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Indigenous Goby Population in Mandulog River System and its Conservation by Communities in Iligan City, Philippines

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ABSTRACT

Threats of water pollution, unregulated extraction of resources, and sprawling urbanization are some of the common issues of Mandulog River, a home for indigenous freshwater gobies. This study was conducted to assess the status of freshwater gobies and how the resident communities exert conservation efforts to the river and the inhabiting gobies. Standard method of collection of gobies was done. Interviews with semi-structured questionnaires were used to know the conservation measures of the residents. Ten goby species belonging to three families namely, Family Eleotridae (Belobranchus belobranchus), Giuris margaritacea, and Oxyeleotris lineolata, Family Gobiidae (Awaous melanocephalus), Awaous ocellaris, Glossogobius celebius, Glossogobius giuris, Periophthalmus barbarus and Sicyopterus lagocephalus, and Family Rhyacichthyidae (Rhyacichthys aspro), can be an alternative source of food and livelihood. They were caught by-catch, while employing some destructive fishing methods like cyanide fishing, electric fishing, and use of fine mesh nets. The awareness of the residents to the adverse impacts of water pollution, unregulated human activities, and destructive fishing had strengthened their conservation measures. A multi-stakeholder management approach is created through concerted proactive conservation measures like protection of the goby population, the river-riparian ecosystems, enhanced scientific information, and the legal intervention of the local government.

Key words: *goby population, indigenous species, resource conservation, Mandulog River*

INTRODUCTION

The inland waters of the Philippines such as lakes and rivers have high biodiversity. In fish population diversity, gobies are mostly diverse with no less than 2,117 species, including other freshwater fish species. Moreover, 330 species are Philippine endemics, of which, 48 genera and 127 are goby species (*Herre 1927*). However, only few studies on gobies were conducted despite the goby species diversity, with more concentrations recently in the inland waters of Southern Luzon (*UPLB Limnological Research Station 2011*). Some morphological characteristics and reproductive potentials of gobies were studied like the *Glossogobius celebius* (*Corpuz 2011*), *Rhinogobius* sp. (*Vedra and Ocampo 2012*) and *Rhyacichthys aspro* (*Vedra and Ocampo 2013*). Before, studies on gobies are concentrated on its life history (*Manacop 1953*), including its fishery, biology, ecology and implications for conservation and management (*Manacop 1953; Montilla 1931; Blanco 1956, Herre 1927*). This study assessed the abundance of goby species in Mandulog River system, which is suspected to harbor indigenous goby population; and the conservation initiatives of residents in Iligan City, Lanao del Norte in Northern Mindanao, Philippines.

Diversity and endemism of gobies to inland waters are due to the archipelagic nature of the Philippines that in turn, contains various flora and fauna in its landscapes and seascapes. The megabiodiversity nature of the Philippines is negated due to the alarming rates of habitat destruction and fragmentation, increasing population growth, loss of species, uncontrolled pollution levels, and introduction of invasive exotic species in national and local scales. Threats of a changing climatic pattern with erratic rainfall patterns, increased in temperature, occurrence of strong typhoons and prolonged occurrence of drought can also exacerbate the loss of Philippine biodiversity. The adverse impacts affecting higher degree of endemism and diversity will contribute negative repercussions relative to the balance of various ecosystem functions and services, and eventually cease the provision of basic necessary socio-economic and ecological benefits for the present and future generations. Mandulog River is one of the rivers in the Philippines that is undergoing threats of pollution, severe extraction of its resources, and sprawling urbanization.

The continuing investigations on gobies, are still promising in the whole goby study in the Philippines, has led into the conduct of this study. The species accounted in Mandulog River, may be similar or different from other

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gobies found in the inland waters of the Philippines. In contrast to the Philippines, worldwide studies on gobies were done for scientific purposes and recently as part of the ornamental fisheries with high commercial values. Extensive studies on goby, particularly its early life history, recruitment dynamics and fisheries were conducted in Dominica, West Indies (*Bell and Brown 1995; Bell et al. 1995; Bell 1997*), and its biology and genetics in Hawaii (*Ego 1956; Radtke et al. 1988; Fitzsimons and Nishimoto 1990; Fitzsimons et al. 1990; Kinzie 1993*). In Asia, several goby studies were also conducted. In particular, the freshwater fishes of genus, Rhinogobius (*Gill 1859*) are common benthic fish fauna found not only in Taiwan, the Ryukyus, and in mainland Japan (*Akihito et al. 1984; Akihito et al. 1993; Chen 1994; Chen and Shao 1996*) but also in continental Southeast Asia from China to Thailand (*Chen and Miller 1998; Chen et al. 1999*).

