STUDIES ON

# SOME ASPECTS OF THE ECOLOGY AND BIOLOGY OF *Channa gachua* (HAMILTON) & *Channa stewartii* (PLAYFAIR)

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I certify that the thesis entitled " STUDIES ON SOME ASPECTS OF THE ECOLOGY AND BIOLOGY OF CHANNA GACHUA (HAMILTON) AND CHANNA STEWARTII (PLAYFAIR)" submitted by Miss SUKHBEER KAUR for the Degree of DOCTOR OF PHILOSOPHY of the NORTH - EASTERN HILL UNIVERSITY, Shillong (India) embodies the record of original investigations carried out under my supervision. She has been duly registered and the thesis presented is worthy of being considered for the award of a Ph. D. Degree. This work has not been submitted for any degree of any other University.

DATED : Shillong
The 15th July, 1981

( S. A. K. NASAR)

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# P R E F A C E

The unity of organisms and their environment is the basic principle of modern ecology. Any population, species, or organisms (including fish) live at the expense of their environment; in the absence of this interaction it ceases to exist. The successful existence and development of any fish, like other organisms, depends on its adaptive interaction with its environment and it is based on the interrelationships with their abiotic and the biotic environment. Any alteration in the nature of any fundamental abiotic and or biotic component, inevitably evokes a reconstruction not for the better but normally for the worse of the entire system of relationships between the organisms themselves and their immediate habitat. The characters of the interdependence of organisms to its natural environment, is known to be specific not only for the various species, but also for different individuals of the same species.

Fishes have great significance in the life of mankind, being an important natural source of protein and providing certain other useful products as well as in the economy of many nations, particularly in a developing country like ours. Freshwater fishes too, form a vital part of the diets of people throughout the tropics. The fact that the world catch of fish, which was increasing until recently, has now started declining at an alarming rate, mainly due to over-exploitation and other factors. However, today almost all the inland water bodies are undergoing eutrophication, in other words, a step prior to pollution, particularly due to our bergeoning population, growing advancement in the cultural activities etc. This lays emphasis on the urgent need to develop these resources fully and to achieve this, we need to understand the factors governing fish production.

The application of fisheries sciences and limnology to Aquaculture has been late in arriving, because these sciences themselves had to develop specific technical and conceptual tools in population biology, fish physiology and analysis of abiotic and biotic component along with nutrient dynamics in water. It is this, the growth of scientific approach of aquaculture, which may eventually develop into an applied scientific discipline.

The North-Eastern Hilly Regions of India are mostly inhabited by tribal people and most of them are meat eaters having inadequate sources to fulfill the great protein deficiencies. Moreover, it is well known that the tribals of the hilly areas in Meghalaya (Khasis, Jaintias and Garos) have less land for agriculture, but 85% of the population subsists on agriculture. Apart from animal husbandry and mining of sillimanite, coal etc. there are no industries in Meghalaya. There is, however, plenty of rain and sufficient water bodies to grow fish in this part of the country. Hence, introduction of fish farming in these highlands would certainly help to grow a new occupation which will raise the economic status of small farmers. There is however, hardly any practical information available on the structure and function of freshwater ecosystems and on the biology of fish that naturally grows in this region.

There is a paucity of information on the biology and ecology of the fishes indigenous to the highlands of the North-Eastern part of India and knowledge of these is of utmost importance, not only from the academic point of view, but its utility in increasing the technological efficiences of the fishery entrepreneurs for evolving judicious management measures in culture operations of these fishes. Hence, on a virtual absence of scientific knowledge on these aspects, prompted to undertake the present investigations. It is therefore, earnestly hoped that the information embodied in this dissertation, apart from academic importance, it would have application and relevance to the socio-economic development of these areas of the country.

