

# The status of Lake Lanao endemic cyprinids (*Puntius* species) and their conservation

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**Abstract** The endemic cyprinid species flock of Lake Lanao, Philippines is a classic example of explosive evolution. Based on historical surveys, most of the 18 endemic cyprinid species in Lake Lanao are now believed to be extinct. We compared results of landing and market surveys conducted in 2008 to information from historical surveys. Field sampling and fishermen interviews provided additional information on the status of the endemic and other fish species in Lake Lanao. *Puntius lindog* and *Puntius tumba* were the only two endemic species recorded in 2008, accounting for 0.01 % and 0.04 % respectively of the total weight harvested. Our discovery that at least two endemic cyprinids remain in Lake Lanao is surprising

and significant as the lake is increasingly imperiled by human disturbances, exploitation and introduced species. Protecting and conserving the remaining endemic species are important management priorities.

**Keywords** *Puntius tumba* · *Puntius lindog* · Species flock · Philippines

## Introduction

Ancient lakes are usually home to endemic species flocks and contain the highest known density of species in the world (Goulden 2001). However, the limited geographic range, poor dispersal capacity, low fecundity, small populations and frequent stenotopy of many of the endemics make them vulnerable to extinction. These factors, coupled with introductions of non-native species, have been known to cause displacement and even extinction of the endemic species in ancient lakes such as Malawi, Baikal, Titicaca, Biwa and Lanao (Cohen 1994).

Lake Lanao (Fig. 1), located in the province of Lanao del Sur at the southern part of the Philippines, is one of the world's ancient lakes. Lake Lanao, estimated to be about 5.3–5.6 millions years old, is noted for its unusual endemic fish species. The endemic cyprinids consisted of five genera and 18 (or more) species. Lake Lanao has attracted a lot of scientific attention regarding the origin and evolution (Herre 1924, 1926, 1932, 1933; Myers 1960) of its endemic fish fauna (Helfman 2007). Some scientists doubted

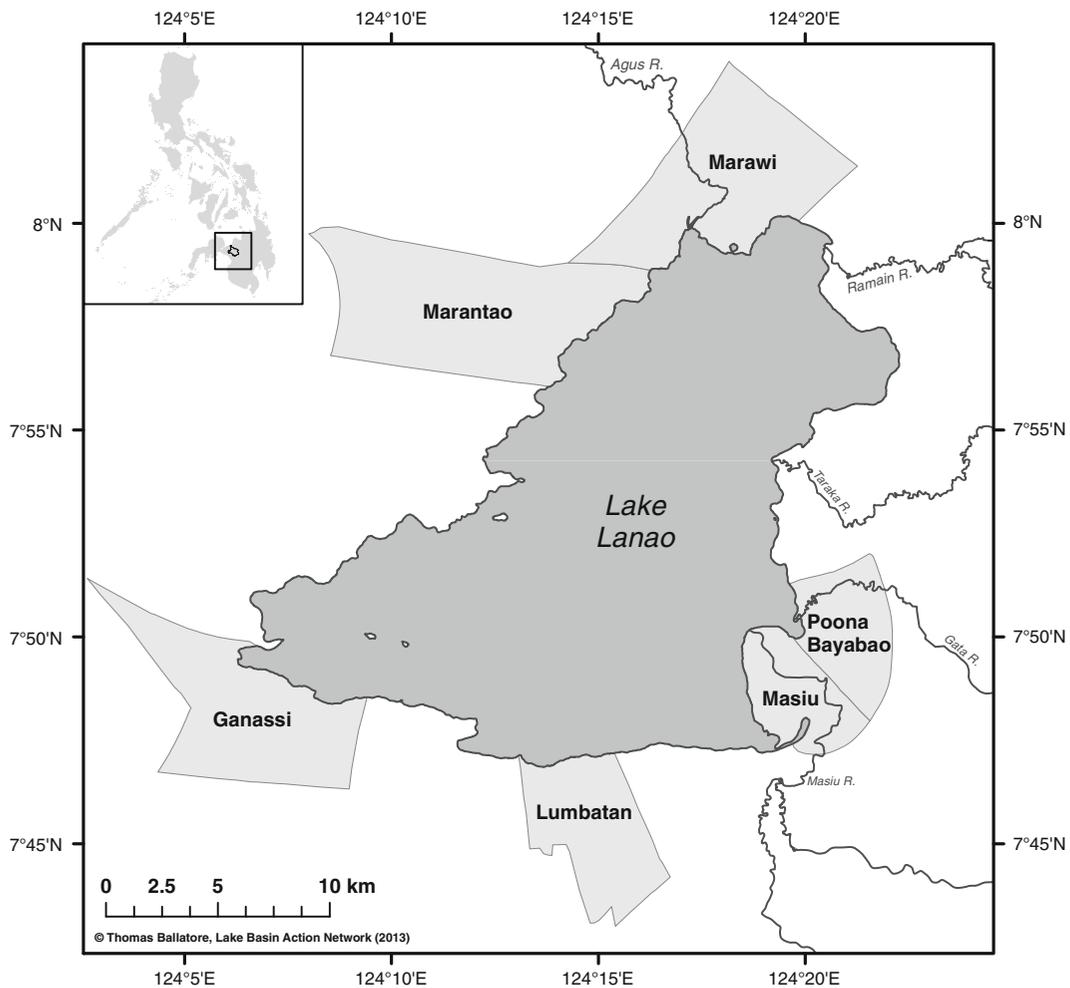
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**Fig. 1** Map of Lake Lanao to show location in the Philippines, with tributaries and out flowing river, and administrative regions surveyed in this study (reproduced with permission from Lake Basin Action Network)

