Fishes and Macroinvertebrates of Bago River, Negros Occidental, Philippines

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The fishes and macroinvertebrates of Bago River were surveyed for three months each during wet (July, August, and September 2009) and dry (February, March, and April 2010) seasons to establish baseline data on species composition and distribution. Collection of fishes and macroinvertebrates made use of a variety of gears, including cast net, gill net, hook and line, and two indigenous gears called "garab" and "taon", supplemented by hand picking. Within the six-month period, 55 fishes, and 21 aquatic macroinvertebrates were collected and identified. Bago River diversity is dominated in terms of abundance by introduced species. The study made a comprehensive list of fishes and macroinvertebrates of Bago River.

KEYWORDS: Bago River, Negros Occidental, biodiversity, fishes, macroinvertebrates

INTRODUCTION

Freshwater ecosystems may well be the most endangered ecosystems in the world (Dudgeon et al., 2006), including rivers that are among the richest in terms of biodiversity (Ward &

Tockner, 2001).

Tropical Asian rivers support a rich but incompletely known biota, including a diverse array of fishes (Allen, 1991; Zakaria-Ismail, 1994; Kottelat & Whitten, 1996; Fu, Wu, Chen, Wu, & Lei, 2003; Davies, 1999; Bhakta & Bandyopadhyay, 2008), benthic invertebrates (Chase & Bruce, 1993), and an assemblage of vertebrates adapted to riverine wetlands (Dudgeon, 2000). Despite their importance to human communities, rivers in Asia have remained poorly studied (Kottelat & Whitten, 1996).

In the Philippines, most of the studies done in the past decades were mainly on the taxonomy of fishes (Herre, 1923, 1924, 1927, 1953; Roxas & Ablan, 1940) and crustaceans (Chase & Bruce, 1993; Ng & Takeda, 1993a, 1993b). Recent studies on river fishes include Chavez, de la Paz, Manohar, Pagulayan, and Carandang (2006) and Hubilla, Kis, and Primavera (2007).

Bago River originates between two large mountain ranges in northern Negros, namely the Mt. Kanlaon Volcano and the North Negros Mountain Range. It stretches to about 76 km, passes through five municipalities bound by 24 barangays and drains into the Guimaras Strait. The river is relatively wide, with approximately 400m width near the mouth. Bago River supports the agricultural, fisheries, industrial, and domestic needs of the communities lining its banks. A proposal has also been made by AltoPower Management Corporation to dam the river to generate 40 MW electricity and provide irrigation (San Carlos City SP Resolution 09-44) despite the river's poor water holding capacity (Cadagat & Ombi-on, 2002) and slow rate of discharge (PNOC, 1995).

This paper presents the result of a six-month survey on the aquatic fauna of Bago River, Negros Occidental to establish baseline data on the fishes and macroinvertebrates as part of the study characterizing the biodiversity and hydrology of Bago River.

MATERIALS AND METHODS

Description of the Study Site

The map of Bago River (Figure 1) shows the location of the four study sites. Selection of these sites was based on their distance from the river mouth and presence of existing anthropogenic activities in each area, believed to affect the river. In addition, each site also varied in

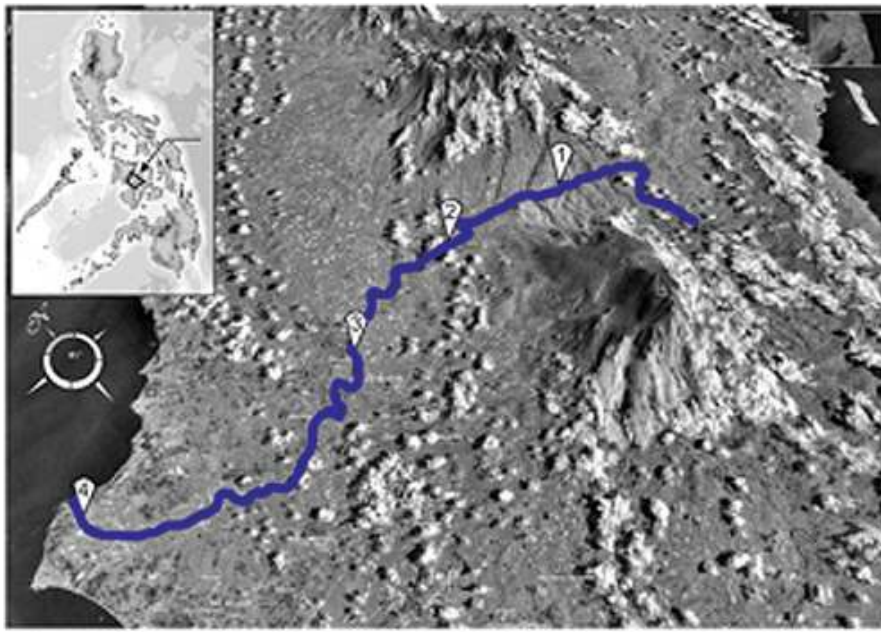

Figure 1. Map of North Negros showing location of the four study sites in Bago River (Modified from World Wind).

depth, predominant substrate type, as well as presence of riparian vegetation. These sites and their corresponding base reference points beginning at the headwaters going downstream were as follows: Sitio Mambanao, Barangay Kumaliskis, Municipality of Don Salvador Benedicto (10° 31.760' N, 123° 12.854' E), Purok Urban, Barangay Lopez Jaena, Municipality of Murcia (10° 33.450' N, 123° 04.140' E), Barangay Damsite, Municipality of Murcia (10° 33.234' N, 123° 02.143' E), and between Barangay Lag-asan, Bago City and Barangays Tapong and Ubay, Municipality of Pulupandan (10° 31.204' N, 122° 50.260' E).

