

REVIEW OF WORK PROGRAMMES CARRIED OUT IN INDIA
ON THE BIOLOGY OF THE MILKFISH CHANOS CHANOS

by

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Abstract

This account is a brief review of the investigation carried out in India on the various aspects of the biology of the milkfish. It covers the records of observations on the distribution of Chanos fry in the coastal areas, food and feeding of the fish, its growth, maturity, fecundity and spawning, and also certain experimental results on the physiological adaptation of the fish together with the histological structures of its kidney, pituitary and thyroid. While emphasising the paucity of data on the adult milkfish in the wild, the priority areas where information is lacking especially on the spawning ground, reliable identifying characters of the egg as well as on the possible existence of different racial stocks have been discussed.

Introduction

The milkfish occurs in the seas around India and in limited numbers the fish are caught near the coast of Orissa, Andhra Pradesh and Tamil Nadu on the east and Kerala and Karnataka on the west coast. The fish is also being captured near the islands of the Andaman-Nicobar group in the Bay of Bengal and around the Laccadives in the Arabian Sea. The fish in all cases are invariably obtained in the nets operated by local fishermen within about 8 km. from the coast. One fact remains that in place in this country does the milkfish constitute a significant commercial fishery; its position in this country's fish catch statistics being almost nil. In certain backwaters, estuaries and lagoons there is a seasonal fishery of some magnitude and this is restricted to the juveniles whose size rarely exceeds 500 mm. Thus, the status of this fish in the present commercial fish production of India is comparatively low and insignificant.

While its natural fishery is poor, it is noteworthy that there is a fairly abundant occurrence of the fry and fingerlings of the fish in many tidal creeks, estuaries and backwaters along the coast of peninsular India

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and also in tidal inlets of the bay islands. An assessment of this valuable resource or its proper utilization is yet to be carried out. This is largely because salt water fish farming in an organized and scientific manner has been initiated in this country only in recent times and the efforts in this direction so far have been only on experimental basis. For this reason, biological studies on the milkfish, Chanos chanos also have been limited. This paper presents a brief review of the various items of research carried out on the biology of the fish (culture excluded), together with identification of the major gaps in our existing knowledge.

Distribution and Abundance of Fry

In view of its utility in brackishwater culture operations, investigations on the availability and abundance of the fry and fingerlings were initiated since the early thirties (Raj, 1931; Chacko, 1942; Job and Chacko, 1947; Ganapati et al, 1950; Panikkar et al, 1952; Chacko and Mahadevan, 1956; Rao, 1972). In the zone extending from Orissa State in the east to Karnataka in the west, the State of Tamil Nadu is found to furnish the maximum yield of milkfish fry and fingerlings, with the Ramanathapuram-Tirunelveli districts constituting the most important region. It was further pointed out (Tampi, 1973) that intensive collection of data on the occurrence and abundance of Chanos fry has not been made so far. Neither any particular effort has been taken nor any adequate survey methods have been followed till now. It was estimated that with greater efforts and by extending the period of collection throughout the fry season all along the Tamil Nadu coast alone, at least ten million fry could be collected every year. And, a rough estimate for the whole of the peninsular India would take us to the order of nearly twenty millions of fry and/or fingerlings per annum. It is obvious that the collection of data on the milkfish fry resources remains an important piece of work to be taken up.

Chanos fry occurring in the shallow lagoon adjoining the Palk Bay were first observed in 1952. The fry find their way through the temporary connections that are established between the sea and the lagoon in certain years and continue to remain in the lagoon during the season as long as the sand bars remain open. In the adjacent areas along the coast itself, however, it has not been possible to locate any fry. Some experiments were conducted to see if the fry could be made to enter other areas. For this purpose shallow channels were excavated at strategic places which led to small pools. The experiments were rewarding in that we were able to make collections of fry in such artificial channels. During the fry seasons in subsequent years also similar experiments were repeated with success. It thus appears possible to make fry collections

