

SUVA LAGOON OPISTHOBRANCH MOLLUSC DIVERSITY: ASSOCIATED CHANGES IN THE PAST 20 YEARS

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ABSTRACT

The opisthobranch mollusc fauna of Suva Lagoon was investigated from December 1983 to January 1988 and again over a six-week period from April to May 2005. A total of 212 species were recorded from nine sites during the first sampling period and twenty-five of these species were rediscovered at six of the same sites during the 2005 re-sampling period. The rates of species found per sampling visit were similar between the two time periods. However, several obvious habitat changes were observed during the 2005 re-sampling visits. These observations include; the widespread distribution of the macroalga *Sargassum* species to the exposed reef sites, an increase in sponge cover within the sheltered sites, and an increase in human related activities such as rubbish accumulation, gleaning and artisanal/subsistence fishing within the lagoon area.

INTRODUCTION

The invertebrate phylum Mollusca is large and diverse containing at least 100 000 described living species and 35 000 extinct species in seven classes (Ruppert et al, 2004). Three of these classes – Gastropoda, Cephalopoda and Bivalvia – contain members with well-recognised molluscan fisheries roles, while the remaining four – Scaphopoda, Polyplacophora, Monoplacophora and Aplacophora — are somewhat lesser known.

Gastropoda, can be divided into three sub-groups: 'prosobranchs', pulmonates and opisthobranchs. The latter group, the opisthobranchs, are a highly diverse group of marine slugs, the majority of which have undergone shell reduction or loss. As a consequence of this loss, these animals have developed a wide range of alternative defensive mechanisms. The opisthobranchs are globally widespread and occupy a wide diversity of habitats and lifestyles. There are estimated to be over 3 000 species of these slugs in the Indo-Pacific Ocean (Gosliner and Draheim, 1996). These slugs are significant in evolutionary terms because of their high levels of adaptive radiation (Wägele, 2004).

Opisthobranch molluscs are often used as a symbol of the natural beauty of coral reefs, and are particularly well known within the dive industry and by marine education and

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interpretative agencies. Their bright and cryptic colouration often indicates defensive toxins, which make them of considerable interest to natural product chemists (Ávila, 1995). Opisthobranchs also are often a component of the economically important marine 'fouling' communities that quickly appear on any new or exposed marine surface, such as ship hulls or port infrastructure.

Because of their often-specialised food preferences, the majority of opisthobranchs are directly linked to the benthic cover of their habitat. A high level of diversity among the relevant food organisms (e.g. algae, sponges, ascidians, bryozoans and associated epifauna) is therefore likely to correspond with a high level of opisthobranch species richness.

The subclass Opisthobranchia contains six different benthic orders. The first three orders (Anaspidea (sea hares), Acochlidia (caddis slugs), Sacoglossa (sap-sucking slugs)) are herbivorous. The second two orders (Notaspidea (side-gilled slugs) and the largest order Nudibranchia (seaslugs)) are carnivores. Members of the remaining order, Cephalaspidea (bubble shells), are herbivorous and carnivorous. Two pelagic orders (Thecosomata (shelled sea butterflies) and Gymnosomata (naked sea butterflies) also exist but will not be considered in this study. Readers interested in these last two groups are referred to Lalli and Gilmer (1989).

The opisthobranch mollusc fauna of Fiji is known to be rich and diverse (Willan and Brodie, 1989; Brodie and Brodie, 1990; 1995; Brodie et al., 1997; Brodie, 2004). Although the majority of Fijian opisthobranch fauna has an Indo-west Pacific distribution, two species are considered to be endemic: the freshwater acochlidian *Acochlidium fijiensis* Haynes and Kenchington, 1991 and the cephalaspidean *Runcina fijiensis* Thompson and Brodie, 1988.

Members of the sea hare order Anaspidea, particularly *Dolabella auricularia* (green and black colour forms (or **veata** and **veataika** respectively) are of particular interest because of their role as fishery targets throughout Fiji, including Suva Lagoon (Quinn and Davis, 1997).

Opisthobranch species richness is an indicator of marine biological diversity within Fiji waters and Suva Lagoon (Suva Harbour/Laucala Bay). The species therefore form part of the Convention on Biological Diversity established by the United Nations Development Program (UNDP) in 1992 and to which Fiji became a signatory on the 9th of October 1992.

