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Sound Production Behaviour in a Marine Croaker Fish, *Kathala axillaris* (Cuvier)

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Abstract: Sound is a means of communication by animals. Many fishes are capable of producing sounds with the help of specialized structures. The teleost family-Sciaenidae, collectively known as the croakers and drums because of their ability for making sound. It includes about 70 genera and 270 species in worldwide. We selected *Kathla axillaris* to study the sound producing mechanism in the present study. Sciaenids communicate each other during courtship and spawning, are able to recognize these sounds as an indicator of spawning areas. Over a period of 2 weeks, sounds produced in the tanks were recorded and the behaviour associated with these were also monitored by direct observation at different time of the day. These sounds consisted of a combination of three pulses with a pulse record of 0.082s. The pulses showed a fundamental frequency component from <50 to 500 Hz. (mean-356.72, S.D. =48.00). The first pulse was always more intense than the second and third one and richer in harmonics. Thus, these evidences suggested that *K.axillaris* emitted a remarkable sound using a muscle-swimbladder mechanism.

Key words: Sound % Hydrophone % Fish. Sciaenidae % Swimbladder

INTRODUCTION

Many fish species have mechanisms allowing them to emit species-specific sounds [1-3]. One of these sound-producing mechanisms is the result of swim bladder vibration due to the action of specialized muscles. These muscles are external element pertaining to the swim bladder in various Ophidiiformes[4] Holocentridae[2] or Sciaenidae [5-7]. The action of these induces a production of sounds with a fundamental frequency ranging from 100 to 300 Hz.

Drum fish (Family Sciaenidae) are known for their sound production during mating, from which the family derives its name [8]. Members of the drum family are dominant species in the large and valuable commercial and recreational fisheries in North Carolina and the Southeastern USA. Recently, concerns have been raised about the decline in the population and spawning stock of some sciaenids, especially the red drum, *Sciaenops* ocellatus [9]. One management option that has been suggested is to create spawning reserves, but spawning areas must be surveyed first in order to protect them. Sciaenid fishes held in captivity produce species-specific sounds associated with spawning behaviour [7, 10, 11] and recently spawned eggs and sounds co-occur in field samples [12, 13]. Spectral analysis of these sounds allows us to identify each sciaenid species based on their sound production, even when they co-occur in the same area [7,14].

Many authors have reported maximal sound production to occur during the spawning season from the period of dusk to several hours after nightfall. Holt *et al.* [5] documented maximal spawning of Sciaenids occurred within this same time of day. Because fish sound production serves as a useful proxy for spawning activity, hydrophone surveys provide a powerful, cost effective and non-destructive method of documenting spawning time and location [16].

Because sounds are produced by male fishes in the Sciaenidae in communication during courtship and spawning, are able to use these sounds as an indicator of spawning areas. This study aimed to describe the sounds produced by *K.axillaris*.

MATERIALS AND METHODS

Six fishes of *K.axillaris* (four males and two females: mean=12.8 cm total length: S.D=0.7 cm) were caught with a trawl net and transported to the laboratory. They were maintained in a rectangular tank (length 426 x width 226x

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depth 122 cm) designed for acoustic experiment in sea water circulation. On the sand covered bottom, three stone refuges were built and, during seven days before beginning the experiment, the fish were allowed to establish territories.

The study was carried out under sunlight and ambient water temperature (25-29°C). Each fish was identified by its natural body marks, size and the position of its refuge. Fish were fed twice a day with mollusks and crustaceans.

Hydrophones are used for recording the sound in underwater. They are made from Piezoelctric material. Under the pressure of sound wave, the piezoelectric element fixes and gives of electrical signals. These sounds can be recorded the later analyzed with computer programs to determine the properties of the sound wave, including amplitude and frequency.

Sound production was monitored by a Hydrophone (Reson model TC4032 manufactured from Denmark) with a sensitivity of-170 dB and with flat frequency response upto 40 Khz, placed approximately in the middle of the experimental tank. Sound was analysed in a software RT pro Dynamic signal analyzer, LDS-Dactron Premont, C.A software.

Over a period of 20 days, fish sound in the tank was recorded and the behaviour associated were monitored by direct observation at different periods of the day (in six periods of 60 min each, randomly distributed during the light hours). After finishing the experiment, fish were killed to determine their sex, size, weight and swimbladder volume.

