REVIEW OF
LITERATURE
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The fishes of family Leiognathidae form a well defined group and are widely distributed in Indo-Pacific waters. Though small in size, a few species form dense schools in shallow regions, offering great potentialities for commercial exploitation. They are important source of food and fish meal. Most of the published literatures are available from the eastern hemisphere.

Existing reports point to the presence of nineteen species of silver bellies in the seas around India. Eight of them viz; Leiognathus jonesi, L. Splendens, L. bindus, L. dussumieri, L. equulus, L. brevirostris, Secutor insidiator and Gazza minuta are considered commercially important. Out of nineteen species, except L. blochii, L. elongatus and L. indicus all the other sixteen species occur in the Palk Bay and Gulf of Mannar areas around Mandapam. Of these 16 species L. jonesi is the most dominant contributing to the bulk of catches in Palk Bay. The species was first described by Jones (1971), from the Gulf of Mannar. Jayabalan and Ramamoorthy (1977) reported 11 species belonging to three genera of Leiognathids from Porto Novo waters. They were L. splendens, L. equulus, L. bindus, Leiognathus species, L. dussumieri, L. berbis, L. daura, Gazza minuta, Gazza species, Secutor insidiator and Secutot ruconius. Biology of Leiognathus splendens (Cuv) has been studied by Arora (1951) from the Palk Bay. Krishnamoorthy (1964) assessed the vertical migrations of Leiognathids and their possible influence on the estimation of fish stocks. Leiognathids possessing canine teeth are accommodated under the genus
Gazza. Day (1889) reported three species of Gazza from the Indian waters, viz; G. minuta, G. equulaeformis and G. argentaria. Later G. equulaeformis and G. argentaria were synonymised with G. minuta by subsequent workers (Jordan and Starka, 1917; Weber and Beaufort, 1931). A new species G. achlamys was established by Jordan and Starka (1917). This was confirmed by number of authors (James, 1975; Jayabalan, 1980). In 1985, Jayabalan described a new species of Gazza from Porto Novo waters and named it Gazza shettyi. More than thirty species of pony fishes belonging to the family Leiognathidae have been reported from the Indo-Pacific waters (Weber and de Beaufort, 1931; Tiews and Caces - Bojra, 1965; Fisher and Whitehead, 1974; James, 1975; Jayabalan, 1980; Fisher and Bianchi, 1984).

Fishery of the silver bellies in the Palk Bay has been studied extensively by James & Adolf (1965), James (1973) and Venkatraman and Badrudeen (1974). Fishes of the family Leiognathidae, popularly called silver bellies contribute to an important fishery in the states of Tamil Nadu, Kerala, Andhra Pradesh and Karnataka. Of these states, Tamil Nadu accounts for the bulk of the catches of silver bellies. Within Tamil Nadu, the south east coast comprising Palk Bay and Gulf of Mannar regions yields very high catches of silver bellies. In these regions, the fishery is almost continuous throughout, generally from April to October along the Palk Bay and November to March along the Gulf of Mannar coast (James and Badrudeen, 1981). Different species dominate the catch in different areas. For example of the 16 species occurring in Palk Bay
*L. jonesi* contributes to the bulk of the catches in Palk Bay (James and Badrudeen, 1981).

In the Gulf of Mannar, the relative abundance of various species varies considerably, *L. dussumieri* being one of the dominant species. Other species commonly found in the Gulf of Mannar are *L. bindus, Secutor insidiator, S. ruconius* and *Gazza minuta* (James and Badrudeen, 1981). Krishnamoorthy (1957) has given an account of the silver belly fisheries of the Rameswaram Island. Venkatraman and Badrudeen (1974) have studied the diurnal variation in the catches in Palk Bay. Silver bellies contribute to about 3% of the total marine fish catch in India (Annam and Dharma Raja, 1981). Venkatraman and Badrudeen (1974) found that *L. jonesi* migrate to upper layers of water in great quantities during night, thus escaping the trawls operated at the bottom.

Several studies have been made on the fishery, systematic, biochemistry, biology, proximate composition and bioluminescence of Leiognathids. Fischer and Whitehead (1974) described 13 species of Leiognathids from Eastern Indian Ocean and Western-Central Pacific. Much of the systematic of Leiognathids comes from the works of James (1967, 1969, and 1975) and Jayabalan and Ramamoorthy (1977).

