Sains Malaysiana 39(5)(2010): 697–704

Size, Growth and Age of Two Congeneric Archer Fishes (*Toxotes jaculatrix* Pallas, 1767 and *Toxotes chatareus* Hamilton, 1822) Inhabiting Malaysian Coastal Waters

(Saiz, Pertumbuhan dan Penentuan Umur Dua Spesies Ikan Sumpit Kongenerik (*Toxotes jaculatrix* Pallas, 1767 dan *Toxotes chatareus* Hamilton, 1822) dari Persisir Pantai Perairan Malaysia)

K.D. Simon, A.G. Mazlan*, A. Samat, C.C. Zaidi & A. Aziz

ABSTRACT

The size, growth and age of two congeneric archer fishes Toxotes jaculatrix *and* Toxotes chatareus *collected from Johor coastal waters, Malaysia was studied. The standard length (SL) and body weight (BW) ranges of the two species caught in the study area were 7-12.2 cm SL (9.35±0.19 cm), 11-55 g BW (27.04±1.62 g) and 8-12.2 cm SL (9.88±0.17 cm), 15.12-54 g BW (30.52±1.72 g), respectively. The ratio of male and female specimens of* T. jaculatrix *and* T. chatareus *were 70%, 30% and 68.6%, 31.4%, respectively. The estimated von Bertalanffy growth parameters were* L_∞ *= 12.78 cm, 13.59 cm and K = 1.46 year*$^{-1}$*, 1.53 year*$^{-1}$ *with a growth performance index of Ø' = 5.48 and 5.64 in both species, respectively. In order to determine the age, the technique of reading and interpretation of the daily growth increments/rings in the sagittae otoliths and scales were applied. Daily growth increments and annulus of scales counts confirmed that the ages of the samples for both species were typically less than one year (<1) and the remnant samples were between one and two years. The similarity between scale and otolith age determination was identical and dissimilarity was observed only in few samples of both species.*

Keywords: Growth; otolith; scale; size; Toxotes chatareus*;* Toxotes jaculatrix

ABSTRAK

Saiz, tumbesaran dan umur bagi dua spesies ikan sumpit Toxotes jaculatrix *dan* Toxotes chatareus *yang dikumpul dari perairan persisir Johor, Malaysia telah dikaji. Julat panjang piawai (SL) dan berat badan (BW) bagi kedua-dua spesies yang telah ditangkap dari kawasan kajian adalah masing-masing 7-12.2 cm SL (9.35±0.19 cm), 11-55 g BW (27.04±1.62 g) dan 8-12.2 cm SL (9.88±0.17 cm), 15.12-54 g BW (30.52±1.72 g). Nisbah spesimen jantan dan betina untuk* T. jaculatrix *dan* T. chatareus *adalah masing-masing 70%, 30% dan 68.6%, 31.4%. Parameter tumbesaran von Bertalanffy yang dianggarkan daripada populasi ikan tersebut ialah* L_∞ *= 12.78 cm, 13.59 cm dan K = 1.46 tahun*$^{-1}$*, 1.53 tahun*$^{-1}$ *dengan suatu indeks keupayaan tumbesaran Ø' = 5.48 dan 5.64 masing-masing bagi kedua-dua spesies. Bagi menentukan umur, teknik membaca dan menterjemahkan peningkatan tumbesaran harian/gegelang dalam otolith sagita dan sisek telah diguna pakai. Pengiraan peningkatan tumbesaran harian pada gegelang anulus sisek mengesahkan bahawa umur bagi kebanyakan spesies ikan yang dikaji adalah kurang dari satu tahun manakala bakinya adalah antara 1-2 tahun. Kesamaan penentuan umur antara sisik dan otolith didapati sama dengan sedikit perbezaan pada sejumlah kecil sampel bagi kedua-dua spesies.*

Kata kunci: Otolith; saiz; sisik; Toxotes chatareus*;* Toxotes jaculatrix*; tumbesaran*

Introduction

There are seven species in the genus *Toxotes*, commonly referred to as archer fishes (Allen 2004). According to Allen (1978) and Froese and Pauly (2005), these fishes are mainly in the brackish water of mangrove-lined estuaries. These fishes are relatively scarce and specimen collection is cumbersome in a complex rooting systems of mangrove forest complimented with their sharp eye vision and fast swimming speed (Blaber 2000). As a corollary, little is known about the biology and ecology of these fascinating fishes.

Recently we reported some biological aspects of archer fishes (Simon & Mazlan 2008a, 2008b; Simon et al. 2009; Simon & Mazlan 2010). Detail information vis-à-vis size and growth are essential for a complete knowledge of life history, growth rates, age at sexual maturity, and average life span (Chung & Woo 1999; Polat et al. 2001). Moreover, knowledge of age structures of fish populations allows estimation of growth, mortality and recruitment, and thus contributes to calculations of production rates of populations (Hilborn & Walters 1992).

Determining the age of fish often involves counting increments in skeletal structures such as otoliths (Francis et al. 1992), opercula (Hostetter & Munroe 1993), vertebrae (Francis & Mulligan 1998), scales (Jones 1980), or fin spines and rays (Davis 1977). However, not all structures are of equal reliability or application, e.g., external structures such as scales may be taken without sacrificing fish, but are likely to underestimate age (Beamish & McFarlane 1983). Currently, the interpretation of otolith structure is the primary method used for ageing Teleostean fishes (Stevenson & Campana 1992), yet all methods of ageing must first be validated to both ensure that estimates are accurate, and to assess the precision of counts (Beamish & McFarlane 1983). Recent research indicates that there is a close relationship between otolith weight and age (Lou et al. 2005). Such relationships have been demonstrated in numerous species of both temperate and tropical fishes (Lou et al. 2005) other than archer fishes.