Sampling Methods

Fishes. Samples were collected using gill nets, cast nets (3 m diameter) and a variety of indigenous gear such as hook and line, spears, forked spear called "garab" and bamboo traps called "taon". Pools along river edge were also sampled using dip nets. Fishes were sorted to species, weighed, and measured. Fresh specimens were photographed and identified on site based on available references such as Allen (1991) and the FAO Guide to Fishery in the Indo-Pacific Series (Carpenter & Niem, 1999). Representative samples of each species caught were

fixed in 10% formalin and later stored in 70% ethanol for taxonomic verification and storage at Silliman University-Rodolfo B. Gonzales Museum of Natural History (SURBG).

In addition, photographs of samples were sent to fish taxonomists in various museums and institutions for verification. Some of the fish samples were also shipped to the United States National Museum of Natural History (USNM), Smithsonian Institution, Maryland, USA through Dr. Jeff Williams (Collections Manager of the Fish Division) and were examined by fish specialists (e.g. Dr. David G. Smith for all eels and Dr. Ed Murdy for gobioid fishes). These fish specimens will become part of the worldwide collection of USNM.

Macroinvertebrates. Samples were collected using an indigenous bamboo trap called "taon", supplemented with hand picking. Twenty pieces of traps were set randomly in the riffle area of the river at 6pm and collected by 6am the following day. Organisms caught were sorted to species, counted and weighed. Identification followed Chase and Bruce (1993) for shrimps, and Ng and Takeda (1992, 1993) for crabs.

Water Quality. Data on water quality were obtained from Linaugo et al. (in this issue). Collection of fishes and macroinvertebrates were coordinated with water quality monitoring to establish possible correlation between biological and physico-chemical parameters of Bago River.

Habitat Description. The four stations of Bago River had varying geomorphology, vegetation cover and existing anthropogenic activities. These variations in habitat condition were considered in the selection of study sites in order to highlight the potential influence of habitat to the river's biodiversity.

[a] ***Kumaliskis (SSA1).*** The area is in Bago River's headwaters. The surrounding mountains form steep walls of the winding river. In some sections of the mountain sides, terraces were built for agriculture. Rice, bananas, cassava, and corn were among the commonly planted food crops. Most areas had extensive riparian vegetation because of steep walls. There were huge boulders of rocks scattered along certain sections of the riverbanks and along the river, particularly in the upstream section. The downstream section was relatively deep and the substrate consisted of coarse sand.

[b] ***Lopez-Jaena (SSA2)***. The area is a long stretch of river that

receives inputs from two river tributaries namely, Pula River and Caliban Creek. The river is surrounded by moderately sloping areas, which were also converted into rice and sugar cane plantation. Nevertheless, riparian vegetation still lined most of the river's edge. Sand quarrying occurs in several sections of the river, resulting in many pools (1 > meter deep) or channels scattered in flood plain areas. Huge boulders also scatter in the midstream area of the river, while the upstream and downstream areas were deep and with sandy substrates.

[c] ***Damsite (SSA3)***. This section of the river also forms a long stretch. It is adjacent to Bulad Creek which drains water from Bago Irrigation Project. The area is bound by extensive plains used for agriculture on the left and stacked rock boulders on the right side. The river is deep (< 30m) before the dam and shallow (< 0.5m) after the dam. Substrate type is generally sandy with scattered rocks in shallow portions of the river.

[d] ***Lag-asan (SSA4)***. The area is lined by riparian vegetation dominated by Nypa fruticans. It is highly inhabited and utilized for fishing and sand quarrying, and is considered as receptacle for swine and domestic sewage. The riverbed is generally rocky, although certain sections have sand and are covered by a thick layer of muddy substrate near the mouth.

Data Analyses

Fishes and macroinvertebrates collected per sampling were tabulated to obtain the number of individuals per species for each site. Using these data, percent contribution was determined using the formula:

$$\text{Percent contribution} = \frac{ni}{N}$$

where ni is the no. of individuals/
N is the total no. of individuals

Fish and macroinvertebrate abundance was based on the total counts of individuals caught per month for all gear types. In addition, species richness that refers to the number of species encountered per site was used to compare species diversity among stations for each season.

Two-way ANOVA was used to test for significant differences in fish and macroinvertebrate abundance as well as species richness among stations for both wet and dry seasons. Duncan's Multiple

Range Test was applied to determine where the difference lay.

RESULTS

Species Composition

Fishes. Fifty-five fish species belonging to 33 families were recorded (Table 1), with 48 species and 33 species collected in the wet and dry seasons respectively. The fishes were categorized according to Davies (1999) of which 11 species (20%) were primary freshwater fishes, one species (2%) secondary freshwater fish, one species (2%) migratory fish, and 42 species (76%) sporadic visitors. The Family Gobiidae had the highest number of species (seven), followed by Ophichthidae (six), while Eleotridae, Mugilidae, Poeciliidae had three species each; Carangidae, Chandidae, Cyprinidae, Engraulidae, Leiognathidae, Moringuidae, and Terapontidae had two species each, and the remaining 21 families had a single species each.

There were nine species of anguilliform fishes namely, one Mottled Eel, *Anguilla marmorata*, and eight estuarine species composed of the spaghetti eel Moringuidae (*Moringua* spp.), the moray eel Muraenidae (*Strophidon sathete*) and the snake eels Ophicthidae consisting of *Cirrhimuraena, Yirrkala, Muraenichthys, Neenchelys*, and *Scolecenchelys*. A single species of swamp eel (not a true eel) *Synbranchus bengalensis* was also collected. Further details on the eel fauna is discussed in a separate paper.

