

PROBLEMS CONCERNING FISHERY OF HILSA, HILSA ILISHA (HAMILTON) IN THE RIVER INDUS

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Hilsa fish is liked very much by the people of southern West Pakistan. It used to reach Multan before the barrages were constructed on river Indus. By construction of Llyod's Barrage at Sukkur, its passage was cut down but the distance from the sea was quite enough for its breeding. After the construction of Ghulam Mohammad Barrage the distance for its ascent was considerably shortened and may result in depletion which can only be proved by further observations.

The biology, life-history and other habits have been studied. It has been found that the fish breeds to a very small extent down the barrage. The fish ladders provided in the barrage are unsuitable for the ascent of this fish. Measures for counteracting the adverse factors have been suggested and it has been recommended that detailed studies should be carried out in order to save this important fish from depletion.

Introduction

Although casual observations have been made by many workers on Hilsa, which is known as "Palla", in West Pakistan, no systematic or concerted effort was previously made to work on the biology of this fish in this area.

Considering the importance of Hilsa in the Indo-Pacific Region, specially for Burma, Pakistan and India, problem of its fishery was considered at the 3rd Session of the Indo-Pacific Fisheries Council in 1951 at Madras and it was decided that urgent action should be taken by Member Governments to secure the fullest possible information on the species and on the fishery which bear upon it.

This paper deals with investigations carried out in West Pakistan. In this short period it was not possible to finish all the items stated above. Messrs. M. A. Salam Kazmi, A. H. Bhuiyan, Tahir Ahmad Hashmi and Inayatullah Khan have made contributions in the scheme and their work was liberally consulted for the preparation of this paper. The area of river Indus under observation was about 180 miles (from the mouth of river to Ghulam Mohammad Barrage) and some observations in connection with the ascent of Hilsa were made above the barrage also.

Historical

Hilsa is a fish of great importance to Pakistan and India and has been reported also from Iran, Burma, Thailand and some islands of Malaysia. Regular investigations on Hilsa fishery were initiated by the Fisheries Department of Madras as early as 1907, followed by a year or so later by

the Departments of Fisheries, Bengal, Bihar and Orissa.

Aitkin¹ has given a brief account of this fish, and Jenkins³⁴ has described spawning and the size of eggs and other habits of Hilsa. Southwell and Prashad,⁶⁴ besides relating the habits of this fish, have discussed artificial propagation of Hilsa in Bengal waters. Hora and his co-workers²⁰⁻²⁵ have carried out systematic investigations in Bengal waters on the biology, migration and young stages of Hilsa which were found in the municipal water works at Pulta.

In Madras, Raj,⁵⁰ Devanesan,¹⁷ Chacko Ganapati and Zobairi,¹⁸ Chacko and Ganapati¹¹ and others have done extensive work on the breeding habits, age, and effect of dams on the migration of Hilsa and have also been successful in artificial hatching of its eggs.

Mention may be made of the research workers who have carried out quite extensive investigations on various aspects of this fish in West Bengal. Jones *et al.*^{38,42} have been successful in collecting fertilized eggs, and larval stages of Hilsa from the River Hoogly. They have also conducted studies on the migration and biology of this fish in the Hoogly and Chilka lake. Jones also compiled a bibliography of Hilsa in 1952.³⁸ Pillay⁴⁸⁻⁵¹ has published papers on the biology, migration, morphological and physiological characters of the blood, tagging and other problems concerning Hilsa.

Kulkarni⁴³ has given a detailed account of its breeding habits and early life-history. Qureshi,⁵⁵ Ahmad,² Bhuyian,⁸ Hussain and Sufi²⁶⁻²⁸ have specially mentioned migration of this fish in the River Indus and the effect of dams on its breeding.