the validity of this example of apparent explosive speciation (Reid 1980) and called the diversity of the cyprinids a taxonomic artifact (Kornfield and Carpenter 1984). Furthermore, various hypotheses were suggested to explain the complex diversity of the Lanao endemic cyprinids. These included multiple colonizations, extensive hybridization (Kosswig and Villwock 1964), and allopatric origins (Woltereck 1941; Kosswig and Villwock 1964; Wood 1966). However, some scientists believe that the lake itself was the cause of the species' complex evolution (Herre 1933; Myers 1960; Beadle 1974).

Chronicling of such important species is critical. Herre's original collection (1924) of the Lanao endemic species was destroyed during World War II.

However, a few specimens were subsequently collected and are presently in the Natural History Museum of Stanford University and the U.S. National Museum. Specimens of two endemic species we collected from our 2008 survey were deposited in the collections of the College of Fisheries, Mindanao State University, Philippines.

Several significant historical fish market and landing surveys have been conducted in the region of Lake Lanao (Villaluz 1966; Sanguila et al. 1975; Escudero et al. 1980; Escudero and Demoral 1983; Escudero 1994). The results of those surveys showed an alarming decline in the number of endemic species. Relative abundance of the most important commercial endemic Lanao fish species *Puntius lindog*, had

dramatically declined while a number of introduced species, such as *Hypseleotris agilis* and tilapia species, steadily increased (Frey 1974).

### Objective, hypothesis and predictions

It has been more than 20 years since the 1990–1991 survey collected information on the fish species in Lake Lanao. The objective of our study was to collect and report information on the status of the endemic fish species in Lake Lanao based on landing and market surveys conducted during 2008. We compared that information to the previous surveys (Villaluz 1966; Sanguila et al. 1975; Escudero et al. 1980; Escudero and Demoral 1983; Escudero 1994). Field sampling and fishermen interviews were also conducted to collect additional information on the status of the endemic and other fish species in Lake Lanao. Our working hypothesis was that the endemic cyprinids are threatened by a combination of introduced species, habitat changes and human harvest. We predicted that the numbers of endemic species will have continued to decrease since the 1990–91 survey.

## Methods

### Study area

Lake Lanao is the largest (surface area 357 km<sup>2</sup>; volume 21.5 km<sup>3</sup>) and deepest (maximum and mean depth of 112 m and 60.3 m) freshwater lake in the Philippines. It is located in the southern part of the country, on the island of Mindanao in the province of Lanao del Sur (Fig. 1). The province consists of 39 municipalities of which Marawi City is the capital. Lanao del Sur has a Type III tropical climate, with a dry season lasting only from 1 to 3 months (December - February or March - May). Frey (1974) reported a mean annual rainfall of 2,865 mm for Marawi City with 237 rainy days per year.

