Zooplankton and White Goby (*Glossogobius giuris* Hamilton 1822): Correlation and Fishers' Perception in Selected Sites in Laguna de Bay, Luzon Island, Philippines

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ABSTRACT

White goby (*Glossogobius giuris* Hamilton 1822) is an omnivorous, native fish species which can be found in Laguna de Bay and its tributaries, and in other bodies of water in the Philippines. Deteriorating water quality, unsustainable fishing practices, aquaculture and predation by introduced invasive species are threatening the population of white goby and other native fish species in Laguna de Bay. This study was conducted to correlate select physico-chemical parameters of lake water and zooplankton abundance, and to assess white goby population based on fishers' perception. Water samples were collected in three sites in June, September and December 2014. Twenty one zooplankton species belonging to 12 families were identified. The most abundant and frequently encountered zooplankton species is *Eurytemora affinis* Poppe 1880. Zooplanktons were most abundant in June and lowest in September. Key informant interviews with local fishers revealed that white goby population was abundant in April to August while catch report showed that fish catch is abundant in June and least during December. The fish abundance in April to June could be attributed to high productivity especially in summer season. The fishers perceived that the population of white goby was declining mainly due to water pollution, aquaculture, and predation by invasive alien species. A multi-stakeholder sustainable watershed management should be adapted to improve the water quality and extinction of native fish species in Laguna de Bay.

1. INTRODUCTION

Laguna de Bay, the largest freshwater lake in the Philippines, is a multiple use resource that provides important ecosystem goods and services to Metropolitan Manila and nearby provinces of Laguna, Rizal and Quezon. The most important ecosystem service is its freshwater resource which is economically important for aquaculture and fisheries (Tan et al., 2010; Israel, 2008; Israel, 2007), industry, transportation, and as a future freshwater source for Metropolitan Manila. At present, various anthropogenic pressures due to rapid population growth, shifting food presence, market demand, landscape modification, urbanization, and industrialization of its watershed affected the ecological balance of the lake ecosystem, native species' composition and water quality. The ecological status, sediment quality, water quality, and pollution load in Laguna de Bay and its catchment areas is alarming (Partnerships in Environmental Management for the Seas of East Asia, 2013; Fabro and Varca, 2012; Hernandez et al., 2012; Papa et al., 2012; Sanchez et al., 2012; Paraso et al., 2011; Kosmehl et al., 2008; Chavez et al., 2006; Tamayo-Zafaralla et al., 2002). Among the consequences of deteriorated water quality in Laguna de Bay are periodic algal blooms (Cuvin-Aralar et al., 2002), bioaccumulation of heavy metals in edible fish (Molina et al., 2011) and possible species feminization due to endocrine disrupting chemicals (Paraso and Capitan, 2012).

White goby (*Glossogobius giuris* Hamilton 1822) or "*biyang puti*" in Philippine local dialect, is a native fish species and a traditional fish food which can be caught in Laguna de Bay (Santos-Borja and Nepomuceno, 2014; Bagarinao, 2001;

Lopez, 2001) and in its tributaries. The presence of white goby was also reported in the watershed of Mount Makiling Forest Reserve (Paller et al., 2011) and in other freshwater ecosystems in the Philippines such as Taal Lake (Masagca and Ordoñez, 2003), Lake Mainit, Surigao del Norte (Joseph et al., 2016), Lake Lanao, Lanao del Sur (Mahilum et al., 2013), Lake Buluan, Sultan Kudarat (Dorado et al., 2012), Maragondon River, Cavite (Bayot et al., 2014), Mandulong River, Lanao del Norte (Vedra et al., 2013), Pansipit River, Batangas (Mendoza et al., 2015), Bago River, Pagatban and in Siaton River, Negros Island (Bucol and Carumbanan, 2010). White goby feeds on zooplankton (Vedra et al., 2013), insects, cladocerans, fish larvae and debris (Bejer, 2015), copepod, chironomid larvae, shrimp, fish egg, algae and epiphyte (Mendoza et al., 2015). However, despite their ecological importance and socio-economic value, the population of white goby and other native species in Laguna de Bay is declining due to deteriorating lake water quality, destructive fishing practices, predation by invasive species, and aquaculture (Guerrero, 2014; Araullo, 2001; Bagarinao, 2001).

To the best of our knowledge, the most recent published studies on zooplankton abundance and distribution in Laguna de Bay were reported by Papa et al. (2012). Recent studies on seasonal abundance and population of white goby in Laguna de Bay are lacking. Therefore, this study attempted to correlate select physico-chemical properties of lake water (dissolved oxygen, pH, salinity, total dissolved solids, total suspended solids, and turbidity) to zooplankton abundance, and to assess the seasonal abundance and population of white goby based on the perception of local fishers. Due to financial and time limitations, this study was limited to three sampling periods and three sampling sites only. Nonetheless, the findings of this study could be useful for future studies related to zooplanktons and white goby in Laguna de Bay and similar areas.

2. METHODOLOGY

2.1 Study area

Laguna de Bay (approximately 700 km^2 total surface area and 2,920 km^2 watershed area) is the largest freshwater lake in Luzon Island and in the entire Philippines (Figure 1). It is also considered as the second largest lake in South East Asia. This lake is surrounded by the provinces of Laguna, Rizal, Quezon, and Metropolitan Manila (Ancog et al., 2008).

Lake water, zooplanktons, and white gobies were collected in three sites in Laguna de Bay. The first site is located in the south bay in Barangay Bayog, Los Baños, Laguna (Figure 2a). The second site is in the central bay in Barangay Janosa, Talim Island, Binangonan, Rizal (Figure 2b). The third site is in the south bay in Barangay Masili, Calamba City, Laguna (Figure 2c). The sampling sites were chosen on the basis of our key informant interviews, which pointed out that white gobies were usually caught in these areas. The lake water samples and zooplankton were collected in June 22, September 30, and December 21, 2014.

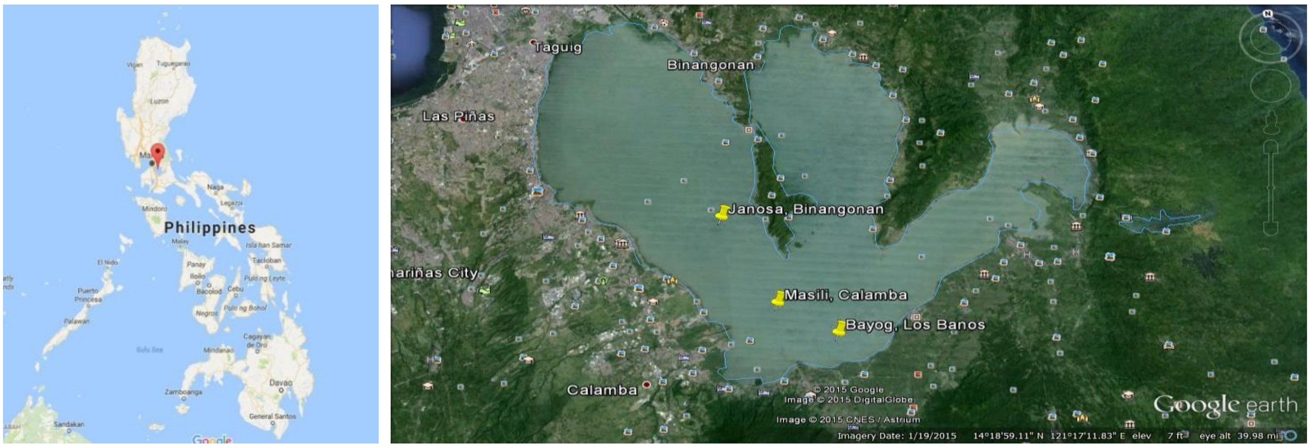


Figure 1. Location of Laguna de Bay in the Philippine map (left). Location of the three sampling sites in Laguna de Bay (right).

2.2 Water quality parameters

Dissolved oxygen (DO), pH, salinity, total dissolved solids (TDS), total suspended solids (TSS), and turbidity of lake water were determined on-site using a portable water quality checker (Horiba) by submerging the probe to a depth of about 1-2 meters. This was repeated three times.

2.3 Collection of zooplankton

For zooplankton collection, plankton net was lowered to a depth of about 1-2 meters and slowly hauled back to the water surface. The water collected at the cod-end of the net was drained into sampling bottles. A total of 800 ml water samples were collected and 10 ml of 10% formalin was immediately added. The water samples were decanted until 10 ml were obtained, transferred into a vial, and stained with rose bengal. The zooplankton species were identified using a photomicroscope and were counted using a Sedgewick-rafter counting chamber. Relative abundance (RA) was determined by dividing the number of individual species to the total number of species. Zooplankton species identification was performed by Dr. Noe B. Gapas of National Museum of the Philippines.