Several studies are available on the fishery importance of Leiognathids; Arora (1951), Krishnamurthy (1957), Mahadevan (1958), Balan (1963), James and Clement (1966), Rao (1973), Satyanarayana *et al.*, (1972), James (1973),

Datta (1974) observed some biometric features of *Leiognathus splendens*. Caces-Borja (1975) reported the bionomics, population dynamics and food and feeding habits of Leiognathids from Philippines. Donaldo, (1979) have discussed the length weight relationship, spawning season, maturation and fecundity of *Leiognathus splendens*.

Jayabalan and Ramamoorthy (1986) have reported the length frequency distribution of *Gazza minuta*. Livingston et al., (1988) studied the size at first maturity and spawning season of *Leiognathus jonesi, Leiognathus brevirostris, Leiognathus berbis, Leiognathus equulus, Leiognathus dussumieri, Gazza minuta, Secutor ruconius and Secutor insidiator*. Kayalvizhi (2005) studied the morphology of olfactory organs in some Leiognathids.
Knowledge of reproductive biology is essential for understanding the population dynamics of the species. Many studies have been made on the reproductive biology of Leiognathids. Jayabalan (1986) reported on the reproductive biology of *Leiognathus splendens* of Port Novo coast. It appears to spawn twice a year for a short duration. Gonado somatic indices correspond well with the peak spawning months. *Secutor insidiator* spawns once a season, but has a longer duration (Jayabalan and Ramamoorthy, 1985).

James and Badrudeen (1986) have discussed maturation, spawning season and fecundity of 17 species of Leiognathids. Most of the species spawn over a prolonged period, a few spawn twice a year.

*Secutor insidiator, Secutor ruconius, Leiognathus dussumieri* has a prolonged spawning season while *Gazza minuta* has a restricted spawning period (Pillai, 1972). Observations on the age and growth, reproduction and feeding habits of *Leiognathus brevirostris* reveal that the species spawns twice in a year. Female fish produces maximum number of 16,243 eggs (James and Badrudeen, 1975).

Within the females of *Leiognathus dussumieri*, the immature, maturing, mature and spent-recovering females differ from one another in length-weight relationship. Males weigh comparatively less than females. Generally females predominate over males in the commercial catches. They spawn during April – May and November – December (James and Badrudeen, 1981).
An important component of many studies of fish reproductive biology is the assessment of the stage of gonad development of individual fish. Histology is the most accurate technique, but it is time consuming and expensive.

Reproductive studies of fishes, such as assessment of size at maturity, duration of spawning season, diel or lunar spawning and fecundity; require knowledge of the stage of gonad development in individual fish. The methods in use, range from histology - the most detailed but the most time consuming - to visual staging based on the external appearance of the gonad - possibly the least certain but the most rapid.(West, 1990).

One method developed recently, is the staging of ovaries based on appearance of their most advanced oocytes when viewed under a stereomicroscope (Forberg, 1983). This method requires that the appearance of whole oocytes be related to their stage of development (determined by histology), and since the criteria for staging whole oocytes are cruder than those used in histology, it is desirable to check the accuracy of whole oocyte staging (West, 1990).

In Sprattus sprattus, De Silva, (1973) observed seven stages in the process of ovarian maturation. His observation also revealed a long - spawning season and high proportion of females in the population of this species. In Mallotus villosus villosus, Forberg (1982) classified the oocytes into 10 stages based on morphological characters.
Reproductive biology of haddock was investigated by Robb (1982). He observed the histological changes occurring in the ovary during maturation and influence of varying food rations on the number of eggs released during the spawning season. In tautog ovarian development was described by eight microscopic gonad stages. Immature ovaries were characterized by the presence of oogonia and primary growth oocytes. Developing stage ovaries were characterized by presence of cortical alveoli and partially yolked oocytes. The fully developed ovaries were characterized by the presence of primary growth to advanced yolked oocytes and absence of oocytes in final maturation classes. Hydrated ovaries were distinguished by prominence of hydrated oocytes. Running ripe stages were identified by the presence of ovarian lumen. Partially spent or redeveloping ovaries are classified by lack of ovarian lumen. Spent stages were characterized by resorption of yolked oocytes and resting stage ovaries by a thickened ovarian membrane (White et al., 2003).

An analysis was made of sexual pattern, spawning season, sizes at sexual maturation and sex change in black grouper. Sexually active males and females were observed year round, although ripening females with stage-III, IV and V vitellogenic oocytes in the ovaries dominated in December and March (Brule et al., 2003). An analysis was made of spawning frequency, reproductive load, sex ratio, histological analysis of gonads on Gerreid species (Sivashanthini, 2004).

