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Age, Growth and Mortality of Hilsa Shad, *Tenualosa ilisha* in the River Meghna, Bangladesh

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Abstract: The anadromous shad *Tenualosa ilisha* (hilsa) is one of the most important species in coastal and estuarine waters, which contributes over 13% of the total fish production of Bangladesh. Age and growth of this valuable species from the River Meghna Bangladesh, were studied with transverse sections of otoliths. Otoliths opaque zones that formed every year were thought to be annual rings. Growth of this species was rapid during the first two years, reaching 37.0 cm in fork length. Most of the specimens were 2-4 years old and accounted for 90% in total. The maximum age recorded was 6 years with 52.5 cm in fork length. The von Bertalanffy growth parameters L_∞ and K for this species were 52.0 cm and 0.71 for year^{-1}, respectively. The total, natural and fishing mortality were Z = 2.61 year^{-1}, M = 1.22 year^{-1} and F = 1.39 year^{-1}, respectively. The exploitation rate, E = 0.53, revealed a high fishing pressure on the stock. The estimated length-weight relationship for the combined sexes was found to be $W = 0.0225*FL^{2.880}$. The study indicated that age and growth of *T. ilisha* can be determined using its sectioned otolith and process needs to be validated.

Key words: *Tenualosa ilisha*, otolith, exploitation

INTRODUCTION

Otoliths (earstones) are paired calcified structures used for balance and/or hearing in all teleost fishes. The fish otolith has long been known as a timekeeper. While they are clearly more important to the fish than to the fish biologist, that point is easily forgotten. The use of otoliths as indicators of fish age has now reached the century landmark, starting with Reibisch's observations of otolith annuli in 1899. In Pannella's (1971) discovery of daily growth increments helped propel the interpretation of otolith microstructure into the mainstream of fish biology. Over the past decade there have been significant developments in fisheries science, based largely on the technological advances in extracting information from the otoliths of fish (Grant, 1992; Secor *et al.*, 1995; Fossum *et al.*, 2000; Panfili *et al.*, 2002; Campana and Thorrold, 2001; Campana, 2005). More importantly, for fisheries scientists and resource managers, otoliths are natural data loggers that record information in their microstructure chemistry at different temporal scales related to their growth and environment (Kalish, 1989; Campana, 1999). This information which includes age and growth, movement patterns and habitat interactions, can be interpreted at the population level in terms of the ecology, demography and life history of the species and has become fundamental to the management of fisheries and the protection of species around the world. There is almost certainly no other biological structure that is more important to fishery scientist than otolith because of the information they contains.

Tenualosa ilisha as a single species contributes over 13% of national fish production in Bangladesh. Due to its wide and versatile distribution in Bangladesh waters, the fishery employs directly or indirectly about 40% of fisher or 2% of the entire population of the country. Information

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on age and growth of hilsa from different water bodies are available from the studies of Jhingran and Natarajan (1969), Ramakrishnaiah (1972), Rajyalakshmi (1973), Ahmed *et al.* (2002), Amin *et al.* (2002, 2004, 2008), Haldar and Amin (2005) and Rahman and Cowx (2008) based on mostly length frequency data. As for other tropical fish, ageing of hilsa is problematic, because of the absence of annual rings on scales. To partly solve this problem microstructure examination of year marks/daily rings were in otoliths of the species was conducted with limited success in Bangladesh waters (Quddus *et al.*, 1984; Blaber *et al.*, 2003; Rahman and Cowx, 2006). Present study reports the age determination of *T. ilisha* using thin sectioning of otolith followed by microscopic examination and counts of the annual growth zones (annuli). Population parameters were also studied with computer based length-frequency analysis.

MATERIALS AND METHODS

Sampling of Fish

Fish samples were collected from Chandpore Fish Landing Center, obtained from commercial catch in the River Meghna during March 2005 to February 2006. The catch was mainly from the gill net of mesh size range from 8 to 16 cm. A total of 3055 specimens were utilized for length frequency studies and only 56 specimens of different sizes were used for otolith studies. The Fork Length (FL) of each fish was recorded to the nearest mm from the tip of the snout to the tip of the fork of caudal fin and weight upto nearest gram using specific weight balances depending on the size of the fish.

