STOCK ASSESSMENT OF THE THINSPINE SEA CATFISH
*Tachysurus tenuispinis* (Day, 1877) IN THE ARABIAN SEA, OMAN

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ABSTRACT

In the past, marine catfish (family Ariidae) did not have any economic importance and were unacceptable as food by Omani people; however, currently, the interest in these species has increased where the majority of the catfish catch is exported earning more than half million Omani Riyal. With the increase of the economic importance of catfish, it is needed to evaluate its fishery status and detect the main challenges which may face the development of this resource. Based on the data collected during the RV “Al Mostaqila I “survey of the Arabian Sea Coast of Oman between August 2007 and September 2008, age and growth, mortality and exploitation rates, biomass and yield per recruit of *Tachysurus (Plicofollis, Arius) tenuispinis* were studied. In conclusion, for such economically important species additional detailed studies on its biology and life history as well as detecting and conserving the nursery ground are recommended. Moreover, fish biology, population dynamics and fishery characteristics of all trophic levels in the Arabian Sea Coast of Oman should be studied for setting-up an effective management strategy.

Keywords: Arabian Sea; *Tachysurus tenuispinis*; Ariidae; age and growth; mortality; exploitation level; yield per recruit; management.

1. INTRODUCTION

Family Ariidae (Pisces, Siluriformes) includes 27 genera and 153 species of tropical and sub-tropical marine (anadromous or semi-anadromous) catfishes (Fishbase, 2012). In general, these species attain large sizes, are long living, slow growing, have low fecundity and mouth-breed their eggs (Nelson, 1976; Rimmer & Merrick, 1982; Reis, 1986 a & b).

In Oman, ariid species are targeted by both industrial and artisanal fisheries and significantly contribute to the total regional production (Mehanna, *et al.*, 2012). Five ariid catfish species are known till now in Oman waters; *Netuma bilineata*, *Netuma thalassina*, *Tachysurus* (synonym: *Plicofollis, Arius*) *tenuispinis*, *Arius arius* and *Plicofollis (Tachysurus) dussumieri* and significantly contribute to the total country production. *T. tenuispinis*, one of the common ariid species in the Arabian Sea that is found in depths of 20-50 m, is highly concentrated in the area between Masirah Island and Ras Madrakah (Fig. 1). Catfish production in Oman waters contributes by about 4% of the total annual demersal fish landings earning more than half a million Omani Riyal; in fact, the majority of the catfish catch is exported. In the past, marine catfish in Oman received inadequate attention from fishery researchers; it did not have any economic importance and was unacceptable as food by Omani people.
Recently, a great attention is paid to this fishery resource as most of the commercial fish stocks are now overexploited and the demand for food resources has increased.

Although the biology and dynamics of marine catfish have been studied intensively around the world (Sekharan, 1968 & 1973; Mojumder, 1969 & 1971; Chakraborty et al., 1997; Sekharan and Mojumdar, 1973; Dan, 1977 & 1980; Etchevers, 1978; Warburton, 1978; Menon, 1984; Mojumdar & Dan, ; Menon & Muthiah, 1987; Bawazeer, 1987; Vasudevappa and James, 1988; Conand et al., 1995; Chakraborty et al. 1997; Raje, 2003 & 2006; Mandapam & Raje, 2006; Mazlan et al., 2008; Sawant & Raje, 2009; Wu-Shan Chu et al., 2011), there are no studies dealing with the biology and assessment of catfish stocks in Oman waters. The present study is the first to estimate the population parameters, mortality and exploitation level and yield per recruit of *T. tenuispinis* in the Arabian Sea. It aims also at giving scientific advice about the rational exploitation of this fish resource.

### 2. MATERIAL & METHODS

Samples of catfish were collected from the Oman coast of the Arabian Sea from September 2007 to August 2008 during five demersal surveys (Fish Resources Assessment Survey of the Arabian Sea Coast of Oman Project). After sorting species, each fish was measured to the nearest mm for fork length (FL) and weighed to the nearest 0.1 gram total weight, and then sex and maturity were determined. Otoliths were taken for a subsample representing all length groups, cleaned and stored dry for later age determination. The left otolith was embedded in clear epoxy resin and sectioned using a Buehler Isomet low-speed saw containing a diamond wafering blade which cuts a thin section (300µm) through the nucleus. A grinding wheel fitted with silicon carbide paper with different grit sizes (400 to 1200 grit) flushed with water was used to remove excess resin on the face of the sections and to provide a polished face for viewing. The section is then mounted on a glass slide and read under a Zeiss compound microscope equipped with zoom lens and (magnification up to 60×) using transmitted light.

