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ASPECTS OF THE GONADAL CYCLE IN THE ANTARCTIC BIVALVE *LATERNULA ELLIPTICA*

G. BIGATTI,[1] P. E. PENCHASZADEH,[1]* AND G. MERCURI[2]

[1]*Facultad de Ciencias Exactas y Naturales, UBA y Museo de Ciencias Naturales–CONICET, Av. Angel Gallardo 470, Buenos Aires, Argentina;* [2]*Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina*

ABSTRACT Vitellogenesis and oocyte growth in *Laternula elliptica*, a common hermaphrodite bivalve living in the soft muddy bottoms of the Antarctic continent, are reported. Formation of the gelatinous layer surrounding the oocyte, gonadic development, accumulation of mature oocytes, and spawning events were studied through histological evidence. Gonads were observed to reach maturity at a size of 49 mm. Vitellogenesis has been found to last seven months, and storage of oocytes before spawning was observed. It has been observed that once sexually mature, the animals remain with sperm cells and oocytes available during the entire year, suggesting that individuals would be prepared to spawn at any moment, probably depending on environmental conditions.

KEY WORDS: *Laternula elliptica,* Antarctic clams, vitellogenesis, oocyte growth, first maturation

INTRODUCTION

Laternula elliptica (King & Broderip 1832) is possibly the most common bivalve in the Antarctic continent wherever soft muddy bottoms are present (Powell 1965). It burrows deeply into the substrate (Stout & Shabica 1970); densities of 50 individuals per m^2 with a fresh weight biomass of 2–3 kg/m^2 have been reported (Hardy 1972).

Recently several authors have studied different aspects of the reproduction of *L. elliptica* (Pearse et al. 1986; Pearse et al. 1987; Urban & Mercuri 1998; Ansell & Harvey 1997). Several questions remain unanswered, however. This article deals with the vitellogenesis period and oocyte growth within the ovarian portion of the hermaphrodite gonad, the size and age of gonadic maturation, the formation of the gelatinous layer surrounding the oocyte, the accumulation of mature oocytes, and spawning events, studied from histological evidence.

MATERIAL AND METHODS

The material was obtained by one of the authors (G.M.) during a joint German-Argentine project (Klöser & Arntz 1995; Urban & Mercuri 1998), at the location of Potter Cove, King George Island, South Shetland Islands. A monthly sampling was conducted at a fixed station at 10 m depth (see Urban & Mercuri 1998, for locality details). Histologic slides were prepared for one complete year of sampling (1993–1994). Gonads were fixed in Bouin's solution, preserved in 70% alcohol and treated with common inclusion procedures. Sections of 5 microns were stained with Harris' hematoxylin and eosin (Merck). The ovaries of 30 individuals of standard adult bivalves (of about 65–80 mm in shell length) were studied for each monthly sample. A total number of 1113 oocytes (73–117 per monthly sample) with distinct nucleolus were measured, comprising the whole visual field.

In a later sample, in February 2000, gonads of 22 individuals of about 27–73 mm were studied with the same procedures in order to determine the size of gonadal development and maturation.

RESULTS AND DISCUSSION

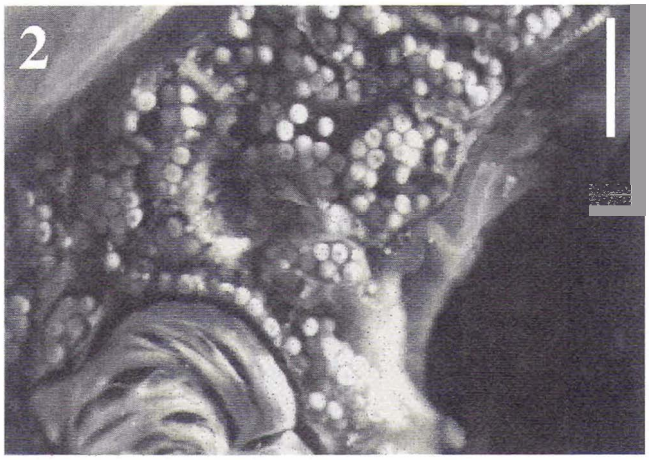
Under the stereoscopic microscope it is possible to observe, in the ovarian portion of mature clams, the mature oocytes and empty spaces related to partial spawning (Figs. 1–3).

