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Zoogeography of the Crustacea (Decapoda and Stomatopoda) in the Tropical Pacific: Issues and Prospects

Joseph Poupin

IRENav, Institut de Recherche de l'École Navale, BP 600, F29240 Brest Armées, France

Crustacea (Decapoda and Stomatopoda) are widespread in the tropical Pacific Islands. Although zoogeographic studies have been conducted intensively for other taxa, such as the corals, fishes, or mollusks, no similar studies have been yet completed for the Crustacea at the Pacific scale. Recent advances in taxonomic studies combined with the emergence of regional databases projects appear nowadays as promising tools for zoogeographic studies of the Decapoda and Stomatopoda within the Pacific islands. The purpose of this study is to assess the issues and prospects that can be achieved in that field of research.

In term of biodiversity the importance of the Decapoda and Stomatopoda in the coral reef ecosystem can be estimated from the figures given by the Australian faunal and marine algae directory, with prevailing importance of the Great Barrier Reef marine organisms. The main taxa there are: mollusks (27%), crustaceans (20%), macro-algae (18%), fishes (11%), sponges (9%), bristle worms (8%), echinoderms (4%), and corals (3%). The crustaceans are represented by about 8200 species, including Amphipoda and Isopoda (4000 species), Decapoda and Stomatopoda (2500 species), Copepoda (900 species), and Ostracoda (800 species). Although numerically not the prevailing group the Decapoda and Stomatopoda are of special interest for zoogeographic studies because about 90 % of their species have been already described, compared to only about 50 % for taxa such as the Amphipoda and Isopoda. This situation is related to the larger size of the species and the existence of a lot of ubiquitous species, with noteworthy coloration and sometimes edible. Another interest to study the zoogeography of the Decapoda and Stomatopoda is that they are not confined to marine environment but are also components of the freshwater and terrestrial ecosystems. Two main difficulties still impede the progress of these zoogeographic studies: a) the regional inventories at Pacific scale are still incomplete and very patchy; b) the refinement of taxonomic studies has shown that more and more species, that were supposed to be cosmopolitan species at the Pacific scale, are in fact complex of species that are very difficult to tell apart from each other.

The first difficulty is linked to the geomorphology of the tropical Pacific with more than 1600 islands scattered in a vast marine area and therefore difficult to visit. As a result, the inventories of many archipelagoes are still incomplete. At present the best studied places, *i.e.* for which updated checklist of species have been published recently, are: eastern Australia, including the Great Barrier Reef; tropical Islands south of Japan (Ryukyu archipelago); Guam and the Marianas, Hawaiian Islands, French Polynesian Islands, Easter Island, and the 'Eastern Pacific outliers', *i.e.* Clipperton, Revillagigedo, and Galapagos. Even for these places the inventories remain incomplete because of sampling difficulties related to: a) small size of several taxa (*e.g.* cryptochirid crabs that do not exceed few millimeters of maximum length); b) nocturnal behavior of many species; c) very efficient camouflage techniques (*e.g.* majid or parthenopid crabs); d) use of inaccessible burrows (*e.g.* alpheid or mud shrimps); e) deep range situated well beyond scuba diving limit (*e.g.* crabs Homolidae from 100 to +1000 m). The difficulty to obtain a comprehensive inventory has been illustrated on a time-series graph representing the number of new records obtained in French Polynesia, Easter Island, and Clipperton atoll since the beginning of carcinological studies in these islands. The first species, a crab *Uca tetragonon*, was reported at Bora Bora in 1829. Since then the number of records has gone up to 1140 species, the figure for these islands in 2006. Half of this biodiversity is reached only by 1986 and since that the number of new records has continued to grow up with no sign of an asymptote and even a remarkable burst of new records (+16 %, 97 species) in 1990 due to deep prospection in French Polynesia and Easter Island (100 to +1000 m). This analysis indicates that the Decapoda and Stomatopoda are still insufficiently known in the area.

The second difficulty is linked to the complexity of the taxonomic nomenclature that rendered accurate determination complicated even for qualified taxonomists. Recent fieldworks in the Pacific islands, with increased use of digital cameras, have revealed that the coloration of the Crustacea is crucial for telling sibling species apart from each others. Beside the intrinsic difficulty of accurate determination of sibling species, the situation in taxonomic research is worsen by the dramatic decrease of qualified taxonomists during the last decades. Only about 50 senior taxonomists, specialized in the Decapoda and Stomatopoda of the coral reef, have been identified and among them 22 % are retired albeit being often the most productive. This failure to renew qualified experts by young taxonomists will be a major handicap to achieve future systematic studies. As an illustration of these forthcoming difficulties part of collections made recently in two isolated places of the Pacific and therefore of particular interest for zoogeographic studies (Rapa and Clipperton Islands) are still awaiting qualified experts to be correctly

studied.

These two main difficulties are fortunately counteracted, at least in part, by recent techniques and tools that help taxonomic studies: databases, electronic keys, and libraries of DNA barcode sequences.

Taxonomic Databases are now common on the Internet with GBIF as a global project that interconnect data from different providers. Although GBIF is still far from being satisfactory for zoogeographic studies in the Pacific area, several countries have already proposed online checklists that are very helpful: Australia (http://www.deh.gov.au/biodiversity/abrs/), Cook Is (http://cookislands.bishopmuseum.org/), Hawaii Is (http://www.bishopmuseum.org/), and French Polynesia (http://decapoda.free.fr/). The latter project has been enlarged recently by the addition of Easter Island and Clipperton fauna. Preliminary analysis on this data set show that 150 species are endemic to these islands (13 %) with two noticeable areas: Marquesas Islands (31 endemic species); and Rapa and Easter Islands (38 endemic species). The second area indicates a faunistic link between the islands that lie along the southern edge of the tropical Pacific, a result also verified for the mollusks. For Clipperton, the analysis indicates that this remote atoll marks the border between the Indo-West Pacific and East Pacific zoogeographic provinces, its crustacean fauna being composed almost equally of eastern Pacific species (58 %) and Indo-West Pacific species (42 %).

Electronics keys dedicated to Crustacea have been developed by an Australian team at http://www.crustacea.net/ with use of DELTA and INTKEY softwares. The major advantages of these tools are that: a) they use a lot of illustrations, including color photographs, and therefore can be used by ecologists that are not familiar with the terminology used in the taxonomy of Decapoda and Stomatopoda; b) they differ from traditional dichotomous keys in that you can select any available character for the identification and you can re-identify your taxon more than once using different sets of characters. As a contribution to the Crustacea.net project, two data sets have prepared for species that are widespread in the Pacific area, the hermit crabs *Calcinus* and lobsters *Enopolometopus* (http://biomar.free.fr/).

Libraries of DNA barcode sequences will help many people to quickly recognize known species and constitute an invaluable tool to study complex of sibling species. This has been done in the context of this study for the shrimps of the *Alpheus lottini* complex. Distinct populations have been recognized in the Marquesas-Hawaii, Clipperton, and south of French Polynesia (Fangataufa atoll and Thiers Bank). As these populations, albeit morphologically very similar, are also distinct by their color pattern their formal description as distinct species is in project for the future which will significantly modify

the zoogeography of *Alpheus lottini*.