Synopsis of the Thesis Entitled

FISH AND FISHERY OF HILSA (FAMILY: CLUPEIDAE) OF GUJARAT STATE WITH REFERENCE TO MIGRATION

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By

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INTRODUCTION

A standout amongst the most nutritive rich and economically imperative fishes found in the Indian waters is Hilsa, *Tenualosa ilisha* (Family: Clupeidae) already known as *Hilsa ilisha*. It was characterized out of the blue by Russel (1803) in the beach front waters of Visakhapatnam and was given the name 'Palash'. He gave the principal portrayal and drawing of the fish (however his classification was defective), and commented that the hilsa is a 'rich and delicious fish with quite a bit of herring flavor'. It was then named *Clupanodon ilisha* by Hamilton (1822). It is essentially an anadromous angle which implies a fish occupying the marine waters in all its years' length yet to spawn and reproducing purposes, it moves to fresh waters. It is known to climb waterways through its territory of dispersion. In the marine condition they are conveyed from Iran and Iraq in the Persian Gulf toward the west shoreline of India in the Arabian Sea and the Bay of Bengal. The perceptions made in the conditions of Tamil Nadu, Andhra Pradesh, Orissa, West Bengal and Gujarat has demonstrated that Hilsa breeds in the upper stretches of estuaries or waterways where the water is new[1, 2, 3, 4, 5, 6, 7, 8, 9].

The interest in Hilsa aroused after the preliminary investigations by Francis Day (1873) for his book, Fishes of India and the recommendation by K. G. Gupta (1908). Later on, the Fisheries Departments of West Bengal, Bihar and Orissa started up further investigations of the fish including artificial breeding of Hilsa. Further, Chaudhari (1916) observed the presence of Hilsa in the Chilka Lake, Orissa throughout the year. Jhingran *et al*. (1963) have given a brief account on age and growth of the fish.

The Indian shad is one vital individuals from the Clupeidae family. The grown-up Hilsa is of shiny shading shot with gold and purple. The youthful ones are generally of a bronze shading along the back, with brilliant sides and a polished shiny band going from over the eye to the upper portion of the caudal balance, and the caudal blade is regularly profoundly edged with

dark in its whole circuit. With nonattendance of teeth and nearness of scales in normal lines everywhere throughout the body and many even finished the caudal blade.

Hilsa is a hetero animal types in which female becomes speedier than male and the assortment of female is more extensive than the male with bigger circumference. Urinogenital opening of the gravid female is level however slender on account of male where papillae are relatively noticeable[10, 11, 12, 13, 14]. It approaches maturity during the monsoon when the inland rivers are flooded. It was expressed that there are no fixed breeding grounds for the fish in the generally accepted sense of the term and that they probably breed during the rainy season, when conditions such as weather, temperature and other undetermined factors are suitable[15].

Hilsa is considered to be a major food source in India, Bangladesh, Pakistan and the Arabian Gulf occurring in rivers and estuaries as an essential part of fisheries. These fish enter estuaries and rivers for spawning in different dates and duration in different regions. It stated that the fish spends the first year of its life in the lower reaches of the rivers and goes to the sea in the third year. It was observed that after leaving the rivers they do not go far into the sea, but move about in shoals in the estuaries and foreshores[16].

The migration of Hilsa (shad) is of two types:

1. **Monsoon migration**: The anadromous character of Hilsa is one of the main factors behind such migratory pattern. During consequent flooding of the rivers, the Hilsa swims against the tide and goes to the river for spawning and breeding.
2. **Winter migration**: Not only in monsoon, the Hilsa migration is limited to winter season too for a short period of time. The period is from February to March.

The Hilsa, being anadromous in nature follows a life cycle that follows the pattern of breeding upstream and the larvae hatching from the free floating eggs. The immature young

stages grow in river channels and descend to the sea for the period up to growth to a mature male/female stage before returning to the rivers for breeding to complete the cycle.

OBJECTIVES

The objectives of the study are:

1. Diversity and spatio-temporal distribution of Hilsa in Gujarat
2. Taxonomic and molecular identification of Hilsa.
3. Fishery ecology and stock assessment of Hilsa in Narmada River.
4. Bio-assay studies of Hilsa in relation to migration in Narmada River.

STUDY SITES

The Hilsa shad is an anadromous species, yet two different ecotypes – a fluvial potamodromous compose and a marine kind have been perceived. The potamodromous stocks seem to stay in the center compasses of the waterways consistently and breed there in. The anadromous stocks, whose ordinary living space is the lower district of the estuaries and the foreshore zones, rise the streams amid the rearing season and come back to the first territory in the wake of generating.