MATERIALS AND METHODS

Specimen collections

The specimen collection sites were in the three barangays of Iligan City, namely, Barangays Rogongon (upstream), Digkilaan (midstream) and Hinaplanon (downstream), which are traversed by Mandulog River (**Figure 1**). In each collection site, five-replicate sampling stations with specific geographical coordinates and elevation were established (**Table 1**).

A hand-held seine, measuring 3 m by 1.5 m with 3.5 mm mesh and a heavy lead line, was used for the collection of goby specimens. Seining was performed by three field assistants: two held each pole, while the other one had disturbed the substrate for fish to be caught into the net. Other methods used were small improvised spear guns, use of cast and stationary nets, use of kerosene-powered lamps for goby fishing and hook and line with earthworm baits. Collection of goby specimens was carefully done to avoid harm to the fish and other aquatic organisms. It was conducted in a quarterly basis for one year, that is, on February, May, August, and November, 2011, that represents dry and wet seasons.

Species composition and richness were determined by counting all species found per collection period per site. Relative abundance was based on the number of individuals in a species divided by the total number of individuals in all species. Friedman's test was used to differentiate the significant differences of goby abundance in three specified sites of the river.

Gathering of residents conservation initiatives

An entry protocol visit and reconnaissance surveys were done together with the Barangay Councils, the city government office, and some residents to explain the objectives of the research and to obtain permission to conduct the study in the area. It was also done to ensure