Figure 2a. Site 1 in Barangay Bayog, Los Baños, Laguna.

Figure 2b. Site 2 in Barangay Janosa, Talim Island, Binangonan, Rizal.

Figure 2c. Site 3 in Barangay Masili, Calamba City, Laguna.

2.4 Fish collection and zooplankton analysis in gut

White gobies (Figure 3) were captured using a fish net and were placed in an ice box. For gut analysis, ten matured white gobies were dissected and the guts were removed, and were fixed with 20% formalin solution. The zooplankton species were identified using a photomicroscope and were counted using a Sedgewick-rafter counting chamber. Zooplankton species identification was performed by Dr. Noe B. Gapas of National Museum of the Philippines.

Figure 3. Captured white gobies in this study.

2.5 Survey on fishers' perception

A semi-structured interview was conducted to elicit information on the following: a. perception on the population of white goby, b. possible reasons associated to the decline of the population of white goby, c. economic and ecological importance of white goby and, d. awareness to Fisheries Administrative Order (FAO) No. 35 (Regulation on the kalakad pangbiya and the conservation of *biyang puti* in Laguna de Bay and its tributaries). The respondents of this study were the coastal dwellers and local fishers (18 years old and above). A total of 300 respondents (100 respondents randomly selected from each barangay) participated in this study.

2.6. Data analyses

Kruskal Wallis test was used to determine the significant differences in the abundance of zooplankton and physico-chemical parameters with respect to sampling sites and sampling periods. Spearman's rho was used to determine the correlation in zooplankton abundance and physico-chemical parameters. Data were interpreted at $p<0.05$ using MiniTab version 17.

3. RESULT AND DISCUSSION

3.1 Physico-chemical characteristics of lake water

Table 1 presents the water quality characteristics of lake water samples in three sampling sites in terms of DO, pH, salinity, TSS, and turbidity for three sampling periods.

For DO, it ranged from 6.6 to 12.1 mg/l and was comparatively similar to surface water DO of Lake Taal (Papa et al., 2011) and much higher than surface water DO of Paoay Lake (Aquino et al., 2008) in the Philippines. DO was highest in Barangay Bayog in June (12.1 mg/l) while lowest DO was in Barangay Bayog in September (6.6 mg/l). Higher DO in June could be related to increased photosynthetic activity and high nutrient level. There was no significant difference in the DO in three sampling periods (h=4.87, p=0.088).

The pH values ranged from 7.69 to 8.62. The water pH was highest in Barangay Bayog (8.62) in June while the lowest pH recorded was in Barangay Masili (7.69) also in June sampling. There was no significant difference in the pH in three sampling periods (h=0.61, p=0.739).

Salinity ranged from 0.2 ppt to 0.4 ppt but there was no significant difference in the salinity in three sampling periods (h=1.15, p=0.564).

TSS was higher during the months of September and December but there was no significant difference in the TSS in three sampling periods (h=2.85, p=0.240).

The highest turbidity was recorded in Barangay Masili during December and lowest in Barangay Bayog during June and December. Higher turbidity was also noted in September which could have been caused by Tropical Storm Mario (Tropical Storm Fung-wong) that brought high amount of rainfall and caused surface water runoff around Laguna de Bay watershed. However, there was no significant difference in the turbidity in three sampling periods (h=1.87, p=0.393).

Table 1. Lake water quality in the coastal waters in Barangay Bayog (Site 1), Barangay Janosa (Site 2), and Barangay Masili (Site 3) in June, September and December 2014.

Parameters	June 2014			July 2014			August 2014		
	Bayog	Janosa	Masili	Bayog	Janosa	Masili	Bayog	Janosa	Masili
DO	12.1	11.3	8.1	6.6	7.9	7.9	7.1	8.1	7.6
pH	8.62	8.21	7.69	8.50	8.07	8.21	8.31	8.37	8.35
Salinity (ppt)	0.3	0.4	0.2	0.3	0.2	0.3	0.3	0.2	0.2
TSS (mg/l)	25	25	25	29	31	39	36	23	33
Turbidity (NTU)	2.4	51.7	77.1	65.6	94.1	103.2	2.54	20.4	119

Note: Values are average of three trials.

Due to the proximity of Laguna de Bay to the highly urbanized Metropolitan Manila and industrial and agricultural zones in the provinces of Laguna, Rizal, Cavite, Batangas and Quezon, the lake serves as a sink for municipal, agricultural and industrial wastes that contributes to its high nutrient level, elevated turbidity, heavy metals and persistent organic pollutants including pesticides, petrochemicals and endocrine disrupting compounds (Sanchez et al., 2014; Fabro and Varca, 2012; Paraso et al., 2012; Molina et al., 2011; Paraso et al., 2010; Kosmehl et al., 2008). In comparison to other lakes in South East Asia, the mean fecal coliform in wet season (Chavez et al., 2006) in Laguna de Bay is greater than the mean fecal coliform in lakes Tinh Tam, Cay Mung, Tan Mieu and Ho Ve in Vietnam (Ky and Lam, 2016). The lack of local and central sewage treatment facilities and failure to implement effective solid waste management further makes the water quality of the lake problematic (Ecosystems and People: the Philippine Millennium Ecosystem Assessment Subglobal Assessment, 2005; Barril, 2013). The largely untreated wastes generated from household, commercial, industrial, and agricultural activities in the watershed of Laguna de Bay are discharged into the lake that contaminate the lake water with alkylbenzenesulfonates (Eichhorn et al., 2001), heavy metals (Chavez et al., 2006), genotoxic organic compounds (Kosmehl et al., 2008), and 17β-estradiol (Paraso and Capitan, 2012; Paraso et al., 2011). In addition, suspended sediments contributed by accelerated soil erosion, agriculture and changing land use pattern (Hernandez et al., 2012) increase the TSS and turbidity. Elevated levels of organic wastes and nutrient enrichment increases DO consumption as a consequence of biological decomposition and mineralization of organic wastes. In this study, the DO level in sampling sites ranged from 6.6-12.1 mg/l and if DO concentration drops to less than 5 mg/l, the fish and invertebrate communities will be impaired (Dyer et al., 2003 and the reference therein).

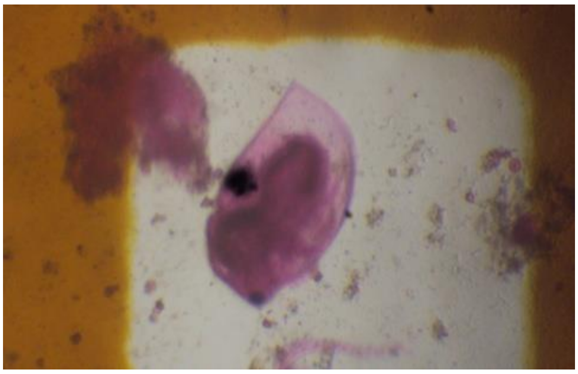
3.2 Zooplankton composition

Figure 4 shows the photomicrographs of the zooplankton species identified in three sampling sites in Laguna de Bay. In this study, twenty one species belonging to 12 families were identified. The species together with their family are *Bosmina longirostris* O.F. Muller 1776 and *Eubosmina coregoni* Baird 1857 (Family Bosminidae), *Moina macrocopa* Straus 1820 (Family Moinidae), *Alonella diaphana* King 1853 (Family Chydoridae), *Ceriodaphnia lacustris* Birge 1893, *Ceriodaphnia megalops* Sars 1862, *Ceriodaphnia quadrangula* O.F. Muller 1785, (Family Daphniidae), *Calanus helgolandicus* Claus 1863 (Family Calanidae), *Diaptomus siciloides* Lilljeborg 1889, *Eodiaptomus japonicas* Burckhardt 1913, *Sinodiaptomus sarsi* Rylov 1923 (Family Diaptomidae), *Eurytemora affinis* Poppe 1880 (Family Temoridae), *Cyclops strenuus* Fischer 1851, *Cyclops vicinus* Uljanin 1875, *Eucyclops macrurus* G.O. Sars 1863, *Mesocyclops leuckarti* Claus 1857, *Thermocyclops oithonoides* Sars G.O. 1863 (Family Cyclopidae), *Canthocamptus staphylinus* Jurine 1820 (Family Canthocamptidae), *Ergasilus genuinus* Kokubo 1914 (Family Ergasilidae), *Keratella heimalis* Carlin 1943 (Family Lecanidae), and *Lecane luna* Muller 1776 (Family Lecanidae).

