1. Introduction

World aquatic resources

Water is a renewable natural resource and it can only be replenished through the process of its cycle. Water is essential for maintaining adequate food supply, productive environment for the human population, animals, plants and microbes around the world. About 70 % of the earth surface is covered with water and out of that 97 % is available in the form of oceans water and 3 percent is available in the form of freshwater. This small fraction of freshwater is available in the form of glaciers, polar ice, groundwater, lakes, ponds, rivers etc.

India is endowed with a rich and vast diversity of freshwater resources contributing about 4% of world's freshwater resources and considered in the top ten water rich countries. The availability of inland water resources in the country are in the form of rivers and canals - 29000 km, reservoirs - 3.15 million ha, ponds and tanks - 235 million ha, oxbow lakes and derelict waters - 1.3 million ha, brackish waters - 1.24 million ha and estuaries - 0.29 million ha (Ayyappan, 2011).

Gujarat is the seventh largest state and situated in the western corner of the country. It comprises third largest proportion of inland water resources of the country in the form of rivers and canals - 3865 km, reservoir - 2.86 lakh ha, beels, oxbow and derelict - 0.71 lakh ha. The reservoir of the state is categorised as small (<1000 ha), medium (1000-5000 ha) and large (>5000 ha) on the basis of area. Gujarat state comprising 711 reservoirs with total area of 2.86 lakh ha in that 676 are small reservoirs containing 29% area (84124 ha), 28 are medium containing 20% area (57748 ha) and 7 are large reservoirs containing 51% area (144358 ha) of total area of reservoir (Dash *et al.* 2013).

The major rivers of the country like Ganga, Indus, Brahmaputra, Narmada, Tapi, Godavari, Krishna and Mahanadi flow in the country with their numerous tributaries considered as lifeline of growth and culture. Most of the rivers drain their waters into the Bay of Bengal and Arabian Sea. Optimum management of the river water is required, and specific plans should be evolved for various river basins in the form of dams and reservoirs which are technically feasible and economically viable.

Reservoirs, the water bodies which are formed by the construction of dam across the river for specific purposes like drinking, industry, power generation, agricultural irrigation, river regulation, flood control, commercial fisheries, sports, navigation and canalisation. Reservoirs are considered as important water resource because 25% of flowing waters to the seas have previously been impounded in it (UNEP, 1991). India ranks third in dam construction after Unites State and China with 19,370 reservoirs spread over 15 states and comprising 3.15 million ha which is about 50 % of total reservoir area in South-East Asia (Singh, 2001).

The reservoirs paly important role in commercial fisheries and it contribute 1.5% of total inland production (6.13 million tone) of the country during 2013-14. The average fish production of Indian reservoir is 20 kg/ha commemorating 11-15 kg/ha from large and medium reservoirs while 150 kg/ha from small reservoirs. According to Sinha and Katiha, (2002) the average fish production of India is 20 kg/ha whereas it is 47 kg/ha in Thailand, 283 kg/ha in Sri Lanka and 150 kg/ha in China. India is lacking in reservoir productivity and stand at the bottom of this list though the resource size is enormous, production potential is untapped, climatic condition is tropical and scientific man-power in fisheries sector is adequate and very high in the country.

This low level of fish production and productivity in Indian reservoirs can be attributed to inadequate management practices, lack of fish biological data such as the formation of fish population, fish population dynamics, the abundance of fish in the stocks and their biomass, growth pattern of fish and maximum sustainable yield. The rate of the primary and secondary productivity is not channeled to fish production in many reservoirs with that inadequate knowledge of reservoir ecosystem often comes in the way for adopting effective management measures. These management tools which determine reservoir ecology with reference to nutrient status and fish biological data including longevity of fishes, age and growth and harvestable size are important tool to improve the productivity and sustainability of the reservoirs. In the current study these management tools enlisted as below mentioned objectives which help to improve the reservoir production, to interpret the ecological information and fish biological information.

Objectives

1. To evaluate the physicochemical property of reservoir and correlate with the productivity of Indian major carp
2. To compare the growth performance of *Catla catla, Labeo rohita* and *Cirrhinus mrigala* in reservoir condition.
3. To determine the seasonal growth, annual growth, condition factor, specific growth rate, length-weight relationship of *Catla catla, Labeo rohita and Cirrhinus mrigala* in selected water body.
4. To study the Gastrosomatic index of these fishes.