Ten introduced species belonging to seven families were documented in this study. Three of these species are important food species: the Nile Tilapia *Oreochromis niloticus* (Cichlidae), the Common Carp *Cyprinus carpio* (Cyprinidae), and the Thai Catfish *Clarias batrachus* (Clariidae). The remaining seven species were aquarium fishes consisting of the American Sailfin Catfish or Janitor fish *Pterygoplichthys disjunctivus* (Loricariidae), Three-spot Gourami *Trichopodus trichopterus* (Osphronemidae), Zebra fish *Danio rerio* (Cyprinidae), and three species of Poeciliidae namely, Rainbow Guppy *Poecilia reticulata*, Molly *Poecilia sphenops*, and Swordtail *Xiphophorus helleri*. All of these species are primary freshwater species occupying the river's main stream.

Of the 2,306 fishes collected for the six-month sampling period, 1,326 individuals (57.50%) were caught in the wet season and 980 individuals (42.50%) in the dry season. *Oreochromis niloticus* of family

Cichlidae was collected in all surveys and in most stations of Bago River. It dominated the catch in the wet season, contributing 14.33%, along with family Gobiidae (69.68%). *O. niloticus* (59.90%) was also most abundant in the dry season, along with family Cyprinidae *Cyprinus carpio* (11.33%).

Comparison of fish species composition of each station (Figure 2) showed that primary freshwater fishes were collected even at the river mouth while sporadic visitors that are marine species were also found further inland in the upstream Kumaliskis station. However, the migratory species *Anguilla marmorata* was only encountered in the upstream and midstream stations of the river.

Macroinvertebrates. Twenty-one species of macrobenthos were collected from Bago River (Table 2). The shrimps belonging to two families contributed 47.62% of the macrobenthos species; crabs consisting of four families made up 28.57%; and mollusks with five families made up 23.81%. The shrimp family Palaemonidae had the highest number of representative species (eight).

There were 2,843 individuals collected within the six-month sampling period; 1,796 individuals (63.17%) were caught during the wet season and 1,047 individuals (36.83%) in the dry season. The most abundant macrobenthos for both wet and dry seasons were the shrimps (mainly *Macrobrachium latidactylus* and *Macrobrachium equidens*), comprising 91.43% of the total catch and present all throughout the survey. The crabs contributed 8.18% and 12.23% for the wet and dry seasons, respectively, with *Varuna litterata* contributing 7.29%, collected in large numbers at Lag-asan in August, 2009. The most commonly observed mollusks included *Pomacea canaliculata*, *Corbicula manillensis*, and *Melanoides granifera*.

Seasonal Variation in Species Abundance and Diversity

Two-way ANOVA showed that fish abundance was significantly lower in Lag-asan than Kumaliskis station ($p = 0.003$), particularly during the wet season (Figure 3). Nevertheless, Lag-asan had significantly higher species richness compared with other stations (Two-way ANOVA $p = 0.001$) for both wet and dry seasons (Figure 4).

Similarly, macroinvertebrate abundance was significantly higher in Lag-asan compared to Damsite and Kumaliskis (Two-way ANOVA $p = 0.016$ and $p = 0.005$, respectively) (Figure 5). Species richness did not vary significantly among stations for both wet and dry seasons

(Figure 6).

Water Quality

Seasonal differences in water quality (Table 3) were observed in Bago River. Total dissolved solids (TDS), total suspended solids (TSS), turbidity, and nitrate were among the physico-chemical parameters that exhibited more pronounced seasonality. TDS, TSS, and turbidity were generally higher in the wet season. However, most notable was the very high TDS (1,940.33 mg/L) and TSS (114.22 mg/L) values obtained in Lag-asan during dry season when the other stations were having TDS values of only 48-67.44 mg/L and TSS values of 4.89-7.33 mg/L. In addition, values for nitrate concentration were higher in the dry season compared to those obtained in the wet season.

DISCUSSION

Species Abundance and Diversity of Aquatic Organisms

Various sampling methods were applied to collect fishes and macroinvertebrates in Bago River because no single gear could effectively capture all the organisms. Cast nets and gillnets were the most commonly utilized gear in the river, but spear was considered more effective in the dry season because gill nets got entangled with filamentous algae. Also, the smaller-sized species e.g. gobioids and poeciliids could not be collected by larger-sized mesh of the cast and gill nets.

Fish species abundance was generally low in all stations during wet season, except for Kumaliskis station where a significant number of fishes, mostly gobioid fishes were collected. In the dry season, however, fish abundance was higher in the mid-stream stations, Lopez Jaena and Damsite, but was not significantly different with Kumaliskis and Lag-asan.

Bago River supports a high diversity of aquatic fauna. In particular, its fish species are comparable to Agos River in Luzon with 53 species (Carumbana, 2002), and higher compared to Siaton River in Negros Oriental (Carumbana, 2006), Langaran River in Misamis Occidental with 26 species (Gomez-Roxas, Boniao, Burton, Gorospe-Villarino, & Nacua, 2005), Okoy River in Negros Oriental with 18 species (Cabanban & Luchavez, n.d.) and to each of the five tributary rivers

of Subic Bay Forest Reserve with 16-40 species (Pagulayan, n.d.).

Majority of the fish species collected in Bago River were sporadic visitors that are marine or estuarine fishes, while only few species were primary freshwater fishes. This agrees with results of other river studies where freshwater fishes contribute less to species composition (Pagulayan, n.d.; Gomez-Roxas et al., 2005). Paucity of primary freshwater fishes in inland waters is due to the oceanic origin of most Philippine fishes and the significant contribution of marine associated migratory species (Davies, 1999). In addition, marine fishes are known to temporarily enter river mouths as juveniles to feed (Baran, 2000).

