Chapter 2

Review of Literature
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REVIEW OF LITERATURE

2.1. Freshwater fish diversity

2.1.1. Global freshwater fish diversity

Freshwater fishes comprise until now almost 13,000 species or about 15,000 species if all species occurring from freshwater to brackish waters are included globally. All these freshwater fish species belong to some 170 families. In each continent, except Asia ichthyo-regions were identified. These regions or provinces are with a distinctive evolutionary history and hence more or less characteristic biota at the species level. There are 207 families of fresh and brackish water fishes at global scale (Leveque et al., 2008). About 121 families (34 primary and secondary division freshwater fishes and 87 peripheral) were recorded from inland waters of Asia (Lundberg et al., 2000) of which cypriniforms are the dominant groups followed by siluriformes. Knowledge of the fish fauna of tropical Asia is still in its exploratory phase particularly in India where ichthyofaunal survey is incomplete. Many fish species have still to be identified or to be discovered.

On Global scale, freshwater fish distribution pattern varies and each continent has a distinctive freshwater fish fauna (Berra, 2001), but most of the species belong to five taxa: Siluriformes, Cypriniformes, Characiformes, Perciformes and Cyprinodontiformes (Leveque et al., 2008). Siluriformes are by far the most widespread among primary freshwater groups and are found in North and South America, Africa, Europe and Asia. Whereas Perciformes and Cyprinodontiformes belonging to the secondary freshwater fishes are the most widespread and distributed in North and South America, Africa, Europe and Asia (Briggs, 2005). The Neotropical region is the richest in fish diversity with over 4,035 species in 705
genera and whereas Australia has the lowest fish diversity with about 261 species in 94 genera.

2.1.2. Freshwater fish diversity in India

A review of the previous studies conducted on the freshwater fishes of India in general is attempted. India is one of the mega biodiversity countries in the world with respect to freshwater fish fauna and occupies the ninth position in terms of freshwater mega biodiversity (Mittermeier and Mittermeier, 1997), eighth in the world and third in Asia (Kottelat and Whitten, 1996). There are 2,500 species of freshwater fishes recorded in the Indian subcontinent out of which 1570 are marine (Kar, 2003) and remaining 930 are categorized as freshwater species (Jayaram, 1999) which are distributed amongst approximately 20 orders, 100 families and 300 genera (Daniels, 2000).

Earlier studies on the ichthyofauna of India started with the pioneer works of some British officers who take much interest in the natural history of India. The great pioneers Lacepede (1800) followed by Bloch and Schneider (1801) contributed to the history ichthyological studies in India. The pioneer works of Hamilton-Buchanan (1822) and Day (1865-1889) paved the way for the subsequent studies conducted till date. Hamilton-Buchanan (1822) in The Fishes of Ganges” described 271 species of freshwater and stuarine fishes. McClelland (1839) an eminent ichthyologist published a detailed account of 138 cyprinids of India.

Day (1865-1889) most outstanding personality in the history of Indian ichthyology described 1340 species of freshwater and marine fishes in his book ‘The fishes of India’ which remains to be the most widely referred book by the ichthyologists in India and said to the Bible of Indian Fishes. Fishes of Inland waters of India were described by various fish taxonomists; Jerdon (1849), Day (1865 &

2.1.3. Freshwater fish diversity in Andhra Pradesh


Recent works of several authors documented the occurrence of freshwater fish fauna from different locations of Andhra Pradesh: Rao et al., (2011) documented the ichthyofauna of Pocharam and Wyra lakes of Andhra Pradesh. Rao et al., (2013, 2014) documented 63 fish species from river Champavathi at Vizianagaram district and 66 species from river Sarada at Visakhapatnam district respectively. They also identified the threats and suggested proper conservation measures for the conservation of fish diversity of the rivers. Ramulu and Banarjee (2013) reported the occurrence of 30 species from Nagaram tank, Warangal. Thirupathaiah et al., (2013) reported the
occurrence of 44 fish species from lower Manair reservoir from Karimnagar District. Reddy et al., (2013) reported 30 species of fish from Thummalapalle uranium mining.

