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REVIEW OF OTOLITH STUDIES IN FISHES OF INDIA

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Introduction

Otoliths are dense calcareous bony structure found in the inner ear of fishes. Hearing and balancing functions are carried out by this part. They are the first hard part formed in the fish and grow continuously by successive deposition of mineral-rich calcium carbonate (aragonite) and protein-rich layers. Otoliths are metabolically inert, not subject to reabsorption and remodelling by growth and their characteristic shape will not be affected by fish preservation. Having these qualities, otoliths proved themselves as good recorders of life history of the fish and its surrounding environment. While the otolith morphology is species-specific, the pattern of growth rings in an otolith microstructure reveals the age and temporal growth of the fish in relation to the environmental conditions whereas the elemental composition can answer questions on its preoccupied and current habitat features. A vast array of research has been conducted on a wide variety of fishes based on otolith analyses.

Otoliths are the most reliable ageing structure in a number of fish species. There is significant correlation between otolith length and weight with fish size. It is useful to determine the age of the candidate species. The knowledge of age and growth of an economically important fish is essential for understanding the age composition of the stocks and the role of various class-years in the fisheries. It is also essential to determine the mortality and survival rate of various year-classes and success of the yearly broods after recruitment. The age of fishes at different periods of their lives is determined after the study of the growth rings found in the otoliths, scales and other bony parts. Recent studies on otolith helped to provide a reliable estimate of age information with accurate and precision of clear growth pattern in life stages. Otolith is widely used in the study of stocks identification essential for fisheries management. Accordingly, knowledge of age and growth is of vital importance in the fisheries management.

Recent studies illustrate how otoliths microstructure data have been used to reveal environmental influences on larval growth, traits that lead to higher survivorship mechanisms of larval transport, dynamics of dispersal and population connectivity were carried out and statistically significant difference between them was found.

In the present paper the recent developments made in India in this discipline of fishery biology is briefly reviewed.

National Review

Work on fish otoliths was initiated in India in thirties by Rao (1935) on *Psettodes erumei.*

Chacko *et al* (1948) worked on the radii of the scales of *Hilsa ilisha (Ham.)* as an index of growth and age. Chidambaram and Krishnamurthy (1951) presented growth rings in the mackerel otoliths. Seshappa *et al.,* (1951); Seshappa and Bhimachar (1951, 1955); Seshappa's (1958) described growth annuli in the scales of the 'ghol' *Pseudosciaena diacanthus* and Chidambaram *et al.,* (1951) observed growth rings in the otoliths of the Indian mackerel *Rastrellliger kanagurta* Russel. Radhakrishnan and Campana (1954) described occurrence of growth rings on the otoliths of the Indian whiting, *Sillago sihama*. One of the causes for the formation of 'larval rings' as stated by Saetersdal (1958) is that the otolith being a more sensitive organ than the scales records smaller changes in the conditions of the fish than does the scales. Venkatasubba Rao (1961) studied the age of "Ghol", *Pseudosciaena diacanthus* (Lacepede) using scales and otoliths. Narayanan Kutty (1962) described scales and otoliths of the koth *Otolithoides brunneus* as age indicators. In *Pseudosciaena diacanthus* the annuli ranged from a single one in a fish of 44.6 cm (mean length) to as many as eight in fish of 115.3 cm mean length. Otoliths also showed hyaline and opaque zones, the distances between successive hyaline zones being measured and taken for back-calculation of the fish lengths at different ages. Narayanan Kutty (1962) found one annulus in the smallest specimen of 140-149 cm (mean length) in. In both the species the results from scales and otoliths were in fair agreement. Krishnayya (1968) worked on the use of otoliths in the determinations of age and growth of the Gangetic whiting, *Sillago panijus* (Ham.) in the Hooghly Estuary. Srinivasa Rao (1971) also corroborated the validity of the rings and their annual nature in the 'ghol'. He also found a larval ring (perhaps equivalent to the larval ring reported by other authors in some fishes) but he differed from Venkatasubba Rao (1961) who

thought that the cause of annuli formation was multiple, including both external (environmental) factors and inherent physiological rhythms in the fishes.

Seshappa (1972) discussed the problem of age determination in the Indian mackerel, *Rastrelliger kanagurta* (Cuvier) by means of scales and otoliths. Mugiya (1972) studied aberrant sagittas of teleostean fishes. Qasim (1973) stated that most of the tropical fishes have a short life span of 2-3 years and mature when they are 1-2 years old, except a few species such *as Otolithoides brunneus, Trichiurus haumela, Pseudosciaena dia- canthus and Lethrinus lentjan,* and those fishes from inland waters of northern India showing well defined seasonal cycles of growth. Jayaprakash (1976) described age and growth using otoliths of the juveniles of koth, *Otolithoides brunneus* (Day) in Bombay waters. Karakiri *et al.,* (1989) presented preliminary notes on the formation of daily increments in otoliths of *Oreochromis aureus* and described daily growth patterns in otoliths of larval and juvenile plaice *Pleuronectes platessa* as influenced by temperature, salinity and light conditions. Deshmukh (1973) found good annuli in both scales and otoliths in the 'karkara' *Pomadasys hasta* and studied them for about six years from the trawler landings along the Gujarat and Maharashtra coasts, and found 1, 2, 3 and 4 annuli respectively in the fish measuring 24.6, 34.6, 46.5 and 52.0 cm respectively in length. He observed that temperature is responsible for the formation of the rings and that they were not spawning marks because two rings were already formed when the first spawning occurred.

