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Biodiversity and conservation of freshwater fishes in selected rivers on Choiseul Island, Solomon Islands

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ABSTRACT
During a terrestrial biodiversity survey of Choiseul Island, we conducted freshwater fish surveys in seven sites between July 2005 and August 2006. We found 32 fish species from 15 families (38% of known Solomon Island freshwater fish). Most species were uncommon with the exception of Kuhlia marginata (6/7 sites), K. rupestris (5/7 sites) and Glossogobius sp. 1 (5/7 sites). No introduced species were found in any of the sites. Species richness ranged from 2-14 species per site and was highest in Lumutu River and Kolombangara River. This difference between sites is partially attributed to substrate type (higher richness in sites with gravel substrates than mud) and distance from the coast (higher richness near the coast than inland). The results of this survey in conjunction with a previous survey bring the total number of freshwater fish species on Choiseul Island to 41. This diversity is threatened by habitat degradation through sedimentation and over harvesting of some species. We recommend a number of activities to ameliorate these threats including seasonal banning of fish harvest during breeding periods and mass juvenile migrations, discouraging the practice of streamside agriculture, and education of locals on the negative impacts of logging on watershed health and productivity.
Keywords: *species richness, substrate type, distance from coast, introduced species*

1 INTRODUCTION

Freshwater ecosystems are among the most productive and diverse ecosystems and are estimated to support over 10,000 species of fish (Nelson 1994). In the Indo-Pacific region freshwater fish species richness is highest in Indonesia (1,300 species) and Papua New Guinea (329) (Allen 1991; Kottelat and Whitten 1996). Freshwater fish diversity is much lower in neighbouring Pacific countries and ranges from 200+ species in Australia (Allen *et al.* 2002), to 90+ species in Fiji (Boseto 2006), 60+ species in New Caledonia (Marquet *et al.* 2003) and Vanuatu (Nimoho 2000), to only 7 species in the Cook Islands (Ryan 1991). Despite this general eastward decreasing trend in Pacific freshwater fish diversity, the insular nature of many Pacific Island countries gives rise to more than 170 endemic species on the Pacific Plate (Springer and Williams 1990) making freshwater fish an important taxa in the region.

The low freshwater fish diversity recorded for Pacific Island countries can, in some cases, be attributed to the absence of research being carried out on this taxa in the region. To date, most of the work done on Pacific Island fish has focused on Papua New Guinea (Allen 1991; Jenkins 1999), Fiji (Boseto 2006), and only recently, the Solomon Islands (D. Polhemus pers. comm. 2006). Surveys of the freshwater fish diversity of the Solomon Islands have recorded 89 species from 35 families (D. Polhemus pers. comm. 2006; A. Jenkins and D. Boseto pers. comm. 2006).

Of the 1,000+ islands in the Solomon Islands, Choiseul Island is recognised as one of the most biodiverse for a number of terrestrial taxa including birds (McClatchey *et al.* 2005), plants (McClatchey *et al*. 2005), reptiles (McCoy 2006) and frogs (Morrison *et al.* in press). This has been primarily attributed to its relatively large land size (3,100 km^2), diversity of habitats and relatively low current levels of logging (McClatchey *et al*. 2005). The first freshwater fish survey of Choiseul Island was conducted in March 2005 by the Smithsonian Institute and the Bishop Museum as part of a larger project on the freshwater biodiversity of the Solomon Islands (D. Polhemus pers. comm. 2006). Twenty-six fish species were recorded from three sites during this survey.

In July 2005 the BP Conservation Foundation awarded a grant to our team to study the distribution, habitat and conservation status of the two endemic giant rats of Choiseul Island (*Solomys* spp.). As part of the project we conducted biodiversity surveys of freshwater fish in the same sites to (a) complement the fish survey done in March 2005 and (b) provide biological information to aid in the compilation of a conservation management plan for terrestrial taxa on Choiseul Island. The specific aims of this study were to (i) produce a more complete freshwater fish species checklist for Choiseul Island and (ii) determine the conservation significance of these taxa on Choiseul Island.

2 METHODS

2.1 CHOISEUL (LAURU) ISLAND

Choiseul Island is the western most major island (and province) in the political Solomon Islands and is located between 6.5°S-7.5° S and 156.5°E -157.5° E (Fig. 1). The island is approximately 185 km long and roughly 30 km wide on average. It is a rugged, mountainous island with many rivers, the largest of which is Kolombangara River in the south-central region.