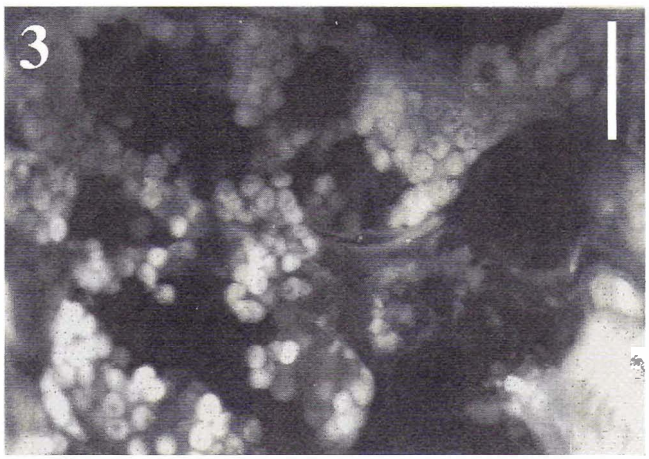
A gelatinous layer (Figs. 4–9) envelops the mature oocyte. This outer layer becomes visible (3.1 SD 1.3 microns thick) during vitellogenesis when the oocytes are 90–100 microns in diameter. Maximum thickness (13.6 SD 5.0 microns) of the gelatinous layer is reached in oocytes of 220 microns in complete diameter (these oocytes have a mean cytoplasmic diameter of 193 microns).

According to the histograms of oocyte diameter frequencies, this process of wall formation takes 3–4 months, starting in March–April and ending in September (Figs. 10 and 11). Ansell and Harvey (1997) stated that after fertilization this gelatinous envelope condensed to form a strong, sticky, elastic capsule in which further development took place. We consider this gelatinous layer to be a vitelline membrane, formed by the oocyte itself (Huebner & Anderson 1976).

The largest oocyte mean diameter we measured, including the gelatinous layer, was 220.7 microns in February 1994 (Fig. 10), but we consider the oocyte to be mature at 171.5 microns external diameter, and the mean mature oocyte is 195.2 microns (including gelatinous layer).

*Corresponding author. E-mail addresses: penchas@bg.fcen.uba.ar (P.E.P.); gbigatti@bg.fcen.uba.ar (G.B.)





Figures 1–3. Ovarian portion of gonads of *Laternula elliptica* (>60 mm shell length) viewed through stereoscopic microscope. (1) Ripe ovary; (2) Partially spent ovary; (3) Spawned ovary with remnant oocytes. Scale Bar = 1200 microns.

The modal diameter peaks for bigger oocytes show no variation from January to July (171.5 microns). But modal diameters of the small oocytes show a remarkable constant tendency to grow from January (55.5 microns) to June (142.5 microns); this is the main period of vitellogenesis. The period of favorable light conditions to phytoplankton growth in Potter Cove appeared to be very limited, approximately 1.5 months during summer (Schloss et al. 1997). Apart from that, resuspension of benthic material and possible input of terrigenous material constitute the main carbon source in summer time, while resuspended material or secondary bacterial production would account for it during the rest of the year (Schloss et al. 1997).

We consider that, as resorption of unspawned oocytes was never observed in any case, there is currently a storage of large mature oocytes in the female follicles, ready to spawn during the entire year. Protected lecitotrophic embryos, nourished by a considerable amount of yolk reserves which enable them to avoid a free swimming larvae stage in the first phases of the development, is the reproductive mode for *L. elliptica* (Pearse et al. 1986; Bosch & Pearse 1988).

Urban and Mercuri (1998) found that ripe ovaries seem to dominate, with values between 60–80% throughout the whole year, and only during the warmest two months (February and March) spent ovaries dominated, with ripe ovaries being reduced to about 25%. The authors suggested that it is most likely that the oocyte development cycle last longer than one year. Our results conclude that the oocytes complete their growth in less than seven months, and are stored until spawn. Once sexually mature, the animals remain with sperm cells and oocytes available during the whole year, suggesting that individuals would be prepared to spawn at any moment, probably depending on environmental conditions.

In a later sample performed during February 2000 in the same study area, microscopic differentiation of both testicles and ovarian follicles was observed at a size of 27 mm. Taking into account growth rates estimated by Brey and Mackense (1997) and by Urban and Mercuri (1998), this size corresponds to individuals <2 years old. Maturity in the male portion of the gonad is evidenced by the existence of mature sperm cells at a size of 30 mm shell length (Fig. 6).

At a shell length of 32 mm, which corresponds to individuals ~3 years old, it is possible to observe some oocytes covered by the characteristic gelatinous layer (up to 140 microns in external diameter). Ovaric maturity might then be reached when the individuals attain a size of 49 mm shell length, which corresponds to an age of approximately 4 years. It is at this stage that the gelatinous layer containing oocytes of 170 microns external diameter can be observed.

We conclude then that *L. elliptica* is a simultaneous hermaphrodite, completely mature at the age of 4 years. Information is still needed about its first stages of development, in order to assess the possibility of early development of any of the gonadic portions relative to the others.