3.3 Zooplankton abundance per sampling site

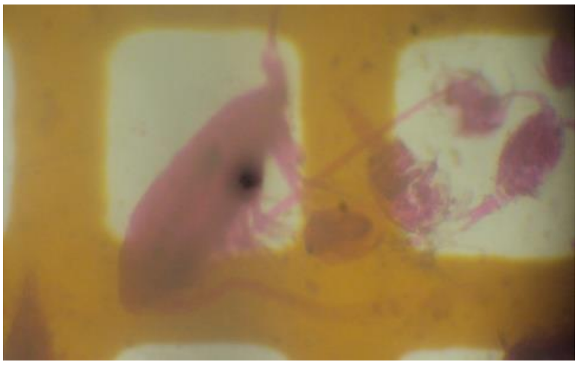
Tables 2-4 and Figures 5-7 show the frequency and relative abundance (RA) of zooplankton species collected in three sampling sites in Laguna de Bay in June, September and December 2014.

For June 2014 sampling (Table 2 and Figure 5), the most abundant species were *Eurytemora affinis* Poppe 1880 (A=31, RA=8.59, in Barangay Bayog), *Eubosmina coregoni* Baird 1857 (A=23, RA=6.46, in Barangay Masili), and *Mesocyclops leuckarti* Claus 1857 (A=29, RA=7.18, in Barangay Janosa). On the other hand, *Canthocamptus staphylinus* Jurine 1820 and *Sinodiaptomus sarsi* Rylov 1923 were not present in Barangay Masili and Janosa, respectively. The greatest number of zooplanktons were collected in Barangay Janosa (404 total species). Kruskal Wallis test showed that the abundance of zooplankton species in three sampling sites was not significantly different (h=1.92, df=2, p=0.379).

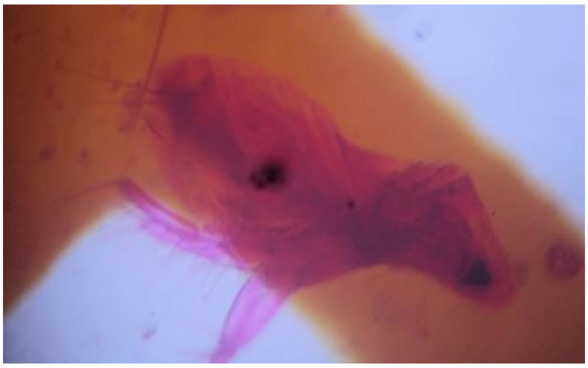


Alonella diaphana King 1853

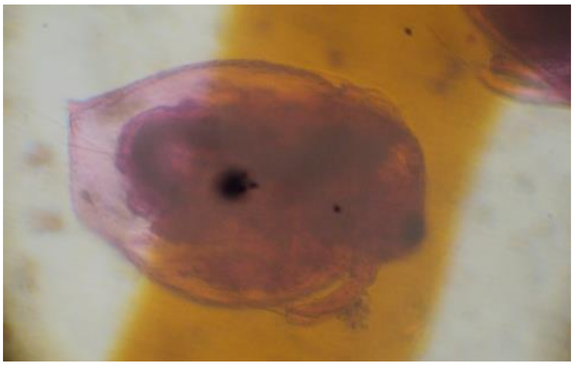
Bosmina longirostris O.F. Muller 1776



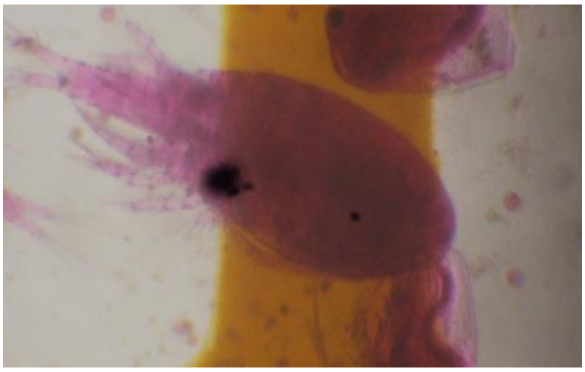
Calanus helgolandicus Claus 1863



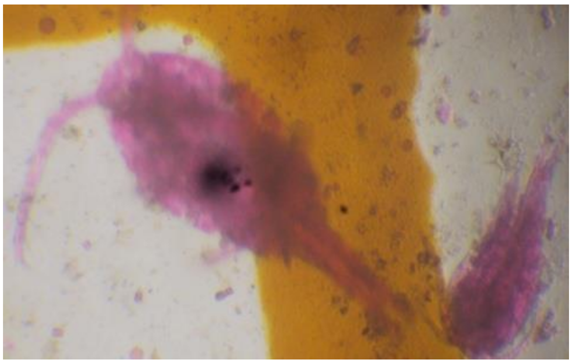
Ceriodaphnia megalops Sars 1862



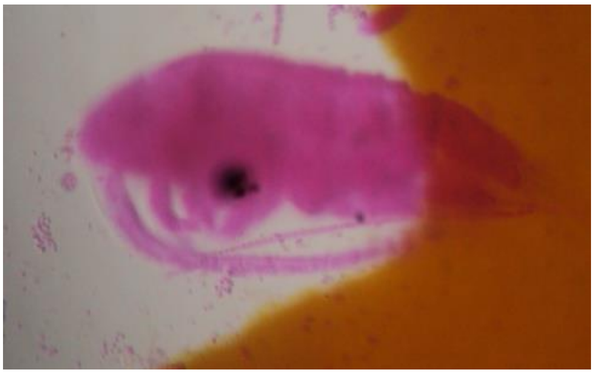
Ceriodaphnia quadrangula O.F. Muller 1785



Cyclops strenuus Fischer 1851

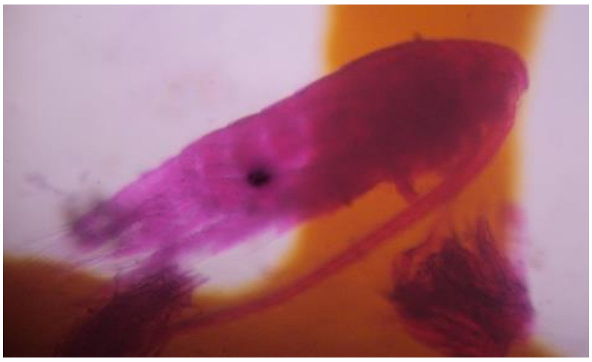


Cyclops vicinus Uljanin 1875

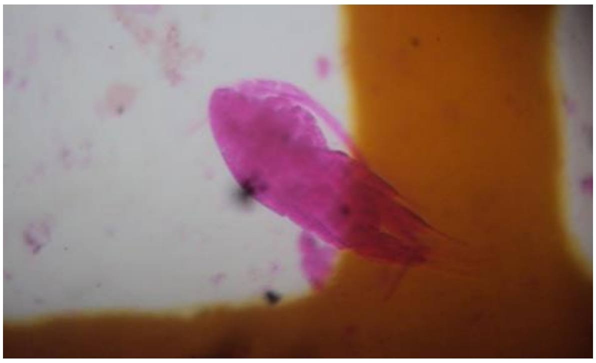


Diaptomus siciloides Lilljeborg 1889

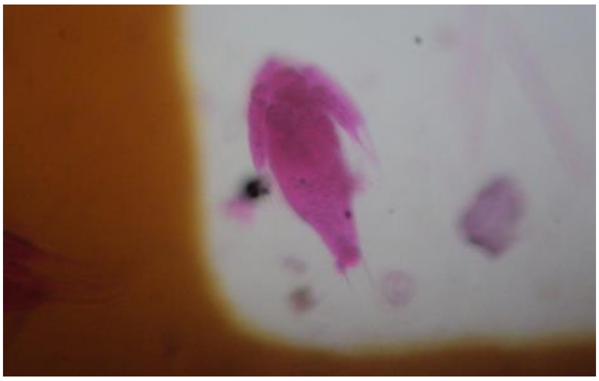
Figure 4. Zooplankton species collected in three sampling sites (Barangay Bayog, Barangay Masili, and Barangay Janosa) in Laguna de Bay in June, September and December 2014.



