Chapter II
REVIEW OF LITERATURE

Western Ghats, constituting the mountains along the west coast of the Indian Peninsula, is considered a biological hot spot (Myers, 1988; WCMC, 1998; CAMP, 1998) and these areas harbors over 30 percent of the total life forms, known from India. Several authors have described the richness of fish diversity and high endemcity of fish fauna in the Western Ghats system (Kottelat and Whitten, 1996; Subhash Chandran, 1997; Myers et al., 2000; Gopalakrishnan and Ponnaiah, 2000; Gopi, 2000; Ramadevi and Indra, 2000; Chandrashreekharai et al., 2000; Acharya and Iftekhar, 2000; Yadav, 2000; Arunachalam et al., 2000; Bhat, 2001, 2003, 2004; Ghosh and Ponniah, 2001; Dahanukar et al., 2004). Out of the 617 freshwater fish species identified in the country (Gopalakrishnan and Ponniah, 2000), over 287 are reported from the Western Ghats (Shaji et al., 2000) of which 207 is exclusively from the Kerala region (Gopi, 2000), which makes the region a ‘hotspot’ of fish biodiversity. The distribution of fish fauna in rivers of Kerala have been described by several authors (Shaji et al., 2000; Lal Mohan and Ramadevi, 2000; Ajith Kumar et al., 2000) and management strategies have also been emphasized (Kurup, 2000; Padmakumar et al., 2002). Gopalakrishnan and Ponniah (2000, 2000a) has made an extensive review of the endemic fish diversity of the Western Ghats and gave an elaborate account of the ornamental, sport and food fishes endemic to peninsular India.

2.1. Threats to Biodiversity

With increasing human interventions, habitat loss and degradation, freshwater fish biodiversity has been reported to be exposed to increasing pressures the world over (Mc Allister, 1999; Brautigam, 1999) and as a consequence many fish species have become extinct or are reported to be endangered. It is predicted that about half of the estimated 13.6 million species on earth may become extinct by the year 2050 unless appropriate measures are taken to save them (Myers, 1999; Wilson, 1992). Collares-Periera and Cowx (2004) has enumerated a wide array of factors that underlie the decline and extinction of many such species. Several authors (Pullin
1894; Lowe-McConnell, 1999; Narain, 2000; Kurup, 2000; Cowx, 2002) have elucidated details of a wide variety of anthropogenic disturbances that lead to disappearance of endemic species and these inter alia include species introductions, translocations, impoundment of rivers, habitat degradation, over exploitation and pollution.

Non sustainable utilization of water resources by multiple uses, overuse and destruction is a major factor that threaten the survival and existence of many native species. Despite the constitution of National Commission on Integrated Water Resources Development (Ghosh and Ponniah, 2001) entrusted with the task of integrated planning and utilization of the riverine systems, fish biodiversity in river systems in India is continued to be exposed to greater threats (Menon, 1988). Although India supports over 7 percent of the flora and 65 percent of the fauna globally, this diversity is fast disappearing (Narain, 2000) although the situation is altogether not less grave at the global level. According to IUCN (1996), 20 percent of freshwater fishes comprising around 10,000 species are threatened with extinction globally. Brautigam (1999) reported that over 39 percent of the freshwater fishes in US and 33 percent in Australia and 42 percent in Europe are extinct or at the risk of extinction.

There are a number of studies that shows that habitat alterations have affected native fishes in the Himalayan river systems (Shrestha, 1990; Sehegal, 1994). Maitland (1993) and Dhanze and Dhanze (1994) reported that damming of rivers and construction of reservoirs generally bring about conditions most unfavorable for rheophilic species owing to rapid changes in fast moving habitats in the uplands. Decline of Hilsa fishery in the upstream of Farakka barrage on the river Ganga, up to 83 to 98 percent, has been reported by Ghosh and Ponniah (2001). Adverse impact of damming on anadromous migration of Hilsa in the Cauvery and Godavary rivers has also been illustrated by Sunder Raj (1942) and Sreenivasan, (1976, 1977). All these authors implicate the unregulated development of dams in reducing flood plain breeding grounds of many commercial fishes. Dubey and Ahmad (1995) described in detail that dams and barrages have negative impact not only on many endemic and migratory food fishes such as Tor tor but also several small species such as Glyptothorax lonah, Nemacheilus dayi, Ompok pabda etc.
Singh (2000) reported the disappearance of *Puntius dubius*, a gravel spawner from Stanley reservoir in Tamil Nadu, due to smothering of breeding ground by fine silt. Disappearance of *Puntius carnaticus* from Trimoorthi and Amaravathi reservoirs have also been attributed to damming (Sreenivasan, 1976).

