ISSN:0971-1260

Vol-22-Issue-16-August-2019

Ecological, Economical and Research Importance of *Channa* – A Snakehead Fish

MIMANSA, RAHUL SINGH*

School of Bioengineering and Biosciences
Lovely Professional University, Phagwara, Punjab, India

Abstract

Channa is popularly known as snake headed fish due to the presence of large scales over flattened head, cylindrical and elongated body. From fossil records migration is confirmed from west and central Europe, eastern and western Kazakhstan, southern Siberia to tropical and subtropical countries like India, China, Bangladesh and so on during middle **Miocene** period. *Channa* belongs to order ophiocephaliformes has a single family ophiocephalidae. 27 species have been reported by different workers from 1758 to 2002. *Channa* are a bottom dweller, surface feeder and show bimodial respiration. It is larvicidal, carnivorous, piscivorous and cannibalistic fish. *Channa* species are consumed in Asia pacific regions for their taste, less intramuscular bones, high protein content, wound healing and anti-inflammatory properties. Exposure to contaminants from industries like heavy metals, insecticides, fertilizers lead to inhibition of enzymes that are important for cellular activity are indicators of water contaminants. Development of *Channa* can be divided into six main stages embryo, hatchling, larva, fry, fingerling and adult.

Keywords: Murrel, Miocene, Bimodial respiration, Fin Rot, Vitellogenic stage

ISSN:0971-1260

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Introduction

From last few years a growing amount of interest among fisheries workers has been noted towards teleost fishes due to increased consumption of these fishes for nutrition requirement. Several experiments are therefore conducted on group of fish to understand their reproductive biology, seasonal rhythms and environment cues affecting them.

Channa species popularly known as **murrel** or snake headed fish belongs to family Channidae. It has large scales over flattened head and cylindrical and elongated body. *Channa* is found in tropical and subtropical countries like India, Thailand, Bangladesh, Malaysia, Pakistan, China, Sri Lanka, Myanmar. Fossil records confirm evidence of *channa* presence in west and central Europe, eastern and western Kazhkstan, southern Siberia during middle Miocene. Migration of the fish is confirmed by fossil records in areas of central and south Asia during middle to late Miocene [1].

Channa is genera of fresh water fish inhabiting ponds, swamps, rivers, irrigation channels, reservoirs and streams. It can live in state of torpor in oxygen deficient areas like in sewage fed tanks, road side nallahs, ditches, below hard baked mud crusts, semi fluid mud[2]. It shows bimodial respiration exploiting water as well as air for survival using gills, air and suprabranchial respiratory organ respectively[3]. Accessory respiratory organ located dorsally to gill arches, opens into buccal cavity anteroventrally and into opercular chamber posterolaterally. This organ helps to survive fish even if it is kept moist for upto 8 hours (C*hanna striatus).* Extreme drought, air exposure, desiccation cause structural changes in accessory respiratory organ and gills, like swelling and bulging of blood capillaries, engorgement of R.B.Cs, reducing distance between blood in respiratory organ and atmospheric oxygen for compensating failure of branchial respiration. Lodging of metabolic waste commonly ammonia and retention of toxic metabolites [4].

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Channa is a bottom dweller and surface feeder. In both stages i.e. juvenile and adult, it feed majorly on small fishes and larvae as well as prefers crustaceans (prawns, shrimps, and crabs), molluscs (Unio and Pila larvae), insects (water bug, mosquito larvae, insect pupae) and very less amount of plant [5]. Hence *Channa* is considered as larvicidal, carnivorous, piscivorous and cannibalistic fish. Observation s of relative gut length (RGL) that is high during fry stage and low during adult stage support the feeding habit that changes from omni-carnivorous to highly carnivorous respectively. Ten species have been reported by different workers from 1793 to 2002 (Table 1).

It also changes its food preference along with seasonal variation due to availability and nutritional content of food. Preference also varies with different stages - zooplankton for fry, insects for juvenile and for adults fish is the most preferred or dominant choice because of high protein content followed by insects, crustaceans and rest eatables, found in the surroundings. Feeding intensity also varies with season to season and can be analysed by gastro-somatic index(GSI). It decreases during winter because of low metabolic rate. It also reduces during pre-monsoon and breeding season due to development of gonads occupying most of the abdominal space [6]. Cannabalistic behaviour increases during low feed availability.