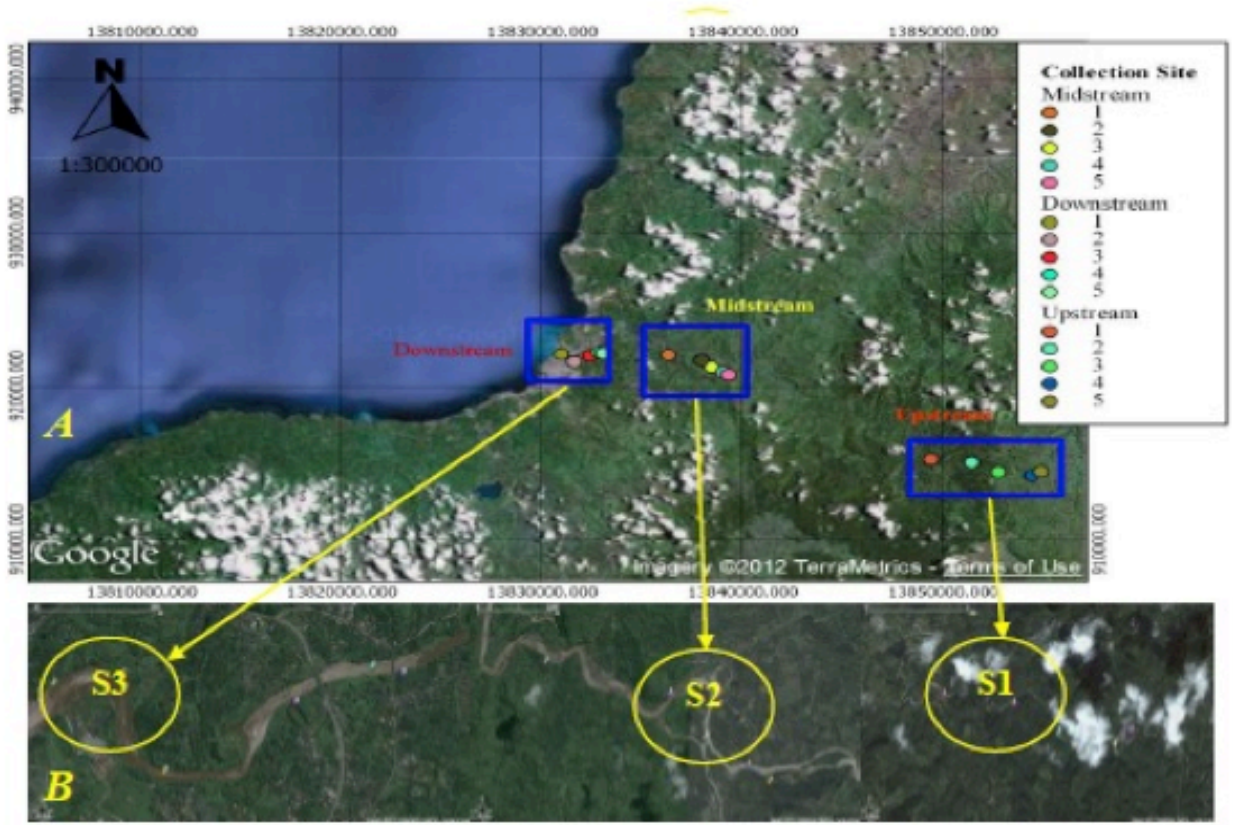

Figure 1. Google Earth generated map (A) showing the collection sites in Barangays Rogongon (S1), Digkilaan (S2) and Hinaplanon (S3) representing the upstream, midstream and downstream, respectively, (B) of Mandulog River system, Iligan City, Lanao del Norte.

Table 1. Geographic coordinates and elevation of the collection sites at Barangays Rogongon, Digkilaan and Hinaplanon traversed by Mandulog River in Iligan City, Lanao del Norte.

	Brgy. Rogongon (upstream)		**Brgy. Digkilaan (midstream)**		**Brgy. Hinaplanon (downstream)**	
	Geographic coordinates	Elevation (masl)	Geographic coordinates	Elevation (masl)	Geographic coordinates	Elevation (masl)
1	8° 11' 38.69N, 124° 24' 41.92E	183	8° 15' 16.08N, 124^0 17' 38.55E	41	8° 15' 17.86N, 124° 14' 45.31E	5
2	8° 11' 31.62N, 124° 25' 48.20E	216	8° 15' 04.87N, 124° 18' 32.22E	27	8° 15' 02.53N, 1240 15' 06.61E	5
3	8° 11' 12. 27N, 124° 26' 31.36E	237	8° 14' 49.85N, 124° 18' 47.66E	27	8° 15' 14.41N, 124° 15' 31.80E	4
4	8° 11' 04.48N, 124° 27' 25.07E	268	8° 14' 40.08N, 124° 19' 06.11E	38	8° 15' 20.80N, 124° 15' 46.50E	6
5	8° 11' 13.10N, 124° 27' 39.48E	322	8° 14' 34.40N, 124° 19' 15.45E	44	8° 15' 19.39N, 124° 15' 52.30E	7

the community's support and cooperation in obtaining information and in making data available from their units.

Interviews with semi-structured questionnaires were conducted to the residents, particularly on the topics concerning the goby fishery, its volume and frequency of harvest, and methods used in fishing. Other fish species used in fishery were asked to compare its relevance to goby fishery potential. Respondents, in this context of study, refer to all household heads or any member in the family of age group 20 years and older. There were 89, 91 and 93 respondents representing the households located in the upstream, midstream and downstream portions, respectively. of the river. Number of respondents per household was used to assume as one fishing unit using the formula of *Slovin* (*1960*) *as cited in Pagoso and Montaño* (*1998*) and *Sevilla, et al.* (*1997*).

RESULTS AND DISCUSSIONS

Ten goby species were found belonging to three families, namely: Eleotridae, Gobiidae, and Rhyacichthyidae. Three species were within Family Eleotridae, namely: *Belobranchus belobranchus* (Batingulo), *Giuris margaritacea* (Panghal), and *Oxyeleotris lineolata* (Bunak). Six species belong to Family Gobiidae: *Awaous melanocephalus* (Iswil), *Awaous ocellaris* (Iswil), *Glossogobius celebius* (Busaw-busaw), *Glossogobius giuris* (Subok), *Periophthalmus barbarus* (Talasak) and *Sicyopterus lagocephalus* (Anga). *Rhyacichthys aspro* was the only species representing Family Rhyacichthyidae (**Figure 2**).

