Aquaculture International **8:** 227–235, 2000.
© 2000 *Kluwer Academic Publishers. Printed in the Netherlands.*

Reproductive cycle of the south American scallop *Amusium laurenti* (Gmelin, 1791) (Bivalvia, Pectinidae)

PABLO E. PENCHASZADEH[1,2], CLAUDIO PAREDES[1] and JUAN J. SALAYA[1]

[1]*Universidad Simón Bolívar, Departamento de Estudios Ambientales. Apartado 89000, Caracas, Venezuela (e-mail: ppenchas@usb.ve / cparedes@usb.ve);* [2]*present address: Museo Argentino de Ciencias Naturales-CONICET, Argentina (e-mail: pablop@mail.retina.ar)*

Abstract. *Amusium laurenti* is a functional hermaphrodite with well differentiated male and female gonadal areas. The gonadal index varies throughout the year with maximum values occurring in January, March and July, and minimum ones in August and September. Partial spawning (with respect to the individual and the population) occurred from January to February and March to May. The major spawning event coincided with the end of the period during which bottom water temperature increased to temperatures above 26 °C (July–August). Subsequently temperature decreased to 22 °C, with a period of gonadal restoration and increasing gonadal index. Histological analysis of the gonads correlated with the gonadal index.

Key words: *Amusium*, gonadal index, gonad histology, Pectinidae, reproductive cycle, tropical scallop

Introduction

Scallop landings in Venezuela varied greatly in the last 30 y, with a reported maximum of 2,000 t (whole animal) in 1987 (Novoa et al., 1998). *Amusium laurenti* [genus *Amusium* according to the description by Abbott (1974) and Díaz and Puyana (1994)] has recently been referred to as *Euvola* (Waller, 1991). *A. laurenti* is, along with *Amusium papyraceum*, the most common scallop in the trawl fishery of central Venezuela; while in the Gulf of Venezuela, the main species is *Argopecten gibbus* and in the Margarita area the dominant scallops are *Euvola ziczac* and *A. papyraceum*. *A. laurenti* is a common scallop inhabiting shrimp grounds 20–50 m depth in northern South America, including the Caribbean and the Atlantic coast.

The reproductive cycles of other species of *Amusium* have been studied. *A. balloti* from Western Australia is a dioecious species (Heald and Caputi, 1981), while *A. pleuronectes* from the Philippines and *A. papyraceum* from

Venezuela are functional hermaphrodites (Llana and Aprieto, 1980; Salaya and Penchaszadeh, 1988).

The objective of this study was to assess the gametogenic cycle of *A. laurenti* in Golfo Triste, Venezuela, by means of histological examination and gonadal indexes. The reproductive cycle was analysed with respect to seasonal changes in the bottom water temperatures.

To our knowledge this study is the first attempt to describe the reproduction of *A. laurenti*.

Material and methods

The shrimp fishery in Venezuela uses a Florida trawl, with the operation of two simultaneous nets. *Amusium laurenti* is found around 20–50 m of depth. Histological preparations of 660 individuals of 60–79 mm (shell height) (18–45 monthly, from January to November 1979) were examined. Sections of 4–6 μm were stained with haematoxylin-eosin. Prior to fixation, the animals were weighed to obtain the gonadal index (as percentage ratio of gonad fresh weight to whole animal fresh weight).

Golfo Triste bottom water temperature figures for the study period were obtained from Penchaszadeh and Salaya (1983). They report a bimodal cycle with minimum temperatures (22 °C) in March, a period of rising temperature from March to August (23–27 °C), maximum temperatures are reached from August to September (27 °C) and finally there is a period of temperature decrease from September to March (27–22 °C).

Results

Amusium laurenti (Figure 1) is a functional hermaphrodite with well differentiated and separated male and female gonadal areas.

There are some variations in the size of the follicles within each specimen at every stage of development. With the exception of newly spent gonads, the female part contains follicles with oocytes in all stages of development.

The stage of gonad growth, is characterised by growing follicles. At the early stage of gonad development much connective tissue is found between follicles (Figure 2A and E). Follicles are still small and sparse, with alimentary canal still visible. A more developed stage shows oocytes on the walls of female follicles, many half grown oocytes, appearing stalked, and a few young oocytes, less connective tissue, but still continuous between follicles.

