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ชีววิทยาของปลากริม : ปลาที่สร้างเสียงได้

Biology of croaking gourami *Trichopsis vittata* : The fish that croaks!

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Abstract

Croaking gourami *Trichopsis vittata* Cuvier, 1831 is a small tropical freshwater fish of the suborder Anabantoidea, family Osphronemidae. This fish is very popular in the aquarium fish trade in occidental countries because of its interesting behaviour and easy keeping. Male is slightly larger than female. This fish commonly inhabits shallow standing water with dense aquatic or floating vegetation. Additionally,





croaking gourami can survive in poorly oxygenated water due to the existence of an air-breathing organ called a labyrinth. Both sexes produce a croaking sound by rapid pectoral fin beating during courting and fighting.

บทคัดย่อ

ปลากุรุมเป็นปลาน้ำจืดขนาดเล็กในเขตร้อน จัดอยู่ใน suborder Anabantoidea, family Osphronemidae นิยมเลี้ยงเป็นปลาคู่ในประเทศแถบตะวันตกและยุโรป เนื่องจากมีพฤติกรรมที่น่าสนใจและเลี้ยงง่าย ปลากุรุมเพศผู้มีขนาดใหญ่กว่าปลากุรุมเพศเมียเล็กน้อย โดยปกติแล้วปลากุรุมจะอาศัยอยู่ในแหล่งน้ำนิ่งที่ตื้นและเต็มไปด้วยพืชน้ำ นอกจากนี้ปลากุรุมยังสามารถมีชีวิตรอดในแหล่งน้ำที่มีปริมาณก๊าซออกซิเจนละลายอยู่น้อยมากได้ เนื่องจากมันมีอวัยวะพิเศษที่เรียกว่า labyrinth ปลากุรุมทั้งสองเพศสามารถสร้างเสียงได้จากการกระพือครีบออกอย่างรวดเร็วในระหว่างการเกี้ยวพาราสีและการต่อสู้

Why is this Fish Named “Croaking Gourami”?

Croaking gourami *Trichopsis vittata* Cuvier, 1831 is a freshwater fish of the suborder Anabantoidea, family Osphronemidae native to Java, Borneo, Sumatra, Malaya, Indo-China, and Thailand and spans perhaps a wider geographic area than any other species of gouramis (Smith, 1945; Sandford, 2000). This species also has some commercial value in the aquarium fish industry.

This fish species has a variety of common names (Table 1), but it usually is called the croaking gourami or croaking gouramis (i.e. plural name) which refers to the high-pitched rattling or croaking sound clearly made by both sexes during breeding displays and the establishment of dominance hierarchies among males (Kratovich, 1978). The latin word “*vittatus*” means “band” and refers to the three horizontal stripes on the fish’s body. Thus, this fish is occasionally called the striped croaking gourami. Scientific synonyms are *Osphromenus vittatus* and *Ctenops vittatus*. Croaking gourami is

sometimes called labyrinth fish because it possesses an accessory breathing organ known as the labyrinth organ (McInerny and Gerard, 1966).

What are the Distinguishing Traits of Croaking Gourami?

Croaking gourami is a small torpedo shaped fish with a size about 3.0-4.0 cm. Male is slightly larger than female. The mouth is small upstanding and the tail is pointed. The colouration is highly variable from pale brown and green to dark purple. Female tends to be paler than male and has a slightly shorter anal fin. All fins are reddish with blue highlights like an iridescent coloration on their edges (Liengpornpan et al., 2006). The male’s dorsal fin is pointed, while the female’s is rounded. The fins are long; the first pelvic fin ray of the male is modified into an elongate filament (McInerny and Gerard, 1966). The anal fin has threadlike extension on the back end of the fin and starts approximately 2/3 down the body. Adult has 3 spines plus 7-8 branch rays on the dorsal fin, and 6-9 spines

Table 1 Common names of croaking gourami in some countries.