In Gujarat, Rivers like Mahi and Tapi have been seen with the presence of Hilsa fishing in the past and presently too though at a very small proportion, but the fishing activity in Narmada River has been much superior to the other rivers of Gjarat and so is mainly focused in the present study. It is the main waterway where Hilsa climbs around 129 kms from the ocean. Perceptions were made on the course of the stream demonstrated that there is not really any substantial scale Hilsa angling past the town of Zanor (65 kms from the ocean) as reefs don't appear to climb past this zone. Yet, it appears to rise to the town of Garudeshwar. Past this town, the waterway bed is rough and soak and subsequently the ebb and flow is substantially more grounded. The high speed of the stream current might be the primary factor for limiting

the movement of the Hilsa in this zone. In the past, it has been recorded that in the stream Narmada, Hilsa are found in its lower comes to amid the storm a long time with no point by point writes about producing[17]. Examinations were done in a similar waterway yet at towns of Nikora and Zanor, 65 kms upstream from the ocean along the course of the stream and around 12 to 25 kms from the town of Bharuch. This zone is somewhat under tidal influence however the water at this piece of the region stays new or salt free. There is a slight increment in water stature amid rainstorm or high spring tide.

Previously it was realized that Hilsa additionally rises around 33 kms into the Purna River along the Gujarat drift. Be that as it may, appropriate data on any such catch is obscure starting at now. In this way it's imperative to take note of that in streams like Ganges and Indus this fish ventures especially inside the crisp waters yet in the western bank of India it is having particularly constrained relocation in the waterways.

From starter review, it has been realized that in the waters of Narmada, two types of Hilsa are discovered: *Tenualosa ilisha* and *Hilsa kelee*. *Hilsa kelee*, genuinely profound and compacted, tummy with particular bottom of scutes contrasted with *Tenualosa ilisha* having no scutes. At introduce, Hilsa has been recording a quick diminishing in its populace in the previous 10 years. The transitory example taken after by the fish has changed to some degree. It utilized the movement to an exceptionally broad part in the crisp waters yet at present it is found up to the estuarine waters of Bhadbhut, a place near Bharuch however no such work or verification have been directed in this piece of the nation for Hilsa. Another species, *Hilsa toli* has been observed in seas along the Coromandel Coast, Tamil Nadu[18]

METHOD AND MATERIALS

The present study will be helpful in evaluating the present status of the Hilsa in Narmada River by considering the distribution pattern, fishery status, stock assessment and also the nutritive profile and bio-assay studies with respect to the migratory behavior of Hilsa.

The distributional assessment of the Hilsa was done at all the major landing centers of both freshwater and marine zones. With the help of various standard available keys, morphological and morphometric characters were observed and measured respectively. The molecular identification has been carried out by barcoding the COI gene of the specimens to be matched with the records of the database of BOLD and NCBI. The secondary data derived from these sources and the primary data from the present study would assist in creating phylogenetic maps at species level and phylogeography studies on the distribution pattern of Hilsa.

The landing centers along the course of the major rivers of the Gujarat were sampled wherein different sized specimens of Hilsa (Juvenile-Male-Female) in seasonal and yearly basis with estimation of total catch and based on morphometrical and morphological analysis from both fresh and marine environment[19]. Length-weight relationship which is an important tool in fish biology, physiology, ecology, fisheries assessment and fish conservation. In the present study, length weight relationships and condition factor of *T. ilisha* were estimated to know the status of the hilsa fishery, which could be helpful for management of the fishery. Also, the pertinent required water quality parameters vital for the suitability of fish migration during the high tidal influence have been checked.

Further, the regenerative cycle of an animal types for the all year fortnightly or month to month interims can be dictated by gonadosomatic index (GSI). It is an extremely valuable technique to demonstrate the generating period of the species at the field level. GSI expect that a gonad increments in estimate with expanding improvement contrasting and the mass of the gonad (GW) to the aggregate mass of the creature (BW). The generating seasons decided

in view of the month to month changes of GSI lists and extents of every development[20]. Use of hepatosomatic index (HSI) as an indicator of energy status[21] and its negative correlation with GSI[22, 23, 24] are indicative of importance of liver capacity to store glycogen, physiological condition, reproduction activity, feeding habit and food availability[25]. The gut content examination of the Hilsa were done which would give a general reflection about the kind of sustenance material accessible to the creatures in evolved way of life and at last it is a portrayal of nourishment in the biological system.

