CHAPTER 2

Review of Literature

REVIEW OF LITERATURE

2.1. *Monopterus cuchia*

Roy et al. [88] and Neog and Konwar, [3] reviewed the economic importance, medicinal and nutritional value of the fresh water, carnivorous air breathing fish mostly available in North-eastern India, Bangladesh, Pakistan, etc. (Fig. 2.1). The fish has high demand in national as well as international markets and the consumption of the fish is recommended because of its large protein content and calorific values. *M. cuchia* can survive in the extreme environmental conditions like high temperature, high salt conditions, and low oxygen levels.

Fig. 2.1. *Monopterus cuchia*

2.2. Special physiological characteristics of *M. cuchia*

2.2.1. Morpho-histochemical adaptation of the digestive tract

The pattern of feeding habits as well as the dependence on specific food resources can be understood by evaluating structural adaptations in the gastrointestinal tract of the fish [89, 90]. Stating to Verma et al. [91] the gastrointestinal tract is morphologically similar to that of carnivorous fish showing typical features *viz.* sub-terminal mouth, short muscular oesophagus, expendable stomach, short intestine, and rectum. Due to the carnivorous nature of the fish, teeth are arranged in a special manner for digging and catching mud-dwelling prey in the pharyngeal region and the oral cavity.

2.2.2. Respiratory adaptations

This fish can inhabit mud tunnels as well as buckets without water for a long time with the help of this modification [92]. The fish has specialized pharyngeal pouches present on both sides of the head that help in aerial and aquatic respiration [3]. A combination of respiratory sacs is present on both region of the head and the gills of the fish are reduced [93]. In an adult fish air sac measure about 19 and 15 mm in length and width, respectively [93]. Slit-like apertures are also found at the base of the gill filaments [94]. It has also developed pharyngeal pouches that function in gas exchange in both water and terrestrial ecosystems [92]. A protective mucous layer that is connected to the epithelium cover the entire respiratory membrane. The non-vascular area of the respiratory membrane contains a large number of mucous glands that secrete mucus continuously.

2.2.3. Epidermal adaptations

Mucus in the epidermis protects the fish from injury during searching for food at the bottom and helps to preserve skin health [3]. The body surface of the fish is provided by the Gps and mucous goblet cells that help in swimming by reducing body friction in the water. The Type I and Type II mucous goblet cells prevent the growth of pathogenic microorganisms on the surface of the skin of the fish providing the first line of the defence mechanisms [3]. The high lipid content in the epidermis plays a vital role in the desquamation regulation and energy production [95]. The sheaths of connective tissue called myocommata rich in glycogen aid in the metabolic activities of the fish during swimming [96]. The skin of the fish is flexible and metabolically active which defend, nurture, and plays a crucial role during its gliding movements in both terrestrial and aquatic habitat [3].

2.3. Reproductive cycle of the fish

The knowledge on the reproductive physiology of the fish is important for successful fishery management and culture practice of *M. cuchia* [97]. The knowledge of spawning season and gonad development is very important for the management of the species [98]. Several authors have studied the reproductive physiological characteristics *viz,* monthly gonado-somatic index, developmental stages of the gonad, egg diameter, fecundity, external sexual characters, etc. to identify the peak breeding season of *M.*