Collection and Preparation of Otolith

Otoliths were removed from the fish, washed with tap water and then kept in dried condition. The right otolith (sagittae) were used for age determination; the left sagittae were used if the right sagittae were damaged when extracted from the fish or during the sectioning process. The dried otoliths were then transported to the laboratory of Marine Biology and Oceanography, Faculty of Fisheries, Kagoshima University, Japan, for further processing. Otoliths length were measured under microscope (Olympus SZ-40, Japan) and weighed with a balance (Satorius 2462, Zeiss, Germany). Measured otoliths are embedded in epoxy resin, a mixture of Dodencenyl Succinic Anhydride (DDSA), Epok 812 (Epoxy equivalent 148), Methyl Nadic Anhydride (MNA), Dimethyl Aminomethyl Phenol (DMP) (4.8:2.2:3.2). Embedded otoliths were cut with a microcutter (Model MC-201; Maruto Co., Ltd, Tokyo, Japan) and polished using a grinder (Model 9820; Makita Co., Ltd, Tokyo, Japan) in order to make transverse sections crossing the focus, leaving a thin slice of approximately 0.2 mm thick and mounted on a glass slide and coated with nail enamel.

Reading of Otoliths

The number of ring marks (outer edge of opaque zone) on sectioned otoliths was counted using a microscope (LEICA MZ 12.5; Leica Microsystems, Heerbrugg, Switzerland) with transmitted light under a black background at 40x magnification. The annuli were counted by two readers and if there was an agreement between both readers, the resulting counts of the annuli was adopted. The ages were assigned to every individual according to the number of opaque zones observed in sectioned otolith.

Growth and Mortality Parameters

The monthly length frequency data of *T. ilisha* were analyzed using FiSAT (FAO-ICLARM Stock Assessment Tools) as explained in details by Gayanilo *et al.* (1996). The fitting of the best von Bertalanffy growth curve was based on the ELEPHAN-I program (Pauly and David, 1981), which allows the fitted curve through the maximum number of peaks of the frequency distribution. With the aid of the best growth curve, the growth constant (K) and asymptotic length (L_∞) were estimated.

Estimates of instantaneous total mortality (Z) were obtained using the linearized length-converted catch curve (Pauly, 1984). Natural mortality (M) was estimated using the general regression equation of Pauly (1980):

$$\text{Log}_{10}\ M = 0.0066\text{-}0.279\ \text{Log}_{10}\ L\infty + 0.6543\ \text{Log}_{10}\ K + 0.4634\ \text{Log}_{10}\ T$$

where, L_∞ and K are the parameters of the von Bertalanffy equation. Parameter T is the annual mean water temperature (°C), which was 28 °C for the given sampling area. The instantaneous rate of fishing mortality (F) was estimated from the difference between Z and M. The exploitation rate (E) was determined according to Gulland (1971): E = F/Z.

Length-weight relationship was calculated by applying exponential regression:

$$W = aL^b$$

where, W is the weight (g) and L the fork length (FL) (cm).

RESULTS AND DISCUSSION

Otolith Description

The sagitta is obvate and laterally compressed. The distal surface is concave and the proximal surface is convex with a deep longitudinal groove know as sulcus acusticus. The dorsal margin is smooth and slightly taper off outwardly. The ventral margin is serrated. The anterior margin is bifurcated. The rostrum is smaller and antirostrum is larger and they are separated by a wide deep excisural notch (Fig. 1). The posterior margin is rounded dorsally. The sulcus is homosulcoid and its opening is ostio-caudal type. The anatomy of the sagitta of *T. ilisha* is similar to other clupeid fishes (Atlantic thread herring) depicted by Smale *et al.* (1995).