Common or vernacular name	Country
Croaking gourami	USA, Australia
Talking gourami	UK
Pla krim, pla kadpa	Thailand
Cá bai tràu	Viet Nam
Cupang, jeplang	Indonesia
Karim	Malaysia
Pa math or pa mat	Laos
Knorrande gurami	Sweden
Knurrende gurami	Denmark
Knurrende gurami	Germany
Murisijarihmakala	Finland
Skrzeczyk pregowany	Poland
Trey kroem kdah	Cambodia
條紋短攀鱧	China Main

Source: <http://filaman.ifm-geomar.de/comnames/CommonNamesList.cfm?ID=4728>

plus 19-28 branch rays on anal fin (Hemsiri and Termvidchakorn, 2001). This fish has three blackish horizontal stripes on the body in which two stripes run from the mouth to the anal fin, while another stripe starts behind the eye and goes to the anal fin. The iris is bright blue or purple. There are several varieties of croaking gourami even from the same locality. Some adult fish have no spot; on the other hand, others have one or two spots located near the gill cover. If the spot is present, it is usually larger in male than in female. This spot was formerly believed to be a male sign (Sandford, 2000). At present, female was identified by its ovary showing through the scales as yellowish

elongated structures extending posterior as far back as the dorsal fin (Figure 1) (Marshall, 1967; Liengpornpan et al., 2006). The best way to see this is to look at the fish in a small container and hold it up to the light to see its ovary.



Figure 1 Croaking gourami female with ovary.



What are the Natural Habitat Characteristics of Croaking Gourami?

Croaking gourami is a tropical freshwater fish that commonly inhabits small weedy streams, roadside ditches, rice paddies, irrigation canals and just about every other small body of water throughout this range even polluted waters (Bhaibulaya et al., 1979). The fish will become severely stressed in bare tanks without various hiding places. A darker substrate will make this fish species feels comfortable and helps show-off its subtle colour. This fish is often found in company with wild Siamese fighting fish.

The natural flooded habitats of croaking gourami in Nakhonsithammarat Province, southern Thailand ($08^{\circ} 29.381' - 08^{\circ} 29.384' \text{ N}$, $99^{\circ} 55.138' - 99^{\circ} 55.437' \text{ E}$) are characterised by low values in pH, dissolved oxygen (DO), transparency, biochemical oxygen demand (BOD), nitrite, nitrate, phosphate and water depth but high values in specific conductance, total dissolved solids (TDS) and temperature relative to water qualities measured from natural streams and rivers (Liengpornpan et al., 2006). Croaking gourami is tolerant to fairly high temperature which can be used to eliminate fish diseases in aquarium. In addition, higher temperature brings out the colours of croaking gourami.

How does Croaking Gourami Respire?

Croaking gourami can survive in poorly oxygenated water due to the existence of an air-breathing organ called a labyrinth or an air-filled suprabranchial chamber (Graham, 1997). This organ is located above the gill and consists of skin

folds called lamelli filled with blood vessels, through which oxygen can be absorbed from the air. The membranes in the labyrinth are richly supplied with blood vessels so that the chamber serves for auxiliary breathing in water that is deficient in oxygen. The highly vascularised and convoluted tissue stores air and allows croaking gourami to gulp air directly from the atmosphere. This fish is capable of utilising the oxygen present at the water surface by swallowing air bubbles at frequent intervals, holding them in the labyrinth organ for extended periods of time, and then forcing them out through the gill covers (Moyle and Cech, 2000). With the ability to breathe air directly from the atmosphere, croaking gourami is able to survive in anoxic water. One impact of predation on croaking gourami is the frequency and location of atmospheric air breathing. In the presence of the predator, the fish tends to breathe air less frequently. Most activities, including territorial defence, ritualised behaviour, and courtship displays are always interrupted by the need for croaking gourami to take an air breath (Graham, 1997). In addition, male croaking gourami expels air bubbles through its mouth and builds nest of froth on the water surface. Female lays its eggs in the nest, which is subsequently tended by the male. The froth nest and labyrinth organ of croaking gourami are obviously adaptations for life in the stagnant hypoxia water. In addition, air breathing serves to protect croaking gourami from excessive water pollution so it plays an important role in the biological control of insects in urban areas.

