REPRODUCTIVE BIOLOGY OF THE GOLD SPOTTED GRENADIER ANCHOVY, *COILIA DUSSUMIERI* (CUVIER AND VALENCIENNES), ALONG THE NORTHWEST COAST OF INDIA

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**ABSTRACT**

Four major gonad maturation stages and within them eight minor maturity stages could be identified in *Coilia dussumieri*. Maturing and mature fish (E to H stages) develop only one batch of ova which is spawned in the first spawning act, and the new batch of ova developing at stage H would spawn within six months of the previous spawning. Spawning in the population as a whole is throughout the year as is evident from continuous recruitment and occurrence of maturing and mature fish. However, as the recruitment pattern shows, the larval survival is high in the calmer premonsoon season (March to May) and low in the turbulent southwest monsoon (June to August). The spawning and nursery grounds are around the 40 m depth zone. Fecundity ranges from about 1,000 to 5,000 eggs per female at sizes ranging from 15.7 to 19.0 cm in total length respectively. The ripe ova in stage H measure 0.82 to 0.90 mm in diameter. The minimum length at first maturity is 12.0 mm, when the fish is 6 to 7 months old. The correlation in the linear relation between fecundity and length (r = 0.7187) and between fecundity and weight (r = 0.7621) is high. The overall ratio of males to females in the population was 1:0.75. The fecundity per tonne of spawning females in a single spawning is $253 \times 10^3$ and the population fecundity for a single spawning for the annual biomass of 12,483 tonnes of adult females is $3,158 \times 10^4$. Since the spawning interval of individual fish is assumed to be less than or about six months, the fecundity per tonne of spawning females and the annual population fecundity is at least twice the above values.

**INTRODUCTION**

The gold spotted granadier anchovy, *Coilia dussumieri* is caught along with a variety of other fishes by the indigenous dol nets (fixed bag nets) and trawls and ranks sixth in the marine fish landings in the vicinity of Bombay throughout the year. The annual catch of this fish during 1982-’83 was 8,509 tonnes (3.18%) and 5,483 tonnes (2.79%) in the total marine fish landings respectively in the Maharashtra and Gujarat states which constitute the northwest coast of India. Preliminary studies on the reproductive biology of *C. dussumieri* from this area include that of Palskar and Karandikar (1953), Bal and Joshi (1956) and Gadgil (1965). The study under report, made in 1982-’83, attempts to determine the size and age at first maturity, breeding season and grounds, fecundity, sex ratio and recruitment pattern.

**MATERIAL AND METHODS**

Weekly random samples of *C. dussumieri* were collected from dol net and trawl catches at the three major landing centres in Bombay (Ferry Wharf, Varsova and Sassoon Docks) and Dhakti Dahanu. Additional

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samples were obtained from the Central Institute of Fisheries Education research vessels, MFV Saraswati and MFV Narmada. The fishing grounds, ranging from 10 to 40 m in depth, are located within 19° and 21°N and 71° and 73°E where the population is considered to be a unit stock.

The length, weight, sex, gonad weight and gross maturity stage data were recorded for each specimen in the sample. Length was measured to the nearest 0.1 cm, weight to the nearest 0.1 g, gonad weight to the nearest 0.01 g, weight of the sample number of eggs (300 eggs) for fecundity to the nearest 0.1 g and the diameter of ova in the sample to the nearest 0.02 mm (0.02 mm = 1 ocular division). Sex of very young fish was ascertained by examination of the gonad under a dissection microscope.

Maturity, frequency of spawning and spawning season were determined by: (i) a gross classification of the gonad into four stages based on their colour and the shape and size of the developing ova (Table 1), and by examining the distribution of the gross stages according to months; (ii) finer classification of the ovaries into successive stages based on the position of the modes of the most mature and preceding groups of ova in the ova size frequency polygons as given by Clark (1934), June (1963), Mc Gregor (1957) and Devaraj (1983).

Recruitment pattern was determined by tracing back the length frequency distributions to zero time, i.e., the time of spawning, by means of the age-length key (Pauly, 1982). Recruitment pattern helped to identify the extent of spawning seasons and the number of spawning peaks.

Eggs taken from the middle section of either lobe of formalin (5%) preserved ovary were measured for ova diameter. Individual frequency polygons were plotted and compared, and those similar with respect to the position of the most mature and preceding groups of ova were pooled. The lines denoting the size frequency distributions of ova represent the actual frequencies smoothened by a running average according to the formula; \((a + 2b + c) / 4\), in the order to remove chance fluctuations (Fig. 2) as followed by Clark (1934) and Mc Gregor (1957). The deviations of the ova diameter frequency distributions for each of B to H stages, from the average ova diameter frequency distribution for stage B to H have been fitted in order to clearly identify the number of boundaries of the modes (Devaraj, 1983). For the purpose of fitting these deviations, the square roots of the difference of each stage from the mean of B to H stages were smoothened twice by a running average of three (Fig. 3) as followed by Clark (1934) and Mc Gregor (1957).