Jhingran (1989) and Dubey and Ahmad (1995) observed that thermal effluents and ash from power stations blanket rivers and bring about damages to the breeding grounds. Chatterjee and Sharma (1994) observed that in Sarni reservoir, indiscriminate discharge of effluents from the Satpuda thermal power station resulted in excessive growth of macrophytes which changed the reproductive cycle of fishes. Agriculture pesticides and industrial wastes invariably find their way to aquatic ecosystems and cause havoc to fish resources (Jhingran, 1990). Dubey and Ahmad (1995) observed that major carps in Gandhisagar reservoir, Madhya Pradesh and mahseer in Bhimtal and Naini Lakes have been the sufferers of rapid soil erosion that affected the benthos.

Several workers have shown that introduction of non native species to improve the diversity of fisheries is at great costs to indigenous species, and alien species introduced deliberately or unintentionally invade and out compete native species (McNeely, 1999). Invasion of exotic stocks in natural waters not only expose the endemic fishes to competition for food and space but also result in direct predation of native populations (Cowx, 1994; Hickley and Chare, 2004; Winfield and Durie, 2004) and this ultimately lead to endangerment of the native fauna (Chakraborty, 1996; Chandrashekharaiah et al., 2000). Jhingran (1989) observed that in Govindsagar reservoir, Madhya Pradesh, India, the landings of Catla, which stood at 28 percent in 1977-78 decreased to 6.8 percent by 1987-88 and silver carp, was observed to almost replace (80 percent) indigenous catla. Kurup and Ranjeet (2002) reported invasion of exotic fish species such as *Cyprinus carpio* and *Oreochromis mossambicus* in Periyar lake of the Western Ghats river system in Kerala, posing threat to several endemic fish species. The alarming penetration of *Clarias gariepinus* in the Yamuna, Sutlej, Godavari river systems and the urgent need to clean up these rivers has been highlighted by Sugunan (2002). Raghubanshi et al. (2005) observed that the threat to biodiversity due to invasive alien species is second only to that of habitat destruction. Cowx and Gerdeaux (2004) however, reported that risk of
introductions appear to be less when species are translocated within eco-regions or stocking of indigenous species.

Ghosh and Ponniah (2001) made an extensive review of issues involved in management of fish diversity and categorized the pressures on freshwater fish stocks principally into two types, 1) Factors within the sector and 2) Factors outside the sector. Disappearance of Mahseer *T.khudree* and *Acrossocheilus hexagonolepis* from Kaveri river system owing to habitat changes consequent to construction of Stanley and Bhavanisagar reservoirs has also been documented to be a case of habitat disturbance. Nutrient overload from terrestrial ecosystems due to increased agricultural activity often lead to eutrophication of water bodies causing havoc to aquatic flora and fauna including fishes (WRI, 1998). Modern biotechnology that commercialized genetically modified fish or transgenic fish capable of mating with wild fish is identified yet another potential threat to the diversity of wild population and gene pool (McNeely, 1999)

2.2. Vembanad Wetlands

Flood plain lakes which act as reservoirs for the large volume of water discharged by rivers during the monsoon are highly productive from fisheries point of view (Hoggarth *et al.*, 1999). Fish biodiversity in Vembanad wetlands, the largest floodplain wetlands on the west coast of India, down streams the major Western Ghat rivers has been studied by several workers. Although over 150 species of fishes belonging to 100 genera, under 56 families were reported earlier from this wetland (Kurup and Samuel, 1987), in later studies, only 38-40 commercially important fish species were encountered on the southern stretches constituting predominantly freshwater situations (Unnithan *et al.*,2001; Padmakumar *et al.*, 2002), which has been attributed to habitat disturbances and human interventions. The situation called for concerted efforts for conservation of the endangered species by habitat protection and recruitment promotion by *in situ* or *ex situ* conservation.