2.1.4. Ichthyofaunal diversity of lake Kolleru

Ichthyofaunal studies on lake Kolleru was initiated by Chacko et al., (1952) who recorded 44 species of which only 25 are primarily freshwater species and the remaining are of marine origin. Murtyraju (1964) gave a detailed account of the fishermen and their socio-economic conditions along some preliminary observations on the fish and fisheries of the lake. A taxonomic account of the fishes of the genus *Cirrhinus* from the lake was given by Dutt and Murthy (1971). Murthy (1973) studied the taxonomy of the family cyprinidae and the biology of *Puntius sarana* from the lake. Dutt and Murthy (1976) made a comprehensive study on the fish and fisheries of lake Kolleru and recorded 52 fish species of which 40 are primarily freshwater species. A detailed taxonomic study on 18 species belonging to 11 genera from cyprinid fishes from lake Kolleru by Dutt and Murthy (1976) presented some remarks on some diagnostic characters. Dutt (1983) made a study on the capture fishery of Lake Kolleru reported 11 additional species from the lake and a status position was given and an approach document for the eco-development of the lake was proposed. Rao et al., (1987) reported 61 species of fish together with 12 prawn species. Luther Das et al., (2003) studied the catfish resources of the lake. Recent studies on ichthyofaunal diversity after restorations of the lake were initiated by Rao et al., (2013) and Raju et al., (2014), who reported 92 species of fish from the lake including their ecology, commercial importance and threat status.

Physico-chemical characteristics of the lake Kolleru were studied by various authors. Anjaneyulu (2003) discussed the various characteristics of water along with sediment features while Padmavathi and Durga Prasad (2003) made a comprehensive

2.2. Ornamental fishery status

Ornamental fish culture is an important commercial component of aquaculture providing aesthetic requirements and up-keeping of environment. Aquarium keeping of fish began in 1805. India’s share in the global ornamental fish industry is negligible. Growth is also insignificant compared to trade in food fishes. Much of the work on ornamental fish is confined only to the north eastern and coastal parts of the country. Recent investigations of various authors throughout the country are boosting up the industry (Table 1). Water bodies in India are richer with qualitative ornamental fishes in respect of their docile nature, characters suitable for domestication with fascinating, attractive and brilliant colouration (Table 2) and potentiality for developing techniques for captive breeding (Kumar et al., 2013). Even though ornamental fish are widely distributed in various parts of India (Table 3), no attempt has so far been done to introduce most of these species in the international market and securing positions in the national as well as international markets for which they deserve (DAHD, 2013).
The trade in ornamental fish has been increasing globally since 1985. The value of international trade has increased steadily, touching US$ 350 million in 2007. Developing nations contributed two third of the total export value (FAO, 2013). The wholesale value of the global ornamental fish trade is estimated to be US$ 1 billion while the retail value is US$ 6 billion. The entire industry, including accessories and fish feed, is estimated to be worth around US $ 18-20 billion. More than 2,500 species are traded and some 30-35 species of fresh water fish dominate the market. While more than 90 percent of freshwater fish are captive bred, only 25 out of nearly 8,000 marine ornamentals fishes are bred in captivity. The trade of ornamental fish with an annual growth rate of 8 percent offers a lot of scope for development of the sector (MPEDA, 2013). About 120 countries import ornamental fishes. The major importer is the EU, followed by North America and Japan. UK with 19% and Germany with 18% of the trade share are the major markets in EU. France, the Netherlands, Belgium, Spain and Italy are also among the major importers of ornamental fishes. USA is the largest player in North America with over 85% of the import share. Singapore is the largest exporter for many years and exports more than double that of the top five exporters for the last 2-3 decades. Singapore is regarded as a major trade hub in the region (FAO, 2013, MPEDA, 2013). As per the statistics of the Marine Product Export Development Authority (MPEDA) of India (2000-2001), India exports ornamental fish worth about Rs. 22.8 million, to Japan (24.1%), Singapore (20.2%), the USA (19.7%), China (10.5%), Germany (6.1 %), UK (4.4%), Taiwan (6.4%), Thailand (2.6%), Hong Kong (2.6%), Sri Lanka (1.3%), the Netherland (1.2%), France (0.8%), Bangladesh (0.8%), Belgium (0.7%), Malaysia (0.7%), Nepal (0.6%), Switzerland (0.2%), Finland (0.2%) and Maldives (0.1%). In the year 2009,
the Indian exported ornamental fishes valued at more than Rs. 50 million (MPEDA, 2013; DAHD, 2013).