The reproductive activity and recruitment of white mullet was determined by observations of gonad development and coastal juvenile
abundance. Spawning time was determined from the observation of macroscopic gonadal stages. The relation between the timing of successful spawning and the intensity of coastal recruitment in white mullet was likely due to variations in food availability for first-feeding larvae as well as to variations in the duration of the transport of larvae shoreward as a result of varying current conditions associated with upwelling. (Marin et al., 2003).

The reproductive biology of gold-lined seabream has been examined focusing on duration, timing and frequency of spawning and on determining potential annual fecundity. Histological sections of numerous ovaries were used to determine the timing of the formation and degeneration of postovulatory follicles, the relative abundance of different stages of atresia in ovaries at different times during the spawning period. (Hesp et al., 2004).

Reproductive and growth parameters of Rex Sole were studied. Through histological analysis, ovaries that contained a sufficient number of advanced yolked oocytes or oocytes with migratory nucleus or unovulated hydrated oocytes for one spawning were classified as active. Ovaries without advanced yolked oocytes (AY) or major atresia of AY oocytes were classified as inactive (Abookire, 2006).

Other studies in the family Leiognathidae include, Proximate composition of four types of salted and dried Leiognathids fish in Ceylon (Nagakura and Sachithananthan, 1971); Physiological and morphological state of symbiotic bacteria from light organs of pony fish (Dunlap, 1984). Osteological studies on
Leiognathus splendens (Vasanth et al., 1984); Comparative morphology of light organs (Jayabalan, 1989).

Relationship between accumulated fat and reproduction has been well documented in oviparous animals. Role of fat accumulation in the reproductive activity of fishes has been observed by Channon and Saby (1932), Lovern and Wood (1937), Hickling (1947), Bailey (1952) and Hoar (1957 a, b). It has been observed that lipids stored in different parts of the fish body are channalized towards vitellogenic synthesis and oocyte recruitment during reproductive seasons. Satyanarayana Rao (1967) observed the period of utilization of lipids in storage sites and the accumulation of lipids in gonads of Leiognathus splendens during maturation. Jorgensen et al., (1997) studied the distribution of lipid in different body parts of the anadromous fish Salvelinus alpinus (L.). They have observed that 80% of lipids are lost during spawning in female fish. Gonadal development represents a major drain on the lipid stores of female fish (Dutil, 1984, 1986; Jonsson et al 1991) and much of this lipid is lost at spawning when the eggs are shed (Fleming, 1996). The influence of season on the lipid profiles were studied by Luzia et al., (2003) in five commercially important species of Brazilian fish. Role of diet on the lipid class and fatty acid composition of Arctic charr Salvelinus alpinus (L.) was worked out by Olsen et al., (1991).

Attempts to investigate the lipid dynamics in relation to reproductive cycle of fishes are less. One of the important contributions in this respect on teleost
fishes is of Sebastes species from California waters (Larson, R.J. 1991). An analysis was made to assess the total lipid content, the major lipid classes and the fatty acid composition of distinct anatomical fractions of commercially farmed, market size Atlantic salmon of Norway (Aursand, 1994).

2.1. Scope of the Study

Silver bellies are very important in the fishery of peninsular India particularly in the coasts of South India. It is a cheap source of proteins, lipids and other nutrients. There are 19 species in the seas around India. The landings are continuous year round, though seasonal fluctuations occur in the quantity and in the type of species captured. Thus it becomes essential to understand the biology of silver bellies and their reproductive pattern. Extensive work has been done on the Biology and fishery of *Leiognathus jonesi* and *L. dussumieri* in and around the Palk Bay and Gulf of Mannar. Jayabalans (1985, 1986 and 1988) has contributed to the biology of *Leiognathus splendens, Gazza minuta* and *Secutor insidiator* from Porto Novo waters. Silver bellies are considered by the local population as medicinally valuable and it is also used in the dried and salted forms. Considering the fishery importance in the Pondicherry waters and the need to understand the reproductive biology of this family, we decided to investigate two commonly available species of this family viz; *Leiognathus dussumieri* and *Secutor insidiator*.

There is little information available on the reproductive biology of *L. dussumieri* and *Secutor insidiator*. The aim of this work is mainly to understand
the ovarian stages and spermatogenesis during spawning and maturity, which will help in the management of fishery in Puducherry coast.

In short, the present work was designed to find out the following:

- Length – Weight relationship
- Condition factor
- Sex ratio
- Potential annual fecundity
- Spawning frequency
- Peak season of breeding
- Synchronous or asynchronous spawning
- Lipid dynamics in relation to reproduction
- Age and growth