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Editorial

Final Note of Special Issue "Tardigrades Taxonomy, Biology and Ecology"

Łukasz Kaczmarek

Department of Animal Taxonomy and Ecology, Adam Mickiewicz University, Poznań, Uniwersytetu Poznańskiego 6, 61-614 Poznań, Poland; kaczmar@amu.edu.pl

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Abstract: Tardigrada (water bears) are microscopic invertebrates inhabiting aquatic (freshwater and marine) and terrestrial habitats. They are thriving in almost all Earth ecosystems from deepest oceans to highest mountains, from tropics to polar regions. Water bears are probably most famous for their cryptobiotic abilities, which allow them to survive a broad spectrum of extreme environmental conditions. The Special Issue on tardigrades was launched to popularize research on these fascinating microinvertebrates. The published papers were focused on (a) marine and terrestrial tardigrades diversity, (b) interpopulation variability of Antarctic eutardigrade *Paramacrobiotus fairbanksi*, (c) encystment in freshwater eutardigrade *Thulinius ruffoi* and (d) use of a metabarcoding approach to community structures studies in microenvironments.

Keywords: diversity; encystment; interpopulation variability; metabarcoding; new species; Tardigrada; taxonomy

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Tardigrada (known colloquially as water bears or moss piglets) are microscopic invertebrates inhabiting aquatic (freshwater and marine) and terrestrial habitats. They are very frequent in almost all of Earth's ecosystems from deepest oceans to highest mountains, from tropics to polar regions. They can be found in lichens, mosses, soil and aquatic sediments [1–6]. Tardigrades are relatively poorly known, up to now ca. 1300 species of tardigrades have been described [7] and new species are still being described every year (http://www.tardigrada.net/newsletter/index.htm.). Water bears have a bilaterally symmetrical body and four pairs of legs mostly terminating in claws. A tardigrade's body is divided into a head (cephalic) segment and four trunk segments each bearing a pair of legs. Body length ranges from 50 μm in marine or juveniles of freshwater or terrestrial, to 1200 μm in adults with an average of 250–500 μm. The cuticle is soft in Eutardigrada or covered by cuticular plates in Heterotardigrada. They have a complete digestive system and body cavity, with numerous free-floating storage cells, which is responsible for respiration and circulation. The nervous system consists of a simple brain and a ventral nerve chain with four bilobed ganglia. Tardigrades are bisexual, parthenogenetic or hermaphroditic [1]. Tardigrades can be herbivorous and feed on algae, bacteria or plant cells; carnivorous, feeding mainly on microscopic invertebrates such as rotifers or nematodes, but also on other tardigrades; or omnivorous and feed both on plants and invertebrates, see [1–8]. Water bears are probably the most famous for their cryptobiotic abilities, which allow them to survive a broad spectrum of extreme environmental conditions, e.g., lack of water, very low and high temperatures, ionizing radiation, starvation, lack of oxygen, high levels of different types of chemicals or space vacuum, see [9–12]. What is even more exciting, tardigrades can possibly "cheat death" and do not age during anhydrobiosis [13].

Although the tardigrades are known in general, there are numerous knowledge gaps to be fulfilled. For this reason, as a guest editor, I thought about proposing the Special Issue: "Tardigrades Taxonomy, Biology and Ecology" in the *Diversity* journal. Overall, five papers were published, providing novel insights into this fascinating group of invertebrate animals.

Janelt and Poprawa [14] analyzed the poorly studied phenomenon of encystment in the freshwater eutardigrade, *Thulinius ruffoi* (Bertolani [15]). Authors described in detail a process of cyst formation, as well as the morphology of cysts and animals inside the cyst. In the main conclusions, they stated that the cyst capsule is composed of three cuticle layers. Cuticle layers are increasingly simplified (from outside to inside). Tardigrades inside the cyst are covered with a cuticle that develops like nonencysted specimens of this species and possesses claws and produces only one functional buccal-pharyngeal apparatus [14].

Gomes-Júnior et al. [16] studied deep sea (between 150 and 3000 m bsl) tardigrades of the genus *Coronarctus* Renaud-Mornant [17] from the south-western Atlantic Ocean and described three species new for science. The authors also discussed the most important morphological characters in the genus and presented identification key to all known *Coronarctus* species [16].

Berdi and Altındağ [18] studied terrestrial tardigrades in the province of Karabük (Turkey) and reported two species, *Echiniscus granulatus* (Doyère [19]) and *Diaforobiotus islandicus* (Richters [20]), new for this province. Moreover, the authors provided a current checklist of tardigrade species reported from Turkey, indicating their localities and geographic distribution [18].

In the next paper of the SI, Kaczmarek et al. [21] focused on terrestrial Antarctic tardigrades. Authors reported eight tardigrade taxa from this region including parthenogenetic *Paramacrobiotus fairbanksi* Schill, Förster, Dandekar and Wolf [22], which are considered by authors as cosmopolitan species which confirm the “everything is everywhere” hypothesis. Moreover, Kaczmarek et al. [21] analyzed morphological and genetic differences between the few populations of *Pam. fairbanksi* from distant localities and small statistically important genetic and morphological differences were shown.

Arakawa [23] studied community structures within xeric and mesic mosses. The author used metabarcoding to identify all prokaryotes and eukaryotes, including tardigrades. In xeric mosses xerophilic tardigrades and other anhydrobiotic invertebrates seem to have limited diversity and the prokaryotic population was dominated by cyanobacteria, which suggests that in such environments only organisms resistant to extreme desiccation are able to survive. In conclusion, such combined metabarcoding approaches can be highly useful to study community structures within microscopic ecosystems, i.e., microecology [23].

As a guest editor for this Special Issue, I would like to express my gratitude to all the authors for their contributors and the reviewers for their work in the manuscript evaluations. I am confident that this Special Issue not only shows the diversity of studies carried out in the field of tardigrades but also will inspire different research teams to conduct subsequent investigations and further explore this fascinating phylum of microinvertebrates.

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