cuchia. Chakraborty et al. [99] identified three and four developmental stages in the ovary and testis of *M. cuchia*, respectively. 62.8 g and 8.2 g were the reported maximum mean gonad weights in females and males, respectively recorded in May. In addition to this, the development of mature testis and oocytes was prominent from May to July. Kurbah and Bhuyan, [100] found that the highest gonado-somatic index value in males (3.4) and females (7.3) was observed during May and the lowest value of 0.02 and 0.3 was found in males and females during September. The peak breeding season of the fish occurs in May and this species breeds only once a year. Furthermore, the actual pattern of the maturation of gonads was observed histologically which helps in determining the induced breeding of the fish Kurbah and Bhuyan, [100]. In case of males, the testis is soft, elongated, and dorsally attached to the body cavity. Testis consists of several seminiferous tubules where spermatogenesis takes place. It opens through the urogenital aperture via the spermatic duct which is formed by the union of posterior-ventrally located as vasa deferens. The mature testis of *M. cuchia* is creamy white while the ovary is single-lobed and cylindrical. A thin mesentery connects the elongated and cylindrical ovary lobe along their dorsal surfaces. The mature ovary is yellowish whereas the immature one is compact and cream colour. The ova diameter (4.2 mm) and gonadosomatic index value of the fish reach peak value during the months of May-June [101]. Similarly, Rahman et al. [102] found that the ova diameter of *M. cuchia* varies from 0.3 mm to 4.0 mm. Jahan et al. [101] reported that the fecundity of the eel eggs ranges from 370-647. Chakraborty et al. [99] reported that the weight of gonads gradually increases from January to July in the case of male *M. cuchia* and reached a maximum value (6.6 g) in June. But in the case of female, the weight of the gonad gradually increases from January to June and reached a maximum value (48.6 g) in June. In addition to this, fecundity is directly proportional to the weight and length of the fish and there exists a highly significant linear relationship between fecundity and the gonadal weight of the fish [99]. They, thus, concluded that the gonadosomatic index (GSI) and fecundity could be the two important parameters for identifying the spawning cycle of *M. cuchia.* Therefore, knowledge of the reproductive biology of the fish would be helpful to save this economically important fish from getting extinct.

2.4. Nutritional characterization

Due to their high nutritious value aquatic foods are important in improving the health of people and the economy of a nation as well [103]. Fish and fishery products are

regarded as key elements in a healthy diet owing to their high content of essential nutrients, proteins, long-chain omega-3 fatty acids, etc. *M cuchia* is an excellent source of protein and has a high calorific value of 303 kcal 100 g^{-1}. High nutritional components have been recorded from different eels including *M. cuchia*. Variable amounts of minerals like selenium, manganese, zinc, sodium, potassium, phosphorus magnesium, iron, and calcium have been reported in the eel fish. Moreover, unsaturated and saturated fatty acids and vitamins like vitamin B12, choline, vitamin B6, vitamin E, pantothenic acid, niacin, riboflavin, and vitamin C has also been reported [104]. The Na/K ratio in females and males was found to be 0.21 and 0.20, respectively [103]. The data available on the nutrient value of the fish is obtained from raw fish nutrient profiles. However, it has been reported that the nutritional profile of the fish is based on many parameters including thermal-based cooking, and varies once the parameters are changed. Islam et al. [105] studied the effect of different cooking methods on the nutritional profile of the muscle of cuchia fish. They found that moisture content remained the same in raw muscle as well as the boiled products. However, frying, grilling and microwaving decreased the moisture content. The protein content was higher (21.9%) in cooked muscle than in fresh one (14.5%). Grilled and microwaved mud eel muscle contain the highest protein content than the fried ones. The lower moisture content in cooked muscle contributes to the overall increased protein content. High amount of ω-3 polyunsaturated fatty acids was present in the raw muscle of the fish ranging from 7.5-13.7%. However, the heat effect during cooking lower the amount of ω-3 polyunsaturated fatty acid. It was also demonstrated that both raw and cooked muscle contains a high amount of calcium. Faruque et al. [106] performed a comparative study of nutritional quality in muscle between female and male freshwater mud eels. The proximate composition was found to be the same in both male and female fish. The predominant amino acids found in the muscles of both sexes were glutamic acid, aspartic acid, lysine, leucine, and arginine. The essential and non-essential amino acids ratio was found to be similar (0.7) in both sexes. The percentage of fatty acids (mono-unsaturated and poly-unsaturated) was higher in females than their male counterparts. The primary saturated fatty acids which varied significantly between sexes were heptadecanoic acid, pentadecanoic acid, and palmitic acid. The mineral content in both sexes was found to be in the order as follows: K>Na>Ca>Mg>Mn>Zn. Rana et al. [107] investigated the seasonal alteration in the nutritional profile (proximate compositions, amino acids, and

fatty acids) of the *M. cuchia*. The lipid content showed vast variations as compared to the protein content of the fish due to seasonal variations. The amino acid amount also varied seasonally.