The spawning grounds and migratory pattern were determined from the spatial and temporal distribution of larvae and postlarvae, and from various maturity stages and the different age groups in the catches from different localities and depths.

Fecundity was calculated as:

\[
\text{Fecundity} = \frac{\text{No. ova in subsample} \times \text{Weight of paired ovaries}}{\text{Weight of subsample}}
\]

Fecundity (F) in relation to total length (L) or weight (W) of fish was found to be linear, and hence, fitted by the equation: \(F = a + bL\) and \(F = a + bW\). Fecundity per tonne of spawning females was estimated from the Eq. \(F = bW\) derived by forcing \(a\) in \(F = a + bW\) to zero as this does not lead to any significant loss of accuracy (Devaraj, 1983). Population fecundity was estimated by multiplying fecundity per tonne of spawning females by the biomass of adult females which was determined from the stock esti-
mates (Fernandez, 1986) using age at first maturity, age structure of the population and sex ratio.

**Observations**

The gonad of *C. dussumieri* consists of two equal sized lobes resting on the ventral wall of the body cavity.

**Maturity stages**

Gross examination of gonads show that both males and females pass through four maturity stages, namely, immature, maturing, mature and spent (Fig. 1). The spent stage could be further classified into the partially spent and fully spent stages depending on the presence or absence of remnants of ripe ova in the ovary. Classification of ovaries according to the position of the modes in the ova size frequency distributions has resulted in eight finer stages designated serially from the most immature stage A to the most mature stage H within the gross maturity scale of four stages (Table 1; Figs. 2 and 3).

![Fig. 1. Percentage of fish in different maturity stages according to months.](image)

![Fig. 2. Ova diameter frequency polygons for stages B to H. The lines represent the values smoothed by the formula \((a + 2b + c)/4\).](image)

**Spawning periodicity and season**

Although the distribution of ova is bimodal in stages B to D, only the most mature group is very dominant in stages E to H, suggesting that the female spawns only one batch of eggs in a given spawning season. A small secondary group of ova of 0.24 - 0.32 mm size (corresponding to stage B) develop at stage H at which the most mature group of ova (ripening to ripe ova) are of 0.72 - 1.10 mm size. After the spawning of the most...
<table>
<thead>
<tr>
<th>Stage</th>
<th>Female gonads</th>
<th>Male gonads</th>
<th>Macroscopic examination</th>
<th>Microscopic examination</th>
<th>Macroscopic examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immature</td>
<td>Ovaries are small and thread-like and become apparent in fish of length between 9.0 and 10.0 cm. Ova transparent.</td>
<td>Stage A : Frequencies with a mode between 0.02 and 0.2 mm.</td>
<td>Testes small and thread-like. They are whitish in colour.</td>
<td></td>
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</tr>
<tr>
<td>Maturing</td>
<td>Ovaries are as long as the body cavity. Lobes distinct and light orange in colour.</td>
<td>Stage B : Frequencies with a mode between 0.22 and 0.30 mm. Stage C : Frequencies with a mode between 0.32 and 0.40 mm. Stage D : Frequencies with a mode between 0.40 and 0.50 mm. Stage E : Frequencies with a mode between 0.52 and 0.60 mm.</td>
<td>Testes are as long as the body cavity and are cream in colour.</td>
<td></td>
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</tr>
<tr>
<td>Mature</td>
<td>Ovaries fill the body cavity and are dark orange in colour. The ripe ovary is more of a reddish tinge and exudes eggs on pressure. The eggs are large and are incompletely or completely yolked. Eggs flow freely in ripe specimens.</td>
<td>Stage F : Frequencies with a mode between 0.62 and 0.70 mm. Stage G : Frequencies with a mode between 0.72 and 0.80 mm. Stage H : Frequencies with a mode between 0.82 and 0.90 mm.</td>
<td>Testes fill the body cavity. On exertion of slight pressure milt exudes. In ripe specimens it exudes freely.</td>
<td></td>
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</tr>
<tr>
<td>Spent</td>
<td>Ovaries are baggy and blood shot. They are empty and contain very few residual eggs.</td>
<td></td>
<td>Testes have a reddish tinge and a shrunken appearance.</td>
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mature group of ova at stage H, the secondary group of ova are likely to take the same time period that the B stage ovary has taken to attain the spawn ripe stage H (Fig. 3). Since the age at first maturity is about six months, the time taken by an A or B stage ovary to attain stage H is likely to be a maximum of not more than six months, and therefore, the duration between successive spawnings of individual fish is, at the maximum, six months.

Even if individual fish might spawn only twice a year, spawning in the population as a whole is protracted over the entire year as evident from the occurrence of maturing and mature fish in all months (Fig.1). Continuous spawning is also evident from the recruitment pattern constructed by projecting the monthly length frequencies to the zero times, i.e., to the origin of the brood

Fig. 3: Deviations from the average frequency polygon of stages B through H. The deviations are smoothed twice by a running average of three to remove chance fluctuations.

