Melatonin, biological clock keep singing fish on time

September 23 2016, by Krishna Ramanujan

A nest with male and female midshipman fish (Porichthys notatus) and developing embryos attached to the rock. Credit: Margaret A. Marchaterre/Provided

In the 1980s, people living on houseboats in the San Francisco Bay were puzzled by a droning hum of unknown origin that started abruptly in the

late evening and stopped suddenly in the morning.

A lengthy investigation revealed the culprit: male plainfin midshipman fish (Porichthys notatus) that sing at night to attract mates. The fish, which can grow to 15 inches in length, live along the Pacific coast from Alaska to Baja, California.

A study published online Sept. 22 in the journal *Current Biology* reveals how melatonin, a time-keeping hormone, and daily light cycles keep the nocturnal fish singing through the night.

Very little is known about the roles of melatonin and circadian rhythms in nocturnal vertebrates, including fish that vocalize during mating season. Other studies on diurnal (day-active) songbirds have shown that melatonin suppresses singing at night but increases the duration of syllables when these birds do sing.

In the current study, the researchers found that melatonin had an opposite effect on these nocturnal fish compared with diurnal birds: Its release provided a "go signal" for night singing. But similar to diurnal songbirds, the hormone also acted to lengthen calls when the fish sang.

"Our results, together with those of others that also show melatonin's actions on vastly different timescales, highlight the ability of hormones in general to regulate the output of neural networks in the brain to control distinct components of behavior," said Andrew Bass, professor of neurobiology and behavior in the College of Arts and Sciences, the paper's senior author. "In the case of melatonin, one hormone can exert similar or different effects in diurnal vs. nocturnal species depending on the timescale of action, from day-night rhythms to the duration of single calls."

"Melatonin is an ancient and multifunctional molecule that is found

almost ubiquitously in the animal kingdom," said Ni Feng, Ph.D. '16, a former graduate student in Bass' lab who is currently a postdoctoral researcher at Yale, the paper's first author.

"Similarly, circadian rhythms govern the daily lives of diverse lineages, from plants to animals," Feng said. "Our study helps cement melatonin as a timing signal for social communication behaviors."

In the study, the researchers brought wild-caught midshipman fish into the lab, where they could control lighting. In one experiment, they tested if the male fish's daily nocturnal song was controlled by an internally generated circadian rhythm. They put the fish in constant darkness without any light cues for seven days at a time, and found the fish still sang but on a 25-hour schedule, so they started one hour later each night.

"You can think of it as a clock that can help the fish predict the best time to be vocally active," Feng said. "We found that this clock ran with a delay of about an hour, causing a drift in vocal activity with respect to the 24 hour light-dark cycle, highlighting the importance of internal clocks to be recalibrated by environmental cues on a daily basis."

To understand melatonin's effects on behavior, fish were exposed to constant light for 10-day stretches. The pineal gland produces melatonin in vertebrates but only in the dark, and constant light significantly suppressed the fish's humming. But when fish were given a melatonin substitute, they continued to hum, though at random times of day without a rhythm.

"Melatonin acts as a 'go' signal for the nocturnal call of the midshipman fish," Feng said. "Surprisingly, at the single call timescale, constant light also decreased hum duration, but melatonin maintained hum duration at normal levels, a finding also found in diurnal birds."

Finally, Bass and Feng located specific melatonin receptors – sites where melatonin triggers an action in the brain – in brain regions that control reproductive and social behaviors, including vocal initiation centers, the same as in birds and other vertebrates.

More information: Ni Y. Feng et al. "Singing" Fish Rely on Circadian Rhythm and Melatonin for the Timing of Nocturnal Courtship Vocalization, *Current Biology* (2016). DOI: 10.1016/j.cub.2016.07.079

Provided by Cornell University