CHAPTER ONE

INTRODUCTION AND REVIEW OF LITERATURE
1.0 Introduction and review of literature

India apart from possessing rich mangrove areas, is a land of rivers, reservoirs, lakes, tanks and ponds and hence abounds in rich and diverse freshwater resources of the wetland type. The total water spread area is about 4.5 million hectares (Srivastava et al., 1985) of which inland aquaculture resources cover about 3 million hectares (Mathew, 1975; Belsare, 1982; Jhingran, 1982). These include about 0.72 million hectares of natural lakes and 2.0 million hectares of man made reservoirs. The seasonal and perennial tanks in peninsular India cover an area of 2,75,000 hectares (Jhingran, 1988). Although the national policy for aquaculture lays emphasis on optimal utilization of natural inland water resources (George and Sinha, 1975), a significant part of the inland water resource has remained either unutilised or underutilised (Mathew, 1975).

The state of Karnataka has over 2,187 perennial and 29,588 seasonal tanks with a total waterspread area of 2,96,316 hectares (David et al., 1974). The average annual fish yield from these tanks has been estimated to be 198 kg fish ha⁻¹ yr⁻¹ (Jhingran, 1988) which is well below the suggested production 800 kg ha⁻¹ of fish yr⁻¹. This low production has been attributed to the paucity of information on the ecological conditions and biotic features particularly that of plankton of the habitats.

Studies on 'plankton' and 'limnology' the science of
freshwater have become inseparable from one another. No limnological investigation of a lake and of its "production biology" is possible without proper consideration being given to plankton studies (Thienemann, 1954). Since plankton forms the "first link", in the food chain (Davis, 1955; Colebrook, 1972; Singh and Swarup, 1979; Purushothama, 1985; Chakrapani, 1989), an insight into the distribution, composition and succession of plankton in perennial freshwater habitats, provide valuable clues for determining the fishery grounds, selection of suitable species for stocking and estimating the level of utilization of the available food by the existing stock of fishes (Almazon and Boyd, 1978; Sugunan, 1980). A historical resume has been presented by Michael (1980) and the status of science of limnology has been discussed by Gulati and Schulz (1980). From these excellent reviews, it is evident that the work on limnology of freshwater impoundments in India portray either (i) momentary pictures of physical chemical and biological conditions of water during a day or two or for a few months or (ii) mere records of the occurrence of one or other individual organisms without much descriptions of the habitat features and the relative importance of the environmental factors over these biotic forms. Thus, there are more papers on classical limnology than on limnology in relation to plankton or fisheries. In every habitat, the two aspects viz., "structure" ascribing to the available nutrient resources and the varied biotic components and function, comprising the eco-dynamics and eco-energetics of the system cannot be delinked (Chakrapani,
1989). Hence, understanding the ecological features and conditions of freshwater habitats is an essential prerequisite for developing programmed intensive culture of freshwater fishes in tanks to achieve optimal yield (Pillay and Dill, 1979; Daubner, 1979).


The importance of bottom sediments as nutrient reservoirs of aquatic habitats has been stressed from time to time (Mortimer, 1971; Hendricks and Silvey, 1973; Jhingran, 1982). However, review of literature indicates that information concerning the physico-
chemical characteristics of bottom sediments of Indian freshwater habitats particularly those of fish ponds are fragmentary.

Zooplankton which occupy the first secondary trophic level in the food chain of aquatic environments, play a dominant role in consuming the food synthesised by the phytoplankton and transferring it to higher trophic levels. Further, as a result of their position in the food web and rapid excretion rates, zooplankton are important in the cycling of nutrients within the lake ecosystems and contribute a substantial fraction of the phytoplankton requirement (Rigler, 1973). Protozoans, rotifers and crustaceans form the dominant components of zooplankton community. In India work on the distribution, abundance and production in lakes and ponds have been covered from time to time (Ganapati, 1943; Michael, 1968a; Sumitra Vijayaraghavan, 1970; Shirgur, 1971; Victor and Michael 1975; Murugan, 1976; Prabhakar et al., 1976; Yosuf and Quadri, 1981, 1983; Chakrapani, 1989. Appreciating the studies carried out so far, it is apparent that studies on zooplankton dynamics in fish ponds in relation to limnology are lacking in Karnataka in general and Bangalore in particular. In Bangalore district alone there are 1793 tanks with a total waterspread area of 22,628 hectares. These water bodies are known to harbour several species of fishes and prawns (Nagendran, 1980; Rao et al., 1982; Anantha Raman et al., 1986). Ayyappan (1987) has described the diversity of bacterial populations and water quality of a few freshwater habitats located in and around Bangalore.
Similarly Chakrapani (1989) has detailed the occurrence and distribution of plankton in the seasonal and perennial tanks of Bangalore district, while Sukumaran (1990) has studied the plankton dynamics in a freshwater tank in Bangalore. There is paucity of information on the dynamics of zooplankton in fish ponds. In the wake of rapid urban expansion, development and industrialisation, the existence of numerous freshwater habitats (particularly tanks) are seriously threatened in and around Bangalore. The problems of eutrophication of freshwater habitats have also increased tremendously and therefore studies on zooplankton dynamics in fish ponds may to some extent ameliorate the needs to tackle these problems. Further, such studies would also provide information to select the candidate species of zooplankter for mass production.

