SOUVENIR

20th Anniversary

Central Marine Fisheries Research Institute

(Government of India)

ISSUED BY
THE ORGANISING COMMITTEE C. M. F. R. I. RECREATION CLUB
MANDAPAM CAMP

Physiological Studies in Relation to Fisheries

M. NARAYANAN KUTTY

Central Marine Fisheries Research Institute

Studies on the physiological mechanisms and responses of fishes, which are closely linked with their ecology, have a significant role to play in fisheries development inasmuch as optimum survival of fishes is desirable and planned both in the capture and culture fisheries. While knowledge of the influence of various environmental factors on fishes are of direct value in formulating improved methods of fish culture, information on those responses of fishes which lead to their concentrations in fishable waters are of immense use in evolving more efficient methods of capture. Even though fish and prawn culture in India have existed for centuries the emphirical knowledge gained so far can be perfected, as pointed out elsewhere, only by acquiring a fuller understanding of the physiology of the animals concerned.

Among the ecological factors governing the life of aquatic animals the physical and chemical characteristics of the water in which they live are the most important. Physiological experiments designed to study the influence of these factors on fishes can provide information on the physiological mechanisms and also on the tolerance range of each of these identities. With knowledge accumulated as a result of such studies it is possible to know the suitability of a body of water for holding and culturing fish. However, it must be stated that there is wide variation in the physiological requirements of the different species and therefore it is difficult to draw general 'norms of water conditions' suitable for fishes. A solution in such a situation is possible only by studying the responses of the individual species separately with reference to each factor and also the interaction of the various factors on the species concerned.

The adaptive abilities of animals to new environments are marked The process by which an animal becomes attuned to the new environment is called acclimation. This phenomenon is so important in studying the influence of the environmental factors on the animal that a proper definition of the past history of the animal with reference to the ecological identities concerned are of paramount importance. This has been classically proved to be so in the case of lethal temperature relations of fishes. In the case of goldfish (*Carassius auratus*) it was shown that the upper lethal temperature can be shifted by as much as about 10°C by changing the temperature of acclimation. Recently it was shown that change in the acclimation level of ambient oxygen causes a reduction in the energy expended in terms of oxygen consumption by goldfish to do the same work (swimming at a given speed). Information of this nature is of much value in planting and culturing fish.

Among the primary conditions of water which regulate the life of fishes can be listed temperature, dissolved oxygen, salinity, pH, dissolved carbon dioxide and toxic

substances such as ammonia, inorganic sulphides and salts of certain metals such as zinc, copper, lead etc Studies on the influences of the various factors listed above on fishes are relatively fewer with reference to marine environment.

The interspecific differences in the tolerance of temperature are large. It is seen that the upper lethal limits of the cold water fishes such as the trouts are near 25°C, whereas those of the warm water or tropical fishes such as Tilapia (*Tilapia mossambica*) and goldfish are above 40°C. Among warm water fishes themselves the tolerance range of temperature is quite wide. Experiments at the low lethal temperatures on Tilapia and on mullet (*Liza macrolepis*) (both acclimated to 30°C), which often occur together in the brackish waters around Mandapam, showed that at 18°C the mullets died within 42 hours while *Tilapia* lived for days together at this temperature. Another marked difference lies in the temperature resistance or in the effective time, which is the time required for the death of 50% of the test group of animals. At 14.5° and 16°C mullets took respectively 420 and 1200 minutes to die, whereas *Tilapia* took almost double the time (930 and 2280 minutes) to die at the same temperatures. The interspecific differences in the value of lethal temperatures and resistance times have been found to be so sharp that the lethal temperature has been found as an efficient 'tool in taxonomy'. It may be pertinent to mention here that though a functional concept of the species has been incorporated in the earliest definition of species, only a proper delineation of categories of ecological factors as per their influence on the animal, and physiological experiments as those mentioned above have made it possible to describe the 'species' from a physiological standpoint.

OXYGEN dissolved in water acts as a limiting factor on fish metabolism and activity. The lethal level of dissolved oxygen varies much with species In fishes such as the trouts which normally live in swift-flowing and colder waters the lethal level is near 2 p. p m., whereas at this level fishes such as the carps and *Tilapia* which live normally in stagnant warmer waters, can survive for months As shown recently these fishes derive considerable energy anaerobically when forced to live at low oxygen concentrations. It has been shown that the crucian carp (*Carassius carassius*) can live for months in water practically devoid of oxygen at 4°C deriving energy almost entirely through anaerobic means. Possibly anaerobiosis is more common than is actually known among those fishes which are known to tolerate hypoxic conditions. Investigations in these lines will be of value in piscicultural practices.

