General Introduction

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Food has been a constant source of energy for human being from the early age of civilization. Since days immemorial, human civilizations have been obtaining food by hunting animals and by agriculture. The term food also contains a diverse, emergent and ever-demanding issue for society. The second highest contribution, that provides global food security after cereal and cereal products, comes from animal resources. Fish and fisheries share a considerable portion of animal protein that conveys nutritional security to a large extent. The global food security index (GFSI 2018) predicted a worldwide perspective of food insecurity and growing competition for natural resources in near future. Malnutrition, starvation and subsequent mortalities are also posing a serious threat to the developing nations. About 8 million children in India are presently thriving from acute malnutrition. In this context, fish is the most widespread, affordable and healthy source of animal proteins that can play substantial role in preventing protein-calorie malnutrition. In 2016, worldwide production of fish was 171 million tons (FAO 2018). Simultaneously, the world per capita fish consumption has grown steadily from 9.0 kg in 1961 to 20.5 kg in 2017 (FAO 2018). In the recent decade, it is estimated that fish has supplied 17% of total worldwide animal proteins and 6.5% of total proteins (WWF 2016).

Consumption of fish and fishery products varies with geographical margins, demographics, socio-cultural attributes and local availability. The worldwide demand for fish and fishery products will expand more than 2 million tons by 2020 (Ibrahem 2015). The capture fishery production has become relatively static since the last two decades and the substantial decline in world's fish stock has led to an increasing demand of aquaculture farming. A sustainable approach to the development, management and regulation of

aquatic resources is being required for long-term commercial, ecological and social benefits. The knowledge regarding geographical distribution of indigenous fish diversity can conserve them from further deterioration. Wise management techniques and advanced scientific knowledge are now widely being applied in aquaculture.

Aquaculture is an age-old traditional practice of farming aquatic animals by regulating the rearing process to increase the production of aquatic resources. It is becoming a growing as well as vibrant sector and a potential source of protein-rich food throughout the world (Tacon and Metian 2015). Southern Asia, one of the most fertile freshwater fish-diversity areas, is the habitat of many indigenous fish species including *Clarias batrachus* (Linn.). India, Sri Lanka, Pakistan, Bangladesh, China, Burma, Malaya, Singapore, Philippines, Borneo, Java and Thailand come under the territory range of *C. batrachus* (Talwar and Jhingran 1991).

Clarias batrachus (Fig. 1) is an air-breathing catfish of the genus *Clarias* under the family Clariidae, found in a wide range of habitats. They can be cultured in paddy fields, shallow ponds, muddy lands, sewage water and even in cemented cistern. It has a broad depressed head covered with bony plates, the snout of which contains four pairs of sensory barbels (Jayaram 1981). The body, generally grayish-black, is cylindrical and tapers towards the caudal peduncle. *C. batrachus* (Fin formula: D 70-76; A 45-58; P I 8-11; V i 5; Talwar and Jhingran 1991) generally attains a standard length of 225-300 mm. However, in India it is found to be around 183.1 mm in length (Ng and Kottelat 2008). The skin mucus often contains bactericidal proteins and provides protection against invading pathogens (Elavarasi et al. 2013). The nutritional profile of *C. batrachus* includes high-grade protein, iron, minerals, good cholesterol and polyunsaturated fatty acids. It is also a

rich source of vitamin A, vitamin D and essential amino acids (Mohanty et al. 2014). It is a commercially important catfish due to exceptional nutritive value and delicious taste.

Fig. 1: Adult healthy indigenous *Clarias batrachus*.

The taxonomical hierarchy of *C. batrachus* (Linn. 1758) is given herewith:

Domain: Eukaryota

Kingdom: Animalia

Subkingdom: Bilateria

Phylum: Chordata

Subphylum: Vertebrata

Class: Actinopterygii

Order: Siluriformes

Family: Clariidae

Genus: *Clarias*

Species: *Clarias batrachus* (Linn.)

