Age determination of the Indian whiting, Sillago indica using otolith ring count

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ABSTRACT
Using length-weight relationship and otolith dimensions, an attempt was made to estimate the age of Sillago indica (n = 175) from Karwar Bay. Length-weight relationship was established using power equation (W = aL^b). Condition factor (K) and relative condition factor (K_n) were calculated for each fish using the formulae K = W x 10^5 / L^3 and K_n = W/w respectively. Otolith dimensions such as diameter (OD), weight (OW) and growth ring count (ORC) were recorded from sagittae. The results revealed that length-weight relationship follows cube law thus, W = -3.74 L ^ 2.46 suggesting the isometric pattern of growth of this fish. K and K_n increased up to 190 mm (when otoliths showed 3 growth rings) and then decreased giving a clue about the size and age of attainment of sexual maturity in this fish. Otoliths obtained from different sized fishes revealed the presence of 1-5 growth rings. Further, ORC, OW and OD showed a positive correlation with fork length (FL) and total weight (TW). Likewise, FL and TW also showed a linear correlation.

Introduction
Age and growth-rate are two important parameters which influence population dynamics in fishes (Bal and Rao, 1984; Pawson, 1990; Seshappa, 1999). Generally, age of fishes is 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). However, expression of growth rings in otoliths is known to be more distinct and clear than in other hard structures; therefore, they are extensively used with appreciable accuracy to determine the ageing protocols for both elasmobranchs and teleost fishes (Pawson, 1990; Waldron, 1994; Polat and Gumus, 1995; Newman et al., 2000).

The Indian estuarine fisheries consists of several edible fishes of which nine species of whittings belong 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; Jayasankar, 1991). Reports are available on the distribution-pattern, taxonomy, morphometry, meristic characters and reproductive biology of S. sihama and S. panijus (Jhingran 1977; Sujatha, 1987; Jayasankar, 1991).
Similar investigations on other whitenings are virtually lacking. *S. indica* is the second most dominant commercially important fish next to *S. sihama* from the Karwar Bay (Jayasankar, 1991). The present study is an attempt to determine growth-rate, age and their inter-relationship in *S. indica*.

**Materials and methods**

Fishes were collected from the wholesale fish distributors of Hubli - Dharwad (Karnataka) from June to December 2001.

**Length-weight relationship, condition factor and relative condition factor**

The relationship between length and weight was determined by the power equation $W = aL^b$ where, $W$ is the total weight (TW), $L$ the fork length (FL), $a$ a constant and $b$ an exponent ($a$, $b$ were calculated by transforming the data to the logarithmic form (Dasgupta, 1991; Newman et al., 2000). The condition factor ($K$) for each fish was determined using the formula $K = W x 10^5/L^3$ where, $W =$ total weight, $L =$fork-length and, $10^5$ is the factor bringing the ponderal index or condition factor ($K$) near unity (Dasgupta, 1991). The relative condition factor ($K_n$) was calculated for each fish using the formula $K_n = W/w$ where, $W =$ observed weight and $w =$ expected weight for the observed length (Dasgupta, 1991).

**Otolith studies**

To obtain the otoliths, an incision was made on the dorsal side of the head, to expose the brain on either side of which the otic capsules are located. The sagittal otoliths (largest of their kind) were removed from the otic capsules by opening the otic bulla. Both sagittae were retrieved intact from each specimen, washed in water, and cleaned from all extraneous tissue. Then, each otolith was weighed to the nearest 0.001 mg. The diameter was measured to the nearest 0.01 mm using a standard calliper rule (Newman et al., 2000). Otoliths were then immersed in 50% glycerol and observed under binocular microscope (Lawler and McRae, 1961). Growth rings were clearly visible as alternate opaque and translucent zones that were enumerated.

**Statistics**

The relationship if any, between FL and TW, FL and otolith weight (OW), FL and otolith diameter (OD), TW and OW, TW and OD was assessed by plotting scatter diagrams and using regression analysis (Zar, 1984). The relationship between otolith ring count (ORC) and FL, ORC and TW, ORC and OW, ORC and OD was determined by calculating the correlation factor ‘r’ by Karl Pearson’s method (Zar, 1984).

**Results and discussion**

Of the 175 fishes sampled, the FL ranged from 165-240 mm with an average of 194 ± 1.4 and TW varied between 50 and 120 g with a mean of 82 ± 1.5 (Fig. 1). Calculation of the constant ‘$a$’ and the exponent ‘$b$’ by the least square method and their substitution into the power equation indicated $W = -3.74 L^{2.46}$ (where, $a = -3.74$ and $b = 2.46$) for this fish. There was a high degree of positive correlation ($r = 0.94$) between FL and TW (Fig. 1). The condition factor ($K$) and relative condition factor ($K_n$) showed an increase up to a size of 190 mm (when 3 growth rings were visible in otoliths) and decreased thereafter gradually with an increase in FL (Table 1) and in ORC (Table 2).