The SALINITY of water tolerated by the aquatic animals depend on the osmotic regulation they are capable of. Fresh water fishes are known to tolerate upto 14‰ salinity. Fishes such as *Liza macrolepis*, L. *parsia*, *Tilapia mossambica* and *Gerres abbreviatus* were recorded at salinities as high as 87–92‰ in the land locked tide pools around Mandapam. Important contributions have been made from this Institute on the osmotic regulation in the milk fish, *Chanos chanos* and in the penaeid prawn, *Metapenaeus monoceros*. Both these are known to stand wide changes in salinity as also observed in the case of many other fishes and prawns occurring in the brackish waters of the Indian coast. In *Metapenaeus monoceros* it was shown that the animal maintains osmotic equilibrium by active regulation of chloride in blood at salinities ranging from that of fresh water to hypersaline conditions. More

recent studies at this Institute on another penaeid prawn, *Penaeus indicus* have shown that the osmotic regulation is achieved by the young ones of this prawn with comparative ease at salinities ranging between 7 and 21‰, there being little difference between their oxygen consumption at these salinities between 19° and 29°C. Most of the Indian penaeid prawns are known to tolerate a wide range of salinity as could be judged from their migratory patterns from the sea to the brackish water and from there to the sea for spawning. A study of the olfactory responses of these migratory animals, as shown in the case of the salmon (*Onchorhncus kisutch*) migrating up the rivers of North America, may aid in the understanding of their migratory behaviour. What factors are responsible for these movements of these prawns? Is it possible to make them stay at low salinities and breed too? Answers to these questions can be obtained by proper design and execution of physiological experiments. A solution to these problems when found will usher in new vistas for prawn farming in India and elsewhere.

pH varies with the amount of carbon dioxide in various forms such as free CO_2, bicarbonate and carbonate in water. Acidic and alkaline pollutants discharged into natural waters change their pH considerably. Fish are known to tolerate pH within the range of 5–9. Determination of the levels of pH which permit growth and reproduction will need extended study.

Tolerance of dissolved carbon dioxide differs markedly in fishes. Some fishes like the goldfish can tolerate free CO_2 concentrations as high as 200 p. p. m. When coupled with a low oxygen environment the critical level of carbon dioxide will be much lower. Observations of the latter type are significant in that, as pointed out earlier, consideration of interaction of factors is essential to fix the safe levels of the various ecological factors influencing an animal.

Certain instances of mass mortality of aquatic animals and their total disappearance have been attributed to the occurrence of toxic substances in their environs. This is especially true of toxic substances emanating from industrial wastes disposed off into waters which support fisheries. Toxic substances can also be of bacterial origin such as those liberated by the bacterial decomposition of organic matter.

Mass mortalities of fishes reported from the sea are often attributed to sudden unfavourable changes in the environmental conditions brought about by natural causes as evidenced by data obtained at the time of 'red tide'. While occurrence of toxic substances or oxygen depletion might be a good reason for some instances of mass mortality of fishes, temperature as one of the potential factors should not be overlooked especially if there is evidence for upwelling of colder waters. Since the normal temperature to which tropical fishes are exposed to is quite high, as shown earlier, relatively the low lethal temperature of these fishes must be also quite high. In this context information on the lethal levels of oxygen and temperature of various fishes will be of much value.

Studies on the behaviour of fishes in relation to water currents also need attention from a fishery-point of view. It is known that most fishes do orient and swim against water currents. Fishes such as the mackerel and other scombroids cannot obtain sufficient

oxygen for their sustenance unless they swim permitting water, relatively rich in oxygen, to flow past their gills at fairly rapid rates. Swimming abilities and energetics of swimming in fishes are of applied value especially in the design and use of tackle such as the trawl and also in the designing of fish passes or fish ways at dam sites of the rivers. Studies on the physiology of swimming in the mullet (*Liza macrolepis*) and the milk fish which are being carried out at this Institute, are yielding interesting results. Plate I shows the apparatus used in these studies. Preliminary observations on the oxygen consumption of *Liza macrolepis* showed that at intermediate swimming velocities the metabolic rate of tagged mullet (plastic opercle tag) was not markedly different from that of the untagged.

Studies on the internal mechanisms of fishes, not referred to earlier, such as the studies on the pituitary gland and the hormonal control of maturation and spawning in fishes are also of much practical value. Considerable work has been done in India in this field especially with reference to carps.

Knowledge of the food requirements and absorption of nutrients to estimate the conversion rate of food to fish meat are also useful in fish farming.

Physiological studies were initiated at this Institute in 1947 with the primary purpose of studying the physiological mechanisms of estuarine and marine animals of economic importance. Reference have already been made to the observations on the osmoregulatory capacities of the milk fish *Chanos chanos* and the Penaeid prawn *Metapenaeus monoceros*. Useful information has also been obtained on the energy requirements, as judged from the oxygen consumption, of the milk fish and the marine catfish, *Plotosus anguillaris* at various salinities and oxygen levels. Observations of value have been made on the relation of salinity on the spawning and settlement of the Indian backwater oyster, *Crassostrea madrasensis*.