In the upstream part of Mandulog River system, seven species of gobies belonging to three families were present. These were: *A. melanocephalus*, *A. ocellaris*, and *S. lagocephalus* of Family Gobiidae; *B. belobranchus*, *G. margaritacea* and *O. lineolata* of Family Eleotridae; and

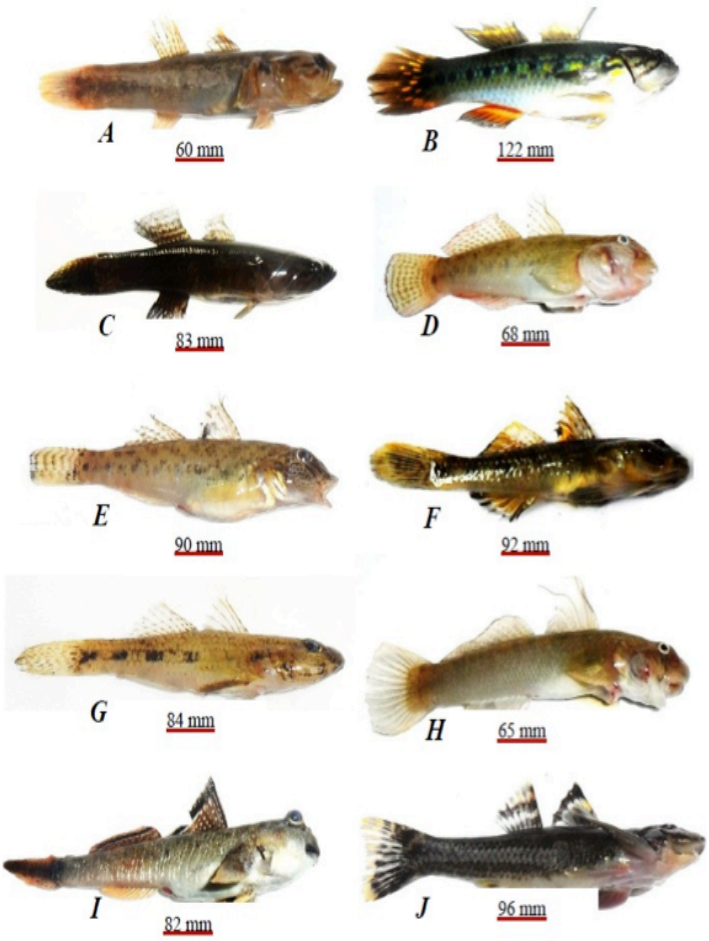

Figure 2. Freshwater gobies: *Belobranchus belobranchus* (A), *Giuris margaritacea* (B), *Oxyeleotris lineolata* (C), *Awaous melanocephalus* (D), *Awaous ocellaris* (E), *Glossogobius celebius* (F), *Glossogobius giuris* (G), *Sicyopterus lagocephalus* (H), *Periophthalmus barbarus* (I) and *Rhyacichthys aspro* (J) inhabiting the Mandulog River system in Iligan City, Lanao del Norte captured on February to November 2011.

R. aspro of Family Rhyacichthyidae. Of these seven goby species, the most abundant was *O. lineolata* with 106 total number of individuals, both in dry and wet seasons, comprising 36.8 % of the total number of individuals of all goby species collected. The least abundant goby species was *R. aspro* since only a total of 10 individuals during dry and wet seasons, that comprised 3.5 %. The clinging goby, locally known as Anga or *S. lagocephalus* had 54 individuals or 18.8 %. These species are present even in the tipmost parts of the headwaters because of their suckling ventral fins that are used to climb into the stiff cliffs and falls. The least abundant *R. aspro* goby preferred habitats in rock bottoms and crevices in highly oxygenated parts of the river like falls and cliffs with running oxygen-rich waters, hence limiting its abundance and distribution to this type of specific habitat.