Fish species richness in Bago River was significantly higher in the river mouth station for both wet and dry season. Although proximity to the coast may contribute to high species richness, the rocky substrate provided more heterogeneous habitats for fish; Boseto, Morrison, Pikacha, and Pitakia (2007) similarly attributed high species richness in rivers of Choiseul Island, Solomon Islands to proximity to the coast.

Macroinvertebrate community is an important element of tropical river fauna (Welcomme, 1979). In Bago River, they contribute to the food resources and are commonly harvested as a fishery. Most of the macroinvertebrates collected in the study were decapods (shrimps and crabs) and mollusks. The low density of mollusks might be due to the unstable sandy substrate which is unfavorable to mollusks (Hansel et al., 2005; Carumbana, 2006). Among the mollusks collected, only *Melanoides granifera* was widely distributed in the river.

Macroinvertebrates abundance was observed to increase towards downstream, with significantly higher abundance at the river mouth station. Although macroinvertebrates appeared to be more abundant with increasing concentration of total dissolved solids and nitrates, no significant correlation was noted between macroinvertebrates abundance and these parameters.

There were no significant differences in species richness among the four stations in wet and dry seasons, but more species were encountered during the wet season. The list of macroinvertebrates collected may have been underestimated; the gear used was not efficient in capturing the organisms in varying substrates at different stations.

Dominance of Introduced Fish Species

Majority of the primary freshwater species were introduced exotic species that entered the river through aquaculture and aquarium fish

trade. Presence of introduced species is noteworthy because invasion of freshwater areas by non-native species is reported to threaten local fish populations (Vitousek, Antonio, Loope, Rejmanek, & Westbrooks, 1997) through competition with and predation on native species, habitat alteration, and water quality deterioration among others (Hubilla et al., 2007). Two of the introduced species in Bago River, *Cyprinus carpio* (Cyprinidae) and *Oreochromis niloticus* (Cichlidae), were widely distributed and were dominant especially during the dry season. Both species are voracious feeders and are known to compete with native species for food and habitat (Huchette, Beveridge, Baird, & Ireland, 2000).

The occurrence of introduced species in rivers is often talked about but not documented. This survey has confirmed the anecdotal accounts of introduced species dominating fish catches. The impact of their presence in Bago River is still unknown, but the threat they pose to the native species remains.

Threats to Biodiversity of Bago River

Natural. Seasonal changes that cause extreme climatic conditions (e.g., drought or flood) can heighten the impact of environmental problems. High evaporation rate during the dry season intensifies the effect of reduced river discharge because it increases the concentration of dissolved substances and suspended particles in the water (Smith & Smith, 2004). This was noted as increased levels of total dissolved solids (TDS) and total suspended solids (TSS) in Lag-asan station.

Anthropogenic. Pollution due to application of pesticides in Bago River can be intensified by flooding. Cymbush (a pesticide commonly used in the area) was reportedly applied in the surrounding agricultural areas of Kumaliskis and Damsite during the six-month sampling period. Run-off water carrying pesticides and silt goes directly to the river, polluting and increasing its turbidity due to erosion that can disrupt feeding success of fishes and affect the quality of water. A reduction in fish diversity was similarly observed in perennial water bodies in East Midnapore, India resulting from agriculture-based anthropogenic activities (Bhakta & Bandyopadhyay, 2008).

In addition, the presence of dams prevents the normal flow of water, affecting migration patterns of fishes. During dry season, fish species caught in Damsite were all introduced species which included *Oreochromis niloticus, Cyprinus carpio, Clarias batrachus*, and a few

Pterygoplichthys disjunctivus. The reduced volume of river discharge caused by drought and the presence of a dam restricted the flow even more, preventing migratory fishes such as *Anguilla marmorata* to move effectively to downstream station. Fu et al. (2003) also observed a similar situation in Yangtze River basin where hydrological alterations brought about by the dam modified fish distribution which they considered the largest threat to fish biodiversity.

CONCLUSION AND RECOMMENDATIONS

Bago River has high fish biodiversity that is potentially under threat by anthropogenic activities and the presence of introduced exotic species. Conservation and management efforts on aquatic organisms must focus on the regulation of these activities to minimize habitat degradation and reduce the impact of climate change. The invasive nature of the introduced species should be studied and ways to eliminate them should be given priority attention before they harm the native species.

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Table 1.

List of Fish Species Caught during the Wet and Dry Seasons in Four Stations of Bago River (Categories based on Davies et al.*, 1999).*

Family	Species	Local Name(s)	Wet Season				Dry Season			
			Station				Station			
			1	2	3	4	1	2	3	4
I. Primary freshwater species (20%)										
1. Anabantidae	*Anabas testudineus*	Puyo	—	—	—	—	—	x	—	—
2 Osphronemidae	*Trichopodus trichopterus*	"Gourami"	—	—	—	—	—	x	—	x
3. Channidae	*Channa striata*	Dalag	—	x	—	—	—	x	—	—
4. Cyprinidae	*Cyprinus carpio*	Karpa	x	x	x	—	x	x	x	—
	Danio rerio	"Zebra Fish"	x	—	—	—	—	—	—	—
5. Clariidae	*Clarias batrachus*	Pantat	x	x	x	—	x	x	x	—
6. Loricaridae	*Pterygoplichthys disjunctivus*	"Janitor Fish"	—	x	—	—	—	x	x	x
7. Poeciliidae	*Poecilia reticulata*	"Guppy"	x	—	—	—	—	—	—	—
	Poecilia sphenops	"Molly"	—	—	—	—	—	—	—	—
	Xiphophorus helleri	"Swordtail fish"	x	—	—	—	—	—	—	—
8. Synbranchidae	*Synbranchus bengalensis*	Sili-sili	—	x	—	—	—	—	—	—
II. Secondary freshwater species (1.82%)										
1. Cichlidae	*Oreochromis niloticus*	"Tilapia"	x	x	x	x	x	x	x	—

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Table 1. (Continued...)