2.3. Conservation Management

The concept of fish conservation is known from time immemorial in India, King Asoka, 246 BC, have ordered prohibition of fishing during ‘Chathurmas’ (July
to September) based on their breeding periods (Menon 1988). The Indian Fisheries Act 1897, prohibits destructive fishing methods such as dynamiting, poisoning etc to conserve living aquatic resources several Acts have been promulgated *inter alia*, the Water (Prevention and Control of Pollution) Act, 1974; CESS Act, 1977; the Wildlife Protection Act 1972; the Environmental Protection Act, 1986 and the Insecticides and Pesticides Act 1968 (Dubey and Ahmad, 1995). However, we are yet to awaken to issues and challenges of biodiversity conservation, and holistic approach is still lacking.

Cowx and Gerdeaux (2004) made an extensive review of the management practices for biodiversity conservation and identified fish stock enhancement, rehabilitation and habitat management as the principal mechanisms for inland fisheries management, apart from regulation in fishing. Ghosh and Ponniah (2001) made a review of freshwater fish habitat management in India and observed that inland fishery management has not been generally attempted seriously by any developmental agencies, as it involved both living aquatic and terrestrial ecosystems management. However, lately, *in situ* and *ex situ* conservation of biodiversity have become key areas of research world wide, after the convening of the International Workshop by ICLARM (1992) on aquatic germplasm conservation. Nevertheless, successful programmes targeting conservation of freshwater fishes are meager, except for isolated examples as in the case of salmon, *Salmo salar* (Cowx, 1996).

Global efforts on biodiversity conservation (CBD, 1994) on a sustainable basis got initiated with the adoption of the resolution in the Biodiversity Convention in the Earth Summit, 1992, in Rio de Generio. Collares-Periera and Cowx (2004) in a recent review on efforts on conservation of fish biodiversity observed that fish species that are threatened far exceeds most other vertebrate classes. In the context that too many species are now in need of immediate intervention, Cowx and Collares-Periera (2002) highlighted the urgent need for research on basic ecology of the species, so as to generate the best available information to develop conservation programs.

2.4. Ranching and Stock Enhancement

Possibility of ranching of hatchery reared seeds in conservation management of commercial fishery has been studied by several authors (Kulkarni and Ogale, 1979;
Schegal, 1991; Kurup, 1993, 2001a; Ogale, 2002; Padmakumar et al., 2002; Naryani and Tamot, 2002). Most of these studies point to a compromise between maximum biodiversity and maximum productivity for rehabilitation fisheries. And there is no difference of opinion that fish conservation programs in riverine systems should focus also on reinstating lateral and longitudinal connectivity, habitat diversity and flow regimes. Juradja et al. (2004) elucidated that in lowland floodplain areas, reconnection of backwaters with adjacent ecosystems which represent valuable spawning and nursery habitats is integral help to increase species richness and fish abundance.

While the dwindling supply of popular food fishes is a matter of public concern, conservation of fish fauna and habitat is a scientific concern. According to Ghosh and Ponniah, (2001), lack of species specific data on breeding and habitat requirement of endangered fishes is a stumbling block in formulating species specific recovery programme. Cowx and Gerdeaux (2004) highlighted the essential need for baseline studies to elucidate the imbalances in riverine systems and catchments in order to evolve valid measures for species rehabilitation. Garg et al. (1998) emphasized the importance of studies on mapping and inventory of wetlands using remote sensing satellite data. Srivastava et al. (2001) reported findings on investigations on a GIS platform to arrive at optimum habitat requirement of Tor putitora in Himalayan hill streams.