METHODS

1980s

The opisthobranch fauna of Suva Lagoon was sampled regularly over a four-year period from December 1983 to January 1988. Nine sites were sampled (Figure 1): three in the sheltered harbour area (Veuito, Nasese, Cowrie Patch) and six on the more exposed reefal areas (Makuluva, Nukubuco, Suva Main Reef [Crown-of-Thorns Starfish Site], Suva Main Reef [Taiwanese Wreck], Rattail and Joske's Reef). The number of sampling visits to each site was directly linked with accessibility and ranged between four and 48 days. Site 2 (Nasese) and Site 6 (Suva Main Reef – 'Crown of Thorns

Starfish Site') were visited on a more regular basis (48 trips to Site 2, 30 trips to Site 6). Sampling effort per visit varied depending on the number of people present on each collecting trip and their level of experience. Sampling was predominantly intertidal hand collection at low tide (about three hours' duration per trip) supplemented opportunistically by SCUBA-diving hand collection (about one hour's duration per trip). Specimens were returned alive to the laboratory for photography and identification. Representative samples of each species were preserved in 8% formalin in seawater and lodged in the Museum of Tropical Queensland, Townsville, Australia.

2005

Six of the nine sites sampled in the 1980s, were revisited and re-sampled in a six-week period from 14 March to 29 April, 2005. Eight field trips were undertaken that included four exposed sites (Makuluva, Nukubuco, Suva Main Reef [Crown-of-Thorns Sampling Site] and Suva Main Reef [Taiwanese Wreck]) and two sheltered sites (Nasese and Veiuto). Sampling was undertaken as described above, however larger specimens were photographed *in situ* while smaller species encountered for the first time were returned to the laboratory for photography. All specimens collected were returned to the marine environment except for those for which identification was uncertain.

RESULTS

1980s

In Suva Lagoon 212 opisthobranch species were recorded, including the endemic cephalaspidean *Runcina fijiensis* (the type locality of this species is near Makuluva Reef). Eighty-four species were found at the three sheltered sites, while a total of 166 species were found at the six exposed sites. Thirty-eight species were found in both the sheltered and exposed areas. Unexpectedly, even in the most intensely studied sites, 'new' species records were often found despite four years of continuous sampling (see Brodie and Brodie, 1995).

The important Fijian fisheries species *Dolabella auricularia* (= **veata**) were relatively widespread, being found in all of the sheltered sites and three of the six exposed reef sites (although not on the Suva Main Reef) during the sampling period. The mean length of the nine specimens collected in March/April (for all years) was 96 mm.

2005

Twenty-five species were found. Three species (*Bulla vernicosa*, *B. punctulata*, *Phanerophthalmus luteus*) were found only in the sheltered sites, twenty species were found only in the exposed sites (Table 1) and two species (*Dendrodoris nigra* and *Dolabella auricularia*) were found in both sites (habitat types).

The fisheries target sea hare, *Dolabella auricularia*, was therefore found at only two of the six re-surveyed sites (Suva Main Reef – Taiwanese Wreck and Veiuto) during the 2005 March/April field surveys. The mean length of the five specimens collected was 118 mm.

In addition, *D. auricularia* specimens were observed for sale in the central Suva market, although they may not have originally come from the Suva area. These latter specimens consisted of a sale unit of approximately 30 individuals, each measuring about 80 mm in length (Figure 2). The internal organs of these molluscs are removed and sold separately (Figure 3).

Of the twenty-five species found in 2005 all were found in the earlier 1980s surveys, although an unidentified orange dorid nudibranch from Nukubuco (Sandbank) Reef requires further investigation.

Species-visit plots of the exposed sites (Figure 4) and sheltered sites (Figure 5) both show a continuous rise in the cumulative 'new' species found, although the total number of species found in the sheltered sites (five) seems low. The exposed sites yield 4.4 species per trip, while a rate of 1.7 species per trip was achieved in the sheltered sites.