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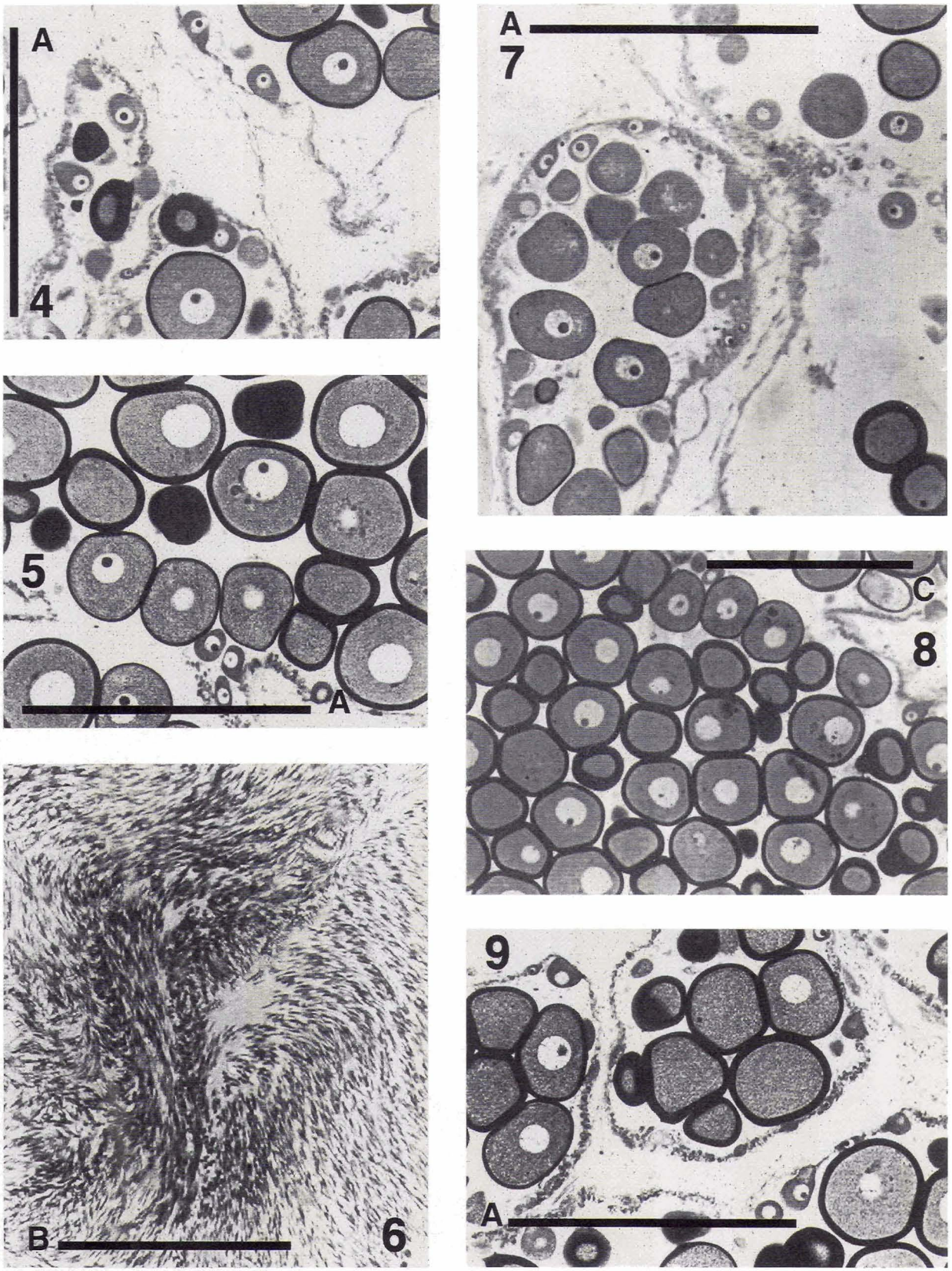

Figures 4–9. Light micrographs of *Laternula elliptica* gonad. (4) Female follicles containing both mature and new growing oocytes; (5) Most oocytes show the characteristic gelatinous layer; (6) Detail of a male follicle full of sperm cells; (7) An ovarian follicle partially spawned and another with growing oocytes; (8) Ripe ovary with packed mature oocytes. (9) Growing female follicles with both mature and immature oocytes. Scale Bar A & C = 500 microns. Scale Bar B = 100 microns.