The sectioned otoliths were read independently by two readers with no reference to the previous readings and without any knowledge of the length or weight of the fish. The precision was measured by the percentage of agreement between the two readings (Lowerre-Barbieri *et al.*, 1994). Only counts with agreements were used in...
subsequent analysis. Reproducibility of the resultant age estimation was evaluated with the coefficient of variation (CV) (Chang, 1982) and the index of average percent error (IAPE) (Beamish & Fournier, 1981).

The total radius of otolith and the radius of each annulus were measured to the nearest mm. Regression analyses of otolith maximum radius - total length was calculated by the method of least squares. Back-calculated lengths-at-age were computed by using the Lee method (Lagler, 1956).

To estimate the relation between total length (L) and total weight (W), the variables were log-transformed to meet the assumptions of normality and homogeneous variance. A linear version of the power function: \( W = aL^b \) was fitted to the data. Confidence intervals (CI) were calculated for the slope to see if it was statistically different from 3.

Growth curves, based on biological ages were constructed using the von Bertalanffy growth function as: \( L_t = L_\infty (1 - e^{-kt}) \) where \( L_t \) = length at time \( t \), \( L_\infty \) = asymptotic length, \( k \) = growth coefficient, \( t \) = time, and \( t_o \) = age at time zero. While \( "t_o" \) was estimated by undertaking linear regression between age (t) and \( \ln(L_\infty - L_t/L_\infty) \) (Gulland, 1969).

The total mortality coefficient \( Z \) was estimated using two methods: Beverton & Holt’s (1956) equation as \( Z = K^*(L_\infty - \bar{L}_t)/(L_\infty - \bar{L}) \), where \( \bar{L}_t \) is the mean length of fish of length \( \bar{L} \) and longer, while \( \bar{L} \) is the lower limit of the length class of highest frequency, and the linearized catch curve method of Pauly (1983).

The natural mortality coefficient \( M \) was estimated as the mean of two methods (Rikhter & Efano, 1976 and Pauly, 1980), while the fishing mortality coefficient \( F = Z - M \) and the exploitation rate \( E \) was estimated as \( E = F/Z \) (Gulland, 1971).

The length at first capture \( L_c \) was estimated by fitting the catch curve using the method of Pauly (1984 a & b). The relative yield per recruit \( (Y/R)' \) and biomass per recruit \( (B/R)' \) were estimated by using the model of Beverton & Holt (1966) as modified by Pauly & Soriano (1986) and incorporated in the FiSAT software package.

3. RESULTS & DISCUSSION

3.1. Age validation

To validate age determination of *T. tenuispinis* from the Arabian Sea, Oman, ages were determined by comparing the growth increment readings on 446 sectioned sagittal Otoliths (Fig. 2). It was found that the number of annuli counted for each individual was similar for the two readings and there was a high congruence (95.6%) between the age estimations done by the two readers. Of the all sections examined, consensus reached 93.5%. The index of average percent error (IAPE) of band counts for each reading did not differ greatly. Precision of repeated age estimation was high; the first reader counts were 94% in agreement with the second one. The values of the IAPE and the CV suggested that the precision levels obtained are according to the reference point values indicated by Campana (2001).

![Figure 2: Sectioned otolith of *T. tenuispinis* from the Arabian Sea (2 and 6 years old)](image)
The results revealed that the maximum observed ages for *P. tenuispinis* in the Arabian Sea was 6 years and age group two was the most dominant group in the catch and constituted 38%, while age group six was the least age group and formed 3.5% of the catch. The only previous work dealing with age determination of this species is that of Dan (1980). He found that *T. tenuispinis* attained seven years old for total length ranging from 14 to 45 cm.

### 3.2. Back-calculations and growth in length

Mean fork lengths at age were back-calculated for *T. tenuispinis* using the resultant equation from fork length-otolith radius relationship (Fig. 3). It was found that the observed (empirical) fork lengths were consistently higher than the back-calculated lengths-at age for individual age groups, the fact which indicated that seasonal growth had occurred since the formation of a new annulus. The results showed that *T. tenuispinis* attain their highest growth rate in length at the end of the first year of life (22.3 cm FL), after which a gradual decrease in growth increment was noticed with further increase in age (Fig. 4).

![Figure 3: Fork length-Otoliths radius relationship for *T. tenuispinis* from the Arabian Sea](image)

![Figure 4: Back-calculated fork length and growth increment for *T. tenuispinis*](image)

**Length – weight relationship and growth in weight**

The measurements of fork length and total weight of 1345 specimens of *T. tenuispinis* were used to estimate the length-weight relationship (Fig. 5). The fork length ranged between 19 and 46.7 cm while the total weight varied from 170 to 1500 g. The obtained equation was:

\[ W = 0.0277 \, L^{2.8324} \quad (r^2 = 0.95) \]
A negative allometric growth was observed for this species where CI was 2.7899 – 2.8753. The calculated weights for each year of life were computed by applying the corresponding length-weight relationship to the estimated fork lengths. It is obvious that, the growth in weight was very slow during the first year of life and the annual growth increment increased with further increase in age until it reached its maximum value at age group III (Fig. 6).