Although archer fish are available in Malaysia, information regarding population size structure, age and growth of these fascinating fishes are still lacking. Therefore, the aim of the present paper is to elucidate the population size structure, growth and age of the two congeneric archer fishes *T. jaculatrix* and *T. chatareus* collected from Johor coastal waters, Malaysia.

Materials and Methods

FIELD SAMPLING AND LABORATORY PREPARATION

Sampling of the fish was carried out in the estuaries of south Johor (01°24'53 N; 104°09'44 E) the southern part of Peninsular Malaysia, from August 2007 to July 2008. Samples were collected using 3 layered trammel, cast, scoop nets, as well as traps. These gears were set up at random in appropriate places along the study areas. The mesh sizes of the trammel and cast nets were 4.2, 6.5, 7.5 and 2 cm, respectively. Mesh size of the scoop net was 1.5 cm. The length of the trammel net was 20 m, 250 cm for cast net and 40 cm diameter for scoop net. Specimen identification was carried out in the field according to the description given by Allen (2004).

A total of 85 archer fishes were caught throughout the study. Sex of the mature specimens was determined by dissection and visual macroscopic examination of the gonad. The specimens were kept in the ice prior to subsequent analysis in the laboratory.

Growth Studies

LENGTH-AT-AGE ANALYSIS

The lengths (Total length, TL and Standard length, SL) of the fishes were measured to the nearest centimeter (cm). Body weight (BW) was determined to the nearest 0.01 g using an electronic balance. Length-at-age analysis was based on the SL and age estimated from scales and otolith growth rings. The growth performance index was obtained using FiSAT II vers. 1.22 (Gayanilo & Pauly 2004) and the following equation; $\varnothing'$ (*phi pirme*) = In K + 2* In L_∞ (Munro & Pauly 1983; Pauly & Munro 1984). Population growth estimation were based on the von Bertalanffy growth function (VBGF), $L_t = L_\infty\ (I - exp^{-K(t-t_0)})$ where L_t is the length at age t, L_∞ is the asymptotic length and K is the growth coefficient. Estimation of t_0 was performed using the Von Bertalanffy Plot as shown in Figure 5a. The length weight relationship (LWR) was calculated using the allometric regression analysis ($W = a \times SL^b$)(Le Cren 1951; Abdallah 2002), where W is body weight (g), *SL* is standard length (cm), a is the intercept, and b is the slope (fish growth rate).

Age Determination Out of 85 specimens, 33 of *T. jaculatrix* and 21 of *T. chatareus* individual scales and otoliths were examined and yielded interpretable age estimates. The remnant scales and otoliths were rejected because they were either broken or unreadable. For each specimen about 10 scales were sampled from the central portion of the body below the lateral line (Chung & Woo 1999; Paul 1967). The scales were treated in 0.5% ammonia solution for at least 2 days, rinsed thrice with distilled water, dried and mounted between two microscope slides. Regenerated scales were discarded (Chung & Woo 1999). The sagittae otoliths were taken by dissecting the dorsal part of the fish head, where upper head sections were cut diagonally just below the base of the periscopic eyes. The sagittae otoliths were processed to the desirable thickness and mounted on an epoxy-resin block prior to grinding using fine carbonized sand papers (# 1000, # 3000) (Mazlan & Rohaya 2008; Secor et al. 1991). The mounted scales and otolith were labeled, observed and photographed under a "HITACHI Table Top Scanning Microscope TM-1000" as well as "ZEISS Stereo Microscope Stemi DV4/DR". The scales and otolith were weighted to the nearest 0.0001 g precision using an analytical balance "A & D Model-GR-200".

The largest and shortest diameters of the otolith were measured for both species according to Moreno and Morales-Nin (2003) (Figure 1(a)). The daily increment or rings of the scale were repeatedly counted using the Adobe™ graphic software with slight modification of Mazlan and Rohaya (2008). Age of the fishes was estimated based on the number of daily increment or rings (age in days) as well as the annulus (age in years) on the scale, as shown in Figure 2 (Campana & Neilson 1982; Werder & Soares 1985).

Results and Discussion

GROWTH STUDIES

The largest individual found was a female with a SL of 12.2 cm and BW 55.0 g; the largest male was 11.5 cm and BW 47.81 g. The most abundant year class was found to be