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2.2 SITE DESCRIPTIONS

Surveys were conducted at seven sites in the south central, western and northern interior areas of Choiseul Island ranging from small streams to large rivers (Table 1, Figure 1). Six sites were situated near the coast in lowland rainforest and one (Manapagu River) was an inland rainforest site. Stream flow speed ranged from slow (e.g. Sene Creek) to fairly rapid (e.g. Sui River). Surveys were conducted between August 2005 and January 2006.

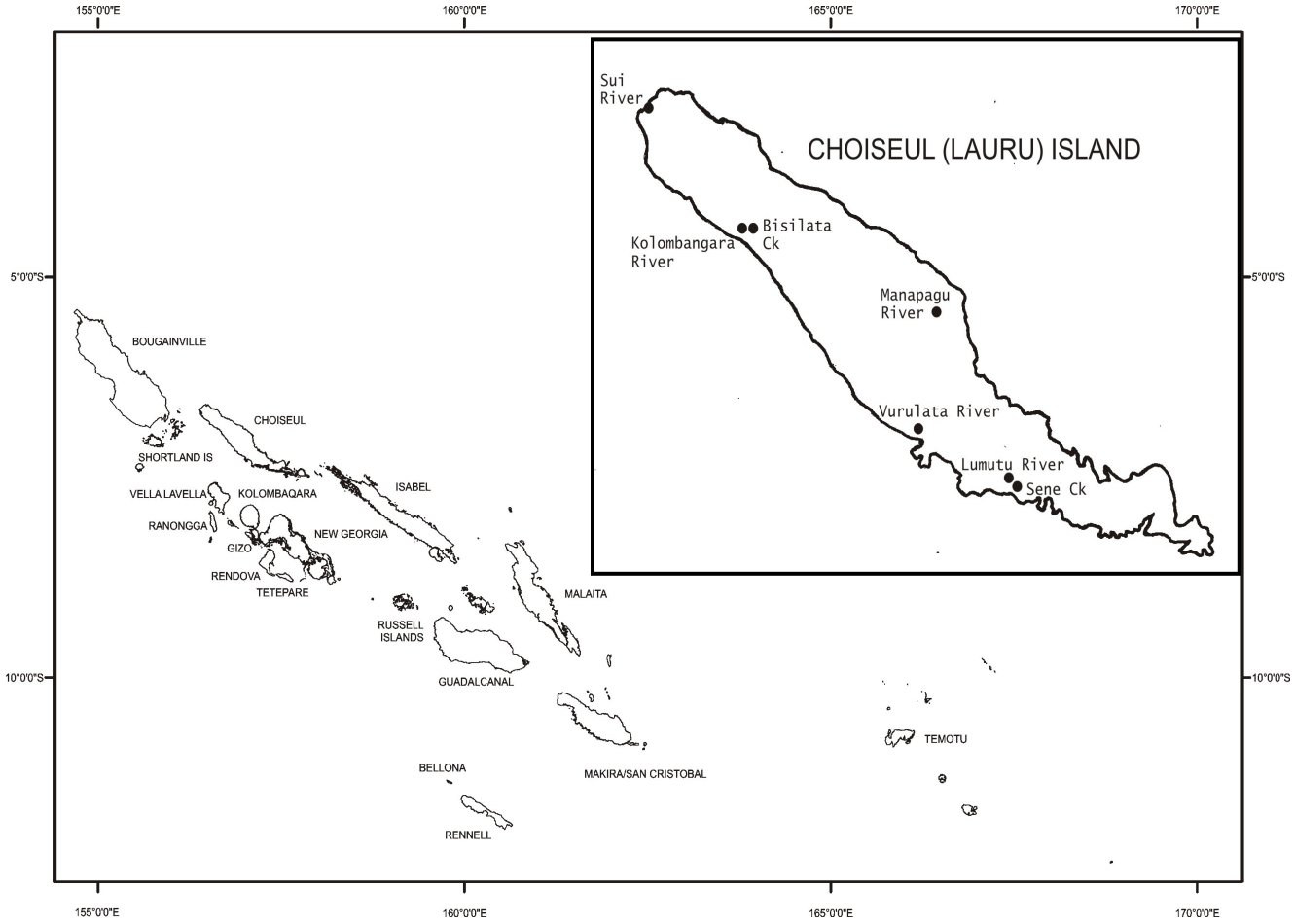

Figure 1. Sites surveyed for freshwater fish on Choiseul Island between August 2005 and January 2006. Note: Bougainville is not part of the political Solomon Islands.