Jayaprakash (1973) made a preliminary study on the use of vertebrae of fish for age determination. There is no literature available on the biology of this fish. Hence investigation was undertaken by the author from January 1970 on its biology. His work deals with the age and growth of the juveniles based on a study of length-frequency distribution, scales and otoliths.

The Indian estuarine fisheries consist of several edible fishes of which nine species of whitings belonging to Family Sillaginidae (Genus: *Sillago*). These species are found distributed from the Hoogly estuary in the east coast to the Bhadreswar estuary in the west coast (Bal and Rao, 1984).

Nolf (1991) described a small fauna from the middle to late Eocene from eastern Pakistan, followed by a more substantial paper on middle Eocene otoliths from India and Java (Nolf &Bajpai,1992). Seshappa, (1999) explained that Age and growth-rate are two important parameters which influence population dynamics in

fishes..Generally, age of fishes estimated by enumerating the growth marks laid down in otoliths and other skeletal structures such as vertebrae, dorsal spine, opercular bones, pectoral spines, scales or fin rays (Pollock, 1981; Bal and Rao, 1984; Polat and Gumus, 1995; Seshappa, 1999). Seshappa (1999) explained recent studies on age determination of Indian fishes using scales, otoliths and other hard parts.

The first Ypresian otoliths from India were mentioned by Samant &Bajpai(2001),who figured six taxa, with tentative identifications at the familial or sub-ordinal level. Finally, Bajpai and Kapur (2004) described two species of gobiods, at the Vastan Lignite Mine (Ypresian),which is the same locality that provided the otoliths studied herein. Samant *et al.*, (2001) studied fish otoliths from the subsurface Cambay Shale (Lower Eocene), Surat Lignite Field, Gujarat (India).

Bajpai *et al.*, (2004) presented oldest known gobiids from Vastan Lignite Mine (early Eocene), District Surat, Gujarat. Annappaswamy *et al.*, (2004) studied length- weight relationship of Indian sand whiting, *Sillago sihama* in Mulki estuary, Mangalore. Ramcharitar, *et al.*, (2004) studied form and function in the unique inner ear of a teleost the silver perch. Nolf *et al* (2006) worked on fish otoliths from the Ypresian of Vastan, Gujarat.

Jawad(2007) presented a comparative morphology of the otoliths of the triple fins(Family: Tripterygiidae). Saini *et al.*, (2008) described comparative morphometrics of two populations of giant river catfish (*Mystus seenghala*) from the Indus River system. K. V. Radhakrishnan *et al* (2009), explained that Otoliths are the biological CD-ROMs of fish and the otolith applications can be classified under the following aspects: (1) Age and growth estimation, (2) Early life history recruitment, (3) Habitat shifts and migration, (4) Stock determination and (5) others.

Shamshan *et al* (2010) has worked on the study of age and growth of Indian sand whiting , *Silago sihama* from Zuari estuary, Goa. Sarkar *et al,* (2010) studied biodiversity, ecohydrology, threat status and conservation priority of the freshwater fishes of river Gomti, a tributary of river Ganga (India) based on shape indices of otoliths and external outline analysis showing that otolith shape is a powerful indicator for population discrimination. Shahista *et al.*, (2011) described comparison of age estimates from otoliths,vertebrae, and pectoral spines in African sharp tooth catfish, *Clarias gariepinus*(Burchell). Sajina *et al.*, (2011) studied stock structure analysis

of *Megalaspis cordyla* (Linnaeus, 1758) along the Indian coast based on truss network analysis. Khan *et al.*, (2012) reported morphometric variation of snakehead fish, *Channa punctatus,* population from three Indian rivers. Pillai *et al.*, (2012) explained Biology, Fishery, Conservation and Management of Indian Ocean Tuna Fisheries. Pawan Kumar *et. al.*, (2012) studied comparative otolith morphology of sciaenid's occurring along the north - west coast of India.

In 2012, growth performance of Indian major carp (*Catla catla*, Ham. 1822) was studied using key scales in three different sized water bodies namely Mahi Bajaj Sagar (MBS), Survania Dam (SD) and Aasan Pond (AP) situated in the tribal dominated Banswara district of Rajasthan. The annual rings or annuli and growth data in samples were observed and used to estimate selected growth parameters. High value of correlation coefficient evident and speak for strong correlation in total length of fish and scale radius. Mathur, 2014 has worked on otoliths morphology of four species of *Channa* of Meerut region and also observed the statistical relationship between Fish length with otolith length and Fish mass with otoliths mass. Shubhra *et al* 2014 has reviewed the significance of Fish otoliths taxonomy. On reviewing the literature the authors have come to the conclusion that otoliths studies on Indian fishes both marine and freshwater are still in its infancy. Less than 10% of the total fish species known have been studied so far for otoliths morphology.

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