Rearing conditions:

pH of water should be 7 - 8.4 in range. Low pH (2.8 to 6.5) can cause inhibition of active ion transport in gills[7], reduced consumption of oxygen [8] and thick mucus layer over gills, all will create hypoxia condition.

Channa species survive with normal health condition at 14 ˚C - 25 ˚C. Temperature above 30 ˚C thrive fish under stressful conditions exhibiting visible signs of erratic swimming, loss of body equilibrium. Higher temperature generally causes decrease in blood glucose level, neutrophils, affect glycogen content in liver and muscle [9].

Nutritional Value:

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Channa species are consumed in Asia pacific regions for their taste, less intramuscular bones, high protein content and wound healing and anti-inflammatory properties. Polyunsaturated fatty acids (omega-3 and omega-6) and certain amino acids like aspartic acid, glycine and glutamic acid presence in *Channa* species provide wound healing properties. Fish is rich in **arachidonic acid** upto 19.02 % in *Channa striatus* which is a precursor of prostaglandins and thromboxane helping in wound healing and anti- inflammatory properties. ω3:ω6 ratio is upto 2.37 in *Channa micropeltes* indicating healthy human diet. Crude protein (% Dry Weight) reached upto 23 in *Channa striatus* providing a proteinaceous diet to consumer. DHA is present in *Channa* species would be useful in muscle pain, inflammation and coronary heart disease [10].

Number of plants and animals are exploited for having antimicrobial properties. Since pathogens are gaining resistance against most of the antimicrobial agents. One of the species belonging to genus *Channa* found to have antimicrobial properties in their mucus. *Channa punctatus* mucus has antimicrobial activity against *vibrio cholera, Salmonella aureus, Proteus mirabilis, Proteus aeruginosa* [11].

Except direct benefits it can also be used as climate proxy because of their ability to migrate, being good jumpers and potential to survive in low oxygen conditions. Distribution of the fish is dependent on highly precipitated warm season. Areas having precipitation >150mm and mean temperature >20˚C are favorable and preferred by the fish [1].

Channa species belongs to order ophiocephaliformes that can be identified using following features given by Srivastava, 2014:-

1. Head not prolonged into beak

2. Body not eel- like.

3. Scales on head.

4. Dorsal fin without spines.

5. Long dorsal fin and no white spot on occipit.

Order **Ophiocephaliformes** has a single family **Ophiocephalidae** and single genus ***Channa***.

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Experiments with *Channa*:

Industrilization worldwide leads to environmental contamination. Heavy metals, insecticides, fertilizers and effluents affect number of important enzymes required for cellular and brain of a fish that are in direct exposure via water. The severity was observed in different species of *Channa*.

1. Mercury

Fish are sensitive to exposure of heavy metals. They can accumulate it in different organs, brain, blood which can cause pathological changes. Lethal concentration of mercuric chloride can severely affect important enzymes that maintain brain activity. Alkaline phosphatase, a cell surface protein in neurons responsible for permeability inhibits on chronic exposure of mercuric chloride (1.8 mg/L).Oxygen supply is limited to brain on chronic exposure which inhibits glucose -6-phosphatase responsible for converting glucose-6-phosphate into glucose and phosphate. Adenosine triphosphatase responsible for transport of adenosine triphosphate across neuronal cell membrane inhibits on mercury exposure. Exposure also inhibits lactic dehydrogenase, pyruvic dehydrogenase and succinic dehydrogenase which are important in cellular activity. Enzyme present in synapse, acetyl cholinesterase also inhibits on chronic exposure[12].

2. Insecticides

In agriculture highly potent **type II pyrethroids** on large scales are used as insecticides including λ-cyhalothrin and cypermethrin. These insecticides inhibit acetylcholin esterase present in synapse that normally converts acetyl choline into acetate and choline. Acetylcholin esterase inhibition leads to continuous stimulation of action potential via sodium ion permeability that can cause neurotoxicity [13]. This neuronal imbalance can be caused in brain, muscles and gills on action or exposure of these two insecticides.