Importance of the study

Fish growth is depended on the energy which is derived from biotic and abiotic factors of aquatic resources. These factors directly or indirectly affect the quality and suitability of water for the distribution and production of fish (Moses, 1983). Growth performance of fish in water body, variation in growth and its influencing factor could be enumerated by the current study covering the following aspects:

1) Climatic condition and physicochemical study of the water body

The water body is affected by Climatic condition of the area which impact on quantity, variability, timing, intensity of precipitation and rate of evaporation that directly or indirectly alters the physicochemical property of the aquatic resources. Water is not just where the fish live but the quality of water is directly affects the feed efficiency, growth rates, health and survival rate of fish. Good quality of water resources depends on number of physicochemical and biological parameters including temperature, dissolve oxygen, hardness, nitrate-nitrogen, nitrite-nitrogen, ammonia-nitrogen, total nitrogen, phosphate, silicate, chlorophyll (b) and plankton. These water quality parameters are important because temperature regulates the metabolic activity of living organism including fish whereas turbidity effects the light transmission and water clarity therefore primary productivity and the amount of dissolved oxygen are adversely affected. Dissolved oxygen influences chemical and biological processes of living component within a water body. It is necessary to maintain aerobic conditions in waters and is considered as a primary indicator for the suitability to aquatic life. Nitrogen containing parameters are required for the production of amino acids, an essential component of proteins in plants and animals while phosphate is a vital nutrient converting sunlight into usable energy which is essential for cellular growth and reproduction. Silicate is not the limiting factor in any water body, but it regulates the diatom growth which is consumed as food component by the fishes. Similarly amount of chlorophyll (b) and the availability of plankton in number per litre in water indicate the biological productivity of water body.

2) Age and growth

Information on fish age, growth and development are the cornerstone in fishery research and management. Individual age provides a means to life span or age-structure of a population and through its examination can be assessed strong and weak year classes of fish. Age study of fish provide the information on its longevity, age of first maturity, age recruitment and growth more over the age length key or age composition data, catch curves and these data are helpful to calculate annual production and mortality or survivability of the fishes. Age data can be acquired through various means i.e. anatomical method, length-frequency analysis and direct estimation.

Counting the regular growth marks formed on hard tissues such as scales, otoliths, vertebrae, spines and tail bones is anatomical method for age estimation of the fish. The choice for the use of age structure estimation for a fish depends on accuracy of true age reflection, has the clearest zones and has the most cost-effective preparation method. The most common method of age estimation is the hard parts i.e. calcified structures including otolith, vertebrate, opercula, cleithra, scales, fin rays and spines examination. Among these hard parts scale is most extensively used in tropical region as it can be removed non-lethally and growth history of fish can have calculated quite accurately. Van Leeuwenhoek is credited with being the first to recognize the importance of fish scales, identifying the relationship between marks on scales and the age of fish (Elliott and Chambers, 1996 and Jackson, 2007).

Growth of organism is the change in length and weight or both with increasing age. Growth is generally an increase in size due to conversion of the food components into the body mass building in the body. Fishes continue to grow throughout their life, but rate of growth varied to a large extent from species to species, geographical location and seasons. Growth of the fish can be estimated by empirical method, length frequency method, anatomical method and biochemical methods.

In anatomical methods, fish scales capture information on an individual's life history that typically relate to variability in space and time. The derivation of this information often relies on the relationship between the size of scales and the body length of fish (Bagenal and Tesch, 1978 and Horppila and Nyberg, 1999). This relationship is widely used in fisheries science to estimate body size at a younger age by "back-calculation" (Weisberg, 1986 and Casselman, 1990) a technique often used to generate length-at-age data (Francis, 1990 and Horppila and Nyberg, 1999). In addition, back-calculated length can be used to evaluate fish growth over an entire life span and determine changes in growth due to life-history events and environmental stochasticity.

The fish's length is linear measure (in centimetre) and the weight is body mass (in gram) whereas the growth of fish is its volume (cubic centimetre). Hence, weight of a fish is a function of length. The study of length and weight has its applied importance in fish biology because it uses to assess the growth of fish. This is often faster and more convenient method than weighing fish individually. It provides the information on wellbeing and changes in life cycle of the fishes. Like other morphometric parameters, length-weight relationships also fluctuate with life cycle events like metamorphosis, growth and onset of maturity (LeCren, 1951). The relationship can be expressed by the hypothetical equation $W= aL^3$ the value of exponent may considerably deviate from the value 3, as most fishes change their form or shape when they grow (Martin, 1949). This variation from expected weight to the actual weight of individual fish is assessed by analysing the length weight relationship (LWR). Inter-conversions of these variables are required for the information about body forms of different groups of fishes and its growth pattern.