The study pertains to the specimens of Channids (= Ophicephalids) commonly known as "Murrels" or "Snake-Heads", collected during the period from September 1978 to August 1979 from a pond and a torrential hill-stream situated in Shillong (Meghalaya), India. The results obtained during the present study are presented here under the title "Studies on some aspects of the ecology and biology of *Channa gachua* (Hamilton) and *Channa* *stewartii* (Playfair)", and the investigations were carried out at the Fish Ecology Laboratory, Department of Zoology at the North-Eastern Hill University, Shillong, under the supervision and guidance of DR. S.A.K. NASAR, Ph.D.,F.A.Z.,F.Z.S. (Lond.).

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K Sukhbeer
15th July 81

( SUKHBEER KAUR )

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# G E N E R A L   I N T R O D U C T I O N

Ecology may be defined broadly as the science of the interrelationship between living organisms and their abiotic and biotic environment and emphasizing interspecific as well as intraspecific relations. This science has undergone profound changes as far as range and scope are concerned, since the publication of certain pioneering studies on synthesis of the ecological facts and ideas of their day (Shelford, 1913; Elton, 1927). However, according to Regier (1974) limnologists and ecologists, at least those interested particularly in fish, can turn to the writing of their scientific leaders of 50 years ago and not find them obviously outdated.

One of the origins of animal ecology was Shelford's (1913) early account which attempted to explain the distribution mainly on the result of different tolerances and responses of organisms to the physico-chemical conditions of the environment. Much work by so called autoecologists, is derived from this conception and it has produced many valuable discoveries. A major aim of modern ecologists is to obtain better understanding of entire functioning of the organisms living in the natural world. It can therefore, be said that ecology has a central, rather than a peripheral role to play in the development of biology (Weatherley, 1972).

According to Nikolskii (1963) the ecology of fishes is the section of Ichthyology in which the mode of life of fishes is investigated namely: the dynamics of fish populations, intraspecific and interspecific variations, distribution, migrations, diurnal and seasonal rhythms in life processes, character of feeding inter-relationships, reproduction and so on. Naturally, the mode of life of any organisms (including fishes) is inseparably connected with its structure and function of its organs.

It is an established fact that the organisms cannot exist without the environment. Any population, species or organism live at the expense of its environment, without this interaction it ceases to exist. The successful existence and development of any organism depends on its adaptive interaction with its environment. The system of adaptive interactions of fish with its environment is composed of interrelationships with the abiotic and the biotic environment. Any alteration in the nature of any fundamental biotic and or abiotic component in the environment of the fish, inevitably evokes a reconstruction not for the better, but normally for the worse of the entire system of relationships between the fishes themselves and their immediate habitat. The character of the interdependence of the fishes to its natural environment, is known to be specific not only for the various species, but also for different individuals of the same species. The interaction of the fishes and the environment bears an adaptive character and every adaptation is specific. Adaptation is a property directed towards securing the preservation and flourishing of the species under which it lives and to which it adapted itself in the process of its evolution. Hence, it is obvious that the adaptation to the corresponding biotic and abiotic conditions should be related to morpho-physiological changes. A species is characterized by a relative morpho-physiologo-ecological stability, which is the result of adaptation to a particular environment under the conditions of which the species was formed and with which the species is in unity.

The features of the species reflect its adaptation to particular condition of existence. It must be emphasized that the character of the interaction of the fish with any particular element of its environment depends to a significant extent upon the condition of the fish itself; its state of nourishment; fat content; the state of maturity of its gonads; and so on. All these factors are generally taken into account while studying the interactions of the fish with any particular element of its abiotic and biotic environment.

The individuals of any species do not reflect all of its properties. The species is a continually changing plurality, and the very character of this change i.e. the type of its population dynamics (time of spawning, life span and so on), are specific features. The variability is greater in species adapted to the more variable conditions. Populations of species which live under less stable conditions possess a greater amplitude of variation in those features which are adaptations to the varying factor of the environment, whereas populations of species which live under more stable conditions possess less variability. The amplitude of variability is also an adaptive property which ensures more favourable conditions of life for the population. The amplitude of variation of the features and properties of species with a restricted distribution is usually less than that of species with a wide distribution. Within the limits of distribution of the species, the amplitude of variation, like other species properties, ensures the unity of the species with the environment.