2.3. Freshwater fish diversity and conservation

There is an increasing concern worldwide for the loss of aquatic ecosystems and associated biodiversity (Georges and Cottingham, 2002). Freshwater fishes, for example, may be the most threatened group of vertebrates on earth after amphibians and the global extinction rate of fishes is believed to be in excess of higher vertebrates (Bruton, 1995). However, conservatory measures to mitigate the impact of the pressures have not only been slow but also inadequate and as a result many of the aquatic species are declining rapidly. The main causes are habitat destruction and defragmentation, water abstraction, industries and private use (Dawson et al., 2003) exotic species introduction (Copp et al., 2005), pollution (Lima-Junior et al., 2006) and global climate change impacts (Leveque et al., 2005).

2.4. Biological control of mosquito larvae – larvivorous fish

Biological control refers to the introduction or manipulation of animals to suppress the population of vector. A wide range of organisms helps to regulate mosquito populations naturally through predation, parasitism and competition. As biological mosquito control agents, larvivorous fish (*i.e.*, those that feed on immature stages of mosquitoes) are being used extensively all over the world since the early 1900s (pre DDT era) (Raghavendra and Subba Rao, 2002).

According to Waage and Greathead (1988) selection of biological control agents should be based on their potential for unintended impacts, self-replicating capacity, climatic compatibility, and their capability to maintain very close interactions with target prey populations. Job (1940) explained the characteristic features of the larvivorous fish, According to him fish must be small, hardy and
capable of getting about easily in shallow waters among thick weeds where mosquitoes find suitable breeding grounds. They must breed freely and successfully in confined waters. Larvivorous fish should be surface feeders and carnivorous in habit and should have a predilection for mosquito larvae even in the presence of other food materials.

Hora and Mukherjee (1938) classified the larvivorous fish into the following categories: Typical surface feeders - *Aplochelius* and which fulfill the characteristic features of larvivorous fish; surface feeders – *Oryzias*, which are less efficient owing to their mode of life; sub-surface feeders – *Amblypharyngodon mola*, *Danio* and *Rasbora*; Column feeders - *Puntius* species, *Colisa*, *Chanda* and *Anabas* that feed on mosquito larvae when chance permits; Fry of carps and mullets, which are helpful in controlling mosquito larvae and Predatory fishes like *Channa*, *Notopterus* and *Mystus* whose fry may destroy mosquito larvae but whose adults may predate upon other fish including larvicidal fish species. Recognizing the high larvivorous potential of *Gambusia affinis*, it was purposely introduced from Southern USA to various countries in the world (Chandra *et al.*, 2008). Beginning in 1908, another larvivorous fish, *Poecilia reticulata* from South America was also introduced for malaria control into British India and many other countries (Raghavendra and Subba Rao, 2002).

*Gambusia* is a voracious and highly aggressive fish that compete with the native fish very successfully for viable food and space. *Gambusia* essentially depletes all large zooplankton while rotifers and phytoplankton densities increase (Hurlbert and Mulla 1981; Bence 1988). Both *Gambusia* and Guppy being invasive in nature (Rehage *et al.*, 2005; Manna *et al.*, 2008) may compete with the indigenous fish species as well as other aquatic organisms that use mosquito larvae as food.
In a list of studies related to the use of fish for mosquito control, as mentioned by Laird (1970), 719 studies had been carried out during 1901 - 1966. The genera of larvivorous fish studied for their efficacy to prey on mosquitoes include *Aplocheilus*, *Colisa*, *Chanda*, *Oryzias*, *Danio*, *Macropodus* and *Xenentodon* (Chandra et al., 2008).

Haq *et al.*, (1993) reported 24 species of larvivorous fish of which *Rasbora daniconius*, *Esomus danricus* and *Colisa fasciatus* are potential larvivorous and play a significant role in controlling mosquito breeding in Shajahanpur district of Uttar Pradesh. Sharma (1994) assessed the larvivorous capacity of six indigenous fish * viz. Puntius ticto, Colisa fasciatus, Aplocheilus panchax, Rasbora daniconius, Chanda nama* and *Esomus danricus* from Haryana. Das (2013) assessed the larvivorous efficiency of 5 native indigenous fish species from north India *viz. Mystus blekeri, Channa stewartii, Rasbora daniconius, Colisa fasciatus* and *Danio aequipinnatus*. Gupta and Banerjee (2013) compared the mosquito biocontrol efficiency of *Poecilia reticulata* and *Aplocheilus panchax*, two popular fish species which so far have been used for mosquito biocontrol here in India. Study of the predation efficiency in relation to fish size and larval size has revealed significant better predation efficiency of *Aplocheilus panchax* over *Poecilia reticulata* in all size groups. *Channa gachua*, commonly available snakehead fish is very efficient at mosquito larval control (Phukon and Biswas, 2011).