There were nine goby species in three families present in the midstream, namely: *A. melanocephalus*, *A. ocellaris*, *G. celebius*, *G. giuris* and *S. lagocephalus* of Family Gobiidae; *B. belobranchus*, *G. margaritacea* and *O. lineolata* of Family Eleotridae; and *R. aspro* of Family Rhyacichthyidae. The most abundant goby was *O. lineolata* with a total of 272 individuals or an average of 29.2 % of the total number of individuals of all goby species caught during dry and wet seasons. *R. aspro* goby was the least abundant with only eight individuals or 0.8 %, caught during dry and wet seasons. *A. melanocephalus* and *A. ocellaris*, known locally as Iswil, were mostly observed in the sandy substrate, while the carnivorous gobies like *G. celebius*, *G. giuris*, *G. margaritacea*, *O. lineolata* and *B. belobranchus* were present in all habitat types like riffle areas with rocks, pool areas, eroded banks with exposed roots of trees and sandy areas. They were part of subsistence fishery in the area used as alternative source of food among the residents in lieu of important fish species like snakehead and catfish.

There were nine goby species in two families present at downstream, namely: *A. melanocephalus*, *A. ocellaris*, *G. celebius*, *G. giuris*, *P. barbarus* and *S. lagocephalus* of Family Gobiidae; and *B. belobranchus*, *G. margaritacea* and *O. lineolata* of Family Eleotridae. *O. lineolata* was the most abundant goby with 127 individuals or 34.2 % of the total number of individuals of all goby species caught during dry and wet seasons. The least abundant goby was *S. lagocephalus* with only 12 individuals or 3.2 %.

In terms of abundance per site of the river, the midstream had the highest abundance with 559 (62.4%) and 372 (53.2 %) individuals relative to the total number of individuals of all goby species caught during dry and wet seasons, respectively. Upstream had the lowest abundance of 141 (15.8 %) and 147 (21.2 %) individuals relative to the total number of individuals of all goby species caught during dry and wet seasons, respectively (**Tables 2 and 3**).

There were 895 and 695 total number of individuals of all goby species in dry and wet seasons, respectively. There were significant differences ($X2= 2.45$, $P<0.05$) in the number of individual species collected per site per season. One potential explanation is dry season allowed sufficient plankton production due to nutrient and sunlight availability, which in turn provide enough food sources for these goby species. During dry season, it was assumed that the amount of pollutants coming from the upstream towards downstream were reduced as surface runoffs from various sources were also reduced. During wet season, the gobies were probably carried downstream and eventually ended up into the coastal waters of different water quality characteristics. Their abundance in the river system might be a result of the availability of their food sources and habitats, and may be influenced by water pollution sources from domestic, agriculture, quarry and mining activities occurring within the river system and its periphery. Climatic factors might have some influences as well, although its direct relationship to the large number of goby population is still unknown.

Goby conservation and management

The increasing level of awareness based on the indigenous knowledge of the fishers on goby population would help local people assessed the relative importance of gobies to fisheries as potential source of food and livelihood. It was observed that gobies were sparsely seen (20.9 % to 86.0 %) and were already scarce (13.4 % to 79.1 %) (**Figure 3A**). It was also observed that the disappearance of the cohorts of adults and juveniles are migrating upstream. The respondents also failed to see the various gobies when they used to fish, particularly in the pool areas where several goby species can be seen moving around the pool. It was cited that the possible causes of goby scarcity were the use of destructive fishing methods (22.6 %) like use of cyanide, electric fishing and fine mesh nets, unregulated pollution in the river (18.7 % to 62.9 %), and goby overfishing (37.1 % to 81.3 %) (**Figure 3B**). The use of cyanide, particularly, the use of pesticides and local plant known as tubli, have killed both the adults and juveniles of gobies. Some cited that the cyanide fishing is targeted to catch snakeheads and catfish, and yet, the toxicity had affected the non-targeted gobies, considered as by-catch without any fishing intention. As mentioned by the locals, pollution in the river would displace the cohort and may enter into other stream tributaries. It may affect the usual goby population present in the main river. The locals knew that the fish catch would probably decline. Overfishing of the goby-fry at downstream would affect the recruitment of the gobies towards adulthood and be the spawners in the future. This was compromised on the excessive extraction of the goby-fry, especially that it costs higher market prices as compared to adult gobies.

Table 2. Abundance (A) and relative abundance (RA) of each goby species inhabiting the upstream (US), midstream (MS) and downstream (DS) of Mandulog River system, Iligan City, Lanao del Norte captured during dry season from February to May 2011.

