An analysis of the nutritional profile of Clarias Batrachus (Linnaeus, 1758) for the Fundamentals of Intensive Culture and Conservation of Asian Catfish

Chiranjib Ghosh
Ph.D Research scholar, Department of Zoology ,Om Parkash Jogender Singh(Opjs) University

Dr. Ravindra Paul
Assistant Professor, *Department Of Zoology* ,Om Parkash Jogender Singh(Opjs) University

ABSTRACT

Clarias batrachus (Linnaeus, 1758) is a highly prized and healthful indigenous freshwater fish in India. This fish is extremely healthy because to its high protein content, vitamins and minerals, and a significant amount of Poly Unsaturated Fatty Acids. The species has medicinal/therapeutic importance and is in great demand due to its nutritional content. It is exceptionally wholesome, not only as a food product with high protein content, vitamins, and minerals but also as a rich source of Poly Unsaturated Fatty Acids. This fish has traditionally been used to heal numerous illnesses. It is one of the most important species of local food fish. Under the wild, it may flourish in any situation. The Asian catfish population is suffering as a result of overfishing in the wild. To maintain this species' genetic resources, habitat conservation, intensive culture, and sustainable consumption of this great fish species are all required. In the present paper, a nutritional profile of this catfish along with its dietetic value, conservation status, and essentials of intensive culture is discussed.

Key words: Clarias batrachus, Biological profile, Nutritional value, Conservation, Intensive culture

---

1. Introduction

The Asian catfish, commonly known as the walking catfish and in Maharashtra as the „Magur‟ C. batrachus (Linnaeus, 1758) is a highly valued endemic to India that is now in severe decline in the majority of its native habitat. One of the 16 Asian species that has attracted the greatest attention is C. batrachus (NG and Kottelat, 2008). This fish favors slow-moving, frequently sluggish waters such as those found in ponds, marshes, streams, and rivers, flooded rice fields, and temporary pools that may dry up. One of the most significant local food fish species is the Asian Catfish. This fish has traditionally been used to cure anaemia, as well as those suffering from childbirth and chicken pox. This fish species is exceptionally nutritious, not only as a food product with high protein content, vitamins, and minerals (Paul et al., 2015; Thorat, 2017), but also as a rich source of Poly Unsaturated Fatty Acids (PUFA) (Jakhar et al., 2012). C. batrachus is an ideal species for dietetic food and its consumption would help prevent nutritional deficiencies. The species has medicinal/therapeutic significance and is in high demand, notably in India's North East (Borah, 2020). Capturing fish from natural resources by the local fishermen community is a common practice in peninsular India. In Vidarbha region, Maharashtra particularly in Gondia, Bhandara, Chandrapur, and Gadchiroli districts having both lacustrine waterways, lentic and lotic freshwater, utilized for capturing naturally existing fish by local fisherman community for livelihood. This activity is crucial to the economical growth of this fishing community. It demands a significantly higher market price in India and Bangladesh than carps and other economically important food fishes (Chakraborty et al., 2021). Globally it is listed as Least Concern in IUCN (Ng and Low, 2019), due to lack of major threats to this species population (Froese and Daniel, 2011), while in India it is listed as „Vulnerable‟ (CAMP, 1998). According to FAO estimates, global demand for catfishes is growing, and C. batrachus, with its several benefits, continues to be popular among Asians in particular. This study highlights the considerable content of serum HDL (High Density Lipoprotein) and summarizes the important research conducted throughout the world that has contributed to our understanding of the life and biology of C. batrachus. To maintain this species' genetic resources, habitat conservation, vigorous culture,

and sustainable consumption of this fish species are all required. In the present paper the nutritional value, conservation status, and essentials of intensive culture is discussed.