How does Croaking Gourami Produce Sound?

Croaking gourami produces intraspecific sound (Wysocki and Ladich, 2002) which starts parallel to the development of lateral display and prior to mouth opening and biting (Henglmüller and Ladich, 1999). Even though the original functions of the pectoral fins of croaking gourami are locomotion and hovering, they have become modified as a sound-producing organ (Ladich and Fine, 1992). This sound producing organ consists of the two enlarged tendons attached to the 4th and 5th pectoral fin rays like guitar strings. The character of sound changes widely during ontogeny probably due to the development of the sound-generating structures (Henglmüller and Ladich, 1999).

Initially as 8-week-old juvenile, croaking young sound is built up mainly in a single pulse produced by one enlarged tendon of each pectoral fin (Figure 2) (Henglmüller and Ladich, 1999). This single pulse is high in frequency and low in amplitude. Later as 4 month-old adult, both sound-producing mechanisms and pectoral fin-movements

are fully developed, single pulses give way to double pulses produced by two enlarged tendons of each pectoral fin. This double pulse is low in frequency and high in amplitude. If one of two tendons is cut, the former double-pulse turns into a single pulse (Kratochvil, 1978). A series of double pulses is called a croak and the period between the onsets of pulses produced by different pectoral fins is known as the pulse period (Henglmüller and Ladich, 1999).

Croaking gourami sound appears to be very important among individuals in social interaction. This fish species can assess the age and the size of the others from their croaking sound. Decreasing sound frequencies with increasing body size is a general phenomenon in animals, and is based largely on resonance (Henglmüller and Ladich, 1999). The winner of croaking gourami fight produces a higher sound level and at a lower dominant frequency (Ladich, 1998). This implies that the fish that produces the loudest and deepest sound will be the winner. This result signifies the importance of acoustical signals in addition to visual displays and is cautionary because the significance of the croaking sound is only revealed when asymmetries in other parameters such as territoriality and size are small (Ladich et al., 1992). In addition during the courtship behaviour, female croaking gourami produces a purring sound consisted of one short single-pulsed burst and two long double-pulsed bursts (Ladich, 2007).

During ontogenetic development of sound production, the temporal characteristics of croaking sounds (i.e. total duration, the number of pulses, and pulse period) increase. The pulse period in-

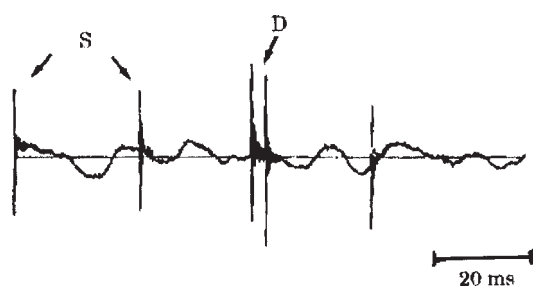


Figure 2 Oscillogram of croaking gourami sound. S and D represent single pulse, and double pulse. (Modified from Henglmüller and Ladich, 1999.)



creases from 6.0 ms in single pulse to 35.8 ms in double pulse (Wysocki and Ladich, 2002). The frequency decreases from 3.5 kHz in the youngest croaking gourami fish to about 1.5 kHz in the oldest fish (Henglmüller and Ladich, 1999). Generally, fish produces sound composed of low frequencies, with most of their energy lying below 3 kHz (Pitcher, 1993).

How does Croaking Gourami Hear Sound?

The labyrinth located lateral to the sacculus of the inner ear (Wysocki and Ladich, 2002) can potentially serve to enhance the hearing range of croaking gourami up to 1-2 kHz (Ladich and Yan, 1998). Croaking gourami is observed with the best hearing sensitivities especially during violent circling at distances of 1.0-3.0 cm. Besides temporal patterns, amplitude fluctuations and the frequency content of sounds can be represented in the auditory system and help the fish to extract important information for acoustic communication. Comparing the ontogeny of hearing and sound production in the croaking gourami reveals that these two processes develop independently from each other. Auditory sensitivity develops prior to the ability to vocalise and that vocalisation occurs prior to the ability to communicate acoustically (Henglmüller and Ladich, 1999).

