I N T R O D U C T I O N

Growing of aquatic organisms under controlled conditions (Aquaculture) can make a unique contribution to nutrition by virtue of extremely high productivity, being primarily protein crops and many of them have filter feeding (fishes and molluscs) ingesting microscopic plankton, which cannot be used directly by man (Hardach et al, 1972).

Fresh water fish culture is a profitable undertaking, with low investment, quick result and low cost. The meat production rate of fish culture is highest among all forms of animal culture. In case of fish culture, the problem of fry supply can be solved easily. Production in water can be

done in a vertical way. And the waste of agriculture be used in fish culture. So the development of agriculture, fisheries and animal husbandry can promote one another.

The biggest constraint in fish culture is the lack of quality seed in adequate quantities. Against an annual demand of 16 billion fish fry in India, the actual production is less than one billion.

The possibilities of obtaining quality fish seed in adequate numbers from natural sources are rather limited. Artificial propagation methods constitute the only practicable means of providing enough quality seed of the river spawners for rearing in confined waters such as fishponds, reservoirs, lakes, etc. The hypophysation technique has revolutionized quality seed production and provided great opportunities for development of inland fisheries. This technique permits incubation and hatching of eggs and rearing of seed under well protected and weatherindependent conditions. Depending on the perfection of the system, 10 to 70% of the eggs produced can be raised to viable fingerlings. Survival rate in natural spawning is generally much less than one per cent of eggs produced. Induced breeding technique also makes possible to obtain out of season supplies of fry and fingerling. This technique provides the

easiest tool for improvement of stocks of cultivated fishes, whereby fast growing, disease resistant, temperature tolerant and tasty strains can be selectively raised. Eggs, larvae, fry and fingerlings produced through artificial propagation technique can easily be transported to great distances with reduced threat of transmitting disease (Csoynarovich and Horvath, 1980).

In India, semiartificial propagation in so-called 'bundhs' is prevalent. These are special type of ponds where riverlike conditions are stimulated. They are usually constructed along the slope of an undulating terrain and provided with proper embankments. They receive considerable quantities of rain water rushing in from their extensive catchment area. Bundhs have outlets for excess water and shallow areas to serve as spawning grounds. Bundhs are of two kinds, namely, wet bundhs, which are perennial, the deeper areas contain water while the shallow areas are dry; and dry bundhs, which are seasonal, water accumulates only during early rains. Spawning is triggered after a heavy shower when bundh becomes flooded. Silt laden and well oxygenated rain water are, however, necessary. The advantage of bundh is that it can be used to obtain pure seed of any one species of major carps.

While fish production from inland fisheries in India (culture fisheries) increased from 0.2 million tons in 1950 to 1.0 million tons in 1979, fish landing (capture fisheries) increased from 0.5 million tons to 1.4 million tons, obviously fish production of inland waters has grown at a faster rate (Dwivedi, 1983). However, per capita fish consumption is 4 Kg per year in India and is very low in comparison with other countries. Calculating at 56 g of proteins needed for a balanced diet and, if 20 g were to come from fish source, the country would need to produce 13 million tons of fish annually, out of which some 7 million tons must come from fish culture (Dwivedi, 1983). Acceleration of development of fish culture need hardly be emphasized.

We owe to Houssay (1930) the concept of application of pituitary injections (hypophysation) for successful spawning of fish. In India, Khan (1938), Hussain (1945), Ramaswamy and Sundararaj (1956, '57), Chaudhuri and Alikunhi (1957), Alikunhi et al (1960), Chaudhuri (1960, '63), Das and Khan (1962), Jhingaran (1959), Tripathi and Bhimachar (1972), Khan and Jhingaran (1975), Moitra and Sarkar (1975, '76a, b, '77, '78) all successfully bred various species of fishes by hypophysation. Although use of mammalian LH and LH like hormones in culture of fishes is no longer under dispute (Ramaswamy and Lakshman, 1958, '59; Tang, 1965), their use has still not become a practice and mostly pituitaries are taken from donor

malesor females of the same species. Common carp pituitaries are often used for hypophysation of major carps. Bhowmick et al (1979) opined that use of catfish pituitaries for hypophysation of Indian carps is feasible. Tremendous potential exists for further experimentations in this field.