2.3 FISH SAMPLING

At each sampling site a 200 m transect line was laid along the bank and fish were collected using different sized hand nets, spearguns and visual observations (snorkeling etc.). We surveyed the water column (large pools and deeper streams), the underside of hanging rocks, in small crevices, and under streamside vegetation. We also conducted interviews with local guides regarding the fish fauna of the watershed and their habitats. These interviews were used primarily to get an indication of seasonal variation in fish diversity as our field surveys were conducted during a single time period and not replicated in different seasons.

At each of the sampling sites we recorded the substrate type, the creek and river type and the flow rate as this information determined the fishing methods used. These physical characteristics were recorded before the fish surveys began. Although freshwater fish in general are influenced by physical water parameters including salinity, we were unable to record salinity during this study. Given that most sites were more than 1.5 km from the ocean, we do not think that salinity levels would have a significant effect on our results.

2.4 COLLECTIONS

Fish specimens collected were fixed in a 10 % formalin solution and transferred to 70 % ethanol solution after five days of fixation. As colour loss is rapid, accurate descriptions of colour patterns were recorded by photography. Fresh specimens were placed in a portable aquarium with some local aquatic vegetation and benthos to enhance the photography. Voucher specimens were brought back to the Institute of Applied Sciences (IAS), University of the South Pacific.

2.5 FISH IDENTIFICATION

Fish were identified to family level using the Gestalt Method (Shape/location). Taxonomic keys by Allen (1991), Watson (1992), Allen *et al.* (2000) and Marquet *et al*. (2003) were used to identify specimens to the genus and species levels. Mr. Aaron Jenkins (a freshwater fish taxonomist) was also consulted to make sure that the fish were correctly identified.

3 RESULTS

A total of 32 freshwater fish species from 15 families were found during our surveys of the seven sites (Table 2). All species recorded were native species. The identification of five goby species, *Glossogobius* sp 1, *Sicyopterus* sp. A, *Sicyopterus* sp. B, *Stenogobius* sp. 1 and *Stiphodon* sp. 1, and one Apogonid, *Apogon* sp. are currently being conducted by fish taxonomic experts.

Most species were uncommon and found in only one (17 species) or two (6 species) sites (Table 2). Three species *Kuhlia marginata* (6 sites), *K. rupestris* (5) and *Glossogobius* sp. 1 (5) were very common while *Stiphodon rutilaureus* was fairly common (4 sites).

The highest species richness (14 species) was recorded in Lumutu River and Kolombangara River while only two species were found in Sene Creek (Table 2). Sites with gravel or rocky substrates had higher species richness (mean = 11.2 ± 3.3, N = 5) than those with a muddy substrate (mean = 4.0 ± 2.8, N = 2; $t = 2.9$, $t_{crit} = 2.8$, p = 0.049).

Table 1. Description and location of the seven freshwater fish survey sites on Choiseul Island.

Site/ Physical Characters	Sene Creek	Lumutu River	Vurulata River	Kolobangara River	Bisilata Creek	Sui River	Manapagu River
Date surveyed	16/08/05	17/08/05	18/08/05	23-24/08/05	25/08/05	3/09/05	8/01/06
Width (m)	2 - 3	8 - 14	8 - 12	7 - 15	2 - 5	1.5 - 4	6 - 9
Depth (m)	0.1 -1	0.1 - 3	0.1 - 2.4	0.1- 3.2	0.1 - 1	0.1 - 2.2	0.1 - 1.2
Speed (m/s)	0.1	0.5 - 1	0.2 - 0.7	0.5 - 0.8	0.1 - 0.3	0.5 - 1.5	0.5 - 0.8
Distance from ocean (km)	2.0	3.25	3.75	5.25	6.0	1.5	11.25
Stream type and major habitat	Riparian plants along creek edge. Flows through lowland tropical rainforest	Riparian plants along river edge. Flows through a lowland tropical rainforest	Paragrass and ferns are the dominant riparian plants on the river edge	Paragrass and ferns are the dominant riparian plants on the river edge	Paragrass and ferns are the dominant riparian plants on the river edge	Sui River above Parasi Waterfall. Flows through garden and low land secondary forest	Riparian plants along river edge. Flows through primary tropical rainforest.
Major substrate type	Soft, muddy bottom	Boulders in the river with sand and gravel bottom	Muddy on the river edge with gravel and sand on river bottom	Muddy edge with gravel bottom	Soft, muddy bottom	Limestone rock with gravel bottom	Rocky river edge, boulders in the river with gravel bottom
Lat/Long	$07^0$18’04.6” S $157^0$05’57.3” E	$07^0$14’49.9” S $157^0$07’12.6” E	$07^0$11’26.3” S $156^0$59’16.2” E	$06^0$59’05.6” S $156^0$45’57.8” E	$06^0$59’23.6” S $156^0$46’34.8” E	$06^0$41’46.0” S 156^0 26’28.3” E	$07^0$04’19.3” S $157^0$01’45.2” E

