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Length-Weight Relationships of Fishes in Eight Floodplain Lakes of Agusan Marsh, Philippines

Joycelyn C. Jumawan* and Romell A. Seronay

Biology Department, Caraga State University, Butuan City, Philippines

Length-weight relationships (LWRs) of 16 fish species caught from eight floodplain lakes of Agusan Marsh in the Philippines in January 2014-2015 are reported. The species collected belong to nine families and were mostly introduced to the country. Samples were collected using five types of fishing gear. The "b" values in the LWR W= aL^b ranged from 2.196 to 3.34 and showed a mean value of 2.95. These measurements of fishes from Agusan Marsh contribute baseline information for the management and conservation of this critical wetland. The dominance of introduced over the native species and the risks accompanying this scenario is discussed.

Key words: Agusan Marsh, introduced fish species, lakes

INTRODUCTION

Marshes serve as a unique habitat for fishes due to its high production of vascular plant detritus, nutrients and it is spatially complex set-up. Tropical wetlands are hotspots of biodiversity (Gopal & Junk 2000). However, wetlands are subjected to increasing human pressure such as pollution, over utilization of natural resources and changes in natural flood regime which increases its vulnerability to invasion and dominance of introduced species (Junk 2002). The critical changes in management methods of this unique ecosystem have led to the declining fisheries diversity and production in most tropical countries (Dudgeon et al. 2006).

The Agusan Marsh is an ecologically and economically important wetland in the Philippines (Varela & Gapud 2008). Agusan Marsh is one of the largest and most contained freshwater wetlands in the country (Tabios 2008). It was declared as protected site internationally through Ramsar Convention in 1999 and locally through National Integrated Protected Area System (NIPAS) Act of 1994. The area around and inside the Agusan Marsh is home to 110,827 indigenous people, mainly Manobo, constituting about 42% of the total population (Agusan del Sur Provincial Profile 2012). While the manobos are now immersed in modern fishing practices and fishing gadgets, they also utilize indigenous fishing gears and practices that could contribute to the conservation of the rich biodiversity of the marsh. Nonetheless, the aquatic diversity in the marsh is threatened by habitat loss, over-exploitation of fishery resources, pollution, population pressure and the deliberate and accidental introduction of invasive fish species (Hubilla-Travis et al. 2008). Very few ichthyofauna studies in the past years show the domination of introduced species (Talde et al. 2008) and decline in fish composition (Hubilla-Travis et al. 2008).

The relationship between the length and weight of fishes is expressed by the equation W=aL^b (Froese 2006) and values of regression coefficient "*b*" provide information on fish growth. The LWRs presented here supplemented

*Corresponding author: joycejumawan1981@gmail.com

previous reports of fishes in three floodplains of the marsh (Talde et al. 2008) and their conspecifics in Candaba wetland (Garcia 2010). This paper furnishes information of an updated inventory of fish species caught from eight floodplain lakes of Agusan Marsh. An updated inventory of the current surviving fish species and fishing practices, as well as LWRs of these fishes will be helpful in measures towards the conservation and management of the fishery resource in the area.

MATERIALS AND METHODS

Fishes were obtained from eight floodplain lakes (Panlabuhan, Mihaba, Tugno, Kasawangan, Mambagongon, Sabang-Gibong, Kilobidan, and Tikgon) inside Agusan Marsh (Figure 1). Sampling of fishes covered January 2014 to January 2015. Fish samples were either purchased from the local community fish buyers or caught by resident fishermen partners. Information on the sampling gear (material and usage), study stations, fish common and scientific name, total length (cm) and body weight were recorded. Following capture or purchase on site, fishes were measured and sorted according to species. Sex of these species was not determined. Total length (TL) was obtained with a measuring board, tape measure or a ruler, depending on the length of the fish.

