Chapter 7

SUMMARY AND CONCLUSION

India is one of the 12 megadiverse countries of the world and supports 4 terrestrial biodiversity hotspots, highly biodiversity-rich, but endangered eco-regions (Myers et al., 2000). The coastline of India is about 7516.6 km long, with the mainland contributing 5422.6 km and the offshore islands contributing 2094 km (Andaman and Nicobar Islands: 1962 km; Lakshadweep Islands: 132 km) (Ahmad 1972; Kumar et al., 2006). The coastal area is divided into the west coast and the east coast. Both the coasts are significantly different in their geo-morphology. The Western coast of India is dominated by rocky shore habitat, while the east coast of India mostly has sandy beaches, mudflats, lagoons, and marshes. Crustaceans exist to the fourth-largest diversity, and they are the second most abundant diverse animal group on the planet. They abundantly inhabit the coastal marine environment. Gujarat is the western proximity of India and harbors the longest coastline of approximately 1650 km. The state's coastline is divided primarily into three coastal areas, *i.e.,* the Gulf of Kachchh, the Saurashtra coast, and the Gulf of Khambhat. The coastline of Gujarat encompasses almost all types of intertidal habitat, from hyper-saline estuaries, salt marsh, mudflats to sandy and rocky shores with every degree of exposure, and widely different profile. The subtidal habitats are equally diverse and rich.

Prawns and shrimps belong to Order Decapoda, infraorders Dendrobranchiata and Pleocyemata, respectively, and they are one of the most diverse and important groups of crustaceans. Prawns are the most significant food source with great economic importance as both capture and culture fisheries. Shrimps also have been attractive due to their great diversity throughout their evolutionary history and ornamental values.

Some species may not have commercial value but are important to form an integral part of the food web of the tropical marine system. The commercial marine species are generally found in shallow or moderately deep-water regions along the continental shelves at less than 100m depth, and some are found even at nearly 5700 m depth. Many shrimp species are pelagic, but most of the species are benthic, living on a variety of hard and soft substrates like rock, mud, sand, shell particles, or a mixture of these fragments, and some species are symbiotically associated with other marine organisms.

Prawns and shrimps are a highly important group of marine decapods, and so far, 4048 species belonging to 471 genera are reported globally (Grave and Fransen, 2011). In India, so far, 364 species belonging to 128 genera are reported (Samuel et al., 2016). The maximum number of species are reported from the East coast of India compared to the West coast. As compared to the other coastal states of India's western coast, the prawn and shrimp fauna of Gujarat is less studied in terms of intertidal species. In 2015, Trivedi et al. reviewed the literature available on the crustacean fauna of Gujarat and compiled a checklist. They have reported 30 species of prawns and shrimps belonging to 12 genera. It is noteworthy that all the earlier studies on the prawn fauna of Gujarat were focused on the commercial species (e.g., population study, stock assessment) as compared to the intertidal species. The landing centers of the Gulf of Kachchh and Saurashtra region are maximally explored compared to the other area. Only a few studies are carried out on the systematics of this group.

The present study of the taxonomy and systematics of marine prawns and shrimps revealed 52 species belonging to 27 genera and subgenera, 11 families, and 4 superfamilies. The taxonomic characters with the systematics for each family, genera, and species are elaborated in this chapter with the delicate line drawings and photographs.

- Among all the families recorded, family Penaeidae and Alpheidae were dominant in the study area.

- *Three species of shrimps of suborder* Pleocyemata like *Gilvossius rotundicaudatus, Alpheus chiragricus,* and *Athanas parvus* were recorded for the first time from India.
- *Microprosthema validum* know as a rock lobster, was the first time reported from India's West Coast.
- Three species of caridean shrimp *viz. Synalpheus coutierei*, *Thor amboinensis,* and *Procletes levicarina* were reported first time from the western coast of India
- In the present study, species like *Megokris granulosus, Megokris sedili, Parapenaeus fissuroides indicus, Solenocera choprai, Latreutes anoplonyx, Alpheus lobidens, Alpheus malabaricus, Alpheus edwadrsii, Alpheus pacificus, Lysmata vittata , Palaemon pacificus, Palaemon serrifer,* and *Cuapetes grandis* were first time reported from Gujarat.
- So, the present study adds three more species to the list of prawns and shrimps of India, 4 more species to the checklist of India's western coast, and 22 more species to the checklist of prawns and shrimp of Gujarat.

Information on species distribution and habitat preference of marine invertebrates is the fundamental requirement to understand the presence of different species in benthic communities, providing baseline information for successful conservation of the habitat and benthic fauna. Studies on the distribution and diversity of local fauna are of great importance because they lead to the best understanding of the local animal community's structure, function, and problems (Fransozo et al., 1992; Hebling et al., 1994). The major highlights and recommendations for future studies are listed below.