4 DISCUSSION

4.1 TOTAL FRESHWATER FISH SPECIES RICHNESS ON CHOISEUL ISLAND

The survey in March 2005 by the Smithsonian Institute/Bishop Museum recorded 26 freshwater fish species including nine species that were not found in our later survey. These additional species were *Liza vaigiensis, Caranx papuensis, Toxotes jaculatrix, Ophieleotris hoedti, Awaous* sp., *Schismatogobius* sp., *Engraulis* sp., *Hypseleotris* sp., and *Microphis* sp. (D. Polhemus pers. comm. 2006). This brings the total freshwater fish species richness on Choiseul Island to 41 species or 49% of all freshwater fish species known from the Solomon Islands. To date this is the second highest island species richness recorded for freshwater fish in the Solomon Islands (Tetepare Island is the most species rich with 60 species, A. Jenkins and D. Boseto, pers. comm. 2006).

4.2 INDIVIDUAL SPECIES AND FAMILIES

Kuhlia marginata and *K. rupestris* were the most common fish species found during the surveys, a result

that can be mainly attributed to biological characteristics of the two species. This primarily involves their ability to live in different habitats (e.g. sites with both gravel and/or muddy substrate) unlike most of the other species found which preferred rock/gravel substrates. In addition, the adults usually form schools while juveniles are common in pools making them easier to observe (Randall and Randall 2001).

The freshwater mullet (*Cestraeus plicatilis*) had not been recorded from the Solomon Islands prior to this survey. On Choiseul Island local villagers report that it was once very common but has now disappeared from most of the rivers on the island. Interviews with local villagers suggest that it is still present in small numbers in the Kolombangara River, Kakasa River, and Vurulata Rivers in south Choiseul and the Kamaga River in North Choiseul.

The Gobiidae were the dominant family observed and collected during this survey (13 species). As this family is among the most structurally diverse and numerically speciose fish families in the world (Miller 1986), this result is not surprising. The gobies prefer rocky/gravel substrates and high water quality which was present in five of the sites.

Approximately half of the species recorded during our surveys were uncommon (found in only 1 or 2 sites). This may be due to the fairly specific habitat requirements of freshwater fish (Gehrke and Harris 2000; Keith 2003), or may be due to the sampling techniques used during our surveys which relied heavily on observation. As some of the smaller fish, in particular the Sicydiinae gobies, are very cryptic and burrow into the substrate, it is likely we missed them in some sites. Other species that live under riparian plants and/or burrow into the soft mud on river edges may also have been missed in a number of sites.

4.3 SITE RICHNESS

Two important factors influencing freshwater fish species richness are (i) stream morphology/substrate type and (ii) site location in relation to the coast (McDowall 1991; Jowett and Richard 1994; Haynes *et al*. 1989; Pusey *et al.* 1993).

Freshwater fish species richness is often higher in areas with rock or gravel substrates than mud or sand as this substrate provides a variety of habitat niches for a range of species (Marquet and Mary 1999; Haynes *et al.* 1989). In this study the average species richness was higher in sites with gravel substrates than those with mud substrates. With the exception of the *Kuhlia* species, the fish species that were found in the muddy substrate sites (Sene Creek and Bisilata Creek) were generally restricted to these sites and were not common in the rocky substrate streams.

