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The reproductive cycle of the asteroid *Coscinasterias muricata* in Port Phillip Bay, Victoria, Australia

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Abstract

The reproductive cycles of two populations of *Coscinasterias muricata* from Port Phillip Bay, Victoria, Australia are described in terms of organ indices, oocyte development and progesterone levels. Both Governor's Reef and South Channel Fort populations exhibited clearly defined reproductive cycles with two spawning periods, during summer and during spring. In both populations, the pyloric caecal index and gonadal index showed inverse cycles suggesting nutrient translocation from the pyloric caeca to the gonads for gametogenesis. Physiological changes, such as decreases in pyloric caecal index, and increases in gonadal index and oocyte diameter were observed following the months of increased progesterone concentrations in the female pyloric caeca. These results indicate a role for this steroid in the reproductive cycle. The results from the Governor's Reef population suggest that the influence of progesterone on the reproductive cycle of female *C. muricata* is regulated by photoperiod. Results also provide evidence of a role for seawater temperature in the reproductive process of this species.
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Keywords: Asteroid; *Coscinasterias*; Echinodermata; Photoperiod; Progesterone; Reproduction

1. Introduction

The reproductive cycles of asteroids have been postulated to be controlled by various exogenous factors such as photoperiod, lunar cycle, salinity, seawater temperature and food availability (Pearse et al., 1986; Bouland and Jangoux, 1988). Laboratory studies have shown that sensitivity to environmental changes differs according to the developing state of the gonads. The initiation of gametogenesis and spawning seem to be reliant on environmental factors, while development progresses regardless of the environmental conditions (Bouland and Jangoux, 1988). The endocrine system has been suggested to be the likely mediator of environmental regulation of gametogenesis and gonadal growth (Xu and Barker, 1990a).

Asteroids that are broadcast spawners often exhibit a gametogenic cycle that allows the development, differentiation and temporary storage of vast quantities of gametes (Walker, 1982). Gonad size, measured as the gonadal index, will therefore increase as a result of gamete accumulation and decrease during periods of spawning and gonadal recession (Pearse and Eernisse, 1982). However, delineation of the asteroid reproduc-

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tive cycle often requires information about gamete development (Nichols and Barker, 1984b). The inclusion of oocyte size data may provide complementary quantitative insight into the stages of female gamete development (Schoenmakers and Voogt, 1980).

Oocyte diameter and gonad development have been shown to be related to asteroid feeding condition (Xu and Barker, 1990b; Skold et al., 2002). Generally, the pyloric caeca of asteroid species are thought to be the origin of the reserve materials required for gonad development and often have clearly defined annual cycles (Lawrence and Lane, 1982). This is frequently indicated by the inverse relationship observed in the sizes of these organs during the reproductive cycle. Because of the perceived importance of the pyloric caeca to asteroid reproduction, the biochemistry and physiology of these organs have been studied extensively (Oudejans and van der Sluis, 1979; Oudejans et al., 1979; Xu and Barker, 1990c; Barker and Xu, 1991a). As the weight of the pyloric caeca has been shown to increase with food abundance, the relative weight of the caeca to total body weight, known as the pyloric caecal index, is often used as a direct reflection of the nutritional condition of asteroid populations (Barker and Xu, 1991b).

This study describes the reproductive cycle of *Coscinasterias muricata* through the examination of variations of parameters including the pyloric caecal and gonadal index, oocyte diameter and the progesterone concentration in the pyloric caeca. The influence of exogenous factors such as photoperiod and temperature were also considered.

2. Materials and methods

2.1. Collection of asteroids

Asteroids of the largest size class were collected ($n=20$ per collection) from two sites within Port Phillip Bay, Victoria, Australia (Fig. 1) by SCUBA. Asteroids were sampled from Governor's Reef (<3 m depth) at monthly intervals from October 1999 to December 2000. For comparison, asteroids were collected every second month, December 1999 to December 2000, from South Channel Fort (12 m depth), an artificial island subject to strong ebb and flooding currents. Both sites are within the daily water exchange zone of Port Phillip Bay and thus are considered relatively clean.

2.2. Dissection of asteroids

Asteroids collected were transported to the Queenscliff Marine Station (Fig. 1). Prior to dissection, asteroid wet weight and length (the distance measured from the tip of the longest arm to the opposite interradius) were measured. Upon dissection, the total wet weight of the pyloric caeca and gonads were measured. Samples to be used for biochemical analyses were immediately frozen in liquid nitrogen and stored at −80°C.

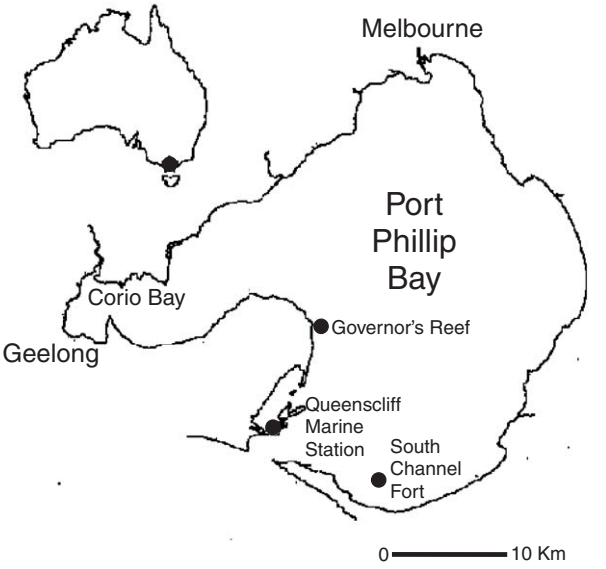

Fig. 1. Location of sampling sites within Port Phillip Bay and the Queenscliff Marine Station, Victoria, Australia.

2.3. Histology

Approximately 0.5 g of gonad tissue of each asteroid was fixed in 10 mL of Buoin's solution (containing saturated picric acid, formalin and acetic acid) for at least 18 h. Samples were rinsed three times with 70% ethanol before storage in 70% ethanol. The tissues were later dehydrated and embedded in wax prior to sectioning (5 μm width). The sections were haematoxylin and eosin stained.

To determine oocyte size, representative areas of sectioned ovaries containing, where possible, at least 100 oocytes per asteroid were photographed and scanned using Spot advanced version 3.1 software. From these images, the circumferences of 100 oocytes per asteroid were traced and measured using Optimas software (version 6.5) at the Central Aging Facility, Marine and Freshwater Resources Institute, Queenscliff, Victoria. By approximating the sectioned oocytes as circles, the diameters were calculated from the area.

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