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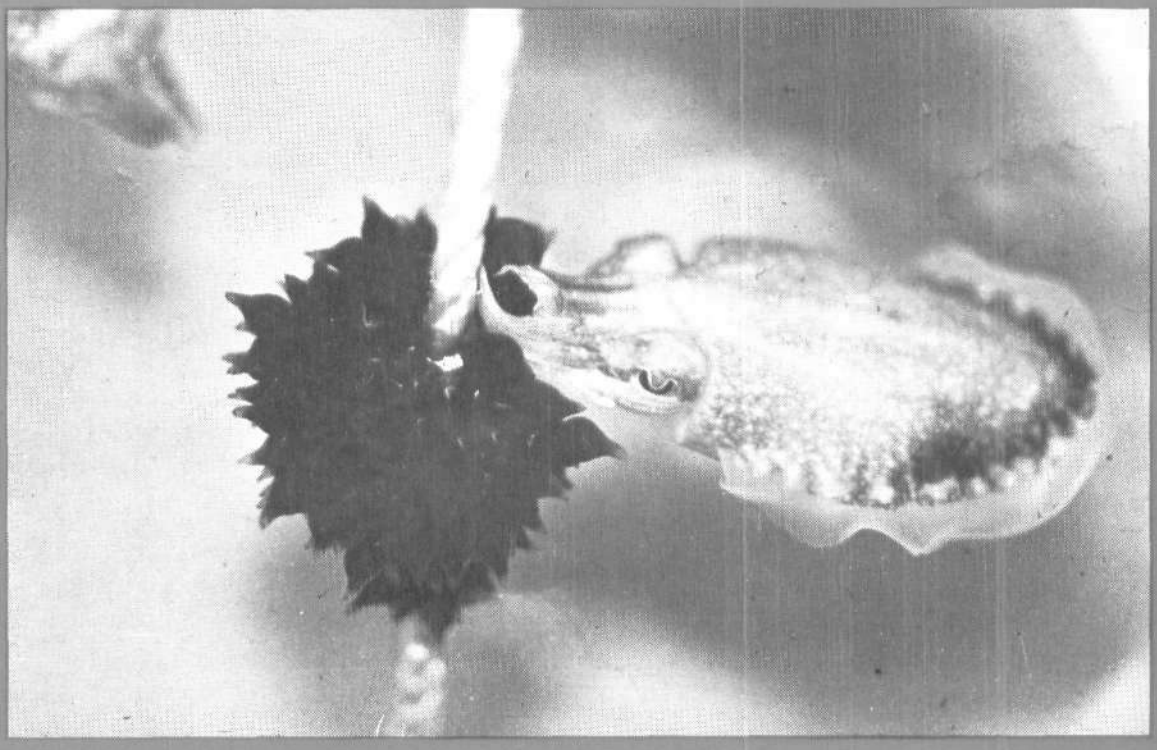

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896 ON THE OCCURRENCE OF GIANT MALE AND FEMALE GROUPERS WITH A NOTE ON SEX CHANGE IN GROUPERS

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Introduction

Serranid fishes are popularly known as 'Groupers' or 'Rock cods' and locally 'Kalava'. Their contribution in the capture fishery along the Indian coast has been dealt by several authors (*CMFRI Bull.*, 1994, No. 47: 137 pp). In view of their importance in aquaculture, Bensam (1993) has elucidated the prospects of farming groupers in India (*Mar. Fish. Infor. Serv. T & E Ser.*, No. 123 : 1-4). A perusal of literature reveals that biological information pertaining to the reproductive cycle, sex ratio and sex reversal of groupers in the natural population along the Indian coast are rare although groupers are known to be protogynous hermaphrodites. In view of their importance in the capture and culture fisheries, the present account on the record of giant female groupers [*Epinephelus tauvina* (Forskal), *Epinephelus malabaricus* (Bloch and Schneider) and *Promicrops lanceolatus* (Bloch)] of more than two metres in total length and their sex ratio] in the natural population from the Indian coast (Table 1) deserves special attention.

Diversity of sexual forms in fishes

Fishes exhibit wide diversity of sexuality such as gonochorism, hermaphroditism, unisexuality and sex reversal. 'Gonochorism' is the existence of separate sexes which is the normal mode of sexuality as in higher animals. In 'hermaphroditism', an individual can be male and female simultaneously or successively in its life time; in which 'normal hermaphroditism' is characteristic of the species rather than of the individual whereas 'abnormal hermaphroditism' refers to certain individual fish of the species having normal gonochoristic life style exhibiting abnormal signs of both sets of primary sexual characteristics.

Three basic forms of hermaphroditism are found in fishes : (a) 'Protogynous hermaphroditism' in which individuals develop first into females and turn later into males. This is the commonest form among normal hermaphrodites; (b) 'Protandrous hermaphroditism' in which the male state differentiates first; and (c) 'Synchronous hermaphroditism' where both male and female states coexist functionally.