Ecological Features of the Indus River

The Indus is the main river in West Pakistan, it originates in the Himalayas and after traversing about 1500 miles of territory falls into the Arabian Sea. It has five tributaries besides Kabul river. The length of the river under study was the portion in the former Sind. Formerly only one barrage at Sukkur, known as Lloyd's Barrage, existed. Hilsa used to ascend and was caught in large numbers down this barrage till 1953. Another barrage, Ghulam Mohammad Barrage, was constructed in 1954 reducing the distance between the mouth of the river and the barrage from 476 to 180 miles, thereby restricting the stretch for the ascent of fish. Due to the construction of G.M. Barrage the saline water has intruded further in the lower reaches of the river. During the monsoons and melting of ice, floods counteract the salinity and the sea water is pushed back. Very little work on plankton has been done but the conditions may be more or less the same as reported by Dutta, Malhotra and Bose⁷¹ for river Hoogly. The studies carried out in the estuarine area and the coast show that a bloom of plankton is found from the months of September to November.

Material and Methods

Data were collected from fish landing centres along the 180 miles stretch of the river down the barrage. These main centres were (i) Thatta about 100 miles, (ii) Goni about 135 miles and (iii) Jamshoro (Hyderabad), 180 miles from the mouth of the river.

Taxonomic Identity

Over 200 fishes, caught from different localities, were examined and it was found that there was very little variation. Meristic characters, vertebrae and non-meristic characters were studied in detail in order to determine whether different races of this fish exist.

From the morphometric study of a large number of specimens it was inferred that there is a single homogeneous stock of Hilsa, viz. *Hilsa ilisha* (Hamilton) in the river Indus (Fig. 1).

Fecundity

Views of workers on fecundity differ. Some say that the fecundity varies with the size.

Lehman⁷², however, has shown that the relation between fecundity and length is linear in the American Shad, *Alosa sapidissima*. He found that there is a direct proportional increase in fecundity

with increase in length, weight and age of the fish.

In order to determine the fecundity of the fish, ovaries of 115 specimens were examined. Only those females were taken for study which had more or less ripe eggs. The ovaries were preserved in 5% formalin.

First the entire ovary was weighed after removal of surface moisture. Then a cross-section of the ovary was cut out and weighed, this was done for the anterior, middle and posterior regions of each ovary. The six samples were immediately weighed, each was teased out and eggs counted under a stereoscopic microscope. The number of eggs were found between 80,000 to 2 million in the ovaries.

Maturation and Spawning

Fishes were collected at three landing centres, viz., Thatta, Goni and down G. M. Barrage (Jamshoro). The females were examined to see the maturity of ovaries. The eggs were yellowish in colour and of uniform diameter when examined with naked eye.

According to James and Menon,⁴¹ the size of fully mature ova of Hilsa is only 0.7 mm, of oily transparency, pale yellow in colour and demersal in character. Kulkarni⁴³ gives the size of unfertilized fully mature ova as 1.3 mm.

