Age-Growth Parameters of Crescent Grunter, *Terapon jarbua* (Forsskål 1775) in Mindanao, Philippines

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ABSTRACT

Otolith studies provide a breadth of information valuable in investigating the life history of reef fish species. When incorporated with analysis on length-weight relationships, this biological information becomes useful in understanding the population dynamics of economically important reef fishes. This study looked into the length-weight relationship and age-growth parameters of *Terapon jarbua*, a euryhaline fish species that is commonly harvested in coastal areas of Mindanao, Philippines. The length-weight relationship for 160 *T. jarbua* individuals (9– 22.4 cm, standard length) collected from Davao Gulf (n=105) and Iligan Bay (n=55) is given by the equation $W = 0.0428 \times SL^{2.8484}$, with an R^2 value of 0.85. Results of Student t-test identified that *T. jarbua* from these areas exhibit a negative allometric growth pattern, where the fish grows more in length than in weight. High R^2 values were obtained from linear regressions between the fish standard length and otolith length ($R^2 = 0.85$), standard length and otolith weight ($R^2 = 0.83$), and standard length and otolith mass ($R^2 = 0.82$), indicating feasibility of otolith measurements in predicting fish size. Based on the pooled age data from all readable otoliths (n = 86) fitted to the von Bertalanffy growth function, this study provides a theoretical maximum length (L_∞) of 21.720, curvature parameter (*K*) of 0.259, theoretical age at length zero (t_0) of 0.522, and growth performance (Φ') of 2.086 for *T. jarbua* collected from Iligan Bay and Davao Gulf in Mindanao, Philippines. Moreover, the age estimates of *T. jarbua* reported in the current work presents the first attempt of providing age-growth parameters using sagittal otolith microstructure.

KEYWORDS

age, growth, length-weight relationship, otolith, *Terapon jarbua*

INTRODUCTION

Otolith studies have been applied in various fields of knowledge to shed light on the life history of teleosts (Campana, 2005) and to understand the impacts of environmental factors on their growth (Geffen et al., 2016). Literature on age and growth of fishes is extensive (Hilborne and Walters, 1992; Secor et al., 1995; Campana, 2005) and has presented valuable applications to ecosystem-based fishery management (Geffen et al., 2016). Much of these reflect a century of research about major stocks of exploited fishes, primarily those of temperate waters, open-ocean, and deep-water habitats. However, there is limited age-based demographic information for coral reef fishes (Choat and Robertson, 2002). Most age-based studies have been conducted in Australia, New Caledonia, and other temperate regions where environmental conditions are different than in a tropical setting. In the Philippines, several otolith studies have been published and most were done for variety of interests. Otolith studies with implications for management include works on *Thunnus albacares* in southern Philippines (Yamanaka, 1989), *Sardinella lemuru* in Zamboanga Peninsula (Naguit, 2016; Bagarinao and Campos, 2017; 2018), and *Plectropomus leopardus* in Palawan (Padilla et al., 2003). Some otolith studies that explored other aspects include investigation on migratory patterns of *Anguilla* spp. using otolith microchemistry (Briones et al., 2007) and analysis on otolith morphology of *Siganus fuscescens* (Perez et al., 2016) and of six gobiid species (Pattuinan and Demayo, 2018). Published age-based studies include the early life history of *Siganus spinus* (Soliman et al., 2010), *Siganus canaliculatus* (Bobiles et al., 2015), and *Chaetodon vagabundus* (Leahy et al., 2015) and provision of age-growth parameters for *Lutjanus vitta* (Palla et al., 2016) and *Lutjanus bohar* (Fortaleza and Nañola, 2017). While there are several studies that utilized otoliths for different purposes, the need for age-based information for common yet understudied fish species in the Philippines is important because these studies provide the biological basis for fisheries

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management, especially for those of high economic importance.

The crescent grunter, *Terapon jarbua* is a euryhaline fish commonly called “bugaong” or “gunggong” in the Philippines (Froese and Pauly, 2016). It is a catadromous species that inhabits estuaries as nursery grounds and goes out into the open ocean to reproduce (Vari, 2001). It has a pelagic larval phase of 25.1 days (Lavergne et al., 2012) and is widely distributed throughout the Indo-Pacific region (Vari, 1978). Moreover, the species has also been reported to occur in the Mediterranean Sea (Golani and Appelbaum-Golani, 2010). They are moderate-sized fish reaching a maximum length of 35 cm TL (Vari, 1978; Rao et al., 2000) and they are easily identified by their longitudinal bands that are curved downwards on their silvery white or silvery gray bodies (Vari, 1978, 2001). In Taiwan, *T. jarbua* is among fish species with high economic value (Liu et al., 2015).