The same findings were reported by Raje (2003) where he estimated the b-value of *T. tenuispinis* from India as 2.9603.

**Figure 5:** Fork length-weight relationship for *T. tenuispinis* from the Arabian Sea

**Figure 6:** Calculated weights and growth increment for *T. tenuispinis*

### Growth parameters and growth performance index

The mathematical description of growth is of vital importance in the field of fisheries management, since the obtained growth parameters (*L*∞, *K* and *t*0) are the basic inputs in several fishery production models (Sparre et al., 1989; Hilborn & Walters, 1992). The most frequently used model is that of von Bertalanffy (1938). The resultant von Bertalanffy growth equations for *T. tenuispinis* (Fig. 6) in the Arabian Sea were:

For growth in length: 
\[ L_t = 50.15 \left( 1 - e^{-0.38(t+0.5)} \right) \]

For growth in weight: 
\[ W_t = 1807.76 \left( 1 - e^{-0.38(t+0.5)} \right)^{2.8326} \]
The only previous two studies dealing with the estimation of growth parameters of *T. tenuispinis* is that of Dan (1980) who gave $L_\infty = 82$ cm TL, $K = 0.211$ year$^{-1}$ and $t_0 = 0.177$ year for length range 14-45 cm, and Alagaraja & Srinath (1987) who gave $L_\infty = 58$ cm TL and $K = 0.78$ year$^{-1}$ in India for length range from 5 to 49 cm TL.

![Von Bertalanffy growth model for *T. tenuispinis*](image)

**Figure 7:** Von Bertalanffy growth model for *T. tenuispinis*

**Mortality and exploitation rates**

The total mortality ($Z$) estimates from the two methods (Beverton and Holt, 1956 and Pauly, 1983) didn’t differ, where the results were $Z = 1.76$ and $1.78$ year$^{-1}$ from the two methods respectively. The obtained mean value of natural mortality coefficient ($M$) was $0.79$ year$^{-1}$, while the fishing mortality coefficient ($F$) was estimated as $0.98$ year$^{-1}$. Accordingly, the exploitation ratio was 0.55, which is close to the optimum one (Gulland, 1971).

**Length at first capture "$L_c"**

The length at first capture (the length at which 50% of the fish at that size are vulnerable to capture) was estimated as a component of the length converted catch curve analysis (FiSAT). The value obtained was $L_c = 31.18$ cm FL (Fig. 8).

![Probability of capture and $L_c$ estimation for *T. tenuispinis*](image)

**Figure 8:** Probability of capture and $L_c$ estimation for *T. tenuispinis*
3.3. Relative Yield per Recruit (Y/R)' and Biomass per Recruit (B/R)'

The model of Beverton and Holt (1966) was applied to estimate the relative yield per recruit and biomass per recruit of \textit{T. tenuispinis} from the Arabian Sea. This model allows a relative prediction of the long term catch weights and stock biomass under different exploitation rates.

The plot of (Y/R)' and (B/R)' against E was shown in Fig 9. It is obvious that the yield per recruit increases with the increase of exploitation rate and the maximum (Y/R)' was obtained at an exploitation rate one, which is higher than the present level of exploitation rate (0.55). Both of \(E_{0.1}\) (the level of exploitation at which the marginal increase in relative yield per recruit is 1/10\(^{th}\) its value at E=0) and \(E_{0.5}\) (the exploitation level under which the stock has been reduced to 50\% of its unexploited biomass) were estimated. The obtained values of \(E_{0.1}\) and \(E_{0.5}\) were 1 and 0.41 respectively.

It could be concluded that, the \textit{T. tenuispinis} stock in the Arabian Sea is operating near its optimum situation and needs some precautionary measures to avoid its overexploitation. Additional detailed studies on its biology and life history as well as detecting and conserving the nursery ground are recommended. In addition, fish biology, population dynamics and fishery characteristics of all trophic levels in the Arabian Sea Coast of Oman should be studied for setting-up an effective management strategy. It would be better to study this fishery along with other stocks particularly shrimps to arrive to a final conclusion on the suitable levels of mesh size and effort pressure as the catfish juveniles are the major component in the catch of shrimp by bottom trawl in Oman (Mehanna, et al., 2012).

4. REFERENCES