In the case of 'unisexuality', the species is represented only by females where sexual reproduction normally depends upon males of other related species. In the case of 'sex reversal' process, the species that is protogynous in the initial stage turns into males and the species that is protandrous in the initial stage turns into females during the later course of life span. According to Colin (Genetics and Fish Breeding, 277 pp. 1993), the sex reversal which occurs in protogynous and protandrous hermaphroditism is permanent.

Most of the species exhibiting normal hermaphroditism are tropical reef-associated marine fishes belonging to the Order perciformes which also exhibit gonochorism. The major groups among perches to exhibit

normal hermaphroditism are the fishes of the Families Serranidae and Sparidae (Colin, 1993). According to Dorairaj (1973), polynemids also exhibit normal hermaphroditism in Indian waters (*Indian J. Fish.*, 20 (1 & 2) : 256 - 259).

Sex change in groupers

Perusal of literature reveals that the groupers exhibit normal hermaphroditism and sex reversal. According to Lee *et al.*, (1995), the greasy grouper *E. tauvina* is a protogynous hermaphrodite and the reproductive cycle and sex change in the protogynous *Epinephelus morio, E. cruentatus* and *E. striatus* have been described from the Eastern Gulf of Mexico (*Proc. Symp. Reprod. Physiol. Fish.*, 1995, 389 pp). Clark (1959) observed synchronous hermaphroditism in *Serranus scriba (Science,* 129: 215-216); and Smith (1959) studied sex reversal in the protogynous *Epinephelus guttatus, E.striatus* and *Promicrops itaiara* from Bermuda (*Pap. Mich. Acad. Sci.*, 44: 111-119) in which the female sex appeared in smaller ones at a younger stage and male sex in larger ones at an older age with a phase of inter-sex in between.

Once a species is said to have normal hermaphroditism, there is a general belief that all the individuals of that species are passing through hermaphroditism in its life time. Thus in the cases where sex reversal is known, it is presumed that those individuals upto a certain age and length function as one sex (females in the case of protogynous hermaphrodites and males in the case of protandrous hermaphrodites), after which they change to opposite sex with a short period of inter-sex (transitionals) in between. But it is not so with all the individuals of the so called hermaphrodite group or species as it is evident from the record of mature giant female specimens of *E. tauvina, E. malabaricus and Promicrops lanceolatus* from the natural population (Table 1) which are supposed to be protogynous.

Mature functional gonads of giant male and female *E. tauvina* weighing 14-15 and 17 kg respectively have been described by Selvaraj and Rajagopalan (1973) alongwith the ova diameter and fecundity estimates of ripe ovary (*Indian J. Fish.*, 20 (2): 668-671). The occurrence of mature functional giant females of more than two metres in total length of these 'protogynous' species in the wild population suggests that all the females are not undergoing sex reversal in the population. The studies conducted by Johnson and Thomas (1995) on the seasonal changes in gonadal histology and sex steroid harmone levels in the field population of the protogynous hermaphrodite *E. morio* during 1993-'94 (*Proc. Symp. Reprod. Physiol. Fish.*, 1995, p. 234), reveal that they have also recorded (a) females with mature ovaries, (b) fully developed males and (c) transitionals in the catch. According to them, sexual succession occurred in a small proportion (about 2% only) of females of 4-7 years old. The present study also supports the view that only a few members of the protogynous species are subjected to sex reversal.

Sex ratio

In the case of the giant groupers where sex of the individual fish were recorded [*E. tauvina* (3 nos.), *E. malabaricus* (2 Nos.) and *P. lanceolatus* (3 nos.)] of size ranging between 1,920 mm and 2,360 mm in total length (Table 1), the sex ratio for the males and females of *E. tauvina* was 2:1; *E.malabaricus* (2 females) and *P. lanceolatus* 2:1, and transitionals were absent. According to Colin (1993), the females grow faster than the males after sexual maturity has set in. Accordingly, the giant sized *E. tauvina* landed at Visakhapatnam on 20-3-1991 with 2,360 mm in total length and 300 kg weight and a giant sized *P. lanceolatus* caught off Kanyakumari in March 1990 with 2,410 mm in toal length and 250 kg weight (Table 1) could also possibly be mature females.

According to Colin (1993), primary sex ratios in fish i.e., the relative frequencies of females and males at hatching or soon after the initiation of sex determination are usually 1:1, but secondarily may get distorted. This may arise by the pursuit of different life styles of the two sexes. For example, in some

anadromous brown trout (*Salmo trutta*) populations, only the females go to the sea and the males remain in the river of their birth. Sampling error occurs in cases when males and females migrate separately to the spawning ground as in the case of marine flat fishes and for feeding purpose into the inshore waters. Deviation in sex ratio may also occur by differential survival rates of males and females and also by sex reversal in the hermaphrodite species. According to Wootton (1982), the sex ratio is biased towards females in protogynous species (*Proc. Symp. Reprod. Physiol. Fish*, 1982, 210-219).