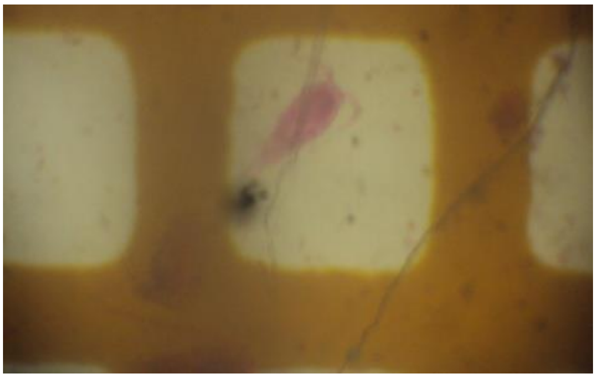
Eodiaptomus japonicus Burckhardt 1913



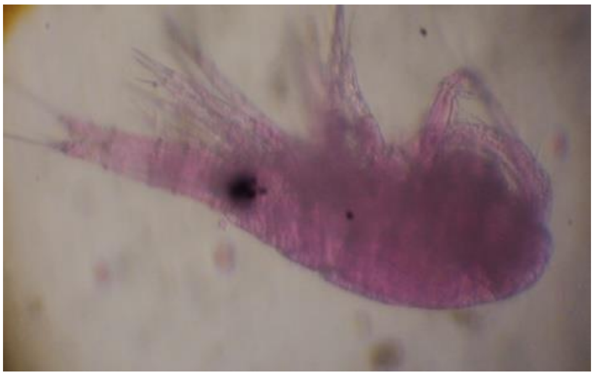
Eucyclops macrurus G.O. Sars 1863



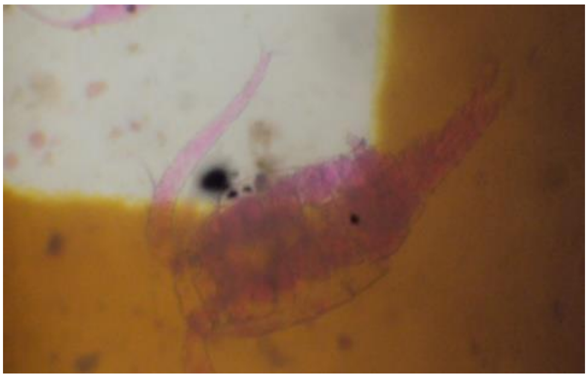
Eurytemora affinis Poppe 1880



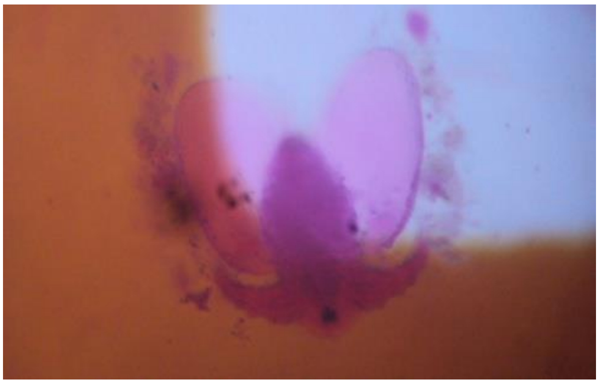
Ergasilus genuinus Kokubo 1914



Mesocyclops leuckarti Claus 1857



Thermocyclops oithonoides Sars G.O. 1863



Moina macrocopa Straus 1820

Sinodiaptomus sarsi Rylov 1923

Figure 4. Zooplankton species collected in three sampling sites (Barangay Bayog, Barangay Masili, and Barangay Janosa) in Laguna de Bay in June, September and December 2014. (cont.)

Table 2. Abundance (A) and Relative Abundance (RA) of zooplankton species in three sampling sites (Brgy. Bayog, Brgy. Masili, and Brgy. Janosa) in Laguna de Bay in June 2014. Species are arranged in alphabetical order.

Zooplankton species	Bayog		Masili		Janosa	
	A	RA	A	RA	A	RA
Alonella diaphana King 1853	19	5.26	16	4.49	16	3.96
Eubosmina coregoni Baird 1857	19	5.26	23	6.46	23	5.69
Bosmina longirostris O.F. Muller 1776	17	4.71	19	5.34	23	5.69
Calanus helgolandicus Claus 1863	23	6.37	19	5.34	21	5.20
Canthocamptus staphylinus Jurine 1820	12	3.32	0	0.00	19	4.70
Ceriodaphnia lacustris Birge 1893	21	5.82	18	5.06	19	4.70
Ceriodaphnia megalops Sars 1862	13	3.60	17	4.78	13	3.22
Ceriodaphnia quadrangula O.F. Muller 1785	15	4.16	21	5.90	19	4.70
Cyclops strenuus Fischer 1851	21	5.82	18	5.06	16	3.96
Cyclops vicinus Uljanin 1875	17	4.71	16	4.49	17	4.21
Diaptomus siciloides Lilljeborg 1889	1.6	4.43	12	3.37	16	3.96
Eodiaptomus japonicus Burckhardt 1913	17	4.71	19	5.34	26	6.44
Eucyclops macrurus G.O. Sars 1863	15	4.16	20	5.62	19	4.70
Eurytemora affinis Poppe 1880	31	8.59	22	6.18	36	8.91
Keratella hiemalis Carlin 1943	10	2.77	12	3.37	12	2.97
Lecane luna Muller 1776	14	3.88	16	4.49	12	2.97
Ergasilus genuinus Kokubo 1914	19	5.26	19	5.34	28	6.93
Mesocyclops leuckarti Claus 1857	22	6.09	21	5.90	29	7.18
Thermocyclops oithonoides Sars G.O. 1863	22	6.09	13	3.65	23	5.69
Moina macrocopa Straus 1820	8	2.22	19	5.34	17	4.21
Sinodiaptomus sarsi Rylov 1923	10	2.77	16	4.49	0	0.00
TOTAL	**361**	**100**	**356**	**100**	**404**	**100**

For September 2014 sampling (Table 3 and Figure 6), the most abundant species were *Eurytemora affinis* Poppe 1880 (A=28, RA=11.72, in Barangay Bayog; and A=28, RA=9.03, in Barangay Janosa), and *Ergasilus genuinus* Kokubo 1914 (A=23, RA=8.33, in Barangay Masili). The following species were not present: *Cyclops strenuus* Fischer 1851, *Diaptomus siciloides* Lilljeborg 1889, *Lecane luna* Muller 1776, and *Sinodiaptomus sarsi* Rylov 1923 (in Barangay Bayog); *Eubosmina coregoni* Baird 1857, *Cyclops vicinus* Uljanin 1875, and *Lecane luna* Muller 1776 (in Barangay Masili); and *Alonella diaphana* King 1853, *Diaptomus siciloides* Lilljeborg 1889, *Moina macrocopa* Straus 1820, and *Sinodiaptomus sarsi* Rylov 1923 (in Barangay Janosa). Similar to June sampling, the highest number of zooplankton species were collected in Barangay Janosa (310 total species). Kruskal Wallis test showed that the abundance of zooplankton species in three sampling sites was not significantly different (h=5.28, df=2, p=0.071).

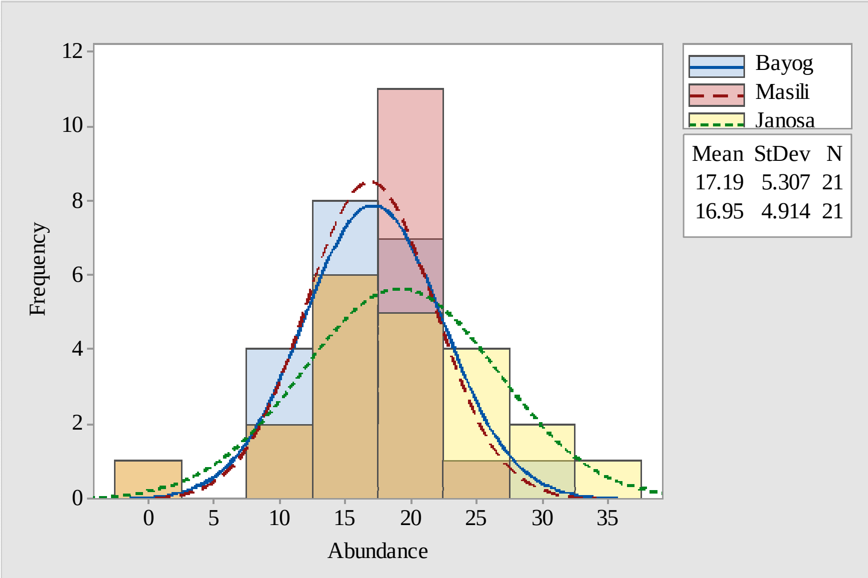


Figure 5. Abundance of zooplankton species in Barangay Bayog, Masili, and Janosa, in June 2014 sampling period. Based on Kruskal Wallis test (p>0.05), abundance was not significantly different.

Table 3. Abundance (A) and Relative Abundance (RA) of zooplankton species in three sampling sites (Brgy. Bayog, Brgy. Masili, and Brgy. Janosa) in Laguna de Bay in September 2014. Species are arranged in alphabetical order.