- The study is divided into three major regions based on the distinctive character and habitat variation.
- The maximum diversity was observed from the Saurashtra coast, followed by the Gulf of Kachchh and the Gulf of Khambhat. The Gulf of

Kachchh supports the growth of marine organisms, and it is considered one of the biologically most productive marine habitats.

- The habitat preferences and association of intertidal shrimp species were recorded and studied.
- *Alpheus lobidens* is a single species, which was reported from all the microhabitats except mangroves.
- *A. malabaricus* is a single species that was exclusively reported only from the mangrove habitat.
- The variation in the distribution pattern and abundance of organisms in different microhabitats of the intertidal area has provided the basis for so many ecological aspects, especially for the rocky intertidal organisms.

The morphometrical analysis was conducted using a truss network system on 28 Dendrobranchiata and 11 Pleocyemata shrimp species collected from the Gujarat coast during the present study. Fifty-one morphometric characters representing the carapace, thoracic appendages, and abdominal segments were used to derive the truss network system (morphometric matrix). In the taxonomical relationship of 28 shrimp of Dendrobranchiata based on morphometrical characters, the standardized size values of species were closely related to respective genera such as *Penaeus*, *Metapenaeus, Parapenaeopsis*, *Parapenaeus,* and *Solenocera* clearly explained the species relationship.

UPGMA cluster analysis showed *Metapenaeus* and *Parapenaeopsis* species came closely, whereas *Penaeus monodon* formed a separated clade. Morphometric relationships of penaeidae were congruent with the molecular and morphological classification of previous studies. Based on the results, it has been concluded that discriminant function analysis and cluster analysis proved to be an effective procedure for distinguishing and classifying species and describing the taxonomical relationship of penaeidae species. *P. penicillatus, P. japonicus, P. merguiensis,* and *P. cancaliculatus* came closely. Species belonging to the family solenoceridae

are close to each other, and they are not arranged in a single clade except one species *viz. S. choprai*. *P. indicus*, *P. merguiensis,* and *P. penicillatus* are morphologically similar, which was also supported by the cluster analysis. All the species belonging to the genus *Metapenaeus* came closely except three viz *M. kutchensis*, *M. moyebi,* and *M. dobsoni.* In the suborder pleocymeta, the UPGMA cluster analysis based on the morphometric traits does not work effectively. For this, we need a greater number of specimens of all the families that come under this group.

The phylogenetic study of Dendrobranchiata and Pleocymeta species was investigated based on COI gene sequencing analysis collected from the Gujarat coast during the present. DNA was successfully extracted from the 47 samples, and 42 samples were successfully amplified using the two different primers. The positive amplicon was sequenced, and a total of 42 species sequences were developed. The BLASTn analysis of all 42 sequences was performed and 70% of species matched with respective species available on the NCBI database. In addition, 6 sequences were obtained from the NCBI for the phylogenetic analysis. The phylogenetic analysis of Dendrobranchiata involved 28 nucleotide sequences (27 developed and 1 obtained). It is well supported. All the species level grouping within the genus *Alpheus* came under a subsequent clade that was strongly supported with high bootstrap value. The position of the family Alpheidae is closer to Hippolytidae. Based on the cladistic analysis, the taxonomy of Hippolytidae is not clear.

The standardized usage of mt COI gene sequences as DNA barcoding has emerged as an accurate tool for the rapid identification of various organisms providing high species resolution (e.g., Costa et al., 2007; Burns et al., 2008) and is increasingly used for the prawn identification (Mamatha et al., 2016; Subbaiya et al., 2017; Kundu et al., 2018). The use of the mitochondrial COI gene proves to be a useful technique in resolving long-standing problems in the identification of prawns. Morphological examination of cryptic species can lead to incorrect identification (e.g.,

genus *Alpheus*; on the other hand no misidentification occurs using DNA barcoding. The morphological examination approach overlooks morphologically cryptic species. The standard method described in this chapter can easily be applied and used anywhere else to identify prawns and shrimp. Our study presents the most comprehensive and robust molecular phylogenetic survey of Dendrobranchiata and Pleocymeta species to date from the Gujarat coast. It is also the first molecular phylogenetic study.

In the present study, the phylogenetic relationship of different genera *Penaeus*, *Metapenaeus*, *Parapenaeopsis*, *Penaeopsis,* and the other genera reported based on the molecular tool is congruent with cluster analysis. Thus, it could be concluded that molecular phylogeny using the mtCOI gene is more useful for phylogenic studies of Dendrobranchiata and Pleocymeta species than traditional morphometric study.