Pushpangadan and Nair (2001) illustrated that knowledge on diversity, distribution ecology, biology, and conservation and utilization prospects of diverse species is most essential for sustainable management of endemic biodiversity. Studies of habitat requirements and breeding grounds of Indian fishes are very few and most of the studies on Indian freshwater habitats were focused on water quality parameters. However, community ecology of fish fauna in the streams and rivers of Western Ghats have been studied extensively by some authors (Arunachalam et al., 1997; Arunachalam, 2000). Information on microhabitat usage by juvenile and adult cyprinids in stream pools of south Indian river, Kallar was elucidated by Arunachalam et al. (1997a)
The science of biodiversity conservation of freshwater fish fauna in India is only nascent. Kapoor et al. (2000) has brought out a database on fish biodiversity in India. Efforts on biodiversity conservation in hotspot locations in Western Ghats and North East India have been documented lately in a series of investigations under the National Agricultural Technology Project (Mercy et al., 2002; Kurup et al., 2003; Padmakumar et al., 2004a; Singh et al., 2005, 2005a,b,c; Gopalakrishnan et al., 2006). Studies on spawning and habitat requirement of golden Mahseer Tor putitora have been carried out by Shrestha (1997) and that of Chocolate mahseer by Ghosh (1996). The spawning and feeding habitat of Indian fishes was described by Jhingran (1968) and Mitra (1968). Bhat (2004) made investigations on the community ecology of freshwater fishes in four river systems in the central Western Ghats of India and analyzed the patterns of fish species distribution with reference to substratum type and environmental parameters. The functional role of riparian vegetation in determining the hydrological regime and source of organic nutrients has also been studied (Lowe-McConnell, 1975). Kondolf and Wolman (1993) indicated that composition of the spawning ground substratum is one of the key factors determining the success of natural spawning.

Species richness is invariably dependent on physical factors such as habitat diversity (Gorman & Karr, 1978). Obordoff et al. (1995) observed that the surface area of the drainage basin of the river, the annual river discharge and net primary productivity are important factors influencing fish species richness. Several workers have demonstrated that community diversity is linked to vegetation complexity (Mac Arthur, 1964; Pianka, 1967; Rosenweig and Winaker, 1969).

2.5. Biological Attributes for Conservation

Ponniah and Lal (2000); Sarkar et al. (2000) and Natarajan and Aravindan (2000) highlighted the utility of life history parameters in conservation management and genetic upgradation of endemic fish fauna. Sarkar et al. (2002) reviewed the significance of studies on life history traits for fish biodiversity conservation and observed that variations in life history traits of fish populations indicates the phenotypic plasticity of the species. Poncin and Philippart (2002) showed that paucity
of information on general biology and in particular reproductive characteristics is a major problem for artificial propagation of fishes.

Ponniah and Lal (2000) observed that variations in reproduction, growth and other life history fitness traits are crucial for the long term viability of the fish species. Such information is also important and indispensable for understanding basic biology or planning conservation and management of a species (Sarkar et al., 2002). Scott et al. (2005) pointed out that captive breeding is an important and potentially effective tool for conservation biologists and this require sound knowledge on biological attributes of the species. Several authors have indicated that detailed knowledge of reproductive biology and specific habitat requirement are the crucial factors for reproductive manipulation and captive breeding of fishes (Seth, 2001; Singh, 2001; Maitland, 2004; Rutaisire and Booth, 2005).

Several studies have demonstrated that rearing conditions and brood stock management practices have direct bearing on breeding fitness. Broodstock management strategies for captive fishes have been studied by several authors (Lee, 1979; Bautista et al., 1988, Ridha and Cruz, 1989; Little et al., 1993; Ridha, 2004). Padmakumar (2001) reviewed the broodfish management practices for captive breeding of endemic food fish species. Haniffa et al. (2001) and Mercy (2001) gave an account of the optimum rearing conditions for artificial propagation of catfishes and ornamental fishes respectively.

Lehtonen (1987) reported that size at maturity show wide variations between populations and this is linked to differences in growth rate. Similarly, Craig (1987) observed that fecundity is also linked to food supply. And Shlumberger and Proteau (1991) demonstrated that under good food condition GSI can reach as high as 22 percent directly before spawning (Maitland, 2004; Rutaisire and Booth, 2005).