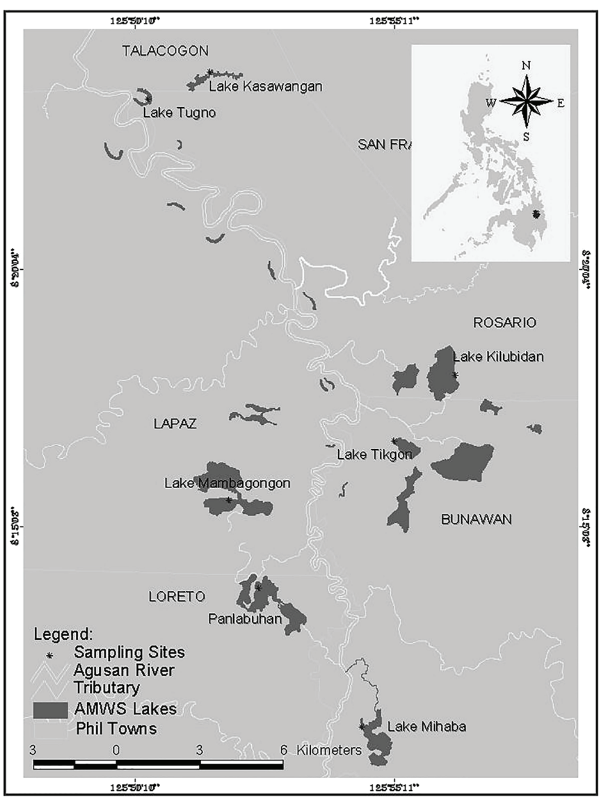

Figure 1. Study stations in Agusan Marsh, Philippines

Body weight of specimens > 1000g were measured using a kitchen scale while individuals weighing < 1000g were measured using an electronic bench scale to the nearest 0.1 g after blot-drying excess water.

The length-weight relationship (LWR) of fishes was expressed by the equation $W = aL^b$, where W is the total body weight, '*a*' as the regression intercept, '*L*' as the total length and '*b*' as the regression coefficient (Froese 2006). The expression of the relationship is represented by the following formula: $\text{Log } W = b \log L + \log a$. The "*a*" and "*b*" for the LWR values were obtained from linear regression of the log-transformed L and W of fish with "W" as the dependent variable. The coefficient of determination (r^2) of the LWR was computed. The '*b*' is an exponent with a value between 2.5 and 3.5 to describe typical growth dimensions of relative well being (Bagenal 1978). Transformations were made using the natural logarithm of the observed lengths (TLs) and weights.

RESULTS AND DISCUSSION

A total of 3200 fish individuals comprising 16 species from 9 families were collected during the sampling period in the eight floodplain lakes. Table 1 shows for each species, the sample size (*n*), the maximum, minimum and mean body weight (±SEM); the maximum, minimum and mean total length (±SEM), the LWR parameters *a* and *b*, the standard error of the slope, and the coefficient of determination, r^2. Fish species documented in this study were limited to the kind of sampling gear utilized by the community. A total of nine catching gears were documented. However, locals for each of the floodplain lakes did not consistently utilize these catching gears. Update on the LWRs of some conspecifics recorded through Froese and Pauly (2016) was also indicated.

The sample size of fishes ranged from 10 individuals for *Clarias batrachus* to 1108 individuals for *Channa striata*. The r^2 values ranged from 0.856 for *Glossogobius giuris* to 0.989 for *Osphronemus goramy*. All regressions were highly significant (<0.001). The *b* values ranged from 2.12 for *Clarias batrachus* to 3.34 for *Oreochromis niloticus*. Three species showed $b<2.5$ however no fish species exceeded 3.5. The median value of *b* was 2.95±0.12. Only four species showed isometric growth, ten negatively allometric and two positively allometric in growth. Three species were noted to have relatively different mean growth dimensions compared to their Bayesian length-weight estimates (Froese et al. 2014).

In Agusan Marsh, *Cyprinus carpio* exhibited isometric (3.015) growth while *Oreochromis niloticus* (3.25) and *Pterygoplichthys disjunctivus* (3.14) Showed positively allometric growth dimensions. This is in contrast to

Table 1. LWRs of the 16 fish species from Agusan Marsh, Philippines.

