2. BIOLOGY OF *Channa striatus*

*Channa striatus* commonly called snakehead murrel, is an important freshwater teleost fish which has been widely cultured for its tasty flesh along with nutritional and medicinal values (Rajesh *et al.*, 2016). It belongs to the family Channidae and is also known as snake-head fish or serpent-headed fish. It is carnivorous in nature and eats frogs, small fish, insects, tadpoles and earthworms. It is an air-breathing fish that can survive in harsh environments with low dissolved oxygen and high ammonia contents (Marimuthu and Haniffa, 2007). It can stay alive without water as long as its gills remain moist. Snake-heads are cultured in cages and ponds in some of the Southeast Asian countries (Wee, 1982; Abdul Majeed *et al.*, 2014).

*Channa striatus* is a freshwater fish that is nutritionally high values among all the freshwater fish. The fish is native to tropical regions such as Asia and Africa (Muthmainnah, 2007). The fish can be easily found in various open waters in Indonesia, mainly in the islands of Java, Sumatra, Kalimantan, Sulawesi, Bali, Lombok, Singkep, Flores, Ambon and Maluku under various local names (Brotowijoyo, 1995). The local names for snakehead include Kutuk (in Java), Kocolan (in Betawi), Aruan or Haruan (in Malaysia and Banjarmasin). In English it is known as the common snakehead, snakehead murrel, chevron snakehead, or striped snakehead. The scientific name is *Channa striatus*, the fish is identified as the following:
Systematic position of *Channa striatus*

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<th>Kingdom</th>
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Snakehead fish which is a carnivore and also a predator has not been widely cultivated. It is nearly spherical in shape, lengthy and more compressed as getting to the back. The back part of the fish is convex, while the stomach is quite flat with head like those of a snake. The fish is dark green on the back and cream or white on abdomen, and has a wide long anal fin, semicircular tail fins, and broad with rounded pectoral fin. The snakehead also has a dorsal fin and hard spines inside. The fish can reach a length of 90-110 cm (Pudjirahaju, 1992). The fish *Channa striatus* morphology is depicted below.
MORPHOLOGY OF *Channa striatus*
Original description


Common names

Striped snakehead; banded snakehead; common snakehead; soali (Pakistan); murrel (India); haal, shawl, shol (Assam, India); shol (West Bengal, India); morrul, morl, soura (Bihar, India); sowl, dhoali, carrodh (Punjab, India); dolla (Jammu, India); sola (Orissa, India); korramennu, korra-matta (Andhra Pradesh, India); sowrah, veralu, kaunan (Kerala, India); pooli-kuchi, koochinamarl (Karnataka, India); sohr, dekhu (Mararashtra, India); hal path maha, lulla (Sinhalese, Sri Lanka); viral (Tamil, Sri Lanka).

Characters

Characteristics of *Channa striatus* fish that make it a desirable cultivable fish include high market value, rapid growth, tolerance to high stocking rates, medicinal value and utilization of atmospheric oxygen for respiration in oxygen depleted water (Mollah *et al.*, 2009). About 28 to 30 *Channa* species have been reported in the global scenario with 8 to 10 species in India. Murrel farming is a very important value chain in Indian scenario, but till date this value chain is missing in Production to Consumption System and the only source is capture fisheries (Mehrajuddin *et al.*, 2011).
Mouth is very large and lower jaw with 4-7 canines behind a single row of villiform teeth that widen to 6 rows at the jaw symphysis. Villiform teeth on prevomer and palatines. Pectoral fin about half of head length. Dorsal fin with 37-46 rays, anal fin rays 23-29, pectoral rays 15-17, pelvic rays 6, caudal fin rounded. Scales on top of head large with a rosette of head scales between orbits, with frontal head scales forming central plate of rosette, 9 scale rows between preopercular angle and posterior border of orbit, predorsal scales 18-20, scales 50-57 in lateral series (Talwar and Jhingran, 1992). Coloration is quite variable in *Channa striatus* complex. The dorsum is often dark brown to black, typically obscuring the markings dorsally. A distinguishing marking, however, is the dark stripe extending from just above the maxillary posteroventrally towards the opercular curvature.