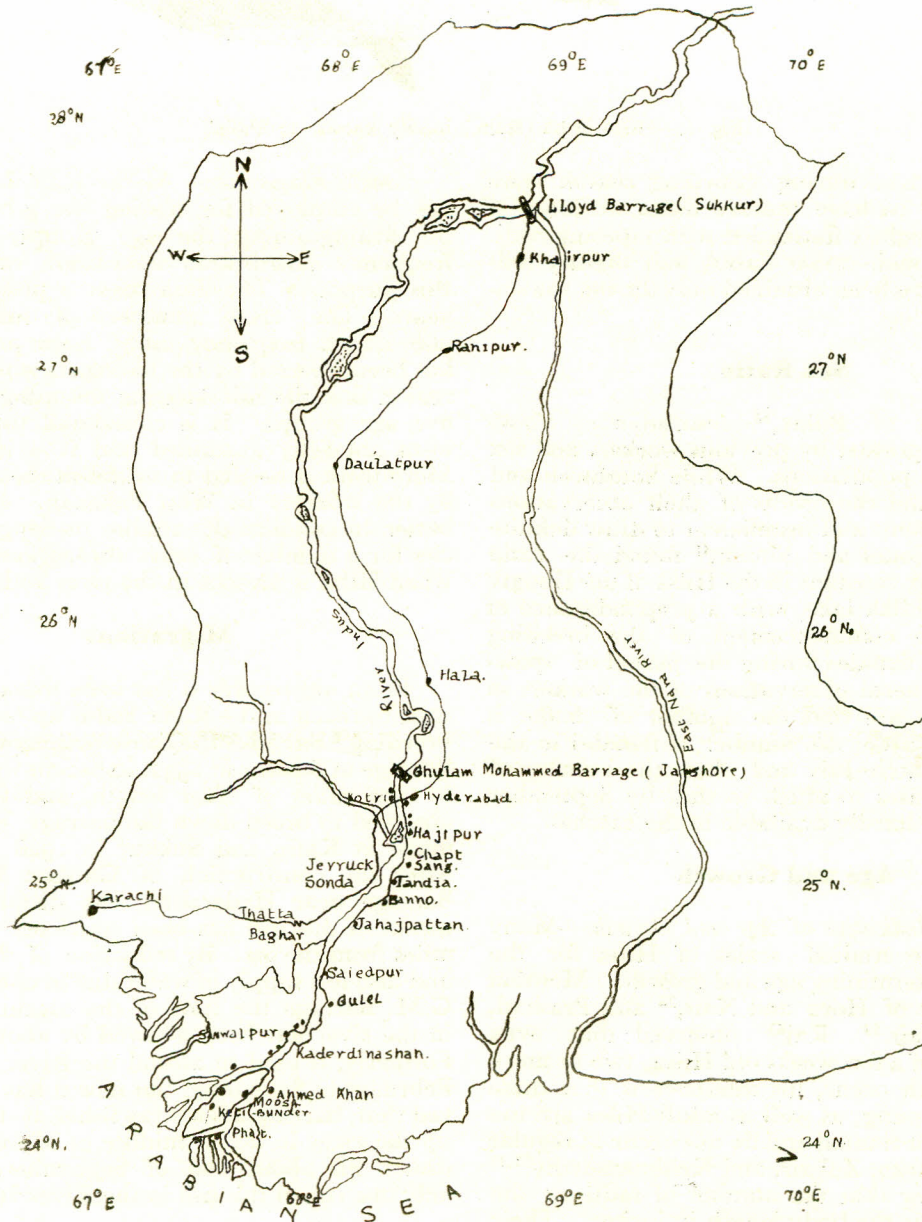
Spawning Grounds.—The size of the ova taken from the gonads from different localities were analysed and it was found that the size increased slightly as the fish ascended further up. Oozing females and male were not found in fair numbers. Only 5 females and 7 males were observed in fully mature condition during one season. It has been inferred that, by reducing the distance between the mouth of the river and the barrage from 476 miles (which was available before the construction of G.M. Barrage) to 180 miles, the fish has not adjusted itself to the lesser distance now available and the changed ecological conditions. The work done on the West coast of India indicates that Hilsa breeds in the river Nerbada at a distance of only 40 miles as it cannot go upstream owing to the hilly nature of the river.⁴³ In the river Indus, it has been reported that Hilsa used to ascend up to Multan and my observations show that before the construction of G.M. Barrage, near Hyderabad, large number of oozing males and ripe females were caught 2 miles down the Lloyd's Barrage at Sukkur personally observed in 1948 and 1950. It is now to be observed whether Hilsa will be able to adjust itself to the

curtailed distance now available to it in the river Indus.

Maturation of Females.—The ovaries are rounded with two lobes which are united at the distal end, sometimes only one lobe is present. Pillay⁵⁸

has observed that spent ovaries are of blood-red colour and floccid. In most cases they are very shrivelled up, and microscopic examination shows the presence of only small immature ova in them.