Existing studies on the crescent grunter are focused on its taxonomy and biology (Vari, 1978), feeding habits (Whitfield and Blaber, 1978), reproductive biology (Miu et al., 1990), trophic ecology (Davis et al., 2012), population structure (Lavergne et al., 2012), and genetic stock structure (Liu et al., 2015). While *T. jarbua* is common, there is little information about its age and growth parameters. More importantly, incorporating age-growth data to length-weight information is necessary to understand the population dynamics of *T. jarbua* in the same area of interest. Hence, this study provides information on the age structure and length-weight relationship of *T. jarbua* collected from Iligan Bay and Davao Gulf in Mindanao, Philippines.

MATERIALS AND METHODS

Fish Collection and Morphometrics

Fish samples (n = 160) were collected opportunistically from the wet markets of Davao City, Southern Mindanao and in Iligan City, Northern Mindanao (Fig. 1). Fish collection was conducted during the intermonsoon (October 2016, n = 44 and October 2017, n = 27) and northeast monsoon (March 2017, n = 61 and January 2018, n = 28) periods. Fish landing sites were also considered for fish collection to ensure that the fish samples were collected from the area of interest and not transported from other areas. Standard body measurements, such as standard length (SL), total length (TL), and body weight (BW) were obtained for all fish samples.

Otolith Extraction and Morphometrics

Extraction of the sagittal otoliths followed the up-through-the gills method described by Secor et al. (1991). The gill isthmus was cut and the head was severed and then cleared to expose the prootic bulla. The prootic bulla was cracked carefully using a pair of forceps to extract the sagittal otoliths. Extracted otoliths were cleared of adhering connective tissues and stored in Eppendorf tubes containing 95% ethanol. Digital caliper was used to record the otolith length (OL) and otolith width (OW). A digital weighing scale (ALC210.4 Acculab) was used to determine the otolith mass (OM), with an accuracy of 0.001 g.

Otolith Processing and Age Determination

Right sagittal otoliths were selected for otolith processing. The otolith embedding procedure was adapted from Robbins and Choat (2002) where small amount of thermoplastic resin (Crystal Bond 509) was melted on a glass slide to mount the otolith. The thermoplastic resin was cooled until the otolith is fixed and then ground by hand on wetted sandpaper of various grits (#600, #1200, and #2000). Otolith sections were viewed under light microscope (Optika Microscopes, B-382PL ALC) and captured using OptixCam Microscope Camera and OptixCam Toupview software.

Captured images were post-processed using GIMP (GNU Image Manipulation Program, 2007) to enhance the readability of annual rings. In the case

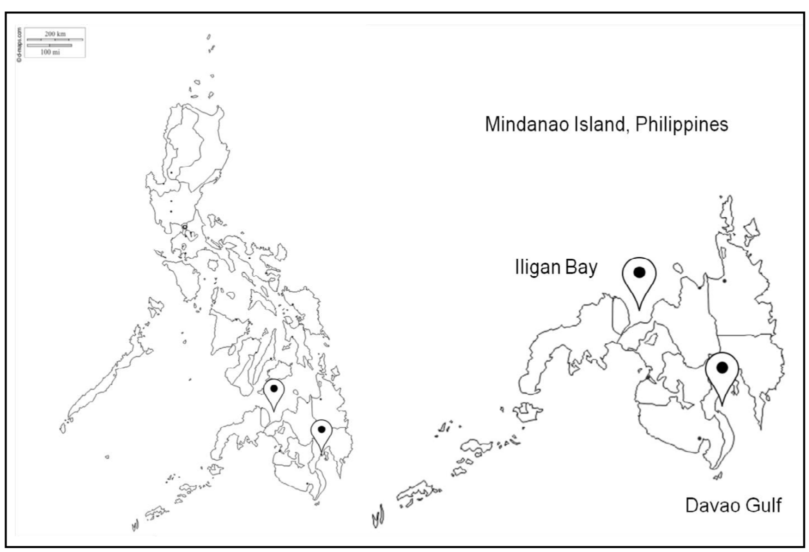

Figure 1. Map showing the location of Davao Gulf and Iligan Bay in Mindanao, Philippines.

of *T. jarbua* otoliths, a distinctive notch is formed, similar to what was observed by Robbins and Choat (2002) in the otoliths of acanthurids and serranids. Each of the opaque bands observed along the sulcal groove is assigned one year (Fig. 2). Age reading method followed that of Marriot et al. (2007) where opaque increments having uniform density are considered and counted. The precision of age estimates is calculated following the index of average percent error (IAPE) and those with ≤5% APE are considered for age data. Readers had no prior knowledge on the corresponding fish size of otoliths and when readings did not match, the sample was discarded.

