

Long-term study of gamete release in a broadcast-spawning holothurian: predictable lunar and diel periodicities

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ABSTRACT: Annual and monthly patterns of gamete release by the sea cucumber *Isostichopus fuscus* on the coast of Ecuador were studied to determine the proximal spawning cue and variations in reproductive output throughout the year. Several hundred newly collected individuals were monitored nearly every month for 4 yr. *I. fuscus* displayed a lunar spawning periodicity: 0.7 to 34.9% of individuals consistently spawned 1 to 4 d after the new moon. Spawning mostly occurred within one evening; however, some gamete release was often recorded over 2 to 4 consecutive evenings. Individuals maintained in captivity for several months retained their spawning periodicity and timing with the lunar cycle. Conversely, newly caught individuals that were shaded from the moonlight did not spawn, thus demonstrating the apparent lack of endogenous rhythms and prevalence of lunar luminance over other cues (i.e. tidal cycle, fluctuations in barometric pressure). On a spawning night, males typically initiated gamete release around sunset; females spawned just after the peak male broadcast. The percentage of spawning individuals was higher and a greater overlap between male and female peak spawning activity was observed during clear conditions compared with overcast conditions. The gonads of individuals that did not spawn in a given month showed a variety of maturity levels, including post-spawning, growth and mature gametogenic stages. Hence, the individual reproductive cycle is apparently longer than the monthly spawning periodicity observed at the population level, enabling *I. fuscus* populations to be reproductive year round.

KEY WORDS: Spawning · Periodicity · Lunar cycle · Reproductive synchrony · Holothurian · Echinoderm · *Isostichopus fuscus*

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INTRODUCTION

Synchronous gamete release is prevalent as a means of maximizing reproductive success in broadcast-spawning marine invertebrates (Babcock et al. 1992, Levitan 1995). The mechanisms through which this synchrony is achieved have been the subject of numerous studies, yielding a rich array of timing patterns. To date and for most species, spawning periodicities have typically been assessed by repeatedly sampling populations to measure gonado-somatic indices (GSI),

gametogenic state and/or larval abundance in correlation with environmental factors (e.g. abundance of phytoplankton, temperature, photoperiod). Such studies have been conducted in holothurians (see review by Smiley et al. 1991) and other echinoderms (see review by Giese et al. 1991).

Many marine organisms display a lunar or semi-lunar component in some phase of their reproductive behaviour (Giese & Kanatani 1987, Morgan 1995). Such rhythmic cycles have been shown to favour population persistence under conditions of high female:

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