3. Fertilisers

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Fertilizers effluents are mixed in lakes, ponds, oceans and rivers. Effect of effluents and its toxicity on different organ i.e. liver, heart, gills, brain, kidney and muscles was assessed using *Channa striatus* as model organism[14]. Effluent has high concentration of ammonia, chromium, high alkalinity and other heavy metals which inhibits an important carbohydrate regulatory enzyme - lactate dehydrogenase. Lactate dehydrogenase responsible for converting pyruvate into lactate due to active site conformation change. Long exposure to 7% (v/v) significantly inhibits level of lactate dehydrogenase in brain. Magnitude of effluent has more significant effect on inhibition of enzyme with exposure time.

4. Pathogens

Channa being an edible fish comes under light in relevance of diseases associated with it that can pass into humans causing health hazard. Tuberculosis in fish is one such disease that was found to be caused by *Mycobacterium poriferae* (gram +ve bacteria) identified using mycolic acids by HPLC. This bacterium was first identified by Padgitt and Mosheir in 1987 from a marine sponge[15]. Marine trash fish fed to *Channa* could be a reason for transmission of this bacterium to fresh water [16].

Epizootic ulcerative syndrome (EUS) affects number of species and is caused by *Aeromonas hydrophila* (Gram -ve bacteria) and *Aphanomyces invaderis* (fungus). *Aphanomyces invaderis* can thrive between 19˚C - 31˚C and causes maximum mortality at 19˚C at which immune response of fish is highly reduced [17]. *Nocardia asteroids* (gram +ve bacteria) cause nocardiosis a systemic disease leading to lesions in skin, granulomatous nodules in internal organs and erratic swimming before death [18].

Tail and fin rot disease is common among fishes and caused by *Pseudomonas aeruginosa* (gram negative bacteria) also leading to damaged lepidonts , dispersed and contracted chromatophores [6].

Reproductive Physiology:

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Spawning of the fish is proceeded by active swimming of male below the female followed by slow upward and downward movement of mating pair. For releasing all the gametes male is observed to hit snout on vent of female. Courtship behaviour can be carry on for 28 - 30 hrs. vary species to species. Fertilized eggs of *Channa* are buoyant and 6-14cm of diameter by adhering to each other. Aggressive behaviour of male is observed during eggs protection. Ventilation around eggs with the help of pectoral fins is a common practice by males to prevent fungal infection and good hatching rate. Males show parental care up to fry or fingerling stage varying with species[19]. Development of *Channa* can be divided into six main stages [20]:-

1. **Embryo-** Embryo occurs inside chorion, an acellular coat. It shows meroblastic cleavage that lasts for 24 hrs after fertilization. Heart beat commences after 20 hrs, 146-150/minute. Caudal region detaches and become free from yolk mass after 22 hrs of fertilization.

2. **Hatchling** - Hatchling is transparent and dull brown in colour. Fin fold originates at this stage. It is in eleuterembryonic period and capable of exogenous feeding.

3. **Larva -** Larva increases from 4.3 to 6.9 mm in length during 20 days after hatchling stage. Yolk sac is absorbed and shows autonomous feeding. Fins develop and color bands appear on body. Aerial respiration starts at the end of 17^{th} day.

4. **Fry -**It increases from 7.5 to 7.8 mm in length. It is lemon yellow in color and shows dull longitudinal black bands.

5. **Fingerling -** It increases from 18.3 to 21 mm in length. It is covered with scales and appears like an adult.

6. **Adult -** Complete development.

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Several experiments are therefore conducted on group of fish to understand their reproductive biology, seasonal rhythms and environment cues affecting them. Reproductive biology is influenced by number of environmental and physiological characters. Most vital environmental factors are photoperiod and temperature [21]. *Channa* has three main stages of development pre-spawning, spawning and post-spawning [22] shown in table 5.

These three stages in *channa* can vary among species and can be identified in any fish by gonado somatic index, hepato somatic index and histology of gonads. Gonado somatic index has a direct relation with the spawning period. GSI reaches to its maximum value during the spawning period when ovaries are matured and ripped and lowest value of GSI observed during post- spawning period. It has been observed in *Channa* that HSI has an inverse relation GSI [23]. It seems that the energy utilized in gonad development resulting in weight loss of liver. Ova diameter also predict the seasonal change the fish is going through as it is maximum during the spawning period when ovaries are, ripped and matured whereas turned out to be lowest during post-spawning period .