Influence of various anaesthetics on the fingerlings of milk fish has also been studied, providing useful information on live-fish transportation and in the handling of fish during tagging. Presently the influence of various salinities and temperatures on the prawn, *Penaeus indicus* and the mullet, *Liza macrolepis*, and the swimming abilities, including the physiological effects of tagging, of certain fishes occurring around Mandapam are being studied.

Results obtained from such laboratory studies will have to be checked under field conditions before actual procedures are recommended, since it is common knowledge that the field conditions are more complex. A synthesis of knowledge gained from such laboratory and field studies could be successfully employed in the development of our aquatic resources especially with reference to their culture.

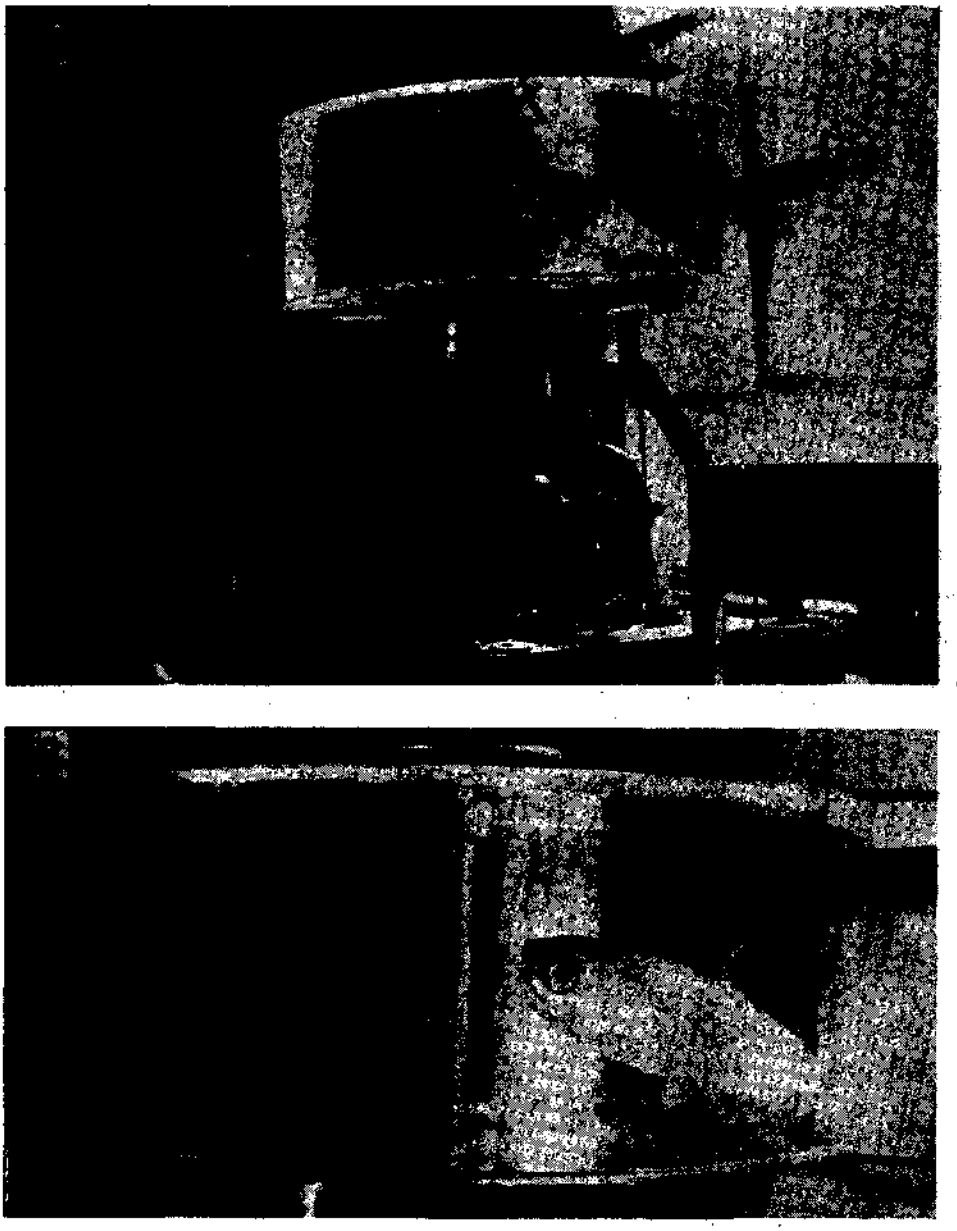

Plate I. A: Fry's respirometer which is in use in the physiology laboratory of the Central Marine Fisheries Research Institute. The annular chamber (transparent plastic) can be rotated on a turn-table at desired speeds. The apparatus is used in estimating the energetics of swimming in fishes.

B: Close-up of the activity – metabolism chamber. A milk fish. *Chanos chanos* measuring about 30 cm in length is shown swimming inside the chamber. Milkfish with their long and gracefully curved caudal flukes are good swimmers.