A. Characteristics of Asian Catfish: The Asian catfish has an elongated body form and may grow to be about 0.5 m or 1.6 ft long and 1.2 kg or 2.6 lb. in weight. The body is mostly grey or grayish brown, with little white patches on the sides. This catfish has long-based dorsal and anal fins, as well as multiple pairs of sensory barbells. The skin is scale less, but coated with mucus, which protects the fish when it is out of water. Because of the imbedded sting or thorn-like protective mechanism buried under its fins, this fish must be handled with care when fishing Das (2002). Occipital process is more or less triangular, in male genital papilla is elongated and pointed.

Fig.1. C. batrachus captured (left) near Baghnadi at Shirpur Dam (right) MH

B. Global distribution: C. batrachus (Linnaeus, 1758), is classified as, Kingdom-Animalia, Phylum-Chordata, Class-Actinopterygii, Order-Siluriformes, Family-Carridae. C. batrachus is often known as the Asian cat fish or walking cat fish, is one of India's most significant native food fish. The freshwater air-breathing catfish C. batrachus is native to Southeast Asia (Ramesh and Kiran, 2016). True C. batrachus only has a normal range on the Indonesian island of Java, although it is commonly mistaken with three closely related and more widespread species. These include C. magur, a probable undescribed Indochina species, and another likely undescribed Indochina species from the Thai-Malay Peninsula, Sumatra, and Borneo. This species is surrounded by a lot of taxonomic confusion, and it's been confused a lot with other close cousins (Froese, et al., 2011). The synonyms of the C. batrachus are Silurus batrachus, Linnaeus, 1758; Macroatheromatous magur, Ham., 1822; C. jagur, (Ham., 1822); Macroatheromatous magur, Ham., 1822; C. magur , (Ham., 1822); C. punctatus, Valenciennes, 1840; C. assamensis, Day, 1877.

C. Feeding Habits and Habitat: C. batrachus is a scavenger who can spend months without eating. During a drought, huge numbers of walking catfish may concentrate in isolated pools and prey on other fish. They have been found to infiltrate aquaculture operations, where they feed on fish populations in ponds. C. batrachus is a benthic, nocturnal, tactile omnivore that eats detritus, aquatic weeds and eats smaller fish, mollusks, big aquatic insects, tadpoles, other invertebrates when the opportunity arises. Because it is a voracious eater who depletes food supply quickly, it is considered dangerous when invasive. Asian catfish may be found in a variety of habitats; however, they are most usually found in high turbidity stagnant, muddy, or marshy water. It is known to live in medium to large rivers, swamps, ponds, ditches, flooded fields, rice paddies, and pools left in low locations when rivers flood. It has also been documented to live in inter-coastal waterways with salinities as high as 18 ppt. It is a tropical species with a modest resistance to cooler waters, with a lower fatal temperature of 9.8°C observed. Walking catfish burrow into the edges of ponds and streams during the winter dry months, where they lay dormant until the spring rains arrive (Masterson, 2007).

D. Spawning habits: Fish may dig nests in submerged mud banks and embankments in flooded fields during the rainy season, when rivers flow and fish can excavate nests in submerged mud banks and dikes. During the season, these catfish breed with a single mate via many spawning cycles that generate increasing numbers of eggs. During the spawning embrace, the eggs are internally fertilized, and a mature female will produce about 9,000 eggs every season. After three days, the walking catfish fry became self-sufficient (Argungu et al., 2013).