In the filling stage, fewer young oocytes are present; lumen contains more half-grown and a few almost fully grown (60–80 μm) oocytes. Follicles are

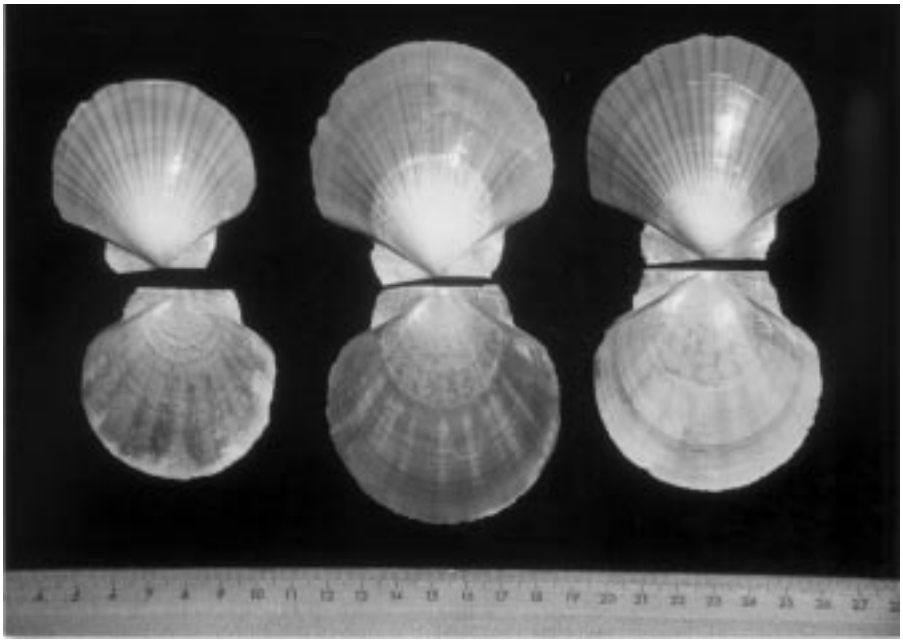

Figure 1. Amusium laurenti (Gmelin, 1791) from Golfo Triste, Venezuela.

larger, becoming packed together. Lumina is filled with almost fully grown oocytes. No connective tissue is seen between follicles (Figure 2B).

When full mature, the gonad becomes larger and thicker. Follicles have reached their maximum size. Male follicles are packed with spermatozoa, still arranged radially (Figure 2F). Female follicles are packed with fully-grown (80–90 μm) polygonal or pear-shaped oocytes.

When spent and partially spent, the follicles are smaller and collapsed, containing large spaces. Some connective tissue is visible.

Partially spent gonad retains more genital products. Many residual spermatocytes and spermatozoa and half-grown and almost fully grown oocytes are seen.

Spent gonad after complete spawning often contains a few residual primary germ cells, spermatogonia and spermatocytes on walls of male follicles, but few or no spermatozoa; female follicles have a few primary germ cells, oogonia and young oocytes on walls.

Small oocytes less than 20 μm are well represented during April, May, June, August, October and November. It is possible to recognise that oocytes with diameters of 60 to 80 μm disappear due to partial spawning events in the period of January–February.