Maturation of Males.—The male fish that



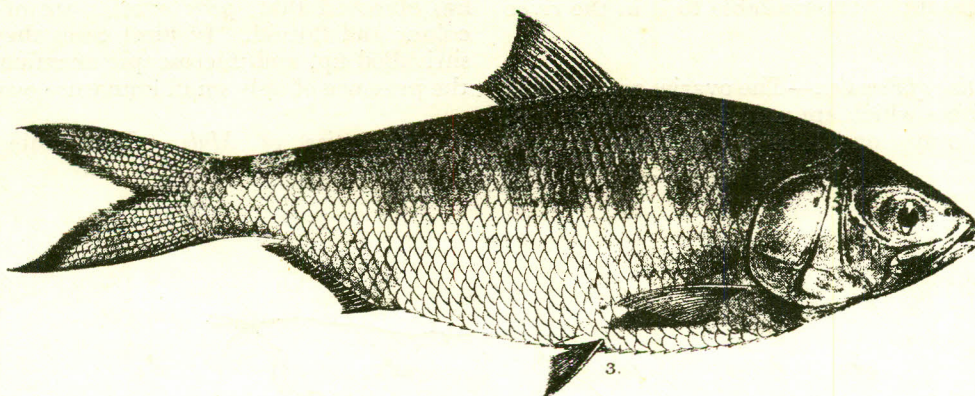


Fig. 1.—Hilsa ilisha (Ham.) locally known as 'Palla'.

ascend the river during spawning season were found mostly to have mature testes, the lobes of which were slightly flattened with tapering ends. Spent males with rather flabby and slightly reddish testes have been obtained only during spawning season.

Sex Ratio

According to Pillay,⁵⁸ contradictory views have been expressed by previous workers and sex ratio of Hilsa populations. While Southwell and Prashad⁶⁴ found the results of their observations to be inconsistent and insufficient to draw definite conclusions, Jones and Menon⁴¹ found the ratio to be generally constant in the Hilsa of the Hoogly River and Chilka lake, with a preponderance of males at the commencement of the breeding season and of females during the period of spawning. The general observations of the workers in West Pakistan are that the number of males is much greater than the number of females in the months of March–July and then the number of females increases so much so that by September the males are hardly available in the catches.

Age and Growth

Scales as Indicative of Age and Growth.—Many workers have studied scales of Hilsa for the purpose of determining age and growth. Mention may be made of Hora and Nair,²⁴ and Prashad, Hora and Nair.⁵³ Raj⁶³ observed that even in the scales of a few weeks old Hilsa, two or more lines of growth occur, his inference is that these rings in the young, as well as adult Hilsa are too numerous to be annual and do not occur at regular intervals. Chacko, Zobairi and Krishnamurthy^{12,13} are of the view that the number of radii on the scale represents the body length in inches. Their assumption is that probably age in months is correlated to the radii found on the scales.

Length Frequencies.—As the scale method could not be employed for tracing the growth rate of for distinguishing the age groups, the length frequency distribution data were examined for this purpose. The data cover a period of three years. The total number of fish measured and length frequency tables were prepared. It has been inferred by the biologists working in this region that the fish entering the fishery belong to five age groups. It is considered that the data were not fully examined and it is inconclusive. More work is needed to establish the claim made by the workers in West Pakistan. It would be better to conduct the studies on length frequencies for a number of years throughout the season when Hilsa is present in the river Indus.

Migrations

From old records it has been found that Hilsa used to reach in the River Indus up to Multan for breeding,¹ but after the construction of the Lloyd's Barrage at Sukkur in 1932, its ascent was restricted to 476 miles of river length, and the fish was observed to breed down the barrage (observations made at Katin and Sukkur in 1948 and 1950). After the construction of Ghulam Mohammad Barrage near Hyderabad, the distance for the ascent of this fish has been restricted to only 180 miles from the sea. By reduction of the distance and also less supply of water due to construction of G.M. Barrage the time of the ascent of the fish in the river has been delayed by about a month. Formerly, it used to ascend the River Indus from February to September but now it has been observed that, barring a few stray fishes, it starts coming up the river in about middle of March and continues till about end of September. There is only one run of this fish in the River Indus.

Hora and Nair^{24,25} consider that the upward ascent of Hilsa is largely dependent on two

main factors, viz., monsoon and the state of sexual maturity.

As regards the state of sexual maturity being the factor that induces the migration, Hora^{24, 25} has stated that the swarming of the mature Hilsa into the rivers during the flood season is mainly for spawning purposes, but a number of young individuals also ascend and these travel far inland before they become sexually mature.