Although species richness was generally higher in rock/gravel substrate sites, there was one exception to this pattern. Manapagu River which was a rocky substrate site had only five fish species. This low species richness is likely due to its inland location. Generally, freshwater fish species richness decreases with distance from the coast (McDowall and Taylor 2000). This pattern is mainly due to natural fish barriers e.g. waterfalls, which restrict the movement of most fish species from more coastal areas to higher inland sites. In addition, lowland coastal sites often have a number of estuarine fish species that spend some of their life cycle in freshwater which adds to the species richness of these areas (Jowett *et al*. 1996).

4.4 INTRODUCED SPECIES

During this survey there were no sightings and reports of introduced species such as tilapia (*Oreochromis mossambica*), mosquito fish (*Gambusia affinis*) and guppies (*Poecilia reticulata*) in the rivers. This suggests that invasive species are currently not having an impact on the native fish fauna on Choiseul Island. There were however, reports of local people farming tilapia in some rural communities in Choiseul. Should this species enter waterways, it will be devastating for the native species populations.

4.5 THREATS TO FRESHWATER FISHES OF CHOISEUL ISLAND

Currently there are three major threats to the freshwater fishes of Choiseul Island; (i) over harvesting of freshwater mullets (*C. plicatilis*) during the spawning season, (ii) the mass harvesting of juvenile fish during migration from ocean to freshwater, and (iii) sedimentation of streams and rivers due to soil erosion caused by extensive logging.

The spawning season for the freshwater mullets usually takes place between June and July of each year. During the spawning period female mullets brood their eggs internally (in the stomach) making them relatively slow moving. This is when they are usually harvested by local villagers using gill nets who collect 300-400 individuals per catch.

The mass migrations of the juveniles returning to freshwater from the ocean has created an opportunity for villagers to develop a culture of harvesting the juveniles in huge numbers as an important source of protein (Bell 1999; Keith 2003). This practice of juveniles harvesting is common throughout the Indo-Pacific and is unsustainable. It is this movement from ocean to rivers that is the key link in completing the diadromous life cycle and crucial to maintaining the populations of fish species in the freshwaters (Keith 2003).

Logging industries and poor agricultural practices often result in erosion of soil and increased turbidity which may disrupt feeding success of fishes (Gratwicke *et al*. 2002). Furthermore, these pollutants pose a major threat by significantly altering the chemical and biophysical characteristics of the water, making the habitat non-conducive to aquatic life.

5 CONCLUSIONS AND RECOMMENDATIONS

The freshwater fish of Choiseul Island are excellent indicators of watershed health. As the majority of species (especially Gobiidae) inhabit areas with high water quality and intact riparian vegetation, declines in the diversity and abundance of these species from a waterway is often a reliable early indication that water quality is deteriorating and/or riparian vegetation is being removed.

In order to maintain a healthy biodiversity and abundance of freshwater fishes on Choiseul Island we recommend that the following activities/conservation measures be put in place; (i) do not harvest freshwater mullets during their

spawning period in June and July of each year; (ii) do not mass harvest juveniles migrating up river; (iii) do not allow the introduction of invasive species such as tilapia, mosquito fish and guppies into the streams; (iv) educate locals about the life cycles of freshwater fish and about the negative impacts of logging on the environment including the freshwater ecosystem; and (v) conduct freshwater fish surveys of additional streams and using alternative techniques (e.g. electrofishers) on Choiseul Island to obtain a complete inventory.

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REFERENCES

Allen, G.R. 1991. *Field Guide to the Freshwater Fishes of New Guinea*. Publication No. 9 of the Christensen Research Institute, Madang, New Guinea.

Allen, G.R., Hortle, K.G. and Renyaan, S.J. 2000. *Freshwater fishes of the Timika Region, New Guinea.* P.T. Freeport Indonesian Company, Timaka, Indonesia.

Allen, G.R., Midgley S.H. and Allen, M. 2002. *Field Guide to the Freshwater Fishes of Australia.* Western Australian Museum, Perth.

Bell, K.N.I. 1999. An overview of goby-fry fisheries. *Naga Manila* **22**, 30-36.

Boseto, D. 2006. *Diversity, distribution and abundance of Fijian freshwater fishes*. MSc Thesis. University of the South Pacific. Suva, Fiji.

Gehrke, P.C. and Harris, J.H. 2000. Large-scale patterns in species richness and composition of temperate riverine fish communities, south-eastern Australia. *Marine and Freshwater Research* **51**, 162-182.

Gratwicke, B., Marshall, B.E. and Nhlwatiwa, T. 2002. The distribution and relative abundance of stream fishes in the upper Manyame River, Zimbabwe, in relation to land use, pollution and exotic predators. *African Journal of Aquatic Sciences* **28**, 25-34.

