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Depth-related shift in life history strategies of a brooding and broadcasting deep-sea asteroid

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Abstract Combining field and laboratory work, this study investigated the reproductive cycle, aggregative behavior, spawning periodicity, development and early growth of the sea star *Henricia lisa* living at bathyal depths off eastern Canada. Marked differences were found between individuals from ~1,300 and ~600 m deep. The former had a male biased sex ratio and an aperiodic reproductive cycle, whereas the latter displayed an equal sex ratio and a biannual breeding pattern. Furthermore, the maximum size was larger and female fecundity roughly five times higher in shallower compared to deeper populations. In the tanks, aggregative behavior was recorded twice a year during the summer and winter breeding periods. The onset of aggregations and spawning coincided with a temperature of 3–4°C. Males spawned first and females typically responded inside 30–60 min. Between 12 and 20 eggs were retained to be brooded under the arched arms of the female, whereas the remainder were broadcasted and developed without parental care. The fertilized eggs underwent a first cleavage after 12 h, reached the brachiolaria stage in 1 month, became juveniles within 3–4 months and reached ~ 4 mm in diameter after 14–17 months of growth. The embryos and juveniles developed at the same rate whether brooded or not, and development of winter cohorts was typically slower due to lower prevailing temperatures. This study of *H. lisa* provides the first evidence of lecithotrophy in a seasonally breeding deep-sea echinoderm and of brooding in a deep-sea asteroid.

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Introduction

The life history of deep-sea organisms remains poorly studied to this day, owing much to the difficulties associated with keeping live specimens in sufficient numbers and in good enough health for them to exhibit feeding and reproductive cycles consistent with their natural behaviors. Nevertheless, laboratory studies are perceived as one of the most appropriate means of gathering knowledge on their biology, especially when combined with field observations (Thatje et al. 2006). Echinoderms are among the most ubiquitous deep-sea animals and have received a good deal of attention (Young 2003), although many aspects of their reproductive biology remain poorly understood, especially with respect to social interactions, spawning periodicity and parental care. This is particularly true for deep-sea asteroids, as previous studies have focused on preserved samples (e.g., Tyler and Pain 1982; Tyler et al. 1984; Ramirez-Llodra et al. 2002).

Evidence of breeding aggregations exists for a number of shallow-water sea stars (Komatsu 1983; Minchin 1987; Run et al. 1988; Young et al. 1992; Slattery and Bosch 1993; Hamel and Mercier 1995). Many authors suggest that such aggregations could minimize sperm dilution and increase fertilization success (Ormond et al. 1973; Levitan 1991, 1992). Although deep-sea aggregations and pairings have been reported (Young 2003), few papers address their