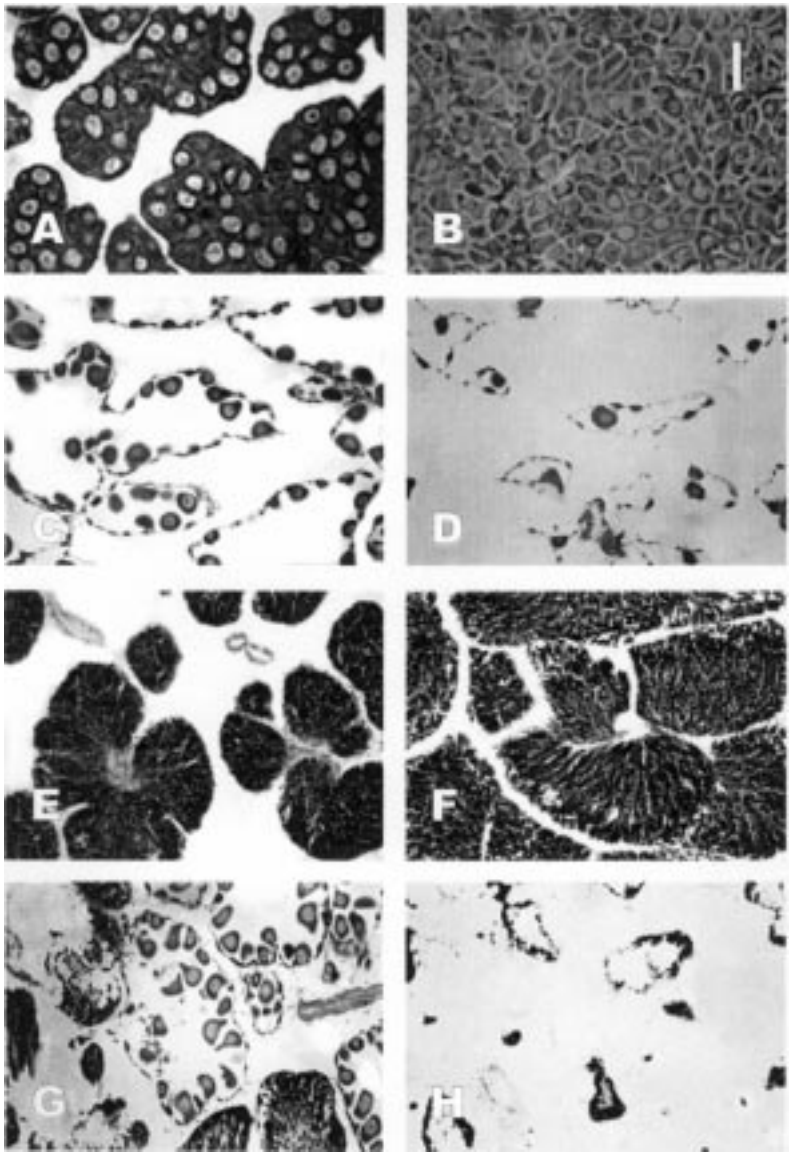

Figure 2. Gonadal stages of *Amusium laurenti* in Golfo Triste.
A: Developing and filling female follicles
B: Fully developed female follicles
C: Partially spent female follicles
D: Spent ovary, with few residual oocytes
E: Developing male follicles
F: Filling male follicles, presence of spermatozoa
G: Partially spawned gonad, a view of male and female follicles
H: Completely spent male follicles
Scale bar = 100 μm.

Table 1. Relative frequency of the gonadal index values for *Amusium laurenti* (60–79 mm shell height) from Golfo Triste, Venezuela

Gonadal Index	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov
13				3.8			6.2				
12			2.4								
11	10.7			1.6			6.3				1.0
10	20.8		20.0	3.8	1.7		11.2			5.6	1.9
9	10.0		19.5	4.8	6.1		16.3			4.6	5.0
8	15.8	3.0	17.1	1.6	3.9		20.0			3.0	18.0
7	8.7	16.9	26.7	22.9	4.4		24.4		2.9	5.6	13.2
6	10.6	27.1	4.8	38.3	11.2	17.8	13.1	1.0	5.3	5.6	25.1
5	9.3	39.7	4.8	11.9	18.5	17.8		2.0	9.5	17.2	26.1
4	10.3	10.6	2.4	4.8	30.0	17.9		17.1	24.9	33.3	4.8
3	2.9	2.8	2.4	4.8	14.2	32.2	1.2	22.3	40.0	24.3	1.9
2	1.0			1.6	10.1	14.2	1.2	52.4	17.4	1.0	2.9
1								5.0			
0											

The developing and fully grown oocytes measured 60–90 μm in diameter. From August to November, the recovery period after the major spawning peak, the follicles contain more young oocytes than mature ones. The follicles in a newly spent gonad contain only a few remains of developing oocytes and spermatocytes (Figure 2G and H) attached to the follicle wall (Figure 2C and D). There are almost always some not fully developed gametes present in the follicles which are not spent, and some fully developed which undergo lysis (Figure 2D).

Typical gonadal index for ripe gonads is 7.0 to 11.0, whereas spawned gonads are represented by a gonadal index of about 2.0 to 4.0. We found that for *A. laurenti* in Golfo Triste, spawning occurs several times throughout the year. This is indicated by the large variations observed in the gonadal index (Table 1). There are two partial and one major spawning events; evidenced also in Figure 3 by the proportion of gonads in each developmental stage throughout the year.