Fish eggs and larvae provide a relatively untapped source of biological material. Apart from their intrinsic interest, experimentally based information on these early stages is required for further progress in the advancing fields of fish culture and fisheries research (Blaxter, 1969).

With the country's growing population and the increasing hazards of domestic and industrial pollution to the inland waters, a rapid degradation of water quality is obvious. A wide array of agricultural pesticides and insecticides are seriously aggravating the pollution problem both from the point of view of public health as well as aquaculture (Jhingaran, 1982). Aquatic organisms are affected both directly and indirectly. Some of the effects (Jhingaran, 1982) may be -

(i) an increase in osmotic pressure,

(ii) violent alterations in pH of water, all acids being lethal when pH is less than 4,

(iii) decrease in oxygen content,

(iv) specific toxic ingredients,

(v) destruction of biota,

(vi) destruction of spawning ground (Gopalakrishnan et al, 1966),

(vii) pathogens carried to human beings through fish cultured in polluted waters,

(viii) cumulative effect of insecticides and pesticides on fish as well as on man.

(ix) accelerating aging of lakes and ponds. Sewage pollution, even in small quantities may change the character of an aquatic environment. With gradual process of aging, deep, clean oligotrophic lakes may become sedimented, becoming mesotrophic, then eutrophic and eventually turning into bogs.

Whereas the effects of metallic pollutants like mercury (Sastry and Agrawal, 1977; Panigrahi and Misra, 1978; Das et al, 1980), copper (Lett et al, 1975; Wong et al, 1977), zinc (Speranza et al, 1977; Wong et al, 1977; Khangarot and Majbanshi, 1979; Shafi, 1980), lead, chromium, cadmium (Jhingaran, 1982) and pesticides, like chlorinated hydrocarbons and organophosphorus insecticides (Verma et al, 1977a & b; Mahajan and Juneja, 1979; Dalela et al, 1980; Mukhopadhyay and Dehadrai, 1980a & b; Singh and Singh, 1980) on adult fish metabolism have been

extensively studied in India and abroad, very little is known of their effects on eggs and larvae.

No wonder Hoynarovich and Horvath (1980) observed that survival rate in natural spawning is generally much less than one per cent of eggs produced. With hypophysation technique and hatching of eggs and rearing of seed under well protected and weather independent conditions, 10 to 70% of eggs can be raised into fingerlings. Monitoring optimum conditions of development, following induced breeding, the production of fries, fingerlings and eventually fishes can be increased manifold. Solberg (1936) pointed out that F. undulus eggs were very sensitive soon after fertilization. Sensitivity decreased 10 times between early cleavage and 4-5 days later. Battle (1944) also reported that fish eggs and larvae go through periods of mortality. Fish eggs seem specially delicate until the completion of gastrulation although this has not been systematically tested. Perhaps sensitive morphogenetic processes in the early stage or failure to osmoregulate are the cause. Similarly, there are stages, such as the eyed stage in Salmonids, where eggs may be particularly resistant to damage. After hatching, further stages of mortality may be experienced which can sometimes be connected with the

further development of certain organs and with certain important physiological changes (Blaxter, 1969). All these are very clear pointers to the importance of studies on developmental biology, i.e. the causal mechanics of development, in terms of the assessment of optimum requirements of DO, salinity, temperature, pH, ions, etc. of developing eggs of different species of fishes, conducive to decreased mortality at different embryonic stages and increased rate of incubation and hatching percentages. Studies on protein, lipid and carbohydrate metabolism, the ionic requirement and regulation at different stages could be most rewarding. The effect of pollutant ions such as Ni^{+}, Cu^{++}, Cd^{++}, Fe^{++}, F^{-}, PO_4^{+} even K^{+} have been studied in developmental stages of certain species of fishes. Higher concentration of these ions are too well known to have deleterious effects. Embryos are known to get affected with absence or decreased concentrations of Ca^{++}, Mg^{++}, Si^{++} etc (Shingaran, 1982). Assessment of ionic and other requirements and management of water quality are the absolute necessities in any fish culture undertaking.