The lake is 702 m above sea level with a mean monthly surface temperature varying between 22.2 °C and 27.6 °C (Naga 2010). It is of tectonic-volcanic origin and its basin is shallowest in the north and progressively becomes deeper towards the south. The lake is considered to be oligotrophic or relatively low in nutrients. The lake has four large main river

tributaries: Ragain, Taraka, Gata, and Masiu, providing up to 21.5 cubic kilometers of freshwater, with an average annual inflow of 3.34 cubic kilometers (Naga 2010). The main outlet is the Agus River, with an average annual discharge of 3.35 cubic kilometers (Naga 2010).

Political stability and peace and order among the human population have been issues for decades in the province of Lanao del Sur. Preliminary interviews with the local people, the fishermen and the fish market vendors were conducted before the surveys began to confirm the feasibility of the sampling approach. We also obtained permission from the local community leaders. Municipalities included in the surveys were chosen based on their locations around the lake and on the availability of contact people for security purposes. Furthermore, municipalities located in the southern part of the lake were included based on information reported in Escudero et al. (1980) that the endemic *Puntius lindog* is limited to the south where the lake is deepest.

### Species sampled

All species were identified based on published descriptions, historical photos (Herre 1924, 1926; Escudero et al. 1980; Escudero and Demoral 1983), past fish surveys and interviews with the fishermen and vendors. Furthermore, endemic species obtained were confirmed and personally identified by Professor Pedro Escudero of Mindanao State University. In the landing site and market surveys, the introduced species *Clarias macrocephalus* and *Clarias batrachus* were collectively recorded as one species (*Clarius* spp.) since most of the fishermen could not distinguish between them. Similarly *Glossogobius celebius* and *Glossogobius giurus* were recorded as *Glossogobius* spp. and *Oreochromis mossambicus* and *Oreochromis niloticus* were recorded as tilapia spp. This method was also used in all the past surveys conducted by Villaluz, Sanguila and Escudero.

The weights of fish species sampled were measured in kilograms in both past surveys and in our 2008 survey. In the 2008 landing survey, fish species were observed in large metal basins. According to the fish vendors, the weight of fish in a full large basin was estimated to be 38 kg. Moreover, recycled plastic jars were used by the fishermen or middlemen to measure out adult *Hypseleotris agilis*

depending on how much the fish vendors would buy. A plastic jar was estimated to hold about 1 kg. Small *Hypseleotris agilis* were sold in sacks, with one sack being equivalent to 50 kg.

### Surveys

*Landings survey* Three landing ports were surveyed around Lake Lanao - Marawi City, Ganassi and Lumbatan (Fig. 1). For each sampling event the samplers (Gladys Ismail and one or two assistants) would wait at the fishing port early in the morning and record for every fishing boat that arrived, the fish species landed, the total weight of each species caught, and the location or area where the species were caught in the lake. The survey operations would typically start at 06:30 h and last until 09:00 h or until all fishing boats on that particular day were sampled.

Marawi City has the largest landing port and fish market in the province. Thus, the landing survey concentrated on this area. Fish coming from the different towns around the lake were carried to the landing site in Marawi City by fishermen or middlemen. Middlemen refer to persons who bought fish from the fishermen in their respective town and carried them to the landing site where they would sell the fish to the market vendors.

Ganassi and Lumbatan are located southwest and south of Lake Lanao, respectively. Both municipalities are accessible either by boat or car. Both municipalities were surveyed only once.

*Market survey* There were four markets in different municipalities around Lake Lanao (Fig. 1) that were surveyed a total of 13 times from July to October 2008. A maximum of 10 different vendors in Marawi, eight in Ganassi and also eight in Lumbatan markets were surveyed and interviewed. The sampling events usually were from 09:00 until 11:00 h. Palitan and Banggolo are the two major markets in Marawi City (Escudero et al. 1980). Freshwater and marine fishes are sold in Palitan market, which is located on the lakeshore of the city. In contrast, Banggolo market exclusively sells marine fishes that come from neighboring towns such as in Iligan, Lanao del Norte and Malabang, Lanao del Sur.

For each sampling event in the Marawi Palitan market, we surveyed a maximum of 10 vendors to determine and record the kinds and prices of each species sold from Lake Lanao. Stalls of fish vendors that sell fish from the lake are all located in one particular area. Furthermore, fish vendors usually sell a particular kind of fish. For instance, a tilapia vendor will sell only tilapia and a mudfish vendor will sell only mudfish. Stalls at the markets were also carefully examined for any species not seen during any of the previous landing surveys. Markets in Poona Bayabao and Lumbatan were smaller and exclusively sell fishes from Lake Lanao.