Zooplankton species	**Bayog**		**Masili**		**Janosa**	
	A	**RA**	**A**	**RA**	**A**	**RA**
Alonella diaphana King 1853	15	6.28	16	5.80	0	0.00
Eubosmina coregoni Baird 1857	10	4.18	0	0.00	15	4.84
Bosmina longirostris O.F. Muller 1776	12	5.02	19	6.88	19	6.13
Calanus helgolandicus Claus 1863	13	5.44	15	5.43	16	5.16
Canthocamptus staphylinus Jurine 1820	13	5.44	16	5.80	22	7.10
Ceriodaphnia lacustris Birge 1893	15	6.28	16	5.80	18	5.81
Ceriodaphnia megalops Sars 1862	17	7.11	16	5.80	12	3.87
Ceriodaphnia quadrangula O.F. Muller 1785	10	4.18	11	3.99	15	4.84
Cyclops strenuus Fischer 1851	0	0.00	10	3.62	13	4.19
Cyclops vicinus Uljanin 1875	13	5.44	0	0.00	17	5.48
Diaptomus siciloides Lilljeborg 1889	0	0.00	8	2.90	0	0.00
Eodiaptomus japonicus Burckhardt 1913	11	4.60	15	5.43	20	6.45
Eucyclops macrurus G.O. Sars 1863	12	5.02	11	3.99	16	5.16
Eurytemora affinis Poppe 1880	28	11.72	20	7.25	28	9.03
Keratella hiemalis Carlin 1943	16	6.69	12	4.35	16	5.16
Lecane luna Muller 1776	0	0.00	0	0.00	15	4.84
Ergasilus genuinus Kokubo 1914	16	6.69	23	8.33	23	7.42
Mesocyclops leuckarti Claus 1857	13	5.44	17	6.16	26	8.39
Thermocyclops oithonoides Sars G.O. 1863	10	4.18	16	5.80	19	6.13
Moina macrocopa Straus 1820	15	6.28	22	7.97	0	0.00
Sinodiaptomus sarsi Rylov 1923	0	0.00	13	4.71	0	0.00
TOTAL	**239**	**100**	**276**	**100**	**310**	**100**

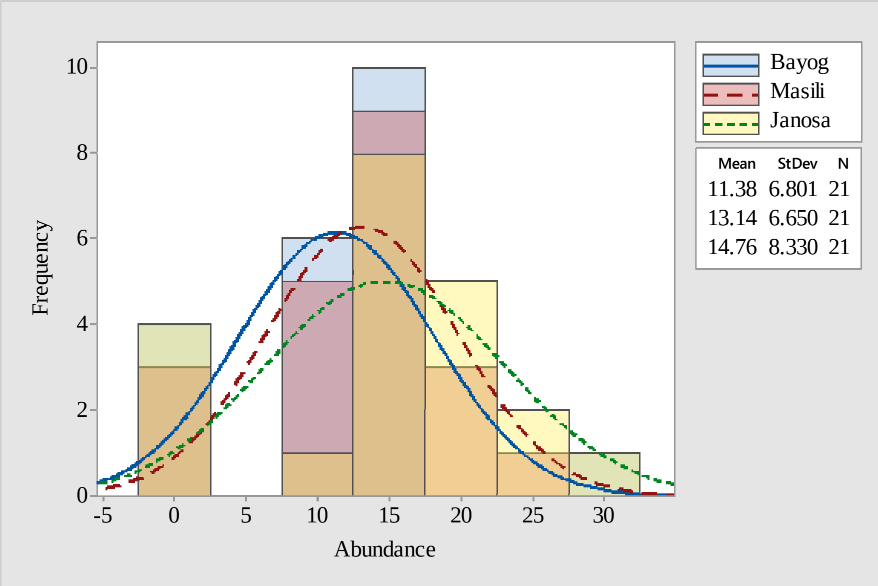


Figure 6. Abundance of zooplankton species in Barangay Bayog, Masili, and Janosa, in September 2014 sampling period. Based on Kruskal-Wallis test (p>0.05), abundance was not significantly different.

For December 2014 sampling (Table 4 and Figure 7), the most abundant species were *Eurytemora affinis* Poppe 1880 (A=26, RA=7.41, in Barangay Bayog), and *Ergasilus genuinus* Kokubo 1914 (A=26, RA=10.00, in Barangay Masili; and A=22, RA=7.48, in Barangay Janosa). All 21 species were present in Barangay Bayog and Janosa except *Ceriodaphnia lacustris* Birge 1893, *Diaptomus siciloides* Lilljeborg 1889 and *Sinodiaptomus sarsi* Rylov 1923 which were not present in Barangay Masili. Contrary to June and September sampling, the highest number of total species were in Barangay Bayog. Kruskal Wallis test showed that the abundance of zooplankton species in three sampling sites was significantly different (h = 7.08, df = 2, p = 0.029).

Overall, the number of zooplanktons decreased in the following order: June (1,121 total species) > December (904 total species) > September (825 total species). This indicated that zooplanktons were abundant in summer season and this result was in agreement with Deepthi et al. (2014). Kruskal Wallis test showed that zooplankton abundance in three sampling months was significantly different (h=18.25, df=2, p=0.000).

A recent study on zooplankton species composition of Laguna de Bay was reported by Papa et al. (2012). The study revealed a total of 12 rotifer, 5 cladocera and 3 copepod species from the west bay. In the present study 21 species were identified. However, the species identified in the study of Papa et al. (2012) were not present in our study area.

Table 4. Abundance (A) and Relative Abundance (RA) of zooplankton species in three sampling sites (Barangay Bayog, Barangay Masili, and Barangay Janosa) in Laguna de Bay in December 2014.

Zooplankton species	Bayog		Masili		Janosa	
	A	RA	A	RA	A	RA
Alonella diaphana King 1853	13	3.70	8	3.08	10	3.40
Eubosmina coregoni Baird 1857	15	4.27	12	4.62	12	4.08
Bosmina longirostris O.F. Muller 1776	19	5.41	22	8.46	17	5.78
Calanus helgolandicus Claus 1863	18	5.13	10	3.85	15	5.10
Canthocamptus staphylinus Jurine 1820	16	4.56	21	8.08	16	5.44
Ceriodaphnia lacustris Birge 1893	16	4.56	0	0.00	10	3.40
Ceriodaphnia megalops Sars 1862	22	6.27	17	6.54	10	3.40

Table 4. Abundance (A) and Relative Abundance (RA) of zooplankton species in three sampling sites (Barangay Bayog, Barangay Masili, and Barangay Janosa) in Laguna de Bay in December 2014 (cont.).

Zooplankton species	Bayog		Masili		Janosa	
	A	RA	A	RA	A	RA
Ceriodaphnia quadrangula O.F. Muller 1785	12	3.42	8	3.08	11	3.74
Cyclops strenuus Fischer 1851	17	4.84	16	6.15	12	4.08
Cyclops vicinus Uljanin 1875	15	4.27	14	5.38	15	5.10
Diaptomus siciloides Lilljeborg 1889	10	2.85	0	0.00	10	3.40
Eodiaptomus japonicus Burckhardt 1913	16	4.56	10	3.85	12	4.08
Eucyclops macrurus G.O. Sars 1863	18	5.13	12	4.62	11	3.74
Eurytemora affinis Poppe 1880	26	7.41	22	8.46	19	6.46
Keratella hiemalis Carlin 1943	12	3.42	10	3.85	15	5.10
Lecane luna Muller 1776	16	4.56	9	3.46	13	4.42
Ergasilus genuinus Kokubo 1914	19	5.41	26	10.00	22	7.48
Mesocyclops leuckarti Claus 1857	21	5.98	16	6.15	19	6.46
Thermocyclops oithonoides Sars G.O. 1863	23	6.55	17	6.54	16	5.44
Moina macrocopa Straus 1820	15	4.27	10	3.85	13	4.42
Sinodiaptomus sarsi Rylov 1923	12	3.42	0	0.00	16	5.44
TOTAL	**351**	**100**	**260**	**100**	**294**	**100**

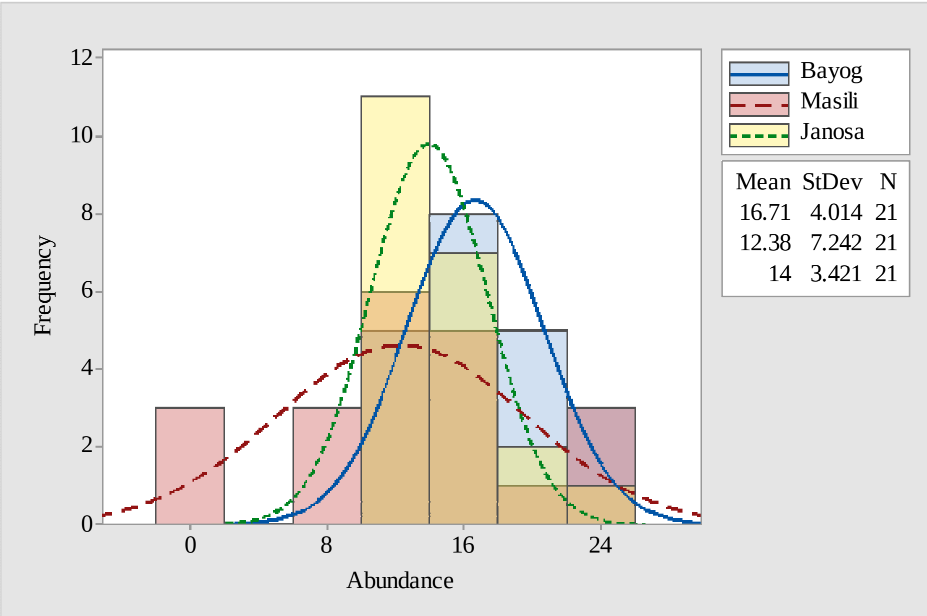


Figure 7. Abundance of zooplankton species in Barangay Bayog, Masili, and Janosa, in December 2014 sampling period. Based on Kruskal Wallis test (p<0.05), abundance was significantly different.