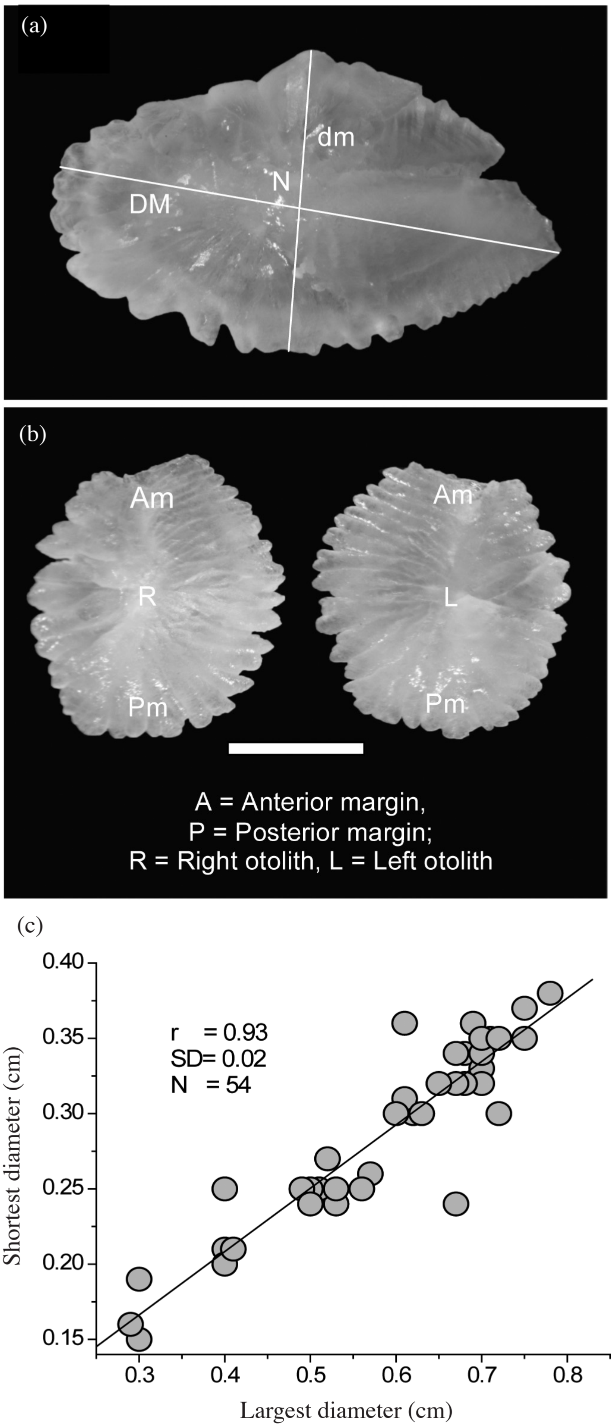

FIGURE 1. (a) External morphology of the sagittae otolith (dm-shortest diameter, DM-largest diameter, N-nucleus) (b) right and length otolith of archer fishes (scale 0.15 cm) (c) relation between largest and shortest diameter of otoliths in archer fishes

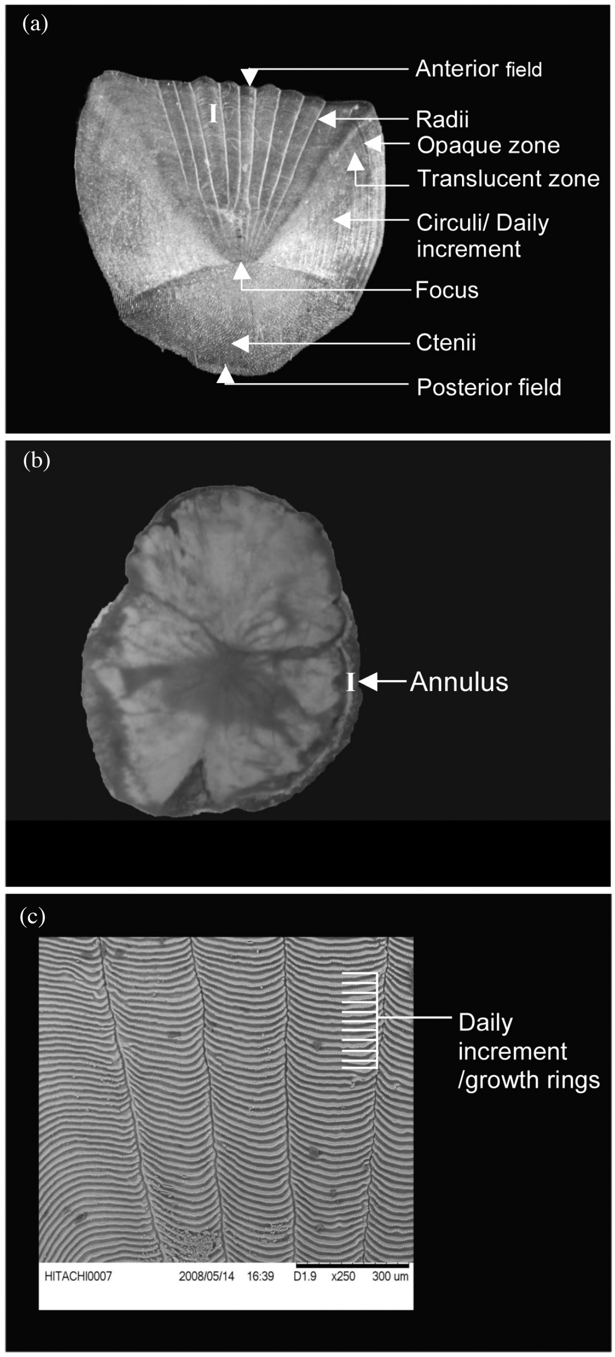

FIGURE 2. Scale and sagittae otolith from an age 1+ individual archer fishes (a) scale (b) otolith (I = one annulus) (c) electron micrograph showing daily increment/ growth rings

less than a year (Figure 3) and the most abundant length class ranges were from 8 to 10 cm.

The length-weight relationship is presented in Figure 4, with the parameters of LWR obtained in this study. The overall growth exponent ‘b’, obtained in this study ranged from 3.082 to 3.157. In isometric growth pattern, the growth exponent, ‘b’ = 3, where the body form maintains a constant proportion to the length (Weatherley & Gill 1987). When ‘b’≠ 3, allometric growth pattern takes the form which could be negative or positive. When ‘b’ < 3, negative allometry in growth pattern is indicated and when ‘b’ > 3, the pattern of growth is described as positive allometry.