Family and Species[a]	n	Total Length Range (cm)	Body weight range (g)	a (95% CI)	b (95% CI)	r^2	Status
Anabantidae							
Anabas testudineus (2,5)[b]	32	9.6-17	15.50-77.6	0.086 (0.042-0.098)	2.86 (2.72-3.0)	0.925	Native
Channidae							
Channa striata (1,2,3,5,9)	1108	23-61	50-1500	0.017 (0.012-0.019)	2.89 (2.62-3.01)	0.972	Introduced
Cyprinidae							
Cyprinus carpio (1,2,3,5,6,7,9)	320	11.4-58	18-2700	0.026 (0.018-0.038)	3.02 (2.908-3.121)	0.968	Introduced
Puntius binotatus (1, 2,4,5,8)[b]	160	5.6-12	2.4-26.6	0.0076 (0.061-0.0083)	3.01 (2.82-3.14	0.924	Native
Clariidae							
Clarias macrocephalus (2,5,6,9)	18	25.5-41	115-500	0.033 (0.029-0.038)	2.92 (2.270-3.19)	0.923	Native
Clarias gariepinus (2,5,6,9)	820	20-55	100-1000	0.083 (0.0074-0.0088)	2.98 (2.92-3.05)	0.962	Introduced
Clarias batrachus (2,5,6,9)	10	27-30.5	83-55	0.0062 (0.0051-0.0131)	2.68 (2.12-3.01)	0.975	Introduced
Chandidae							
Ambassis interrupta (1,5)	23	5.5-12	1.7-12.1	0.015 (0.0082-0.0163)	2.77 (2.37-3.18)	0.926	Native
Cichlidae							
Oreochromis niloticus (1,2,3,5,6,7,10)	261	11.5-47	25-2000	0.031 (0.022-0.029)	3.25 (3.16-3.34)	0.967	Introduced
Gobiidae							
Ophiocara porocephala (1,4,5)[b]	12	18-27	75-250	0.0102 (0.005-0.021)	2.854 (2.596-3.11)	0.924	Native
Glossogobius giuris (1,2,4,5,8)[b]	19	10-19.5	5.8-36.2	0.017 (0.011-0.019)	2.9432 (2.553-3.10)	0.856	Native
Osphronemidae							
Trichogaster trichopterus (2,4,5,8)[b]	246	4.9-11.5	1.7-21.5	0.029 (0.021-0.038)	3.046 (2.921-3.172)	0.966	Introduced
Trichogaster pectoralis (1,2,5,6,9)	27	12-24	31.1-200	0.017 (0.011-0.022)	2.904 (2.82-3.02)	0.955	Introduced
Osphronemus goramy (1, 2,3,5,9)[b]	23	10-64.5	19.3-5450	0.017 (0.00901-0.023)	3.032 (2.83-3.11)	0.989	Introduced
Loricariidae							
Pterygoplichthys disjunctivus (2,5,9)[b]	87	12-57	11.3-1325	0.072 (0.056-0.089)	3.14 (2.76-3.21)	0.972	Introduced
Pterygoplichthys pardalis (2,5,9)[b]	34	14-49	10.11-310	0.034 (0.022-0.048)	2.935 (2.56-3.19)	0.952	Introduced

a: catching gear used. 1-improvised purse seine/ *lambat*; 2-cast net/*pukot*; 3-Gill net/ laya; 4-Boto trap; 5-electrofishing; 6-hook and line/*bingwit*; 7-palangre fishing; 8-scoop net/ *sibut*; 9-improvised fyke net trap/*bantak*.
b:species lacking length or weight data based on Froese and Pauly2016 (http://www.fishbase.org, version; accessed September, 2016)

the negative allometric growth estimates for *Cyprinus carpio* and *Oreochromis. niloticus* and isometric growth estimates for *P. disjunctivus* (Froese et al. 2014). While *P. disjunctivus* has ideal (b=3) estimates, *Pterygoplichthys* species often exhibit a marginal (b=2.5) or near marginal values as in the case of *P. disjunctivus* in Candaba Wetland (Garcia 2010) and Marikina River, Philippines (Jumawan et al. 2016). *Liposarcus multiradiatus* in Kaoping River, southern Taiwan (Liang et al. 2005) and *Pterygoplichthys pardalis* in Langat River, Malaysia (Samat et al. 2008) also exhibited marginal growth dimensions.

