2. BIOLOGY OF *Channa striatus*

*Channa striatus*, known as “Striped murrel” in India, is a native freshwater fish of tropical Africa and Asia (Ng and Lim, 1990). 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).

Snakehead is a type of freshwater fish that is nutritionally of high values. 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*

- **Kingdom**: Animalia
- **Phylum**: Chordata
- **Class**: Actinopterygii
- **Order**: Perciformes
- **Family**: Channidae
- **Genus**: Channa
- **Species**: striatus

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

Gular region of head without patch of scales. Mouth large; 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 this species or species complex. The dorsum is often dark brown to black, typically obscuring the chevron-like markings dorsally. A distinguishing marking, however, is the dark stripe extending from just above the maxillary posteroven-trally toward the opercular curvature.

Native range

Pakistan (Indus River basin; Mirza, 1975), most drainages of India, southern Nepal (Koshi, Gandaki, and Karnali River basins; Shrestha, 1990), Sri Lanka (Mendis and Fernando, 1962; Fernando and Indrassna, 1969; Pethiyagoda, 1991); Bangladesh, Myanmar, Thailand, Cambodia, southern China, Malay Archipelago including Malaysia, Sumatra, Borneo (Pethiyagoda, 1991; Rainboth, 1996; Jayaram, 1999); Sabah (Inger and Kong, 1962); western Java (Giltay, 1933; 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.

Introduced range

Channa striatus has been considered the most widely introduced species of snakehead. Various reports indicate it was released into Hawaii before 1900, established (Jordan and Evermann, 1903;
Cobb, 1905; Smith, 1907; Tinker, 1944; Brock, 1952, 1960); Madagascar, in 1978, established (Raminosoa, 1987; Reinthal and Stiassny, 1991; Stiassny and Raminosoa, 1994; Leveque, 1998); Philippines, date unknown (Seale, 1908; Herre, 1924, 1934; Conlu, 1986); Vogelkop Peninsula, Papua, Indonesia, probably during 1970s or 1980s, established (Allen, 1991) and identification confirmed by photographs provided by Gerald Allen (personal commun., 2002); Sundaland, Sulawesi, Lesser Sundas, Moluccas, date unknown, established (Welcomme, 1981; Kottelat et al., 1993; Lever, 1996); Fiji, establishment questionable (Maciolek, 1984; Eldredge, 1994); Mauritius, established (Parameswaran and Goorah, 1981).

Size

To 90 cm (Bardach et al., 1972); 91.4 cm (Sen, 1985). Can attain a length of 30-36 cm in 1 year (Bhatt, 1970). Talwar and Jhingran (1992) stated that this species is sexually mature at 30 cm, but added that 2 years were required to reach that size. Murugesan (1978), however, 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 25-27 cm in 13\(\frac{1}{2}\) months and 23.4-31.7 cm in 9\(\frac{1}{2}\) months in Kerala State, India; 32 cm in 2 years in West Bengal; and 30.51 cm in 2 years in Madras. In rivers of Uttar Pradesh, chevron snakeheads grew to 32 cm in 2 years.
Habitat preference

*Channa striatus* usually lives in estuaries or lakes, and may inhabit 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.

The snakehead fish (*Channa striatus*) is an indigenous species of the Mekong River Delta (MRD) (Khoa and Huong, 1993). With its obligatory air breathing behavior (Vivekanandan, 1977) and tolerance of a wide range of temperatures and pH (Lee and Ng, 1994), this species appears in a variety of water bodies (Khoa and Huong, 1993;
Lee and Ng, 1994) and is often found in rice paddies (Ali, 1990; Fernando, 1993). The snakehead fish has traditionally been an important and preferred source of protein for rural and urban populations and this type of wild fish production has contributed a significant percentage of the human diet of Asian populations (Edwards et al., 1997) but has recently been in decline. Although there is no hard data on population sizes or annual yield of rice paddy fish (Fernando, 1993), it is the clear perception of the rural population that fish catches, including *Channa striatus*, have seen significant reductions and now are estimated at around 30-60% of those 30 years ago.

It inhabits in freshwater ponds and streams, usually in stagnant muddy waters but primarily found on plains in India (Talwar and Jhingran, 1992). It occurs in reservoirs in Sri Lanka (Fernando and Indrassna, 1969). Nevertheless, in Malaysia this species is reported to exist in rivers, lakes, swamps, rice paddies, mining pools and roadside ditches (Mohsin and Ambak, 1983; Lee and Ng, 1991). Ng and Lim (1990) listed this species from "open country areas," adding that it is the primary snakehead in shallow waters (1 m or less) with dense vegetation. In India, it can be found in reservoirs and rice paddies (Jhingran, 1984). In Keoladeo National Park, Bharatpur, Rajasthan, north-central India, it may be found in open water to dense mats of aquatic vegetation (Kumar and Mittal, 1993). Herre (1924), Umali (1950) and Conlu, 1986) recorded it from lakes and lowland
rivers in the Philippines, and its introduction to two crater lakes at an altitude of about 1,050 m above sea level. Kottelat (1998) reported a preference for "standing waters." Lee and Ng (1991) noted that this species seems to be the most adaptable snakehead, tolerating "quite foul water" and able to move overland.

*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 in surfacing and related activities. Varma (1979) recorded a pH range for *Channa striatus* of 4.25 to 9.40 with 100 percent survival over 72 hours, 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. More common 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 bottom mud 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 ophicephali* in the intestine and *Neocamallanus ophicepahli* 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). It carrier very economic importance on 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,
ambush feeder (Lee and Ng, 1991). Conlu (1986) stated 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 percent by volume) in a lake in central Java. Dasgupta (2000) found that this snakehead consumed primarily insects (40 percent) followed by fishes (30 percent) 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”.

**Reproductive habits**

The snakehead can reproduce throughout the year and mass spawning is only seen during the rainy season from May to November (Ali, 1999) and for this species, 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, which have seen intensification in crop practices including agrochemical use (VanCong et al., 2009).

Lee and Ng (1991) indicated this species 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 nonadhesive, 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 C. striatus.

**Commercial importance in native range**

*Channa striatus* is reported as being cultivated in Pakistan and India. 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 chevron snake-head is described as a popular and highly prized 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). Fernando and Indrassna (1969) stated that it is the only species of snakehead in Sri Lanka of economic value, although three additional species (C. gachua, C. marulius, and C. punctatus) are used as food fishes. It is also cultured in Vietnam (Pantulu, 1976; Bard, 1991), Thailand, Java (Hofstede et al., 1953), and the Philippines (Guerrero, 2000). Bard (1991) noted that this species is the most expensive fish produced by aquaculture in northern Vietnam. Ali (1999) cited it as "a popular food fish in Malaysia" remarking that rice fields have provided the largest source of this fish. Populations in Malaysia are reported to be depressed due, apparently, to over fishing, raising costs for live specimens. China is culturing C. striatus and some of the product is being canned for sale in Malaysia (Wan Ahmad, personal commun., 2001).

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) indicated 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 (Lee and Ng, 1991).

Cream extracts of haruan 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).

Lee and Ng (1991) indicated that the flesh of these larger snakeheads 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. Herre (1924) reported much the same for the Philippines. 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.