The result showed that the population growth pattern was allometrically positive with regression coefficient ‘b’ at 3.082±0.078 for male and 3.157±0.142 for female (Figure 4). This implies that they tend to become more

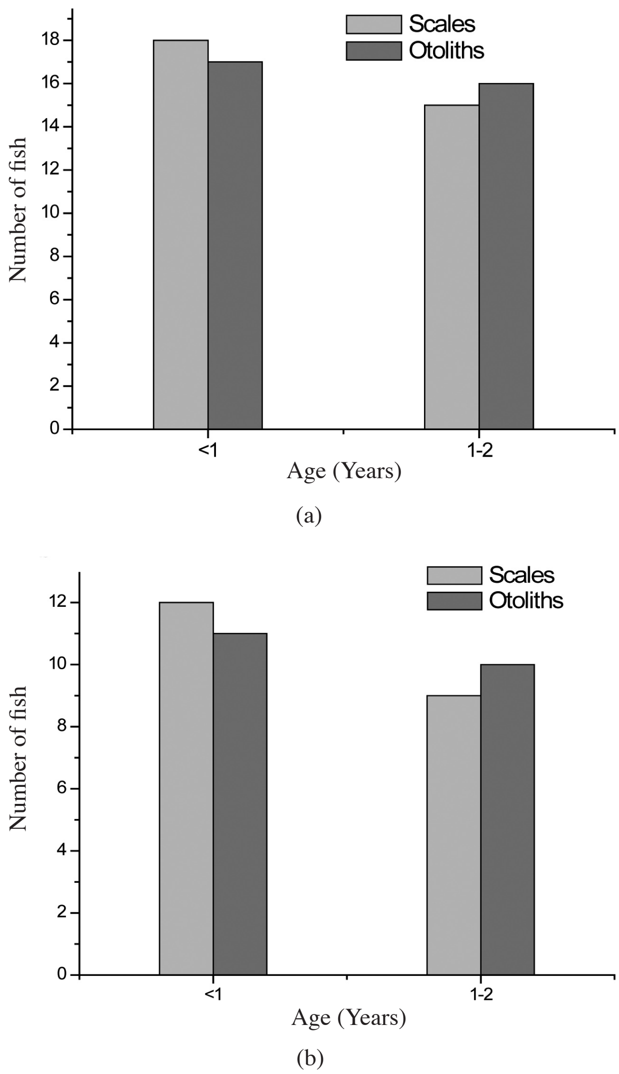

FIGURE 3. Age of archer fishes (<1= < 365 days, 1-2 = 365-730 days) (a) *T. jaculatrix* (b) *T. chatareus*

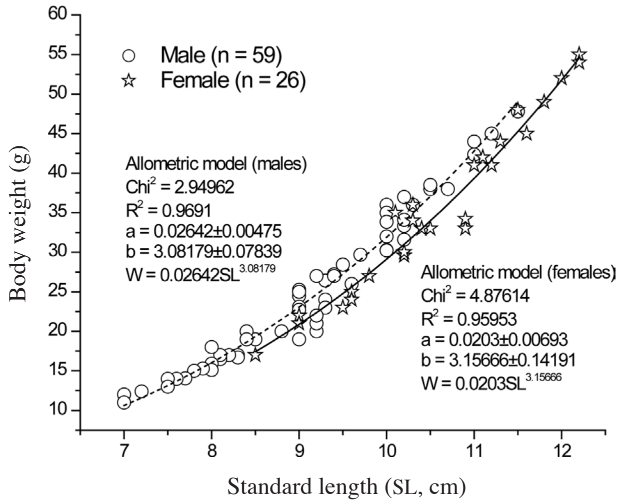

FIGURE 4. Length-weight relationship of male and female *T. jaculatrix* and *T. chatareus* (polled data). Dotted regression line represents non-linear fit of male samples in both species while solid regression line represent non linear fit of female samples in both species

spherical as they grow larger. According to Pauly and Gayanilo (1997), 'b' values may range between 2.5 and 3.5 and the calculated 'b' values for the two species between sexes fall within this range. Estimates of the allometry coefficient can be related to ecological processes and life history (Andrade & Campos 2002). Within the studies species, population growth conditions for female were more positive allometric than males.

In the present study, the goodness of fits for length-weight relationship model was analyzed using χ^2 (chi-square) and the results demonstrated that the best fitted model (no significant differences as denoted by low χ^2 values) was both species female in comparison to their males (Figure 4).

Commonly practiced fish population dynamics research uses large amounts of length frequency data for population growth estimates. The present study collected a total of only 85 specimens over 12 months. The estimates of the von Bertalanffy growth parameters provide only preliminary information on the growth patterns of the archer fishes from the limited study area. The von Bertalanffy growth model, fitted to the observed length-at-age data is illustrated in Figure 5.

The estimated growth parameters for both species L_∞ = 12.78 cm and 13.59 cm SL, K = 1.46, 1.53 year^{-1}, with growth performance Ø' = 5.48, 5.64, respectively (Table 1) in the present study were not comparable with other archer fishes elsewhere because of size differences.

AGE DETERMINATION

Scales and otoliths for the two species showed clear growth zones (Figure 2) with each zone consisting of wide translucent band and narrow opaque band. The length and weight of scales were highly correlated (r^2 = 0.924), similar result also observed in otolith length and weight (r^2 = 0.937), even though there were some divergences in their exponent 'b' values. In scale the exponent 'b' = 2.917 indicated that scale length augmented as scale weight increased (approaching to isometric type of growth pattern) while in otolith 'b' = 1.834 revealed the opposing growth pattern in comparison to scales (Figure 6(a, b)). Moreover there was a linear correlation with scale and otolith length with fish standard length (SL) (r = 0.973, 0.921). (Figure (6c, d)).

