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Editorial

Species Richness and Diversity of Aquatic Ecosystems: Lessons from a Special Issue

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Aquatic ecosystems around the world are under increasing pressure from human activities and global warming, either directly or indirectly. Primary research focusing on aquatic biodiversity and ecosystem functioning is key to prioritizing interventions and to safeguard life in and around water. In order to stimulate research on the fascinating world that thrives under water, we have composed this Special Issue of the MDPI journal *Water*, entitled "*Species Richness and Diversity of Aquatic Ecosystems 1.0*". In this collection, 20 original articles (18 research papers and 2 reviews) are published related to life in aquatic ecosystems, including species richness, biology, biogeography, evolution, ecology, systematics, plasticity, threats, conservation and state-of-the-art techniques. Due to the large interest we received, we have continued with a second Special Issue on the same topic (and with the same guest editors), which will be finalized in 2023.

The papers in the first volume cover a wide range of aquatic organisms, from bacteria [1] and unicellular algae [2,3] to microscopic crustaceans [4–6], macro- and meiobenthos [7,8] and different planktonic animals [9–11], to fishes [12,13]. The focus area is primarily, but not restricted to, Eurasia and surrounding seas [1,7,10], including Eurasia as a donor region of biological invasions to Australia [6]. Most papers are focused on present biodiversity while some contributions deal with the earlier Holocene–Pleistocene and even older [14] history of community- and ecosystems reconstructions, based on paleontological [3,15,16] and phylogeographic [6] approaches.

Several short papers of this Special Issue concern "descriptive" science [17], which is sometimes inappropriately discriminated by "modern style" biologists, although previous pretensions to its "archaism" are apparently answered by using the "integrative" approach [18,19]. However, still, "*the so-called 'descriptive' aspects of taxonomy are in fact the most important tasks of taxonomy*" [20], although they can be enriched by approaches such as molecular phylogeny, geometric morphometry, the analysis of ecological preferences and others. Our Issue contains several "integrative taxonomy" papers concerning different organisms, from chrysophytes (Chrysophyceae) [2] and diatoms (Bacillariophyceae) [21] to marine siphonophores (Hydrozoa) [10] and diaptomid copepods (Crustacea) [11]. Three other publications demonstrate that many new methods could be added to this integrative approach, such as geometric morphometry [22], trophic resource partitioning of sibling species and species flocks based on stable isotope analysis [12] and physiological adaptations of different taxa [1]. These methods are applied to different macrotaxa, but, of course, experience of such studies could be used for the study of other taxonomic and ecological groups. In total, five species new to science have been described in this Special Issue (three diatoms [21], one isopod [22] and one siphonophore [10]).

Ecological contributions to this collection are represented by "conventional" studies of the fauna of freshwater bodies in Poland [9] and more distant areas such as the Lena

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Delta in the Siberian Subarctic [8] and the continental seas located at two different ends of Eurasia [4,7]. Such studies are also re-enforced by new approaches, such as using machine-learning algorithms and fuzzy sets, which can be of great help for future zooplankton monitoring under changing climate scenarios, although the road is still long [23]. Furthermore, using acoustic backscatter data for analyzing krill along the East Sea in Korea is another way of monitoring for a specific purpose [4]. Similarly to taxonomy, ecology moves towards its own integrative approach.

New tools for assessing diversity and threats are key to aquatic ecosystems globally, and contributions in this volume also contribute to several tools that help in understanding and better managing biodiversity richness. Four papers of this Special Issue deal with an increasingly strong challenge for life on earth: biological invasions [24–27]. Water fleas (Crustacea: Cladocera) are among best known freshwater invaders with a strong negative impact on indigenous ecosystems. Hence, the review of Kotov et al. [28] on the invasions in Cladocera, based on an analysis of over 200 years of literature, is an important step towards assessing the contribution of a key zooplankton group to a potential future global faunal mixing in major aquatic ecosystems.

The Volga River is the largest river in Europe and its basin is highly vulnerable to biological invasions (i.e., being interconnected with other river basins). A new set of primers for PCR reactions for successive identification of indigenous and non-indigenous species of fishes based on "long" and "short" fragments of the mitochondrial cytochrome oxidase subunit 1 (COI) gene, 16S mitochondrial and 18S nuclear rRNA genes was proposed [13]. Short primers could be used in future metabarcoding studies as a prospective basis of monitoring to reveal non-indigenous taxa, not necessarily limited to the Volga basin but also in other Palaearctic rivers. In addition, in the Volga basin, a genetic screening of a population of *Daphnia curvirostris*, a very common cladoceran species, revealed a single, very specific population, with mitochondrial DNA from another species, a Far Eastern-endemic *D. korovchinskyi*. It is a trace of past transportation of the latter from the far east of Russia, probably as ephippia attached to car wheels [5].

However, the Holarctic also serves as a donor region of non-indigenous taxa. Populations of a common water flea, *Chydorus sphaericus* have appeared in Australia as a result of colonization from the Holarctic. Moreover, several events of long-distance transportation took place, associated both with waterfowl migrations and occasionally human introduction, probably together with non-indigenous fish [6]. To date, no harmful impact on ecosystems has been revealed, although in some cases we can definitively consider such consequences for some cladoceran communities in the Australasian region, i.e., cases of entire replacements of indigenous taxa in some lakes by others [29]. The impacts of exotics are not always clearly documented in the literature, but the problem is more widespread for zooplankton than previously assumed [28].

Therefore, recent changes in distribution areas are a direct continuation of similar processes from the past, only re-enforced by human activity. Such influence of indigenous human settlements to local faunas through an extermination of bird colonies in the Aleutian Islands has had a strong impact on the continental waters in the islands which could be traced through diatom analysis [3].

Two papers in this Special Issue concern the analysis of the Pleistocene faunal changes in the branchiopod Cladocera in northeast Asia, and they demonstrated controversial patterns at different latitudes. In the so-called "Beringian" zone, the taxa recently inhabiting this zone co-existed during the Pleistocene with taxa which are now living in more southern territories [16], in some cases forming non-analog communities [30]. In contrast, in more southern regions, in the Transbaikalian Area, "*the branchiopod community in shallow steppe water bodies has been unchanged since at least the Pleistocene, demonstrating long-term morphological and ecological stasis*" [15]. This is as far as we know from morphology. Genotypes in such key species can be replaced over short time-spans in aquatic environments, as we illustrate in our review on cladoceran invasives [28].

The Issue also contains a review of the information on different fresh- and brackish-water cold-tolerant species of Southern Europe. Based on the analysis of zoogeographic, paleogeographic and molecular data, the authors of the review [14] concluded that the ancestors of many fresh- and brackish-water cold-tolerant hydrobionts of the Mediterranean region and the Danube River basin likely originated in East Asia or Central Asia. Most probably, they are migrants from the remaining waters of the Para-Tethys that finally colonized the Arctic.

Although the topics of the aforementioned set of papers are very diverse, we believe that the selection is a reflection of recent approaches to the studies of species richness and diversity of aquatic ecosystems. We believe that this Special Issue will provide a basic resource for researchers interested in the current processes and baseline of aquatic diversity as well as long-term trends, forecasting and potential solutions to challenges.

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