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Dissertation abstract

SHALLOW MARINE OSTRACOD FAUNA OF THE FIJI ARCHIPELAGO
(フィジー諸島の 浅海貝形虫群集)

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ABSTRACT

Intertidal fringing reef flats across 10 localities in Fiji were sampled for ostracods. A total of 40 ostracod species were collected from algae, coral rubble and sediment habitats. While a few of these 40 species illustrated cosmopolitan behavior, most indicated restricted geographical distribution. Geographically restricted distributions were imposed by environmental settings and impact of anthropogenic activity. An examination of ostracod species and its associated habitats indicated most species have no habitat preferences, generally favoring structurally complex algae habitats, while a second set of species indicated habitat preferences. Of the 40 ostracod species found, 12 were taxonomically evaluated – 1 Bairdoppilata, 3 Paranesidea, 1 Paracypria and 7 Xestoleberis species. All described species indicated habitat preferences, while Paracypria and most Xestoleberis species illustrated geographically restricted distribution as well. Capsule shapes of Fijian Xestoleberis hemipenes were used to categorize them into four groups. Cladistics analysis based on morphological characters of Xestoleberis species split the Fijian Xestoleberis species into three paraphyletic groups, which were consistent with hemipenes-capsule-shape categorization. Majority of Fijian species grouped closely with Australian species (one case of Fijian and Indonesian species grouping). Similar to previous studies, Fijian Xestoleberis species appear to have origins from Australian and East Indies region.
Introduction

The lack of ostracod related knowledge in the Pacific Islands has been repeatedly highlighted (Brady 1890; McKenzie 1986; Hartmann 1988; Titterton and Whatley 1988). In Fiji, ostracod studies are limited to Brady (1890), McKenzie (1986), Hartmann (1988) and Hiruta (1994). In addition, ostracod samples analyzed by Brady (1890) were collected using dry preservation techniques; hence there were no soft part description. Also, Brady (1890) only explored sediment habitats for ostracod samples. Both McKenzie’s (1986) and Hartmann’s (1988) work are based on Brady’s (1890) findings. Ostracod studies in Fiji (an archipelago situated in the South Pacific Ocean) are limited to a handful of reports that are at least 22 to more than a hundred years old. Since ostracod records for Fiji are both limited and outdated, the present study focuses on examining shallow marine ostracods of Fiji. In order to achieve the goal of the study, the following objectives were addressed.

i. Investigation of the distribution patterns of shallow marine ostracods of Fiji.

ii. Taxonomic evaluation of selected shallow marine ostracods of Fiji.
   a. Family Bairdiidae (1 Bairdopphilata sp. and 3 Paranesidea spp.)
   b. Family Paracyprididae (1 Paracypria sp.)
   c. Family Xestoleberididae (7 Xestoleberis spp.)

iii. Determination of the origin of shallow marine Xestoleberis species of Fiji based on morphological character analysis.
Methodology

Ostracod samples were collected from 10 localities across Fiji (Fig. 1). Five of these sites were sampled in 2015 (Korovou, Naviti Island, Yasawa Islands (S1), Korotogo, Viti Levu (S5), Natuvu, Vanua Levu (S8), Viani, Vanua Levu (S9) & Naselesele, Taveuni Island (S10)), two sites were sampled in 2016 (Nakorokula, Viti Levu (S6) & Nabouwalu, Vanua Levu (S7)) and three sites were sampled in both 2015 and 2016 (Northwest Tavewa Island (S2), Northeast Tavewa Island (S3) & Southeast Tavewa Island (S4)). Collections were made from algae, sediments and coral rubble.

Figure 1: Map of the Fiji archipelago illustrating the study sites (S1–S10). Orange circles indicate sites sampled in 2015, blue circles indicate sites sampled in 2016. Black arrows show the fast flowing Bligh Water currents.
Results and Discussion