*Field sampling and fishermen interviews* Field samplings were conducted in the municipalities of Ganassi, Marantao and Masiu (Fig. 1). A fisherman from each of the three towns was hired and instructed to catch fish using his regular fishing method on the first sampling and any alternative fishing methods on the second sampling. The fishermen were also interviewed to provide additional information concerning the fish species caught in Lake Lanao. A total of 55 fishermen from the municipalities of Lumbatan, Ganassi, Marantao and Masiu were asked to complete a questionnaire approved by the Oregon State University Institutional Review Board. Fishing experience, fishing methods, species often, rarely or never caught and species preference were some of the questions asked.

*Comparison with past surveys* The landing surveys were done to identify directly the fish species present in the lake and to establish the relative abundance of the various species found, while the market surveys were conducted in order to determine and record species that might not be seen during the landing surveys, as well as to estimate the market demand and prices paid for different fishes. Results of the 2008 surveys were compared with the historical landing survey conducted by Villaluz in 1963–64, Sanguila et al. in 1973 and with the three market surveys conducted by Escudero in 1974–77, 1982–83 and 1990–91. The objective of the comparison was to determine if there had been changes in the number and relative abundance of species caught in Lake Lanao, whether the

number of endemic species had changed and which species now dominated the lake.

Marawi City, as the capital city of Lanao del Sur where Lake Lanao is located, is the center for merchandise and has the biggest fish market and landing port in the province. Villaluz (1966) identified the various fish species caught and obtained a total weight of Lake Lanao fishes landed in the Marawi market in 1963–64 but his report did not describe in detail how his survey was conducted or how much sampling he did. Furthermore, Villaluz combined all the weights of the endemic species surveyed. Because he mentioned the word ‘landed’, we assumed that he did a landing survey in Marawi City, one of the areas where we conducted our 2008 landing surveys.

In August to December 1973, Sanguila et al. (1975) also did a landing survey in Marawi City. There is no description on how the survey was done except that the total landed fish weight caught was compared with the Villaluz survey. Although Escudero et al. (1980) mentioned in their methodology that he undertook a daily fish market survey at Marawi City market from 1974 to 1977, the results of his study showed only partial coverage and not the entire 12 months of a year.

The historical surveys were conducted sporadically with no definite sampling method but had a similar objective, which was to obtain records of the kinds and quantity of Lanao fish species sold in Marawi City. To determine the fate of the endemic cyprinids and other Lanao fish species and with the historical surveys being the only Lanao fisheries data, we therefore assumed that it is reasonable to compare our results to the estimates of total catch of the past surveys.

## Results

### Surveys

**Landings survey** We recorded 12 species in the landings site of Marawi City, Ganassi and Lumbatan (Table 1): one endemic species, *Puntius lindog*; one native species, *Ophicephalus striatus* (mudfish); and 10 introduced species, *Anabas testudineus* (climbing perch), *Clarias macrocephalus* (bighead catfish),

*Clarias batrachus* (walking catfish), *Cyprinus carpio* (common carp), *Glossogobius giurus* (white goby), *Glossogobius celebius* (Celebes goby), *Hypseleotris agilis* (sleeper goby), *Oreochromis mossambicus* (tilapia mozambique), *Oreochromis niloticus* (Nile tilapia), and *Trichogaster pectoralis* (gourami).

**Market survey** The species found in the landing ports of Ganassi and Lumbatan were also all found in their respective markets. Meanwhile, all the 11 species recorded from the landing survey in Marawi City plus the endemic *Puntius tumba* were found in the market. *Puntius tumba* and *P. lindog* were both placed in a cellophane container (Fig. 2d) with water and sold by groups usually for 100 pesos (US\$2.00) per 5–8 fish (about 150 g), depending on the size.

**Field sampling and fishermen interviews** The introduced *Hypseleotris agilis*, *Ophicephalus striatus*, *Trichogaster pectoralis* and *Tilapia* spp. were the only species caught during the field sampling. Gillnets, the common fishing method used by Lake Lanao fishermen hired for the field sampling, caught primarily *Hypseleotris agilis*.