Haynes, J.W., Leathwick, J.R. and Hanchet, S. M.1989. Fish distribution patterns and their association with environmental factors in the Mokau River catchment, New Zealand. *New Zealand Journal of Marine and Freshwater Research* **23**, 171-180.

Jenkins, A.P. 1999. *A comprehensive inventory of freshwater fishes in the Pacific Islands region and production of a field guide: a critical foundation for conservation of threatened freshwater resources*. Wetlands International – Oceania. Suva, Fiji.

Jowett, I.G. and Richardson, J. 1994. Comparison of habitat use by fish in normal and flooded river conditions, New Zealand. *New Zealand Journal of Marine and Freshwater Research* **28**, 409-416.

Jowett, I.G., Richardson, J. and McDowall, R.M. 1996. Relative effects of in-stream habitat and land use on fish distribution and abundance in tributaries of the Grey River, New Zealand. *New Zealand Journal of Marine and Freshwater Research* **30**, 453-475.

Keith, P. 2003. Biology and ecology of amphidromous Gobiidae of the Indo-Pacific and the Caribbean Regions. *Journal of Fish Biology* **63**, 831-847.

Kottelat, M. and Whitten, T. 1996. *Freshwater biodiversity in Asia with special reference to fish.* World Bank Technical Paper no. 343. Washington D.C.

McClatchey, W.C., Sirikolo, M.Q., Boe, H., Biliki, E. and Votboc, F., 2005. A proposed PABITRA study area on Lauru Island, Western Solomon Islands. *Pacific Science* **59**, 213-240.

McCoy, M., 2006. *Reptiles of the Solomon Islands*. CD-ROM. Available from filmsolomons@gmail.com

McDowall, R.M. 1991. Freshwater fisheries research in New Zealand: processes, projects and people. *New Zealand Journal of Marine and Freshwater Research* **25**, 393-413.

McDowall, R.M. and Taylor, M.J. 2000. Environmental indicators of habitat quality in a migratory freshwater fish fauna. *Environmental Management* **4**, 357-374.

Marquet, G., Keith, P. and Vigneux, E. 2003. *Atlas des poissons et des crustacés d'eau douce de Nouvelle – Calédonie*. Patrimoines Naturals, Paris.

Marquet, G. and Mary, N. 1999. Comments on some New Caledonian freshwater fishes of economical and biogeographical interest. In: *Proceedings of the 5th Indo-Pacific Fish Conference, Noumea 1997*. B. Seret and J. Y. Sire (Eds), Society of French Icthyology, Paris, 29-39.

Miller, P.J. 1986. Reproductive biology and systematic problems in gobioids fishes. In: Indo-Pacific fish biology. *Proceedings of the 2nd International Conference on Indo-Pacific fishes 1986*. T. Uyeno, R. Arai, T. Taniuchi and K. Matsuura (Eds), Ichthyological Society of Japan, Tokyo, 640 – 647.

Morrison, C., Pikacha, P., Pitakia, T. and Boseto, D. *In press*. Herpetofauna, community education and logging on Choiseul Island, Solomon Islands: implications for conservation. *Pacific Conservation Biology*.

Nelson, J.S. 1994. *Fishes of the World*. John Wiley and Sons, Inc. New York.

Nimoho, L.T. 2000. *Freshwater fish and crustaceans of Vanuatu*. Vanuatu Environment Unit. Port Vila.

Pusey, B.J., Arthinton, A.H. and Read, M.G. 1993. Spatial and temporal variation in fish assemblage structure in the Mary River, southeastern Queensland: the influence of habitat structure. *Environmental Biology of Fish* **37**, 355-380.

Randall, J.E. and Randall, H.A. 2001. Review of the fishes of the Genus *Kuhlia* (Perciformes: Kuhliidae) of the Central Pacific. *Pacific Science* **55**, 227-256.

Ryan, P.A. 1991. Records of three new freshwater fishes of the Fiji Islands. *Pacific Science* **35**, 93-95.

Springer, V.G. and Williams, J.E. 1990. Widely distributed Pacific-plate endemics and lowered sea-levels. *Bulletin of Marine Science* **47,** 631-640.

Watson, R.E. 1992. A provisional review of the genus *Stenogobius* with descriptions of a new subgenus and