GENERAL INTRODUCTION

Fish is considered as the ancestors of all other vertebrates. Before 500 million years ago, ostracoderms swam in the world's sea which did not have jaws and fins but they did have backbones. So the fishes are known first vertebrates on the earth during the Devonian periods. Fishes have evolved during Ordovician period and widely distributed during Devonian period where the fish reached substantial diversity at this time, it is also known as the golden age of the fish. The various kinds of fish differ so greatly in shape, color and size that it is hard to believe they all belong to the same group of animals. Nearly all fish are cold-blooded animals-mainly in fresh and marine water of seas, lakes, streams, ponds and rivers.

Fish is well endowed with minerals such as calcium, iron, zinc and vitamin A especially retinol. Fish is ready available, relatively inexpensive and provide nutritious protein and beneficial fat, which can ultimately contribute to a healthy food. Omega-3 fatty acid appears to have passive effects on heart rhythm. Dietary supplementary of omega-3 fatty acids reduce the risk of heart diseases.

Fishes are the dominating vertebrate group as far as number of species is concerned and in their immense variety have adopted many nutritional habits Bahuguna, et al., (2012). According to Sadaf Anis Don and Shaikh, (2016) there are atleast 25,000 species of fish and perhaps more about whose existence is unknown. Functional morphology of fish can be used to provide explanation for differences between species in ontogenic diet switch (Wainwright, 1996).

According to Mani (2013) traditionally fish is cheaper than meat, highly nutritious and is a source of cheap protein besides being a major foreign exchange earner. Approximately 3, 63, 000 million tons of organic material is produced in the oceans of the world each year (Weihaupt, 1979) but only a small fraction of this is recovered by way of fisheries for direct consumption. Abro (2014) described that the aquatic food products are an integral part of the human diet in many parts of the world and significantly contribute to the supply of high quality protein.

Functional morphology of feeding deserves detailed exploration because of its intimate linkage to all aspects of fish evolution and biology. There are few creatures on the earth the earth that have developed such an intresting and unique set of

physical charecterstics such as fish. Their special adaptations have allowed them to survive in an environment completely different from human. Yet despite obstracles in life fish have some unique anatomical adaptations that allow them to flourish .Singh, et al., (2014) described that scientist concerned with any activity of fisheries must understand well about fish feeding activity, which is the dominant activity in any animal's entire life.

Kapoor, et al., (1975) reported that the digestive tract of fishes shows a remarkable diversity of morphological and functional characteristics; this is related to different feeding habits and to taxonomy as well as body shape, weight, size and sex. Parihar (2016) reported, it has been noticed that the fry and fingerlings of various species of fishes have different feeding habits than the adult. They possess a small and short intestine and usually prefer zooplankton consisting of microscopic animals, protozoan, rotifers, cladocerans and their eggs and larvae.

According to Parihar (2016) the importance of studying food and feeding habit of fish lies in the fact that one can decide as to what programs should be taken up for the development of the water bodies to get more fish. Oronsaye and Nakpodia (2005) reported the study of food and feeding habits of freshwater fish species is a subject of continuous research because it constitutes the basis for development of a successful fisheries management programs. According to Adewumi and Amoo (2014) information on food and feeding habits of fish can provide baseline data, useful in artificial feed formulation for the species during culture and for proper management of the fish.

Singh, et al., (2013) noted, for successful fish farming a thorough knowledge about the food and feeding habits is necessary. Dewan, et al., (1985) described that the knowledge of food and feeding habits help to select species that produce maximum yield by utilizing all the available potential food of the water bodies without competition.

According to Albrecht, et al., (2006) the oesophagus, stomach, intestine and pyloric caeca are tubular organs that are able to food storage, digestion and absorption. Agrawal and Mahajan (1966) reported that the alimentary canal of fish consist of mouth, buccal cavity, pharynx, oesophagus, stomach, intestine, rectum, digestive glands, liver and pancreas. Singh, et al., (1993) Bahuguna and Maithani (2005) suggested buccal cavity and pharynx in fishes form single unit of structure and

function, therefore, it is termed as buccopharynx. The other organs like lips and barbels are the associated parts of the buccopharyngeal region. The barbels which are the house of taste buds act as chemoreceptor to locate the food material while the lips help to scrap the food items from the bottom or substratum of the environment.

Khanna and Singh (2015) observed that the buccal cavity of fish leads into pharynx which is perforated on each side by the opening of spiracles and gill pouches. Khanna (1996) described the buccopharynx of fishes performs two important functions first respiration and second catching the food and conveying it to the oesophagus. According to Khanna and Singh (2015) oesophagus is a short and narrow tube in number of fishes where large number of mucus secreting cells are scattered in the mucosa and taste buds are also seen which lubricate the food.