The bio-assay studies were customarily restricted to the nutritive profile of the fish – protein content extracted by the Biuret method[26], fat content[27]. Protein and fat content variety is influenced by reproducing ability, planktonic eating regimen and climatic changes in year. The most noteworthy and least protein content related to reproducing, producing and organic relapse, resting stages, separately. The other proximate analysis like moisture content, ash content[27] and fractionation of muscle proteins[28]. These studies have been on seasonal basis during the course of migration in Narmada River. Examination of level of moisture and ash content in body muscle tissues of Hilsa would serve as an essential certainty to choose the protection technique and further preparing for export of fishes after the catch.

OBSERVATIONS

The primary survey in the major rivers and their estuarine regions was conducted and Hilsa (Indian Shad) were sampled for identification. The distribution was found to be highest in the Narmada River, accounting for more than 60% of total fisheries production from the estuarine region, as per the secondary data available for the last decade from the Department of Fisheries, Government of Gujarat. The detailed morphological characters and morphometric dimensions of Hilsa (Indian Shad) were found to be relating with *Tenualosha ilisha* (Fig. 1), inhabitating the fresh and marine niches. The molecular investigation using

DNA barcoding of the COI and 16S gene suggests wide phylogenetic variation has been found among the species found in the waters of Narmada River when compared to other found same species. The phylogeographic studies are being continued to determine more divergence studies in the Indian Shad family.

Fig. 1 shows the varied Hilsa (Junvenile – Male – Female) as per maturing seasonal measurements inhabiting the waters of Narmada River

The demographic distribution suggests the decreased known inflow distance of Hilsa migration into Narmada River. Currently, the migration is restricted to Zadheswar from known Jhanor, a total of 23 kms decreased distance resulting due to lessened water flow, higher siltation and probability of industrial effluents cannot be denied.

The length weight relationship was acquired after seasonal and annual collection of data from major landing centres along Narmada River like Bhadbhut, Megham and Hansot from June 2016 to present date. On an average, a total of 200 samples of juvenile-male-female were assessed weighing from 16 gms to 930 gms in every season. The pooled data as per length and sex of the species and data analysis was done using Microsoft Excel. The regression analysis was found. The statistical relationship between length and weight of the fish was

derived by parabolic equation suggested by Le Cren (1951), i.e. $W = aL^b$. The values found for length and weight for *T. Ilisha* showed very insignificant values every year. The mean condition factor (CF) esteem was observed to be 1.63325 and 1.08225 in female and male hilsa separately. High estimations of CF in female fish because of substantial weight amid development. The mean estimation of relative condition (Kn) was 1.0496801 and 1.010145 in female and male fish separately. High estimations of the CF and Kn in various length demonstrate a general prosperity and flexibility of the fishes.

The gonadosomatic index analysis showed varied results in seasonal basis. In the month of November to January, immature gonads were found, February to April showed nearly ripe gonads and finally with the onset of spawning monsoonal season of April to June, ripe gonads in both males and females were found. The fecundity growth of female ovaries were found to be increased manifold with the commencement of the monsoon with respect to the early summer season. The ratio of gonads to body weight in females during monsoons was found to be from 15.3966 to 21.4582 and in males average gonad to body weight was found to be ranging from 1.322 to 2.783 in the ripe season of spawning.

Fig. 2. Dissection of Hilsa for gonadosomatic and hepatosomatic index analysis during the ripe period of June - October

Hepatosomatic index (HSI) is less in pre monsoonal and monsoonal time showing the liver capacity to develop ovarian tissue. In post monsoonal time again HSI esteem builds demonstrating the liver development. HSI esteem has positive connection with the body weight, however it is less in monsoonal and post monsoonal angles. Liver substance is diminishing. It appears the liver gives essential vitality to the fishes to get ovarian development. Increment of GSI esteems in monsoonal male fishes is likewise the characteristic of the testicular development. At post monsoonal time testis is relapsing which is seen by low estimation of male GSI. A solid positive relationship is found in the middle of the body weight and monsoonal GSI in the male fishes. The expanding pattern of these qualities from pre storm to monsoonal time is demonstrative of the testicular development.