Cyprinus carpio (Linnaeus), an exotic fish, commonly known as common carp was introduced in India from Bangkok (Bangkok strain) in 1957 and Ceylon (German strain) in 1939. This is voraciously

omnivorous, efficiently converting food ingested into flesh, grows very fast and is prone to artificial feeds. It is nonpredatory and breeds naturally in confined waters. The biggest advantage is that it spawns throughout the year in tropical climate with 2 peak breeding periods (mid Jan. to March) and the other (July to August). This author has felt that apart from advantages of meat production, this species of fish is ideal for studies in developmental biology and the effect of pollutant ions, synthetic fertilizers and the pesticides. There has been hardly any work on developmental biology of a fish species in India. Even taking the global picture, extensive study of developmental biology of fishes have been confined to Salmo species (Gray, 1920, '26, '32; Hayes, 1930, '49; Hayes et al, 1951, '53; Suyama, 1958; Alderdice and Wickett, 1958; Alderdice et al, 1958; Ando, 1962; Combs, 1965; Garside, 1966; Hoar, 1967; Terner, 1968 a, b; Terner et al, 1968; Rudy and Potts, 1969; Takama et al, 1969; Boulekbache et al, 1969, 70; Timoshina, 1969, '71; Nakagawa and Tsuchiya, 1969, '71, '72, '76; Iuchi and Yamagami, 1976; Hagmor and Garside, 1977; Zeitoun et al, 1977; Chen and Leatherland, 1978; Zitko and Saunders, 1979). Other fishes, which have been studied to some extent, include, Brachydanio rerio (Uchirone and Gross, 1968; Niimi and Lahem,

1975; Speranza et al, 1977; Hart and Pentier, 1979; Uzoh, 1979; Yosha and Cohen, 1979), Fundulus heteroclitus (Scott and Kellicott, 1916; Amberson and Armstrong, 1933; Solberg, 1938; Gabriel, 1944; Kaighn, 1964; Oppenheimer, 1964), Misgurnus fossilis (Chajlakhyan and Shilyanskaya, 1973; Neyfakh and Abramova, 1974; Stoika et al, 1979; Soulekbache, 1981), Oryzias latipes (Ikeda, 1937 a & b; Yamamoto, 1954; Monroy et al, 1961; Nakano and Yamamoto, 1972; Yamagami, 1974). Work on developmental biology of Cyprinus carpio thus far includes those of Malone and Blaylock (1970) on toxicity of insecticide formulations, Sabodash (1970, '71) on localization and dynamics of zinc contents respectively, Tatarko (1970) on sensitivity to high temperatures, Blaylock and Griffith (1971) on effects of acute beta and gamma rays, Vladimirov (1971) on the changes in the rate of zinc accumulation and effect of its addition, Kamler (1972) on effect of 2,4-D-Na, Gulidov (1974) on reactions of chronic hyperoxia, Konovalov and Mestechkina (1975) on peptide hydrolase activity, Kim (1976) on phospholipids and cholesterol levels, Melnik and Sabodash (1976) on ionic permeability to cytoplasmic membranes, Bhasker and Swarup (1977) on localization of succinate dehydrogenase activity, Saur and Toor (1977) on toxicity of pesticides, Konovalov (1978, '79) on proteinases' activity and

physiological and chemical indices of proteins condition, Claylock and Frank (1979) on toxicity of Ni^{++}, Chin and Budderuddin (1979) on effect of methamidophos, Subhedar and Rao (1980) on Dalapon toxicity and Chetty et al (1982 a & b) on amino acids and proteins and activities of acid and alkaline phosphatases respectively.

This dissertation includes the author's study on levels of key metabolites, enzymes, inorganic ions and effect of some cations in the different embryonic stages of Cyprinus carpio (Linnaeus).