CHAPTER 5

SUMMARY AND CONCLUSION
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### CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 Summary</td>
<td>201</td>
</tr>
<tr>
<td>5.2 Conclusion</td>
<td>209</td>
</tr>
</tbody>
</table>
5.1 SUMMARY

The work entitled “Systematics and bionomics of silverbellies of Kerala coast” is an attempt to access information on the current systematic account, distribution and species diversity of silverbellies (Order: Perciformes, Family: Leiognathidae) along Kerala coast (south west coast of India) by preparing taxonomic keys for the identification of genera and species. Morphometric and metistic characters were described along with the morphological description of each species collected during the study period. Study also embodies some biological parameters of principal leiognathid species. Even though, many authors reported various biological aspects of leiognathids from the east coast of India, work in this regard from the Kerala coast is still lacking. The present endeavor is aimed at gathering knowledge on food and feeding habits, length-weight relationship and relative condition factor and reproductive biology of three pony fish species, *Leiognathus brevirostris*, *Gazza minuta* and *Secutor insidiator* and light organ and sexual dimorphism study in 2 species, *Secutor insidiator* and *Photopectoralis bindus*

**General introduction**

The chapter is mainly meant for giving an explicit idea about the objectives of present work. Due importance has been given to silverbellies being an important demersal fishery stock and the bulk quantities landed making them favorable for fresh fish industry as well as dry fish and other fish byproduct industries in the country. Lot of research effort have been going on the molecular phylogenetic analysis of leiognathids and attempts are thereby progressing to clarify many taxonomic problems that plague the family for several years. A
narration on literature oriented around the distribution and landings of silvebellies along the east and west coasts of India, various gears used for fishing, biochemical and biological studies on silverbellies occupied considerable space of the first chapter.

**Review of literature**

This chapter deals with the previous work done in silverbellies regarding systematics, food and feeding habit, length - weight relationship, reproductive biology, light organ and sexual dimorphism from abroad as well as our country.

**Materials and methods**

This chapter is entirely devoted for mentioning the specimen collection centers and methods adopted for carrying out this research.

**Result and discussion**

**4.1 Systematics**

The systematics of leiognathids collected from the coastal and estuarine waters of Kerala was described. 14 species of leiognathids belonging to 8 genera were collected. A key to systematic sequencing of the genera was prepared. Morphometric and meristic features were studied in detail for the identification and description of the genera and species. The following species could be identified and described; *Leiognathus equulus, Leiognathus brevirostris, Leiognathus striatus, Aurigequula facsiata, Equulites leuciscus, Equulites absconditus, Eubleekeria splendens, Photopectoralis bindus, Karalla dussumieri, Karalla daura, Secutor insidiator, Secutor ruconius, Gazza minuta* and *Gazza achrnms*. Among these *Leiognathus striatus* is the first time report from Kerala coast. Some subgenera were recently elevated to generic status and only those generic and species names accepted by ‘fish base’ (on line pub.) are followed in
the study. While many pony fish species were widely distributed along the Kerala coast, some were recorded only stray occurrence.

4.2 Food and feeding habits

*Gazza minuta* is basically a predatory fish preying upon small pelagic fishes mainly whitebaits (*Stolephorus devisi*) in addition to eating up post-larval and juvenile shrimps, worms, copepods and lesser amount of phytoplankton. *Leiognathus brevirostris* is mainly a plankton feeder (zooplankton and phytoplankton) even though fish consumed a good quantity of benthic worms. Hence *Leiognathus brevirostris* is reported as a planktophagus and benthophagus carnivore feeding upon 15 dietary items; whereas the diet of *Secutor insidiator* constituted by more than 80% of plankton (zooplankton and phytoplankton) and the fish is reported as a pelagic surface feeder. Significant seasonal variation was observed in the prey types consumed by *Gazza minuta* but not in *Leiognathus brevirostris* and *Secutor insidiator*. Similarly, trophic spectrum of *Gazza minuta* and *Leiognathus brevirostris* showed significant ontogenetic variation which may be explained as a mean to reduce competition for food between juveniles and adults. However, *Secutor insidiator* did not show any significant change in the trophic spectrum as the fish grow in size.

*Gazza minuta* showed a reduced feeding intensity and feeding index during monsoon season, which can be explained due to active spawning of this fish along Kerala coast during monsoon season. Similarly, *Leiognathus brevirostris* exhibited significant seasonal variation in the feeding intensity with reduced feeding during active spawning period and intense feeding during pre and post spawning periods. However, *Leiognathus brevirostris* did not show any significant ontogenetic variation in feeding intensity. *Secutor insidiator* did not
show significant seasonal variation in the feeding intensity but exhibited a significant ontogenetic variation in the feeding intensity. Generally, three silverbelly species showed low feeding intensity and feeding indices during peak spawning season and active feeding after spawning. Gastroscopic indices of three species also followed the same pattern of fluctuation like feeding intensity and feeding index.