There were no new species reported in the present study, except for *P. pardalis* that was first reported here. Hubilla-Travis et al. (2008) reported the existence and threat of *P. disjunctivus* in the ichthyofauna diversity of the marsh but did not mention *P. pardalis*. Jumawan et al. (2011) utilized *Pterygoplichthys* spp. CO1 sequences from Agusan Marsh janitor fish samples that turned out to cluster with *P. pardalis* sequences from janitor fish collected from Marikina River, Philippines that could suggest the possibility of the unreported existence of *P. pardalis* in Agusan Marsh together with *P. disjunctivus*. These two species have very similar features other than the abdominal vermiculation patterns, which distinguish the two species from each other. The number of species reported in this study is higher compared to the number of fish species reported by Talde et al. (2008) from the three floodplain lakes—Mihaba, Tikgon, and Dinagat. Our inventory of fish species is way lower in number compared to the list by Hubilla-Travis et al. (2008) which covered seven aquatic habitats and utilized a wide range of catching gears, including electrofishing. It should be noted that since the earliest report (Herre 1953), the number of native species has decreased and has been replaced and dominated by introduced species.

Different sizes of "*pokut*" or cast nets were the most common catching gear utilized for all lakes studied. The gear comes in various mesh sizes, which, in turn, is a major factor in the abundance and size of fish species collected. Scoop net or "*sibut*" catch small-sized fishes because of its small mesh size. Scissor nets, locally known as "*siid*", could come in different mesh sizes held together by a frame made of slender bamboo or any material that can be bent as a frame to the semi-circular gear. A fish trap locally known as "*boto*", is an indigenous catching gear widely used for the catch of small-sized fishes like *P. binotatus, T. trichopterus*, and small sized *G. giuris*. As fishes caught were small-sized, this indigenous catching gear is used for trapping fish that will be eventually used as bait to catch bigger fishes. Another fish trap known as "*bantak*", an indigenous version of fyke net, is an elongated cone-shaped trap that is often made of bamboo frames held together fastened by strong nylon strings. The trap is mostly sheathed with sturdy nets except for the full circular entrance with a narrow circular opening several inches from the mouth to prevent fishes from escaping. Bantak is positioned on the sides of the river banks. "*Palangre*" is a local fishing gear with multiple hooks attached and is usually placed within lakes. Electrofishing is still rampant as several fish species were bought from lake communities using this gadget.

The present study has shown clearly that introduced species (62%) have dominated the species composition of major lakes in Agusan Marsh. The majority of these introduced species were utilized as major part of the diet of marsh residents and most of the fish-eating public in Agusan Del Sur. The three *Clarias* species, *Oreochromis, Cyprinus* and *Osphronemus goramy,* are important protein sources. The two *Pterygoplichthys* species reported here are considered nuisance ever since the early establishment of the janitor fish in the marsh (Hubilla et al. 2008). The dominance of introduced species could pose many dangers to the aquatic habitat. Compared with native species, the invasive species are usually superior competitors and often have high reproductive potential (Townsend 1996; Sakai 2001; Mills et al. 2004). Hybridizations, extinction and spatial displacement of native species (Dudgeon et al. 2006; Huxel 1999; De Silva et al. 2007) are just examples of possible scenarios of domination of invasive species.

Nonetheless, an evaluation of 62 introduced exotic freshwater fishes in the country showed that the majority (77%) of the introduced fishes for aquaculture, ornamental purpose, recreational fishing and mosquito control have been beneficial for the country particularly by enriching the biodiversity of freshwater systems (Guerrero 2014). There should be more research in ecological impacts, conservation and awareness initiatives to address the paucity of information regarding the actual status of fisheries in Agusan Marsh. Conservation measures for inland capture fisheries should be a priority not only for decision makers but also for residents and indigenous people in the marsh.

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