Fig. 4: Recruitment curve for Coilia dussumieri for the period 1981 to 1983. (Fig. 4; Pauly, 1982). Despite continuous spawning throughout the year, recruitment pattern (Fig. 4) shows that larval survival rises steeply to the highest level in the calmer season (March to May), falls steeply in the turbulent southwest monsoon season (June to August), shows a secondary increase in the relatively calm postsouthwest monsoon season (September and October) and again declines steeply in the somewhat turbulent northeast monsoon season (November and December). An obvious link between a highly patchy distribution of plankton in the calmer seasons and high larval survival is thus indicated.

The occurrence of postlarvae and juveniles of 1 to 5 months age in the catches during the southwest and postsouthwest monsoon seasons (June to October) confirms the premonsoon months (March to May) to be the peak spawning and recruitment season. The broods identified in the monthly
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length frequency data for 1982-'83 by means of the scatter diagram technique of modal progression analysis (Devaraj, 1983), are found to originate in January to March, May, July and October (Fernandez and Devaraj, 1988) which also confirms the very protracted spawning in the population.

**Size at first maturity**

*C. dussumieri* spawn for the first time at an age of 6 to 7 months when they are about 12.0 cm total length (Fernandez and Devaraj, 1988) and the subsequent spawnings seem to take place after every six months. The estimated $L_{\infty}$ is 28.5 cm and the $T_{\infty}$ 7 years. Thus, the fish has a potential for 14 spawnings in its life span at the rate of one for every six months. However, the maximum size encountered in the catches is about 20.5 cm total length at which the fish is 20 months old, thereby indicating a maximum of only about 3 spawnings in the effective life span of the fish. The $L_1/L_{\infty}$ ratio of 0.42 suggests very low reproductive stress as according to Cushing (1968), the closer this ratio is to unity (=1), the higher the stress due to spawning.

**Biomass of spawning females**

The total stock of *C. dussumieri* along the northwest coast for 1982-'83 was estimated to be 29,126.13 tonnes by dividing the annual catch ($Y=13,992$ tonnes) by the annual exploitation rate ($U=0.4774$) (Fernandez, 1986). Using the length frequency data, the sex ratio of $1.0(\delta):0.75(\Omega)\,$, 12.0 cm as the length at first maturity and the length ($L$, in cm) - weight ($W$ in g) relation of $\log W = 1.3426 + 2.0231 \log L$, the adult females portion of the total stock was estimated to be 12,482.63 tonnes, of which the spawn ripe females alone accounted for 93.25 tonnes.

**Fecundity**

Fecundity ($F$) shows a linear relation with both total length ($L$) (Fig. 5) and with weight ($W$) (Fig. 6).

$$F = -6961.48 + 587.70 L; \quad (r = 0.7187)$$

$$F = -779.41 + 252.56 W; \quad (r = 0.7621)$$

Absolute fecundity of *C. dussumieri* based on 35 samples, was found to range from about 1,000 to 5,000 eggs in fish 15.7 cm to 19.0 cm long. The absolute fecundity per tonne of adult females as per the relation $F = 253 \, W$ is $253 \, W \times 10^6$ eggs (for $1 \, g = 253$ eggs, therefore for $1 \, tonne = 253 \times 10^6$ eggs). The population fecundity for a total of 12,483 tonnes of adult females present in the total stock of 29,162.13 tonnes during 1982-'83 was $3,158 \times 10^9$ eggs (i.e. $253 \times 10^6 \times 12,483$). Individual fish seem to spawn at least twice a year, and hence, the annual fecundity per tonne of adult females and the annual population fecundity should be considered as at least twice the above values.

![Fig. 5: Fecundity - length relationship.](image-url)
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Sex ratio

Of the 247 specimens sexed, 141 were males and 106 females, indicating a sex ratio of 1 male to 0.75 female.

Spawning and nursery grounds

The dol net catches at the Sassoon Docks during the monsoon months of June to August were of smaller juveniles (3.5 to 9.1 cm in total length), larger juveniles (10.0 to 12.0 cm in total length) and spent adults (of about 18.0 to 20.0 cm total length) taken from fairly deeper waters of about 40 m within the inshore grounds which extend to a depth of 50 m. Apparently the spawning grounds as well as the nursery grounds are located in the inshore of the 40 m isobath.

Discussion

The gross maturity stages identified in this study are the same as those described by Gadgil (1965) for C. dussumieri. The finer stages determined from the ova diameter frequency analysis according to Clark (1934) delineate the ovarian cycle in which only one batch of ova is developed and spawned in a single spawning act. A new batch of ova that develops at the spawn ripe stage repeats the cycle, which apparently takes about six months to complete. This apparently regular 6 month cycle is masked or obscured by the occurrence of maturing and mature fish throughout the year. These observations indicate that there is continuous spawning in the population as a whole, but individuals spawn only twice a year at intervals of about six months. However, continuous spawning in the population as a whole, even at constant intervals every month, need not necessarily mean constant levels of recruitment every month as larval survival is crucially dependant on the patchiness of plankton as determined by sea surface turbulence (Blaxter and Hunter, 1982; Legendre and Demers, 1983; Krishnan Kutty, 1985). This is evident from the recruitment pattern in C. dussumieri.

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References


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