2.5. Haematological parameters of *M. cuchia*

It has been reported that haemoglobin content of air-breathing fishes is usually higher than non-air-breathing fishes. Furthermore, it has been demonstrated that the erythrocyte indices of *M. cuchia* are significantly high. Nanda et al. [108] studied the morphometric index and its co-relation with the erythrocytic parameter of *M. cuchia* of Eastern Himalayas, India. Haemoglobin content (%), total erythrocyte count (TEC X 10^6 mm^{-3}), and packed cell volume (PCV %) were found to be 21 g% (20.9), 2.6-3.1, and 56.3, respectively. In addition to this, mean cell haemoglobin (MCH), mean cell haemoglobin concentration (MCHC), and mean cell volume (MCV) were also evaluated which were found to be 74.3 (pg), 7.2 (%), and 200.1 (μ^3), respectively. The results indicated a positive correlation (r= +0.85) between the length and weight of the fish. Similarly, a positive correlation (r= +0.96) was found between Hb content and TEC whereas no correlation was found between haemoglobin either with weight (r=-0.03) or length (r=+0.08). In a similar kind of study, Salehin and Mandal, [109] demonstrated about 19.6 g/dl haemoglobin concentration, 54.1 haematocrit (HCT) (%), 6.0-6.5 mm in 1^{st} erythrocyte sedimentation rate (ESR), 3.9 m/cumm total RBC, 139.0 fl MCV, 48.0-50.0 pg MCH, 34.5-36.5 g/dl MCHC, 11850-11850 /cumm total White Blood cells (TWBC), 64.5% lymphocyte percentage, 28.5% neutrophils, 3.0% monocytes, and 3.0-4.0% eosinophils, 305000-315000/cumm platelet counts of *M. cuchia* of Bangladesh.

2.6. Therapeutic and consumable information of *M. cuchia*

The increase in market demand and consumption of *M. cuchia* has been observed in recent years. It has also been considered a major component of the diet of anaemic and weak people. Traditional healers believe that consumption of this species increases haemoglobin content of blood and enhances physical strength in ailing persons [103]. The fish is nutritionally rich with high medicinal value and has also been reported to be an important ingredient in traditional therapeutics of the North-eastern states of India by

different tribes and communities [110]. Some applications of *M. cuchia* are provided in Table 2.1.

Table 2.1 Therapeutic uses of *M. cuchia*

Part used	Therapeutic use	Tribe	Place	Description	Reference
Dried head along with *Garcinia pedunculata*	Treat haemorrhoids	Chutia, Sonowal Kocharis, Deori, Ahoms, Tea-tribe, etc.	Assam	The head is dried and crushed with the fruit of *Garcinia. pedunculata*. Granules are prepared from the mixture and one granule is administered orally before meals thrice a day.	111
Blood with *Leucas aspera*	Treat diabetes		Assam, India	The fresh blood is administered orally in the morning for 4 days continuously. The dosage is followed by preparing the plant extract. The extract is mixed with honey and administered orally. Then, 1/4th glass of lukewarm water is given after 20 minutes. The process is continued for next two days.	112
Blood with *Allium sativum* L.	Localised baldness (Alopecia)	*Chakma* tribe	Bangladesh	Blood is applied on the head and then a paste of *A. sativum* is applied along with *jhul*	113
Fresh or sun-dried	Anti-asthmatic and	*Pahari* and *Danuwar*	Nepal	The dried or fresh gall bladder is rubbed	114

gall bladder	anti-rhinitic properties	ethnic groups		against a stone to obtain powder or paste and is mixed with water, then administered orally	
Fresh blood	Cure general weakness, anaemia, asthma	Naga tribe	Nagaland, India		115
Whole body with ethnomedicinal plants	Treat burn injuries, weakness, piles, anaemia, etc.	*Rabha, Hajong, Bodo, Garo* tribes; the *Koch-Rajbongshi* community	Assam, India		103