The species has a definite area of distribution, within the limits of which the conditions correspond to its morpho-physiologo-ecological specificity. The morphological, physiological and ecological properties of the species are relatively stable in time. Changes within the species, apart from those connected with age and sex, bear a local character i.e., they are adapted to a particular habitat or to a definite geographical part of the range of distribution. This variability of group is a species adaptation, which ensures either that a greater variety of habitats are occupied or else a wider geographical distribution.

Population ecology is one of the most difficult aspects of fish biology to study, mostly because of the problems involved in sampling fish populations adequately. Nevertheless, population ecology is so important that fisheries research programme have tended to concentrate in this subject area. Much of this effort has been directed at determining sizes and fluctuations of exploited fish populations, and at examining age-structure and growth rates to arrive at some idea as to whether the population is declining, stable or increasing and the impact fishing is having upon that population. In particular, much effort has gone into examining the relationships between recruitment of fish into a fishery and size of the parent stock. The first general model of this relationship was developed by Beverton and Holt (1957). Although this model was applied successfully to some fisheries, its application to many others was disastrous, while the study of relationships between stock and recruitment obviously is enormously important, it is also obvious that the reasons for such observed relationships need to be understood as well. This is particularly true since these relationships are seldom straight forward, primarily because many, if not most, factors affecting survival of larval fish are independent of the abundance of the larvae. The biological factors are ultimately regulated by environmental factors, including currents, upwelling and water temperatures. As the importance of these relationships become apparent more research is being devoted to mechanisms regulating growth and survival of fishes, but only a small number of species have been examined and still fewer are well understood. Even with more advanced life-history stages, much basic information is lacking on factors affecting population regulation for all but a handfull of species (Moyle et al., 1979).

Views on various aspects of fish population dynamics are found to be in many countries, but the problem was of no general concern until the mid-nineteenth century. However, Ber (1854) was the founder of the modern progressive theory of productivity and of fish population dynamics. The theory of population dynamics is a division of the general theory of the development of life, which deals with the laws of reproduction, growth and the causes of death of living organisms (Nikolskii, 1969). The main laws of fish population dynamics as for other organisms are as follows. They are concerned with the continuous process of the replacement of generations in time, the birth of a generation, its growth and death. The details of the process are governed by specific adaptations and by the relationships of the years with the environment.

According to Regier (1974), with very notable exceptions, fish biologists have tended to specialize at one particular level of organization, most at the organism, some at the population and fewer at the community level. The population dynamics of commercially valuable organisms is now primarily applied to the problem of providing their maximum yield. This entails a study of the productivity of the biosphere as a whole, which in turn involves the solution of various biological problems. The dialectical materialistic theory of development should be the basis of a progressive theoritical population dynamics for fish and other organisms, especially ideas such as the unity of an organism with its environment, the reality of a species, the adaptive significance of all species features, discontinuous continuity (stages) and so on.

It is well known that the unity of any organism and environment represents a system of adaptive relations between the organism and the biotic and abiotic parts of its environment. The dominant relations are not fixed but are dependent on all the other links in the system. They change during ontogenesis and may differ between populations of the same species.

All the relations with the environment affect the progress of development and are adaptive in nature. Adaptation is a feature that ensures the survival of the species under the conditions to which it is exposed (Nikolskii, 1969). According to Regier (1974) a field ecologist intending to study fish is faced at the outset with the task of locating these creatures in an alien and largely opaque environment. Recently Kerr (1980) expreseed that the niche concept provides a useful framework for analysis at the interface between organism and environment. By definition, all ecologists have a common interest in analysis at the level of biological organization. Fisheries ecology is no exception. Demonstrably, fisheries ecology has long possessed a theoritically sound, extremely developed and eminently practical niche concept which in all but name, anticipated and considerably antedates the contemporary views of theoritical ecology. Accordingly, it is convenient to distinguish an "academic" and a "fisheries" (applied) approach to niche analysis.