3.4 Physico-chemical parameters and zooplankton abundance

In this study, Spearman rank correlation showed that zooplankton abundance was positively correlated with DO (ρ=0.597, p=0.090) (Bir et al. 2015; Jose et al. 2015; Shil et al. 2013; Veerendra et al. 2012; Alam and Kabir 2003) and salinity (ρ=0.237, p=0.539) but not significant (p>0.05). On the other hand, water pH (ρ=-0.335, p=0.379), TSS (ρ=-0.119, p=0.761) and turbidity (ρ=-0.250, p=0.516) were negatively but not significantly correlated with zooplankton abundance. This may indicate that a change in water quality parameters could bring about a change in zooplankton composition and population.

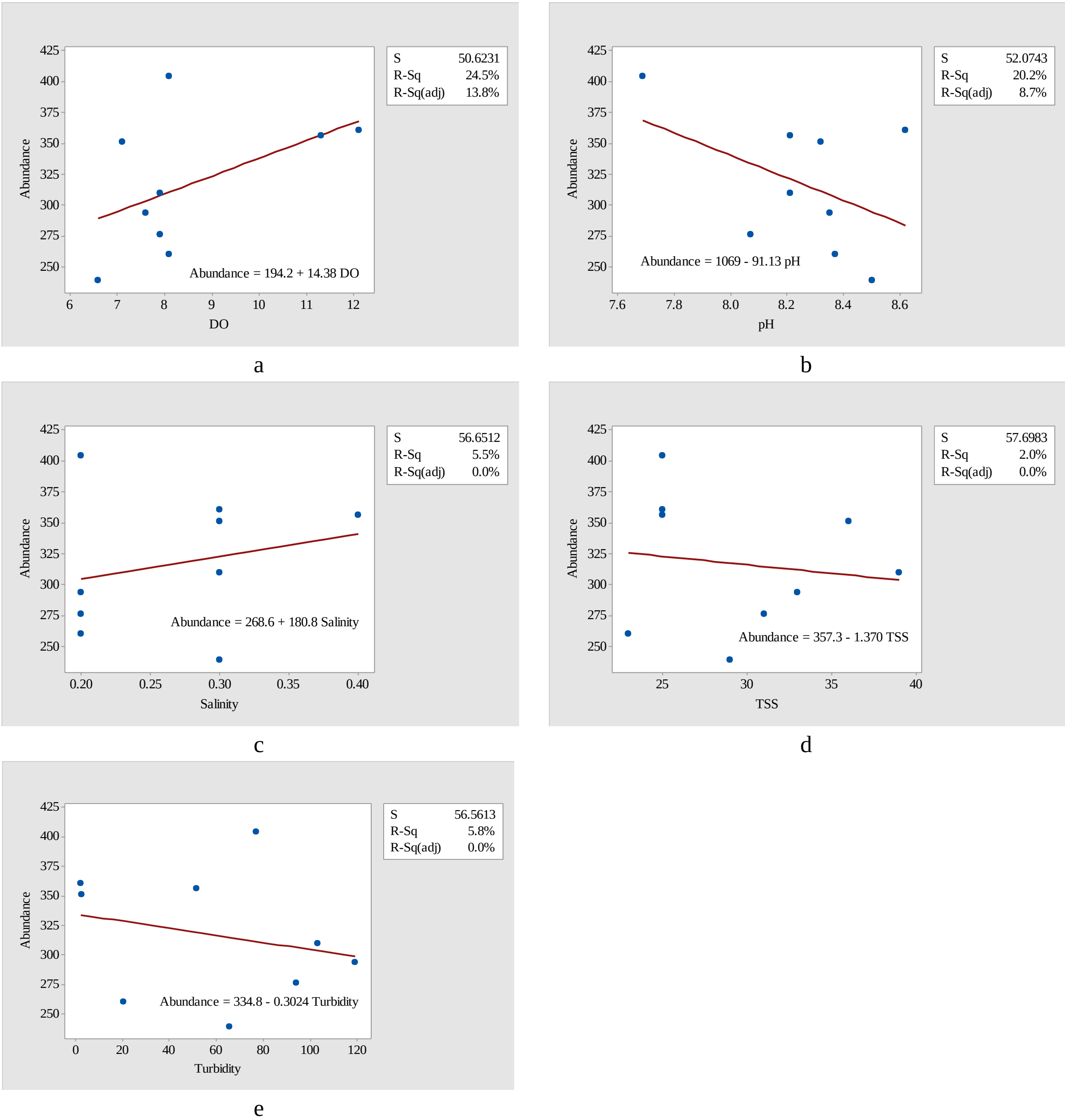


Figure 8. Relationship between zooplankton abundance and (a) dissolved oxygen (DO), (b) pH, (c) salinity, (d) TSS and (e) turbidity.

3.5 Gut analysis

Due to low fish catch and scarcity of white gobies in the months of September and December, only ten fishes that were caught in June in three sites were subjected to gut analysis for zooplankton identification. In these fish samples, seven zooplankton species (*Acetes* sp., *Bosmina* sp., *Bosmina longirostris* O.F. Muller 1776, *Ceriodaphnia* sp., *Cyclops* sp., *Eodiaptomus japonicus* Burckhardt 1913, and *Mesocyclops* sp.) were identified in the guts of white gobies. The total number of zooplanktons present in the fish guts was as following: 188 (Barangay Janosa), 122 zooplanktons (Barangay Bayog), and 73 (Barangay Masili). Of the seven zooplankton species, *Cyclops* sp. and *Eodiaptomus japonicus* Burckhardt 1913 were not present in the guts of white gobies caught in Barangay Masili. This indicated that zooplanktons were part of the diet of white gobies. White gobies are omnivorous fishes that feed on algae, annelids, crustaceans, insects, mollusks, nematodes, and plants (Hossain et al. 2016; Achakzai et al. 2015; Bejer, 2015; Prasad and Singh, 2015). Considering the importance of zooplankton in the aquatic food chain and fish diet, it is therefore essential to regulate nutrient input and maintain good lake water quality as these may affect zooplankton composition and fish population.

3.6 Fishers' perception on the abundance of *G. giuris*

The result of key informant interviews revealed that white gobies were abundant from May to August while less abundant from October to December. The Municipal Fisheries and Aquatic Resources Management Council (MFARMC) catch report revealed that white gobies were most abundant in the month of June and the highest fish catch was recorded in Barangay Janosa, Rizal. In this study, a total of 77 white gobies were collected from Barangay Bayog (37), Barangay Janosa (29), and Barangay Masili (11) in June 2014. There was no white gobies collected in September and only 2 fishes were caught in December. According to the local fishers, the white gobies were abundant in April to August and fish catching is difficult during typhoon season. Related to this study, goby species were more abundant in dry season in Mandulong River in Iligan City, Lanao del Norte in the Philippines (Vedra et al., 2013). The possible explanation is the high productivity during dry season due to sufficient sunlight and nutrient availability. The local fishers of Laguna de Bay perceived that the population of white goby could be influenced by climatic factors, water quality, availability of natural food and predation by invasive species such as janitor fish and knife fish.

Natural food is generally abundant in Laguna de Bay during dry season and less abundant during wet reason. The more inflow of seawater during the dry season stimulates the growth of planktons (Israel, 2008). Seawater backflow has been observed in Laguna de Bay during dry season and high tide when the lake water level is lower than the sea level of Manila de Bay. Napindan Channel is the only outlet of Laguna de Bay and also serves as entrance gate of salt water from Manila through Pasig River (Laguna Lake Development Authority; Bocci, 1999). The clearing effect of seawater intrusion on lake water increases plankton biomass, thus this phenomenon plays a vital role in sustaining the natural productivity of the lake (Lasco and Espaldon, 2005). Based on Participatory Rural Appraisal study of Macandog et al. (2011) in Barangay Bayog, Los Baños, the abundance of fish and productivity in the lake were attributed by local people to Napindan Channel in which the mixing of seawater and freshwater greatly improved the spawning of fish species and fish diversity. This channel also serves as entry and exit route of migratory species such as *Mugil* sp. (mullet), *Angilla* sp. (eel), *Scatophagus argus* Linnaeus 1776 (spadefish), *Megalops hawaiensis* (ten pounder), and *Megalops cyprinoides* Broussonet 1782 (tarpon) (Ecosystems and People: the Philippine Millennium Ecosystem Assessment Subglobal Assessment 2005).