List of Fish Species Caught during the Wet and Dry Seasons in Four Stations of Bago River (Categories based on Davies et al.*, 1999).*

Family	Species	Local Name(s)	Wet Season				Dry Season			
			Station				Station			
			1	2	3	4	1	2	3	4
III. Migratory species (1.82%)										
1. Anguillidae	*Anguilla marmorata*	Sili, bais	x	x	x	—	x	x	x	—
IV. Sporadic visitors (76.36%)										
1. Carangidae	*Caranx sexfasciatus*	Lison	—	—	—	x	—	—	—	—
	Carangoides ferdau	Lison	—	—	—	x	—	—	—	—
2. Ambassidae	*Ambassis interrupta*	*Parangan*	—	—	—	x	—	—	—	—
	Ambassis miops	Parangan	—	—	—	x	—	—	—	—
3. Clupeidae	*Sardinella sp.*	Tabagak	—	—	—	—	—	—	—	x
4. Eleotrididae	*Butis amboinensis*		—	—	—	x	—	—	—	—
	Ophieleotris aporos	Bagtis/Ubog	—	x	—	—	x	x	x	—
	Oxyeleotris sp.		—	—	—	x	—	—	—	—
5. Engraulididae	*Stolephorus commersonni*	Gurayan	—	—	—	—	—	—	—	x
6. Gerridae	*Gerres filamentosus*	Latab	—	—	—	x	—	—	—	x
7. Gobiidae	*Glossogobius giuris*	Palo	—	—	—	x	—	—	x	—
	Sicyopterus longifilis	Bunog	x	—	—	x	—	—	—	—

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Table 1. (Continued...)

List of Fish Species Caught during the Wet and Dry Seasons in Four Stations of Bago River (Categories based on Davies et al.*, 1999).*

Family	Species	Local Name(s)	Wet Season				Dry Season			
			Station				Station			
			1	2	3	4	1	2	3	4
	Periopthalmus argentilineatus	Dalo-dalo	—	—	—	x	—	—	—	x
	Scartelaos histophorus	Tamasak	—	—	—	x	—	—	—	—
	Awaous melanocephalus	Tughod	—	—	—	x	—	x	—	x
	Cryptocentroides sp.	Damulog	x	—	—	—	—	—	—	x
	Rhinogobius philippinus (syn: R. similis)	Bunog	x	—	—	—	—	x	—	—
8. Hemiramphidae	*Zenarchopterus dispar*	Sigwil	—	—	—	—	—	—	—	x
9. Leiognathidae	*Leiognathus equulus*	Sapsap	—	x	x	x	—	—	—	—
	Leiognathus sp.	Sapsap, Dalupani	—	—	—	x	—	—	—	x
10. Lutjanidae	*Lutjanus argentimaculatus*	Pulahan/Gingaw	—	—	—	x	—	—	—	—
11. Megalopidae	*Megalops cyprinoides*	Bulan-bulan	—	x	x	—	—	—	—	—
12. Mugilidae	*Liza subviridis*	Gusaw	—	—	—	x	—	—	—	x
	Liza vaigensis	Balanak, Gusaw	—	—	—	x	—	—	—	x
	Valamugil seheli	Gusaw	—	—	—	x	—	—	—	x
13. Plotosidae	*Plotosus canius*	Alimusan	—	—	—	x	—	—	—	x
14. Polynemidae	*Polynomus sp.*	Kugaw/lanit	—	—	—	—	—	—	—	x

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Table 1. (Continued...)

List of Fish Species Caught during the Wet and Dry Seasons in Four Stations of Bago River (Categories based on Davies et al.*, 1999).*

Family	Species	Local Name(s)	Wet Season				Dry Season			
			Station				Station			
			1	2	3	4	1	2	3	4
15. Scatophagidae	*Scatophagus argus*	Kikiro	—	—	—	x	—	—	—	—
16. Scorpaenidae	*Choridactylus multibarbus*		—	—	—	x	—	—	—	—
17. Sillagonidae	*Sillago sihama*	Oso-os	—	—	—	x	—	—	—	x
18. Syngnathidae	*Microphis sp.*		—	—	—	x	—	—	—	x
19. Platycephalidae	*Platycephalus sp.*	Tuko-tuko	—	—	—	x	—	—	—	x
20. Terapontidae	*Mesopristes cancellatus*		—	—	—	x	—	—	—	—
	Therapon jarbua	Bugaong	—	—	—	x	—	—	—	x
21. Moringuidae	*Moringua raitaborua*	Bais-bais	—	—	—	x	—	—	—	—
22. Muraenidae	*Strophidon sathete*	nipa-nipa	—	—	—	x	—	—	—	—
23. Ophichthidae	*Cirrhimuraena chinensis*	Bais-bais	—	—	—	x	—	—	—	—
	Yirrkala sp.	Bais-bais	—	—	—	x	—	—	—	x
	Muraenichthys thompsoni (syn: M. gymnopterus)	Bais-bais	—	—	—	x	—	—	—	x
	Neenchelys sp.	Bais-bais	—	—	—	—	—	—	—	x
	Muraenichthys sp.	Bais-bais	—	—	—	x	—	—	—	x
	Pisodonophis cf cancrivorus	Uldok	—	—	—	x	—	—	—	x
Total number of species from each study site:			**10**	**10**	**6**	**34**	**4**	**11**	**7**	**25**

Table 2.