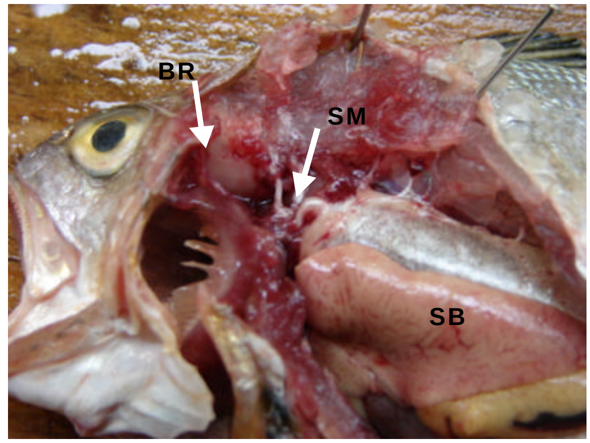

Plate 1: Section of *K. axillaris* fish: SM; Sonic Muscles, SB; Swimbladder and BR; Brain

Plate 2: *K.axillaris*-Swimbladder is carrot-shaped

RESULTS

Sound Producing Organ: In *kathala axillaris* produce sounds by the action of muscles of the swimbladder. The sounds muscles of the *k. axillaris* have been described as one of the fastest twitch muscles. The central tendon runs from the upper part of the sonic muscles across the back of swimbladder to connect with the muscles of the opposite side. The abdominal fascias connect the lower part of the sonic muscles from both sides in the ventral line. The sonic muscles are served by branches of the nerves and blood vessels from the abdominal muscles (Plate 1).

The contracting sonic muscles press the viscera and cause the vibration of the wall of the swimbladder, thus creating sound. The vibrating frequency of drumming muscles and swimbladder is significant in *K.axillaris* sp. In *k.axillaris* swimbladder is carrot-shaped (Plate 2).

Sound Production in the Laboratory: In the present study six specimens (four males and two females) of *K. axillaris* were used for recording the sounds. It revealed the waveform pattern of frequency spectra. Fishes were fed twice a day with flesh of clam (molluscs) and *Acetes* sp (crustaceans). Over a period of 2 weeks, sounds produced in the tank were recorded and the behaviour associated with them was monitored by direct observations at different timing of the day. After finishing the experiment, fishes were killed for further studies.

Description of Sounds: The sounds of *K. axillaris* consisted of a combination of pulses. The fundamental frequency component of the majority of sounds analysed (n=120) from total sounds in the laboratory was low <1 KHz.

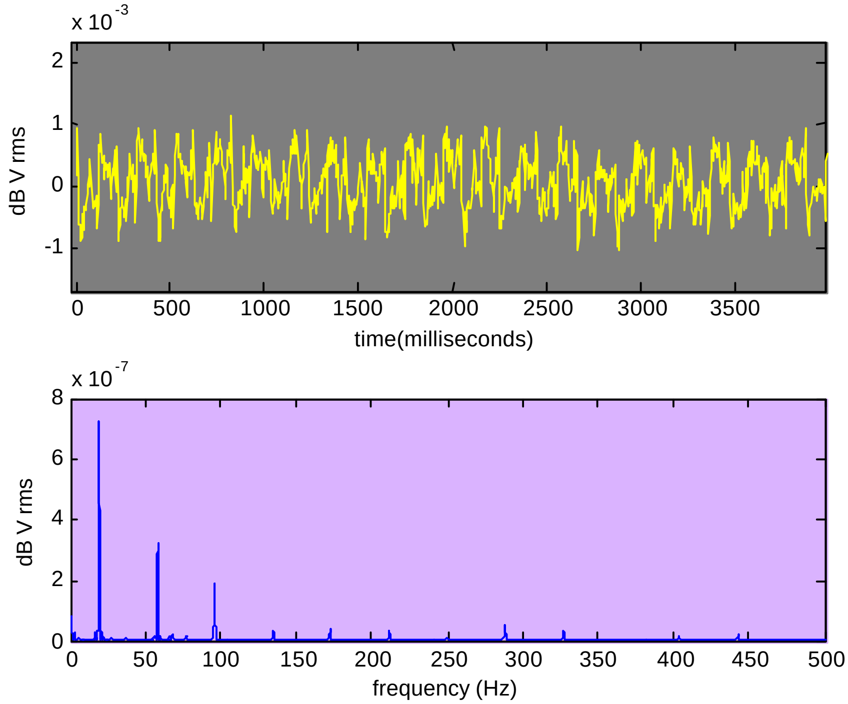

Fig. 1: Sound frequency of *K.axillaris*, Top; sound recording frequency dB/ milliseconds, Bottom; frequency in decibels (MAT Lab software) shows three frequencies produced by fish

The basic sound consisted to one pulse with a fundamental frequency ranging from <50 to 800 Hz (mean=393.55 S.D=97.75) and generally with harmonics upto 2500 Hz.

Sounds composed of three pulses were the most frequently recorded in the laboratory. These sounds consisted of a combination of three pulses with a pulse record of 0.082s when recorded in the laboratory (Figure 1).