According to Meister, et al., (1983) Oesophagus of teleost fishes connects pharynx with stomach or the intestine, its only function seems to provide lubrication. Khanna (1996) described that the stomach is not demarcated externally from the oesophagus but can be distinguished from the layers by difference in the mucosal folds which are thin in oesophagus and become thicker and wavy in outline of the stomach.

Ostrander (2000) Observed that the stomach can be separated into three regions cardiac region, where the food is stored the remaining two region of stomach which are fundic and pyloric are secretory in fish with true stomach. Ostrander, (2000) also described there are different shapes of stomach in fishes which are ‘U’ shaped and‘T’shape. Khanna and Singh (2015) reported, number of species does not possess a true stomach and the anterior part of the intestine becomes swollen to form a sac like structure called intestinal bulb.

According to Evans (2005) the intestine of fishes is extremely variable in form but is generally considered to be divided into proximal midgut and distal hindgut. Buddington, et al., (1997) described intestine as a complex multifunctional organ in addition to digesting and absorbing foodstuff, the intestine is critical for water and entrocyte balance, endocrine regulation of digestion, immunity and metabolism.

Rotta (2003) Described that the knowledge of food preferences and the variations of the structures of digestive system of species are useful for the nutritional development researches, preparation of diet and handling of the feeding.

Priyadarshani, et al., (2012) reported that the quantity and quality of food are one of the important factors that can influence the reproductive period, fecundity at first maturity and the fish survivorship but not all food sorts are taken by the fishes. According to Makmur, et al., (2014) basically fish have high ability to their food and utilizing the available food and food habit is defined to see how far the fish prefers to the food type.

Bhuiyan, et al., (2006) observed like all organisms, fishes require energy to fuel their body machinery and processes including growth, metabolism and reproduction. Similarly Hossain, et al., (2012) described that the basic function of organisms like growth, development, and reproduction take place at the expense of energy which enter the organisms in the form of food. Hynes, (1950) described that the food and feeding habits of fishes vary with the day, season, size of fish, various ecological factors and different food substances present in the water body. Feeding biology is certainly one of the important aspects in the biological investigation in the fishes (Verma, 2015).

Nikolsky (1963) reported variations in the composition of the food with age and size is a substantial adaptation toward increasing the range of food supply of population by enabling the species as a whole to assimilate variety of food. Pandey (2014) found that the food and feeding habits of some fishes living in different part of regime may vary due to the differences in physico chemical and biological characteristics of their feeding niches. According to Singh, et al., (2013) study of food and feeding habit of fishes have manifold importance in fishery biology. Gupta (1981) described that the variations observed in food components in different months may be due to variations in the availability of different food items in the habitat.

Morphological data are also key to understand fish nutrition in ecology and aquaculture and during development as well as mechanisms for physiological adaptations to a changing environment. Teleost have successfully adapted themselves to every type of aquatic habitat, this versatility is reflected in their mode of feeding, fish inhibiting the same habitat resort to different types of feeding to avoid competition for food and also to utilize every available source of food. Dey, et al., (2015) described that the differences in the size and position of mouth, kind and position of teeth and branchial arches, shape and length of intestine all have important

consequences and use. The effectiveness of these structures is dependent on modifications in relation to their food and feeding habits and the environmental niches.

Al Hussaini (1946) described that in fishes the oral and oropharyngeal cavity play an important role in selecting, seizing, detecting and conveying food to the oesophagus. Keast and Webb (1966) described mouth structure is related to the feeding type and habitat of fish and is highly variable between fish species and variations in mouth structure may partly explain the evolutionary success of fish.

Sinha (1986) noted that the adaptations of the buccal cavity and certain other morphological features of the mouth are greatly influenced by ecology, ethology of the food and feeding regimes of the species. Rodrigues, et al., (2006) also observed that in teleosts the position of mouth can be corelated to feeding habits. Yashpal, et al., (2009) described buccal cavity constitute an important element in the organization of the alimentary tract, it is concerned with seizure and selection of food and rejection of undesirable items ingested by fish.

Agrawal and Mittal (1992) reported, in fishes the lips and structure associated with them show characteristic modifications in relation to the nature of the food and feeding habits. Icardo, et al., (2011) described that the lips of fishes and its associated structure may participate with selection, capture, deglutition and predigestive preparation of food. Similarly Northcutt (2004) described that the lips of the fishes could contribute in accurate localization, capture, degulation and predigestive preparation of food by triggering the pickup reflex in analogy with the barbels of some fishes.

According to Kapoor, et al., (1975) the lips of teleosts have biological importance as they are the primary detectors for food capture and have specialized chemoreceptor cells. Bakary (2011) described, in fishes, the tongue is primary organ that is not muscular and is used mainly for chaneling water, the tongue contributes to feeding behavior by either conducting water through the mouth or by activity manipulating the prey within the mouth. According to Norman and Greenwood (1963) gill rakers project across the pharyngeal opening as stiff appendages, serve to strain water which is to breathe the gills and prevent any solid particles from passing over it.