Based on semi-structured interviews, the population of white goby was continuously declining. The possible reasons identified by the local fishers and coastal dwellers were deteriorating lake water quality due to domestic and industrial wastes, aquaculture (fish pens and fish cages), unsustainable fishing practices such as *pangangahig*, uncontrolled fish catching, and predation by *Pterygoplichthys* spp. (janitor fish). Janitor fish is an introduced invasive species that can rapidly multiply and survive in polluted water. According to local fishers, *Pterygoplichthys* spp. and *Chitala* sp. (locally known as knife fish) invaded their fish corrals that negatively affected the supply of marketable fishes and native fish species in the lake.

Another problem in Laguna de Bay that leads to ecological displacement of the native fishes is the introduction of economically important exotic species such as nile tilapia (*Oreochromis niloticus*), milkfish (*Chanos chanos*), asiatic catfish (*Clarias batrachus*) and invasion of gourami (*Trichopterus* spp.) and janitor fish (*Pterydoplicthys disjunctivus* and *P. pardalis*) (Guererro, 2014; Araullo, 2001). These exotic species particularly the bioinvasive janitor fish are predaceous on fingerlings of aquaculture fishes and native fishes and have wider dietary breadth compared to native fish species (Mendoza et al., 2015). Considering the higher market price of marine food fish, the socio-economic importance of native fish species such as white goby as an alternative food fish can be used to feed the families of subsistence fishers in Laguna de Bay. Unfortunately due to colonization and predation of introduced invasive species, current lake water quality status, intensive aquaculture, and unsustainable anthropogenic activities around the Laguna de Bay watershed, the population of white goby is facing near extinction and due to its diminishing population, the supply of white gobies in the local market is low.

On the other hand, the respondents were only familiar with the socio-economic importance of white goby as alternative food and cheap source of nutrition and they had no knowledge of its ecological importance. Native fish species are involved in mutualistic interactions with other aquatic species. For instance, Vedra et al. (2013) cited that *G. giuris* helps control the vast number of returning postlarvae that might feed on algae and zooplankton which is beneficial to *Mesopristes cancellatus* Cuvier 1829. Thus, the presence of *G. giuris* helps regulate the population of species that feed on algae and zooplankton which also ensures abundant natural food for *M. cancellatus*.

FAO No. 35 was created by the Philippines' Department of Agriculture (formerly Department of Agriculture and Natural Resources) in June 1953. This law prohibits catching of immature white goby measuring less than 125 mm long and prohibits the use of cod-end of “kaladkad pangbiya” or landing bag of “abuyan” with a mesh of less than 35 mm stretch out. This law also restricts construction of fish corrals, traps or any device across any river or stream which connects an inland body of water with the Laguna Lake. The result of semi-structured interviews revealed that more than half of the respondents were aware of FAO No. 35 (Barangay Bayog: 96%, Barangay Janosa: 60%, Barangay Masili: 73%). With regards to compliance to this fisheries order, 85%, 47%, and 55% of the respondents from Barangay Bayog, Barangay Janosa, and Barangay Masili, respectively, claimed that they frequently comply with FAO No. 35.

4. CONCLUSIONS

This study suggested that the zooplankton abundance was influenced by water quality, geographic location, and season. Gut analysis of white gobies also showed that zooplanktons were part of the fish diet. Based on the local fishers' perception, the population of white gobies was influenced by season, water quality, lake productivity, abundance and availability of natural foods, and predation by exotic invasive species. It is therefore imperative to implement a multi-stakeholder and sustainable resource utilization management approach for Laguna de Bay, strict enforcement of economic instruments (such as environmental user fee, environmental penalty, and incentives) and lake rehabilitation to sustain its ecosystem goods and services.

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REFERENCES

Achakzai WM, Saddozai S, Baloch WA, Massod Z, Rehman HU, Ain MU. Food and feeding habits of *Glossobius giuris* (Hamilton and Bachannan, 1822) collected from Manchar Lake Distt. Jamshoro, Sindh, Pakistan. Global Veterinaria 2015;14:613-8.

Alam TI, Kabir A. Relationship between zooplankton abundance and physico-chemical parameters in surdurban ecosystem during monsoon. Pakistan Journal of Biological Sciences 2003;6:762-5.

Ancog RC, Briones ND, Florece LM, Alcantara AJ, Alaira, SA. Expansion of environmental users' fee system to households for enhanced water pollution control in Laguna de Bay, Philippines. Journal of Environmental Science and Management 2008;11:58-67.

Araullo DB. Aquaculture practices and their impact on Philippine lakes. Conservation and Ecological Management of Philippine Lakes in Relation to Fisheries and Aquaculture, Philippines. Proceedings of the National Seminar-Workshop; 1997 Oct 21-23; INNOTECH, Commonwealth Avenue, Quezon City: Philippines; 1997.

Aquino MRY, Cho CD, Cruz MAS, Saguiguit, MAG, Papa RDS. Zooplankton composition and diversity in Paoay Lake, Luzon Island, Philippines. Philippine Journal of Science 2008;137:169-77.

Bagarinao T. Aquaculture practices and their impact on Philippine lakes. Conservation and Ecological Management of Philippine Lakes in Relation to Fisheries and Aquaculture, Philippines. Proceedings of the National Seminar-Workshop; 1997 Oct 21-23; INNOTECH, Commonwealth Avenue, Quezon City: Philippines; 1997.

Barril CR. Water quality management: key to sustainable development of Laguna de Bay. [Internet]. 1991 [cited 2016 Feb 16]. Available from: http://www.nast.ph/images/pdf%20 files/ Publications /NAST %20Transactions/NAST%201991%20Transactions%20Volume%2013/Plenary%20II%202%20.%20Water%20Quality%20Management.%20Key%20to%20the%20Sustainable%20Development%20of%20Laguna%20de%20Bay%20%20%20Carlito%20R.%20Baril.pdf

Bayot FA, Joya KNA, Jacinto WR. Phylogenetic analysis and barcoding of gobies in Maragondon river, Cavite, Philippines. International Journal of Current Science 2014;12:50-6.

Bejer JB. Ontogenic variation in the diet composition of Glossogobius giuris from Taal Lake, Batangas, Philippines. Asia Pacific Journal of Multidisciplinary Research 2015;3:95-100.

Bir J, Sumon MS, Rahaman, SMB. The effects of different water quality parameters on zooplankton distribution in major river systems of Sundarbans Mangrove. IOSR Journal of Environmental Science, Toxicology and Food Technology 2015;11:56-63.

Bocci M. Modelling the growth of nile tilapia (*Oreochromis niloticus*) feeding on natural resources in enclosures in Laguna de Bay (Philippines). Ecological Modelling 1999;119:135-48.

Bucol AA, Carumbana EE. 2010. Checklist of fishes found in the fresh and brackish waters of Negros and Siquijor, Philippines. Asian Journal of Biodiversity 2010;1:91-125.

Chavez HM, Casao EA, Villanueva EP, Paras MP, Guinto MC, Mosqueda MB. Heavy metal and microbial analyses of janitor fish (*Pterygoplichthys* spp.) in Laguna de Bay, Philippines. Journal of Environmental Science and Management 2006;9:31-40.

Cuvin-Aralar ML, Fastner J, Focken U, Becker K, Aralar EV. Microcystins in natural blooms and laboratory cultured Microcystis aeruginosa from Laguna de Bay, Philippines. Systematic Applied Microbiology 2002;25:179-182.

Deepthi S, Sadanand M, Yamakanamardi M. Water quality index and abundance of total zooplankton in Varuna, Madappa and Giribettethre lakes in Mysore, Karnataka State, India. International Journal of Environmental Science 2014;4:683-93.

Dyer SD, Peng C, McAvoy DC, Fendinger NJ, Masscheleyn P, Castillo LV, Lim JMU. The influence of untreated wastewater to aquatic communities in the Balatuin River, The Philippines. Chemosphere 2003;52:43-53.

Dorado EL, Torres MAJ, Demayo CG. Describing body shapes of the white goby, *Glossobius giuris* of Lake Buluan in Mindanao, Philippines using landmark-based geometric morphometric analysis. International Research Journal of Biological Sciences 2012;1:33-7.

Eichhorn P, Flavier ME, Paje ML, Knepper TP. Occurrence and fate of linear and branched alkylbenzenesulfonates and their metabolites in surface waters in the Philippines. The Science of the Total Environment 2001;269:75-85.

