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Full Length Research Paper

Estimates of age, growth and mortality of spotted catfish, *Arius maculatus* (Thunberg, 1792), off the Coast of Yunlin, Southwestern Taiwan

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Spotted catfish is a benthic species that can be found abundantly off the coast of Yunlin in southwestern Taiwan. Its biological parameters are little known. In this study, life history parameters of this species were estimated using samples caught by bottom trawling. The spotted catfish was the major bycatch species which comprised 32% of the total catch. The growth parameters estimated by length frequency analysis were: asymptotic fork length (L_∞ = 34.4 cm), growth constant (k = 0.28 year^{-1}) and age at length 0 (t_0 = -0.57 year^{-1}). The total mortality, natural mortality, fishing mortality and the exploitation ratio were 1.29, 0.86, 0.43 year^{-1} and 0.24, respectively. Although spotted catfish is not a target species of bottom trawling, the high fishing mortality and exploitation ratio suggest that they are the major by-catch species, and hence more attention should be paid to the dynamics of this stock. According to the monthly length distribution, the smallest fish (median = 2 cm) appeared in July 2009, which implies that the spawning season of spotted catfish is in June or July. However, the results of this study are preliminary, therefore other methods, such as ring reading of hard tissue, should be utilized to verify the growth parameters of spotted catfish.

Key words: Age and growth, mortality, exploitation rate, spotted catfish.

INTRODUCTION

Spotted catfish, *Arius maculatus* (Thunberg, 1792), is a benthic species in tropical and subtropical waters, inhabiting the bottom of estuaries, rivers and coasts. However, few studies have been conducted on the biology of spotted catfish (Mazlan et al., 2008). The age and growth of fish are an important basis for stock assessment, and relative estimators are dependent on the growth parameters such as mortality. Methods such as hard tissue reading, tagging-recapture and length frequency analyses can be used to study age and growth. However, hard tissue reading requires a considerable amount of time and money, as the periodicity of mark formation is validated before the growth parameters can be accurately estimated (Beamish and McFarlane, 1983). Tagging-recapture experiment is also expensive, and the recovery rate is very low (Rickter, 1973). Also, for length frequency analyses, although the length samples are easily collected and the cost is relatively low, length modes merge as fish grow, and this can be a bias in the analyses.

The objective of this study was to estimate the life history parameters of spotted catfish including the age and growth, mortality, exploitation rate and reproduction periods. The results derived from this study can be used as input data for further stock assessment of the spotted catfish off the coast of southwestern of Taiwan.

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MATERIALS AND METHODS

Source of data

The specimens of spotted catfish were collected on a monthly basis from February 2009 to March 2010. These fish were caught by bottom trawling off the coast of Yunlin County, Southwestern Taiwan. The water depth of the sampling area is about 10 m. Measurements were taken of fork length (FL) to the nearest 0.1 cm and body weight (BW) to the nearest 0.1 g.

Length interval

The length interval may affect the growth parameters estimated by length frequency analysis (Pauly, 1983). In order to select an appropriate length interval, the following empirical Equation was used to estimate the range of length interval:

$$LI = (L_{max} \times 0.1)/ A_i$$

Where, LI is the length interval, L_{max} is the maximum length of the samples and A_i is possible number of age classes. The estimation of the range of the length interval was from 0.5 to 0.9 cm. The length distributions with a length interval of 0.5, 0.6, 0.7, 0.8 and 0.9 cm were examined and compared. The length distribution with a length interval of 0.5 cm showed more obvious modes, and thus was adopted for further analysis.