Earlier work on tropical lakes has projected the importance of diel cycles in the economy of a water body (Talling, 1957; Moriarty et al., 1973; Ganf and Blazka, 1974; Garf, 1974; Ganf and Horne, 1975; Lewis, 1979; Duncan and Gulati, 1983). To understand the thermal regime, nutrient chemistry, zooplankton dynamics and feeding habits of fishes, diel studies are of fundamental importance. These studies throw light on the causes for fish mortality in fish ponds/tanks. While work on diel studies in freshwater tanks and reservoirs of India are reported from time to time (Ganapati, 1955; George, 1961; Verma, 1973; Kant and Kachroo 1975; Anon, 1977; Nasar, 1977; Singh et al., 1980; Pant et
only few have attempted diel studies in fish ponds (George, 1966; Khan and Siddiqui, 1971; Malhotra et al., 1984).

The demand for animal protein has led to new developments in aquaculture. Thus, the present day aquaculture has become one of the important components of biotechnology. Feed and seed (fish larvae) are the two major requirements for promoting successful aquaculture. Considerable progress has been achieved in fish larvae production (Jhingran and Pullin, 1985; Jhingran, 1982). To augment flesh production of fish, research on the production of sterile fish is also under progress (see Pandian, 1988). However, the large scale production of fish larvae has not apparently resulted in large scale availability of fry in stocking ponds due to the mass mortality caused by the non availability of suitable feed during the first few days. In nursery ponds, carp larval mortalities range from 70-80% (Jhingran, 1982; Sarma, 1991). This suggests that the major drawback in the fish culture practices in India, is not the production of viable larvae/fry but the production and supply of suitable live food organisms. Hence, the nutritional requirements of fishes have created immense biological interest because of their application in resource management (Halver, 1972; Millikin, 1982; Cowey and Tacon, 1983). In nature, fish are able to procure food of suitable quality and quantity for survival, growth and reproduction, but as soon as they are propagated for captive farming, there is a necessity to supply feed of suitable quality and quantity (Pitcher and Hart, 1982;
While considerable success has been achieved in the development of artificial feeds for temperate species (Cowey et al., 1972; Cho et al., 1976; Hsu and Wu, 1979; Webber and Nouguenin, 1979; Hilten and Slinger, 1981; Jackson et al., 1982; Hilton et al., 1983, Tacon et al., 1983), in the developing countries, particularly in India, formulation of feed has become a major source of cost in fish farming practices. Hence, in India compounded/formulated diets find limited use during culture practices and largely fish farming is economised by the use of natural fish food organisms.

In any aquatic habitat, among the zooplankton community, rotifers, cladocerans and copepods are considered to be the most important groups in terms of density, biomass, production, grazing and nutrient regeneration (Pace and Orcutt, 1981).

Rotifers, commonly known as wheel animalcules are the most important soft bodied invertebrates constituting the third major group of the freshwater zooplankton (Haque et al., 1988). In recent years, the steady increase in rotifer research has largely been due to (a) their importance in aquaculture as larval food of fishes and crustaceans and (b) their role in ecotoxicology. Rotifers are described as indicators of trophic status and pollution (Datta and Bandyopadhyay, 1985). A survey of literature on rotifers of India indicate that, from time to time papers on the distribution and taxonomy (Arora, 1966; Nayar, 1968, Nair 1972; Sharma and Michael, 1980; Sharma, 1983; Sarma, 1988 and

In India about 251 species of rotifers have been reported (Haque et al., 1988). While in developed countries, considerable progress on the mass culture of a few species of rotifers has been achieved (Ito, 1960; Theilacker and Mc Master, 1971; Pilarska, 1977b; Rezeq and James, 1987; James and Abu-Rezeq, 1988; Vellegas et al., 1990, Awaiss et al., 1992; Nagata and Whyte, 1992), that in India it is still in infancy. Hence, it is imperative to evolve suitable method for the mass production of rotifers.