Fabro L, Varca LM. Pesticide usage by farmers in Pagsanjan-Lumban catchment of Laguna de Bay, Philippines. Agricultural Water Management 2012;106:27-34.

Guerrero RD. Impacts of introduced freshwater fishes in the Philippines (1905-2013): A review and recommendations. Philippine Journal of Science 2014;143:49-59.

Hernandez EC, Henderson A, Oliver DP. Effects of changing land use in the Pagsanjan-Lumban catchment on suspended sediment loads to Laguna de Bay, Philippines. Agricultural Water Management 2012;106:8-16.

Hossain MS, Roy A, Rahman ML. Food and feeding habit of bele *Glossobius giuris* (Hamilton and Buchannan, 1822) collected from Mithamain Haor of Kishoreganj districts, northeastern Bangladesh.

International Journal of Fisheries and Aquatic Studies 2016;4:84-8.

Israel DC. Fishpen and fishcage culture in Laguna de Bay: status, economic importance, and the relative severity of problems affecting its practice. Philippine Journal of Development 2008;35:55-92.

Israel DC. The current state of aquaculture in Laguna de Bay. Philippine Institute for Development Studies Discussion Paper Series 2007;20:1-63.

Jose EC, Furio EF, Borja VM, Gatdula NC, Santos MD. Zooplankton composition and abundance and its relationship with physico-chemical parameters in Manila Bay. Oceanography 2015;3:1-6.

Joseph CCD, Jumawan JH, Hernando BJ, Boyles LZ, Jumawan JC, Velasco JPB, Cabuga CC, Abastillas SOMA, Raquieron EA, and Torres MAJ. Fluctuating asymmetry in evaluating the development instability of *Glossogobius giuris* (Hamilton, 1822) from Lake Mainit, Surigano del Norte, Philippines. Computational Ecology and Software 2016;6:55-65.

Kosmehl T, Hallare AV, Braunbeck T, Hollert H. DNA damage induced by genotoxicants in zebrafish (*Danio rerio*) embryos after contact exposure to freeze-dried sediment and sediment extracts from Laguna Lake (The Philippines) as measured by the comet assay. Mutation Research 2008;650:1-14.

Ky NM, Lam NH. Analysis of changing trend of fecal coliform levels at lakes in Hue Citadel, Vietnam. Environment and Natural Resources Journal 2016;1:1-7.

Laguna Lake Development Authority. 2009 to 2012 Annual water quality report on the Laguna de Bay and its tributary rivers. [Internet]. 2016 [cited 2016 Feb 16]. Available from: ttp://www.llda.gov.ph/dox /waterqualityrpt/awqr_2009-2012.pdf

Lasco R, Espaldon MAO. Ecosystems and people: the Philippine Millenium Ecosystem Assessment sub-global assessment. Los Baños, Laguna: Environmental Forestry Programme, College of Forestry and Natural Resources, University of the Philippines Los Baños; 2005.

Lopez NC. Aquaculture practices and their impact on Philippine lakes. Conservation and Ecological Management of Philippine Lakes in Relation to Fisheries and Aquaculture, Philippines. Proceedings of the National Seminar-Workshop; 1997 Oct 21-23; INNOTECH, Commonwealth Avenue, Quezon City: Philippines; 1997.

Macandog DBM, Balon JL, Engay KG, Nicopior OBS, Luna DA, dela Cruz CP. Assessment of the environmental degradation and proposed solutions in the Los Baños subwatershed through participatory approaches. Journal of Nature Studies 2011;10:1-15.

Mahilum JJ, Camama C, Lalisan JA, Vedra SA. Morphology of goby species, *Glossogobius celebius* (Valenciennes 1837) and *Glossogobius giuris* (Hamilton 1822) in Lake Lanao Mindanao, Philippines. International Journal of Research in BioSciences 2013;2:66-78.

Masagca JT, Ordoñez JA. Karyomorphology of the Philippine rock goby, *Glossogobius giuris* (Gobiidae) from Lake Taal and some rivers of Cavite, Luzon Island. Biotropia 2003;21:11-8.

Mendoza MU, Legaspi KL, Acojido MG, Cabais AC, de Guzman JLE, Favila AM, Lazo SM, Briones JCA, Papa RDS. Dietary habits and distribution of some fish species in the Pansipit River-Lake Taal Connection, Luzon Island, Philippines. Journal of Environmental Science and Management 2015;18:1-9.

Molina VB, Espaldon MVO, Flavier ME, Pacardo EP, Rebancos CM. Bioaccumulation of nile tilapia (*Oreochromis niloticus*) from Laguna de Bay, Philippines. Journal of Environmental Science and Management 2011;14:28-35.

Paller VGV, Labatos BV, Lontoc BM, Matalog OE, Ocampo PP. Freshwater fish fauna in watersheds of Mt. Makiling Forest Reserve, Laguna, Philippines. Philippine Journal of Science 2011;140:195-206.

Papa RDS, Tordesillas DT, Vitug LD, Briones JCA, Zafaralla MT, Kada R. Zooplankton spatial abundance and distribution in the West of Laguna de Bay (Philippines) with notes on potential implications to food and health security. Acta Manila 2012;60:67-75.

Papa RDS, Zafaralla MT, Eckmann R. Spatio-temporal variation of the zooplankton community in a tropical caldera lake with intensive aquaculture (Lake Taal, Philippines). Hydobiologia 2011;664:119-33.

Paraso MGV, Capitan SS. Vitellogenin induction and gonad abnormalities in male common carp (*Cyprinus carpio* Linnaeus) introduced to Laguna de Bay, Philippines. Philippine Journal of Veterinary and Animal Science 2012;38:34-44.

Paraso MGV, Librojo-Basilio NT, Vega RSA, Rebancos CM, Flavier ME, Ocampo PP, Capitan SS. 17β-estradiol and organochlorine pesticide levels in the east and west sites of Laguna de Bay. Journal of Environmental Science and Management 2011;14:36-42.

Paraso, MGV, Espaldon MVO, Alcantara AJ, Sevilla CC, Alaira SA, Sobremisana MJ, Ravalo RO, Macan KRD, Valdez CA. A survey of waste management practices of selected swine and poultry farms in Laguna, Philippines. Journal of Environmental Science and Management 2010;13:44-52.

Partnerships in Environmental Management for the Seas of East Asia. Total pollutant loading study in the Laguna de Bay-Pasig River-Manila Bay watershed. [Internet]. 2013 [cited 2016 Feb 16]. Available from:

http://pemsea.org /sites/default/file/Total-Pollutant-Loading-Study-Laguna-de-Bay-Pasig-River-Manila-Bay-Watershed.pdf

Prasad NK, Singh NP. The comparative study of buccopharynx of labeo dero and *Glossogobius giuris* in relation to their food and feeding habits. Flora and Fauna 2015;21:80-4.

Sanchez PB, Oliver DP, Castillo HC, Kookana RS. Nutrient and sediment concentrations in the Pagsanjan-Lumban catchment of Laguna de Bay, Philippines. Agricultural Water Management 2012;106:17-26.

Sanchez PB, Oliver DP, Kookana RS. Particulate and dissolved forms of N, P, and organic C transported from major land uses in the Pagsanjan-Lumban catchment to Laguna de Bay, Philippines. Journal of Environmental Science and Management 2014;17:38-49.

Santos-Borja A, Nepomuceno DN. Laguna de Bay: experience and lessons learned brief [Internet]. 2014 [cited 2016 Feb 16]. Available from: http://www.worldlakes.org / uploads/ Laguna%20_ 1.13.04.pdf

Shil J, Ghosh AK, Rahaman SMB. Abundance and diversity of zooplankton in semi intensive prawn (*Macrobrachium rosenbergii*) farm. SpringerPlus 2013;2:1-8.

Tamayo-Zafaralla M, Santos RAV, Orozco RP, Elagado GCP. The ecological status of Lake Laguna de Bay, Philippines. Aquatic Ecosystem Health & Management 2002;5:127-38.

Tan RL, Alvaran TAC, Villamor BB, Tan IMA. Cost and return analysis of fishpen operation in Laguna de Bay and the economic implication of “zero fishpen policy”. Journal of Environmental Science and Management 2010;13:14-26.

Vedra SA, Ocampo PP, de Lara AV, Rebancos CM, Pacardo EP, Briones ND. Indigenous goby population in Mandulog river system and its conservation by communities in Iligan City, Philippines. Journal of Environmental Science and Management 2013;16:11-8.

Veerendra DN, Thirumala S, Manjunatha H, Aravinda HB. Zooplankton diversity and its relationship with physic-chemical parameters in Mani reservoir of Western Ghats, Region, Hosanagar, Taluk, Shivamoga District Karnataka, India. Journal of Urban and Environmental Engineering 2012;6:74-7.