Hora (1963) reported that the sense of taste is an important property in fishes for distinguishing between varieties of food available to them in an aquatic environment. According to Fatollahi and Kasumyan (2006) gustatory system in fish is a polysensory establishment and provide the final sensory evaluation in the feeding process where as Kasumyan and Doving (2003) described that the gustatory system in fishes is divided into two distinct sub systems namely oral and extra oral. In fishes, irrespective of their mode of life and feeding strategy, the ultimate phase of the feeding performance is based on function of the taste buds in external gustatory system as they detect chemical substances at a short distance.

Saadatfar, et al., (2010) suggested taste buds of teleost varied in structure depending on the species examined and even on their location in the body. Kasumyan and Doving (2003) reported that many sensory systems contribute to fish feeding behavior, but their role and significance may profoundly differ at different phases of the feeding behavior. The consummatory phase of the feeding behavior starts with the awareness of a food object and terminates with either swallowing or rejection.

Rodrigues, et al., (2011) reported that anatomy and morphology of fish digestive tract are closely related to their feeding habits and adaptive capacity to different natural diet composition. According to Cao and Wang (2009) fish digestive arrangement shows a marked assortment of morphology as well as function. Deshmukh, et al., (2015) described that the fish digestive tract show remarkable differences in their morphology and function due to variation in their feeding habits, food and habitat.

Various studies have been carried out on anatomy of alimentary canal of different teleosten fishes. According to these studies the intestine shows considerable variations in its length in different species, it is generally short and nearly straight in carnivorous predatory fishes but long, thin walled and highly coiled in the herbivorous species, the omnivorous species shows an intermediate condition.

Relationship between alimentary canal length and feeding habits of fish have been well desccribed by many authors, Panday (2014); Manon and Hossain (2011); Geetha, et al., (1990); Hossain, et al., (2012); Ojeda (1986); Wagner, et al., (2009); Maktoof (2013); Choudhary, et al., (2014); Dasgupta (2009); Berra and Wedd (2001); Jyrwa and Bhuiyan (2016); Lakshmi (2010).

Histology is termed as the branch of science concerned with the microscopic structure of cells, tissues and organs in relation to their function. According to Ikpegbu, et al., (2013) histology provides a powerful tool to morphologist that enhances the nature, form and detailed structure of organs.

Slough (2009) described tissue is made up of cells, it forms organs and organ form organ system while organ system forms an organisms. The function of tissue, organ, organ system and organisms are indicated by the type of tissue. There are four types of tissues, epithelial, connective, muscle and nervous. Epithelial tissue protect, secretes, absorbe, lines hallow organs and also forms glands, connective tissues provides a supportive framework for the body. Muscle tissue allows the body to move. Nervous tissues control all functions of the body (Slough, 2009).

According to Abdulhadi (2005) the digestive apparatus of fish shows marked diversity in its morphology and different feeding habits, as well as body shape. Fugi, et al., (2001) described, results in previous studies indicate that some small differences of histological structures among fish stomach are related to feeding habits, food, age, body shape and weight. According to Khojasteh (2012) the histological characteristics of fish intestine can be affected by abiotic and biotic factors.

Many workers studied the anatomy and histology of digestive system of fishes Nijaguna, et al., (1990) has done work on micro anatomy and histology of the alimentary tract of the air breathing fish *Channa gachua* (Ham) by scanning electron microscopic study. Suicmez and Ulus (2005) worked on anatomy, histology and ultrastructure of the digestive tract of *Orthrias angorae* steindacher, (1897). Carrasson, et al., (2006) gave an account on histological, histochemical and ultra structural studies of the digestive tract of *Dentex dentex* (Pisces, Sparidae).

Recently many workers conducted studies on histology of digestive system of fishes, Ghosh and Chakarabarty, (2015) studied histological and histochemical characterization on stomach of *Mystus cavasius* (Hamilton), *Oreochromis niloticus* (Linnaeus) and *Gudusia chapra* (Hamilton): Comparative study. Ali Ebrahim (2015) gave an account on digestive tract of a rare species of Iranian blind cave fish, *Iranocypris typhlops*. Mokhtar, et al., (2015) studied on histological, histochemical and ultrastructural study on the fundic region of the stomach of Nile Catfish (*Clarias*

gariepinus). Khayyami Huseyn, et al., (2015) recently studied the anatomy and histology of the stomach and pyloric caeca in Mugilidae *Liza aurata* (Risso, 1810), *Lizu abu* (Hackel, 1843) and *Mugil cephalus* (Linnaeus, 1758).

The present work deals with studies on annual food composition, seasonal variations in food of *Channa orientalis* and *Cirrhinus mrigala* on the basis of their morphological features and gut content. Attempts have been also made to investigate the relationship between feeding habits, type of teeth, alimentary canal length and histological changes in the gut.