even from places which may not normally constitute a collection centre, provided suitable environmental conditions are created to induce the fry to swarm in (unpublished observations of Tampi and S.V. Job). It is perhaps common knowledge that shallow bays, lagoons and tidal creeks are excellent nursery grounds for the young ones of a variety of fish and crustaceans. Many of these in the early stages of their life history seek entry into the calm sheltered waters of the coast where benthic food organisms and detritus are abundant and where ecological conditions are quite favourable for their life and growth. The fry of a number of marine forms such as the mullets and shrimps exhibit the same type of behaviour. It is thus felt that the behavioural characteristics of the fry could form an important aspect of study and the results could open up possibilities for improving the existing collection techniques.

Food and Feeding

Brief references to the food and feeding of Chanos were made by Chacko (1945, 1949) and Chacko and Mahadevan (1956) that the larvae feed entirely on planktonic organisms like diatoms and copepods found in the shore areas; fingerlings feed on diatoms, copepods and to a great extent on algae in the shore regions; and the adolescents as well as adults feed on diatoms, copepods, larval bivalves, Lucifer, Mysis, etc. indicating indiscriminate feeding in their movements between neritic and oceanic areas.

Tampi (1958) made a more detailed analysis of the food and feeding of milkfish and reviewed the data published in the light of his own observations. For purposes of study, the growth stages were divided into three categories, (i) fry and fingerlings, including all sizes from 14 mm to 100 mm in total length; (ii) juveniles ranging from 100 mm to sexually immature specimens; and (iii) adults which have attained sexual maturity. The fry and fingerlings had fed mostly on diatoms such as Chroococcus, Fleurosigma, Diploneis, etc., blue-green algae, detritus and occasionally on nematodes and crustacean larvae, usually found at the bottom of the shallow swampy areas. Juveniles were found to feed more on algae, particularly blue-green and green algae and less on diatoms. A few fish collected from the sea ranging from 250 to 300 mm showed mainly Microcoleus, Phormidium, Lyngbia, etc. in their stomachs. Specimens above 300 mm in length showed small quantities of mucoid substance, with the alimentary canal collapsed and empty in many cases. The condition of the alimentary canal gave the impression that the fish had been starving for some time before their capture. A few fish collected from culture ponds had shown mostly mud and decaying organic matter with a few diatoms from the pond bottom.

The adult fish caught from the sea revealed the presence of Hypnea and Gracilaria in large quantities, but the most significant feature was the presence of lamellibranch spats in the stomach contents, sometimes in gorging proportions. Based on the fact that these spats are usually found attached to algae, Tampi (1958) was of the opinion that the fish had resorted to browsing among the algae growing near the bottom along the coastal regions where they were caught in shore-seines, and that the fish was able to crush such organisms in the highly muscular gizzard. It has also been inferred from these studies that the adult fish is not as much predominantly vegetarian as had been considered earlier, but that in the later stages of their growth they appeared to be capable of consuming and digesting a variety of animal matter also along with plant material from the surroundings. The observations of Kapoor (1954) on the morphology and histology of the pharyngeal organ in Chanos would be of relevance while interpreting the food and feeding of the fish.

Growth and Age

Our knowledge on the growth and age of Chanos in India is based chiefly on the observations on the fish cultured in marine, brackish or freshwater ponds and very little information is available on the growth and age of the fish from its natural habitats. Chacko and Mahadevan (1956), while reviewing the Chanos culture experiments carried out at Krusadai Island, found that the growth in the first six months was much rapid, (160-170 mm) and considerably slower in the succeeding six months. The fry measuring 50 mm and 85 mm stocked in June had grown to 235 mm and 260 mm by next June. These authors had stated that this limit might be considered to represent the normal growth of the fish in the neritic regions of the sea during its first year. These authors had further stated that the growth of Chanos stocked in certain brackish-water ponds was 320 mm to 425 mm in the first year, 500 mm in the second year and 550 to 600 mm in the third year. This is said to be much faster growth than the condition observed in the sea or in the marine fish farm. These authors had also found that the growth was even more rapid in freshwater tanks, up to 380 mm in the first six months, 600 mm in one year and 750-950 mm in two years. Based on a few specimens collected from the sea, Tampi (1957) had tentatively concluded that the age of females at first maturity, measuring about 1,100 mm could be 4 to 5 years. It was also observed that the females about 600 mm long could be about two years old and those of 900 mm are about three years. In the culture experiment carried out at Mandapan, Tampi (1960) observed a growth increment of 220 mm by the end of one year, the growth being more rapid in the first few months than in subsequent period. Observations on growth checks on fin spines, vertebrae or scales were less helpful in making reliable estimates of age.