### 2.5. Nutritional efficiency of live feed in ornamental fish culture

As conventional feeds tend to become more expensive, it becomes attractive to explore and develop new resources which may hopefully be more cost effective (Sorgeloos and Leger, 1992). Live feed preferred in aquaculture because they are readily ingested and digested more easily (Watanabe *et al*., 1978). The presence of essential growth factors in live feeds promotes growth, high survival, conversion
efficiency and enhanced immune response (Awaiss, et al., 1992). Live feeds such as *Tubifex* sp. (Fischer, 1972), *Daphnia* sp. (Rasawo and Radul, 1986), *Moina* sp. (Alam et al., 1993), *Brachionus* sp. (Lim and Wong, 1997) and *Artemia* sp. (Baylon et al., 2004) have been used preferentially in ornamental fish production. Dependence on live food as starter feed rather than on formulated feed in fish makes it pertinent to evaluate the nutritional composition of live food in aquaculture (Srivastava et al., 2006). Larvae of all cultivable fish species require live planktonic organisms as first food (Garcia-Ortega et al., 1998). Live feeds are the rich sources of dietary nutrients like protein, amino acids, lipid, fatty acids, vitamins and enzymes (Evjemo et al., 2001). Thus the relative contributions of live feed in the nutrition of fish have immense significance (Jana and Chakrabarti, 1993). Despite the effort that has been put in the development of formulated starter feed (Verreth et al., 1987) for fish, live food still remains a better option in terms of survival and growth compared to formulated diet alone. Live food provides a good source of exogenous enzymes and also helps in chemoreception and visual stimuli (Kolkovski et al., 1995).

The early studies indicated that the use of *Artemia* as live food in fin fish and larviculture has been published by Leger et al., (1986), Sorgeloos et al., (2001). Live feed organisms with a thin exoskeleton and high water content may be more palatable to the fish when compared to the hard formulated diets (Stotrup and Mc Evoy, 2003). Bernice (1972) suggested that anostracans such as *Streptocephalus dichotomus* and *Branchinella kugenumansis* could be used as fish fed. According to Pandian, (1973), the growth of the consumer organism is directly linked with rich nutritional diet.

Fairy shrimps have the potential to be used as a feed item for fish such as ornamental fishes that benefit from live food (Prasath et al., 1994). Having considerable importance in aquaculture as live feed, the nutritional values of these
anostracan species were explored by several authors; Raymont et al., (1964, 1969 and 1977), Michael and Chandran (1967), Munuswamy and Subramanian, (1987), Simhachalam et al., (2009) and Velu and Munuswamy (2007). The potential of fairy shrimps as food for ornamental fish culture and freshwater aquaculture has been well documented by Velu and Munuswamy (2003, 2007), Munuswamy (2005) and Wipavee et al., (2012).


Carotenoids are essential for the colour of the ornamental fish. Fish cannot synthesize carotenoids directly, so they must acquire them directly from their diet (Katayema et al., 1972c; Torrissen and Christiansen 1995). Current sources of dietary carotenoids for aquaculture industry are shrimp and crab shell waste (Healy et al.,
1994), algal cultures (Lorentz and Cyseweski 2000), yeast fermentation (Jacobson et al., 2000) and chemical synthesis (Ernst 2002). *Streptocephalus dichotomus* is a promising new source of carotenoids for aquaculture industry and it also contains astaxanthin (30.17%), β-carotene (8.78%) and canthaxanthin (45.73%) as a dominant pigment in their body tissue (Velu and Munuswamy 2007).

Available fairy shrimp of Andhra Pradesh include *Streptocephalus dichotomus* Baird, 1860, *S. spinifer* Gurney, 1906, *S. simplex echinus* Bond, 1934 and *Branchinella kugenumaensis* (Ishikawa, 1894). They occur in fairly large numbers in monsoon and post monsoon seasons in the rocky pools and puddles and they were collected and used for biochemical studies and as live feed for ornamental fish.