2.7. Culture of *M. cuchia*

Due to the shortage of animal protein, most of the people of our country have been suffering from malnutrition. This problem can be reduced by increasing the production of fish through scientific and modern fish culture and management practices [116]. Fish culture practices can be improved by adopting different measures *viz.*, correct doses of fertilizer application, optimum stocking density, regular feeding, prevention of disease, and maintenance of various limnological factors [116]. The extensive and improved culture of *M. cuchia* could be quite profitable for the wider section of society including the ones whose income is dependent on the fish. The culture of the fish can be done in a small space and does not require expensive feed. The culture of *M. cuchia* fish depends on various factors *viz*. feeds, feeding frequency, stocking density, temperature, and habitat. Chowdhury et al. [116] evaluated the production performance of the freshwater mud eel with supplementary feed (50% fish paste, 40% fish meal, 5% rice bran, and 5% wheat bran) in two ponds from Maulovibazar district, Bangladesh. All the necessary conditions for the production of the fish *viz*. shelter (bamboo root, plastic, and bamboo-made hollow

pipe), physicochemical parameters, and liming (250 kg/ha) were maintained appropriately. The total production of the fish in the two ponds was 28.3 and 31.9, respectively. Jahan et al. [117] reported that an earthen pond with live fish is desirable for the domestication of *M. cuchia*. Begum et al. [118] reported best growth of *M. cuchia* larvae was when it was fed with earthworm pests along with the feeding three times a day and at lower stocking frequency (90 larvae/tray) respectively. Rahman et al. [119] observed that the feed intake of the fish is directly proportional to the temperature. The highest feeding rate was found at the highest average temperature (27°C) and the lowest feeding rate was found at the lowest average temperature (14.4°C). They also reported that overall food intake during February and March was double as compared to December and January. Moreover, the fish does not take food at or below the average temperature of 12°C.

2.8. Marketing of *M. cuchia*

The fishery sector plays a significant role in an economic system by increasing living standards, achieving exchange of national-cum-international relationships, influencing socioeconomic development, providing a livelihood for economically backward people, and generating employment [120]. Export earnings of cuchia play an important role in both international and national markets [3]. The majority of the poor people find employment in the collection, production, transport, and marketing of the freshwater mud eel. Accordingly, employment and income-generating opportunities can be developed in both urban and rural areas [120]. *M. cuchia* is in great demand in the international markets due to its therapeutic and nutritional value. Globally eel production was expected to increase by about 58% between 1985 and 1992 [121]. Presently, world aquaculture freshwater mud eel production is around 233,000 mt/year valued at over US$ 975 million [3]. A remarkable fishery business exists in various developed countries like Japan, Korea, Australia, China, USA etc. [122]. Although the fish is cultured and exported from north-eastern states of India but the information regarding the business, export, and market channel is not reported yet.

Bangladesh exports cuchia to China, Malaysia, Hongkong, Taiwan, Indonesia, and Korea [123]. They reported that Bangladesh export cuchia to Japan (3.5%), Malaysia (3.5%), America (3%), Thailand (10%), and China (80%). The freshwater mud-eel is processed and exported in live condition. The processing of the fish is carried out by 8-10

skilled labours 4-5 hours before export [104]. It has been reported that Bangladesh have earned 10.5 million US dollars in the year 2018-19 by exporting 70.0175-ton *M. cuchia* in the international markets [116]. Considering the demand for eel fish in international markets various authors have reported different marketing channels, export quantity, and price margins of the fish from different areas of Bangladesh [3]. A number of limitations *viz.*, poor communications facilities, social and religious restrictions on the consumptions of the fish, higher labour and transport cost, poor water supply, transport and sanitary facilities, exploitation by middlemen due to lower market price as well as political disturbances have been reported in the marketing of the freshwater mud-eel [3]. For better marketing and export earnings cuchia must be available throughout the year from natural sources and farm cultures. The fishery shows future potential considering the export earnings from cuchia. To achieve such development huge support from governmental and non-governmental organizations is required [123].