The results demonstrated for the *T. jaculatrix* in the size of range 9.2-12.2 cm SL (n=33) that estimated ages (both scales and otoliths analysis) were from 260-730 days and 260-728 days, while for *T. chatareus*, ranging from 9-12.2 cm SL (n=21) the estimated ages were from 265-413 days and 265-413 days, correspondingly (Figure 3).

Ageing of fishes from tropical waters has been reported through annual increments in calcified structures such as scales (Werder & Soares 1985; Mayekiso & Hecht 1988), dorsal and pectoral spines (Pantulu 1961; Ezenwa & Ikusemiju 1981), vertebral centra (Brown & Gruber 1988), and otoliths (Fowler & Doherty 1992). Scales are the easiest to collect and process. Using scales as structures

TABLE 1. Estimates of the parameters of the von Bertalanffy growth equation for the two species, their estimated standard errors (SE) and 95% confidence intervals (CI)

Species	Parameters	Estimate	S.E.	95% CI
T. jaculatrix	L_∞	12.78	0.2598	12.21, 12.85
	K	1.46	0.3351	1.783, 2.06
	t_0	-0.22	0.115	-
T. chatareus	L_∞	13.59	7.3025	11.95, 15.94
	K	1.53	2.7664	1.09, 2.04
	t_0	0.03	0.223	-

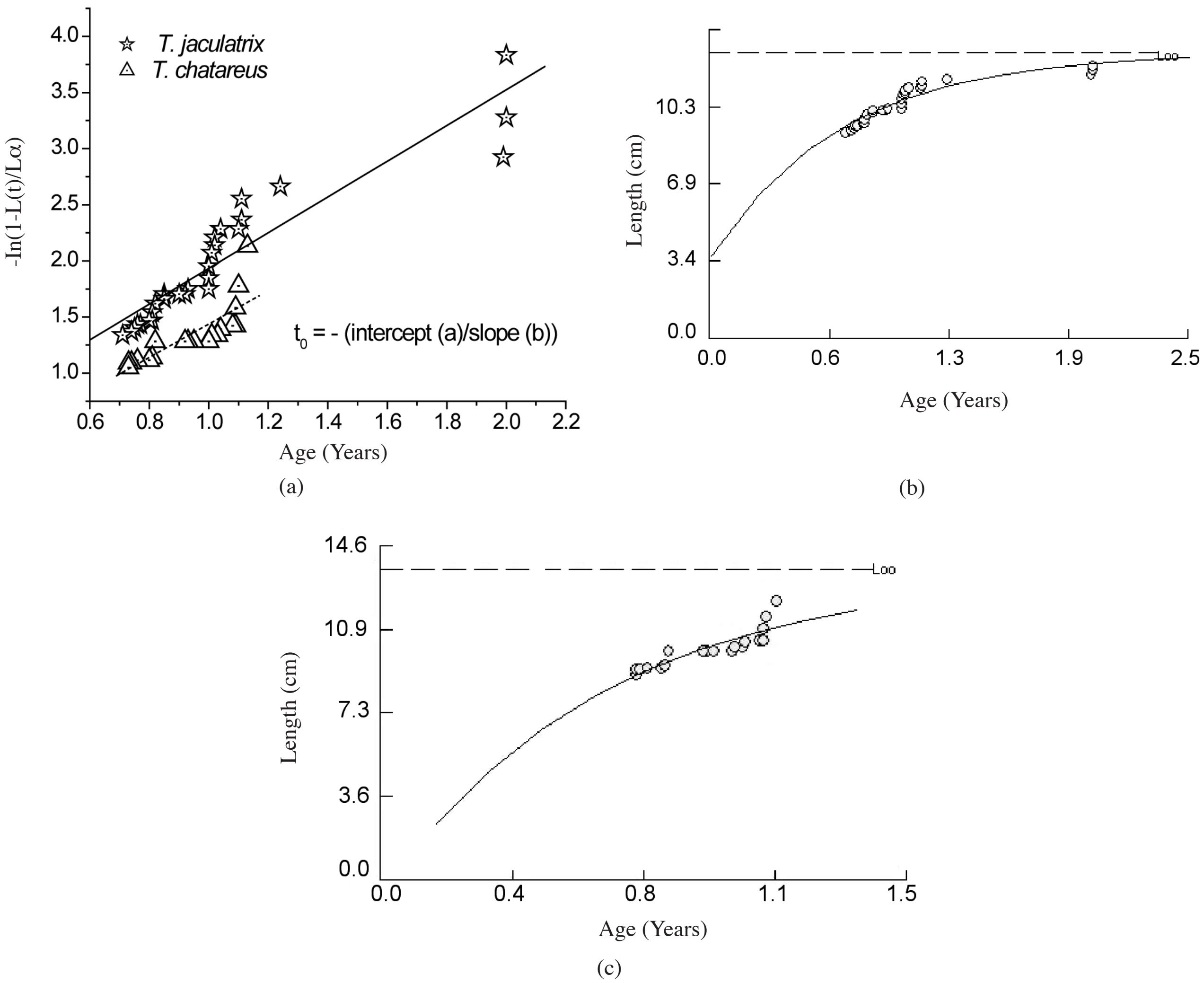

FIGURE 5. Growth of archer fishes according to standard length SL, fitted with the Von Bertalanffy growth equation (a) Von Bertalanffy plot for estimating t_0 from two species of archer fishes (b) length-at-age of *T. jaculatrix* (c) length-at-age of *T. chatareus*

for ageing also avoids sacrificing the specimens like those in ageing methods employing otoliths. Using scales for fish ageing, however, suffers drawbacks for instance, difficulties in reading annuli method has low precision (Lowerre-Barbieri et al. 1994), and that scale ages may become inaccurate when growth becomes asymptotic (Beamish & Mc Farlane 1987; Shepherd 1988). Within the studied species, there were no disparity between sizes and shapes of right (R) and left (L) otoliths (Figure 1(b)) of the same individuals, therefore the overall relationships were calculated with the measurements of the right otoliths. The largest (DM) and shortest (dm) otolith diameters were highly correlated (r^2 = 0.93 and S.D. = 0.02) (Figure 1(c)).