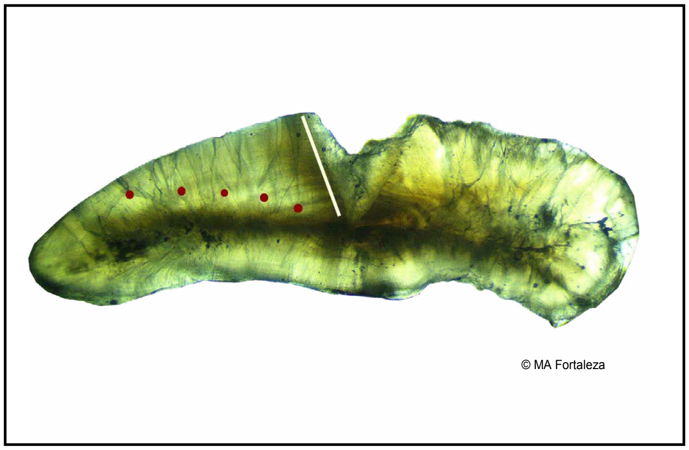

Figure 2. Otolith microstructure of a five-year old *Terapon jarbua* showing the method of counting its age based on the alternating opaque and translucent zones observed along the sulcal groove.

Data Analysis

The length-weight relationship of *T. jarbua* was determined from the equation $W=aL^b$ (Schneider et al., 2000). Morphometric data was log-transformed and the parameters a and b were estimated using ordinary least squares (OLS) regression. Resulting length-weight parameters were then compared with the existing length-weight relationship data for *T. jarbua* (Lavergne et al., 2012) reported from various locations. Relationships between fish and otolith morphometrics were also determined using OLS regression. The age-at-length data was fitted to the von Bertalanffy growth function (VBGF) to determine the growth parameters such as mean asymptotic length (L_∞) curvature coefficient (*K*), and theoretical age at zero length (t_0) (Robbins and Choat, 2002; Marriott et al., 2007; Pardo et al., 2013). The *K* value determines how fast the species can reach L_∞ (Froese and Binohlan, 2000). The growth curve was generated using Paleontological Statistics (PAST) software (Hammer et al., 2001) and then fitted at 95% confidence level. To fit the growth curve at length zero, a t_0 value of 0.211 independent of the working data was used (Zhang et al., 2002). The growth performance index (Munro and Pauly, 1983) of *T. jarbua* was also calculated in this study along with existing age-growth data for comparison using the formula: $\Phi' = \log(K) + 2\log(L_\infty)$, where *K* and L_∞ are similar values generated from the von Bertalanffy growth curve.

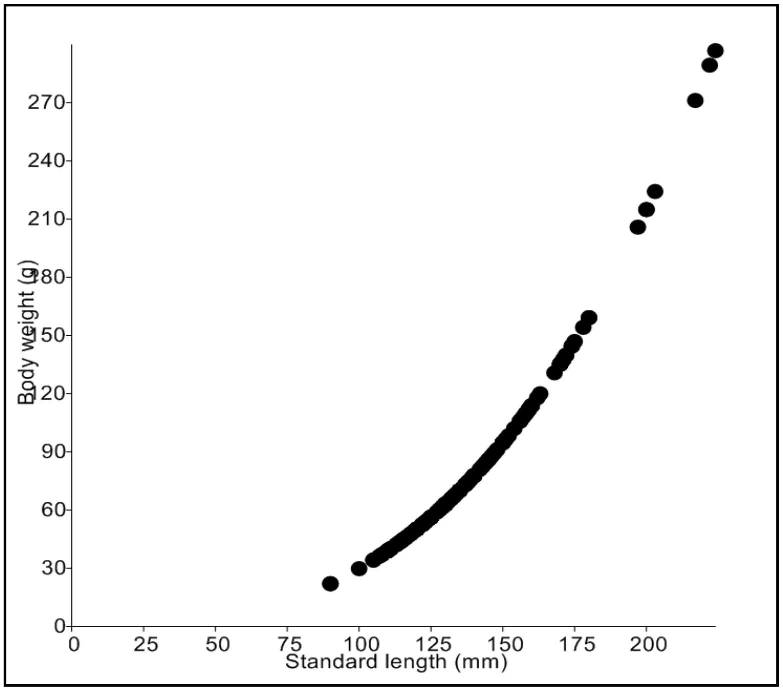

Figure 3. The computed length-weight relationship ($W = 0.00006 \times SL^{2.8484}$; R^2=0.96) of *Terapon jarbua* from Davao Gulf and Iligan Bay, Mindanao, Philippines using log-transformed L-W data.