2.9. Induced breeding of *M. cuchia*

The population of the species has declined to a greater extent due to their habitat destruction, excessive use of pesticides, and uncontrolled aquatic pollution. Hence, it is cogent to culture the fish in closed water bodies and replenishes their stock by artificial propagation. Kurbah and Bhuyan, [100] succeeded in obtaining fertilized eggs and larvae of *M. cuchia* by using Gonopro-FH. The final doses of gonadotropin hormone administered were 1 ml/kg and 0.3 ml/kg to the body weight of females and males, respectively. They evaluated the fertilization and hatching percentage which were about 75-80% and 80-85%, respectively. In addition to this, physio-chemical parameters of water dissolved oxygen (7.4 mg/L), pH (7.2), free carbon dioxide (0.1 mg/L), alkalinity (66.7 mg/L), and hardness (83.2 mg/L) were also evaluated. These factors play a significant role in the proper growth and development of the fish along with the healthy propagation of the fish population. Miah et al. [104] experimented on the reproductive biology and induced breeding status of *M. cuchia*.

2.10. Genetic and Molecular aspects of *M. cuchia*

Identification of threatened fish species accurately is very important for conservation purposes. RFLP analysis of PCR amplified DNA and allele-specific PCR from mitochondrial DNA are the different molecular techniques already established to

identify freshwater eels. Researchers applied a random amplified polymorphic DNA (RAPD) fingerprinting assay to observe the genetic variability of the fish. The analysis reported high degree of intra-specific polymorphism (76.9%) among the fish. Lakra et al. [124] observed the highest genetic distance (27.5%) between *Macrognathus pancalus* and *M. cuchia* highest genetic distance of 27.5%. Abedin et al. [125] applied DNA barcoding and RAPD analysis to measure the genetic diversity among swamp eel species. For RAPD analysis of the two population of the swamp eel (*M. cuchia* and *Ophisternon bengalense*), six primers were used and polymorphisms were found to be low (17.9%). Moreover, the 16S rRNA gene and glutamine synthetase gene has been used for the identification of *M. cuchia* [126]. Several studies have been done on the enzymes that can be used as a potential molecular marker for the establishment of variation in a species complex *viz. M. cuchia* and *M. albus.* The glutatione-S-transferase gene was characterized at a molecular level in two eel species (*M. cuchia* and *M. albus*) [127].

2.11. Diseases of *M. cuchia*

Recalcitrant disease outbreaks are one of the fundamental causes responsible for the declining population of *M. cuchia* from their natural habitat [93]. Water quality parameters vary seasonally that aid in the growth and multiplication of pathogens resulting in the spread of infectious diseases in fish. It has been reported that low temperatures during November to January might be one of the reasons for disease outbreaks fishes [128]. Some of the clinical indications like rough skin, weak body, and deep ulcers were observed in December to January. It was also found that the epidermis and dermis were partly lost in the muscle and skin of *M. cuchia.* Furthermore, necrotic muscles and skin created large vacuums, fungal granuloma, melanomacrophage, fungal hyphae and necrotic liver cells with vacuums, haemorrhage and fat droplets were observed during December and January [128]. *Heliconema monopteri* is a new species of nematode found in Uttar Pradesh, India. It infects the stomach and intestine of the freshwater mud eel [129].

2.12. Toxicological studies and adaptation of the fish to environmental stress

Excessive industrialization and associated anthropogenic activities have added a huge quantity of both organic and inorganic pollutants including plastics, pesticides, metals, hydrocarbons, etc. to both terrestrial and aquatic ecosystems. The environmental stresses due to unabated water pollution have negatively impacted aquatic life in general

and fish in particular [130]. The pollutants affect various behavioural activities of the fish including exploration, sociability, aggressiveness, and some sexual and feeding behaviours as well [131]. *M. cuchia* is subjected to environmental stresses in its natural habitat. To adapt to environmentally unfavourable conditions the mud eel expresses adaptation strategies to overcome the stresses. Some of the environmental stresses and the adaptation mechanisms are discussed.

