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Editorial

Ecology and Diversity of Marine Decapod Crustaceans

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Decapods are one of the most diverse crustacean orders, with around 17,500 extant species [1] of those morphotypes that are most easily identifiable as crustaceans, shrimps, crayfish, lobsters, hermit crabs, and crabs [2]. Although decapods include marine, freshwater and semiterrestrial species, the vast majority of species in this group are marine species [3]. Marine decapods occur in shallow and deep water, including the entire water column (pelagos), and the benthic ecosystems (benthos) over both hard and soft bottoms, including coral reefs, kelp forests, seagrass meadows, macroalgal beds, and hydrothermal vents, wherein they have important regulatory functions (e.g., [4–7]). The feeding habits in decapods include herbivores, detritivores, carnivores, and omnivores. They are consumed by a vast array of other higher-order consumers, thus constituting critical links in many food webs. Decapods have complex behaviors, many of which are mediated by chemical communication [8], and they are often involved in symbiotic relationships with members of many other phyla [9,10]. Many marine decapods sustain important fisheries [11], but their diversity and the ecological roles they play are far from being well understood [12]. Decapods exhibit a diversity of reproduction systems [13], and most species pass through a pelagic larval phase [3]. Therefore, in many species, population connectivity depends on pelagic larvae that develop as part of the meroplankton for weeks or even months, thus also playing a significant role in planktonic ecology.

The purpose of this Special Issue was to invite researchers from around the world to share part of their knowledge on any aspect of diversity and ecology of decapods, whether pelagic or benthic, from any type of marine environment. Manuscripts were received from the Americas, Europe, Asia, and Oceania, with contributing authors from numerous institutions in the USA, Mexico, Brazil, Chile, the Netherlands, Italy, Greece, Pakistan, China, Japan, and New Zealand. The 12 contributions published in this Special Issue address a variety of topics including integrative taxonomy and genetic diversity, DNA barcoding to match larvae to adults, predator-prey interaction, coral-crab symbiosis, Sargassum-shrimp symbiosis, population dynamics of pelagic shrimps, diversity and distribution of oceanic larvae, spatial distribution of crabs, biodiversity of lobsters, and ecology of cave decapods.

The taxonomy of decapods is challenging, but the increasing use of integrative taxonomy is providing new insight into phylogenetic relationships at different taxonomic levels [14,15]. For example, Nishikawa et al. [16] used molecular and morphological analyses to evaluate the variability of the hermit crab *Clibanarius antillensis*. They found no apparent population structure of this species despite its very broad distribution. The authors offer plausible explanations for their results, such as the dispersive potential of the species and the absence of barriers that could prevent gene flow. They also provide a redescription of the species.

Using publicly available mitochondrial and nuclear markers, Sultana et al. [17] evaluated the phylogenetic relationships and genetic diversity among species of the hermit crab genus *Pagurus*, which occurs in a wide variety of marine habitats throughout the world.

The authors established that "Provenzanoi" was the basal group of the genus. They also established several monophyletic species clusters corresponding to previously established morphology-based species groups and resolved the taxonomic position of a number of recently described species. Their study increases insight into the evolutionary relationships among the species within this genus.

Schnabel et al. [18] used a combination of morphological and molecular tools to review the New Zealand fauna of coral and sponge shrimps (Infraorder Stenopodidea). In their extensive and detailed work, these authors described three new species, reported another one in their region for the first time, synonymized two species, and reviewed the distribution range of another one. With this study, the species of Stenopodidea in the New Zealand region increased from three to seven.

As previously noted, most decapods have planktonic larvae, and the larvae of many species are morphologically very different from the adults, making their identification difficult. Varela and Bracken-Grisson [19] used DNA barcoding combined with morphological methods to match larval stages from the northern Gulf of Mexico and adjacent waters with their adult counterparts. They were able to identify 12 unknown larval and two juvenile species from the infraorder Caridea and the suborder Dendrobranchiata, providing taxonomic descriptions and illustrations as well as reviewing the state of knowledge for their respective families.

Phyllosomata, the pelagic larvae of Achelata lobsters, have a long larval duration encompassing multiple stages, but little is known about the mid- to late stages. Muñoz-de-Cote et al. [20] sampled and examined the diversity and distribution of mid- and late-stage phyllosomata in oceanic waters of the Mexican Caribbean during two seasons. They obtained thousands of larvae. Palinurids (five species) outnumbered scyllarids (three species), with *Panulirus argus* dominating over the other species. Overall low densities, lack of a clear spatial pattern, and overlap of the phyllosomata assemblage composition between seasons suggests extensive mixing of the organisms entrained in the strong Yucatan Current.