While the opercular bones and the fin spines did show some definite rings on them, their utility in correlating with age remains questionable. The scales, on the other hand, were found to be too thick and opaque as the fish advances in age and conventional processings had not yielded any satisfactory results.

Maturity

Tampi (1957) found that Chanos below 500 mm in total length generally remain indeterminates. Differentiation of the gonad into testis or ovary under the microscope was possible only in specimens above this length. Two stages of maturity in males were collected, one in a very early stage and the other in an advanced condition. The absence of mitotic figures or dividing spermatogonia in males below 830 mm indicated that spermatogenesis took place in later stages only. In mature males measuring 1,080 to 1,140 mm total length, sperms were observed in spermatic tubules. In the female specimens four maturity stages were recognizable: (i) the earliest one in which differentiation as ovary was possible; (ii) the immature stage with uniform development of ova; (iii) the nearly mature condition with ripe intra-ovarian eggs; and (iv) the spent and recovering stages. The ripe ovaries were bright yellow in colour owing to the yolk-laden eggs. The ova were arranged closely in the ovigerous lamellae in a transverse manner. They were exposed, facing the coelomic wall, showing a gymnovarian condition. The ripe ova were spherical and translucent, without an oil globule, contained finely divided yolk and measured an average diameter of 0.8 mm. The spent ovaries contained bodies resembling stages in the formation of a "corpus luteum".

Although sufficient data and material have not been available on these aspects, the studies of Tampi (1957) have indicated that the ovary starts active development with the formation of oocytes when the fish is more than about 500 mm in total length, but in males the spermatocytes begin to appear only after the fish reaches a size of more than 900 mm. The size ranges of males and females of corresponding maturity stages have shown that the maturation of the testes proceeds faster than the ovaries and that the males are smaller than the females at the same maturity condition. The histological studies of gravid females did not reveal the possibility of the fish having spawned earlier; and, based on this it was assumed that the first spawning takes place when the fish is about 1,100 mm long and 11 kg in weight.

Fecundity and Spawning

Chacko and Mahadevan (1956) gave the fecundity of Chanos as 1.9 to 2 million eggs; but, the studies of Tampi (1957) have shown that mature eggs in gravid females varied between two million and five million in number. It was also found that the number of eggs present was proportional to the length of the fish.

The ova diameter frequency studies undertaken by Tampi (1957) on mature fish have shown the absence of multiple model curves, but the presence of only two widely separated groups of immature and mature eggs, indicating that the fish has only one spawning season in a year. However, the presence of indistinct minor modes and the wide range of size seemed to indicate some sort of fractional spawning within the season.

Based on the observations on the occurrence and availability of the fry, it is inferred that the fish usually spawns during February to May period. Panikkar et al (1952) once recorded the fry during November and December in the Mandapam area when spent females also were collected. Therefore, they had drawn attention to the possibility of a subsidiary spawning during October-December. Rao (1972), based on the continuous occurrence of the fry from February-March to October, is of the opinion that individual fish may be spawning independently of the others in the population.

As in the case of spawning season, the extent of the spawning grounds of Chanos in the Indian seas is to be inferred only from the occurrence and abundance of the fry. The Gulf of Mannar side on the southeast coast is undoubtedly one of the areas which show the most abundant concentration of Chanos fry. Similarly, many places around Point Calimere, Madras, Masulipatnam and Chilka farther towards the north are good collection centers for early fry. Judging by the size of these fry and the time required for their migration to the coast, it may be contended that the spawning grounds are not far off from the coast. But concrete evidences are lacking.