The air bubbles taken by croaking gourami are also important in hearing (Moyle and Cech, 2000). In the chambers of labyrinth, air bubbles are stored adjacent to the membranous windows on either side of the cranium, which contains the inner ear. The slight vibrations picked up by the air bubbles are easily transmitted to the inner ear through this membranous window.

Does Female Croaking Gourami Prefer Larger Male as its Mate?

Female croaking gourami does not choose its mate based on male body size (Liengpornpan et al., 2007). It may choose mate based on other male traits such as coloration (Candolin, 2000), courtship behaviour (Östlund and Ahnesjö, 1998), nest characters (Sunobe et al., 1995; Jones and Reynolds, 1999) or multiple traits such as a combination of large body size and courtship behaviour (Morris et al., 1996) or colouration and courtship behaviour (Candolin and Reynolds, 2001). In fighting, large male croaking gourami is more likely to confer some advantages and win the fight (Liengpornpan et al., 2007). Small male that tends to be the loser, spends much of its time and energy displaying more escaping behaviour while large male that tends to be the winner, waits for the opponents to attack or retreat. Fighting duration decreases as the size differences between the fighters increase. Small male tends to terminate fight quickly and shows a clear escaping signal before serious injury or death occurs when it encounters larger opponent. Sexual size dimorphism in croaking gourami may function through male-male competition, not through female preference.

Does Female Croaking Gourami Prefer Male with Large Bubble Nest?

Considering bubble nest size, female croaking gourami prefers small bubble nest male over large bubble nest male and prefer male without bubble nest over male with bubble nest (Liengpornpan Per. Obs.). This may be due to four possible reasons: (1) small bubble nest may sim-

ply be available during mating season, (2) nest builder would increase the bubble nest size during mating, (3) male may build small bubble nest that fits all the limited eggs in order to reserve it energy for territorial defence and parental care and (4) small bubble nest would be more hidden and less likely to be detected by predator. In addition, male with large bubble nest may not always reflect the male's contribution to paternal care and the outcome of contest because it does not win in the fight.

How does Croaking Gourami Mate?

Breeding this fish in an aquarium is very easy. Lowering the water level to 15.0- 20.0 cm and Raising the water temperature to 28.0-30.0 °C will trigger spawning. Sexual maturity occurs at about 4 months of age (Henglmüller and Ladich, 1999). Male croaking gourami uses air bubbles in constructing the nest (Figure 3a). It creates a nest of froth by taking a bubble of air into its mouth and the bubble becomes covered with an oral sticky mucous that makes it adhere to the others in a mass or binds with emergent plants on the water surface (Liengpornpan et al., 2006). This floating foam bubble nest is rather small and not sturdy. The bubble nest has a dual purpose: (1) to keep the developing young close together for protection and (2) to keep the developing young near the water's surface where the developing young are well oxygenated (Moyle and Cech, 2000). Spawning rarely occurs when there is no nest presents (Marshall, 1967).

Female croaking gourami uses pheromones to attract male during spawning (Moyle and Cech,



(a)



(b)

Figure 3 Croaking gourami mating (a) male builds the bubble nest, and (b) male embraces female.

2000). In the afternoon to late evening after a suitable bubble nest is available, the nest holding male attempts to court the female by enticing it under the bubble nest, moving in front and vibrating male body and croaking (Liengpornpan et al., 2006). If the female accepts this male as a mate, a change in the colour will quickly occur as the normal horizontal stripes become distinct vertical ones. Female will swim in circles with the male beneath the bubble nest and is in a vertical head-up