In addition to the number of opisthobranchs found, several more general observations were made about the re-surveyed field sites, i.e. gleaning pressure, litter (rubbish) levels and benthic cover. Gleaning and subsistence/artisanal fishing was observed during sampling on all re-surveyed sites except Makuluva (where visitation is highly restricted). Fishing was particularly intense at Nasese where up to 15 different adult fishers (both male and female), targeting a variety of organisms (fish, crustaceans, holothurians and bivalves) were observed within a three-hour low tide period. Substantial amounts of rubbish were observed along the high tide mark at Nasese. The large amount of rubbish within the harbour area was even more obvious during the small boat transit to the Suva Main Reef (Taiwanese Wreck) site the day after a period of heavy rainfall, when there was so much floating litter that it impaired navigation.

Benthic cover was also noticeably different from the 1980s sampling visits, with large amounts of the brown macroalgae, *Sargassum* species, growing at all exposed reef sites (Figure 6). The Suva Main Reef (Crown-of-Thorns Sampling Site) site also appeared to have less branching coral (*Acropora* species) and more fire coral (*Millepora* species). At Nasese, large monospecific areas of sponge (Figure 7) dominated much of the hard reefal platform.

DISCUSSION

The 212 species of opisthobranch mollusc recorded in Suva Lagoon in the 1980s include a significant proportion of the 253 species recorded for Fiji by Brodie and Brodie (1990). A comparison with species richness values from other areas of the Indo-Pacific (Table 2) indicate that in the mid 1980s the opisthobranch mollusc diversity of Suva Lagoon was rich and diverse.

The number of opisthobranch mollusc species found within the sheltered harbour sites during the 2005 resurvey was very small (five) particularly considering the author's increased experience with specimen location. However, a species-visit plot shows that total species found increased with the number of visits at a rate of 1.7 species per visit. This rate is identical to the rate found for the Nasese site alone in the 1980s.

The 20 species found within the exposed sites in 2005 is higher than the number of species found by Brodie and Brodie (1995) at one Suva Main Reef site (Crown-of-Thorns Sampling Site) after six trips in the 1980s. However, the overall rate of species found per sampling trip is relatively similar at 5.7 in the 1980s and 4.4 in 2005.

The original dataset collected in the mid 1980s was not designed for comparative analysis as undertaken. Therefore comparison of the results from the two surveys, which have very different time frames and sampling effort, makes any real comparison of opisthobranch species richness limited. However, several biotic changes in the sampling sites, particularly in respect to benthic cover and human usage, are evident.

CONCLUSIONS AND RECOMMENDATIONS

Opisthobranch mollusc species richness is a good indicator of the health and diversity to be found in Suva Lagoon marine environment. However, monitoring is not cost-effective, as it requires very specialised identification skills and a high level of search effort.

Suva Lagoon's other marine invertebrate resources however, particularly the subsistence use of molluscs and echinoderms, need to be carefully monitored to assess any future changes in catch rate, catch size, target species and fishing pressure. In addition, existing information and associated baseline data (e.g. V. Vuki and S.K. Singh, unpublished data) needs to be made readily available via website .pdf files.

It is obvious that recreational swimming and marine tourism (e.g. dive operators and cruise ship activities) in Suva Lagoon has declined because of deteriorating conditions of water quality and the increased amount of rubbish. The potential for future recreational and tourism development in the Suva Harbour area may also be influenced by these polluting factors. The Harbour's environmental conditions need to be urgently addressed as, besides the associated economic, health and fisheries issues, they have also adversely affected the quality of life of many people living in the Suva area.

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Figure 1. Map showing the location of sampling sites in the Suva Lagoon area. Sites 1-3 are classed as sheltered, and sites 4-9 as exposed (to the ocean swell). (1) Cowrie Patch, (2) Nasee, (3) Veiuto, (4) Makuluva Reef, (5) Nukubuco Reef, (6) Suva Main Reef [Crown-of-Thorns Starfish Site], (7) Suva Main Reef [Taiwanese Wreck], (8) Rattail and (9) Joske's Reef.