Growth parameters estimation

The growth process can be described by growth velocity and growth acceleration. Length frequency data were used to calculate the von Bertalanffy growth coefficient (k) and the asymptotic length (L_∞) by model progression analysis using ELEFAN I within the FiSAT program (Munro, 1984, Gayanilo et al., 1994). The von Bertalanffy growth equation is as follows:

$$L_t = L_\infty \left(1-e^{-(k(t-t_0))}\right)$$

Where, L_t is Length at time t; L_∞ is asymptotic fork length, k is growth constant and t_0 is the age at length 0, which can be calculated by Pauly's empirical Equation (Pauly, 1980) given as;

$$\text{Log } 10(-t_0) = -0.3922 - 0.2752 log_{10} (L\infty) - 1.038 log_{10}(k)$$

In this study, data were reconstructed to generate peaks and troughs, and the goodness of fit index (Rn) is defined by Rn = 10(ESP/ASP)/10, where the ESP (Explained Sum of Peaks) is computed by summing all the peaks and troughs hit by a growth curve and the ASP (Available Sum of Peaks) is computed by adding the 'best' values of the available 'peaks'. The possible ranges of L_∞ and k were set as 25 to 50 cm and 0.1 to 1 year^{-1}, respectively. Seasonal variations of growth were not considered in this study. The growth parameter sets and the value of Rn were estimated by ELEFAN, and the best set was selected according to the highest value of Rn.

Mortality

The total mortality (Z) was calculated by the length-converted catch curve (Sparre and Venema, 1992), which was applied to the pooled length frequency data using the estimated growth parameters. The value of Z was estimated using the FiSAT program (Sainsbury, 1982). The natural mortality (M) was calculated by using Pauly's (1980) empirical Equation:

$$\ln(M) = -0.0152 - 0.279 \ln(L_\infty) + 0.6543 \ln(k) + 0.463 \ln(T)$$

Where, T is the mean annual temperature (ºC) which is assumed to reflect the sea surface temperature of fishing ground (in this study, T = 26.5ºC). The fishery mortality (F) value was estimated by subtracting the M from the Z value ($F = Z - M$) (Appeldoom, 1984). The exploitation rate (E) was then calculated according to previous literature (Tesch, 1971):

$$E = F/Z\,(1- e^{-z})$$

RESULTS

Length distribution

From our investigation, spotted catfish was the dominant species of bottom trawling, comprising 32% of the total catch. A total of 3,324 specimens were collected in this study, most of which (254 specimens/trawl) were caught in March 2009, while the second and third were mostly in July and September 2009, respectively (Figure 1). There were two low catch trends from May to June 2009 and November to December 2009. The length of the spotted catfish ranged from 1.5 to 27.5 cm (Figure 2), with two obvious modes at 2.0 and 8.5 cm. However, there were fewer specimens that were longer than 15.0 cm.

Age and growth

The growth parameters were estimated by the ELEFAN I routine using length frequency data. According to the highest value of Rn estimated by ELEFAN, the best fit of growth parameters was selected and the parameters of L_∞ and k were 34.4 cm and 0.28 year^{-1}, respectively. The L_∞ was higher than the maximum observed length (27.5 cm) (Figure 3). The t_0 calculated by Pauly's empirical equation based on L_∞, k and t_o was -0.57 year. The growth curve of spotted catfish is shown in Figure 4.

Mortality

The instantaneous total mortality estimated by the length-converted catch curve, is shown in Figure 5. The plots used for estimating the total mortality was from age 1.71 to 5.89 years. When the age was less than 1.71 years, the population was not fully caught by bottom trawling. In addition, a very low proportion of fish of ages over 5.89 years were caught. These two facts may have prejudiced the estimation of total mortality, and thus this age range was considered for estimating total mortality. The estimated mortality rates for all fish were Z = 1.29 year^{-1}, M =0.86 year^{-1}, and F = 0.43 year^{-1}, while the exploitation ratio was E = 0.24. The catching proportion of spotted catfish was also analyzed and shown in Figure 6. Dominant ages of the study are 0 age and 1 age classes which comprised 54.9 and 37.7% of the total catch, respectively.