Checklist of Macroinvertebrates Collected in Four Stations of Bago River.

Family	Species	Local Name(s)	Wet Season				Dry Season			
			Station				Station			
			1	2	3	4	1	2	3	4
Shrimps										
1. Atyidae	*Caridina laoagensis*		x	x	—	—	—	—	—	—
	Atyopsis spinipes		x	—	—	—	—	—	—	—
2. Palaemonidae	*Cochodytes cf maculatus*		—	—	—	x	—	—	—	—
	Macrobrachium australe	Putian	x	x	x	—	—	—	—	—
	Macrobrachium equidens	Dalapian	x	x	x	x	x	x	x	x
	Macrobrachium jaroense	Kargador	x	x	x	—	x	x	x	
	Macrobrachium latidactylus	Putian	x	x	x	—	—	—	—	x
	Macrobrachium mammillodactylus	Bukid-bukid	—	x	x	—	—	x	x	x
	Macrobrachium rosenbergii	Pahi	—	—	—	x	—	—	—	—
	Penaeus monodon	Lukon	—	—	—	x	—	—	—	—
Crabs										
1. Parathelphusidae	*Sundathelphusa cf longipes*		x	x	x	x	x	x	x	x
2. Portunidae	*Scylla serrata*	Alimango	—	—	—	x	—	—	—	x
	Portunus pelagicus	Kasag	—	—	—	—	—	—	—	x

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Table 2. (Continued...)

Checklist of Macroinvertebrates Collected in Four Stations of Bago River.

Family	Species	Local Name(s)	Wet Season				Dry Season			
			Station				Station			
			1	2	3	4	1	2	3	4
3. Sesarmidae	*Varuna litterata*	Kalampay	x	x	x	x	—	—	x	x
4. Potamidae	*Ovitamon insulamon*	Kalampay	x	x	—	—	x	x	—	—
	Thalamita crenata	Dawat	—	—	—	—	—	—	—	—
Mollusks										
1. Ampullariidae	*Pomacea canaliculata*	Kohol	x	x	x	—	x	x	—	—
2. Corbiculidae	*Corbicula manillensis*	Banag	x	x	—	—	x	x	—	x
3. Thiaridae	*Melanoides granifera*	Awis	x	x	x	x	x	x	x	x
4. Unionidae	*Cristaria plicata*	"Taiwan shell"	—	—	—	—	—	—	—	—
5. Neritidae	*Nerita spp.*	"Moon shell"	x	—	—	x	x	x	—	x
Total number of species from each site:			**13**	**12**	**9**	**9**	**8**	**9**	**6**	**10**

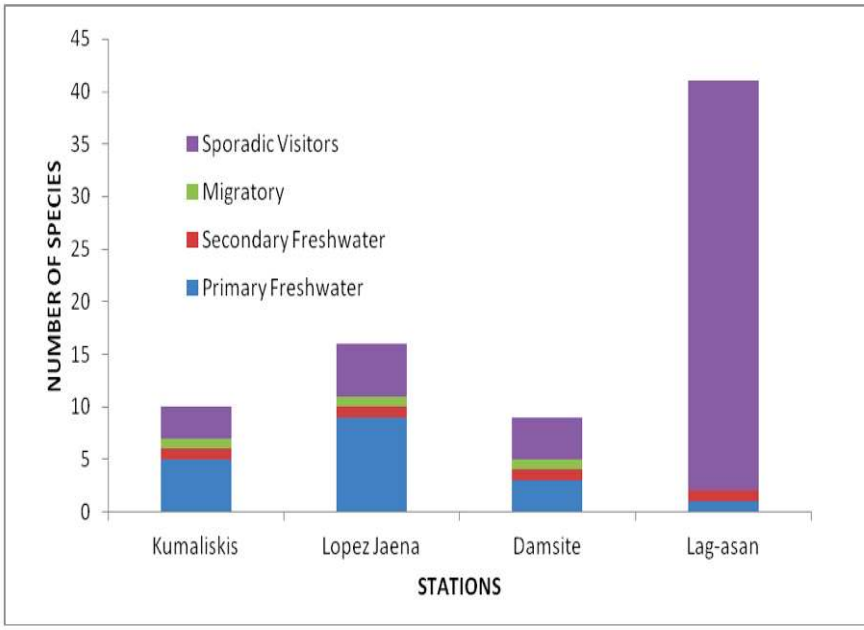

Figure 2. Comparison of fish species composition among the four stations in Bago River.