In addition to the larval stages of most decapods, some species are also pelagic in their adult phase. Sanvicente-Añorve et al. [21] studied the population ecology of two coexisting species of pelagic decapods: the luciferid shrimps *Belzebub faxoni* and *Lucifer typus* in the western Gulf of Mexico. They concluded that *B. faxoni* was far more abundant than *L. typus* and mainly occurred over the inner shelf, where food availability was higher, whereas *L. typus* was more abundant over the slope and oceanic waters, avoiding low salinity waters. The overall distribution pattern of both species could be the result of a long competition process causing partial resource partitioning. The authors also found differences in size and reproductive ecology between the two species.

At the population level, de los Ríos et al. [22] determined the spatial distribution patterns of the grapsoid crab *Cyclograpsus cinereus* at different sites along rocky shores of northern Chile, by counting individuals in random quadrats on the intertidal zone. They found that the negative binomial distribution was the best fit to the data in 15 out of 19 sampling events, and the positive binomial in the remaining four. Their results are consistent with previously reported models for the distribution of decapods on the rocky shores of central and southern Chile.

Most decapods are nocturnal and it is difficult to observe their behavior. Muller et al. [23] reported on a batwing coral crab, *Carpilius corallinus* preying on two individuals of the Christmas tree worm *Spirobranchus giganteus* in Bonaire and described the entire process in detail, even providing a short video. This study brought new light to the little-known predators of Christmas tree worms and their behavior, and on the diet of the Batwing coral crab.

Some decapods establish symbiotic relationships, and factors determining the maintenance of those relationships are often unknown. The effect of chemical cues on habitat choice by two species of *Sargassum*-associated shrimps, *Latreutes fucorum* and *Leander tenuicornis*, was tested by Frahm and Brooks [24]. Neither species showed a strong directional response to *Sargassum* cues, dimethylsulfoniopropionate (DMSP, a chemical excreted by the algae), or conspecific chemical cues, but DMSP cues did cause more shrimp to exhibit searching behavior. Also, males and females responded differently to each cue. The authors suggest that, in the absence of visual cues (previously found to be important for these shrimps), shrimps can detect chemical cues, which could affect both initiating and maintaining shrimp/algal symbiosis.

Canizales-Flores et al. [25] examined the time and conditions when coral symbiont *Trapezia* crabs recruit onto previously unrecruited fragments of *Pocillopora* coral attached to the substrate. They found a relationship between the space available (coral volume) and crab recruitment, given that an increase in substrate complexity is required to provide protection for the crabs and hence maintain the symbiosis. In contrast, abiotic conditions did not appear to influence recruitment. They also found that crabs can move among colonies, which is counter to the theory that, once recruited, these crabs become obligate residents on that specific colony.

Lobsters are important fishing resources wherever they occur. Cruz et al. [26] reviewed the biodiversity and distribution of lobsters in Brazil, with emphasis on fisheries aspects. They listed 24 species from five families: Palinuridae, Scyllaridae, Nephropidae, Enoplometopidae, and Polychelidae, ranging in maximum total size from 30 to 620 mm, with palinurids being the most important from the fisheries viewpoint. Based on available evidence of distribution, biodiversity, life cycle, connectivity, and abundance, these authors proposed a simplified theoretical scheme about the role of lobsters in the ecosystem and their interactions with species from other trophic levels.

Bianchi et al. [27] provide a review of the decapod fauna of Mediterranean marine caves on the basis of a dataset of 76 species from nine Infraorders recorded in 133 caves. The greatest number of species has been recorded in the northern Mediterranean. Most species were found in only a few marine caves, and the proportion of endemic species in caves is low. Decapod occurrence in caves is more correlated with the decrease in light intensity than with other factors that characterize the marine cave environment. These authors call attention to the dearth of knowledge on the population biology of cave decapods and on their ecological role.

The contributions constituting this Special Issue significantly increased knowledge concerning the biology, ecology, and diversity of shrimps, hermit crabs, true crabs, and lobsters. However, decapod populations throughout the world are threatened by climate change, habitat degradation and loss, invasive species, overfishing, and diseases (e.g., [28–30]). Consequently, there is much more to learn about decapods and we hope these contributions encourage other researchers, and especially students, to investigate these fascinating creatures and the roles they play in their ecosystems.

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