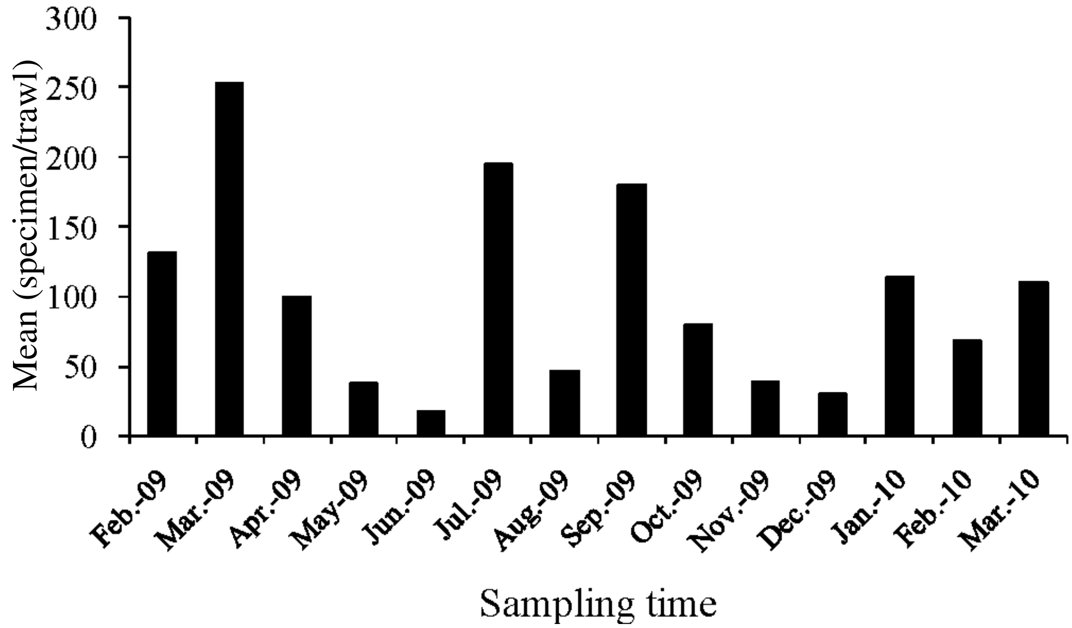

Figure 1. The mean of spotted catfish per trawl from February 2009 to March 2010.

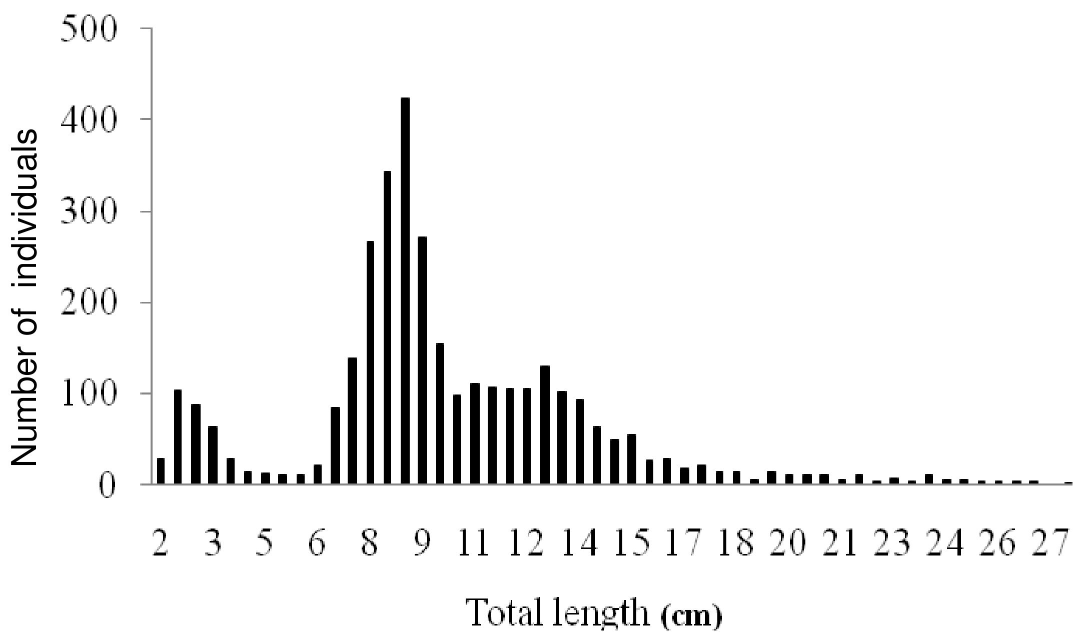

Figure 2. The distribution of length frequency of spotted catfish for all length data.