The dominance of *Hypseleotris agilis* and the ‘disappearance’ of the endemic cyprinids were further recorded during the interviews with fishermen, 47 out of 48 interviewed fishermen listed *Hypseleotris agilis* as the species they often caught. Furthermore, 37 of the 38 fishermen listed the assumed 16 extinct endemic species as species they had never caught while 15 of the 43 fishermen listed *Puntius lindog* and 19 of the 43 fishermen listed *Puntius tumba* as species they had rarely caught.

**Comparison with past surveys** Endemic cyprinids comprised about 43–70 % of the total weight of the landings in the early surveys but then decreased dramatically in the 1982–83 survey when they only contributed 17 % of the total fish catch, a 53 % difference from 1977 survey (Table 1). This further decreased to 12 % (1990–91) and then down to only 0.05 % in 2008 (Table 1).

The fraction of the recorded total fish catch that was introduced species followed a pattern that was more or less a mirror image of the endemic cyprinids. In the early surveys (with the exception of the

**Table 1** Comparison of estimated percentage weights (of total fish market sales) of Lanao species from different landing/market surveys (see text for details of individual surveys; blank values indicate no data recorded, presumably species not present)

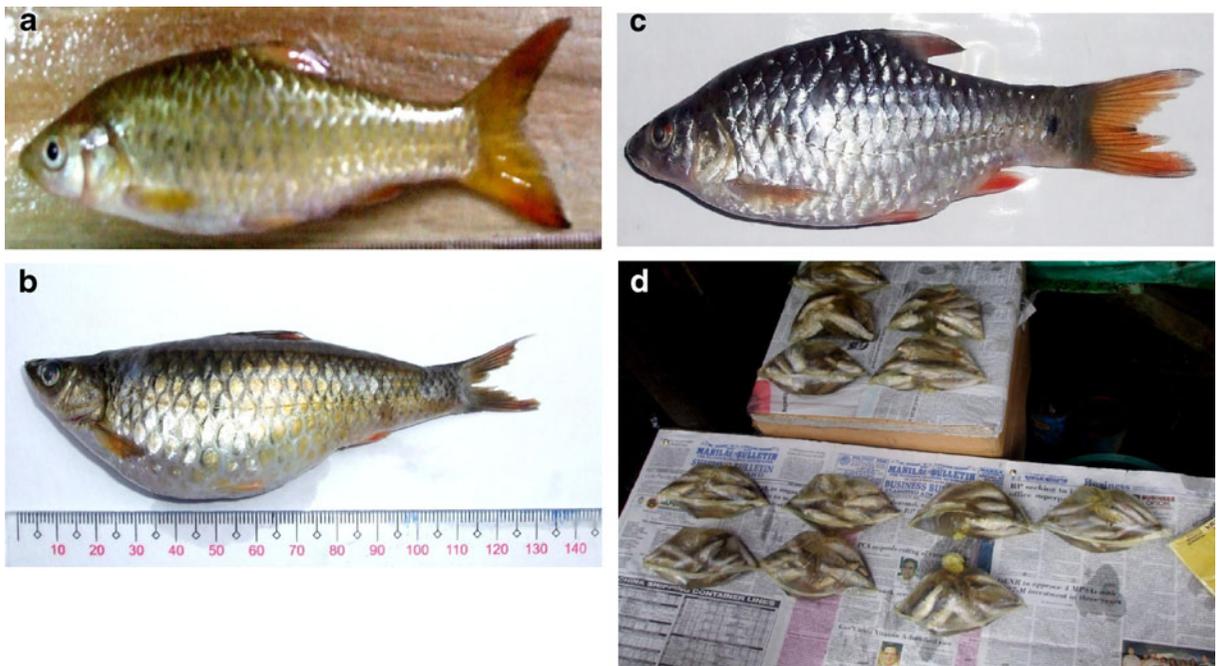
Family and Scientific Name	1963–64	1973	1974	1975	1976	1977	1982–83	1990–91	2008
Anabantidae									
<i>Anabas testudineus</i>	0.53		0.02	<0.01	<0.01	<0.01	0.02	0.04	<0.01
Anguillidae									
<i>Anguilla celebesensis</i>	0.17		0.02	0.03	0.01	0.01	<0.01		
Centrarchidae									
<i>Micropterus salmoides</i>	0.1								
Channidae									
<i>Ophicephalus striatus</i>	14	3.1	14	13	17	13	15	5	6
Cichlidae									
<i>Oreochromis mossambicus</i> <sup>a</sup>									
<i>Oreochromis niloticus</i> <sup>a</sup>	6	11.3	10	6	10	10	17	38	26
Clariidae									
<i>Clarias batrachus</i> <sup>b</sup>									
<i>C. macrocephalus</i> <sup>b</sup>	1	2.7	2	1.4	1.2	0.7	11	0.1	0.8
Cyprinidae									
	57 <sup>c</sup>								
<i>Cyprinus carpio</i>	14	1.7	1.3	0.7	1.5	1.1	2.5	0.1	0.02
<i>Cephalakompsus pachycheilus</i> <sup>c</sup>									
<i>Ospatulus palaemophagus</i> <sup>c</sup>		0.01	<0.01	<0.01					
<i>O. truncatulus</i> <sup>c</sup>			0.02	0.01		0.02		<0.01	
<i>Puntius baoulan</i>		<0.01							
<i>P. clemensi</i>			<0.01						
<i>P. herrie</i>		0.01	0.15	0.18	0.05	0.04			
<i>P. katolo</i>									
Cyprinidae									
<i>P. lindog</i>		43	56	67	51	70	17	12	0.01
<i>P. manalak</i>		0.01	0.01			0.01			
<i>P. sirang</i>		0.01	0.01						
<i>P. tras</i>			0.00		0.00				
<i>P. tumba</i>		0.01	0.08	0.08	0.21	0.20	0.05	0.16	0.04
Eleotridae									
<i>Hypseleotris agilis</i>							27	43	67
Gobiidae									
<i>Glossogobius celebius</i> <sup>d</sup>									
<i>G. giurus</i> <sup>d</sup>	7	38	16	11	20	5	11	1.2	0.7
Osphronemidae									
<i>Trichogaster pectoralis</i>	0.2	0.14	0.21	0.27	0.02	0.03	0.02	0.01	<0.01
Total weight (kgs)	1729005	701632	683990	262970	372815	366758	543964	185058	17560.27