position while the male is in a horizontal position. Female then begin undulating its body while producing a purring sound (Ladich, 2007). When the female of a pair is ready to spawn, it touches the male either on the back or the tail with its mouth (Liengpornpan et al., 2006). Upon this signal, the male moves beside female and embraces the belly until female releases a packet of ~ 3 white opaque eggs per incident, which are immediately fertilised by the male (Figure 3b). Before the fertilised demersal eggs sink to the bottom, the male picks them up in its mouth and spews them into the waiting bubble nest. Male often adds a few more bubbles to its nest. Once all the oviparous eggs are secured in the bubble nest, the pair will spawn again ~ 80 times over a total of ~ 180 min spawning sessions and this result in ~ 300 spherical white eggs released. As spawning progresses, the ovary decrease in size until at the end of spawning the ovary appears as a small pink area seen from the scales. After the mated female lays all its eggs, the nest-building male becomes quite aggressive towards the female and chases female out of the bubble nest. Upon completion, the male will place fine layers of bubbles beneath the eggs ensuring that the fertilised eggs remain in the bubble nest. The male will now take sole responsibility for the fertilised eggs aggressively defending the nest and surrounding territory from intruders. This species is a monogamous pairing. Within ~ 30 hrs, the fry will hatch with a stripe on their bodies and continue hanging head-up and developing within the protection of the bubble nest. If juveniles try to leave the nest early, the male carries them in its mouth and spews them back

into the nest. If male eats the eggs or newly hatched fry, we need to remove male and lower the water level in the aquarium to about 3 cm. Two days after hatching, fish larvae finish their larval development and consume all their yolk sac. They become too active to be kept in the nest and are sufficiently developed to be free swimming with a size of ~ 3 mm. At higher temperatures, they may hatch more quickly. They move slowly near their bubble nest or under heavily floating plants for 1-2 weeks. In the first few days, they will be vertical at the surface and will begin swimming horizontally within about a week. At this stage, the tank is kept covered with more floating plants. This high humidity is necessary for the development of the labyrinth organ.

How does Croaking Gourami Larva Develop?

The larval development of croaking gourami is divided into four stages (Figure 4) (Hemsiri and Termvidchakorn 2001). First, in the yolk sac or early embryonic stage (i.e. 2 days old after hatching), the larva is distinguished by dense pigments scattered on the yolk sac and a black band on the lower body. Second, in pre-larval or transitional embryonic stage (i.e. 3-5 days old after hatching), pigments presented only on the lower part of its body. Third, in post-larval stage (i.e. 7-23 days old after hatching), pigments developed into several vertical bands. Elongate filamentous spine of anal fin and pointed fin are the distinct characteristic of this stage. Forth, in juvenile or post embryonic stage (i.e. 24-50 days old after hatching), juvenile colour pattern changed over the 132 days

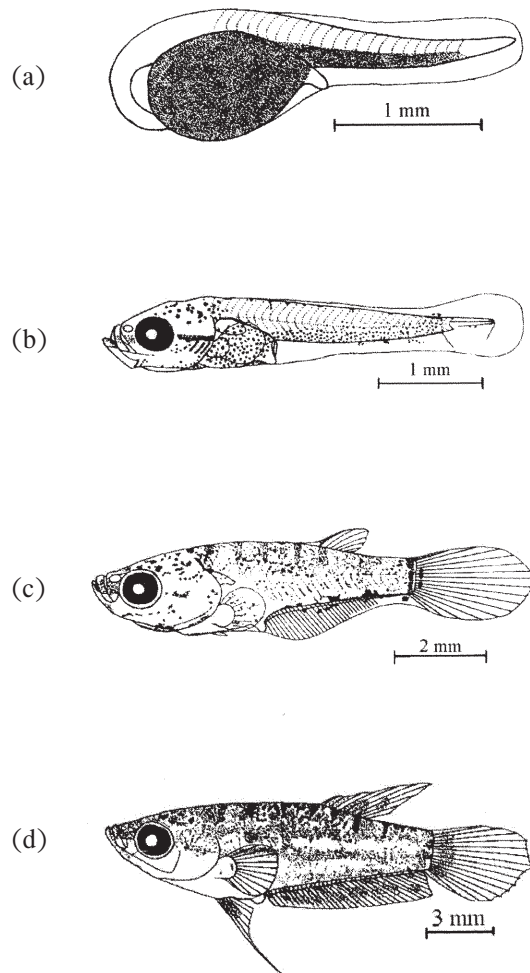


Figure 4 Larval development of croaking gourami (a) yolk sac stage, (b) larval stage, (c) post larval stage, and (d) juvenile stage. (Modified from Hemsiri and Termvidchakorn, 2001.)

of observation (Henglmüller and Ladich, 1999). Young exhibits horizontal eye-bars from the mouth to the operculum at 8 weeks when fish starts to vocalise. From 6-12 weeks old, the fish grows rapidly. It grows very fast when given larger tank.