A better indication of reproductive status of a fish is provided by histological studies and not alone by GSI, HSI and ova diameter. Four main stages are observed during gonad development as listed below –

1. **Primary growth stage -** Multiple nucleoli near periphery of nucleus, oocyte filled with ooplasm.
2. **Cortical alveolus stage -** Granular structures called cortical alveoli fills with ooplasm, nucleus enlarges and becomes irregular in shape, initiation of vitelline envelope formation and thickness of follicular epithelium.
3. **Vitellogenic stage -** Increase in oocyte size, cortical vesicles near the periphery of cytoplasm, increase in size and number of yolk vesicle, irregular shaped nucleus, vetelline envelope develops.
4. **Mature oocyte -** Nucleus can’t be visualized, oocyte diameter reaches maximum diameter out of four stages, vesicles fuses and becomes bigger, vitteline envelope and zona radiate clearly evident.

Conclusion

Channa feeds on small fishes, water bug, mosquito larvae, and insect pupae and therefore can control the population of unwanted organisms in ponds and other water reservoirs. It can also be

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used as climate proxy as distribution is dependent on precipitation and temperature. More than 120mm precipitation and 20°C temperature is favored by the fish. Histopathological study of fish is also an indicator of industrialization and environmental contamination. Exposure to contaminants from industries like heavy metals, insecticides, fertilizers lead to inhibition of enzymes that are important for cellular activity are indicators of water contaminants. *Channa* is highly consumed in Asia for being proteinaceous, low intramuscular bones, wound healing, anti-inflammatory properties and low cost therefore has an economical importance. Since, pathogens are gaining resistance against most of the microbial agents *Channa punctatus* found to have antimicrobial properties against *Vibrio cholera, Salmonella aureus, Proteus mirabilis, Proteus aeruginosa*. Because of these unique and important ecological and economical properties of this fish, it is a good research model.

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Table 1: Different species of *Channa* with their common name.

Name	**Common name**	**Reporting year**
Channa striatus* *(2n=40)	Chevron snakehead	Bloch ,1797

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Channa punctatus* (variety A,2n=34)	Spotted snakehead	Bloch,1793
Channa punctatus*(variety B,2n=32)		
Channa stewartii(2n=66)	Golden snakehead	Playfair,1867
Channa orientalis(2n-76)	Ceylon snakehead	Schneider,1801
Channa gachua(2n=78)	Dwarf snakehead	Hamilton,1822
Channa barca (2n=38)	*barca* snakehead	Hamilton,1822
Channa marulius	Bullseye snakehead	Hamilton,1822
Channa micropeltes	Giant snakehead	Cuvier,1831
Channa lucius	splended snakehead	Cuvier,1831
Channa marulioides	Emperor snakehead	Bleeker,1851
Channa maculata	Blotched snakehead	Lacepède,1802
Channa bankanensis	Bangka snakehead	Bleeker, 1852
Channa bleheri	Rainbow snakehead	Vierke,1951
Channa cyanosiplos	Bluespotted snakehead	Bleeker, 1853
Channa harcourtbutleri	Inle snakehead	Annandale,1918
Channa melanoptera	Blackfinned snakehead	Bleeker1855
Channa melasoma	Black snakehead	Bleeker, 1851
Channa nox	Night snakehead	Zhang et al.,2002
Channa africana	Niger snakehead	Steindachner,1879
Channa insignis	Congo snakehead	Sauvage,1884
Channa obscura	African snakehead	Günther,1861
Channa burmanica	Burmese snakehead	Chaudhuri, 1919
Channa panaw	Panaw snakehead	Musikasinthorn, 1998
Channa baramensis	Baram snakehead	Steindachner,1901
Channa asiatica	snakehead	Linnaeus, 1758
Channa amphibeus	Chel snakehead	McClelland,1845
Channa aurantimaculata	Orangespotted snakehead	Musikasinthorn,2000

***Two varieties of *Channa punctatus* have been identified based on their chromosomal number, variety A has 2n =34 and variety B has 2n =32** [24].

Table 2: Fin formula of various *Channa* species.