Based on the relative abundance of the fry during new moon period than during full moon period (Chacko and Mahadevan, 1956; Rao, 1972), it appears that the spawning intensity is greater during the former period. The observations of Malupillay and Chacko (1959) and Rao (1972) that the peaks of occurrence of the fry were preceded by rainfall, indicate that the spawning process takes place during or soon after the rains. Many marine species of fish are known to become sexually active on the onset of the first rains.

Eggs and Larvae

The only report on the collection of the eggs of Chanos from Indian waters is that of Chacko (1950) from the Gulf of Mannar. Their identification was based on the descriptions given by Delsman (1926, 1929) of Chanos eggs collected from the Jave coast. Detailed descriptions and figures of these eggs and the larvae hatched out of them have not been published so far. Subsequently, Chacko and Mahadevan (1956) had collected from the Nellore coast eggs resembling those of Chanos, but these were said to be smaller in diameter. One of us (P.R.S.T.) had isolated large numbers of eggs from the surface plankton collections of the Gulf of Mannar during January-March 1951, i.e. the months immediately preceding the appearance of fry along this coast and what could be the probable spawning season. These eggs closely agreed with the known descriptions of Chanos eggs. However, the larvae hatched out from them, especially of the second and third days, failed to show the pattern of arrangement of the muscle fibers in the myotomes or the pigmentation said to be characteristic of Chanos larvae. Similar collections were made in subsequent years also from these localities. Difficulties in rearing the hatchings beyond the critical phase and to take them to an identifiable stage have been the main bottleneck in settling the identity of the eggs and larvae.

Physiological Adaptation

Some studies were made of the adaptive responses of the fish to variations in salinity, temperature (Panikkar, et al, 1953) and dissolved oxygen contents of water (Viswanathan and Tampi, 1952). It was found that the fingerlings maintained their blood serum chloride fairly constant in a wide range of external salinity variations. In external salinities corresponding to a chloride content of 5 ppm and less, the serum chloride values were suggestive of a breakdown of osmoregulatory mechanism of the fish. However, the presence of calcium (144 ppm) in the external medium aided the fish in the retention of blood salts thus pointing to the significance of calcium ions in osmoregulatory functions. The salinity of the water did not appear to influence to any significant extent such metabolic characteristics of the fish as heat-death temperature, oxygen consumption, resistance to asphyxiation, etc. Discussing the significance of the data, the authors pointed out that any rational system of fish culture requires as an essential prerequisite information on the tolerance limits of salinity and temperature, the influence of ions in the water and of the size of the fish. The relationships between size and metabolic activity of the fish were found useful in the calculation of the rate of variation of the number of viable fish under transport with the size of the fish and in providing a convenient measure for the comparison of the viability of the fish under different environmental conditions.

Pituitary, Thyroid and Kidney

In view of the importance of the excretory organs and endocrine system in the maintenance of a steady state of internal environment of the fish, a study of the kidney, pituitary and thyroid in different stages of the fish was made by Tampi (1951, 1953 and 1959). The kidney in the adult fish has the conventional histological structure, composed of glomeruli followed by a ciliated neck, a comparatively narrow proximal convoluted segment and a broader distal segment. The kidney in the larval stages in the 15 mm larva (unpublished data of P.R.S.T.) is a much simple structure consisting of 15-20 glomeruli, each with a short, apparently undifferentiated tubule, all of which are embedded in a highly vascular haemopoietic tissue surrounding the main dorsal blood vessel. At this stage the urine is conducted to the outside by means of a common ureter. The significance of the finer structure of the rural tubules, if properly understood through experiments, would be of immense benefit in understanding the osmoregulatory powers of the fish. Structure peculiarities in the pituitary of the early fish were observed although their functional significance is not known. Similarly, there is a fairly good account available on the nature of the thyroid cells of the larval fish under different salinities, temperature and under the influence of certain thyroid inhibiting drugs (unpublished data of P.R.S.T.).