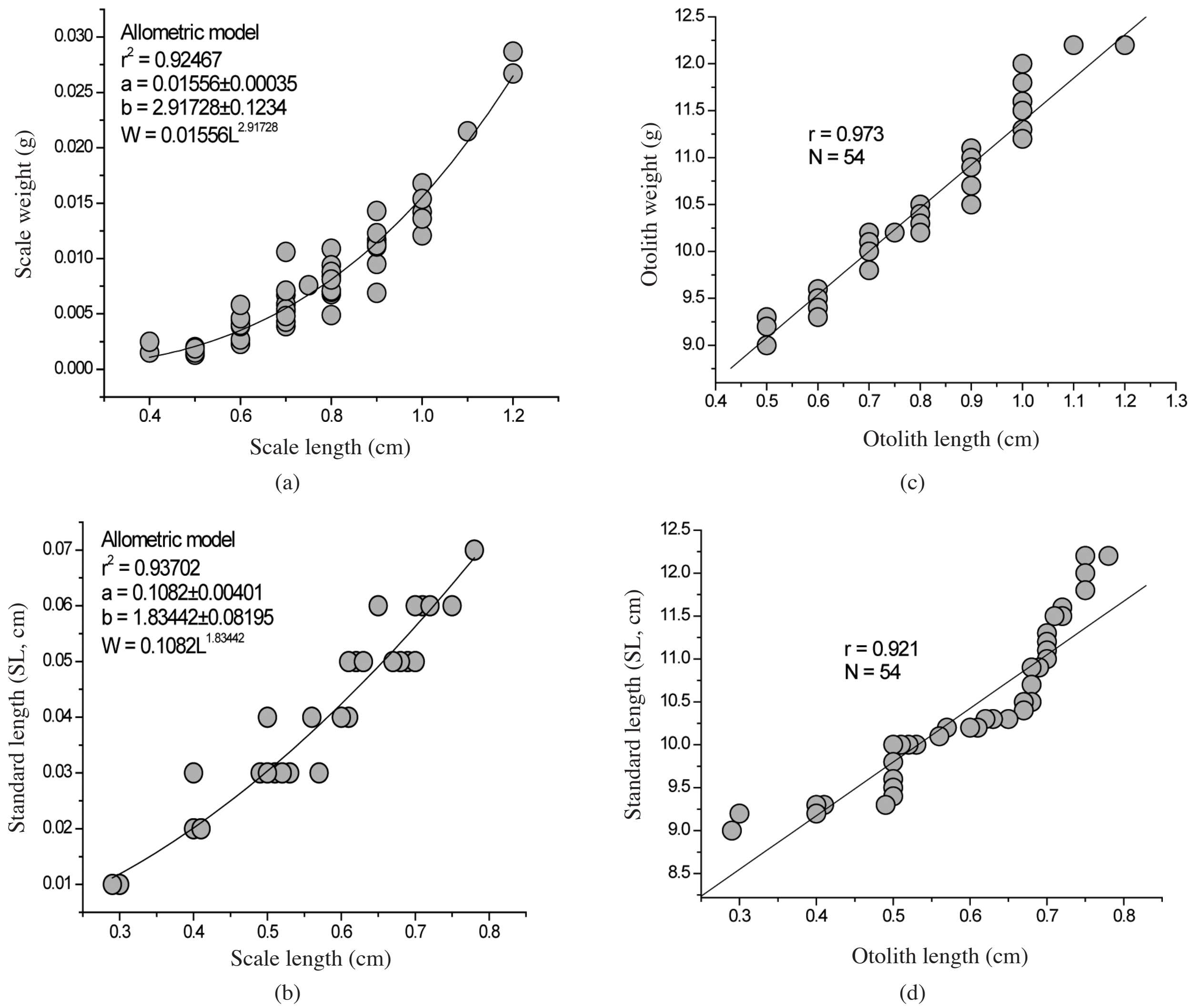

FIGURE 6. Relation of (a) scale length and scale weight (b) otolith length and otolith weight (c) scale length and standard length (d) otolith length and standard length of both species of archer fishes

It was observed in the present study that juvenile specimens (<1 years) were dominated in number than sub-adults and adults (1-2 years) specimens (Figure 3). Moreover it was also noticed that the number of individuals in 1-2 years cohort were relatively higher in otolith ageing in comparison to scales ageing in both species (Figure 3).

Nevertheless, in the present study, both scales and otoliths were found to be a very efficient and effective structure for determining the age of archer fishes and the estimated ages from scales and otoliths were almost analogous for both *T. jaculatrix* and *T. chatareus* fishes (Figure 3). We agree with Sullivan et al. (2003) that, otolith required prolonged preparation than the removal of scales, and the otolith analysis demand special equipment for sectioning and is labor intensive. Besides, we also noticed that otoliths of the archer fishes often proved to be useless for age determination due to high opacity and is delicate for handling.