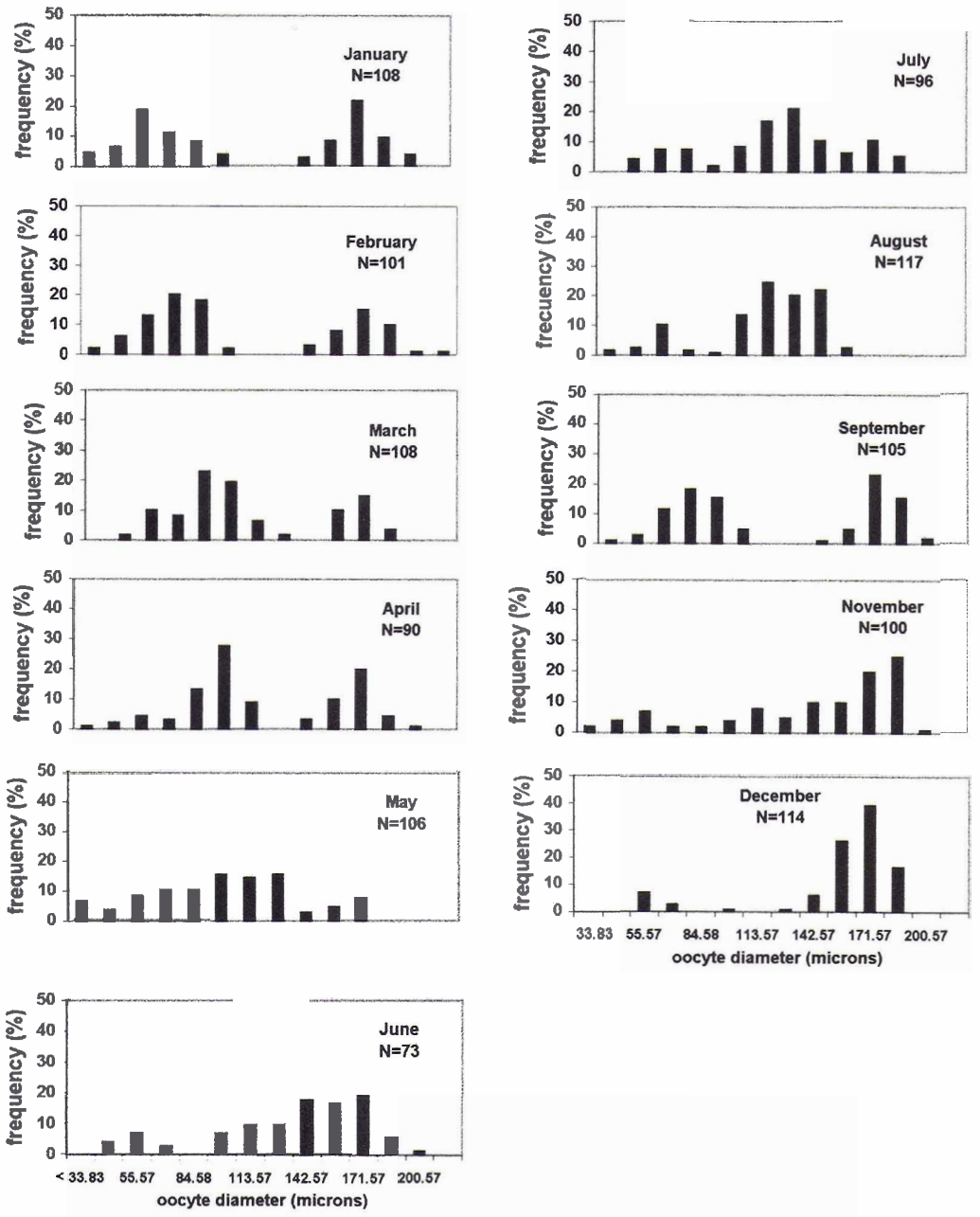

Figure 10. Frequency (%) of oocyte size (microns). N, number of measured oocytes.

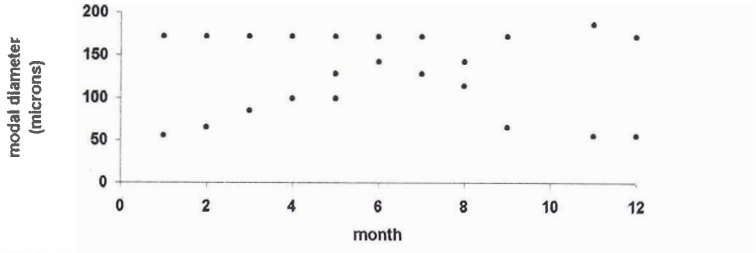

Figure 11. Modal diameter peaks of oocyte size for each sampled month in an annual cycle.

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