<sup>a,b,c,d</sup> collectively recorded as one species

<sup>c</sup> total weight of the endemic cyprinids in the landing survey (see methods for explanation)

1973 survey), the introduced species comprised about 17–32 % of the total landings weight. It then increased markedly starting with the survey in 1982–83,

increasing from 17 % in 1977 to 68 % in 1982–83 (Table 1). Their relative abundance increased in the most recent two surveys, contributing 83 % and



**Fig. 2** **a** *Puntius lindog* collected during the 2008 survey, fork length approximately 11.5 cm (Gladys Ismail photograph). **b** Gravid *P. lindog* collected during the 2008 survey, fork length approximately 12.0 cm (Gladys Ismail, photograph). **c** *Puntius*

*tumba* collected during the 2008 survey, fork length approximately 12.0 cm (Gladys Ismail, photograph). **d** Endemic cyprinids in plastic bags, displayed for sale in the market during the 2008 survey (Gladys Ismail, photograph)

94 % in the 1990–91 and 2008 surveys respectively (Table 1).

*Puntius lindog*

We saw specimens of *Puntius lindog* (Fig. 2a) for the first time in September 2008 during our preliminary landing survey in Lumbatan. An old fisherman, Mr. Dimalipus Kaulan, was about to deliver the endemic species to the house of one of his regular customers. Mr. Kaulan was advised of our research purpose. Then he showed us the plastic container he was holding, half-filled with water with three *Puntius lindog*. One of the fishes was a gravid female (Fig. 2b).

Mr. Kaulan did not reveal any specific area in Lumbatan of where he caught the *Puntius lindog*. Apparently Mr. Kaulan was the sole fisherman and local vendor of *Puntius lindog*. Some fishermen we spoke with did not know that the species still existed or that Mr. Kaulan had been catching it. In fact, some local people who were present during the survey told us that they had not seen the species in 10 years. Some had never seen it before. In addition, specimens of

*Puntius lindog* were caught by the same fisherman a week later, which we discovered when we conducted our regular market survey and fishermen interviews. The total weight that we observed of landings of this species was 1.7 kg.