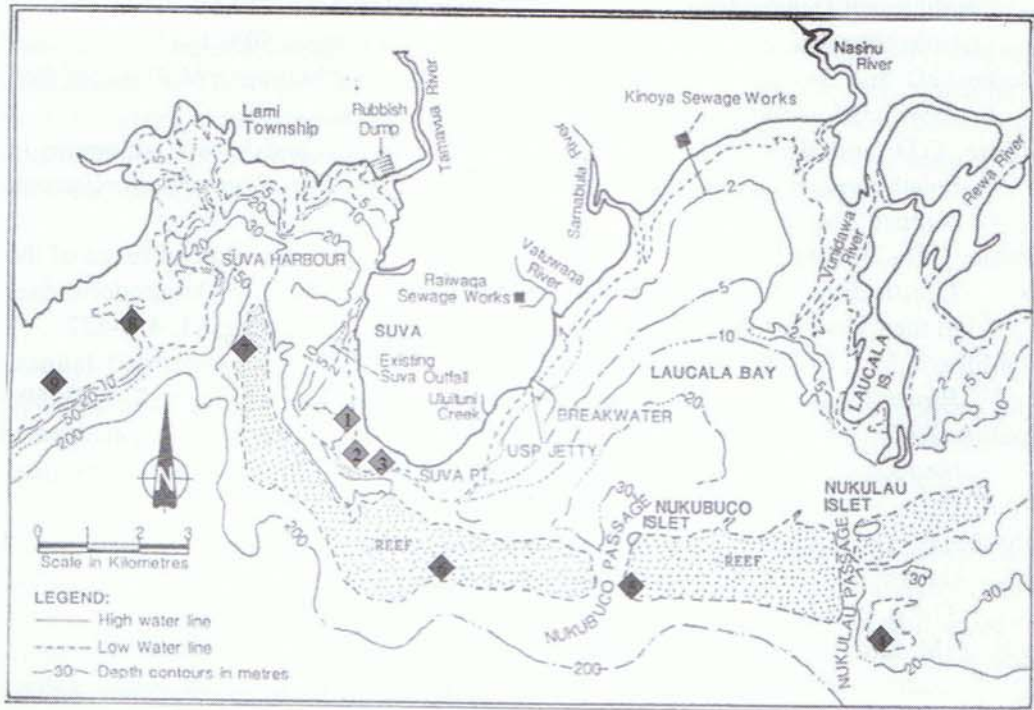


Figure 2. A bundle of sea hares (*Dolabella auricularia*) for sale in the Suva Market.



Figure 3. The viscera of the sea hare, *Dolabella auricularia*, for sale in the Suva Market.



Figure 4. A species-visit plot for the exposed sites visited in 2005.

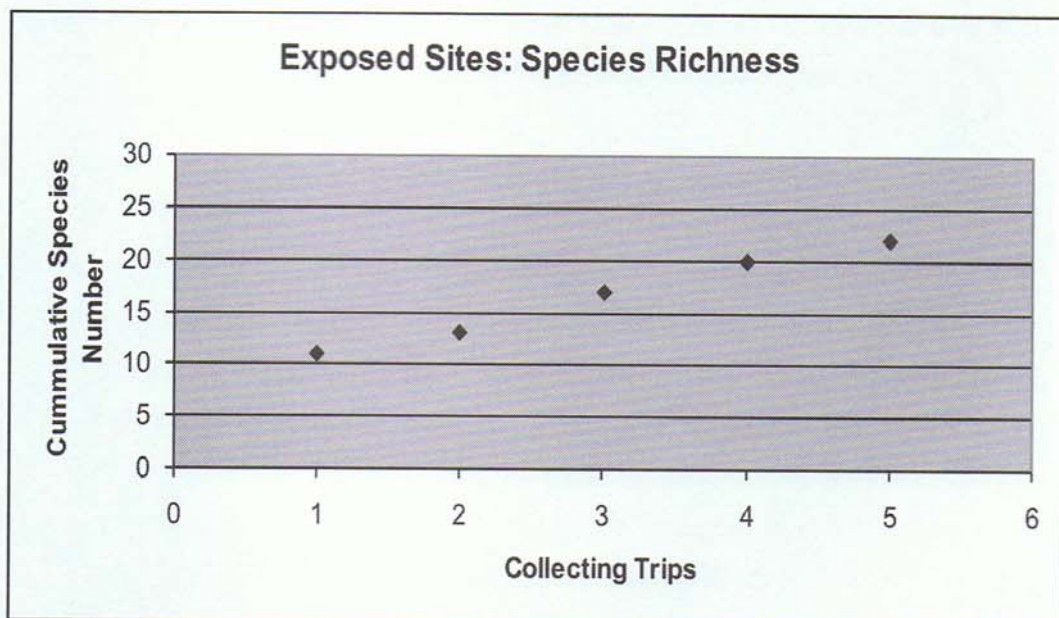


Figure 5. A species-visit plot for the sheltered sites visited in 2005.