RESULTS

A total of 160 *T. jarbua* specimens of varying sizes (9 cm – 22.4 cm, SL) were obtained from opportunistic collections conducted in Davao Gulf (n=105) and Iligan Bay (n=55), Mindanao, Philippines. Pooled data resulted to a length-weight relationship of $W = 0.0428 \times SL^{2.8484}$, with an R^2 value of 0.96 (Fig. 3). The generated length-weight parameters a and b were comparable to the reported data from various locations (Table 1). Student t-test revealed

Table 1. Comparison of length-weight relationship parameters of *Terapon jarbua* from different locations.

	n	min	max		*a*	*b*	R^2
Mindanao, Philippines (This study)	160	9.0	22.4	SL	0.0137	2.85	0.96
Davao Gulf, Philippines (Gumanao et al., 2016)	25	9.0	22.0	SL	0.0417	2.89	0.99
Gulf of Aden, Yemen (Lavergne et al., 2012)	620	4.7	27.9	SL	0.0288	2.99	0.96
South Africa (Harrison, 2001)	70	1.0	14.8	SL	0.0340	2.94	0.99
Gulf of Thailand (Yanagawa, 1994)	6	9.6	26.8	TL	0.0222	2.88	0.99

that the b value for *T. jarbua* in this study (b = 2.84) is significantly different from the hypothetical value for isometric growth (t = -3.478, P <0.05). Linear regressions between fish standard length and otolith measurements, namely otolith length, otolith width, and otolith mass gave high R^2 values (Fig. 4). Of the three otolith measurements, otolith length gave the highest R^2 value of 0.85. This indicates that for *T. jarbua*, fish size is predicted best whenever otolith length information is available however, otolith width (R^2 = 0.83) and otolith mass (R^2 = 0.82) are still valuable predictors of fish size (Waessle et al., 2003; Corral et al., 2013).

Out of 160 fish samples, 86 sectioned otoliths were read successfully, with age estimates ranging between 2 to 8 years old (9–21.72 cm, SL). The otolith microstructure of *T. jarbua* shows incremental deposition along the sulcus (Fig. 5). The pooled age data fitted to the von Bertalanffy growth function gave the following equation: $L_t = 21.72\ (1 – 2.173e^{(0.259)})$, where the theoretical maximum length (L_∞) is 21.72 and the curvature parameter (*K*) is 0.259 (Fig. 6). The growth performance index for *T. jarbua* in this study was also calculated, resulting to a phi prime (Φ') value of 2.086 (Table 2).

DISCUSSION

The current study on *Terapon jarbua* collected from Davao Gulf and Iligan Bay, Mindanao, Philippines gave a b value of 2.84, indicating negative allometry (t = -3.478, P ≤ 0.05). This value is comparable to what was reported previously in western Indonesia (b=2.52) (Pauly et al., 1996) and in Gulf of Thailand (b=2.88) (Yanagawa et al., 1994) where the fish body shape becomes streamlined as it grows (Schneider et al., 2000). Results of somatic and otolith morphometric relationships for *T. jarbua* indicate that all otolith measurements can be used as predictors of fish size. Otolith length and otolith mass can be used as proxies in determining fish size (Waessle et al., 2003), which was also observed in the case of *Siganus spinus* (Corral et al., 2013) and *Lutjanus*

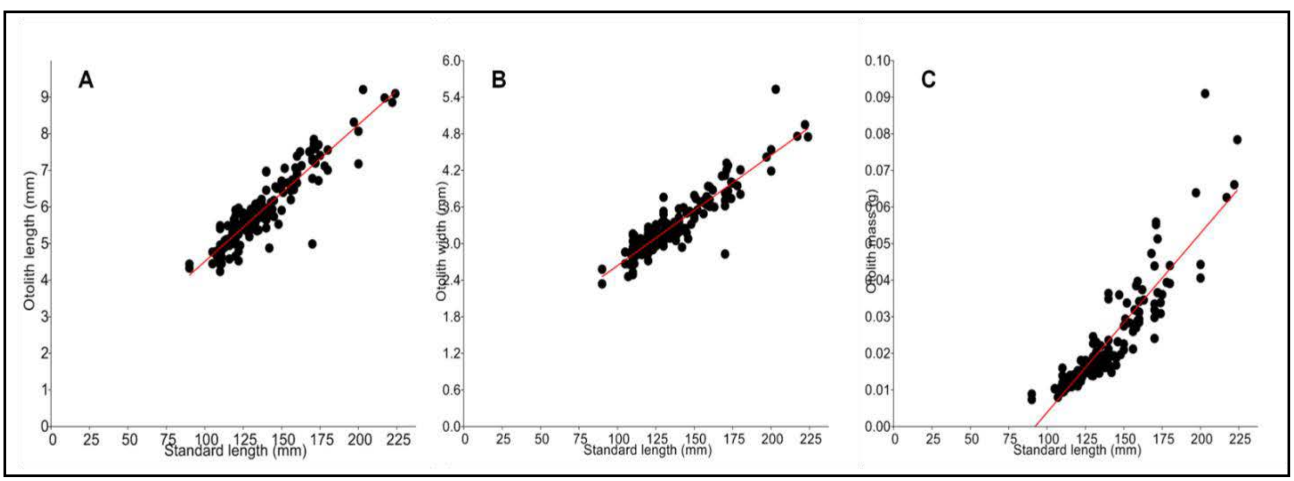

Figure 4. Linear regressions between (A) standard length and otolith length (R^2=0.85), (B) standard length and otolith width (R^2=0.83), and (C) standard length and otolith mass (R^2=0.82).

bohar (Fortaleza and Nañola, 2017).