**Native range**

*Channa striatus* found even in the most drainages of India and southern Nepal (Shrestha, 1990), Sri Lanka (Pethiyagoda, 1991); Pakistan (Mirza, 1975), Bangladesh, Myanmar, Thailand, Cambodia, southern China, Malay Archipelago including Malaysia, Sumatra, Borneo (Pethiyagoda, 1991; Rainboth, 1996; Jayaram, 1999); western Java (Roberts, 1993); Vietnam, Laos (Kottelat, 2001a,b). This is an amazingly extensive "native" distribution for any freshwater fish, indicating that *Channa striatus* is quite probably a species complex.
Size

The fish *Channa striatus* attain a length of 30-36 cm in 1 year (Bhatt, 1970). Talwar and Jhingran (1992) stated that sexually maturity attain at the end of second year. Murugesan (1978) recorded a growth rate of 1.3 to 3.0 mm/day for the first 3 months, slowing to 0.3 to 0.9 mm/day thereafter. He also reported lengths of 30.51 cm in 2 years in Chennai. In rivers of Uttar Pradesh, chevron snakeheads grew to 32 cm in 2 years.

Habitat preference

*Channa striatus* usually lives in estuaries, lakes, dirty water, ditches, rice fields, ponds and even abnormally is able to withstand the drought. This fish can survive in the dry season by burying themselves in the mud. Breathe in anaerobic way and may jump to dry land. As a predator and a carnivore in nature the fish preys on small fish, frog, young turtle and even duckling that are around (Qin and Fast, 1996). The predatory behavior of the fish is investigated in which various sizes of six snakehead fishes were put in an aquarium with fish of large, medium and small in it as prey (Das *et al.*, 1998). The snakehead fishes scrambled to prey on small fish first, then the medium and ultimately the large size of the fishes. The peak time of eating was in the morning and evening and in just 45-50 seconds the prepared preys run out. Then, it appeared that some of the snakehead fishes were in fight each other by attacking the head, mouth and fin areas and this even ended up with body cavities creation. After 2 to 3 days later on amazingly they still survived.
Channa striatus is an obligate air breather. Vivekanandan (1977a,b) stated that the breathing organ is developed in about 60 days during growth from a length of 1 to 4.5 cm at 26-28°C. Singh et al. (1986) noted that at 28°C, this species breathes aquatically until 18 to 20 days following hatching when young reach a length of 1.1-1.2 cm and, thereafter, becomes a bimodal breather. They measured a decrease in oxygen uptake through the gills and skin of almost 42 percent once bimodal respiration began. Pandian (1982) reported that fingerlings of this species spend up to 15 percent of the time insurfacing and related activities. Varma (1979) recorded a pH range for Channa striatus of 4.25 to 9.40 with 100 percent survival over 72 hr, and 90 per cent survival at pH 3.10 for the same period.

Feeding habits

Adults inhabit ponds, streams and rivers, preferring stagnant and muddy water of plains (Menon, 1999). Found mainly in swamps, but also occurs in the lowland rivers. Commonly in relatively deep (1-2 m), still water. The fish Channa striatus is very common in freshwater plains (Tirant, 1929, Vidthayanon, 2002). Occur in medium to large rivers, brooks, flooded fields and stagnant waters including sluggish flowing canals (Taki, 1978). Survive dry season by burrowing in muddy bottom of lakes, canals and swamps as long as skin and air breathing apparatus remain moist (Davidson, 1975) and subsists on the stored fat. Feed on fish, frogs, snakes, insects, earthworms, tadpoles (Rahman, 1989)
and crustaceans (Allen, 1991). Undertake lateral migration from the Mekong mainstream, or other permanent water bodies, to flooded areas during the flood season and return to the permanent water bodies at the onset of the dry season (Sokheng et al., 1999). During winter and dry season, its flesh around coelomic cavity is heavily infested by a larval trematode *Isoparorchis hypselobargi*. Other parasites infecting this fish include *Pallisentis ophicephaliin* in the intestine and *Neocamallanus ophicephali* in the pyloric caecae (Rahman, 1989). It is perhaps the main food fish in Thailand, Indochina and Malaysia (Davidson, 1975). It possess firm white flesh almost bone-free, heavy dark skin good for soup and usually sold separately (Davidson, 1975). In Hawaiian waters the largest specimen taken reportedly exceeded 150 cm (Yamamoto and Tagawa, 2000).