Studies on the breeding biology of Indian fishes are many (Desai, 1973; Sobhana and Nair, 1974; Thakare and Bapat, 1981; Singh et al., 1985; Kurup, 1994). Vasudevappa and James (1980); Ramakrishniah (2000) and Thapliyal and Dobriyal (2003) made investigations on biological aspects of catfishes endemic to Peninsular India. Ayyappan et al. (2001) highlighted the essential need for development of standardized hatchery technology for E. suratensis, as it possess all
essential traits for a food fish species in the coastal states of India. Distribution and abundance of *E. suratensis*, a cichlid endemic to peninsular India and Sri Lanka has been reported by several authors (Munro, 1955; Jhingran and Natarajan, 1969; Fernando and Indrasena, 1969; Ward and Wyman, 1975; De Silva and Fernando, 1983; Chandrasoma, 1986; Amarasinghe and Samarakoon, 1988; Sultana et al, 1995; Unnithan et al, 2001; Padmakumar et al, 2002). The biological attributes of *Etroplus* in diverse ecosystems has also been extensively studied by various authors (Menon and Chacko, 1956; Alikunhi, 1957; Hora and Pillai, 1962; Jhingran and Natarajan, 1969; Prasadam, 1971; Devraj et al., 1975; Sundararaj and Krishnamurthy, 1975; Jayaprakash, 1980; De Silva et al., 1984; Jayaprakas and Padmanabhan, 1985; Keshava et al., 1988a; Ushakumari and Aravindan, 1992). Although, extensive investigations on various aspects of the breeding biology of pearl spots have also been undertaken (Prasadam, 1971; Thampy, 1980; Jayaprakas and Nair, 1981; Raju et al., 1987; Sumitra Vijayaraghavan et al., 1981; Krishnan and Diwan, 1990) utilization of these information for captive breeding has rarely been accomplished. Studies on the breeding of *H. brachysoma* have not been attempted earlier except for some recent studies on reproductive biology (Kurian and Inasu, 2003; Chandran and Prasad, 2006).

2.6. Captive Breeding Protocols

2.6.1. Breeding through Environmental Manipulation

Captive breeding of fishes through manipulation of environment such as temperature and photoperiod have been attempted by several workers (Behrends, 1983; Brummett, 1995; Ridha and Cruz, 1998). Garg (2001) made an extensive review on the environmental manipulation techniques for captive breeding among fishes. One of the major difficulties in captive spawning of fishes is the lack of information on triggers that are crucial for successful reproduction. Luling (1971) demonstrated that decrease in conductivity, increase in pH and alkalinity are some of the spawning cues among fishes. Most of the fishes reproduce in rainy season when the water level rises and the food supply is abundant (Lowe-McConnell, 1975). Lam (1983) concluded that manipulation of environmental conditions can induce the timing of spawning among many fishes. Changes in day lengths and temperature
were identified to be the most important environmental cues that affect the timing of gonad maturation and onset of spawning in temperate species (Bromage and Roberts, 1995; Bromage et al., 2001; Migaud et al., 2006).

Breeding of fishes through environmental manipulation has been shown to be a reliable method. Kunjvankij and Suthemechaikul (1986) demonstrated artificial spawning of sea bass *Lates calcarifer* by manipulation of salinity, water depth and temperature avoiding the use of expensive hormones can reduce stress for the fish. Poncin (1989) showed that *Barbus barbus*, the common barbell in Belgium waters could spawn up to 15 times per year at high thermal regimes by increasing photoperiod in contrast to single late spring spawning in nature. Ramnarine (1995) observed that in armoured catfish *Hoplosternum littorale*, a seasonal breeder, in freshwater swamps, spawning can be induced by reducing conductivity of the water.

Reproductive behavior in cichlids have been a subject of extensive investigation by several authors (Lowe-McConnell, 1959, 1991; Barlow, 1964; Fryer and Iles, 1972; Keenleyside, 1979; Peters and Berns, 1982; Noakes and Balon, 1982; Huntingford, 1986) and some of these studies indicate that these fishes could be categorized into substrate brooders and mouth brooders, or as guarders and bearers. Jalabert and Zohar (1982) observed that spawning of tilapia in high latitudes is seasonal and coincides with periods of highest temperature and light intensity.

Breeding behavior of *E. suratensis* has also been a subject of investigation for many workers (Panikkar, 1924; Jones, 1937; Ganapati et al., 1950, Alikunhi, 1957; Hora and Pillay, 1962; Ward and Wyman, 1975, 1977; Kowtal, 1976; Jayapratik, 1980; Ward and Samarakoon, 1981; Samarakoon, 1981, 1983, 1985; De Silva et al., 1984). Samarakoon (1985) reported that induced spawning of *E. suratensis* in captivity is difficult owing to the complex parental behaviour characteristic to this species.