These same reasons had relatively little appeal for fisheries ecologists. In the first place, fisheries scientists are not often concerned with ultimate causes or equilibrium systems. The immediacy and directness of the pressing problems in fisheries require proximate solutions, scaled in physiological or demographic time, rather than in evolutionary time. Secondly and perhaps more importantly, fisheries ecology already possessed a well developed approach to analysis at the interface between the organism and environment. There was no record to adopt the relatively abstract and less practical approach of the theoritical ecologists.

The basic fisheries approach was set out in detail by Fry (1947) and later expanded and refined by him and others (Fry, 1957, 1971, 1976; Alderdice, 1972; Brett, 1979). Fry's approach has long since been the standard for analysis of environmental factors in fisheries and has found a wide range of applications, so much so that its origins are sometimes forgotten. Its essential characteristic is that it derives from autocology. It is primarily concerned with categorizing environmental factors according to their effects on the activities of organisms, as measured by standard, physiological techniques.

The Fry's method provides several useful advantages. It enables precise description of the lethal limits of a given factor to a specific organism. In Fry's terms, the zone within the "incipient lethal levels" of a given factor defines the "zone of tolerance" of the organism. Except that he did not explicitly extrapolate the zone of tolerance 'n-space' and call it a "niche". Additionally, Fry's methodology allowed precise definition of a "zone of resistance" surrounding the zone of tolerance, reflecting the time dependent capacities of organisms to survive levels of a factor which would be lethal, if prolonged indefinitely. This provision and the ability to measure it precisely, is essential to many analysis of non-equilibrium situations, as for example trout briefly penetrating the thermocline to feed beyond their incipient lethal temperature.

Most significantly, Fry's approach enables useful analysis beyond mere survival. His approach recognizes the metabolic basis for the activities of organisms, providing the conceptual foundation for categorization and measurement of the effects of external factors on the capacities of organisms to function specifically. Fry (1957) defined the metabolic "scope for activities", which is the net metabolic latitude that an organism is able to expend, at a given conjunction of environmental variables, beyond the bases prerequisites for its mere survival. That is, he provided a common measure, in units of energy expenditure of the capacities of organisms to mount useful activities at any point within their zones of tolerance. In effect, Fry provided a universal method for contensing the niche hyperspace.

Given these tools, it is understandable that fisheries ecologists failed to embrace the more recent and less utilitarian alternatives offerred by the academic theoriticians. In fact, the academic and fisheries approaches outlined above are not in opposition. Apart from failure to equate "zone of tolerance" with "niche", the two schools differ chiefly in that the fisheries approach is more usefully quantifiable in standard units of energy expenditure, as opposed to the various measures that have been applied by the academics. However, it seems reasonable to conclude that fisheries and academic ecologists have independently developed parallel and compatible methods of analysis at the organism environment interface.

In the first place, ecology differs from many scientific disciplines in that it simply does not possess a coherent and comprehensive theoretical base, recent progress notwithstanding. Thus, there is less disciplinary pressure to link the applied with the theoritical, allowing the various sub-disciplines of ecology to develop with greater independence than in many other scientific disciplines. Moreover, much existing ecological theory has formed under the evolutionary paradigm that now tends to dominate academic thought. As discussed previously, their approach often appears remote and unrealistic to the fisheries analyst, who typically is concerned with perturbed systems, often far from equilibrium, which require proximate scales of analysis. For these and many associated reasons, fisheries and academic ecology have tended to develop independently. Unfortunately so, because many instances could be cited of intellectual wheels having been unneccessarily reinvented by one or the other sub-discipline. More seriously, one can only guess at the missed theoretical and analytical opportunities that might have been realized from a close coupling of academic with fisheries ecology. Principles of fisheries management must obviously rest ultimately on sound ecological theory. On the surface, then it would seem that fisheries and academic ecologists should be interested in similar problems.

