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Sounds Produced by the Striped Cusk-Eel *Ophidion marginatum* (Ophidiidae) during Courtship and Spawning

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The mechanism of sound production of the striped cusk-eel *Ophidion marginatum* was described long ago, but actual sounds were not recorded until recently when cusk-eels were spawned in laboratory aquaria (Courtenay, 1971; Fahay, 1992). This paper describes sounds produced by cusk-eels that were recorded during courtship and spawning in the laboratory.

Materials and methods.—Cusk-eels were collected at night, on 23 July 1989, by otter trawl in Great Bay, New Jersey, and placed in a tank (1.2 m × 1.2 m × 0.9 m) with 15 cm of sand substrate. Tank contents were maintained at ambient bay water temperatures (21.5–27.5 C) and salinity (23–31 ppt) with flow-through seawater at the Rutgers University Marine Field Station. Fish were fed marsh grass shrimp (*Palaemonetes vulgaris*) daily. Observations were made beginning at sunset until approximately three hours after sunset from 23 July 1989 to 22 September 1989. Behavioral observations were facilitated by a red light over the tank and occasionally flashlights to observe spawning behavior. There were six males (160–193 mm TL) and three females (225–263 mm TL). Sounds were recorded in air using a Panasonic Equalizer 8-Combination Stereo Recorder using the built-in microphone. Sounds were digitized at 22 kHz and analyzed with SoundEdit Pro (Macromedia, Inc.) and SIGNAL (Engineering Design). Number of pulses and pulse periods (msec from beginning of first pulse to beginning of last pulse/number of pulses − 1) were calculated for each sound. Although recordings in air outside aquaria are likely to distort individual pulse characteristics from reflections (including pulse length and frequency), the number of pulses and pulse period will be unaffected.

Results.—Sounds were produced at dusk, from 1812 h to 2030 h, while males were buried and also while males were hovering above females. Sound production began 5–88 min (mean = 41 min) before egg release by females and ended 15–20 min afterward. In some instances, male cusk-eels slowed or ceased swimming activity and exhibited a slight vibration of the head and nape area during sound production. An isolated female was observed producing sounds, and another female apparently produced sounds while vibrating her pectoral fins. The frequency characteristics and amplitudes of the sounds were variable and suggest that they were produced by mulitple individuals, although we cannot be sure which individuals produced which sounds. Sounds consisted of broad-band pulses and contained between one and 27 pulses (Figs. 1–2). There appeared to be three classes of sounds with different numbers of pulses (1–5 pulses, 6–14 pulses, 16–27 pulses; Fig. 2B). The 1–5 pulse sounds occurred immediately after longer pulsed calls and had longer and more variable pulse periods (mean ± SD = 72.3 ± 17.2 msec) than sounds with more pulses (6–14 pulse sounds mean ± SD = 43.8 ± 1.4 msec; 16–27 pulse sounds mean ± SD = 43.0 ± 1.2; $P < 0.0001$; Mann-Whitney U-test; Fig. 2).

Discussion.—Sounds produced by the striped cusk-eel are clearly used during courtship and mating and may be an important means of communication because they spawn at night in very turbid waters. Male cusk-eels have two pairs of sonic muscles, and female cusk-eels have three pairs. These arise on the skull and insert on modified skeletal elements in contact with the swimbladder (Courtenay, 1971). The sounds are similar to those produced by other sonic fishes that have extrinsic swimbladder muscles, such as the sciaenidae (croakers and drums) and gadidae (cods) (Fish and Mowbray, 1970; Hawkins and Rasmussen, 1978). The pulse periods of sounds with six or more pulses were remarkably constant. The coefficient of variation (CV) of pulse period for 16–27 pulse sounds was only 2.8%. Pulse periods are important sound characteristics for species recognition in damselfishes (Spanier, 1979) and anurans (Loftus-Hillis and Littlejohn, 1971), and it would not be surprising to find that other species of cusk-eels have different pulse periods. The significance of the trimodal distribution of the number of pulses in the sounds is not known.

Now that these sounds have been recorded and analyzed, reproductive biology of cusk-eels can be studied better by analyzing temporal and spatial patterns of occurrence of their sounds. The potential of this approach has just begun to be realized (see Mok and Gilmore, 1983; Saucier and Baltz, 1993; Mann and Lobel, 1995), and it may be potentially relevant for this

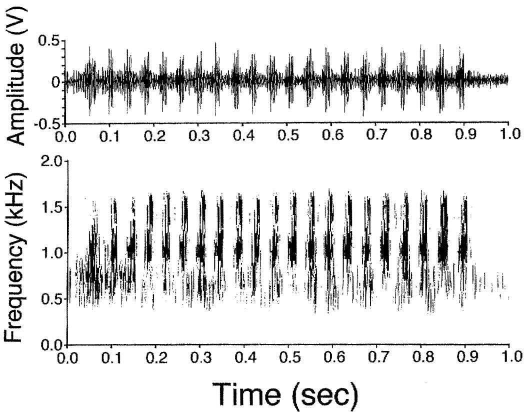

Fig. 1. An example oscillogram (top) and corresponding sonogram (bottom) of a sound produced by *Ophidion marginatum.* The signal was filtered using a matched filter constructed from one of its pulses.