DISCUSSION

The total sample size and the sampling period affect the results of the length frequency analysis (Hoenig et al., 1987). It is therefore suggested that the total sample size should include at least 1,500 specimens and the sampling period should be more than 12 months to get an accurate estimation of the growth parameters by using the length frequency analysis. In this study, the total sample size was 3,323 specimens, while the total sampling period was 14 months consecutively, and thus this data set is believed to be well enough for length frequency analysis. In addition, the L_∞ (34.4 cm) is slightly larger than the maximum observed length, which also suggests that the growth estimates for spotted catfish by the length frequency analysis are reliable.

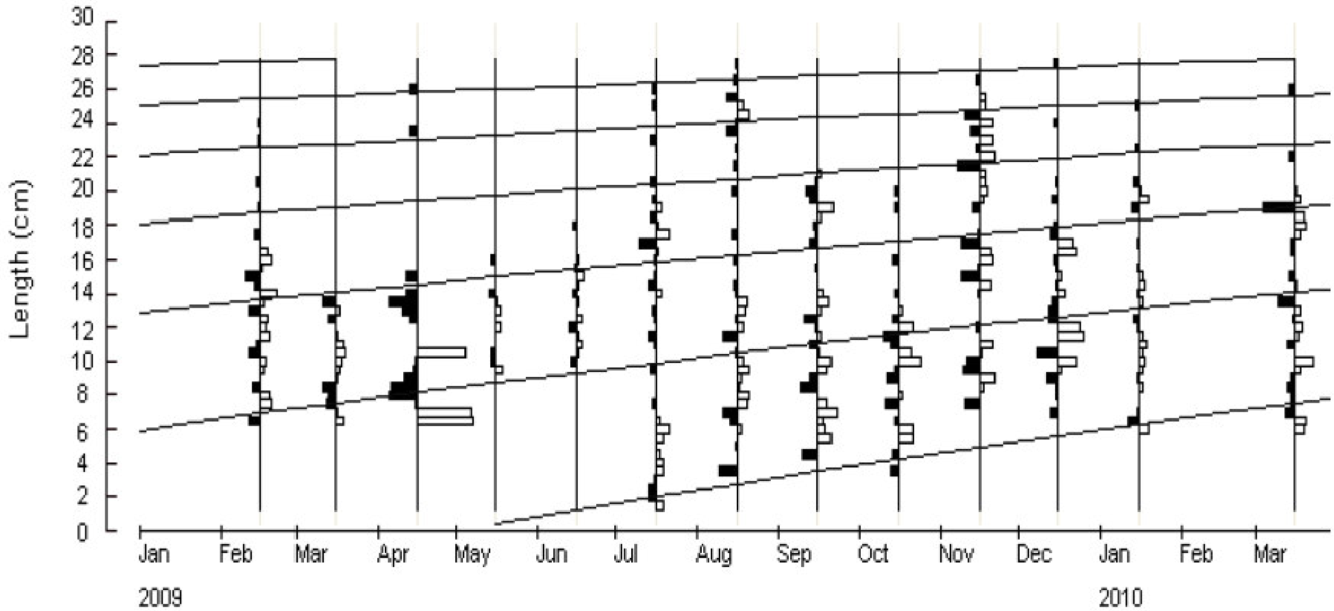

Figure 3. The von Bertalanffy growth curves of spotted catfish as superimposed on the length-frequency histograms.

