Terapon theraps chorus observed in shallow water environment in the southeastern Arabian Sea

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Long term acoustic measurements have been obtained from shallow water environment in the southeastern Arabian Sea (SEAS) off Cochin during the period of January-May 2011. This is the first time record in Indian seas. Based on the spectrogram analysis, call type is found to be chorus, where many fishes called en masse. The chorus produced by the fish ‘Terapon theraps’ sounded like ‘trumpet’ and displayed unique call characteristics throughout the period. They produced daily patterns with the highest activity level before dawn and after dusk. Numbers of trumpet chorus were maximal at the beginning of the January to end of March, but ceased down by the May. The fish chorus for this site reached ~30 dB above ambient noise level at the frequency of their spectral maximum. This chorus is believed to be associated with spawning. Visual surveys are conducted separately to confirm the presence of Terapon theraps contiguous to SEAS.

[Keywords: Shallow waters, chorus, Terapon theraps, spawning]

Introduction

The ‘chorus’ consists of two or more individual callers overlap, with a significant increase above background levels (> 3dB re 1 µPa) for long periods, using an equipment averaging time of one second\(^1\). Chorus enhances the attraction of potential mates\(^2-5\). Fish chorus are species specific and are considered less varied in comparison to vocalizations of other vertebrates and insects\(^6-9\). The sounds produced by fishes are in different mechanisms, including stidulation of bony structures and contraction of sonic muscles causing vibration of swimbladder\(^10\). Fishes are known to make sound associated with a variety of situations, such as courtship, spawning, mating, territory defence, competition for food and to signal alarm\(^11,12\). Study\(^13\) investigated the behavioural significance of sounds from tropical fishes. During spawning season, large active calling chorus from specific fish is globally used by fisherman to locate fish aggregations\(^14,3\). The noise consists of large numbers of sounds from conspecifics produce a greater masking effect than to other sound. Reproductions related to fish chorus are common with calling as group acting to mediate partner selection and release gamete in night time\(^15\). Fish chorus has several benefits for active males to aggregate mate location by females\(^16\) and detection of areas with the necessary physical resources for breeding\(^17\). Females attracted by their calls\(^18\) spawn in the nest and the males provide the protection as a parental care for the young until they start swimming\(^19\). The characteristics of a sound, including series of pulses and duration can be important to its communicative values and behavioural studies\(^20\). The differences in the number and repetition rate of pulses can potentially identify species\(^21\) or individual\(^22,23\). It is known that a particular sound is produced to indicate the particular time of day the fish spawns\(^24-26\).

Study\(^27\) described predominantly evening fish chorus from three tropical locations; West pacific, Timor and Arafura Seas and the eastern Indian Ocean. These chorus reached up to 30 dB above the background noise and most energy lies in the range 0.4–4 kHz. Fish chorus from a deep water site in the eastern Indian Ocean reached highest levels of approximately 12 dB above expected level, at sunset\(^28\). Study\(^29\) suggested fish chorus from the Great Barrier Reef which reached high levels in the evening. This paper describes the patterns of fish chorus in shallow waters of southeastern Arabian Sea (SEAS).

Materials and Methods

An automated sub-surface ambient noise measurement system comprising of vertical linear
array (VLA) of omnidirectional hydrophones with data acquisition modules was deployed at latitude 09°52.996’N and Longitude 76°05.510’E in shallow waters environment off SEAS during the period from January–May 2011 (Fig.1). The omnidirectional hydrophones are capable of measuring in the frequency range 0.05–10kHz, with the sampling rate of 50 kHz per channel simultaneously, for sampling duration of 30s, once in every 3 hours. The system was deployed at an ocean depth of around 30 m and VLA positioned at the mid water column, so that the noise due to surface and bottom reflections could be measured effectively. The first element of the VLA has been taken for analysis. The array of hydrophones sense acoustic pressure fluctuation due to various sources of noise which translates into electrical signals and then logged by the data acquisition system. The recorded voltage is then converted to units of µPa by applying pre-amplifier gain and receiving sensitivity (−170 dB) of the hydrophone. Power level of the noise spectrum enables us in detection and classification of signals buried in the noise. Welch’s averaging periodgram method was used to calculate the noise spectrum level. Multiple spectra are obtained first by segmenting data into smaller portions, windowed with a Hamming window, and a 2048 point FFT with 50% overlap. Spectra are then averaged to obtain the final spectrum. The frequency resolution, determined by the sampling frequency and the number of points in the FFTs in each power spectrum is 24.4 Hz.

For visual observation of the species *Terapon theraps* (*T. theraps*), separate sighting surveys have been conducted on board the boat at the Southwest of Bay of Bengal (Off Olaikuda, Rameswaram Island, Palk bay) i.e. contiguous to the SEAS during the period of 17–19 July 2014. A nursery cage with diameter (1.5 m) and height (1.5 m) was provided by Marine Biotechnology Group, NIOT. Live species of *T. theraps* in different sizes were collected at nursery cage (Fig. 2). The fish species *T. theraps* are extensively distributed in tropical region of the world ocean30. Occurrence of *T. theraps* in shallow waters off Southeastern Arabian Sea (SEAS) has been previously reported31.