The proximate analysis of protein, fat, moisture and ash content measures the nutritive profile of the fish. Proteins are intricate natural mixes and made up of prolong chain of amino corrosive limited together by peptide bonds. Crisp fish meat gives great wellspring of protein to human eating routine, around 90-95% of fish protein is absorbed by human. In this analysis, we have to know how much protein is available in our example or to quantify the fixation or measure of protein in angle muscle tests. The protein concentration in males during the monsoonal period was found to be ranging from 3.67gm/dL to 5.15gm/dL and in females it was found to be 2.45gm/dL to 4.83gm/dL.

The fat content of fish meat is a factor that determines the quality of fish and its price. In many fish species, fats are building up during feeding season and its proportion lowest after spawning season. Fat is source of stored energy. The total fat content in females was 0.16 mg/g of body weight and in males in was found to be 0.48 mg/g of body weight. The ash content in ripe females was 1.16% and 1.33% in males during the monsoon while the

moisture content was ranging in males from 58.5% to 67.3% while in females it was 73% to 80.1%.

The proximate studies shows positive co-relation of Hilsa along the varied seasonal changes in the Narmada River suggesting a good growth as well as also providing a nutritive outline.

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LIST OF PRESENTATIONS

1. Oral presentation on "Occurrence of Malabar Spiny Eel (*Macrognathus guentheri*) in Mahi River, Gujarat" at International Science Congress Association, Pacific University, Udaipur, Rajasthan (2014).
2. Poster presentation on "An Assessment of DNA Barcoding of Freshwater Fishes" at One Day National Seminar on DNA Barcoding, Current Status, Trends and Prospects, HNGU, Patan (2015).
3. Poster Presentation on "Freshwater Fisheries and Aquaculture Potential in Gujarat" at Science Excellence, Gujarat University, Ahmedabad, Gujarat (2015).
4. Presented and awarded (**Best Poster presentation**) on "New Records of *Labeo* spp. and their distribution in Gujarat" at UGC-CAS National Conference on Biodiversity and Bioresource Utilization at Department of Biosciences, Saurashtra University, Rajkot, Gujarat (2017)
5. Presented a poster on "Corals and Coral Reefs: Impact of Climate Change" in National Seminar on "Impact of Climate Change on Biodiversity-III: An approach to reach the unreached through Science & Technology" Organized by ISCA (Baroda Chapter) in collaboration with Department of Botany and Zoology, Faculty of Science, The Maharaja Sayajirao University of Baroda and ISG (Vadodara Chapter), IWSA (Baroda Branch) and IEEE GRSS (Gujarat chapter) held on 29th November, 2017.
6. Abstract selected "Population dynamics and socio-economic impacts for apprehending the current scenario of Hilsa fisheries in Narmada River, Gujarat" to be presented at **International Biodiversity Congress (IBC)**, Indian Council of Forestry Research and Education (ICFRE), Dehradun during **4-6thOctober 2018**.

LIST OF PUBLICATIONS

1. Pandya Khushali, M., **Sarma Kangkan Jyoti**, Parikh Kinjal, V., & Mankodi Pradeep, C. (2014). Occurrence of Zoanthid genus Isaurus from Saurashtra coast, Gujarat, India. *European Journal of Zoological Research, 3*(2), 1-5.
2. Pandya Khushali M., **Sarma Kangkan Jyoti**, Parikh Kinjal V., Vachhrajani Kavuresh D., Desai Abhay Y., Mankodi Pradeep C. (2014). Temporal Variation in Zoanthids abundance at Veraval coast, Saurashtra, Gujarat. *Life Science Leaflets*. 53: 53-56.

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4. **Sarma Kangkan Jyoti,** & Mankodi, P. C. (2017). Deciphering Identification of Inland Fishes of Gujarat Using DNA Barcoding. *Turkish Journal of Fisheries and Aquatic Sciences*, 17(5), 1055-1060.
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7. Thakkar, N., **Sarma Kangkan Jyoti**, & Mankodi, P. C. (2018). First record of *Trypauchen vagina* (Bloch and Schneider 1801) (Perciformes: Gobiidae) in the Narmada River, Gujarat, India. *Journal of Fisheries*, 6(2). DOI: 10.17017/jfish.v6i2.2018.317.
8. Bharatkumar Jethva, C. D., Ahir, K., Parasharya, D., Gadhvi, M., & **Sarma Kangkan Jyoti**. (2017). Faunal Biodiversity Survey for Baseline Assessment of Khijadiya Wildlife Sanctuary in Gujarat. CMPA Technical Series No. 33. Indo-German Biodiversity Programme, GIZ-India, New Delhi.