Bardach (1978) argued that the application of fisheries science and limnology to aquaculture has been late in arriving, because these sciences themselves had to develop specific technical and conceptual tools in population biology, fish physiology and analysis of nutrient dynamics in water and the like. It is this growth, the growth of the scientific approach of aquaculture, which may eventually develop into an applied scientific disciplines.

Since fishes are both poikilothermic and live permanently immersed in water, they are very directly affected by changes in their ambient medium. It is well known that since fish affect the trophic status of other organisms in their environment and alter the condition of water in various ways especially when their population density is high, the relation between organisms and environment are far from unidirectional. A study of biology in fish, offers an ecologist many opportunities to enquire into the dynamic balance and the states of change in aquatic ecosystems. Weatherley (1972) stressed that most studies of fish population dynamics and growth have been restricted to determining responses of a population to changes in certain features of the environment. A limited number of investigations have, however, taken the view that every fish population is a part of an ecosystem, affected by chemical and physical factors while functioning within the system through biotic especially trophic inter-relationships.

It is becoming increasingly clear that wise management of fishery requires a consideration of the total aquatic ecosystem in a given region, since the components of the system interact and the fishery for one species may affect abundance and distribution of other species. Hence, there is a need to determine the basic distribution, abundance and the habitat requirements of the fishes in a particular system. Since air-breathing fishes are in great demand for their nutritive and therapeutic qualities, in recent years, culture of air-breathing fishes is gaining a fillip in the country particularly because of the need to put vast areas of swampy and fallow waters to immediate use for the benefit of mankind without getting involved into costly processes of their reclamation.

As mentioned earlier any programme of fisheries development presupposes an understanding of the salient features of the biology of the species concerned along with their immediate environment and its impact on the biological aspects of the species. While most of the species of air-breathing fishes have extensively been investigated to a variable extent, no systematic studies have so far been conducted on the species belonging to the family Channidae (= Ophicephalidae).

A basic information on the length-weight relationship, morphological variations, condition factor, maturity, spawning, food and feeding habits etc., in relation to their abiotic and biotic environment is indispensable, as no organism can live as isolated units and the activities which comprise their lives are dependent upon and closely controlled by chemical conditions in which they live and the populations of other organisms with which they interact. Hence, on a virtual absence of information and lacuna in our present-day knowledge on the ecology and biology of Channids, it has been aimed in the present investigation to have a basic information on the general biology of Channids from the highlands of the North-Eastern Region of the country, in relation to their environment, as it is essential to be available before realistic models of fisheries can be developed.

The highlands of the North-Eastern India is rich in its freshwater resources ranging from very small ephemeral pools to big perennial ponds, lakes, streams, thermal springs and rivers, spread all over the region, in a wide range of climatic conditions. An extensive survey on the Ichthyo-fauna of this region reveal that both the lotic and lentic ecosystems in Shillong, have a good number of representative of Channids commonly known as "Snake-head" or "Murrels". This is one of the most valued group of air-breathing fishes of the Indian sub-continent, hence attracted the attention and prompted to undertake the present study. The family Channidae is represented in this part of the country by Channa gachua (Ham.), C. stewartii (Playfair) and C. punctatus (Bloch), among which the former is the most common species and have adapted themselves in both the lotic and lentic systems.

Keeping in view, the basic necessity to have a knowledge on the structure of lotic and lentic ecosystems from the same geographical region and on the biology of the air-breathing fishes adapted in such systems, a study has been undertaken on some aspects of the biology of the above mentioned species with particular reference to Channa gachua (Ham.).

The study pertains to the specimens of fish collected from a pond and a stream situated in Shillong (India) during the period from September, 1978 to August, 1979 with emphasis on the following :-

(a) The structure of a pond and a stream with limnological standpoint and impact of the abiotic and biotic factors on the biology of channids; and

(b) An inter- and intraspecific comparisons within channids on some aspects of the important biological parameters.