Species name	US		MS		DS	
	A	RA (%)	A	RA (%)	A	RA (%)
1. *Awaous melanocephalus*	4	2.84	106	18.96	20	10.26
2. *Awaous ocellaris*	5	3.55	86	15.38	34	17.44
3. *Belobranchus belobranchus*	7	4.96	24	4.29	5	2.56
4. *Giuris margaritacea*	42	29.79	32	5.72	13	6.67
5. *Glossogobius celebius*	0	0.00	82	14.67	13	6.67
6. *Glossogobius giuris*	0	0.00	66	11.81	19	9.74
7. *Oxyeleotris lineolata*	56	39.72	147	26.30	61	31.28
8. *Periophthalmus barbarus*	0	0.00	0	0.00	22	11.28
9. *Rhyacichthys aspro*	5	3.55	6	1.07	0	0.00
10. *Sicyopterus lagocephalus*	22	15.60	10	1.79	8	4.10
Total	141	100.00	559	100.00	195	100.00

Table 3. Abundance (A) and relative abundance (RA) of each goby species inhabiting the upstream (US), midstream (MS) and downstream (DS) of Mandulog River system, Iligan City, Lanao del Norte captured during wet season from August to November 2011.

Species name	US		MS		DS	
	A	RA (%)	A	RA (%)	A	RA (%)
1. *Awaous melanocephalus*	13	8.84	48	12.90	23	13.07
2. *Awaous ocellaris*	16	10.88	38	10.22	14	7.95
3. *Belobranchus belobranchus*	5	3.40	27	7.26	8	4.55
4. *Giuris margaritacea*	26	17.69	36	9.68	14	7.95
5. *Glossogobius celebius*	0	0.00	42	11.29	6	3.41
6. *Glossogobius giuris*	0	0.00	46	12.37	7	3.98
7. *Oxyeleotris lineolata*	50	34.01	125	33.60	66	37.50
8. *Periophthalmus barbarus*	0	0.00	0	0.00	34	19.32
9. *Rhyacichthys aspro*	5	3.40	2	0.54	0	0.00
10. *Sicyopterus lagocephalus*	32	21.77	8	2.15	4	2.27
Total	147	100.00	372	100.00	176	100.00

The relative importance of gobies was their potential as source of food and livelihood (61.5 % to 73.1 %). This is especially true when scarcity and higher prices of marine fishes occurred. Gobies were used as alternative fish for consumption. In other way, the goby-fry at downstream is used for sale at prices ranging from PhP 120.00-150.00 kg^{-1} depending on the market demand. The respondents observed that gobies, particularly the fry and juveniles stages served as prey for the aquatic system predators (10.8 % to 16.8 %).It was also observed that goby-fry served as food items for the snakeheads and other fishes. The mere presence of gobies, helped the snakeheads to grow, which eventually, become part of the food consumed by the residents. in addition, it was observed that gobies served the important mutualistic interactions to other important aquatic species in the river (16.12 % to 27.47 %) (**Figure 3C**). For instance, the presence of subok (*Glossogobius giuris*), as predators, would control the vast number of returning postlarvae, that might feed on algae and zooplankton. Locals knew that pigok (*Mesopristes cancellatus*), a high-priced fish in the area, feeds on algae and zooplankton that might be compromised by the huge number of migrating cohort upstream. This, in turn, would provide enough food for the pigok, hence, the higher probability of getting enough numbers of pigok for consumption or for sale.

Given these scenario, gobies could be protected and conserved through the individual conservation practices (17.20 % to 59.34 %). This is related to the socio-cultural differences of the residents living along the Mandulog River system. The Higaonon tribe, the Muslims and Christians

