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Editorial

Biodiversity of Mites

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Nature is a highly complex, intricate system constructed of a network of interdependencies between individual species, their communities and their habitats. When climatic factors (such as temperature and humidity) and environmental factors (for example, latitude) are additionally considered, it comes as no surprise that scientists investigating this complicated and wondrous world face considerable problems. An important role in this complex ecological system is played by mites, which are actively involved in the flow of energy, matter and information. As is commonly known, these tiny, ubiquitous invertebrates are found both in terrestrial and aquatic ecosystems, while additionally being relatively abundant in the aeroplankton. The richness of the mite fauna may be analysed in terms of their zoogeography, ecology, taxonomy, or parasitology, amongst others, or even paleontology. The species composition and the character of their assemblages vary greatly, beginning from pioneering species found in postglacial or volcanic regions and ending with the mind-boggling, still only partly known, richness in tropical forests. In view of all the above-mentioned factors, researchers need to adopt a unique approach to the studied research topics and precisely identify their aims; that is, the scientific problems. A specific methodology will need to be applied to solve such problems ranging from, for example, the morphological analysis of mite specimens embedded in amber to the application of state-of-the-art molecular techniques. A platform for discussions on the biodiversity of mites and the presentation of current challenges faced in acarological studies has been created by Diversity in this Special Issue.

At present, researchers specialising in life sciences focus their studies on the increasingly evident and pervasive effects of climate change. This phenomenon has been the subject of numerous public debates and political decisions. The consequences of climate change are particularly visible in polar regions, in which melting and retreating glaciers expose ground on which primary succession may develop and pioneer species may establish. This line of research is represented in this issue by a study on assemblages of the oribatid mite fauna of the sub-polar Urals [1], especially pertinent since these invertebrates may be good bioindicators of environmental changes caused, for example, by climate change. Melekhina [1], in her paper, identified 163 species belonging to 45 families, among which the leading families in the fauna include Crotoniidae, Ceratozetidae and Oppiidae. The share of Palearctic species is low (23.4%), which separates the fauna of the tundra zone from the taiga zone.

Another study, even more strongly associated with this theme, was conducted in the Svalbard archipelago located in the High Arctic [2]. With rapidly changing climatic and habitat conditions, these islands are an excellent region to observe changes in the ranges of certain species, including mites. Seniczak et al. [2] summarised over 100 years of studies on the Svalbard archipelago by listing 178 mite species (1 Ixodida, 36 Mesostigmata, 43 Trombidiformes, and 98 Sarcoptiformes) and providing their localities on each island of this archipelago. They observed that, in contrast to Trombidiformes and Sarcoptiformes, which are dominated in Svalbard by species with wide geographical distributions, the Mesostigmata include many Arctic species (39%). Such information may prove significant for future studies considering climate change and resulting alterations in the species composition or character of mite assemblages. Moreover, these authors stated that a large number of new species (42 spp.) have been described from Svalbard, including 15 that have so far been found there exclusively. Yet, it is uncertain if any of these latter species are endemic: six are recent findings, the others are old records and, in most cases, impossible to verify.

An interesting problem of endemism was also presented in the paper by Błoszyk and Napierała [3]. They studied the geographical distribution of mites from the suborder Uropodina gathered from literature sources and their own studies conducted on approximately 40,000 samples collected from various geographical regions. On this basis, they attempted to identify a common endemism in this group of mites, or rather, if the distribution patterns observed are the result of sparce sampling and poor identification. By presenting several examples, the authors highlighted the necessity to provide more accurate, precise descriptions of new species, including individual variation, and to conduct extensive taxonomic studies on all the continents.

Acarologists have occasionally focused on species colonising trees, living, for example, in various parts of the stem, branches or leaves. However, limited research has been carried out on the evolution of these mites and their adaptation to the arboreal lifestyle, such as phenotypic adaptations. Fortunately, this research problem was investigated by Schäffer et al. [4], who suggested that an arboreal life evolved independently and that tree-living is more common in evolutionary younger taxa with strong sclerotization, sexual reproduction, and capitate sensilla. Based on the analysis of certain morphological traits of oribatid mites, these researchers stated that it is the capitate sensillus that appears to be a morphological (pre)-adaptation to life on trees (arboreal sensu lato), potentially functioning as a gravity receptor. Moreover, they concluded that only taxa that live on the bark of stems and branches without a layer of lichens or mosses, in the canopy or on twigs and leaves and undergo their whole life cycle on the tree should be regarded as arboreal sensu stricto.