In this research the reliability of scale readings was increased by sampling scales only from a fixed position, where the scales have large uniform size, better symmetry, and high legibility. However, as extremely senescent specimens were unavailable in this research, annuli readings have been relatively legible and reliable (Chung & Woo 1999).

In conclusion, the estimated ‘b’ values derived from the allometric length-weight relationship indicated that both species becomes more spherical as their length increase. The present study found that both *T. jaculatrix* and *T. chatareus* populations in the study area comprises juvenile age group (<1 year) in comparison to sub-adult and adult age group (1-2 years). This young archer fishes apparently grow faster as indicated by estimation of the growth performance indices. We also observed that, the use of scales in age determination for archer fishes is more appropriate in comparison to otoliths. Furthermore the population of archer fish species in Malaysian estuaries is dwindling over time due to fishing pressure and habitat destruction. Therefore the use of scales in age determination and life history study are pertinent for these rare fascinating fish species.

ACKNOWLEDGEMENT

This study was funded by the Ministry of Science, Technology and Innovation, Malaysia (MOSTI) through UKM Science Fund grant # 04-01-02-SF0124 and Operasi Universiti Penyelidikan (OUP) Graduate Research Fellowship scheme 'UKM-OUP-FST-2008' to the first author. The authors would like to express their thanks to all dedicated laboratory technicians for their help in collecting fish used in this study. Dr. Azman Abdul Rahim has generously helped in capturing photographs of scales and otolith and is greatly appreciated. All field sampling and laboratory protocols followed and complied with in the current laws of Malaysia.

REFERENCES

Abdallah, M. 2002. Length-weight relationship of fishes caught by trawl off Alexandria, Egypt. Naga, *The ICLARM Quarterly* V 25(1): 19-20.

Allen, G.R. 1978. A review of the archer fishes (family Toxotidae). *Rec. West. Aust. Mus.* 6(4): 355-378.

Allen, G.R. 2004. *Toxotes kimberleyensis*, a new species of archerfish (Pisces: Toxotidae) from fresh waters of Western Australia. *Rec. Aust. Mus.* 56: 225-230.

Andrade, H.A. & Campos, R.O. 2002. Allometry coefficient variations of length-weight relationship of skipjak tuna (*Katsuwonus pekanis*) caught in South Atlantic. *Fish. Res.* 55(1-2): 307-312.

Beamish, R.J. & McFarlane, G.A. 1983. The forgotten requirement for age validation in fisheries biology. *Trans. Am. Fish. Soc.* 12(6): 735-743.

Beamish, R.J. & McFarlane, G.A. 1987. Current trends in age determination methodology. In *Age and Growth of Fish*, edited by R.C. Summerfelt & G.E. Hall. Iowa State University Press. p. 15-42.

Blaber, S.J.M. 2000. *Tropical Estuarine Fishes Ecology, Exploitation and Conservation*. UK: Blackwell Science Ltd.

Brown, C.A. & Gruber, S.H. 1988. Age assessment of the lemon shark, *Negaprion brevirostris*, using tetracycline validated vertebral centra. *Copeia* 3: 747-753.

Campana, S.E. & Neilson, J.D. 1982. Daily growth increments in otoliths of starry flounder (*Platichthys stellatus*) and the influence of some environmental variables in their production. *Can. J. Fish. Aquat. Sci.* 39: 937-942.

Chung, K.C. & Woo, N.Y.S. 1999. Age and growth by scale analysis of *Pomacanthus imperator* (Teleostei: Pomacanthidae) from Dongsha Islands, southern China. *Env. Biol. Fish.* 55: 399-412.

Davis, T.L.O. 1977. Age determination and growth of the freshwater catfish, *Tandana tandanus* Mitchell, in the Gwydir River, Australia. *Australian J. Mar. Freshwat. Res.* 28: 119-137.

Ezenwa, B.I.O. & Ikusemiju, K. 1981. Age and growth determination in the catfish, *Chrysichthys nigrodigitatus* (Lacepede) by use of the dorsal spine. *J. Fish Biol.* 19: 345-351.

Fowler, A.J. & Doherty, P.J. 1992. Validation of annual growth increments in the otoliths of two species of damselfish from the southern Great Barrier Reef. *Australian J. Mar. Freshwat. Res.* 43: 1057-1068.

Francis, M.P. & Mulligan, K.P. 1998. Age and growth of New Zealand school shark, *Galeorhinus galeus*. *N. Z. J. Mar. Freshwat. Res.* 32(3): 427-440.

Francis, R.I.C.C., Paul, L.J. & Mulligan, K.P. 1992. Ageing of adult snapper (*Pagrus auratus*) from otolith annual ring counts: Validation by tagging and oxytetracycline injection. *Australian J. Mar. Freshwat. Res.* 43: 1069-1089.

Froese, R. & Pauly, D. 2005. *Fish Base*. Available at www. Fishbase.org.

Gayanilo, F.C.JR. & Pauly, D. (Eds) 2004. FAO-ICLARM stock assessment tools. FAO Computerised information series (Fisheries) No. 8. FAO, Rome, 262 pp.

Hilborn, R. & Walters, C.J. 1992. *Quantitative Fisheries Stock Assessment: Choice, Dynamics & Uncertaintity*. New York: Chapman & Hall, International Thomson Publishing.

Hostetter, E.B. & Munroe, T.A. 1993. Age, growth, and reproduction of tautog *Tautoga onitis* (Labridae: Perciformes) from coastal waters of Virginia. *Fish. Bull.* 91: 45-64.

Jones, G.P. 1980. Growth and reproduction in the protogynous hermaphrodite *Pseudolabrus celidotus* (Pisces: Labridae) in New Zealand. *Copeia* 4: 660-675.