2.12.1. High environmental ammonia (HEA)

M. cuchia encounters a high concentration of environmental ammonia (HEA) during summer in its natural habitat [132]. Ammonia excretion becomes difficult for the fish under constricted water conditions *viz*. rice fields, muddy ponds, and canals. During exposure to HEA different tissues of *M. cuchia* accumulate high amounts of toxic ammonia due to which oxidative stress is stimulated in the fish. *M. cuchia* induce abundance of heat shock proteins (Hsp70 and Hsp90 α) under ammonia stress. Under high ammonia conditions, the *hsp70* and *hsp90α* genes are upregulated for hyperproduction of Hsp70 and Hsp90α proteins to counter high concentrations of ammonia [132].

2.12.2. Herbicides

Herbicides are applied to the surface water to control weeds in rice fields which is probably the route of greatest exposure for fish [133]. Studies showed that oryzalin, 2,4-D, diquatdiromide, glyphosate, atrazine, benthiocarb, etc. adversely impact the growth, development, reproduction, smoltification, stress, and the olfactory response of the fishes [133-137].

2.12.3. Paraquat

Paraquat dichloride is one of the extensively used herbicides in India. The herbicide gets washed off to the water bodies inhabited by various aquatic life forms. Due to the direct contact with the aquatic environment, the fish in general and *M. cuhia*, in particular, are vulnerable to high concentrations of this herbicide. Das, [122] investigated the toxic effect of the herbicide paraquat on the haematological parameters, antioxidant enzyme assays, and histopathology of the freshwater mud eel. The RBC count, MCH, and haemoglobin concentration of the fish decreases, whereas there is a subsequent increase in the total leucocyte count. Furthermore, it causes several enzymatic (superoxide

dismutase, catalase) and histopathological changes in the kidney, liver, and intestine. Thus, the study demonstrated the activation of the adaptive immune response towards the presence of herbicide could result in a change of haematological parameters.

2.12.4. Glyphosate

The habitat of the freshwater mud eel makes it more vulnerable to the toxic effect of herbicides. Glyphosate effects the antioxidant defence system of the fish. Various haematologic and enzymatic changes occur in different organs of the fish *viz*. kidney, liver, and intestine as a consequence of the use and accumulation of glyphosate in the body. It upsets the haematological parameters where a significant decrease in RBCs, haemoglobin count, and elevation in WBC count could be observed. The study demonstrated a significant reduction of the antioxidant capacity of the mud eel in presence of glyphosate [122].

2.12.5. Pesticides

Pesticides cause pathological changes in the liver, kidneys, blood vessels, and gills of the fishes [138]. The protein content of the liver, muscle, gill, intestine, blood, and gonads decreased after exposure to nickel, phenylmercuric acetate, and oleandrin in *Heteropneustes fossilis*, *Anabus testudineus*, and *Channa punctatus* [139, 140]. In a freshwater fish, *Labeo rohita* malathion gradually decreases the nucleic acids, protein, free amino acid, and glycogen affecting the normal metabolic pathways that led to the increase in the rate of mortality in the fish population [138]. Mohan, [141] studied the effects of the high and low doses of malathion in the ovary of freshwater fish *Glossogobins giuris*. Chromosomal aberrations in the kidney cells of *Channa punctatus* were observed after exposure to 0.01 ppm concentration of Dichlovors [142]. Sub-lethal and relatively low concentration of pesticides causes behavioural changes and disrupts the immune system in salmon fish [143]. Mastan and Shaffi, [144] reported a differential response of glutaminase to dichlorvas, monocrotophos, and phosphamidon in different regions of the brain of *L. rohita.*

2.12.6. Malathion

Researchers studied the impact of sub-lethal concentration of malathion on the haematological parameters of *M. cuchia* [133]. The study demonstrated that the

erythrocytes count of the fish decreased significantly due to consumption and accumulation of malathion. In addition, a pronounced increase in leucocytes count was reported that directly indicated the ailing condition of the fish. Although immediate death was not recorded, the life-sustaining processes of the fish may be severely affected upon prolonged exposure to malathion.