*Puntius tumba*

Unlike the seller of the *Puntius lindog* in Lumbatan who was also the one who caught the species, Mr. Sultan Hassan, the vendor of *Puntius tumba* (Fig. 2c and d) in Marawi sold fish that others had caught. Initially, Mr. Hassan told us that the species was caught from the lake. Eventually the only *Puntius tumba* seller said that his source of the species was a fisherman from Balo-i Lanao del Norte, the area where the stretch of the Agus River is located. The vendor said that he used to sell *Puntius tumba* from the lake. Unfortunately he had not sold *Puntius tumba* from Lake Lanao for at least 5 years as of the time of our survey. Moreover, this species was found in the market during all the survey months (July to October, 5 surveys), which implies that there

was a stable source for this species. Its presence in the market was not an unusual event.

## Discussion

There were no differences between the kinds of species sold in the four markets and the kinds of species recorded in the landing surveys except for the endemic species *Puntius tumba* that was found in Marawi market but not in its landing port. The endemic *Puntius tumba* and *P. lindog* were the most expensive species in the market. Regardless of being expensive, vendors who sold these species had regular customers and/or could sell the fish instantly. Moreover, the preference for *Puntius lindog* has a long history. *Puntius lindog* was considered the second most prized cyprinid in Lake Lanao next to *Puntius baoulan* (Herre 1924).

Herre (1924) suggested that *Puntius lindog* could be caught among the aquatic vegetation in shallow bays of the lake. This was probably evident at that time because this species was still abundant. Escudero et al. (1980) pointed out that the fishing ground for this species was in the southern part of the lake where it is the deepest. He also noted that the species was then limited to that area. In the 2008 survey, *Puntius lindog* was only caught by a fisherman in Lumbatan, on the southern shore of the lake. This suggests that this species is limited now to the southern area of the lake.

Although Herre (1934) obtained *Puntius tumba* in Dansalan Market (now known as Marawi), it is not clear whether he collected this species in Lake Lanao itself. Herre (1924) however collected this species in a stream east of Lake Lanao, in Lake Uyaan, Lake Nunungan and the outlet of Lake Dapao. Furthermore, Kornfield and Carpenter (1984) collected this species in a stream 100 m from Lake Lanao. Escudero (1994) reported that this species was usually caught in the coves of the lake. In the 2008 market survey, one vendor reported that *Puntius tumba* were caught in the Agus River.

It is a concern that *Puntius tumba* may have become extinct in Lake Lanao itself. However, there were unconfirmed reports that *Puntius tumba* had been caught in the lake, particularly in Marantao. Furthermore, previous studies also reported the occurrence of some of the endemic species outside the Lake Lanao drainage basin (Kornfield and Carpenter 1984). For instance, the endemic species *Mandibularca resinus* was reported to

have thrived in the Agus River (Herre 1924). Because our survey was very limited in the area and time covered, we could not verify the report nor ascertain the real condition of the endemic species.

Of the 18 endemic species identified by Herre (1924, 1926, 1932, 1933) (Table 2) we found that at least two of these species remain in Lake Lanao. Furthermore, both the endemic *Puntius lindog* and *Puntius tumba* are currently listed by the International Union for Conservation of Nature as vulnerable to extinction in the medium-term future (Ismail and Escudero 2011a, b). Based on past surveys through the years there is evidence that sometimes an endemic species would not be evident in the market but then would ‘reappear’ in following years. This happened in Kornfield’s study (1982) in which he only found one endemic species in the market but found five more species during his personal field collections.

Another species that ‘reappeared’ over the course of the market surveys was *Puntius baoulan*. This species was found in the market surveys during 1977 but was not reported again until it was recorded by Escudero in his 1990–91 survey (Table 2). It is significant to note that except for the 1982–83 and 2008 surveys, the other surveys showed different numbers and mixes of the endemic species (Tables 1 and 2). What does this tell us? Does it mean that perhaps other ‘extinct’ endemic cyprinids still exist, but in relatively low abundance?

Kornfield (1982) argued that because of their relatively low abundance many of the endemic species never reached the market but instead were sold and consumed locally. This also happened in the 2008 survey with the endemic *Puntius lindog* where it was only locally sold in the municipality of Lumbatan.