Le Cren, E.D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (Perca fluviatilis). *J. Anim. Ecol.* 20: 201-219.

Lou, D.C., Mapstone, B.D., Russ, G.R., Davies, C.R. & Begg, G.A. 2005. Using otolith weight-age relationships to predict age-based metrics of coral reef fish populations at different spatial scales. *Fish. Res.* 71: 279-294.

Lowerre-Barbieri, S., Chittenden Jr, M.E. & Jones, C.M. 1994. A comparison of a validated otolith method to age weakfish, *Cynoscion regalis*, with the traditional scale method. *US. Fish. Bull.* 92: 555-568.

Mayekiso, M. & Hecht, T. 1988. Age and growth of *Sandelia bainsii* Castelnau (Pisces: Anabantidae) in the Tyume River, Eastern Cape (South Africa). *South Africa. J. Zool.* 23: 295-300.

Mazlan, A.G. & Rohaya, M. 2008. Size, growth and reproductive biology of the giant mudskipper, *Periophthalmodon schlosseri* (Pallas, 1770), in Malaysian waters. *J. Appl. Ichthyol.* 24: 290-296.

Moreno, T. & Morales-Nin, B. 2003. Age determination and validation on otoliths of the sand-smelt *Atherina presbyter* (Cuvier, 1829) (Pisces: Atherinidae) from the central-east Atlantic. *Fish. Res.* 62: 77-87.

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

Pantulu, V.R. 1961. On the use of pectoral spines for the determination of age and growth of *Mystus gulio* (H). *Proceeding National Institute of Science India*. 27B: 1-30.

Paul, L.J. 1967. Early scale growth characteristics of the New Zealand Snapper, *Chrysophrys aurats* (Forster), with reference to selection of a scale-sampling site. *N.Z.J. Mar. Freshwat. Res.* 2: 273-92.

Pauly, D. & Gayanilo, JR. F.C. 1997. A Bee: An alternative approach to estimating the parameters of a length-weight relationship from length frequency samples and their bulk weights. NAGA ICLARM, Manila, Philippines.

Pauly, D. & Munro, J.L. 1984. Once more on the comparison of growth in fish and invertebrates. *ICLARM Fishbyte* 2(1): 21.

Polat, N., Bostanci, D. & Yilmaz, S. 2001. Comparable Age Determination in Different Bony Structure of *Pleuronectes flesus luscus* Pallas, 1811. Inhabiting the Black Sea. *Turk. J. Zool.* 25: 441-446.

Secor, D.H., Dean, J.M. & Laban, E.H. 1991. Manual for otolith removal and preparation for microstructural examination. Baruch Institute Technical Report, University of South Carolina, Columbia.

Shepherd, G.R. 1988. Age determination methods for northwest Atlantic species, weakfish *Cynoscion regalis*. pp. 71-76. In *Age Determination Methods for Northwest Atlantic Species*, edited by J. Penttila & L.M. Derry. *NOAA Tech. Rep.* NMFS 72.

Simon, K.D., Bakar, Y., Samat, A., Zaidi, C.C., Aziz, A. & Mazlan, A.G. 2009. Population growth, trophic level, and reproductive biology of two congeneric archer fishes (*Toxotes chatareus*, Hamilton 1822 and *Toxotes jaculatrix*, Pallas 1767) inhabiting Malaysian coastal waters. *J. Zhejiang Univ. Sci. B* 10(12): 902-911.

Simon, K.D. & Mazlan, A.G. 2008a. Length-Weight and Length-Length Relationship of Archer and Puffer Fish Species. *Open Fish Sci. J.* 1: 19-22.

Simon, K.D. & Mazlan, A.G. 2008b. Trophodynamic analysis of archer fishes (*Toxotes chatareus* and *Toxotes jaculatrix*). In *Proceedings of the IOC/WESTPAC 7th international scientific symposium,* 21-25 May. The Magellan Sutera, Sutera Harbour Resort, Kota Kinabalu, Sabah, Malaysia.

Simon, K.D. & Mazlan, A.G. 2010. Trophic position of archerfish species (*Toxotes chatareus* and *Toxotes jaculatrix*) in the Malaysian estuaries. *J. Appl. Ichthyol.* 26(1): 84-88.

Stevenson, D.K. & Campana, S.E. 1992. Otolith microstructure examination and analysis. *Canadian Special Publication of Fish. Aquat. Sci.* 117: 126.

Sullivan, S.O., Moriarty, C., Fitzgerald, R.D., Davenport, J. & Mulcahy, M.F. 2003. Age, growth and reproductive status of the European conger eel, *Conger conger* (L.) in Irish coastal waters. *Fish. Res.* 64: 55-69.

Weatherley, A.H. & GILL, H.S. 1987. *The biology of fish growth*. London: Academic Press.

Werder, U. & Soares, G.M. 1985. Age determination by sclerite numbers, and scale variations in six species from the central Amazon (Osteichthyes, Characoidei). *Anim. Res. Dev.* 21: 23-46.

K.D. Simon
Marine Science Programme
School of Environmental and Natural Resource Sciences
Faculty of Science and Technology
Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor D.E.
Malaysia

A.G. Mazlan*, A. Samat & C.C. Zaidi
Marine Ecosystem Research Centre
Faculty of Science and Technology
Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor D.E.
Malaysia

A. Aziz
Department of Aquaculture
Faculty of Agriculture II
Universiti Putra Malaysia
43400 Serdang, Selangor D.E.
Malaysia

*Corresponding author; email: magfish05@yahoo.com or mag@ukm.my

Received: 15 April 2009
Accepted: 10 March 2010