	Channa punctatus	***Channa gachua***	***Channa striatus***	***Channa marulius***	***Channa stewartii***
Anal fin	20-22	21-23	24-25	32	27
Caudal fin	12	12	14	14	14
Dorsal fin	29-30	35-37	41-43	46	39-40
Pectoral fin	16-17	15-16	16-18	18	17
Ventral fin	6	6	6	6	6

Table 3: Various experiment with different species of *Channa* and their conclusion.

Species	**Toxicants**	**Dose**	**Category**	**Effects**

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Channa punctatus	(Dimethyl (E) -1-methyl-2-(methylcarbamoyl) vinyl phosphate)	1.86 mg/L	Insecticide	Na+,K+-ATPase activities in muscle, liver intestine, brain,intestine, heart and fish gills[25]
Channa punctatus	Arsenic trioxide	1 mg/L	Heavy metal	Arsenic accumulation in liver, muscle, kidney and gills, increased malondialdehyde, fluctuation in the level of oxidized and reduced glutathione in liver[26].
Channa punctatus	Paper mill effluent	1%(v/v)	Heavy metals	Inhibition of ATPase activity in gills [27]
Channa punctatus	Endosulfan	LC50= 24.3µg/L	Organochlorine pesticide	Increase in glucose level, increased cortisol level in plasma, decrease in acetylcholine esterase and ATPase activity, mild necrosis and infilteration of glial cells[28].
Channa striatus	Fertilisers effluents	LC50= 70%(v/v)	ammonia, chromium other heavy metals	Inhibition of lactate dehydrogenase[14]
Channa punctatus	Zinc (zn2+)	10 mg/L	Heavy metal	High accumulation of Zn in liver, increament in ROS level, decrease of total protein content in liver and kidney, increase in SOD, CAT and GR, increament of micronucleus % in erythrocyte[29]
Channa punctatus	4-nonylphenol	LC50=1.27 mg/L	Non – ionic surfactant	Increase in micronucleated, aberrant and binucleated cells in gill , liver and kidney indicating genotoxicity[30].
Channa punctatus	Acid mine drainage of coal mines	LC50=28% (v/v)	toxic metals like Al, Fe, Mn, Zn, Cu, Ar, Pb	Leucocytosis, decrease in Hb, TEC, OCC, PCV, anemia , haemorrhages, hyperemia[31]

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Table4: List of isolated pathogen from various species and their impacts.

Fish	Pathogen	Nature of pathogen	Alterations
Channa striatus	*Genarchopsis goppo*	Trematode	Destruction and shortening of villi, necrosis, muscle thickening, blood vessel dilation[32]
Channa striatus	*Aphanomyces invaderis*	Fungus	Epizootic ulcerative syndrome(EUS), formation of granulamos[17]
Channa striatus	*Mycobacterium poriferae*	Gram positive bacteria	Tuberculous lesions, granulomatous lesions[16]
Channa maculata	*Nocardia asteroides*	Gram positive bacteria	Nocardiosis, lesions in skin, granulomatous nodules in internal organs, erratic swimming before death[18]
Channa punctatus	*Aeromonas hydrophila*	Gram negative bacteria	Motile Aeromonas Septicemia, Epizootic ulcerative syndrome[33]
Channa punctatus	*Pseudomonas*	Gram negative bacteria	Tail and fin rot disease ,damaged lepidonts, dispersed and contracted chromatophores [6]

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Table 5: Showing different stages and changes in gonads.

Stages		Testes	Ovary
➢ Maturing and recovering spent	**Pre-spawning**	• Elongated • Distended • Whitish • Opaque	• Thin • Extended • Pink • Yolk deposition initiation
➢ Ripening		• Extensive • Pink • Opaque • Oozing out of viscous fluid on slight pressure	• Lobulated • Light yellow • Ova opaque, visible to naked eyes
➢ Ripe	**Spawning**	• Elongated • Distended • Pink • Oozing out of milt on slight pressure at abdomen	• Distended • Light yellow • Ova visible to naked eyes
➢ spent	**Post- spawning**	• White • Weight reduction • No milt on pressure	• Flaccid • Contracted • Remnants of mature ova
➢ Immature virgin		• Small • Transparent	• Thin • Cylindrical • Elongated • Pink • Eggs not visible under naked eyes