Age and growth parameters of *T. jarbua* are available from studies done in Pakistan (L_∞=33.2 cm, *K*=0.69) derived from length frequency data (Khan and Imad, 2000) and in China (L_∞=35.9cm, *K*=0.237) using scales (Zhang et al., 2002) (Table 2). The reported age-growth parameters from these areas are comparable to those in the current study, despite the different methods used for age estimation (otolith sections vs. age estimation using scales) and growth modeling (von Bertalanffy growth function vs. Ford Walford plot and Beverton and Holt plot). The variations observed in the calculated growth performance index for *T. jarbua* in Pakistan (Φ'=2.835), China (Φ'=2.485), and in the current study (Φ'=2.086) might be due to some other factors considering the geographic location where the studies have been conducted. This can be influenced possibly by water temperature (Griffiths and Harrod, 2007), food availability (Pauly, 1989; McLeod et al., 2013), and other related environmental conditions unique to these areas.

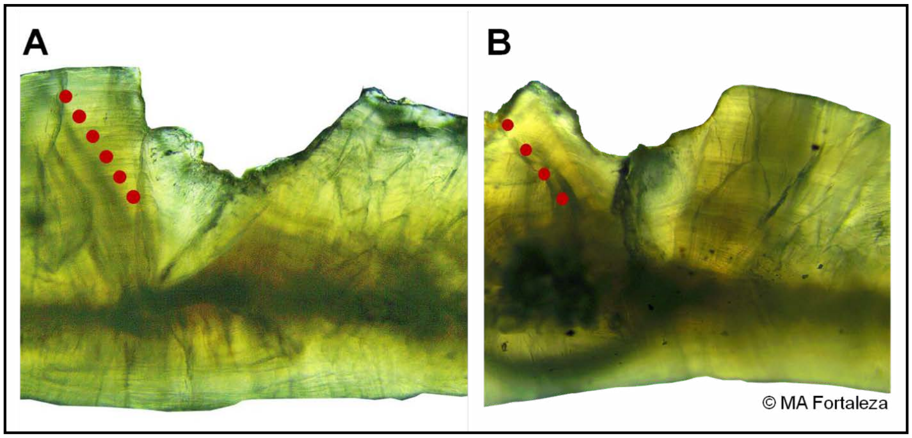

Figure 5. Otolith microstructure of *Terapon jarbua*. (A) Otolith of a 6-year old *T. jarbua* caught during Northeast Monsoon, March 2017 and (B) a 4-year old *T. jarbua* caught during the Intermonsoonal period, October 2016 from Mindanao, Philippines.

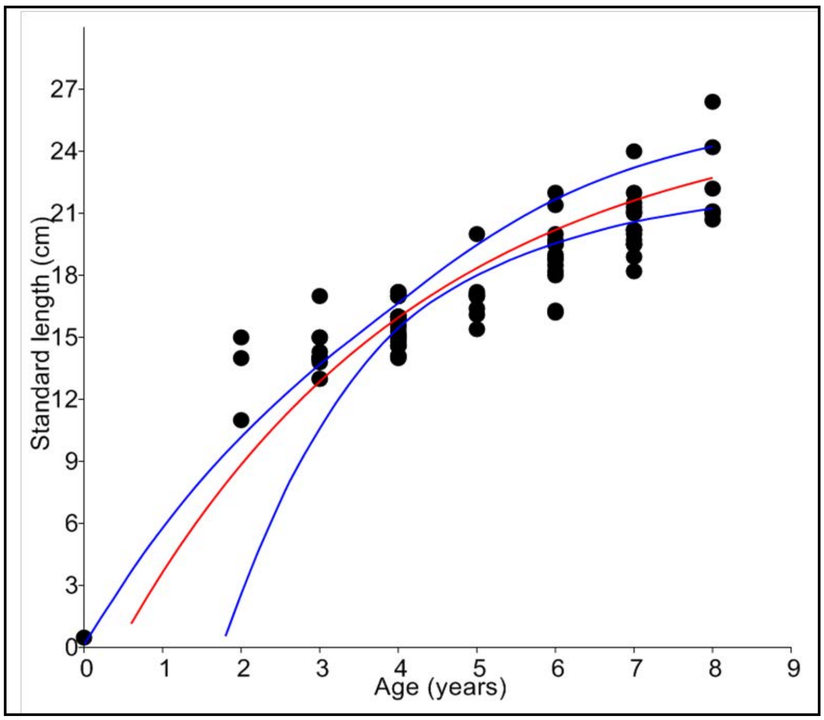

Figure 6. Growth curve (red plot) of *Terapon jarbua* from pooled age data fitted to von Bertalanffy growth function given by the equation $L_t = 21.72\ (1 - 2.173e^{(0.259)})$. Growth curve was fitted at length zero using a t_0 value of 0.211 from Zhang et al. (2002). Blue plots indicate the upper and lower 95% confidence limits.