Harahap et al. (2001) elucidated histological evidences for lunar synchronized ovarian development and spawning, during the new moon phase in *Synganus spinus*, in the Okinawan waters. These authors have also demonstrated that such a tidal rhythm is not the cue for synchronized spawning in confinement. Bryan et al. (1975) and Hasse et al. (1977) have earlier shown that an allied species of *Synganus* spawn
around the time of the first lunar quarter while *S. canaliculatus* spawn 4-7 days after the new moon. However, the type of cue that the fish recognizes in such situations is not known. Almatar *et al.*(2004) demonstrated lunar spawning activity in silver pomfret, *Pampus argenteus* and the spawning was indicated to be concentrated during the first and third quarters of the moon period.

### 2.6.2. Induced Breeding by Hormonal Manipulation

**Ompok bimaculatus** (Sridhar *et al*., 1998) **Ompok malabaricus** (Haniffa *et al*., 2001), **Ompok pabo** (Mukherjee and Das, 2001) have been accomplished and documented.

Embryonic and larval development of teleost fishes have also been studied extensively by several authors (Chakrabarty and Murty, 1972; Nair, 1999; Kurup, 2001; Liang *et al*., 2003; Bascinar, 2004). Although observations on the embryonic and larval development of catfishes (Thakur, 1980; Legendre and Teugels, 1991; Watanabe, 1994; Da Costa *et al*., 1996 and Rahman *et al*., 2004) and cichlids (Raj, 1916; Panikkar, 1920; Jones, 1937; Varghese, 1976; Padmanabhan and Aravindan, 1976) have been attempted by several authors, detailed investigations are rare. Noakes (1991) gave a detailed review of developmental stages, hatching, feeding and social behaviour, parental-young interactions *etc* in cichlids larvae.

### 2.7. Parental Care Behaviour

Wyman and Ward (1972) and Ribbink *et al*., (1981) reported parental care behaviour of substratum spawning cichlids and described their fascinating behaviour of co-operative care of young. Lee (1979); Peters (1983) and Watanabe and Kuo (1985) evaluated the parental care in cichlid fishes and observed that parental behavior suppresses the expression of the reproductive potential, as it increases the interval between two spawning. Fryer and Iles (1972) studied the parental care behaviour in cichlids and observed that cichlids exhibit both uniparental and biparental care and biparental cichlids are usually substrate guarders. Blumert (1982) however observed that biparental care is confined to only 5-6 percent of fish families and vast majority of catfishes exercise no parental care and belongs to the egg scattering or brood hiding type. Fishelson and Heinrich, (1963) probed the parental care behavior in cichlids and observed that the care pattern include male-only, female-only or biparental, in the same population. Keenleyside (1991) illustrated mating systems and parental care behaviour among cichlids. Barlow (1991) traced the evolution of mating system in cichlid fishes from monogamy to biparental care and to polygamy with maternal care. Balshine-Earn (1997) observed that a fish that shows parental care, not only protect the eggs against predation but also aerate the eggs and this promote the growth and development of the offspring.
Leatherland et al. (1992) reported that the cyclic changes in lunar and semilunar phenomenon such as tidal rhythm, intensity of moonlight, time of moon rise, in relation to solar cycle etc influence breeding periodicity in fishes and this they ascribed to subtle alterations in earth’s geophysical forces. Hoque et al. (1999) in a similar study highlighted that rabbit fish *Synganus canaliculatus*, exhibit a lunar periodicity in spawning and breeds 4 days after the new moon during May and June.

2.8. Inbreeding- Precaution Measures

Eknath and Doyle (1990) reported that one of the major problems identified in seed production using captive brood stocks is the problem of inbreeding with negative consequences on released stock especially when small broodstock populations are utilized. These authors therefore demonstrated inbreeding depression, ranging from 2-17 percent in one year among Indian Major Carps in such situations. Bhujel (2000) evaluated strategies for broodstock management with reference to stocking density, sex ratio, brood stock exchange and frequency of seed removal, that can be adopted successfully to overcome this problem (Lee, 1979; Bautista *et al.*, 1988; Ridha and Cruz, 1989; Little *et al.*, 1993; Basavaraju, 2001; Ridha, 2004; Garber and Sullivan, 2006). Meuwissen and Woolliams (1994) therefore suggested that a minimum of 25 to 250 effective or actual breeders should be selected for captive breeding in order to keep rates of inbreeding at approximately 1 percent per generation.