E. Environmental Tolerance: The species' ability to flourish in unfavorable circumstances such as low dissolved oxygen, high stocking density, and poor water depth positions the fish as a good choice for culture in small, swallow ponds. The skin of this fish, which is scale less and mucus-covered, serves as an air breathing organ in addition to the supra branchial chambers, gill plates, and respiratory tree, which serve as accessory respiratory organs of the fish (Dutta Munshi, 1961). The fish exhibits an outstanding level of tolerance in a wide range of environments, indicating an adaptive evolutionary feature. Toxicity and stress studies can provide knowledge on a species' adaptation strategy in response to the changing nature of the wild habitat, much of which has been altered as a result of increased human involvement and exploitation. Excessive use of insecticides, pesticides, and other chemicals for agricultural purposes has recently had a negative impact on neighboring old water sources, causing them to become contaminated. Several research on the influence of specific contaminants such as pesticides, drugs, and heavy metal toxicity on C. batrachus have revealed that stress has a negative impact on fish health, causing population decline and habitat damage. The agriculture fertilizer diammonium phosphate shows as severe hematotoxic effect in C. batrachus (Naqvi et al., 1993). Pollutants such as pesticides, medicines, radionuclides (Joy and Sathyanesan 1981) and heavy metals (Panigrahi et al., 1990) have been shown to harm the liver (Goel and Agrawal 1981), brain (Kirubagaran and Joy, 1990), and kidneys (Kirubagaran and Joy, 1988). C. batrachus has also been shown to have organ and system specific effects on the nervous system (Jyothi and Narayan 2004), immunological system (Datta et al., 2009), endocrine level (Kirubagaran and Joy, 1991), and general metabolism (Begum and Vijayaraghavan 1995). Recent research on oxidative stress (Bhattacharya and Bhattacharya, 2007), DNA damage and apoptosis (Datta et al., 2007), gonadal development (Singh and Joy 2000), reproductive cycles, and other effects of allogens point to the urgent need to preach and practice habitat protection, as well as implement stringent environmental regulations.

F. Nutritional values: The consumption of this cat fish is very popular in many regions of India. The proximate analysis of fatty matter provided in the text for blood plasma may be utilized as a technique for indirect assessment of the nutritional importance of this fish's ingestion in terms of healthy fats. Lipid profile data may also be used to develop high-efficiency experimental diets employing diverse tissues from this fish species. This affects both the taste and the nutritional value. The reference range of lipid profile is given by Debnath, (2009), Total Cholesterol level 227.0 – 252.0 mg/dl, Triglycerides level 59.0 – 69.0 mg/dl, VLDL level 10.0 – 13.8 mg/dl, and LDL level 50.0 – 88.2 mg/dl. The average HDL content in the blood plasma of C. batrachus was determined to be 150 mg/dl - 180 mg/dl, demonstrating the wonderful benefit of ingesting this fish species. C. batrachus has been identified as a good source of unsaturated fatty acid. Jakhar et al., revealed highest value in lipid content, mono and poly unsaturated fatty acid, EPA and Linolenic Acid. C. batrachus contain Polyunsaturated Fatty Acids (PUFA), which play important roles in cardiovascular system to reduce the risk of heart attack (Erkkila et al., 2003) and lower triacylglycerol levels in plasma. PUFA, specifically n-3 and n-6 PUFAs, are advantageous to human health. Unsaturated Omega-3 fatty acids, eicosatetraenoic acid (EPA, 20:5n-3) and docosahexaenoic acid (DHA, 22:6n-3) and its precursor alpha linolenic acid, are abundant in fish flesh and oils (C18:3, n-3). Compared to other meat, fish meat contains a higher level of n-3 PUFAs (Calder, 2004), which are highly preferred beneficial for human health (Dhanpal et al., 2011) as they are cardio protective, anti-atherosclerotic, anti-thrombotic, and anti-arrhythmic and also help to reduce blood cholesterol level (Potter and Kiss 1995).