Similar findings have been observed in *Lethrinus nebulosus* populations where the calculated growth performance indices differed in New Caledonia (Φ'=2.66) (Morales-Nin, 1988), Persian Gulf (Φ'=2.80) (Taghavi Motlagh et al., 2009), and India (Φ'=7.71) (Vasantharajan et al., 2012). For large pelagic species such as yellowfin tuna, *Thunnus albacares,* differences in stock composition, source of the population and methods of data analysis may also contribute to differences in growth performance index values (Zhu et al., 2011). These strongly suggest that the difference in geographic location influences the growth of fish populations.

This study estimated the age-growth parameters for *T. jarbua* using sagittal otolith microstructure, which has not been reported so far for such common species. Much of work on Philippine fisheries has relied on length frequency data and these may no longer become practical under the current state of reef fisheries in the country and given the discrepancies between length-based and age-based data (Laroche et al., 1982; Bagarinao and Campos, 2018). Moreover, we also demonstrate that in studying the growth of

Table 2. Reported age-growth parameters of *Terapon jarbua* using different growth models and methods of age estimation.

	L_∞ (cm)	*K* (year^{-1})	t_0	ϕ'	Growth model and age estimation method used
Philippines (This study)	21.7	0.259	0.522	2.086	von Bertalanffy growth function; sagittal otolith sections
China (Zhang et al., 2002)	35.9	0.237	0.211	2.485	von Bertalanffy growth function; scales under pectoral fin
Pakistan (Khan and Imad, 2000)	33.2	0.620	0.180	2.835	Ford Walford plot and Beverton and Holt plot; length frequency data

fish populations, an age-based approach must be considered. Validation of age estimates reported in the current work is eventually necessary to explore other aspects of the life history of *T. jarbua*.

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LITERATURE CITED

Bagarinao A.A. and W.L. Campos. 2017. Inter-annual variability in early life growth of the Bali sardine, *Sardinella lemuru*, caught off the northern Zamboanga Peninsula and the role of environmental factors. In: International Symposium in Drivers of Dynamics of Small Pelagic Fish Resources; 2017 March 6-11; Victoria, Canada.

Bagarinao A.A. and W.L. Campos. 2018. Age-at-maturity of *Sardinella lemuru* in two fishing grounds in the Philippines: discrepancy between age- and length-based growth models. In: 6th International Otolith Symposium; 2018 April 14-20; Taiwan.

Bobiles RU, V.S. Soliman and K. Yamaoka. 2015. Changes in otolith structure of seagrass siganid *Siganus canaliculatus* during settlement. *AACL Bioflux* 8(1):15-25.

Briones A.A., A.V. Yambot, J.S. Shiao, Y. Iizuka and W.N. Tzeng. 2007. Migratory pattern and habitat use of tropical eels Anguilla spp. (Teleostei: Anguilliformes: Anguillidae) in the Philippines, as revealed by otolith microchemistry. *Raffles Bull Zool*. 14:141-149.

Campana, S.E. 2005. Otolith science entering the 21st century. *Mar Freshwater Res* 56:485-495.

Choat, J. and D. Robertson. 2002. Age-based studies on coral reef fishes. Coral Reef Fishes. pp. 57-80.

Corral, J.M., V.S. Soliman and K. Yamaoka. 2013. Otolith and body length relations in the spiny siganid (*Siganus spinus* Linnaeus 1758). *Asia Life Sciences* 22(1):303-311.

Davis A.M., B.J. Pusey and R.G. Pearson. 2012. Trophic ecology of terapontid fishes (Pisces: Terapontidae): the role of morphology and ontogeny. *Mar Freshwater Res* 63:128-141.

Fortaleza, M.A. and C.L. Nañola. 2017. Age determination and body length relationship of two-spot red snapper (*Lutjanus bohar*). *Banwa B*.

12:1-12.

Froese R. and C. Binohlan. 2000. Empirical relationships to estimate asymptotic length, length at first maturity, and length at maximum yield per recruit in fishes, with a simple method to evaluate length frequency data. *J Fish Biol* 56, 758-773.

Froese R, and D. Pauly (eds.). 2018. FishBase. World Wide Web electronic publication. www.fishbase.org (Accessed April 28, 2017).