3) Condition and relative Condition factor

The condition factor (K) or ponderal index one of the most significant biological parameters that provide information on growth, condition and give insight into the health or wellbeing of fish. In addition, the condition factor is regularly calculated to assess the productivity and physiology changes in fish population. It is strongly influenced by both biotic and abiotic environmental conditions and can be used as an index to assess the conduciveness of the aquatic ecosystem in which fish live. This factor is calculated from the relationship between the weight of a fish and its length. The values of condition factor (K) of a fish suggest the state of sexual maturity, the degree of food source availability, age and sex of some species. Similarly, the relative condition factor (Kn) is the ratio between observed weigh to the calculated weight of fish. Thus, the K factor measures the variations from an ideal fish, which holds the cube law while, Kn measures the individual deviations from the expected weight derived from the length-weight relationship. The condition factor ‘K’ is quantify the condition of fish which influenced by several factors including age of fish, stage of maturation, fullness of gut, type of food consumed, amount of fat reserve and degree of muscular development while relative condition factor indicate the health status of animal as this index is not affected by the reproductive events or the formation of gonads. This parameter also gives information about two comparative populations of different feeding zones, density, climate, and other conditions, in determining the period of gonadal maturation and the degree of feeding activity of a species to verify whether it is making good use of its feeding source.

4) Food components, feeding habit and gastrosomatic Index

The importance of the knowledge about food components and feeding habits of fish in understanding its fishery biology has been well established. Feeding is usually a part of the daily routine and feeding intensity refers to the degree of feeding as indicated by the relative fullness of stomach. The magnitude of fishes’ stocks in a region is a function of its food potentialities. It varies with the species, season, availability and preference of food items, maturity stage and spawning season of the fish. The feeding intensity of mature fish decreases during the spawning season, as compared to the non-spawning season. The feeding intensity of fish can be determined by gastrosomatic index hence knowledge of the relationship between the fishes and food components is essential for the production and exploitation of the fish stocks. An objective study of these relationships should be properly integrated in the orientation of a commercially exploited fishery, taking into account, the diversity of the component species constituting the total fishery of the region. Stomach content analysis provide information on food and feeding habits of fish which helps to understand the tropic dynamic and the prey predator interaction in the ecosystem, which facilitate the ecosystem-based fisheries management.

Considering these facts an attempt has been made to study the qualitative and quantitative analysis of a fish and or estimation of gastrosomatic index. It is an important study with reference to the comparative growth performance in same water body.

Vallabhsagar

The Tapi is the second largest westward draining river of the Peninsula India originates from Betul district of Madhya Pradesh. The river rises in the eastern Satpura Range of southern Madhya Pradesh draining Maharashtra and South Gujarat covers almost 724 Km before emptying into the Gulf of Cambay in Surat District. Its important tributaries are the Suki, Gomai, Arunavati and Aner Vaghur, Amravati, Buray, Panjhra, Bori, Girna, Purna, Mona and Sipna. The Tapi River basin encompasses an area of 65,145 km^2, which is nearly two percent of the total area of India. The basin spreads over 18 parliamentary constituencies comprising 12 of Maharashtra (51,504 km^2), 3 of Gujarat (3,837 km^2) and 3 of Madhya Pradesh (9,804 km^2). Three main reservoirs namely Hathnur in Maharastra while Kakrapar Weir and Vallabhsagar were built across the river in Gujarat. Among these Vallabhsagar reservoir is biggest one and popularly known as Ukai dam or Ukai reservoir situated in Tapi district of Gujarat at 21° 15'N and 73° 35'E geographical location. This multipurpose reservoir was completed in 1971, with catchment area of 62255 km^2 and water spread area of 520 km2 at FRL of 105.10 m above MSL with a mean depth of 11.8 m. The water level of this reservoir fluctuates up to 23 m during different seasons (Sugunan, 1995).

Inland fish production of Gujarat is 94708 tones (2013-14) contributing 1.59 % of total inland fish production of India. Similarly, fish production of Vallabhsagar reservoir is 10004 tons (2013-14) which is 11% of total fish production of Gujarat. Contribution of Indian major carps in total fish production of Vallabhsagar reservoir is remarkably high it contributes 42% (4172 tons) of the total fish production of reservoir (2013-14).

Comparative growth study of Indian major carps in different reservoir shows positive growth traits than any other fresh water fishes as the original habitats of these species are the rivers and backwaters of Northern India, Pakistan and Burma (Sugunan, 1995). Under favourable conditions, they grow rapidly, reaching marketable size within one year in tropical and subtropical countries hence contribute about 90% of total freshwater aquaculture production in India. Growth of Indian major carps depend on stocking density, availability of natural food, competition with other species and environmental conditions. Although the contribution of Vallabhsagar reservoir in fish production is considerable but growth performance study of Indian major carps with respect to physicochemical properties of water has been not evaluated.