According to Jakhar et al., 2012, C. batrachus had the highest PUFA content (25.56 %), followed by Pangas (23.37%), Rohu (15.84 %), and Catla (12.5 %). Paul et al. 2015 discovered 1.34 gm of PUFA out of 5.24 gm total fat content per 100 gm of C. batrachus fish muscle. Omega 3 has 0.42mg of PUFA and Omega 6 contains 0.92mg. According to Tichelaar, (1999) undernourished African children under the age of six, fish protein (C. batrachus) supplementation resulted in considerable weight increase at a rate of 0.68 gm/kg/day, roughly 1.33 times quicker than the control groups. Plasma ferritine level was also shown to be higher, resulting in less Fe (II) deficient anemia. It is important to note that air breathing fishes of all species are in high demand in this region among people of all ethnic groups due to their easy digestion, high iron content, and widespread belief in their therapeutic potential. This species is the most farmed fish in Africa's tropical and subtropical areas, and it is playing an increasingly important part in the country's nutrition as a source of relatively inexpensive animal protein (Debnath, 2009). Iron is a crucial life-sustaining element for both animals and humans. All fish are a good source of iron. The overall iron content of

an adult is around 4 to 5 g. Iron is a crucial component of several enzymes in cellular metabolism, particularly those associated with the mitochondrial respiration chain. Iron is primarily involved in the transfer of oxygen to the tissues (hemoglobin). It is also involved in cellular respiration activities. Iron deficiency anemia is common in children, teenage girls, and nursing mothers (Gehring et al., 2011). According to Islam et al., 2013, the iron content of C. batrachus was 7.06 mg/kg. Calcium is the most prevalent mineral in the human body, accounting for 2% of total body weight, and the fifth most common metallic element in the earth's crust. Calcium is required for development, bone building, blood coagulation, milk creation, vitamin D absorption, and other processes. It is an inert inorganic mineral that is commonly related with the creation of bones and teeth. Calcium deficiency causes rickets, osteomalacia, and osteoporosis (Anderson, 1982). The body has around 1200 g of calcium. C. batrachus has a calcium concentration of 210.10 mg/kg (Islam et al., 2013). Phosphorus is a key component of all animal cells, and it may be found in all natural diets. Primary phosphorus insufficiency is not known to occur in humans. There is muscular weakness and bone discomfort. Urinary phosphorous is just approximately 15 mg/day and plasma inorganic phosphate is relatively low. The majority of phosphate in the body is found in bones, which comprise 600 to 900 g. Phosphate metabolism can be disturbed in a variety of diseases, particularly those affecting the kidneys and bones (Rosenquist and Holmer. 1996). The C. batrachus had more phosphorus (70.05 mg/kg) in this investigation (Islam et al., 2013). The zinc level of C. batrachus was minimal quantities. Zinc is a trace element that is required by animals, humans, and plants. Although zinc accounts for approximately 0.003% of the human body, it is an essential component of at least 110 metallo-enzymes and other cellular components. It is required for protein, RNA, and DNA synthesis. Zinc aids in the transportation of vitamin A. The zinc-to-copper ratio in the diet is critical for disease progression. Zinc levels in the blood drop for two to three days following a heart attack. Growth retardation, anemia, and impaired sexual development are the most visible symptoms of zinc deficiency, as are skin changes, loss of appetite, and white opaque spots on finger nails (Molla, 1991).

Lipid Profile (Debnath, 2009)	
Total Cholesterol	227.0 – 252.0 mg/dl
Triglycerides	59.0 – 69.0 mg/dl
VLDL	10.0 – 13.8 mg/dl
LDL	50.0 – 88.2 mg/dl
HDL	150 mg/dl - 180 mg/dl

Table 1: Lipid profile of C. batrachus (Debnath, 2009)

CALORIE INFORMATION	
Calories	115.40 kcal (482.82KJ)
From Carbohydrate	0.0 kcal
From Fat	48.73 kcl (203.89KJ)
From Protein	66.67 kcl (278.93 KJ)
	(Paul et al., 2015)

Table 2: Lipid profile of C. batrachus (Paul et al., 2015)

PROTEIN AND AMINO ACIDS			
Protein	16.26	Aspartic Acid	1.83
Arginine	072	Serine	0.87
Histidine	0.67	Glutamic Acid	2.39
Isoleucine	0.79	proline	0.21
Leucine	1.36	Glycine	2.32
Lysine	0.69	Alanine	1.18
Metheonine	0.40	Cysteine	0.02
Phenylalanine	0.62	Tyrosene	0.12
Threonine	0.82	Valine	1.06
Tryptophan	0.19		(Paul et al., 2015)