Observations of some workers in rivers of India are that spent fishes returning to sea with the current, remain at the bottom and can be caught only by nets which ply at the bed of the rivers. Some spent females were observed by the workers in the river Indus in the last week of September, 1960. Some spent fishes were observed by the author in the catches of fisherman near Thatta in November for 2 years.

Hardiness and Culturability

It has been found that as far as it remains in the sea and estuarine waters, Hilsa is quite strong and can live in confined conditions.

Rearing of young Hilsa in cement tanks was to an extent made successful by Pillay.^{50, 51} It may be possible to rear Hilsa in ponds if proper ecological conditions and food is provided. Some Hilsa during their ascent or downward travel enter canals and then reach the dhands (artificial lakes) in West Pakistan. Hilsa has been observed by the fishermen and fishery officers in Manchar lake of Dadu District and Kalri lake of Thatta District. This means that if young Hilsa is transferred from the rivers to these lakes or large ponds it may be possible to rear them to marketable size. It is, however, to be seen whether they will breed in the lakes.

The hardiness of the fish is further proved by the tagging experiments of Hilsa carried out by Pillay and others⁵⁰ at the Central Inland Fisheries Research Station (Barrackpore) in the River Hoogly.

Fishery and Effect of Dams

Records show that Hilsa was caught beyond Sukkur but in 1927 Lloyd's Barrage was constructed at a distance of 476 river miles from the sea. It restricted the run of Hilsa to that distance but this length of the river available to the fish was quite adequate. There was no apparent effect on its fishery. The main fishing centres were in Thatta, Hyderabad, Nawabshah, Larkana and Sukkur districts. In 1954-55 the Ghulam Mohd. Barrage was constructed at Jamshore (Hyderabad)

reducing the distance by 296 miles cutting off Nawabshah, Larkana and Sukkur stretches of the river, only Thatta, Goni and Hyderabad remained where fish was caught.

Boats Engaged.—Two types of fishing boats are employed in Hilsa fishery. The smaller one is known as Bathela on which 4-6 fishermen are employed. It is used for the operation of drift net in the river. The larger one, Donda Bari, is utilised for the transport of provisions, catch and merchandise besides using drift (gill) nets. None of the above is mechanized; sails cars and bamboos are used for their propulsion. The number is stated to be varying between 350 to 560 according to the extent of the appearance of Hilsa.

Nets.—Gill (drift) nets are of different meshes and accordingly, have been given local names by the fishermen. Bhan has 50 to 60 pieces of nets which are joined together according to the width of the river. Each piece is 40 ft long and 30 ft deep, with 2 inch mesh in the lower portion and 4½ inch in the upper half. It is placed across the river and usually blocks the full width of river. It is very destructive and harmful. Twenty to twenty-five fishermen are employed when used as beach seine. Ghava consists of pieces of 18 ft × 18 ft with meshes varying from 3 inch to 5 inch. It is operated near the barrage where ascending fish is caught. Ojhani has a length of 500 to 850 ft, depth 6 to 8 ft and mesh of 5 to 6 inches. One end is tied to a boat and the other is left free to drift. Three or four fishermen operate it from a boat. Small clap and lift nets known locally as Sandh and Kalera are used singly by fishermen from a boat or by a single fisherman who drifts with the current riding on a gourd. One fish at a time is caught by these nets. According to the figures collected by the biologists the number of nets employed in the capture of Hilsa is about 2500.

There are indications that the G.M. Barrage has adverse effect on Hilsa fishery in two ways. One is that fish is caught in large quantities in the reduced length of the river. The second is that the reduced distance available to the fish because of the construction of this barrage does not give time to the fish to mature.