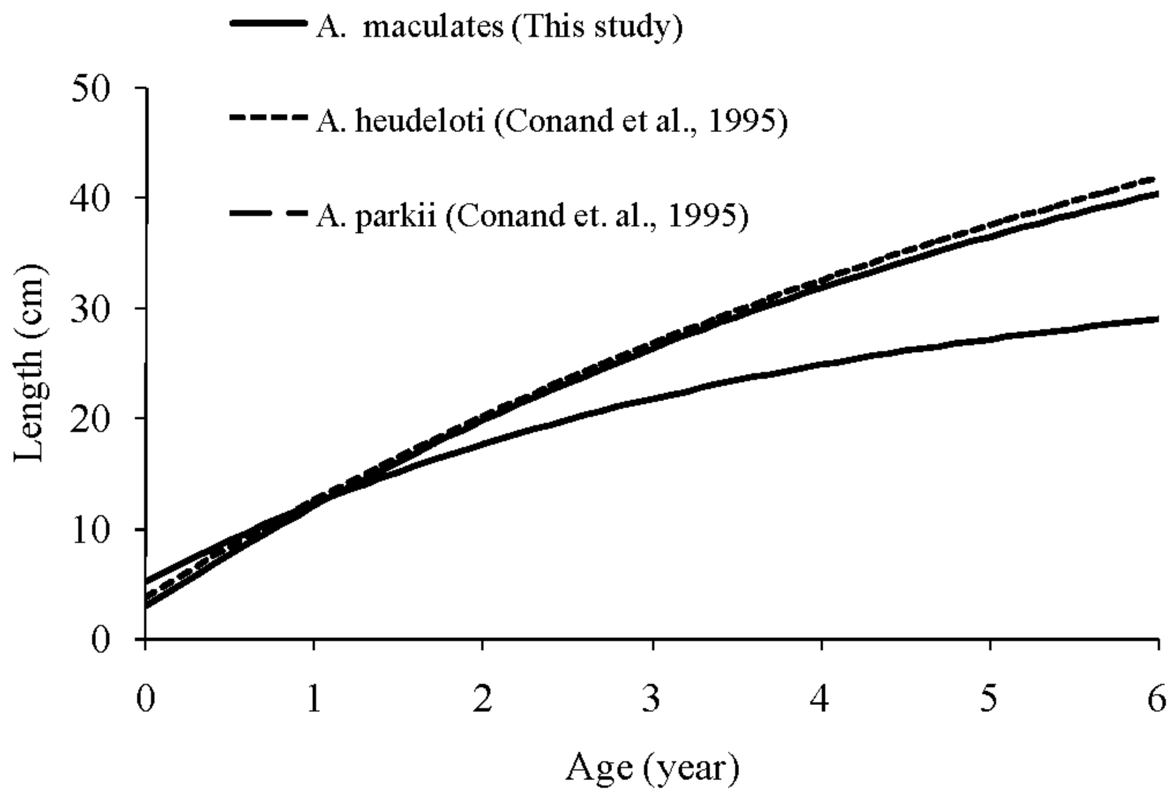

Figure 4. The growth curve of spotted catfish in this study and of other two species of marine catfish.

A comparison of the growth curve for spotted catfish derived by this study with those for two other marine catfish suggested that the spotted catfish grows slower than other species (Figure 5). The maximum length of a spotted catfish collected in this study was 27.5 cm, and this may result in an underestimation of L_∞. However,