2.13. Socioeconomic condition of cuchia catchers

Globally the socioeconomic conditions of cuchia catchers are poor [145]. A section of the population mostly landless people, children, and widows are involved in eel collection for their livelihood earning [3]. There are reports on the age structure, religions, education, housing conditions, sanitary conditions and earnings of the cuchia catchers from different locations. Various factors *viz.* poor economic condition of the parents, physical capabilities, and personal choice of the cuchia catchers may be responsible for such dissimilar reports [3]. Earlier only ethnic people such as garo used to catch cuchia but nowadays nonethnic groups are also involved because of the high demand for cuchia in national and international markets. The fishermen harvest cuchia throughout the year by various conventional methods including physical (hand picking), line (angling), and trapping (bair) methods [146]. Traditionally the fish is captured by the ethnic people by using knives, three popular types of spears locally known as kosh, jathi, and soil, ichthyotoxic plants like *Milletia pachycarpa* and *Derris elliptica,* etc. In addition to this, the *bodo* community uses traditional types of hooks locally known as *cuchia boroshi* for catching cuchia [147]. Farhaduzzaman et al. [97] in their survey reported that out of 200 interviewee, 7% cuchia farmers were illiterate, about 30% passed the primary school education and 11% passed the matriculation examination. The majority of the cuchia catchers were males and they lived in kacha houses whose roofs, floors, and fences were made up of straw, mud, and bamboo, respectively [3]. To uplift the livelihood condition of the cuchia catchers LIFT project titled "Accelerating natural breeding of cuchia and creating employment opportunities of poor people through household-based cuchia farming" has been implemented by HEED Bangladesh from June to mid-September 2017. The initiatives push self-employment, improve the economy, and boost the social status of the cuchia catchers [97].

2.14. Use of *M. cuchia*

As discussed earlier, traditionally it is used to cure general weakness, anaemia, piles, diabetes, heart and kidney diseases, and asthma either alone or in combination of some ethnomedicinal plants. Owing to the abundance of long chain omega-3 fatty acids, proteins, etc. the fish has high nutritional, and medicinal values. Blood of the fish is given to anaemic people to enhance their haemoglobin levels, suggesting a thorough and comparative study with human blood. Furthermore, the gut of *M. cuchia* contains hydrolytic enzymes, therefore, it could be a source of industrially important enzymes. The gut microbiota of the feed needs to be investigated for the isolation protease producing bacteria [148].

Besides, the fish excreta are rich in nitrogen, thus, could be used for the growth of plants. So, the fish waste biomass could serve as a source of essential nutrients in aquaculture and hydroponics, thereby reduces the excessive utilization of chemical agents [149].

Fish farming plays a significant role in the socioeconomic upliftment of developing countries. India being one of the most populated countries in the world have tremendous scope for inland fish farming for uplifting socioeconomic status and delivering better nutritional elements to the folks. *M. cuchia* is a fish species with high nutritional, economic, and therapeutic values. But the population of fish is constantly decreasing and has become vulnerable in Bangladesh due to overexploitation, habitat destruction, intoxication due to excessive use of herbicides, lack of scientific rearing techniques, and absence of conservation measures. Therefore, to replenish the declining population of fish and uplift the socioeconomic condition the government and NGOs should come forward to create awareness about scientific rearing, provide facilities for the timely export of fish, and enhance the conservative measures of the fish. Furthermore, the blood of cuchia is given to weak and anaemic people traditionally, therefore scientific studies are required to evaluate their blood profile and validate the therapeutic potential. Additionally, the gastrointestinal tract of this eel could be a source of industrially important enzyme producing bacteria [3].