Geffen A.J., B. Morales-Nin and B.M. Gillanders. 2016. Fish otoliths as indicators in ecosystem based management: results of the 5th International Otolith Symposium (IOS 2014). *Marine Freshwater Res* 67, i-iv.

GNU Image Manipulation Program. 2007. The free and open source image editor [Internet]. Available from: https://www.gimp.org/.

Golani, D. and B. Appelbaum-Golani. 2010. First record of the Indo-Pacific fish the Jarbua Terapon (*Terapon jarbua*) (Osteichthyes: Terapontidae) in the Mediterranean with remarks on the wide geographical distribution of this species. *Scientia Marina* 74(4):717-720.

Griffiths, D. and C. Harrod. 2007. Natural mortality, growth parameters, and environmental temperature in fishes revisited. *Can J Fish Aquat Sci.* 64: 249-255.

Gumanao, G.S., M.M. Saceda-Cardoza, B. Mueller and A.R. Bos. 2016. Length-weight and length-length relationships of 139 Indo-Pacific fish species (Teleostei) from the Davao Gulf, Philippines. *J Appl Ichthyol* 32:377-385.

Harrison TD. 2000. Length-weight relationships of fishes from South African estuaries. *J Appl Ichthyol* 17, 46-48.

Khan, M.A. and A. Imad. 2000. Population dynamics of *Terapon jarbua* (Forsskål) in coastal area of Pakistani waters. *Pakistan J Mar Sci* 9(1&2):91-96.

Hammer, Ø., D.A.T. Harper and P.D. Ryan. 2001. PAST: Paleontological statistics software package for education and data analysis. *Paleontol Electron* 4(1):9.

Hilborn R. and C. Walters. 1992. Quantitative fisheries stock assessment: choice, dynamics and uncertainty. Chapman & Hall, New York.

Laroche, J.L., S.L. Richardson and A.A. Rosenberg. 1982. Age and growth of a pleuronectid, *Parophrys vetulus*, during the pelagic larval period in Oregon coastal waters. *Fish Bull* 80(1):93-104.

Lavergne, E., Z. Zajonz and L. Sellin. 2012. Length-weight relationship and seasonal effects of the summer monsoon on condition factor of *Terapon jarbua* (Forsskål 1775) from the wider gulf of Aden including Socotra Island. *J Appl Ichthyol* 1-4.

Leahy, S.M., G.R. Russ and R.A. Abesamis. 2015. Pelagic larval duration and settlement size of a reef fish are spatially consistent, but post-settlement growth varies at the reef scale. *Coral Reefs* 34(4): 1283-1296.

Liu, S.Y.V., I.H. Huang, M.Y. Liu, H.D. Lin, F.Y. Wang and T.Y. Liao. 2015. Genetic stock structure of *Terapon jarbua* in Taiwanese waters. *Mar Coast Fish: Dynamics, Management, and Ecosystem Science* 7:464-473.

Marriott, R.J., B.D. Mapstone and G.A. Begg. 2007. Age-specific demographic parameters, and their implications for management of the red bass, *Lutjanus bohar* (Forsskål 1775): A large, long-lived reef fish. *Fish Res.* 83, 204-215.

McLeod, I.M.M., J.L. Rummer, T.D. Clark, G.P. Jones, M.I. McCormick, A.S. Wenger and P.L. Munday. 2013. Climate change and the performance of larval coral reef fishes: the interaction between temperature and food availability. *Conserv Physiol.* 1, 1-12.

Miu T.C., S.C. Lee and W.N. Tzeng. 1990. Reproductive biology of *Terapon jarbua* from the estuary of Tamshui river. *J Fish Soc Taiwan*. 17(1):9-20.

Morales-Nin, B. 1988. Age determination in a tropical fish, *Lethrinus nebulosus* (Forskal, 1775) (Teleosteii: Lethrinidae) by means of otolith interpretation. *Inv Pesq* 52(2):237-244.

Munro, J.L. and D. Pauly. 1983. A simple method for comparing growth of fishes and invertebrates. *ICLARM Fishbyte*, 1:5-6.

Naguit, M.R.A. 2016. Biological impact assessment of the closed fishing season policy for sardines in Zamboanga Peninsula (Region IX). Center for Strategic Planning & Policy Studies, University of the Philippines Los Baños. Working Paper No. 2016-11.

Padilla, J.E., S. Mamauag, G. Braganza, N. Brucal, D. Yu and A. Morales. 2003. Sustainability assessment of the live reef-fish for food industry in Palawan, Philippines. Quezon City: WWF-Philippines.

Palla, H.P,, B.J. Gonzales, F.B. Sotto, A.S. Ilano, and K. Tachihara. 2016. Age, growth and mortality of brown stripe snapper *Lutjanus vitta* (Quoy and Gaimard 1824) from West Sulu Sea, Philippines. *Asian Fisheries Science* 29:28-42.