Although the available data on the rare occurrence of giant groupers in the fish landing is inadequate to determine the sex ratio of *E. tauvina, E.malabaricus and P. lanceolatus*, it is evident that giant sized mature and functional female groupers are also available alongwith males of these species in the natural population. The occurrence of giant sized older female specimens of these three species in the natural population raises the doubt whether these species are actually protogynous hermaphrodites or whether gonochorism also prevails among the groupers as observed in the Family Sparidae, where hermaphroditism and gonochorism (Colin, 1993) are reported. Record of young mature males below the medium size groups from the wild in future would be necessary to confirm that all the individuals of these species are not protogynous hermaphrodites. More information on the maturity stages of gonads and sex ratio of groupers from the Indian waters are needed to arrive at meaningful conclusions.

Influence of environment on sex change

Although sex change is influenced by genetic and endocrinal systems, environmental factors could also play a role in hermaphrodite species. The fact that gonochorism appeared to be more common in fishes dwelling in the deep sea, with stable environment than in species living at shallow or moderate depths where the environment is flexible or less stable suggests that the environment may play an important role in the sex change of hermaphrodite species.

Two major hypotheses have been proposed by Wootton (1982) to account for the initiation of sex reversal : (1) 'the developmental hypothesis' and (2) 'the social control hypothesis' (*Proc. Symp. Reprod. Physiol. Fish*, 1982, 210-219). The former postulates that the sex reversal is initiated when the fish reaches a critical size or age. If the size is crucial, then the environmental factors such as food supply may have an important influence on the rate at which the crucial size is reached. Second hypothesis suggests that it could be the social environment that determines the sex reversal in the protogynous species where the removal of male in the group or locality may result in the sex reversal of one of the females, often the largest. But the mechanism by which the social control of the reversal process is maintained is controversial.

Too little is known of the physiological control of sex reversal in marine fishes. Unfortunately there seems to have no systematic experimental studies on the effects of resource levels such as food on the process of sex reversal. The lack of understanding of the physiology of sex reversal in fishes may be due to the fact that most of the hermaphrodite species are marine forms not easy to rear or handle in the laboratory. This state of affairs is coming to an end with the expanding use of hermaphrodite species for fish farming, and the establishment of hatcheries and marine aquariums with running sea water facilities for the coral-reef associated ornamental fishes and the broodstock maintenance of groupers which would pave the way for effective approach to endocrinology and genetics of fish breeding as it is being developed by the Central Marine Fisheries Research Institute in India. Apart from the approach through aquaculture aspects, biological studies pertaining to maturity stages of gonads and sex ratio from the wild population in future might also throw more light on the sex ratio and sex reversal in groupers.

TABLE 1. *Occurrence of giant male and female groupers in the Indian waters*

Species	Locality	Date	Depth (m)	Total length (mm)	Weight (kg)	Sex	Reference
Epinephelus tauvina	Cochin	3.11.1967	36	1,920	180	Male	Selvaraj and Rajagopalan (1973). *Indian J. Fish.*, **20**: 668–671.
Epinephelus tauvina	Ponnani	11.11.1971	45	2,090	151	Male	-- do --
Epinephelus tauvina	Cochin	19.11.1971	36	2,115	265	Female	-- do --
Epinephelus tauvina	Visakhapatnam	20.3.1991	60	2,360	300	No data	Seshagiri Rao and Varma (1992). *Mar. Fish. Infor. Serv. T & E Ser.*, 117 : 18.
Epinephelus malabaricus	Goa	21.3.1968	18	2,300	197	Female	Dhawan and Gopinathan (1970) *J.mar. biol. Ass. India, 10(1) :* 177–178.
Epinephelus malabaricus	Goa	17.8.1977	10	2,100	160	Female	Doiphode and Rekha (1977), *J. mar. biol. Ass. India*, 17(2): 492–493.
Promicrops lanceolatus	Veraval	28.12.1961	53	2,220	No data	Male	Pai et al., (1967), *J. mar. biol. Ass. India, 7(2):* 477–478.
Promicrops lanceolatus	Veraval	24.2.1962	53	2,240	No data	Male	-- do --
Promicrops lanceolatus	Veraval	24.2.1962	53	2,360	216	Female	-- do --
Promicrops lanceolatus	Cuddalore	3.9.1989	35-40	2,100	200	No data	Mahadevan Pillai (1991), *Mar. Fish. Infor. Serv. T & E Ser.*, 108:16.
Promicrops lanceolatus	Kanyakumari-	.3.1990	27	2,410	250	No data	Jacob Jerold Joel (1991). *Mar. Fish. Infor. Serv. T & E., Ser.*, 108: 15.