Table3: Protein and Amino Acids (Paul et al., 2015)

VITAMINS, MINERALS & OTHER	
Vitamin A	6.03 IU
Vitamin D	44.73 IU
Vitamin E	0.15 IU
Vitamin K	0.53 mcg
Calcium	222.36 mg
Phosphorus	129.42 mg
Sodium	201.49 mg
Potassium	262.09 mg
Iron	2.20 mg
Manganese	0.21 mg
Zinc	0.68 mg
Selenium	0.43 mg
Water	74.72 g
Ash	2.22 g

Table 4: Vitamins, Minerals and other (Paul et al., 2015)

TOTAL FAT 5.24					
Saturated Fat	1.90 g	C15:0	0.12 g	Monosaturated Fat	1.994 g
C4:0	0.005 g	C16:0	0.38 g	C14:1	0.004 g
C11:0	0.005 g	C17:0	0.27 g	C15:1	0.12 mg
C12:0	0.04 g	C18:0	0.45 mg	C16:1	0.34 mg
C13:0	0.13 g	C20:0	0.02 mg	C17:1	0.01 mg
C14:0	0.03 g	C21:0	0.45 mg	C18:1n9	1.52 mg

Table 5: Fats and Fatty acids (Paul et al., 2015)

POLYUNSATURATED FAT	1.34 g	C20:3n6	0.06 mg
C18:2n6	0.73 mg	C20:3n3	0.01 mg
C18:3n6	0.05 mg	C20:5n3	0.16 mg
C18:3n3	0.13 mg	C22:6n3	0.12 mg
C20:2n6	0.08 mg	ω 3	0.42 mg
EPA+DHA	0.18 mg	ω 6	0.92 mg

Table 6. Plyunsaturated Fats in C. batrachus (Paul et al., 2015)

G. Prophylaxis: According to the literature the fish lipids play a significant role in prophylaxis of the blood-circulation disorder (Mariola et al., 1994) and the fish lipids play very important, physiological role in human nutrition and also can lower the frequency of breast cancer and tumors of colon (Ziemianski et al., 1992). Magur supplementation to persons with iron deficiency syndrome resulting in anemia is recognized to have a highly positive influence, especially on undernourished children, new mothers, and young and teenage females. Magur is also recommended for various diseases and traumatized patients for quick recovery, wound healing, and strength (Borah, 2020).

H. Regeneration ability: The process of renewing a lost or removed component of a live body is known as regeneration. In a broad sense, regeneration is the consequence of vegetative reproduction of a range of component cells necessary to restore the destroyed portion. According to Borah and Gogoi (2014) and Poss et al., (2000). C. batrachus has an incredible ability for regeneration of specific missing organs as well as self-healing of wounds and severed parts of the body. While all animals have the ability to make cells and mend bodily wounds to some extent, the ability to regenerate a lost organ or part of an organ differs between species and is limited to particular organs and animals. Planarians and Hydra (Wittlieb et al., 2006, Van Wolfswinkel., et al., 2014), as well as some amphibians (Urodele amphibians, Salamanders) and fin fish (Zebra fish Danio rerio), are capable of regenerating specific organs or parts of the body such as the heart, limbs, fins, optic nerve scales, muscles, and spinal cord (Poss et al., 2000). Borah and Gogoi found that to keep the fish alive after dissection and removal of the testis, the fish has