might have different distinct conservation initiatives that could be very applicable to their individual cultures. For instance, the Higaonons prohibited the use of cyanide, electric fishing and other destructive fishing methods to conserve the gobies. Thus, it is a good conservation initiative for a certain cultural group towards goby conservation. Respondents also said that the concerted efforts of the community (15.4 % to 22.6 %) can be used to conserve the goby population as well as the other fishes in the river. Locals are aware that the fragmented conservation initiatives could not thoroughly provide a holistic goby conservation, as every resident within the Barangay might be serious in abiding with the promulgated mandates by the authorities. Thus, a common ground to implement goby conservation initiatives is needed since it was known that gobies are migrating across the river system, and that the barangays are connected by the entire stretch of the river. Initiating group formation was suggested for this concern. This in turn, respondents mentioned that the presence of various organizations (8.6 % to 8.8 %) could help address the issue on holistic goby conservation. Various groups can do specific task towards goby conservation with the help of other organizations, with one focal group to oversee the appropriate conservation initiative. Another conservation initiative locals knew was the serious implementation of the policies promulgated by the local government (16.1 % to 21.3 %). This refer to the Iligan City ordinance on limiting the goby-fry catchment area to allow efficient recruitment towards adulthood. The issue on the lack of manpower can exacerbate the problem on implementation. Besides, the fishery is open access to all residents that are interested to catch the goby-fry. Lastly, controlled catching of goby fry and adults (16.5 % to 35.5 %) was also seen to be an effective means of goby conservation (**Figure 3D**). The presence of various groups within the river system and the knowledge gained by the residents might serve as tools to effectively address the holistic goby conservation.

CONCLUSIONS AND RECOMMENDATIONS

The indigenous goby population inhabiting the whole stretch of Mandulog River in Iligan City is facing continuing threats of water pollution, unregulated extraction of resources, and sprawling urbanization. Despite these issues, still, an abundant freshwater goby population was observed,