2.9. Habitat Management

There is a strong view that stock enhancement activities through ranching are only short term solutions for fishery management. Collares-Periera and Cowx (2004), therefore underlined the need for simultaneous programs on habitat rehabilitation which calls for a more intimate knowledge on biological, environmental and social issues that affect fish and fisheries.

Kapetsky and Bartley (1995) observed that protected areas can not only lead to increase in yield from fisheries but also enhance diversity of fishes. Jurajda *et al.* (2004) emphasized the need for reinstatement of shoreline habitat and riparian vegetations for promoting fishery recruitment. Pandey and Singh (2001) reported that
fish sanctuaries and parks provide protection and permit natural reproduction of threatened species. Alcala (1988) observed that in Philippines, a significant increase in overall fish abundance could be achieved almost within one year, the establishment of protected areas. Mann et al. (1995) however argued that protected areas are highly beneficial in regions where local fishing pressure is especially high. He attributed this, to the recruitment promotion facilitated in the natural habitats. Lauck et al. (1998) concluded that protected areas are far more effective than enforcing fishery limits. Padmakumar et al. (2002) elucidated increased catches of *E. suratensis* to local fishers with the development of an engineered fish sanctuary in Vembanad lake, India. Noble et al. (2004) elucidated that habitat management and designation of nature reserves can enhance fish population abundance with positive effects on other biota as well. Cowx and Welcomme (1998) however, emphasized the essential need for reinstating longitudinal connectivity and improving water quality for rehabilitation of riverine species. Pullin (1993) demonstrated that *ex situ* conservation although expensive can also be a useful tool that can complement *in situ* efforts.

### 2.10. Holistic Management

Collares-Periera et al. (2002) observed that traditional methods of conservation management such as regulation of exploitation, designation of nature reserves, captive breeding programmes etc., are not very effective for freshwater fishery management. This, they attributed to consideration of fish communities in isolation and not on a wider ecosystem approach. Cowx and Collares-Periera (2002) emphasized that holistic strategies on conservation management by accounting for stakeholder activities within the catchments can only ensure effective preservation of targeted species. All these studies emphasizes the need for identifying mechanisms to overcome the bottlenecks to natural recruitment. Cambray & Pister (2002) observed that involvement of people is a major factor that can ensure the success of conservation projects. Cowx (1998) suggested an integrated approach to aquatic resource management and emphasized that the increasing pressure on aquatic resources dictate that fish conservation can no longer be treated in isolation. Cowx and Gerdeaux (2004) emphasized that fisheries rehabilitation should essentially promote and recreate functional habitats and environmental quality.
Kutty (1999) observed that the Index of Biodiversity in India is quite low and there is an urgent need for incorporation of endemic fishes having good culture potential for aquaculture systems. Although India is considered basically a carp country (Ayyappan et al., 2001), endemic fishes are preferred as a commodity. And, the demand for such species is attributed not only to its specific taste and local preferences but also to their tolerance to survive in local situations such as shallow depths, low oxygen concentration and high turbidity (Moreau, 1988). In spite of a good net work of R&D establishments, national and international, our achievements in biodiversity research are painfully inadequate and this is largely attributed to lack of co-ordinated and integrated efforts of systematic to conservation ecologists and biotechnologist (Pushpangadan and Nair, 2001). Colborl et al. (1996) cautioned the picture of a grim future for mankind if we loose further time in restoring the harmony between human kind and nature. Global Biodiversity Assessment (UNEP, 1995) has warned that unless action is taken to protect biodiversity, we will lose for ever the opportunity of reaping its full potential benefits to human kind. Swaminathan (2000) underlined that sustainable use and equitable sharing of benefits can only result in true management and suggested the involvement of local communities for sustainable management of resources. Despite high biodiversity strength, very little of naturally occurring species are directly exploited by human kind (Wilson, 1992). All these observations underline that unless livelihood security of the people living on a resource are strengthened, sustainable exploitation of biological resources is impossible. The present study on life history traits and captive breeding of *Etroplus suratensis* and *Horabagrus brachysoma*, assumes significance in the context of the unique approach adopted *i.e.*, technology generation for conservation and utilization.