the extraordinary ability to repair the wound without any medicine or stitches within 30-40 days. Sanap et al., (2018) recently demonstrated post-surgery survival of the species' male brooders by sewing using absorbable stitching thread. Human organs are vulnerable to a range of traumas, yet have a limited ability to restore and replace damaged tissue or organs. These discoveries on C. batrachus's amazing ability to regenerate surgically excised testis would pave the way for fresh studies into how to use this ability for the benefit of humanity. Because fish skin has been found as a possible biocompatible, biodegradable skin substitute with high collagen content, the natural healing process in the fish brings up the possibility of employing the skin of C. batrachus as a substrate or skin substitute in the treatment of human wounds (Yamada et al., 2014). Borah and Bordoloi's (2022) attempts at post-surgical revival of the fish (weight 110.0-190.0 g/fish) by performing the incision with minimal injury revealed that the fish had an amazing capacity for wound healing by regeneration of lost tissue with 83.9-92.6 percent (average 87.8 percent) post-surgical recovery. The wound (4.0-4.5 cm in length) healed entirely in 30-35 days without any medication or stitches (Table 7).

Treatment No	**Nos. dissected**	**Wt. of fish(g)**	**Nos. recovered**	**% of recovery**	**Time required for healing days**	**Number and % Occurrence of malformation**
1.	30	138 ± 27	27	90.0	32 ± 1	3(11.1%)
2.	28	160 ± 26	24	85.7	32 ± 2	2(8.3%)
3.	31	155 ± 35	26	83.9	34 ± 2	2(7.7%)
4.	30	142 ± 32	26	86.7	33 ± 2	1(3.8%)
5.	27	128 ± 29	25	92.6	33 ± 3	2(9.1%)

Table 7: Post Surgery revival and healing of mechanical wound in C. batrachus (Borah and Bordoloi, 2022).

I. Intensive Culture: Because of its texture and taste, this is the most popular catfish. Because of its capacity to thrive in poorly oxygenated water bodies due to auxiliary respiratory organs (Singh and Hughes, 1971), this catfish may be farmed in swamps, derelict water bodies, and paddy fields unsuitable for carp farming (Chondar, 1999). Under semi-intensive and intensive cultivation systems, stocking density of this catfish is extremely high (Dehadrai and Kamal, 1993). It breeds naturally in paddy fields once a year during the breeding season; however, farmers do not get enough seed for commercial aquaculture (Ayyappan et al., 2011). Though Goswami and Sarma (1997) performed induced breeding of catfishes using pituitary gland extract (PGE) given at a dosage of 20- 30 mg/kg and GnRH-based medicines (Mishra et al., 2011; Yadav et al., 2011), commercial seed production of C. batrachus has yet to begin (Tripathi, 1990; Thakur, 1991). This fish may be raised at extremely high stocking densities. Because the fish may be sold live, it demands a greater value than carps. Breeding, seed manufacturing and growth out processes have been standardized. A few farmers in various sections of the nation have already implemented these practices. Chaturvedi et al., (2013) tried induced breeding in Uttar Pradesh agro climatic conditions; the incubation duration of induced breeding sets was 10-16 hours after ova prim injection. The average fertilization rate was 90%, except in a few cases where it was just 80%. 10,416 seed were generated from 22,800 fertilized catfish eggs. The spent catfishes were healthy after breeding attempts, and no mortality was recorded. The current study's findings clearly show the success of induced breeding of catfish and the feasibility of a water-flow-through hatchery for seed production under a three-tier system (for rearing unit) for better survival, which is cost-effective and may be easily accepted by fish farmers in Uttar Pradesh and neighboring states. The processes of endocrine regulation pathways including reproductive physiology (Mazumdar et al., 2007) and culture of C. batrachus in natural or controlled environments (Ghosh, 2004) are thoroughly explored. Aquaculture requires induced breeding to create cost-effective and sustainable procedures (Muir, 2005). A variety of stimulators and techniques have been studied in the searching for an effective and cost-effective inducer of spawning and associated alterations, artificial spermiation, ovulation, and maturation of gametes in C. batrachus (Raghuveer and Senthilkumaran, 2009; Sahoo et al., 2007). This species' successful aquaculture might lead to the socioeconomic sustainability of rural populations. Intensive C. batrachus

production will raise in popularity since, unlike many other aquaculture species, it does not require any specific conditioning or growth ingredients. C. batrachus is well suited for commercial intensive culture because to its very easy culture, rapid food conversion (Ali and Jauncey, 2005), and great nutritional profile (Rui et al., 2007).

