General Discussion
8.0 GENERAL DISCUSSION

The Gulf of Mannar is a region of rich biodiversity (Nammalwar and Edwin, 2002). Out of nineteen species reported to be present on the southeast coast of India (Heemstra and Randall, 1993), nine species altogether were sampled from Mandapam and Keelakarai in the present study. Seven species were present in the Mandapam collections and five species were present in that of Keelakarai. Therefore these two places are important landing centres of groupers on the south-east coast.

The large sized commercially important groupers, *E. malabaricus* and *E. coioides* were present only in Mandapam. The smaller species like the reticulated groupers, *E. faveatus* and *E. merra* were abundant at Keelakarai. The size range of the species collected indicated that mostly juveniles were collected in the case of the larger species whereas almost all size classes of the smaller species were obtained. This could be because of the small size of entry into the traps through which the larger individuals could not pass.

According to a report by CMFRI (2002), seven species of groupers have been reported from Mandapam namely, *E. caeruleopunctatus, E. hexagonatus, E. areolatus, E. tauvina, E. polyphekadion, E. bleekeri* and *C. formosa* of which *E. areolatus* was dominant. But in the present study, *E. malabaricus* was observed to be the dominant species at Mandapam and not a single specimen of *E. areolatus, E. hexagonatus, E. tauvina* or *E. bleekeri* was obtained. This could either be due to earlier misidentification or depletion in number of these species due to overfishing.
E. faveatus which is the dominant species at Keelakarai also finds no mention in recent survey reports of the south-east coast of India (CMFRI, 2001, 2002 and 2003).

Many species of groupers resemble each other morphologically and in certain species even the meristic characters have been found to overlap (Table-1). This makes identification a difficult task. Groupers have been misidentified in early literature (Heemstra and Randall, 1993). Total dependence on the colour pattern for identification could be the major reason for this misidentification. In many cases, the species have been summarized as groupers or rockcods due to lack of taxonomic expertise. This could be the reason for the failure in mentioning species like E. faveatus in survey reports.

In the present study, along with the morphological and meristic features, an important internal meristic character called the pyloric caecae was made use of in species identification. Pyloric caecae counts of a few species are given in the FAO catalogue (Heemstra and Randall, 1993) and they have been found to be distinct in species, which resemble each other. The results showed that the pyloric caecae can be a very useful tool to confirm the identity of species whose morpho-meristic characters alone cannot establish identity. In certain groups of species like E. malabaricus, E. coioides and E. polyphemus as well as E. faveatus and E. merra, the morpho-meristic characters overlapped (Table-1) and therefore their identity had to be resolved by other means such as the count and pattern of pyloric caecae.
Zismann (1981) has already reported the use of pyloric caecae in species identification of mullets. Although this method is invasive, it is excellent for resolving taxonomic ambiguities as observed in the present study with groupers. The reliable character i.e. the number, arrangement and form of the pyloric caecae presented here can be used as a helpful additional tool in the FAO catalogue (Heemstra and Randall, 1993) for correct taxonomic identification of groupers. The pyloric caecae counts were useful in the case of distinguishing *E. malabaricus*, *E. coioides* and *E. polypekadion* from each other and also *E. faveatus* from *E. merra* (Table-7, Fig.5). The arrangement of the pyloric caecae either as individual strands or in groups, and form as branched or unbranched were also distinguishing characters. Similarly the appearance of the caecae in the fresh condition was characteristic of each species and it also helped in identification.

It was interesting to note that not a single specimen of the greasy grouper, *Epinephelus tauvina* (having pyloric caecae count of 16 - 18) was encountered during the whole period of study eventhough Mathew *et al.*, (2000), James *et al.*, (1996), Rengarajan and Bennet (1994) and Bensam (1993) have reported the greasy grouper as one of the most common species found in the southern coast of India. This could most probably be a misidentification of *E. malabaricus* which was observed in the present study to be dominant at Mandapam. Occurrence of *E. tauvina* in Indian waters is yet to be confirmed from other coasts with intensive surveys.
The present study also involved the application of RAPID markers for species identification of groupers from Indian waters, this being the second report. The first reported by Govindaraju and Jayasankar (2004). All eight arbitrary primers used gave unique banding patterns for each species. The present results of RAPID analysis demonstrate a separation of gene pools of all 8 species of Groupers, in which all individuals of each species formed close monophyletic species clusters. The very low GD value between *E. polyphekadion* and *E. diacanthus* (0.2366), between *E. faveatus* and *E. merra* (0.2714) and between *E. malabaricus* and *E. coioides* (0.2863) indicated the proximity of these species.

Because of their overlapping morphological characters *E. malabaricus*, *E. coioides* and *E. polyphekadion* have often been confused among themselves, as well as among *E. faveatus* and *E. merra* (Heemstra and Randall, 1993). The present study has segregated these species through the GD values between *E. coioides* and *E. malabaricus* between *E. coioides* and *E. polyphekadion* between *E. malabaricus* and *E. polyphekadion* and between *E. faveatus* and *E. merra* which were 0.2863, 0.3718, 0.3745 and 0.2714 respectively. The reproducibility of RAPD was tested at various stages of the process, leading to consistent banding patterns with all primer amplifications. The use of pyloric caeca is an invasive method and non-invasive methods such as genetic techniques (RAPID fingerprinting) are preferred since they prevent sacrifice of the organism. But an RAPD fingerprint must be prepared only after confirming the identity of the species using its pyloric caeca count and pattern. Following this the RAPD fingerprint can serve as a reference molecular marker.
The teleosts are predominantly dioecious (gonochorists) but hermaphroditism, sex-reversal and gynogenesis occur in some species. The reproductive biology of one grouper namely *E. faveatus* is described in terms of spawning seasonality, sexual development, size at first sexual maturity and fecundity. It was not possible to confirm sexual pattern due to the absence of transitional stages. Evidence in support of protogyny, such as gonads undergoing transition from functional female to a functional male were not available, although transition of females to males and the possibility of direct development of males from juveniles was suggested from size data. It is possible that transitionals (i.e., individuals undergoing sex change), if typically few or if transition is rapid, may have been missed due to the small number of individuals sampled.

Transitionals have represented less than 1 - 2 % of samples in hermaphroditic epinephelines (Moe, 1969; Collins *et al.*, 1987; Hastings, 1989; Hood and Scleider, 1992; Shapiro *et al.*, 1993; Bullock and Murphy, 1994; Koenig *et al.*, 1996) and therefore extensive sampling is required and especially during the non-spawning months. While the sexual pattern could not be resolved in the present study, the presence of males below the 50 % size of sexual maturity of females and the size overlap between sexes suggests that at least some males may develop from the immature stage. Reproductive cycles are characterized by pronounced variations in gonadal size, which is dependant upon the body size. The gonadosomatic index (GSI) eliminates the effect of body size of fish on gonadal weight (De Vlaming *et al.*, 1982; Erickson *et al.*, 1985). The variation in condition factor
with respect to length offers help in determining the size of fish at first maturity (Sarojini, 1957 & 1958; Chan & Chua, 1980; Brusle, 1981). The rise in condition coefficient might be due to the occurrence of ripe gonads, and the drop to the loss of gonadial products as a result of spawning.