The occurrence of mites in specific habitats and microhabitats depends on their locomotion, transport, or on the established manner of their dispersion. One of these is connected with phoresy, that is, a specific form of zoochory when a mite uses other animals, for example, mammals, birds or insects, as a means to spread and disperse. This phenomenon was investigated by Konwerski et al. [5]. They analysed almost a thousand beetle individuals, identifying on their bodies over 25 thousand deutonymphs of mites from the suborder Uropodina. It was observed that, depending on the beetle species, different mite species are transported. Moreover, mites show preferences for different attachment locations on the beetle's body. In the case of the *Oodinychus ovalis* (mite) and *Monochamus sartor urussovii* (beetle) association, the deutonymphs were found mostly on the pronotum and dorsal surface of the elytra, while the highest number of deutonymphs of *Trichouropoda shcherbakae* was on *Tetropium castaneum*, and *T. fuscum* were observed on the legs.

For thousands of years, humans have been converting the natural environment, for example, through the production of arable fields or pastures. Transformation of the forest environment into agricenoses may lead to a reduction in biodiversity as a source of natural richness. Such changes are monitored using various bioindicators, among which are mites. Azevedo et al. [6] analysed the species composition and population size of Gamasina mites in soils covered by natural vegetation and in agroecosystems in the Cerrado region of northern Brazil. A greater species richness of the natural vegetation was clear since, of the 45 identified species, as many as 36 were recorded in soils covered by natural vegetation. This finding persuaded these authors to conclude that arable fields are a threat to the species diversity of mites since many of them are unable to respond to the rapidly changing environmental conditions. The only method to preserve biodiversity may be to establish reserves or protected areas.

Farmers sometimes face the adverse effects of mite pests damaging crops. On the leaves of many crop species (for example, grape, avocado, cassava, cotton), we may find numerous mites which damage these leaves and which are pests reducing the yields of these crops. In turn, other mite species are beneficial as they are predators and control harmful pest species. Situngu et al. [7] focused on the diversity and composition of mites on an economically important plant host (*Coffea aribica*) compared to mites found in a neighbouring natural forest in South Africa. Their results showed that the coffee plantations were associated with only predatory mites, some of which are indigenous to South Africa. This indicates that coffee plantations may be successfully colonised by indigenous beneficial mites.

In Norway, strawberry producers use cereal straw mulching to prevent berries from contacting the soil and to control weeds. Neves Esteca et al. [8] experimentally confirmed the hypothesis that organic matter such as straw mulch also favours the maintenance of predatory mites, which visit strawberry plants at night time. It was found that the dominant species of predatory mites belonged to three families: Melicharidae, Blattisociidae and Phytoseiidae.

Water mites represent the most diverse and abundant group of Arachnida in freshwater ecosystems, with about 6000 species described. However, it is estimated that this number represents only 30% of the total expected species. Despite having strong biotic interactions with their community and having the potential to be exceptional bioindicators, they are frequently excluded from studies of water quality or ecology due to actual and perceived difficulties of the taxonomic identification of this group. These difficulties in the identification of water mite species may be overcome using molecular and genetic techniques, which opens a new chapter in the development of taxonomy. A particular region of the mitochondrial COI (cytochrome c oxidase I) gene, one of the groups known as the DNA barcode region, is the most common sequence used in water mite taxonomy research. Public databases, including the Barcode of Life Database (www.boldsystems.org) or GenBank (www.ncbi.nlm.nih.gov), as well as the use of new bioinformatic tools, represent a breakthrough in species identification. This line of research is represented by the studies of Montes-Ortiz and Elías-Gutiérrez [9], who investigated water mites in the Yucatan Peninsula of Mexico. Applying the above-mentioned method, these authors identified 77 genetic groups or putative species corresponding to 18 genera.

A slightly different subject was investigated by Pozojević et al. [10], who attempted to detect significant differences in water mite assemblages between rheocrene (river-forming springs with dominant riffle habitats) and limnocrene springs (lake-forming springs with dominant pool habitats) in Croatia. As a result, many species not previously observed in that region were reported for the first time.

The paper by Vasquez et al. [11] is a review of the problems of the relationships of aquatic mites being predators or parasites of mosquitoes. In the future, such knowledge concerning these relationships may be crucial for human health since mosquitoes are vectors of many dangerous diseases.

Demodecidae are the most specialized parasitic mites of mammals which typically inhabit the skin, but they have been found in other tissues and organs as well. They can cause demodecosis (a disease which is hazardous and difficult to cure) in humans, domestic animals and livestock. They are parasites with high host and topical specificity, they have been found for most orders of mammals, and they are common in the populations of numerous host species. Therefore, they constitute not only an important subject of veterinary and medical studies, but also an excellent model for faunistic and parasitological studies of different aspects of the functioning and evolution of the host–parasite relationship. This line of research is represented by the study of Izdebska and Rolbiecki [12], who, based on the literature from the years 1884–2020, prepared a list of 122 parasite species of demodecid mites, including their hosts and geographical distribution.

This diversity of subjects presented in the Special Issue Biodiversity of Mites reflects the complexity of research problems currently faced by researchers. Nevertheless, it may also be a source of inspiration for further challenges to gain even greater insight into biodiversity, and thus to be able to more effectively protect the natural richness of our planet.

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