J. Conservation: It is estimated as Vulnerable (VU), a taxon is Vulnerable when it is not critically endangered or endangered but is facing a high risk of extinction in the wild, on the basis of population estimation (CAMP, 1998). Intensive C. batrachus aquaculture in rural water bodies with limited infrastructural development may result in socioeconomic growth in several sections of Bengal and Northeast India. Coordination between government organizations in terms of worker skill up-gradation, market regulation, and so on, as well as the scientific community in assuring timely supply of higher quality seed stock, would result in success stories in intensive C. batrachus culture. Because the species is a part of the natural fauna in this location, cultural techniques will be considerably easier to follow and hence much more economically feasible. Government authorities and organizations should step forward to teach rural jobless youth and women in human resource development and skill enhancement connected to cultural and disease management technological know. Regional rural banks and agro finance authorities should be approached for capital requirements, and Panchayats should lend money to rural businesses.

CONCLUSION:

To the delight of both vendors and buyers, the fish can be offered alive because they can breathe ambient oxygen using a special air breathing apparatus. The species has very high nutritional value among fresh water cultivable fish species, not only as a food item with high protein content, but also as a rich source of poly unsaturated fatty acids (PUFA). The species is thought to have medicinal/therapeutic value due to its distinct flavor and nutritional richness. Furthermore, the fish has an amazing ability to self-heal by repairing missing tissue and restoring critical organs. Appropriate actions must be taken to ensure the survival and expansion of this nutritional, medicinal, and pharmacologically important species. Fisheries and aquaculture are becoming increasingly important as we become more concerned about sustainability, environmentally friendly solutions, conservation, and food security. Today, habitat conservation and long-term use of this magnificent fish are critical. Traditional cultural knowledge, combined with our valuable perspectives on the complexities of multiple physiological processes, will enable sustained yield development and, as a result, ensure future food availability. Several studies have revealed that the lipids of C. Batrachus can be eaten.

REFERENCES:

A.H. Molla (1991). Biochemical and nutritional studies of the Bangladeshi fresh water Eel, Anguilla Bengalensis (Bao Baim), A PhD. Thesis, submitted to the University of Rajshahi.

Ali, M.Z. and K. Jauncey (2005). Approaches to optimizing dietary protein to energy ratio for African catfish C. gariepinus (Burchell, 1822). Aquaculture Nutrition.11, 95–101.

Anderson L. (1982). Nutrition in health and diseases. 17th ed. J. B. Lippicopp Company, Toronto.

Argungu, LA, Christianus A, Amin, SMN, Daud, SK, Siraj, SS, Aminur Rahman M (2013). Asian Journal of Animal and Veterinary Advances. 8: 168-176. DOI:10.3923/ajava.2013.168.176

Ayyappan S, Moza U, Gopalakrishnan A, Meenakumari B, Jena J K and Pandey A K (2011). Handbook of Fisheries and Aquaculture. 2nd Edn. Indian Council of Agricultural Research, New Delhi.

Begum G. and S. Vijayaraghavan (1995). Carbohydrate metabolism in hepatic tract of freshwater catfish C. batrachus L. during dimethoate exposure. Food Chem. Toxicol.1995; 33(5):423-6. Bhattacharya A. and S.

Bhattacharya (2007). Induction of oxidative stress by arsenic in C. batrachus: involvement of peroxisomes. Ecotoxicol Environ Saf. 66(2):178-87.