Other possible reasons why an apparently extinct endemic species would ‘reappear’ in the market are changes in the fishing methods and the areas where the fishermen usually operate their fishing gear. Fishing methods could certainly affect the catch composition brought to the markets. Villaluz (1966) described the wide variety of indigenous fishing methods that the native Maranaos had invented to catch particular fish. The fishermen would use a particular type of fishing gear depending on the kind and size of species they wanted to catch. However in the 2008 survey, the commercial fishermen now only use a few common types of fishing gear such as gill nets. In fact 83 % of the fishermen interviewed said they used gill nets (mesh size 3.5–3.8 cm).

**Table 2** Presence of endemic fish species in Lake Lanao through the years - Herre (1924, 1933), Villaluz (1966), Sanguila et al. (1975), Escudero et al. (1980), Kornfield (1982), Escudero

and Demoral (1983), Escudero (1994). P=indicates species recorded, blank entry indicates species not recorded

Species	1924	1963–64 <sup>a</sup>	1973	1974	1975	1976	1977	1982–83	1990–91	2008
<i>Cephalakompsus pachycheilus</i>	P		P							
<i>Mandibularca resinus</i>	P									
<i>Ospatulus palaemophagus</i>	P		P	P	P					
<i>O. truncatulus</i>	P		P							
<i>Puntius amarus</i>	P							P		
<i>P. baoulan</i>	P	P		P	P	P			P	
<i>P. clemensi</i>	P	P	P	P	P					
<i>P. disa</i>	P	P								
<i>P. flavifuscus</i>	P									
<i>P. herrei</i>	P			P						
<i>P. katolo</i>	P		P	P	P	P	P			
<i>P. lanaoensis</i>	P	P						P		
<i>P. lindog</i>	P	P	P	P	P	P	P	P	P	P
<i>P. manalak</i>	P	P	P	P			P			
<i>P. sirang</i>	P		P	P				P		
<i>P. tras</i>	P			P		P				
<i>P. tumba</i>	P	P	P	P	P	P	P	P	P	P
<i>Spratellicypris palata</i>	P	P						P		

<sup>a</sup> Villaluz (1966) combined all the weights of the endemic cyprinids without species specification. Although he did mention the following species as having great commercial value: *Puntius lindog*, *P. disa*, *P. baoulan*, *P. manalak* and *Spratellicypris palata*

It is important to note that most of the fishermen believed that all the endemic cyprinid species were now extinct. When the endemic species abundance started to decline and the introduced species became more abundant, it probably led the fishermen to stop catching the endemic species and to choose instead to catch more readily available fish, such as the *Hypseleotris agilis*. Moreover, the fishermen’s fishing operations were usually limited to particular areas and certain types of habitat. It is possible that the smaller endemic cyprinids, which may have specific habitat types and therefore require particular fishing methods to be caught, are still extant. An example of this phenomenon is the endemic *Puntius lindog* that was strictly limited to the deeper, southern part of the lake.

**Conclusion**

Our study was limited by time and resources, as well as local societal conditions. However, we were surprised

to find still two of the endemic species that Herre had discovered and carefully described for the scientific community early in the last century. Unfortunately the pattern from the historic surveys shows a decline of the endemic cyprinids and an increase of the introduced species. Apparently this decline in the endemic species is correlated with an increase in the abundance of introduced species, and increasing impacts of human activities in the area surrounding the lake. A longterm study with comprehensive field work in Lake Lanao is needed to further study the endemic species and verify their current status. In the meantime, the future of the endemic cyprinids in Lake Lanao is uncertain—but there is hope that they will survive.

It is worth noting that the presence or absence of the endemic species was inconsistent over the course of the historic surveys. Future surveys should include other techniques for collecting fish and should sample from all areas of the lake including deepwater areas, tributaries, the Agus River and small streams, to identify areas that could be set aside for the protection of the

endemic species. Studies of the biology, ecology and possible conservation hatchery rearing of the remaining endemic cyprinids should be conducted before these species become extinct. Previous attempts at artificially culturing *Puntius tumba* were successful but attempts with *Puntius lindog* were not (Ismail and Escudero 2011a, b) Attempts at stock enhancement through artificial propagation should be continued by improving and modernizing captive breeding and hatchery techniques. Hopefully our study will provide a new beginning rather than the last chapter in the story of the endemic fish species in Lake Lanao.

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