*Channa striatus* economically important fish both cultures and captures throughout southern and southeastern Asia (Vidthayanon, 2002).

*Channa striatus* is carnivorous, feeding on worms, prawns, frogs, and especially other fishes (Mohsin and Ambak, 1983). It is being reported as a solitary (except during breeding season), territorial and ambush feeder (Lee and Ng, 1991). Conlu (1986) reported that young fry feed on algae and protozoans, juveniles feed on small crustaceans, and adults are highly carnivorous, dreaded predators of other pond fish and added that this fish is used as a predator to control tilapias in culture ponds. Jhingran (1984) cited larvae as feeding on
insects, water fleas, and fish fry, juveniles preferring dipteran larvae, zooplankton, and fish fry and adults as piscivorous. Mahan et al. (1978) reported that *Channa striatus* (32 individuals ranging from 3.5 to 36.7 cm in length) fed almost exclusively on shrimp (47 per cent by volume) in a lake in central Java. Dasgupta (2000) found that this snakehead consumed primarily insects (40 per cent) followed by fishes (30 per cent) and crustaceans (10 percent) in waters of West Bengal, India. Rao et al. (1998) noted a preference for crustaceans and fishes from ponds and canals of East Godavari District, Andhra Pradesh, Southeastern India. Ng and Lim (1990) described the enlarged canine teeth of *C. striatus* as “cylindrical in cross section ideal for gripping, killing, and tearing”.

**Breeding habits**

Fishes are exceptional among vertebrates because of their unparalleled variability of reproductive and social patterns (Setu and Ajithkumar, 2010). For development of hatchery production techniques it is necessary to understand the ontogeny of the fish (Haniffa et al., 2002; Haniffa et al., 2003). Breeding behavior or courtship behavior is a very important act in fish breeding. It varies from the simple swimming of the breeders along the side of each other to elaborate act of nest building and intense male competition inherent in group spawning. The absence of breeding behavior from any of the
breeders often results in spawning failure (Marimuthu et al., 2001). Several factors like body size, pigmentation, age, and social dominance, environmental conditions, mating history, female reproductive state, male dominance and aggression are known to affect the mating behavior of fishes in many species (Marimuthu et al., 2001; Arockiaraj et al., 2004; Bilal Ahmad et al., 2013).

*Channa striatus* attains sexual maturity towards the end of the second year of its life. It breeds in ponds and rivers a little prior to or with the onset of monsoon and their spawning season extends to the last monsoons. It is a batch spawner and breeds two or three times in a season. The breeding season extends from February-March to October-November and lay floating egg in a nest made of leafy vegetable. Average diameter of the laid eggs is 1.53 mm. Eggs are laid in nests and both parents guard the nest. The eggs are amber coloured, round, non-adhesive and are found floating in a mass in the centre of the nest.

The fish *Channa striatus* breed throughout the year and mass spawning is only seen during the rainy season (Ali, 1999) and rice fields provide the preferred breeding habitats with more than half the population being found in paddies (Amilhat and Lorenzen, 2005). Therefore, its biology and ecology cannot be isolated from rice fields (VanCong et al., 2009).
Lee and Ng (1991) indicated that *Channa striatus* as solitary except during spawning seasons. In India, pairs breed during most months of the year, laying a few hundred to more than 1,000 amber-colored eggs (Parameswaran and Murugesan, 1976a; Talwar and Jhingran, 1992). Peak spawning coincides with peak rainfall (Parameswaran and Murugesan, 1976a). Howell (1913) said the eggs average about 1.25 mm and are non-adhesive, hatching in 1 to 3 days. Females mature to about 30 cm in length at about 2 years of age (Talwar and Jhingran, 1992; Ali, 1999). Parents clear a shallow depression by biting off aquatic vegetation (Ling Shao-Wen, 1977). Nevertheless, Alikunhi (1953) remarked that *Channa striatus* would spawn in the absence of vegetation. Eggs float to the surface after fertilization (Lee and Ng, 1991). The pelagic eggs are guarded by both parents in the Philippines (Lowe-McConnell, 1987) and possibly throughout the native range of the species. Nevertheless, Herre (1924) stated that one or the other parent guards the nest at all times, and that if food becomes scarce, parents become cannibalistic on the young. He further indicated that in the Philippines, *C. striatus* spawns throughout the year and that many, perhaps all, breed twice annually. Ali (1999) confirmed ripe females present throughout the year in rice fields in Perak, northwestern Malaysia. Peak spawning in southwestern Sri Lanka occurs between May and September, with a secondary spawning October through December (Kilambi, 1986). Jhingran (1984) cited fecundity as 3,000-30,000 ova.
Lee and Ng (1991) stated that they had been collected without seeing parents nearby. It has also been said that eggs hatch in 3 days in Malaysia, the fry developing a deep orange color. This pattern persists until the young reach a length of 15 mm when only an orange lateral stripe remains. At 40 mm in length, all orange color is lost but a "pseudo-ocellus" appears on the posterior lobe of the dorsal fin, a characteristic lost in adulthood. Mookerjee et al. (1948) described and illustrated early development of *Channa striatus*.