General Remarks on Future Lines of Investigations

The paucity of data on the adult milkfish has been a general constraint and the need to have a better understanding of the biology of the fish has been widely stressed. As the distribution of the fish covers a very large region spread over the Indo-Pacific, it is essential that the various countries concerned collaborate and obtain as much reliable information as possible in this respect. Several agencies in these countries are at present actively engaged in studies on the different aspects, most of which perhaps lay greater stress on the practical problems related to its culture. While a cooperative approach could yield quick and useful results in unravelling the problems on the life of such a fish with extensive distribution, it may be possible to tackle some of the studies on a regional or localized basis and depending on the facilities and interests of the specific region. In this manner the existing gaps could be covered so that a complete account could be built up if a planned approach is taken.

When viewed in this background and priorities are drawn up, studies on artificial inducement of spawning of the milkfish may perhaps gain the first place. It is gratifying to note that certain

organizations are seized of this problem and experiments are underway to make the fish breed artificially through the technique of administering pituitary hormones. This technique, as we know today, is applicable only to make sexually mature fish release the gonadal products so that external fertilization of eggs could be carried out. In the case of the milkfish, obtaining sexually ripe fish either in nature or in ponds remains a problem by itself. Therefore, efforts will have to be made to see how the fish could be reared to a stage when pituitary hormone administration could be effective. In this connection some fundamental studies on the physiology of the fish, covering the whole gamut of reproductive physiology together with endocrinology as well as adaptational physiology and metabolism, would be helpful.

The next item where a cooperative effort would be called for is the location of the spawning grounds as well as identification of the eggs and early larvae from the plankton. It is time that the question of identification of the eggs is reviewed in greater detail and the identity established so that the workers in the different regions could have a positive guide in this respect. For this purpose, horizontal and vertical plankton collections during appropriate seasons should be intensified in the different regions and efforts should be made to hatch and rear the eggs to an identifiable stage so that the reliable characters could be delineated. This would also help in the location of spawning grounds of the fish.

A critical study of the spawning season reveals certain interesting features. By and large, the main fry and fingerling season in many regions of the Indo-Pacific coast is during the summer months of April-July. However, in many places fry have been reported to occur in other months; this has led us to believe that there is more than one breeding season, or that individual fish may exhibit variations besides the species as a whole showing protracted spawning behaviors. Apart from the possibility of existence of different racial stocks with different spawning characteristics, one factor which appears to be involved and which does not seem to have been given due consideration is the pattern of migratory behaviour of the fry and fingerlings. For, if the exact time of appearance of fry along any particular coast is carefully analyzed, especially in relation to the size, some definite pattern is likely to emerge. At least, it is so in the case of the occurrence of *Chanos* fry along the east coast of India where the fry are first reported from the Gulf of Mannar area and gradually as the season advances they show up in the northern centres towards the later months. There is some increase in their average size also as they occur in these northern centres. While this is only a general observation which needs more critical analysis and a basis determined, from our unpublished observations along the Indian coast there appears to be a

need to study this aspect carefully. It is not clear if hydrographic factors have any influence on this type of behaviour. Side by side with such studies, it would be advantageous to conduct investigations on factors that tend to attract the fry to specific localities, any periodicity or cyclic occurrence and also their migration back to the open seas when once they pass the fingerling stage. Some tagging operations on fingerlings at selected centres would prove beneficial in unravelling some of the less known problems of behaviour of the fish in this early phase.

For such of those regions which are primarily concerned with this fish as the principal species for brackishwater culture and where potentials exist, it is imperative that a proper survey and estimation of the natural fry resources are completed without further delay. At the same time, those regions indulging in fry collection as a trade would do well to watch the trend of collections from year to year so that any possible effect on the ultimate stock could be studied, although the removal of a few million fry every year from any locality is unlikely to result in any serious adverse effect in the case of a species whose fecundity is phenomenal.