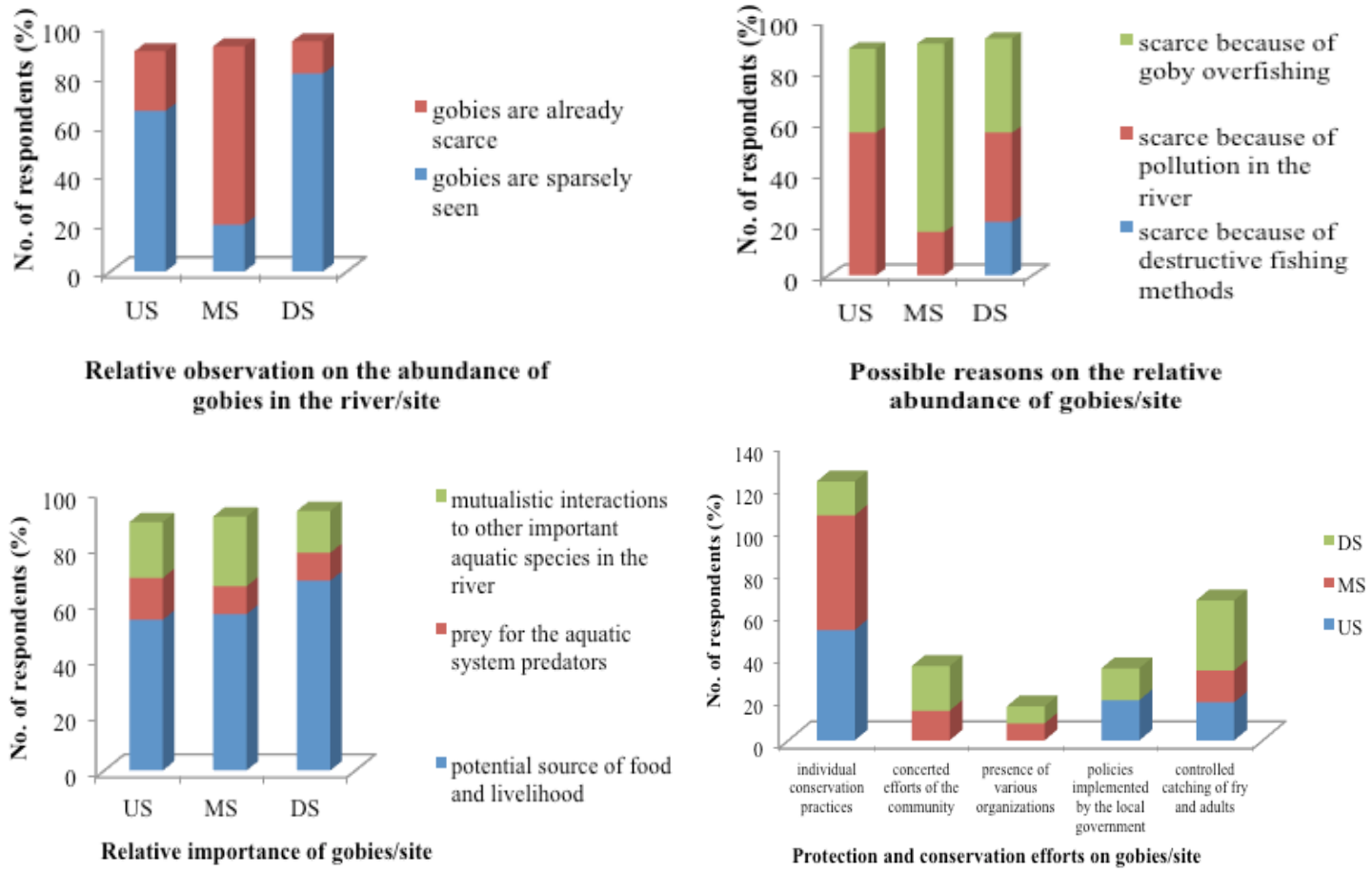

Figure 3. Relative observation on the abundance of gobies (A) and the possible reasons on the relative abundance of gobies (B), relative importance of gobies perceived (C), and protection and conservation of gobies (D) as perceived by the residents living in the upstream (US), midstream (MS) and downstream (DS) parts of Mandulog River system, Iligan City, Lanao del Norte.

belonging to three families namely: Family Eleotridae (*B. belobranchus*, *G. margaritacea*, and *O. lineolata*, Family Gobiidae (*A. melanocephalus*, *A. ocellaris*, *G. celebius*, *G. giuris*, *P. barbarous* and *S. lagocephalus*, and Family Rhyacichthyidae (*R. aspro*).

Majority of the freshwater gobies became an alternative food source while the goby-fry were sold to market. Goby fishing was not a priority by fishers and they were not earning from it. However, as a fishing by-catch, gobies suffered from mortality without utilizing its economic and ecological benefits. Use of destructive means of fishing like cyanide, electric fishing, and fine mesh nets might also adversely affect the goby population although not targeted for fisheries. Therefore, protecting the target fishes would mean protection of the goby species as well. The information sourced from personal interviews and group discussions had one common understanding and knowledge that the river system was already polluted due to unregulated anthropogenic-based disturbances like laundry activities, swimming, fishing, mining, agricultural practices, livestock raising and harvesting of forestal timber resources. Through this information sharing, indigenous knowledge, attitude and perceptions of these residents, the awareness was strengthened by knowing that their common practices would destroy the environment, and yet these people had no choice of abandoning such undertakings as these were part of their day-to-day living for survival. This in turn, would help the people realize of the adverse impacts of activities that could destroy the environment, their food sources and livelihood potentials, and that, proactive means of conservation and management might be done based on their own concerted prerogative actions.

Fishing in the river mouths for food and market was controlled by authorities, however, lack of personnel could not fully implement what the ordinance pertained. However, all stakeholders from fishers to market traders may have a concerted effort to implement the ordinance and follow strictly its implementing rules and regulations. This is true on their beliefs that together, problems on the river and its inhabitants-- humans, plants and animals, would be resolved. With the results of this study and the information shared by the community, a sound scientific inquiry on the status of indigenous gobies and its relations to water quality and human-related activities may strengthen the implementation of the ordinance as they already have a reliable basis on why the ordinance must be implemented. The legal intervention of the city government, prosecution of violators and strict implementation of national legislations must be done to protect the inhabiting indigenous gobies, that currently, were not yet been adversely affected by water pollution. As embedded in the inhabiting indigenous gobies, at present, humans are not yet adversely affected by water pollution. As embedded in the precautionary and sustainability principles, this must be done to prevent further exploitation of the resources that may reduce its economic and ecological values for the present and future generations. A simple information, education and communication campaign could impart the knowledge to the stakeholders of their societal roles in the conservation and management of their natural resources.

Finally, a two-way approach must be done: protecting both the gobies from further exploitation and reducing the level of pollution. This can be done through the concerted efforts of the residents, local government units and all possible stakeholders in the locality to conserve the gobies by regulating goby-fishing and the use of non-destructive fishing methods. As such, a multi-stakeholder management approach must be created through concerted proactive conservation measures like protection of the goby population, the river-riparian ecosystems, enhanced scientific information, and the legal intervention of the local government.

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