**Shallow marine ostracod distribution patterns within Fiji**

On a higher scale ostracod distribution patterns within Fiji waters are depended on the geographical distances of localities, ocean currents set up by the dominant southeast trade winds and deep ocean waters separating the many islands of the Fiji archipelago. An examination of shallow marine ostracods across 10 localities in Fiji revealed distribution patterns on smaller scales to be depended on additional factors apart from geographical distances, ocean currents and depths. Ostracod species diversity and richness were found to be higher in pristine locations (Tavewa Island sites) than sites situated in the vicinity of human developments. Open and sheltered coast settings were found to further influence the distribution patterns of ostracod species within Fiji. Study site groupings based on ostracod species occurrences indicate consistent groupings of sites with respect to open and sheltered coast settings. In addition, an examination of the occurrence of ostracod species across study sites revealed that majority of the species within Fiji waters displayed restricted distribution while only a few species appeared to be cosmopolitan in distribution (Fig. 2). Finally, habitat preferences of ostracod species were found to be another determining factor for species distribution. Structurally complex habitats were found to harbor greater species diversity than habitats with less structural complexities. Habitats with less structural complexities were found to favor a few dominant species only. Therefore, the distribution patterns of Fijian shallow marine ostracods not only depend on larger scale factors such as distance, ocean currents and depths, but smaller scale factors like anthropogenic activity, local environmental settings and habitat types.
Figure 2: MDS plot showing species distribution across the study sites. Species concentrated on bottom left of plot indicate species with restricted dispersal and the more spread out points indicate cosmopolitan species.

**Taxonomic Evaluation**

Twelve of 40 ostracod species found from the shallow marine habitats of Fiji were described. These include: *Bairdoppilata* sp., *Paranesidea* sp. 1, *Paranesidea* sp. 2, *Paranesidea* sp. 3, *Paracypria fijiensis* Chand & Kamiya, 2016 (Chand & Kamiya 2016a), *Xestoleberis becca* Chand & Kamiya, 2016, *Xestoleberis concava* Chand & Kamiya, 2016, *Xestoleberis gracilariaii* Chand & Kamiya, 2016, *Xestoleberis marcula* Chand & Kamiya, 2016, *Xestoleberis natuvuensis* Chand & Kamiya, 2016, *Xestoleberis penna* Chand & Kamiya, 2016 and *Xestoleberis petrosa* Chand & Kamiya, 2016 (Chand & Kamiya 2016b). The hemipenes capsule shapes of *Xestoleberis* species were used to categorize Fijian *Xestoleberis* species into four groups, I, II, III and IV. This grouping was consistent with previous grouping of Japanese *Xestoleberis* species (Sato & Kamiya 2007).
Origin of Fijian of shallow marine Xestoleberis species

Morphological characters of 57 Xestoleberis species from around the world (seven Fijian Xestoleberis species and 50 from other parts of the world) were used to carry out a cladistics analysis to estimate the origin of Fijian Xestoleberis species. The findings revealed three paraphyletic groups within the seven Fijian Xestoleberis species – Groups 1, 2, and 3 (Fig. 3). Group 1 comprised of Xestoleberis petrosa and Xestoleberis marcula, formed close paraphyletic groups with Xestoleberis species from southwest Africa and southern Europe. Group 2 comprised of Xestoleberis becca, which was a sister species to the Indonesian species Xestoleberis sp.3 and paraphyletic to Australian and Fijian species. Group 3 comprised of Xestoleberis concava, Xestoleberis penna, Xestoleberis gracilariaii and Xestoleberis natuvuensis, which formed close paraphyletic groups with Australian species. Five of the seven Xestoleberis species were formed close paraphyletic groups with majority of the Australian species. The three Fijian Xestoleberis species groups as per the cladogram were consistent with the Fijian Xestoleberis species categorization based on male hemipenes in Chapter 5. Grouping of Fijian Xestoleberis species with Indonesian and Australian species were consistent with patterns displayed by recent studies on Fijian gastropods and reef fishes and earlier studies on mollusc and ostracod fossils. Hence, the East Indies and Australian region is suggested to be a possible origin for Fijian marine taxa including the Xestoleberis species.
Figure 3: Cladogram of Xestoleberis species based on morphological characteristics. Fijian species split into three paraphyletic groups – 1. X. petrosa and X. marcula, 2. X. becca, 3. X. penna, X. concava, X. gracilariaii, X. natuvuensis. Tree obtained by the Maximum Likelihood method (bootstrapped 100 times). Bootstrap support values indicated at nodes.
**Conclusion**

A total of 40 ostracod species were collected from intertidal zones of fringing reef systems across 10 localities in Fiji. Shallow marine ostracods of Fiji illustrate geographically restricted distribution. Ostracod species diversity, richness and evenness were found to be higher in sites with low to no human influence compared to the sites in the vicinity of human developments. Sites with similar environmental settings (open and sheltered coasts) have similar species occurrences. Although most ostracod species showed no habitat preferences, mostly favoring algae habitats with high structural complexity, selected species illustrate preference for specific habitat types. *Xestoleberis* species favor calcareous algae, blue-green algae and short dense algae habitats; Bairdioidea species favor coral rubble and calcareous algae habitats; Paradoxostomatidae species favor tall algae and *Paracypria fijiensis* give preference to filamentous type algae. Considering ostracod species occurrences across the 10 sites sampled in Fiji, the vast majority of species indicate restricted distribution while a small number of species appear to be more cosmopolitan.

