the sampling date during cold temperatures at the end of a severe winter in an area where soil freezes to a considerable depth. Possibly only those species particularly well adapted to survival at low temperatures had been able to maintain larger populations (or to use the preceding thawing periods for some recovery). Scarce species (potentially including some not recorded) might have required a longer recovery period in spring and could possibly reach a higher percentage representation in the assemblage at other times of the year. In general, the climate with extreme low temperatures in winter as well as high temperatures and dry spells in summer might be an extreme habitat for soil fauna, in particular in sandy soils sensitive to drought. A third reason might have been the slightly alkaline soil of the sampled piece of land. There are, in general, few data on enchytraeids in alkaline soils. Individual enchytraeid species show preferences for certain ranges of soil pH and most would prefer a soil pH below 7. However, the richest enchytraeid assemblages have been reported from a site with a pH approaching 7: Mellin (1988) found 36 species in a German beech forest on lime stone (the high heterogeneity of soil with a pH (H_2O) range of 4.95–6.8 in the upper 5 cm would have increased species diversity). Schlaghamerský (2010) found 20 enchytraeid species in a Central-European oak-hornbeam forest on flysch with a soil pH (H_2O) of 7.3. The richest enchytraeid assemblage in a grassland, consisting of 27 species, was reported from an old park lawn in Germany (Möller 1971). In Central-European hay meadows and pastures on Cambisols with flysch as the bedrock, covering a pH (H_2O) range of 4.8–6.9 in the upper 10 cm of soil, 11 to 23 species were found per site; the site with the highest pH hosted 17 species (Schlaghamerský & Kobetičová 2006, Schlaghamerský et al. 2007). Therefore it is not probable that a slightly higher pH value, such as the one encountered in the present study, would lead to a substantially impoverished assemblage. However, we know very little about the effect of other soil properties, such as soil texture, on species richness and composition of enchytraeid assemblages. From an ecosystem or landscape perspective, Sandhill prairie consists of diverse (meso-)habitats, also including wetlands in the interdunes (Whitcomb 1989). Sampling the different habitats would probably increase the number of species recorded and reveal the existence of several assemblages typical of individual mesohabitats.

In terms of species composition, the presence, let alone predominance, of *B. librus* is remarkable. An overview of its distribution was given by Dózsa-Farkas et al. (2012). Originally described from Greenland, it was subsequently found to have a Holarctic distribution in many northern countries. Until recently, the southern-most locality known from North America was in southern Alberta, Canada, from where Dash (1970) had described the variety *B. parvus* Nurminen var. *kananaskis* (for synonymy of *B. parvus* see above). He found the species in an aspen and a coniferous forest as well as in a fen, in soils with a pH of 6.4–6.7 (Dash & Cragg 1972). As commented by Nurminen (1973), who found *B. librus* (reported as *B. parvus*) in the vicinity of Montreal, based on the given description the erection of a subspecies seems little justified. Schlaghamerský et al. (submitted) recorded the species at two deciduous forest sites in the north of Minnesota and Wisconsin (the soils had a silt loam texture and the more acid soil of the latter site had a mean soil pH (H_2O) of 4.4 only). In Europe, *B. librus* was recently found as far south as southern Hungary (Dózsa-Farkas et al. 2012); these localities in the Pannonian plain are steppe areas with sandy or loess-derived soils of high pH, thus resembling the present study area. Much earlier it had been reported from the Großglockner area in the Austrian Alps (Nurminen 1977), which was overlooked by Dózsa-Farkas et al. (2012). The present record is six degrees latitude further south than the southern-most localities of *B. librus* known both in Europe (southern Hungary) and North America (northern Wisconsin). Xie et al. (2000) reported the species (as *B. parvus*) from Changbaishan Mountain in north-eastern China at 42°35'N, but the described differences to the original description of the species (in particular the thin-walled oesophageal appendages) raise some doubt about the true species identity (as also admitted by the authors).

Fridericia bulboides is a species wide-spread in Europe and elsewhere (Schmelz 2003, Schmelz & Collado 2010). In North America it was reported from Alberta (Dash 1970, Dash & Cragg 1972), Quebec (Nurminen 1973),

the Arctic Archipelago (Christensen & Dózsa-Farkas 2006), all of Canada and from Maine, USA (Schmelz 2003). The author also found it in low numbers in forests of northern Minnesota and Wisconsin (Schlaghamerský et al. submitted).

Most *Enchytraeus* species are considered to be r-strategists with a preference for neutral soils (Graefe & Schmelz 1999). *E. buchholzi* s. l. represents a complex of species, being among the most drought-resistant enchytraeids. *E. dichaetus* Schmelz & Collado, 2010, is a very similar species, characteristic by its chaetal formula. Schmelz & Collado (2010) mention their record of this species in 'Canadian field soil' without any further detail. The present record and another one made later in 2011 in the Chippewa National Forest in northern Minnesota (Schlaghamerský et al. submitted) are the first records of this species from North America giving actual localities and details about the habitat.

The description of a single assemblage, based on limited sampling of a small area at a single date, presents a very modest contribution to our knowledge of the soil fauna, and enchytraeid fauna in particular, of North American grasslands. Nevertheless, its value becomes apparent when we consider the total absence of such data up to the present day.

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