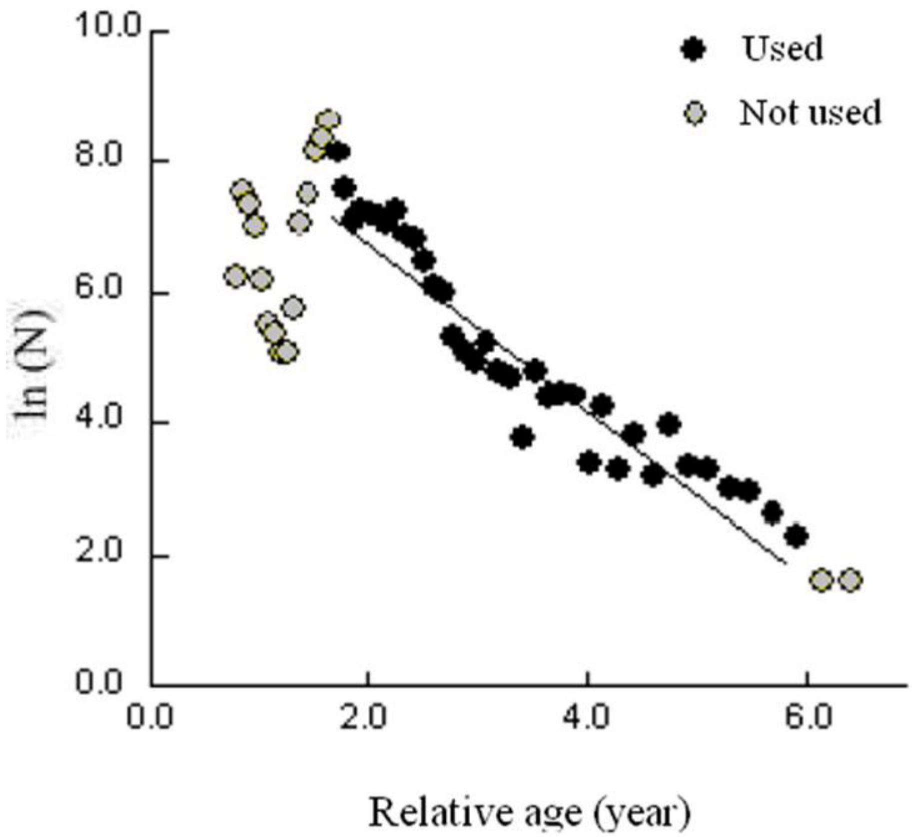

Figure 5. Length-converted catch curve for all spotted catfish specimens. "Not used" indicate the data refer to length classes not under full exploitation.

Figure 6. The catching proportion of spotted catfish in this study.

there are three different species that inhabit different waters, and these may account for the differences. One similar characteristic among these fishes is that they all grow slowly and live a long time. Spotted catfish is the predominant species off the southwestern coast of Taiwan according to the results of this study. However, fewer studies have examined the biology of this species. The major reasons may be because of its low economic value and also not being a target species for bottom trawling. In this study, the age and growth, and mortality of this species were investigated, and the results can provide the biological parameters for a better understanding of this species.

With regard to the length frequency by month, obviously abundant small individual appeared in July 2009, with the median length of 2 cm indicating that the fish were hatched only a few days ago. This small length group appeared only in one month, thus suggesting that the spawning season of species is in June or July. An earlier study reported that spotted catfish only breed once a year with a prolonged spawning season between January and April off the Bombay coast and during the periods of September and October off the Karnataka coast in India (Jeyaseelan, 1998). The spawning mode was periodic, although the individual fish of the species breed only once a year; a different population of the species seems to breed almost all year round. Therefore, the inference of a spawning season that appears in this study is reasonable. In addition, the short spawning season of this species would produce more obvious modes in length frequency distributions. Therefore, length frequency analysis is a suitable approach to estimate the age and growth of spotted catfish.

Spotted catfish is not a commercial species in Taiwan, however, the fishing mortality is very high (F = 0.43 year^{-1}). According to the results of bottom trawl in this study, spotted catfish is a predominating species, as the total catch composition was 32%, and catch proportion was high (Figure 6). This means that spotted catfish is a major bycatch species of bottom trawling, and thus more attention should be paid to the dynamics of this species to avoid severe adverse impacts on this stock. The results of this study provide detailed life history parameters such as growth parameters, total mortality, natural mortality and fishing mortality for the spotted catfish off the Southwestern Coast of Taiwan. However, other aging methods, such as ring counting of hard tissue, should also be utilized to further validate the growth parameters of this species in the future.

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