Twelve ostracod species were subjected to taxonomic evaluation, *Bairdopplata* sp., *Paranesidea* sp. 1, *Paranesidea* sp. 2, *Paranesidea* sp. 3, *Paracypria fijiensis* Chand & Kamiya 2016, *Xestoleberis becca* Chand & Kamiya, 2016, *Xestoleberis concava* Chand & Kamiya, 2016, *Xestoleberis gracilariaii* Chand & Kamiya, 2016, *Xestoleberis marcula* Chand & Kamiya, 2016, *Xestoleberis natuvuensis* Chand & Kamiya, 2016, *Xestoleberis penna* Chand & Kamiya, 2016, *Xestoleberis petrosa* Chand & Kamiya, 2016. Common habitats of Bairdioidean ostracods were coral rubbles and calcareous algae. Overall, the number of Bairdioidea juveniles collected was much higher than adult specimens. In contrast with eastern sites, higher diversity of Bairdioidea was recorded in western sites. However, eastern sites mostly recorded juvenile Bairdioidea, hence, the actual species in these locations could not be determined. Specimens of *Paracypria fijiensis*
were only collected from four locations out of the 10 sampled. *Paracypria fijiensis* appeared to favor filamentous algae habitat types. *Xestoleberis* species were collected in high numbers from calcareous and short dense algae. Of the seven species reported five indicate restricted distribution; *Xestoleberis becca* and *X. concava* display cosmopolitan behavior. Using the capsule shape of the hemipenes Fijian *Xestoleberis* species were divided into four group – I, II, III and IV. These groupings were consistent with Japanese *Xestoleberis* groupings by Sato & Kamiya (2007).

Cladistics analysis based on morphological characters revealed three paraphyletic groups among the seven *Xestoleberis* species. These groups were consistent with groups I, II, III and IV, suggested for *Xestoleberis* species based on capsule shapes of the hemipenes. Majority of the Fijian *Xestoleberis* species grouped closely with many of the Australian *Xestoleberis* species, while *Xestoleberis becca* formed sister species to the Indonesian *Xestoleberis* sp.3. Previous studies on Fijian ostracods indicate their origins to be from the East Indies and Australian regions. In addition, studies on Fijian reef fishes and gastropods indicate close groupings with both Indonesian and Australian populations. Therefore, considering the consistent patterns portrayed by the present study and past studies the possible origin of Fijian *Xestoleberis* species are suggested to be from the East Indies and Australian regions.

**References**


学位論文審査報告書（甲）

1. 学位論文題目（外国語の場合は和訳を付けること。）

Shallow marine ostracod fauna of the Fiji Archipelago

（フィジー諸島の浅海貝形虫群集）

2. 論文提出者（1）所属 自然システム学 専攻

（2）氏名 CHAND PRERNA BHARTI

3. 審査結果の要旨（600〜650字）

本学位論文の第1回目の審査委員会を2月8日に開催し、審査に関する意見交換と方針を議論した。同日公聴会を開催し、その後第2回目の審査会で協議し、以下の結論を得た。

本論文はフィジーの潮間帯現生貝形虫生体群集を10地点の海底、サンゴ礁、底質資料に基づき初めて明らかにして、以下の成果を得た。計40種の貝形虫の産出を報告した。これらの種の多くの分布地点は限定され、これを限定する環境条件を推定した。また、貝形虫種と生息場所の関係から多数の種は生息場の選択性を示すが、満入した構造の海底を好むこと、一部に生息場の選択性の高い種もいることが判明した。さらに軟葉藻類の退化に基づき分類学的検討を行い、40種のうちの12種を詳しく記載した。それらは、Bairdiella sp.、P. longipes、P. Paraclypea sp.、Xestoleberis sp.、Xestoleberis sp.、(フィジー産7種、世界各産から報告された50種)。の形態を分岐分析により解析した結果、3つの系統に分けた。フィジー産種の多くを占めるのは豪州産の種に近縁なグループで、他にインドネシア産種に近い種もあることが判明した。フィジー産貝形虫が豪州とインドネシア（東インド海域）に起源を持つことは、既報のフィジーのサンゴ礁生態系と巻貝について推定された起源者説と調和的である。これらの結果は南太平洋の現生貝形虫の分類・生態・起源に関し、全く新しい知見を与えるものであり、本審査委員会は本学位論文が博士（学術）に倣すると判断した。

4. 審査結果 （1）判定（いずれかに〇印）合格・不合格

（2）授与学位 博士（学術）