Pardo, S.A., A.B. Cooper and N.K. Dulvy. 2013. Avoiding fishy growth curves. *Methods Ecol Evol* 4:353-360.

Pattuinan, J.O. and C.G. Demayo. 2018. Morphometric shape analysis of otolith from selected goby fishes. *Transactions on Science and Technology* 5(2):190-196.

Pauly D. 1989. Food consumption by tropical and temperate marine fishes: some generalizations. J Fish Biol. 35(A): 11-20.

Pauly D, A. Cabanban and F.SB Torres. 1996. Fishery biology of 40 trawl-caught teleosts of western Indonesia. In: Pauly D, Martosubroto P, editors. Baseline studies of biodiversity: the fish resources of western Indonesia. Manila, Philippines: ICLARM. pp. 135-216.

Perez, P.T., J.R. Pante, V.S. Ticzonand P.V. Caumban. 2016. Morphometric analysis of otolith shape variation in *Siganus fuscescens* (Houttuyn, 1782) from the West and Northern Philippine Seas. In: 13th International Coral Reef Symposium; 2016 June 19-24; Honolulu, Hawaii.

Robbins, W.D. and J.H. Choat. 2002. Age-based dynamics of tropical reef fishes: a guide to processing, analysis and interpretation of tropical fish otoliths [technical manual]. Townsville: James Cook University. pp. 1-39.

Schneider, J.C., P.W. Laarman and H. Gowing. 2000. Length-weight relationships. In: Schneider JC, editor. Manual of fisheries survey methods II: with periodic updates. Michigan: Department of Natural Resources. Fisheries Special Report.

Secor, D.H., J.M. Dean and E.H. Laban. 1991. Manual for otolith removal and preparation for microstructural examination. Belle W. Baruch Institute for Marine Biology and Coastal Research.

Secor, D.H., A. Henderson-Arzapalo and P.M. Piccoli. 1995. Can otolith microchemistry chart patterns of migration and habitat utilization in anadromous fishes? *J Exp Mar Bio Ecol* 192:15-33.

Soliman, V.S., H. Yamada and K. Yamaoka. 2010. Early life-history of the spiny siganid *Siganus spinus* (Linnaeus 1758) inferred from otolith microstructure. *J Appl Ichthyol.* 26(4):540-545.

Taghavi Motlagh, S.A., A. Vahabnezhad, S.J. Seyfabadi, M. Ghodrati Shojaei and M. Hakimelahi. 2010. Growth, mortality and spawning season of the spangled emperor (*Lethrinus nebulosus* Forsskål, 1775) in coastal waters of Hormozgan Province in the Persian Gulf and Oman Sea. *Iranian Journal of Fisheries Sciences* 9(1):161-172.

Waessle, J.A., C.A. Lasta, M. Favero. 2003. Otolith morphology and body size relationships for juvenile Sciaenidae in the Rio del Plata estuary. *Scientia Marina* 67(2):233-240.

Vari, R.P. 1978. The *Terapon* perches (Percoidei, Teraponidae). A cladistic analysis and taxonomic revision, *Bull Am Mus Nat Hist* 159:175-340.

Vari, R.P. 2001. Teraponidae. Pages 3305-3316 in: Carpenter, K.E. and V.H. Niem (eds.). FAO species identification guide for fisheries purposes: the living marine resources of the western central Pacific (volume 5). Food and Agriculture Organization of the United Nations, Rome.

Vasantharajan, M., P. Jawahar, T. Francis, M. Venkatasamy and S. Santhosh Kumar. 2012. Age, growth and mortality characteristics of *Lethrinus nebulosus* (Forsskål, 1775) in Thoothukudi Coast of Tamilnadu, India. *SKUAST J Res* 13:6-13.

Whitfield, A.K. and S.J.M. Blaber. 1978. Scale-eating habits of the marine teleost *Terapon jarbua* (Forsskål). *J Fish Biol*. 12:61-70.

Yamanaka, K.L. 1989. Age, growth, and spawning of yellowfin tuna, (*Thunnus albacares*) Bonnaterre 1788, in the Southern Philippines. The University of British Columbia, MSc Thesis.

Yanagawa, H. 1994. Length-weight relationship of Gulf of Thailand fishes. *Naga ICLARM Q*. 17: 48-52.

Zhang, J., B. Song and G. Cheng. 2002. Study on the age and growth of *Therapon jarbua*. *Mar Sci* 26(7):66-70.

Zhu, G., X. Liuxiong, X. Dal and L. Wel. 2011. Growth and mortality rates of yellowinfin tuna, *Thunnus albacares* (Perciformes: Scombridae), in the eastern and central Pacific. *Zoologia* 28(2):199-206.