![Fig. 1–Geographic location of hydrophone moored in shallow waters in SEAS. Hydrophone is shown as ▲.](image1)

![Fig. 2–Visual survey of *T. theraps* contiguous to SEAS, (a) Live species in a nursery cage, and (b) different sizes of the *T. theraps*.](image2)

**Results and discussion**

All in-situ data were analysed using the time/frequency spectrograms and converted into audio files (.wav) to confirm the detection of fish chorus. A total of 160 fish chorus were recorded by the hydrophone. This sound type produced by more than one species is called *en masse* and described as sounding like ‘trumpet’. The chorus is attributed to *T. theraps* (Family Terapontidae). The chorus and call types are similar in characteristics as published in the oscillograms in the literature29,32. The waveform and spectrogram of the *T. theraps* fish chorus is shown in figure 3. A single call duration was about 350–450ms and comprised of a series of pulses ranging from (35–40). Fig. 4 shows the waveform, spectral level and spectrogram of a single call.
Fig. 3–Waveform and spectrogram of the *T. theraps* fish chorus.

The resulting calls for chorus sources and sound producing mechanisms are discussed. The pulse repetition rate appeared in the frequency spectra at 0.1–0.12 kHz and is related to swimbladder mechanism. The swimbladder resonant spectral peak is extended over 0.6–1.5 kHz. The chorus levels of spectra are high as shown in Fig. 5. The *T. theraps* fish chorus in shallow waters off Cochin was ~30 dB above ambient noise levels at the frequency of their spectral maximum, whereas the ambient noise level was ~15 dB higher at lower frequency. The occurrence of these high level choruses dominated the ambient sea noise spectra. The trumpet sound production exhibited a strong daily pattern across the study period. The chorus was generally seen as peaks in noise level before dawn (between 5 AM to 6 AM) and after dusk (between 6 PM to 9 PM) (Fig. 6a). The sound produced was higher during hours of dusk than during hours of dawn. Chorus was maximal from the beginning of January to end of March, but ceased in May (Fig. 6b).
Detailed analyses of *T. theraps* chorus have been discussed. The *Terapon* sound producing organ has been described which is comprising a two-chambered swimbladder driven by laterally paired muscles attached to the anterodorsal surface of the anterior swimbladder chamber, with these muscles extending to attach to the rear of the skull[33]. The chambers are surrounded by a sphincter muscle and separated by a narrow open tube. The *T. theraps* calls recorded in the field were made up of a series of pulses (Fig.4a), with each pulse considered to result from a single muscle contraction applied to the swimbladder. Pulse spacing equalled the muscle contraction rates. Pulse repetition rates of up to 110–140 Hz have previously been measured in the *T. theraps*. The spectral content of individual *Terapon* calls and chorus showed a broad peak related to the swimbladder resonant frequency with sharp spectral peaks separated by the muscle contraction rate and extending into higher frequencies.

From early passive acoustic monitoring experiments, the coral reefs were found to have noisy soundscapes due to the breeding reef fishes chorus[34, 36]. Vocalization, stridulation and hydrodynamic sound signal generation from several reef fishes during the spawning period are significant[38]. Aggregation of several marine fishes occurs over specific diel patterns during the spawning[39]. The generated sound signal behaviour is related with the low light conditions (dawn or dusk)[37]. The presently studied area (SEAS) is associated with tropical coral reef environment such as; *T. theraps* are reef associated fishes[39]. The *T. theraps* acoustic chorus activity peaks at nocturnal, i.e. before dawn and after dusk indicates these sound signals are associated with spawning.

The present study indicates the occurrence of the *T. theraps* prevalent in the SEAS using chorus sound signals. Therefore, time/frequency spectrogram and spectral density analysis tools were employed to identify the recorded *T. theraps* chorus sound. The statistical technique such as probability density function and power spectral density functions are useful tools to characterize the species feeding click sound signal[38]. However, these tools are less viable to characterize with the *T. theraps* chorus sound signal generation mechanisms and scaling behavior or size parameters. Several techniques have been developed to focus on different aspects of the species[39]. The multifractal detrended fluctuation analysis is a robust non-linear mathematical tool to identify the scaling behavior of the species that was not feasible in the spectral analysis[40].

**Conclusion**

This paper has presented a short summary of fish chorus type recorded in shallow water environment off Cochin. The fish chorus reached extremely high levels, in excess of 92 dB and almost 30 dB above ambient noise levels at the frequency of the chorus spectral maximum. The chorus showed their daily patterns with the highest activity level before dawn and after dusk. This chorus is believed to be produced by spawning aggregation as part of the reproductive process during which fish spawned. They can potentially indicate presence of very large numbers in their environment. The fish chorus shows the importance of sound for monitoring and preventive measure to avoid anthropogenic noise in order to protect the marine environment.

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References