The pulses showed a fundamental frequency component from <50 to 500 Hz. (mean-356.72, S.D. =48.00). The first pulse was always more intense than the second and third one and richer in harmonics.

Behaviour Associated Sound Production: In the laboratory recordings, only adult males of *K.axillaris* displayed acoustic behaviour. All daily sounds were recorded, in the laboratory during the period of night; the aggressive behaviour was also noticed. However, an aggressive interaction was not accompanied by sound emission.

Sound production in *K.axillaris* was generally accompanied by characteristic movements of the animal: when it was emitting sounds, the fish changed alternatively its swimming direction by means of strong movements of its caudal fin, swimming in a zigzag manner. All the aggressive interactions observed between fish with chases, bites and attacks without body contact was also noticed.

DISCUSSION

Fish produce a variety of sounds using different mechanisms and for different reasons. Sounds are produced as warnings to predators or competitors, to attract its mates, or as a fright response. These intentionally produced sounds are generally referred to as vocalizations. More than 800 species of fishes are known to vocalize. Other sounds are produced unintentionally such as those made as a by-product of feeding or swimming. The three main ways fishes produce sound that are by rubbing together skeletal components (stridulations); using muscles on or near their swimbladder known as sonic muscles (drumming); and by quickly changing speed and direction (hydrodynamics) while swimming [17].

K.axillaris was strongly territorial and aggressive [18, 19] producing sounds during aggressive interactions. However, the observation of Takemura [20] and Myrberg *et al*, [21] in other pomacentrid species suggested that sound production can also occur during courtship behaviour but no sexual behaviour was observed during the present experiments. The present laboratory results showed that adult males of *K.axillaris* had aggressive behaviour, but it remains unknown if females or juvenile fish share these characteristics. The possible absence of sound production in juveniles and in females of *K.axillaris* requires further study.

The sound of *K.axillaris* consisted of a combination of several sonic pulses, being most frequently composed of groups of three pulses. However, this kind of sound is the most frequent, its proportion decreased in captivity, probably due to lesser swimming activities.

The earlier studies on sounds recorded was exhibited a fundamental frequency ranging from <50 to 800 Hz, with most of the energy concentrated towards the lower end of the spectrum, while the course of the pulse wave exhibited a decay in amplitude but in the present species *K.axillaris* showed the frequency ranged between 19-98 Hz (Figure 1). These features are typical of the fish swimbladder when it was driven into oscillation by action of the specialized muscles [22, 23]. Harmonic sounds resulted from higher pulse repetition rate which yielded a tone-like wave and these were usually generated by a muscle-swimbladder mechanism [24]. Each pulse was produced by a single contraction of a sonic muscles [22, 25]. Thus, these evidences suggested that *K.axillaris* emitted sound using a muscle-swimbladder mechanism. This is also in agreement with the observations reported by Myrberg [26] in *Pomacentrus partitus* (Poey).

The present laboratory observations showed that *K. axillaris* had nocturnal activity. These fish's emitted sounds the whole day increased their sound activity at sunrise and sunset. On the other hand, the acoustic activity of *K.axillaris* decreased around noon, reached the lowest number of sounds emitted during the light period. This diurnal variation in the frequency of sound emission has also been described in other species [20, 27-30]. They also suggested that the increase in the frequency of sound emission at sunrise and sunset was related to active fish feeding during these periods. Unfortunately, the present study there was no relationship was noticed between sound pattern and feeding behaviour of the fish.

Although *K.axillaris* always emitted sounds during aggressive interactions, sounds were generally associated with characteristic swimming movements during aggressive behaviour, using the same sonic display during inter-or intraspecific interactions. If during an aggressive interaction, an attack continues with a chase, the aggressor fish emits sounds during the first phase of the interaction, i.e. the attack. No sounds were recorded during the subsequent persecution and, in accordance with the observations of Torricelli and Romani [31] in a fish *Padogobius martensi* (Cuvier), sound production seems to be limited to the preliminary phase of the aggressive interactions and the same pattern also was noticed in the present study.

Swimbladder does not connect directly with the inner ear. When the wall and the diverticula of the swimbladder vibrate, the sound is transmitted through its anterior diverticula to the external wall of the ear capsule and from there to the perilymph, saccular membrane, endolymph, sagitta and finally to the 8th pair of cranial nerves (auditory nerve).

The drumming muscles and membrane may be present in both sexes or in males only in various Sciaenids. They are present in both sexes they probably serve for sex recognition; courtship and stimulation. Sound production in Sciaenids involves the swimbladder adjacent to drumming muscles or sonic muscles. These muscles are compressed, broad and elongated and are located laterally nearer to the body-wall (Ventro lateral to the viscera and swimbladder).

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