**Commercial importance in native range**

*Channa striatus* is reported as being cultivated in India and Pakistan. There is a "tank fishery" for this species in Tamil Nadu, India. Tanks in India and Sri Lanka are "ancient irrigation reservoirs" (Fernando and Indrassna, 1969). It has been stated that there were more than 1,000 tanks in Sri Lanka alone. In India, the *Channa striatus* is described as a popular and highly priced fish, widely distributed and the most economically important species of the genus (Talwar and Jhingran, 1992). *Channa striatus* is one of the three species of snakeheads commercially fished in Lake Jaisamand, the oldest reservoir in India (Rao and Durve, 1989).

Lee and Ng (1991) cited this species as the most economically important member of the snakeheads and noted that it is cultured throughout most of its range. Hofstede et al. (1953) cited this species
as bringing “the highest prices at the markets” in Indonesia. It is sold either fresh or alive in Cambodian markets (Rainboth, 1996). In the Danau Sentarum Wildlife Reserve of Kalimantan, chevron snakehead comprised 13 percent of the setline fish catch using small (size 12-16) hooks from the Kapuas River (Dudley, 2000).

Ng and Lim (1990) and Lee and Ng (1991) reported that Channa striatus, along with C. micropeltes and C. lucius, are utilized for medicinal purposes, particularly in Indonesia and Malaysia. Mention was made of use in a postnatal diet and during recuperation from illnesses or surgery.

Cream extracts of Channa striatus tissues contain high levels of arachidonic acid, a precursor of prostaglandin, essential amino acids (particularly glycine), and polyunsaturated fatty acids necessary to promote prostaglandin synthesis. Treating wounds with these extracts has been demonstrated to promote synthesis of collagen fibers better than standard use of cetrimide, an antimicrobial quaternary ammonium compound, thus increasing tensile strength (Baie and Sheikh, 2000).

Acidic mucus extracts of the fish has the ability to fight bacterial activity and to inhibit the growth of several human pathogenic bacteria such as Klebsiella pneumoniae, Pseudomonas aeruginosa and Bacillus subtilis (Wei et al., 2010). This suggests that the extracts may have potential antimicrobial agents both in human and fish.
Nitric oxide may play a role in inhibiting the occurrence of pigment aggregation on the melanophores in Indian Snakehead teleost, *Channa punctatus*, induced by extra-cellular calcium (+2) at each concentration level (Biswas *et al.*, 2001). The fish provides good source of albumin for people who has low albumin serum or injuries, burns or has been in post-operative condition. In rural areas, the snakefish is traditionally administered to boys who are just after having circumcised to accelerate healing process. The fish is first steamed to obtain the extract, and this extract is then used as an extra menu for the patients. The administration is positively correlated to elevated levels of plasma albumin and postoperative wound healing (Suprayitno, 2003; Mustafa *et al.*, 2012).

The flesh of these larger *Channa striatus* is rejuvenating following illnesses, prepared by being double-boiled with herbs and only the soup is consumed. Nevertheless, for the soup to be effective in recovery, it is firmly believed that the fish must be killed just before cooking, dispatched with careful but firm blows to the head with a mallet. Conceivably, this could be a reason that obtaining live snakeheads in live-food fish markets is considered important to some persons of Southeast Asian descent living in the United States (Lee and Ng, 1991).