References

- Chacko, P.I. 1942. A note on the rearing of the milkfish Chanos chanos. Curr. Sci., 11:108.
- Chacko, P.I. 1945. On the food and alimentary canal of the Milkfish Chanos chanos. Curr. Sci., 14:242-243.
- Chacko, P.I. 1949. Food and feeding habits of the fishes of the Gulf of Mannar. Proc. Indian Acad. Sci., 29:83-97.
- Chacko, P.I. 1950. Fish eggs and larvae from the plankton of Gulf of Mannar. Ibid.
- Chacko, P.I. and S. Mahadevan. 1965. Collection and culture of the Milkfish Chanos chanos (Forsk.) in and around Krusadai and Rameswaram Islands, with notes on its biology. Gov't. of Madras, Fish Stat. Repts. and Yearbook, 1954-55:145-154.
- Delsman, H.C. 1929. Fish eggs and larvae from the Java Sea, 10. On a few larvae of empang fishes. Treubia, 8:400-412.
- Delsman, H.C. 1929. Fish eggs and larvae from the Java Sea, 13. Chanos chanos. Treubia, 11:281-286.
- Ganapati, S.V., P.I. Chacko, R. Srinivasan and B. Krishnamurthi. 1950. On the acclimatization, transport and culture of some saltwater fishes in inland waters of Madras State. Indian Geogr. J., 25:27-33.
- Job, T.J. and P.I. Chacko. 1947. Rearing of saltwater fish in freshwaters of Madras. Indian Ecol., 2:1-9.
- Malupillai, C. and P.I. Chacko. 1959. Observations on the remarkable adaptability of the Milkfish Chanos chanos (Forsk.). Gov't. of Madras, Fish. Stat. Repts. and Yearbook. 1955-56: 84-93.
- Kapoor, B.C., 1954. The pharyngeal organ and its associated structure in the milkfish Chanos chanos (Forsk.). J. Zool. Soc. India, 6(1):51-58.
- Panikkar, N.K., P.R.S. Tampi and R. Viswanathan. 1953. Some aspects of adaptation in Chanos chanos (Forsk.). Proc. Indian Acad. Sci., B37(6):203-213.
- Raj. B.S. 1931. Administration Report of the Madras Fisheries Department for 1929-30. Madras Fish. Bull., 25:1-104.

- Rao, A.V. Prabhakara. 1972. Observations on the larval ingress of the Milkfish Chanos chanos (Forsk.) into the Pulicat Lake. J. Mar Biol. Ass. India., 13(2):249-257.
- Tampi, P.R.S. 1951. Pituitary of Chanos chanos (Forsk.). Nature. 167:686.
- Tampi, P.R.S. 1953. On the structure of the pituitary and thyroid of Chanos chanos (Forsk.). Proc. Nat. Inst. Sci. India. 19(2):247-256.
- Tampi, P.R.S. 1957. Some observations on the reproduction of the Milkfish Chanos chanos (Forsk.). Proc. Indian Acad. Sci., B46:254-273.
- Tampi, P.R.S. 1958. On the food of Chanos chanos (Forsk.). Indian J. Fish., 5(1):107-117.
- Tampi, P.R.S. 1959. On the renal units of some common teleosts. Proc. Indian Acad. Sci., B50(2):88-104.
- Tampi, P.R.S. 1960. Utilization of saline mudflats for fish culture -- An Experiment in Marine Fish Farming. Indian J. Fish., 7(1):137-146.
- Tampi, P.R.S. 1973. Culturable marine fish fry resources from brackishwater environments. CMFRI, Proc. Symp. Living Resour. Seas around India: 390-397.
- Viswanathan, R. and P.R.S. Tampi, 1952. Oxygen consumption and viability of Chanos chanos (Forsk.) in relation to size. Proc. Indian Acad. Sci., B36(4):148-159.