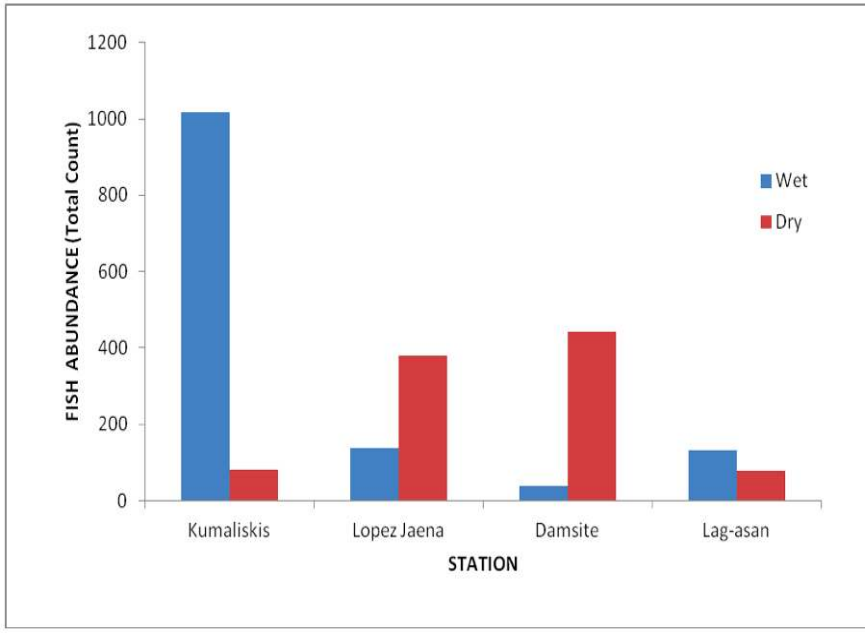

Figure 3. Comparison of fish abundance in four stations during wet and dry seasons.

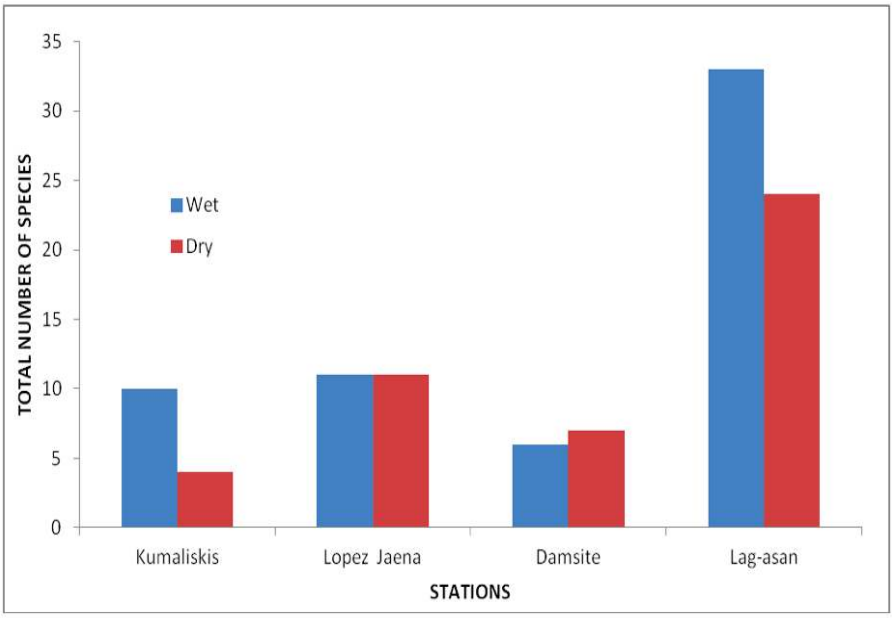

Figure 4. Comparison of fish species richness in four stations during wet and dry seasons.

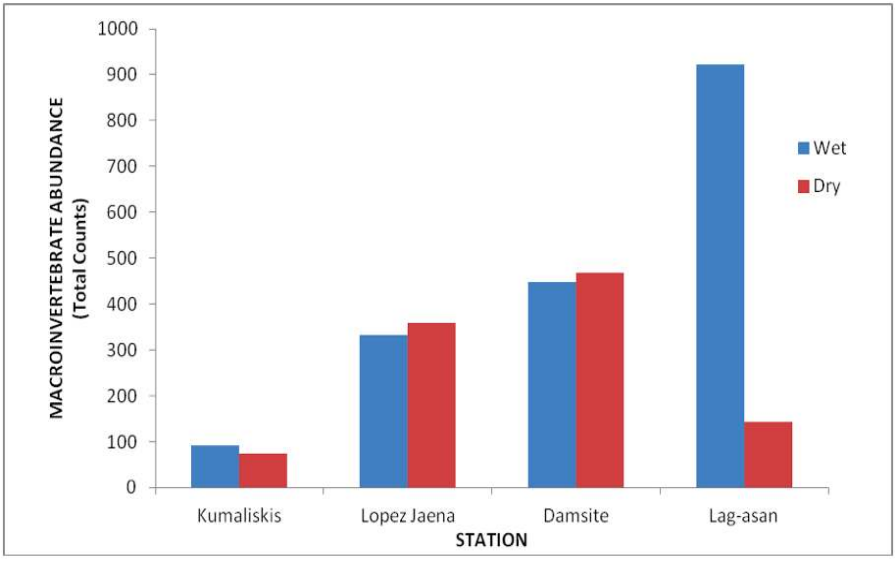

Figure 5. Comparison of macroinvertebrate abundance in four stations during wet and dry seasons.