Earlier authors reported the co-existence of these three silverbelly species along with other species along Kerala coast which is further substantiated by their availability in the same trawl landings in the present study too. Hence comparative mouth morphology and diet overlap was studied in 3 species. The result indicated that, least protrusible, horizontally directed and widest mouth tube opening along with the presence of curved, sharp, canine teeth in both jaws, and very few gill rakers of Gazza minuta is designed to handle large and actively moving prey types like small fish and juvenile shrimps whereas, the highest degree of jaw protrusion in an upward direction, smallest mouth tube opening, small rudimentary teeth and greatest number of gill rakers in Secutor insidiator is associated with planktivorous diet. At the same time, intermediate degree of jaw protrusion in a downward direction, small weak and rudimentary teeth in Leiognathus brevirostris facilitates consumption of 50% plankton and almost equal proportion of benthos and other prey types.

Due to peculiarities in their mouth morphology, diet overlap study indicated only moderate and low level of dietary overlap between these silverbelly species. While considering the species pair, Leiognathus brevirostris and Gazza minuta, and Leiognathus brevirostris and Secutor insidiator, moderate
diet overlap was recorded whereas, for the species pair, *Gazza minuta* and *Secutor insidiator*, only a low degree of diet overlap was obtained.

**4.3 Length-weight relationship**

LWR equation was computed for three species of silverbellies. For *Leiognathus brevirostris*, males showed isometric growth and females showed positive allometric growth. Both sexes of *Gazza minuta* followed isometric growth of an ideal fish whereas males and females of *Secutor insidiator* showed positive allometric growth. Analysis of covariance revealed a significant difference in the ‘b’ estimates of males and females of *Gazza minuta* and *Secutor insidiator* which necessitated separate LWR equations for males and females in these two species. However, for *Leiognathus brevirostris*, a common LWR equation was computed as the difference in the ‘b’ estimates of males and females did not show significant difference.

Kn values of males and females of three silverbelly species showed a rise during the breeding season of the fish and fall during peak spawning period. Similarly, three silverbelly species showed higher condition in length groups which included maximum number of fish with mature and ripe gonads. Based on this observation, the condition of fish can be linked to gonad enlargement. Present also showed the role of good feeding environment in determining the condition of these 3 silverbelly species.

**4.4 Reproductive biology**

For the quantification of maturity stages of ovaries, five stage classification (immature, maturing mature, ripe and spent) was adopted for three silverbelly species; *Leiognathus brevirostris, Gazza minuta* and *Secutor insidiator*. Oocytes at various stages of maturity of *Secutor insidiator* were
studied histologically. *Leiognathus brevirostris* spawns twice in a year for a short period along Kerala coast (from February to April and from September to November). *Secutor insidiator* breeds two times in a year. One prolonged breeding season from May to September and a short breeding season from January to March. Unlike other two species, *Gazza minuta* breeds only once in a year but with prolonged duration (from April to October). In three species, Gonadosomatic index showed a hike during the breeding season of the fish. Highly significant (p =0.01) positive correlation was obtained between the mean oocyte diameter and gonadosomatic index in 3 species. Present study indicated that spawning of *Gazza minuta* and *Secutor insidiator* is correlated with south-west monsoon while spawning of *Leiognathus brevirostris* takes place during pre and post spawning months along the coast off Kerala.

The size at first maturity (50%) recorded for females of *Leiognathus brevirostris*, *Gazza minuta* and *Secutor insidiator* are 75 mm, 78 mm and 70 mm respectively. For the three species, the average absolute fecundity increased with increase in size of the fish. *Leiognathus brevirostris* and *Secutor insidiator* recorded almost similar average absolute fecundity whereas, *Gazza minuta* showed the highest fecundity among these 3 silverbelly species. Relative fecundity estimation showed a linear relationship between fecundity and variables like total length, body weight and ovary weight of fish in three species. In *Leiognathus brevirostris* and *Gazza minuta*, a good fit was obtained for log fecundity and log total length than with other two variables whereas, in *Secutor insidiator*, the best fit was obtained for fecundity and log body weight than other two variables. While multiple regression analysis indicated that, in *Leiognathus brevirostris* only total length contributed significantly to explaining the variance
in fecundity; in *Gazza minuta* both total length and in *Secutor insidiator* all three variables contributed significantly to explaining the variance in fecundity. Apart from these variables other factors such as age and/or environmental factors might contribute considerably to the variation in fecundity in these pony fish species.