Age Determination from Otolith Annuli

Otoliths, as well as other bony structures form yearly rings (similar to that of a tree) known as annuli. Each annulus is composed of opaque and translucent zones, which correspond to periods of fast and slow growth. As a fish begins its life it lays down daily rings as a result of an internal clock

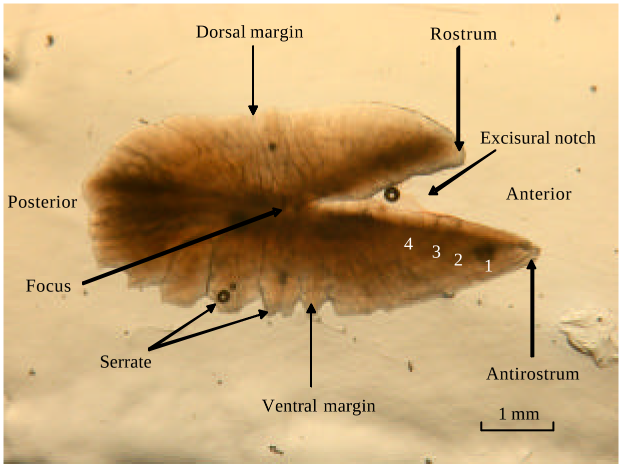

Fig. 1: Right otolith of *Tenualosa ilisha* (lateral view of distal side). Numbers are indicating year marks

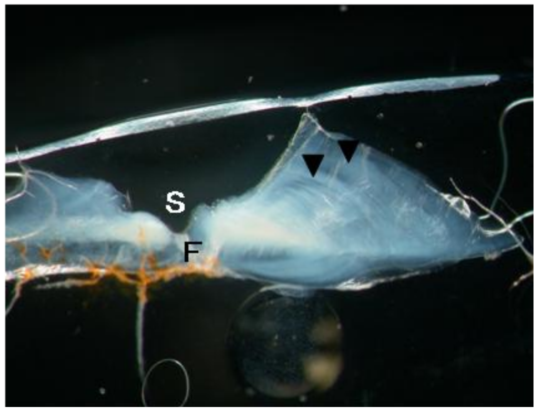

Fig. 2: Sectioned otoliths of *Tenualosa ilisha* showing two year marks (annuli), S = Sulcus, F = Focus

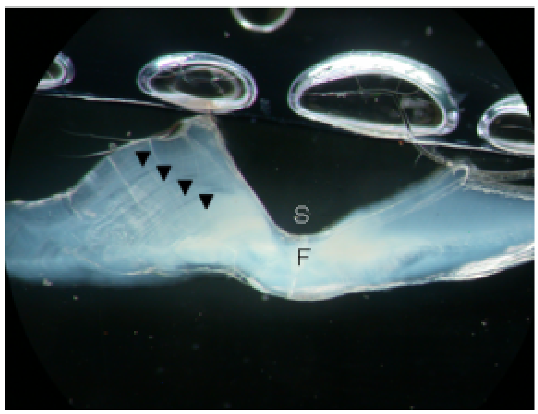

Fig. 3: Sectioned otoliths of *Tenualosa ilisha* showing four year marks (annuli), S = sulcus, F = Focus

is entrained by a 24 h light and dark cycle. In addition environmental factors such as feeding, activity and temperature variations all contribute to the daily cycle (Campana and Neilson, 1985). During periods of slow growth daily rings form extremely close together creating a thick band or annulus. In general, the opaque zone forms during periods of increasing water temperatures, while the translucent zone is formed during periods of reduced growth which may be associated with spawning.

The incidence of opaque and hyaline material at the margin of the otolith through an annual period suggests some degree of periodicity in the ring formation for *T. ilisha* (Fig. 2). In the otoliths examined the opaque rings were always broader, suggesting that they equate with the fast growth or summer rings of this anadromous species (Fig. 3). On the assumption that the rings were laid down annually, age estimates ranged from 1 to 6 years for *T. ilisha*.

As regards the age and growth of adult hilsa, many accounts are available both from Bangladesh and Indian water (Quddus *et al*., 1984; De and Datta 1990; Ahmed *et al*., 2002; Rahman and Cowx, 2006, 2008). In the present study estimated age was 1 to 6 years and the lengths were 22.44, 37.00, 44.76, 49.1, 51.21 and 52.5 cm, respectively. This result is similar to the study of Jhingran and Natarajan (1969) but seems to be little over estimated compared to the study of Quddus *et al.* (1984) and De and Datta (1990).

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