There are two size-groups to each group of siblings. The larger one stays at the top and feed faster. The smaller one remains at the bottom until large enough to compete at the top. However, very cold air temperatures at the water surface may cause damage and lead to infections of the developing labyrinth organ when the young fish begin to take gulps of air. The order of appearance of behavioural patterns during ontogeny corresponds to the order of appearance in fights between adults (Henglmüller and Ladich, 1999). Most croaking gouramis live for about two years but with proper care can live as long as five years in an aquarium setting.

How do Agonistic Behaviours of Croaking Gourami Develop?

The development of social or agonistic behaviours in croaking gourami starts when it is 11 days old and consists of approach and flight in a feeding context (Henglmüller and Ladich, 1999). Lateral display (i.e. spreading of median fins in a lateral position) first occurs during the third week, circling shortly afterwards and pectoral fin beating when fish is 7 weeks old. After vocalisation at the age of 8 weeks, frontal display, mouth biting and retreat behaviour occur at the age of 10 weeks and difference in the body coloration of winner and loser is observed. However, agonistic encounter between individuals younger than 10 weeks is generally shorter and less aggressive than later on.

Full-contact fighting between individuals is relatively rare in nature even during the mating season. This may not be believable to the average aquarist who has pet fish kill each other in the

aquarium. This is not a violation of this law of nature because the loser has no place to escape in such an aquarium. The winner expects the loser to go away without any actual physical combat. If this does not happen, the winner instinctively escalates to physical violence. At the beginning of male-male competition test, agonistic encounter displays high visual stereotypic movement composed of going round in a circle, lateral displaying, mouth opening and biting. Four types of agonistic behaviours, which both males in all pairs show simultaneously, are going round in a circle, lateral displaying (Figure 5a), mouth opening (Figure 5b), and adhering to each other. In pair with big size ratios, the larger male is more often successful (Ladich et al., 1992).

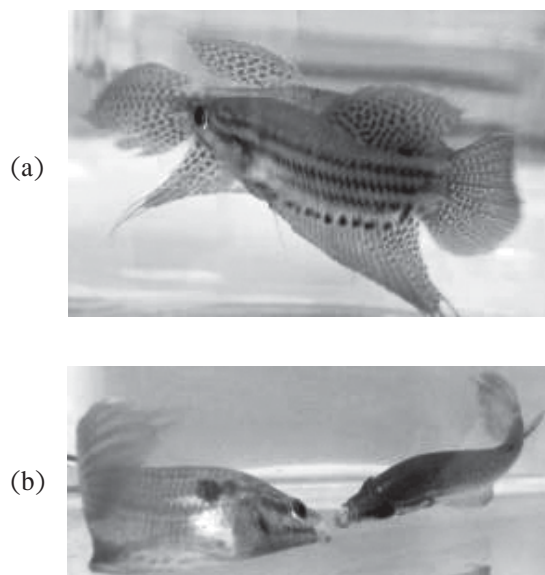


Figure 5 Agonistic behaviour of croaking gouramis
(a) lateral displaying (b) mouth opening

Considering within the genus *Trichopsis*, significant differences among croaking gourami (*Trichopsis vittata*), threestripe gourami (*Trichopsis schalleri*), and pygmy gourami (*Trichopsis pumila*) are found in qualitative and quantitative analysis of displays (Bischof., 1998). Mouth opening occurs only in croaking gourami, whereas a strong tail-beating while vocalising is only observed in pygmy gourami. Fight duration and the number of sound production and going round in a circle are found highest in threestripe gourami.

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