Figure 6. *Sargassum* cover during low tide on Suva Main Reef (Site 6), March 2005.



Figure 7. Sponge cover during low tide at Nasese (Site 2), March 2005.

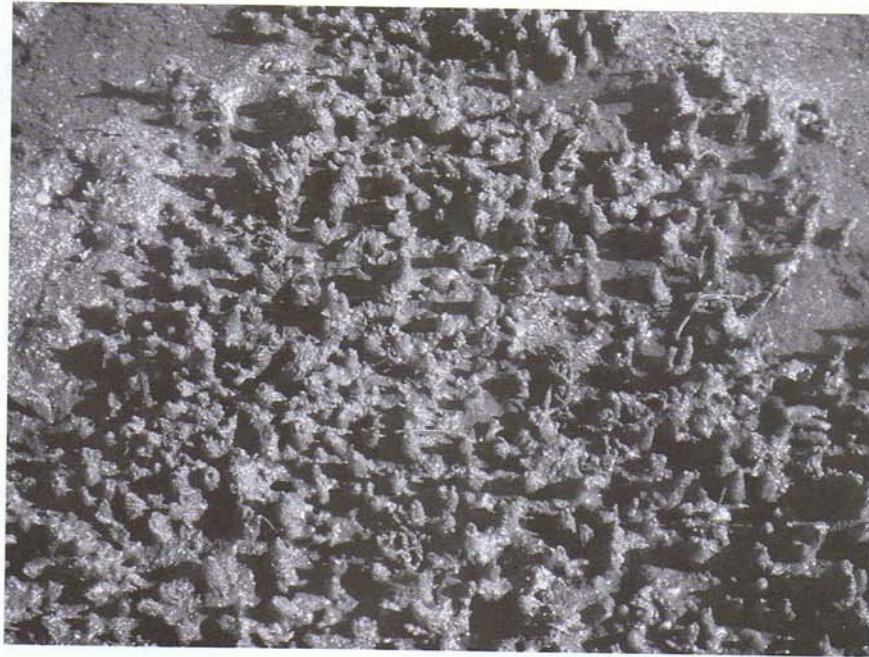


Table 1. Opisthobranch species found only on the exposed reef sites in 2005.

Species name
<i>Berthellina citrina</i>
<i>Berthella martensi</i>
<i>Bornella stellifer</i>
<i>Chromodoris aspersa</i>
<i>Chromdoris fidelis</i>
<i>Dendrodoris albobrunnea</i>
<i>Dendrodoris nigra</i>
<i>Discodoris concinna</i>
<i>Discodoris fragilis</i>
<i>Dolabridera dolabrifera</i>
<i>Doriopsis viridis</i>
<i>Gymnodoris</i> sp.
<i>Haminoea cymbalum</i>
<i>Hexabranthus sanguineus</i>
<i>Phyllidiopsis cardinalis</i>
<i>Phyllidiopsis loricata</i>
<i>Platydoris cruenta</i>
<i>Plocamopherus</i> sp.
<i>Pteraeolidia ianthina</i>
<i>Tambja olivae</i>
Unknown dorid

Table 2. Comparison of opisthobranch mollusc species richness values among tropical areas in the Indo-Pacific.

AREA	AUTHORS	TOTAL NUMBER OF SPECIES	COLLECTION PERIOD
Papua New Guinea	Gosliner, 1992	538	<i>Not indicated</i>
Great Barrier Reef (GBR)	Marshall & Willan, 1999	414	18 years episodic
Heron Island (southern GBR)	Marshall & Willan, 1999	261	18 years episodic
Lizard Island (northern GBR)	Wagele <i>et al</i> , in press	158	5 years episodic
Marshall Islands	Johnson & Boucher, 1983	101	3 years continuous
Fiji Islands	Brodie & Brodie, 1990	253	4 years continuous

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