cryptic species. There are many other fishes with sound-producing muscles whose sounds have never been recorded, including other ophidioids (ophidiids and carapids) and gadoids (morids and macrourids) that live in difficult working environments like the deep sea (Marshall, 1967; Courtenay and McKittrick, 1970; Carter and Musick, 1985).

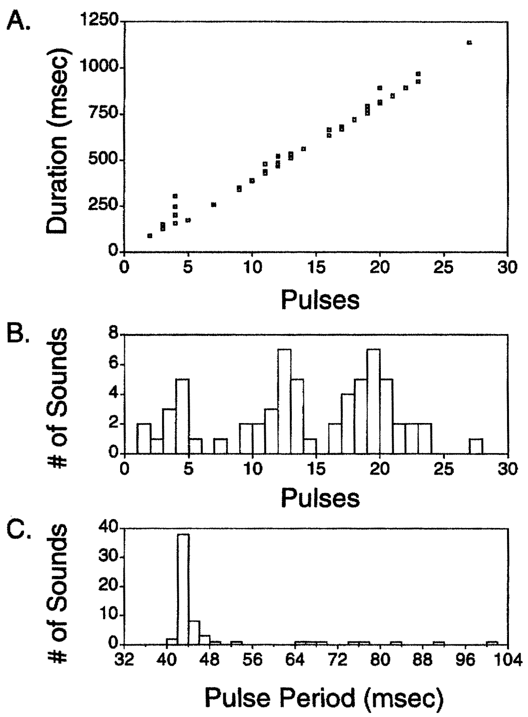

Fig. 2. Characteristics of sounds produced by *Ophidion marginatum.* (A) Number of pulses in a sound versus the duration from the beginning of the first pulse to the beginning of the last pulse. (B) Histogram of the number of pulses in the sounds. (C) Histogram of the pulse periods of the sounds.

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Literature Cited

Carter, H. J., and J. A. Musick. 1985. Sexual dimorphism in the deep-sea fish *Barathrodemus manatinus* (Ophidiidae). Copeia 1985:69–73.

Courtenay, W. R., Jr. 1971. Sexual dimorphism of the sound producing mechanism of the striped cusk-eel, *Rissola marginata* (Pisces: Ophidiidae). *Ibid.* 1971:259–268.

———, and F. A. McKittrick. 1970. Sound-producing mechanisms in carapid fishes, with notes on phylogenetic implications. Mar. Biol. 7:131–137.

Fahay, M. P. 1992. Development and distribution of cusk eel eggs and larvae in the Middle Atlantic Bight with a description of *Ophidion robinsi* n. sp. (Teleostei: Ophidiidae). Copeia 1992:799–819.

Fish, M. P., and W. H. Mowbray. 1970. Sounds of western North Atlantic fishes. Johns Hopkins Press, Baltimore, MD.

Hawkins, A. D., and K. J. Rasmussen. 1978. The calls of gadoid fish. J. Mar. Biol. Assoc. UK 58:891–911.

Loftus-Hillis, J. J., and M. J. Littlejohn. 1971. Pulse repetition rate as the basis for mating call discrimination by two sympatric species of *Hyla.* Copeia 1971:154–156.

Mann, D. A., and P. S. Lobel. 1995. Passive acoustic detection of sounds produced by the damselfish, *Dascyllus albisella* (Pomacentridae). Bioacoustics 6: 199–213.

Marshall, N. B. 1967. Sound-producing mechanisms and the biology of deep-sea fishes, p. 123–133. *In:* Marine bio-acoustics. Vol. 2. W. N. Tavolga (ed.). Pergamon Press, Oxford.

Mok, H.-K., and R. G. Gilmore. 1983. Analysis of sound production in estuarine aggregations of *Pogonias cromis, Bairdiella chrysoura,* and *Cynoscion nebulosus* (Sciaenidae). Bull. Inst. Zool. Acad. Sinica 22:157–186.

Saucier, M. H., and D. M. Baltz. 1993. Spawning site selection by spotted seatrout, *Cynoscion nebulosus,* and black drum, *Pogonias cromis,* in Louisiana. Environ. Biol. Fish. 36:257–272.

SPANIER, E. 1979. Aspects of species recognition by sound in four species of damselfishes, genus *Eupomacentrus* (Pisces: Pomacentridae). Z. Tierpsychol. 51:301–316.

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