Bibha Chetia Borah (2020). "Asian Catfish Clarias magur (Ham), a Wonder Fish for Health and Nutrition". Acta Scientific Nutritional Health 4.2: 139-143.

Borah B.C. and Bordoloi B. (2022). Regenerating capacity of Asian Cat fish, Clarias batrachus (Linnaeus, 1758). International Journal of Biological Innovations. 4(1): 43-50. https://doi.org/10.46505/IJBI.2022.4104.

Calder, P.C., (2004). Long-chain fatty acids and cardiovascular disease: Further evidence and insights.Nutr. Res., 24: 761-772.

CAMP (1998). Report of the workshop on "Conservation Assessment and Management plan (CAMP) for Freshwater fishes of India. Zoo Outreach Organization and NBFGR, Lucknow 22-26 September 1997, 156.

Chakraborty B.K., Bhattacharjee S. and Muniya S. (2021b). A Study on Aquatic Biodiversity of Shuthi-Shaiduli River of Bangladesh. International Journal of Biological Innovations. 3 (1): 58-67. https://doi.org/10.46505/IJBI.2021.3104

Chaturvedi, C.S., Roy, S.D., Nagesh, R. and Pandey, A.K.,(2013). Post-tsunami abundance of Clarias batrachus and Heteropneustes fossilis in Andaman and Nicobar Islands. Journal of Experimental Zoology, India, 16(2), pp.491-494.

Chetia Borah B. (2020). Asian cat fish Clarias magur (Ham.), a wonder fish for health and nutrition. Acta Scientific Nutritional Health. 4(2):1-5.

Chetia Borah B. and Gogoi R. (2014). An observation on the amazing self healing capacity of cat fish Magur (Clarias batrachus). International Journal of Fisheries and Aquatic Studies. 2(2):38-40.

Chondar S. L. (1999). Biology of Finfish and Shellfish. SCSC Pub. (India), Howrah.

Das, S. (2002). Seed production of magur (Clarias batrachus) using a rural model portable hatchery in Assam, India - A farmer proven technology. Aquaculture Asia Magazine, 7(2): 19-21.

Datta, S. DR, Saha. D, Ghosh. T, Majumdar. S, Bhattacharya. S, Mazumder (2007). Sub-lethal concentration of arsenic interferes with the proliferation of hepatocytes and induces in vivo apoptosis in C batrachus L. Comp Biochem Physiol C Toxicol Pharmacol. 145(3):339-49.

Datta, S., S, Mazumder. D, Ghosh. S, Dey. S, Bhattacharya (2009). Low concentration of Arsenic could induce caspase-3 mediated head kidney macrophage apoptosis with JNK - p38 activation in Clarias batrachus.Toxicol. Appl. Pharmacol., 15; 241(3):329-38.

Debnath S. (2009). Traditional Consumption of Magur (Clarias batrachus) an Air Breathing Catfish among the Population of North Eastern India is Rationalized by Its Blood Lipid Parameters CHEMFERENCE, Annual Research Symposium, IIT Madras 22 - 23rd August. Available at SSRN: http://ssrn.com/abstract=1401145.

Debnath S. (2011). Clarias batrachus, the medicinal fish: An excellent candidate for aquaculture & employment generation. International Conference on Asia Agriculture and Animal IPCBEE, Singapore, 2011; 13:32-37.

Dehadrai P V and Kamal M Y (1993). Role of air-breathing fish culture in rural upliftment. In: Souvenir: Third Indian Fisheries Forum (October 14-16, 1993), 28-33. College of Fisheries, G.B. Pant University of Agriculture and Technology, Pantnagar.

Dhanpal, K, A. D. Reddy and G.V.S Reddy, (2011). Beneficial effects of fish oil and its application to human health. Int. journal of medical bio. Frontier., 17(12):137-156.

Dutta Munshi J.S. (1961). The Accessory Respiratory organs of Clarias batrachus (Linn.). Journal of Morphology. 109 (2):115-155.