Ghulam Mohammad Barrage and Fish Ladders.—Constructed on the River Indus at a distance of 180 river miles from the sea, near the city of Hyderabad in 1954-55, the fish ladders are about 30,000 ft long and consist of 44 bays of 660 ft span provided with gates 21 ft deep. Talbot⁵⁸ states that the construction of the barrage at this site obstructs the Hilsa fish in their annual run upriver and deprives them of almost two-thirds.

of their normal spawning area. In an attempt to allow these fish to pass above the obstruction, two fishways have been constructed adjacent to the dividing walls, enclosed pockets containing the head regulators of the canals which take off at each side the barrage. The pockets form desilting devices which allow the canals to obtain water free from the heavier silt which deposits in the pockets. When sufficient silt is deposited the barrage gates below the pockets are lifted and the silt is scoured out of the pockets into the river down-stream of the barrage. Talbot has, in his report, suggested various measures for improving the condition in order to induce the fish to spawn. He further states⁶⁸ that there is no possible way to alter the present fishways so that they will be acceptable to Hilsa. The only recourse for passing Hilsa above the barrage will be to construct new modern fishways. The only place these can now be installed is in the gate bays of the dam. This can be done only if two or more gate bays can be utilized for fishways without restricting the passing capacity of the barrage below the estimated highest peak flow. Also, before workable fishway can be designed it will be necessary to know the maximum and minimum head and tail water elevations that prevail at the barrage during the period of the Hilsa run (April through August).

Day¹⁴ had taken great interest in the migration of Hilsa and effect of weirs, or anicuts, erected in the various rivers of the Madras Presidency. He arrived at the conclusion that "Weirs in India are destitute of fish passes and the migratory fishes will probably soon be exterminated in rivers spawned by these obstacles".

Hamid Khan¹⁹ observed that most of the fish passes in the Punjab are ineffective.

Husain and Sufi, ^{27,28} on the basis of their fishing and observations in the fish ladders in the G.M. Barrage, have come to the conclusion that since there is no means of attracting the fish, they do not negotiate the ladders. Even when the fish were put into the ladders they did not go up, instead they turned back and swam down. They are of the view that the fish does not like rapid current, they turn back after feeling the obstacle and do not jump. Instead of trying to enter the ladder, they congregate at the right flank of the barrage near the guide wall.

An engineer alone or a biologist on his own cannot design a fish ladder as it requires expert knowledge of both. I would, therefore, agree with Ahmad and Ahmad³ who have stated that it needs a detailed, full-scale study by the Irrigation Research Institute, Lahore, in collaboration with the Fisheries Department to evolve a design

most suitable for fishes ascending the rivers, to be fitted at Kotri, Sukkur and Guddu Barrage for the easy passage upstream.

The workers and administrators may be warned that the designing of a fish pass is not an easy matter. It requires many years of practical experience and observations. In U. S. A. and other countries specialists working on designing of fish passes are appointed in the Fisheries Departments where they work with experienced biologists who study habits of fish for which fish passes are to be constructed.

Life-History and Conservation

Some work in India has been done on the life history of Hilsa. Investigations were first taken up by the fisheries workers in Madras and Bengal, where attempts were also made at artificial fertilization so as to liberate the fry into the rivers to supplement the natural stocks.

Wilson⁷⁰ succeeded in artificially hatching and liberating the fry in Coleroon River, South India. Raj⁵⁹ was successful in hatching Hilsa eggs but could not proceed further in rearing the fry.

Hora²⁰ had collected and described young stages of Hilsa from the settling tanks and filter beds of the Water Works of the Calcutta Corporation at Pulta. Nair⁴⁶ described postlarvae and young stages of this fish. Jones and Menon⁴¹ have published an account of the collection of fertilized eggs from River Hoogly, their hatching and development to postlarvae. Kulkarni⁴³ had described the eggs and larvae of Hilsa from River Narbada.

Incidentally, I may here narrate the hatching and development of Hilsa eggs which were done at Bobberlanka, Godavari District. Here the anicuts have been constructed across the branches of the River Godavari. A small hatchery exists near the second anicut for this purpose. In October, 1940, an attempt was made to collect ripe female and male for two days below the anicuts and from the fishermen, these were not available at the same time. Then some oozing males were caught on 11th October, 1940 and kept alive in a conditioning box placed in the river and two ripe females were obtained from the catches of fishermen. When caught the eggs were flowing out and with a little pressure these were collected in an enamel tray. The eggs were fertilized by mixing the milt with a feather and allowed to take full effect for some time.