However, the species is decreasing substantially in Southern Asia where lowland water-bodies are disappearing day by day with the increase in population and industrialization. The unsolicited usage of highly toxic pesticides and industrial effluents in the rice fields is posing a constant threat. Moreover illicit fishing of juveniles, uncontrolled introduction of allied exotic fishes like *Clarias gariepinus* have made the situation worse. Drastic loss of production due to pathogenic infections is another major cause of species depletion. Therefore, it becomes crucial to carry out breeding and rearing of *C. batrachus* to restore the species from extinction. Traditionally this catfish is sold only in living condition as the taste and flavour deteriorates rapidly following the death of the species. *C. batrachus* can't be preserved like major carps and transported over long distances. The cultivation in small production ponds in semi-intensive manner and its supply to the local fish market in living condition would be a better practice for catfish farming. The Central Board of Fisheries (India) also has suggested to put emphasis on *C. batrachus* farming that has been classified as one of the potential national priority in Indian aquaculture (ICAR-CIFA 2016-17). Cultivation of *C. batrachus* is often acquainted with some diseases. Abrupt use of antibiotics to control pathogens may become more harmful as it generates many antibiotic-resistant strains (Bäumler and Sperandio 2016). The application of probiotics for the cultivation of *C. batrachus* is the safest mode to overcome the problems regarding the depletion of the species as well as to promote the nutritional status of the host.

Probiotics are health promoting live microorganisms that confer substantial benefit to the host when consumed in adequate amount. The term probiotic was derived from the composite of Latin word 'pro' and Greek words 'biotic' which simply means 'for life'

(Gismondo et al. 1999). The concept of probiotic may have originated by Ellie Metchnikoff (1907), who hypothesized in his book *'The prolongation of life'* that consumption of lactic acid bacteria may suppress unfavourable microorganisms and modulate gastrointestinal microflora (Mackowiak 2013). Probiotics are biocompatible beneficial microorganisms which are also in increased use to prevent and control aquatic diseases in recent decades. They confer protection against pathogens by production of bacteriocins, siderophores or lysozymes and stimulate immune responses (Bandyopadhyay and Das Mohapatra 2009). This protection induces stimulation of host immune defences by direct bacteria-bacteria interaction and led to the concept that carefully chosen bacteria could be introduced in natural host microbial communities to limit the colonization of pathogen as well as to reduce the overuse and inappropriate use of antimicrobial substances. However, a commercial aquaculture probiotic must follow some essential criteria before application to the culture tank (Fuller 1989). They should be non-pathogenic and non-toxic to the host and must not have any adverse effect on biodiversity. They must be devoid of any antibiotic-resistant virulent gene (Fuller 1989). They must have acid and bile tolerance property to colonize the gastrointestinal tract of the host (De et al. 2014). The interference in quorum sensing through the release of certain molecule is also considered as potential antimicrobial property of probiotic (Defoirdt et al. 2004). Probiotics should also confer protection against fish pathogens in order to remain viable (Gatesoupe 1999). They must be potentially effective for prolonged period under storage and field conditions without genetic mutation. Probiotics must also be able to specifically reach the desired location. The high cell-surface hydrophobicity of the probiotic isolates is

often significative to their capacity of adherence to the intestinal wall (Krasowska and Sigler 2014).

Attention has focused on the use of species-specific autochthonous probiotics, for sustainable development of *C. batrachus* production through aquaculture practices. Keeping this view and considering the high cost of the species the topic **'Assessment of growth and nutrient status of indigenous fresh water catfish (*Clarias batrachus* Linn.) in relation to the application of newly isolated probiotics'** is being selected as the present Ph.D. thesis title with the following objectives:

1) Study of the physico-chemical characters of water of a normal habitat of *C. batrachus* at monthly interval.
2) Isolation and selection of probiotic microorganisms from the intestine of adult *C. batrachus*.
3) Study of the efficiency of the test probiotic as a feed supplement for the growth of the fingerlings of the species, study of nutritional parameters of fishes: amino acid, vitamins, and fatty acids.