### 4.5 Light organ and Sexual dimorphism

Light organ is a simple ‘gland like’ structure encircling the oesophagus in 2 species; *Secutor insidiator* and *Photopectoralis bindus* however, interspecific and intraspecific size and shape specificity were observed in them. Even though, general morphology of light organ was similar in these species, variation was observed in the size and shape of the light organ. In *Secutor insidiator*, it is more or less ‘dombbell shaped’ and in male *Photopectoralis bindus*, it is triangular shaped and in females light organ is circular in shape. Males of these 2 species exhibited hypertrophication of the dorsolateral lobe or lobes of the light organ owing to its enlarged size compared to conspecific females.

Sexual dimorphism was reported in *Photopectoralis bindus* in association with the internal dimorphic light organ. In males of this species, specific transparency was noticed at the pectoral fin base which is lacking in females. Sexual dimorphism was not observed in *Secutor insidiator* even though, light organ is dimorphic in sexes.

Synchronization in gonad and light organ development was noticed only in males of these two pony fish species. A significant positive correlation was obtained for monthly mean GSI (gonadosomatic index) and PLW (percentage light organ weight) only in males of 2 silverbelly species. Males of 2 species showed a significant difference in the mean PLW and significant difference in the mean GSI during various months grouped according to the breeding and non-
breeding seasons of the fish. However, there was no significant difference in the mean GSI and mean PLW of these silverbelly species belonging to different length groups. In females, there was no significant correlation between mean GSI and mean PLW during various months and does not show any significant difference between monthly mean GSI and monthly mean PLW. Similarly, only males at different stages of maturity of these two species exhibited a significant difference between the mean PLW; but not females. In females of these 2 species, light organ was a rather simple structure throughout the life which did not show any further enlargement in connection with the development of ovary during breeding season of fish. However, in males of these species, light organ clearly showed hypertrophication in size and weight in connection with the enlargement of gonads but irrespective of the length of the fish.
5.2. CONCLUSION

Present work is aimed to investigate the current systematic account of silverbellies distributed along the coast off Kerala apart from studying in detail some biological details of principal silverbelly species. Even though, silverbellies occupied an important position in the demersal fishery resource of our country, less attention is paid so far on a detailed biological research generally from west coast of India and specifically from Kerala coast. Hence the present study was undertaken.

Recently, many subgenera were elevated to generic status however, reports on this from Indian waters are still lacking. Hence, in the present study, 14 species of leiognathids collected during the study period was systematically arranged by preparing keys for genera and species by accepting only taxa names reported as valid by ‘Fish base online publication’. Morphometrics and meristics were worked for the description of each species.

Feeding ecology of three silverbelly species was studied and reached in a conclusion that, these three species have variously modified feeding apparatus for the consumption of various food items and showed low or moderate degree of overlap in their diet, facilitating their co-existing in the same coastal waters of Kerala. Moreover, it can be concluded that Gazza minuta functions in the marine ecosystem as a potential prey to many large piscivorus fishes at the same time it is a potential predator of many small pelagic fishes as well as juveniles and post larva of economically important shrimps species off Kerala coast. The other two species, mainly include a considerable quantity of plankton in their diet apart from some benthic prey types. Length - weight relationship study indicated an
interspecific and intraspecific variation in the growth pattern of *Leiognathus brevirostris*, *Gazza minuta* and *Secutor insidiator*. These three species showed relatively good condition round the year even though, there is a fall in condition during active spawning period of fish. From the reproductive biology study, we can reach in a conclusion that, while two species, *Gazza minuta* and *Secutor insidiator* spawn in association with S-W monsoon along Kerala coast; *Leiognathus brevirostris* spawns during pre and post monsoon periods. These fish have very good fecundity, breed almost throughout the year with one or two peaks for active spawning. They attained sexual maturity at a shorter length which may facilitate replenishment of their stocks. Light organ and sexual dimorphism study is the first of this kind from Kerala coast. Result of this study clearly proved the hypothesis that, light organ and gonad development correlated only in male pony fishes species; *Secutor insidiator* and *Photopectoralis bindus*. This finding further provided scientific evidence for the predicted reproductive role of male light organ in a shoal of fish which often contain more than one species and often inhabits turbid coastal waters with poor visibility for maintaining species fidelity and hence leading to reproductive success. This study would definitely help to continue further research in this field which awaits much exploration and scientific findings. Finally, it is suggested that, attention should be given to the migratory patterns and ecological features which determine the location and size of commercially exploitable leiognathid concentration. The leiognathid stocks, however, tend to be more rapidly reduced in size than the total demersal stock of the area where trawling activities are intense. This is probably due to the occurrence of bulk of these fishes in very shallow waters near estuaries and over muddy bottom. Such areas which often also yield good shrimp catches, generally
tend to attract an over proportionate number of trawlers and other gears. Hence proper management measures should be taken for protecting silverbelly stock from depletion.