Fertilized eggs were then transferred at about 7 p.m. to a MacDonald Jar connected to an

overhead tank and water was circulated. At about 4.30 a. m. the hatching started and by 7 a. m. all hatchings floated on the surface and then were collected in an inverted bell jar. Unfortunately, the water in the overhead tank was exhausted and the fry (having yolk sac) began to die. Since there was no further arrangement to develop the larvae, these were liberated in the river. The hatching was incomplete as it had no arrangements for pumping water into it from the river. Secondly, there were no rearing tanks where the fry could be grown to a suitable size in order to liberate them in the river. Had the arrangements been made, it would have been possible to rear hatchings further. This is a very interesting problem and should be pursued by fishery biologists. The hatchery and rearing tanks will cost a few thousands and are worth the expenditure for the sake of research on the development of Hilsa.

Conservation.—Jones and Menon⁴¹ have referred to 3 recommendations regarding the conservation of Hilsa fishery: (1) Hora's²⁰ suggestion that protection of the brood fish and young should be aimed at rather than the construction of hatcheries and fish passes. (2) Raj's⁶² emphasis on successful artificial propagation of Hilsa to supplement the stocks in the rivers. (3) Devenesan's¹⁷ suggestion that the brood should be protected below the anicuts for a specified minimum distance by enforcement of rules regarding a closed period for fishing. Below the dams/barrages at least one mile of the river should be closed for fishing and this will save brood fish from indiscriminate destruction. It is suggested that nets should not be allowed to cover the whole breadth of the river and that small-meshed nets should be totally banned as these are not harmful only to Hilsa but also to all other fishes.

Before enforcing any conservancy measures it is necessary to study thoroughly the life history, migratory, breeding and other habits of fishes.

Summary

Aims and objects of the research on Hilsa have been described. References to the research of the workers specially from India, have been made.

It has been found after study of a large number of specimen, that *Hilsa ilisha* (Hamilton) in the River Indus consists of a homogenous stock.

Fecundity.—The relationship of fecundity of Hilsa to its body weight is linear; the relation between fecundity and length is exponential.

Maturation and Spawning.—There is only one spawning season in the River Indus, starting from March due to increased flow of water by melting of ice and extending up to September owing to monsoon. Individual fish does not spawn all at once but several times during the spawning season. It is concluded that very few fish spawn below G. M. Barrage. Talbot⁶⁸ mentions that judging from the size of the fish in comparison with American shad this (age at which fish ascends the river) is estimated at 4 to 6 years.

Sex Ratio.—The ratio of males to the females is more than 1:1 in the beginning, more females than males are found after July and in September the appearance of males is rare.

Age and Growth.—Only general study of the scales was done in the absence of any suitable apparatus. According to Pillay,⁵⁰ the scales cannot be depended upon for growth determination. By the analysis of length-frequencies it has been found that males attain modal lengths of 24.7 cm, 34.3 cm, and 39.3 cm, and females, 26.5 cm, 39.1 cm, and 43.6 cm in 1½, 2½ and 3½ years, respectively. The growth rates of males and females have been found to be significantly different.

Migrations.—It has been concluded that Hilsa ascends rivers only for spawning and that the spent fish as well as their progeny migrate down the river. It is considered that lower estuaries and coastal waters are the habitat of the species. The probable factors inducing migrations are discussed and references are given of the work done in India also. Further research is necessary for understanding this problem.

Hardiness and culturability.—The fish is not so delicate as described by some workers. It can be handled easily for stripping and has been kept in confined water for some days. Tagging in India has also been done of this fish successfully. Further work on the transport of young Hilsa from the rivers to fresh water lakes and their culture, as an experiment, is recommended.

Fishery and Effect of Dams.—The fishing craft used and the methods of fishing in the River Indus are briefly described. The annual catch of fish from the River Indus is 40,000,000 lb. The effect of Ghulam Mohammad Barrage and effectiveness of the fish ladders in the barrage has been discussed. The recommendations of Dr. G. B. Talbot have also been discussed.

Life History and Conservation.—General observations have been recorded and measures for conservation have been suggested.

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