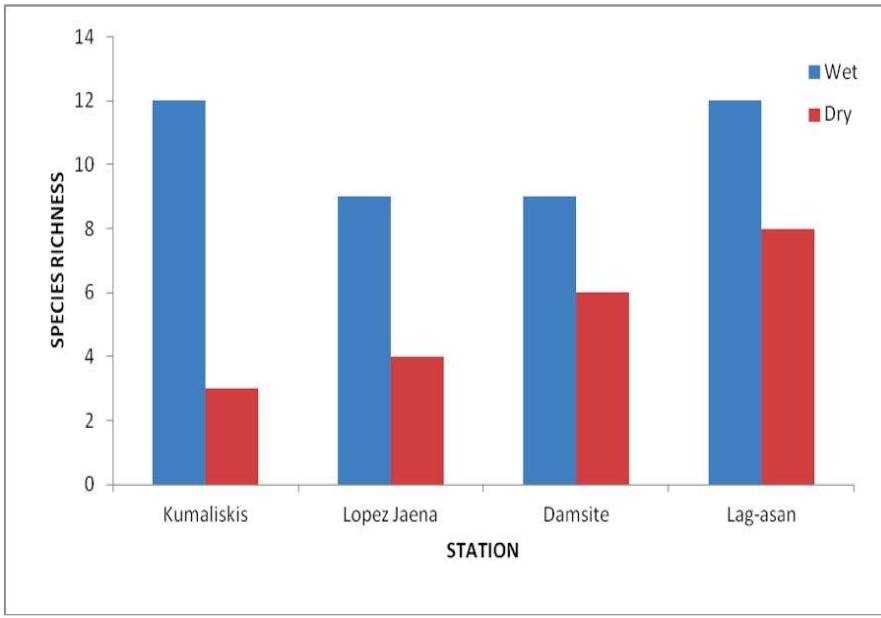

Figure 6. Comparison of macroinvertebrate species richness in four stations during wet and dry seasons.

Table 3.

Summary of Physico-chemical Parameters in Four Stations during Wet and Dry Seasons. (n = 3) (Data taken from Linaugo, et al, *in this issue)*

Parameters	Wet Season Sampling				Dry Season Sampling			
	SS 1	SS 2	SS 3	SS 4	SS 1	SS 2	SS 3	SS 4
Air Temp. (°C)	(22.50-26.00) 24.28	(22.50-29.80) 26.31	(24.10-28.80) 26.25	(24.90-28.50) 26.88	(23.20-28.10) 25.21	(25.20-29.30) 27.94	(26.80-30.40) 28.76	(24.60-29.90) 27.36
Sub-surface Temp. (°C)	(22.60-24.80) 23.68	(22.30-25.50) 24.21	(22.60-25.80) 24.51	(26.00-26.50) 26.16	(22.50-24.90) 23.91	(23.30-25.70) 24.81	(25.00-26.30) 25.59	(26.10-27.80) 26.9
Humidity (%)	(90.00-100.00) 95.00	(79.50-100.00) 89.75	(86.00-100.00) 93.0	(85.00-100.00) 92.5	(72.00-92.00) 88.22	(72.00-92.00) 79.78	(67.00-92.00) 79.33	(68.00-93.00) 84.78
pH	(7.59-9.60) 8.17	(7.00-7.90) 7.49	(7.16-8.00) 7.62	(7.18-7.50) 7.33	(6.50-7.80) 7.57	(7.40-7.90) 7.72	(7.50-8.10) 7.79	(7.60-8.20) 7.90
Dissolved Oxygen (mg/l)	(8.40-11.10) 8.74	(9.10-13.30) 10.76	(9.80-12.20) 11.00	(8.00-10.90) 9.23	(6.00-8.50) 7.39	(10.00-11.30) 10.83	(10.20-12.50) 10.84	(9.10-14.70) 11.08
Salinity (ppt)	(0.01-1.00) 0.38	(0.00-0.50) 0.16	(0.00-0.10) 0.033	(0.00-1.90) 0.29	(1.00-2.00) 1.11	(0.01-1.00) 0.69	(0.00-1.00) 0.33	(1.01-23.00) 7.45
Conductivity (µS/cm)	(114.00-148.00) 117.52	(71.70-333.00) 186.91	(57.30-2,160.00) 458.55	(93.90-1,504.00) 493.64	(68.20-250.00) 135.73	(67.90-207.00) 128.20	(75.10-142.00) 103.03	(35.20-18,500.00) 3,775.41
Total Dissolved Solids (mg/l)	(50.00-74.00) 58.52	(45.00-343.00) 121.33	(29.00-1,080.00) 227.22	(48.30-752.00) 241.60	(34.00-129.00) 67.44	(34.00-114.00) 64.67	(15.00-71.00) 48.00	(18.00-9,260.00) 1,940.33

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Table 3. (Continued...)

Summary of Physico-chemical Parameters in Four Stations during Wet and Dry Seasons. (n = 3) (Data taken from Linaugo, et al, *in this issue)*

Parameters	Wet Season Sampling				Dry Season Sampling			
	SS 1	SS 2	SS 3	SS 4	SS 1	SS 2	SS 3	SS 4
Total Suspended Solids (mg/l)	(55.00-218.00) 147.55	(2.00-48.00) 22.11	(8.00-25.00) 13.22	(13.00-248.00) 97.22	(1.00-11.00) 4.89	(4.00-13.00) 7.00	(2.00-10.00) 7.33	(5.00-261.00) 114.22
Turbidity (NTU)	(50.70-118.00) 80.73	(1.60-85.00) 40.11	(9.23-59.00) 23.60	(12.30-115.00) 46.92	(2.83-14.80) 7.260	(1.83-14.10) 6.61	(2.05-4.01) 2.66	(0.86-15.95) 8.15
Nitrate (mg/l)	(2.50-15.00) 9.45	(2.50-10.00) 5.55	(2.50-10.00) 4.45	(2.50-15.00) 8.37	(10.00-25.00) 18.89	(15.00-25.00) 18.89	(10.00-25.00) 16.11	(20.00-25.00) 24.44
Phosphate (mg/l)	(0.012-0.054) 0.030	(0.020-0.152) 0.062	(0.018-0.105) 0.050	(0.017-0.100) 0.054	(0.018-0.056) 0.040	(0.022-0.122) 0.070	(0.026-0.097) 0.060	(0.024-0.189) 0.080