Cladocera are one of the important components of the zooplankton community in aquatic ecosystems (Saha and Bhattacharya, 1991). In many inland waters, these are the most abundant crustacean plankters and form a major food item of fishes. Among the Cladocerans *Daphnia carinata* King is the most characteristic inhabitant of temporary pools and ponds (Venkataraman, 1981). Much of the earlier investigations have focussed on problems relating to ecology, biology, embryonic development of few species of *Daphnia*, (Sumitra Vijayaraghavan, 1970; Bhanot and Vass, 1970; Venkataraman et al., 1986; Murugan and Moorthy, 1988; Venkataraman, 1990), *Ceriodaphnia* (Michael, 1962; Murugan, 1989), *Moina* (Shirgur, 1971; Murugan, 1975, 1989).
Another cladoceran *Scapholeberis kingi* Sars which is found to occur in lakes and ponds has received less attention. Excepting for the report on longevity, growth and reproduction of this species (Murugan and Sivaramakrishnan, 1976) no headway has been made towards the mass production of *S. kingi*.

The importance of freshwater copepods as food of fish fry has been realised since the beginning of this century (Sehgal, 1977). Contributions on the food and feeding habits of a few species of copepods (Lakshmanan, 1969; Sehgal, 1969, 1977a; Selvaraj and Rao, 1977) and their utilization as fish feed (Sehgal, 1977b) have been made. However, there is paucity of information on the mass production of copepod *Mesocyclops leuckarti* and its use as larval feed.

The dietary requirement of fishes are known to vary (Hoar et al., 1979; Calow and Townsend, 1981) and for a given species of fish, the feeding habits may change with age (Brown, 1957). Research on nutritional requirement of fishes has aimed at providing a balanced diet which will meet the dietary demands of fish and ensure proper growth and reproduction (Cowey and Sargent, 1972; Halver, 1972; Cowey, 1980). The dietary requirement of fishes have been determined by 1) withdrawing a nutrient (aminoacid/vitamin) to estimate the necessity of its presence. 2) feeding different combinations of artificial/natural foods that contain different proportions of nutrients. In India, while considerable work for evaluating artificial feed for fish in which
various ingredients have been used in different proportions, has been carried out (Lakshmanan et al., 1967; Chakrabarty et al., 1973; Vivekanandan et al., 1977; Sukumaran et al., 1981), utilization of natural foods particularly in different combinations has not gained much importance. Although compounded feeds have yielded good results in the rearing of carps from fry to adult stages, (Singh and Bhanot, 1970; Choudhuri et al., 1975), the results on early life history stages of carps are not encouraging. In fishes, the usefulness of any food could be best studied through physiological energetics approach (Nirupa Krishnan, 1985). Physiological energetics deals with the partitioning of food energy for survival growth and reproduction (Pandian, 1975; Webb, 1978; Webb et al., 1980). Further, measurement of daily food intake, growth and conversion efficiency in fish not only provides information on the usefulness of food stuff but also gives the essential clues, to understand the ‘ecological well being’ of the species in its niche (Kinne, 1960).

A survey of literature reveals that information on the physiological energetics of murrels, catfishes and a few cyprinid fishes fed on artificial or natural foods are available (Pandian, 1967a and b; Vivekanandan, 1977; Nirupa Krishnan, 1985; Nirupa Krishnan and Reddy, 1989; Reddy and Katre, 1979). However, except for the production of zooplankton and growth of fish in fish ponds Alikunhi et al., 1955; Hardin, 1975; Sehgal, 1977) almost nothing is known regarding the daily intake growth and conversion
efficiency of carp larvae/fry fed exclusively on zooplankton or on combinations of zooplankton and artificial feed.

Hence, detailed investigations on zooplankton were made covering the following aspects:

(a) Seasonal dynamics of zooplankton in fish ponds
(b) Diel dynamics of zooplankton in man made tank and fish ponds
(c) Mass production of zooplankton and
(d) Physiological energetics of fry of carps and cichlid fish fed on zooplankton/artificial feed.

The information emanating from the study provides a deeper insight into the understanding of the utilization of habitat resources by fishes and thus serve as firm data base for improving pisciculture.