The sagittal otoliths of *S. indica* were elliptical in shape with a broad central
core region and narrow tapering ends. The diameter of sagittae varied between 6.25 and 12.5 mm with a mean of 8.78 ± 1.55 mm (Fig. 3). They weighed between 0.050 and 0.522 mg with an average of 0.192 ± 0.11 mg (Fig 4). Observations under a binocular microscope revealed the presence of growth rings. Usage of techniques such as grinding/acid contact grinding on a carborundum stone (Sinha and Jones, 1967; Pannella, 1971) or burning of otoliths did not improve the clarity in the visibility of the rings. However, preservation in glycerol enhanced the clarity of the growth marks of the otoliths.

Careful observation of otoliths revealed a concentric pattern of alternate opaque and translucent zones. One translucent zone together with the adjacent opaque zone was considered as one growth ring (Fig. 2). In the smallest otolith (6.25 mm in diameter and 0.050 mg in weight) no rings were noticed (Fig. 2A). Twelve otoliths (mean diameter = 6.69 ± 0.18 mm and mean weight =0.060 ±0.007 mg) exhibited one growth ring. Twenty-eight sagittae (mean diameter = 7.28 ± 0.28 mm and mean weight =0.092 ±0.01 mg) expressed two growth rings (Fig. 2B). One hundred and twelve otoliths (mean diameter = 8.95 ± 1.14 mm and mean weight = 0.194 ± 0.07 mg) showed three growth rings (Fig. 2C). In 21 sagittae (mean diameter =10.95 ± 1.28 mm and mean weight = 0.388 ± 0.06 mg) four growth rings were observed (Fig. 2D). The biggest otolith of our sample that measured 12.5 mm in diameter and weighed 0.52 mg showed five growth rings (Table 3). It was generally observed that in older fishes growth rings appeared sharp at the tapering ends of the otoliths owing to heavy deposition of calcium carbonate at the center (Fig. 2). The scatter diagrams indicated that FL correlated positively with OD (r = 0.95; Fig. 3) and OW (r = 0.93; Fig 4). TW also showed a linear correlation with OW (r =0.91; Fig. 6) and OD (r =0.93; Fig. 7). Likewise, the ORC showed a good correlation with FL (r = 0.72), TW (r = 0.76), OW (r = 0.75) and OD (Table 4).
Age determination using otoliths has been reported for many fishes from temperate (Sinha and Jones, 1967; Pawson, 1990; Campana, 1994) and tropical regions (Bal and Rao, 1984; Waldron, 1994; Seshappa, 1999; Newman et al., 2000).

In the present study the otoliths of *S. indica* revealed the presence of growth rings.

### Table 2: Fluctuations in the condition factor and relative condition factor with otolith ring count in *S. indica* (n = 175).

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Otolith ring count (ORC)</th>
<th>Condition factor (K)</th>
<th>Relative condition factor (K&lt;sub&gt;r&lt;/sub&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>1.113</td>
<td>1.01</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1.038</td>
<td>0.99</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>1.087</td>
<td>1.03</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>1.130</td>
<td>1.05</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>0.980</td>
<td>1.02</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>0.068</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Age determination of Indian whiting

Fig. 3. Relationship between fork length (FL) and otolith diameter (OD) in S. indica.

Fig. 4. Relationship between fork length (FL) and otolith weight (OW) in S. indica.

rings similar to that reported for other sillaginid species namely, S. sihama, S. panijus (Bal and Rao, 1984) and S. japonica (Sulistiono et al., 1999). One to four growth (translucent) zones and one to five growth-arrest (opaque) zones were found in fishes of varying body size (Table 3 and Fig. 2). Of the 175 samples, the smallest fish (FL: 165 mm) showed no growth ring in its otolith indicating that the animal may be in its first year of growth. Larger fishes exhibited increased number of growth rings, thus there was a positive correlation between otolith dimensions such as, ORC, OW and OD and FL indicating that ORC can be used as a proxy to assess the age of this fish as reported for tropical snappers by Newman et al. (2000). Further, whether these growth rings are laid down annually as reported in S. japonica (Sulistiono, 1999) needs experimental evidence.

The exponential value of length-weight relationship in S. indica followed the cube law (b = 2.46) indicating an isometric pattern of growth in
Anuradha David and Katti Pancharatna

The analysis of condition factor (K) and relative condition factor (K_n) in relation to FL and ORC indirectly suggested the size (> 190 mm) and age (3rd year) of this fish at first maturity i.e. (K) and (K_n) values increased up to a size of 190 mm followed by a gradual decrease (Tables 1-2). This growth arrest may be due to declined feeding activity in response to commencement of spawning period. Decrease in (K) value with increase in FL and ORC also suggest that juveniles have a better condition factor than adults as reported earlier for Tor putitora (Dasgupta, 1991).

Although, estimation of age in tropical marine fishes has been considered problematic due to the lack of distinct annual rings in their hard structures owing to continuous spawning (Morales-Nin and Ralston, 1990). the present study reveals that 1) in S. indica growth rings are detectable clearly in otoliths 2) the otolith growth rings, and length-weight dimensions of this fish show a positive correlation indicating that growth-rate and ORC can be used as in-
dices to estimate the age 3) S. indica attains sexual maturity when it reaches a FL of >190 mm in the 3rd year. However, long-term experiments are needed to confirm the annual periodicity in the formation of growth rings and the factors influencing this phenomenon.

Acknowledgements

The first author is grateful to University Grants Commission, New Delhi, for financial support under Faculty Improvement Programme.

References


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