During the partial spawning events we found that not every individual spawned and among the spawning there were those who did not release all of their mature gametes (Figure 2C and G). The partial spawning events are indicated by two drops in the gonadal index from 10.0–11.0 to 5.0–6.0

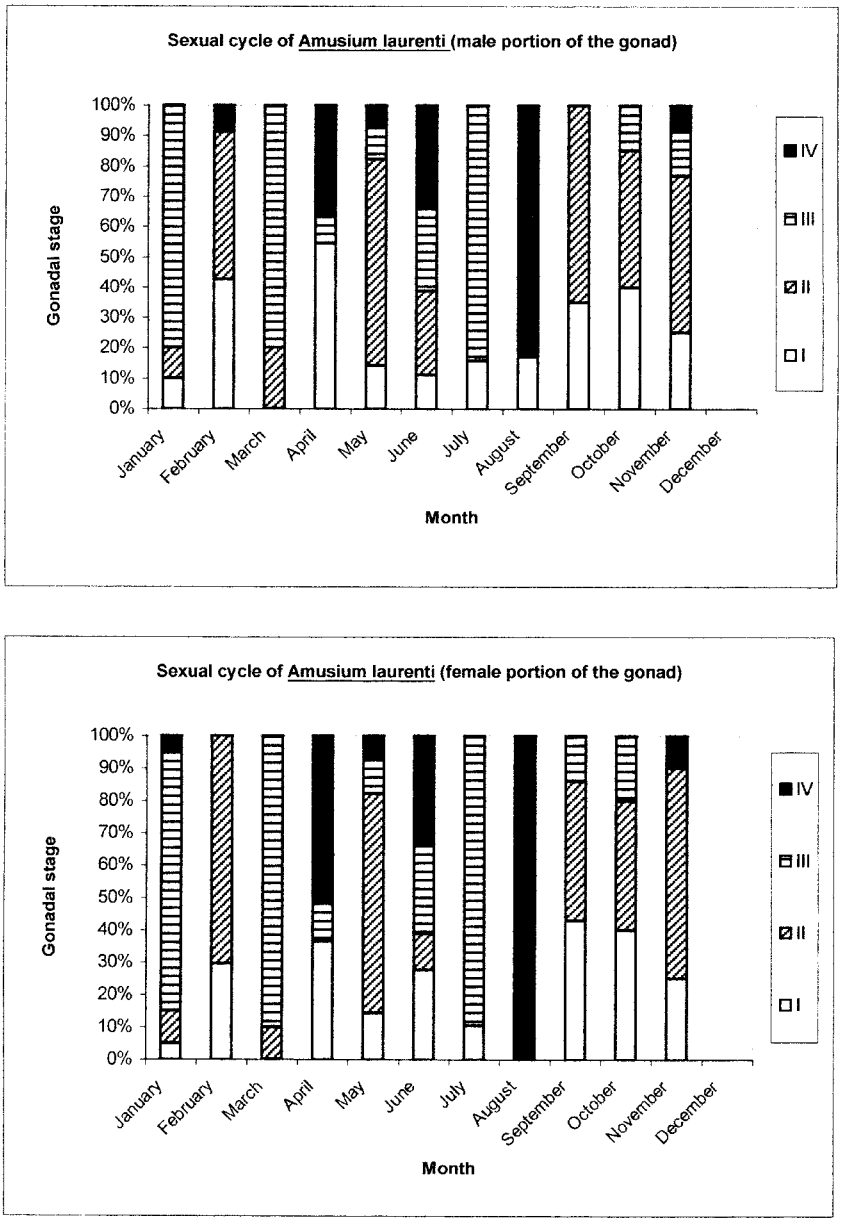

Figure 3. Reproductive cycle of *Amusium laurenti* from Golfo Triste. Based on the histological observation of 660 individuals. The percentage corresponds to the proportion of individuals in each gonadal stage:
I. Developing follicles
II. Partially filled follicles
III. Fully developed, ripe follicles
IV. Spent follicles.

and 8.0–10.0 to 3.0–5.0 in January–February and March–May, respectively (Table 1). These coincide with the end of the temperature decrease period and the beginning of the temperature increase period.

During the major spawning event all individuals sampled show a drastic drop in gonadal index from 7.0–13.0 (July), fully mature gonads (Figure 2B and F), to 1.0–4.0 (August), fully spent gonads (Figure 2D and H) (Table 1). This major spawning event coincides with the end of the temperature increase period when bottom water temperatures are above 26 °C.

A period of gonadal recovery then takes place from August to January when gonadal index slowly increases from 1.0–4.0 to 10.0–11.0 (Figure 2A, B, D and F). During this time there is a temperature decrease period (27–24 °C).

Discussion

Several different sexual structures can be recognised in the Pectinidae. Coe (1943, 1945), stated that most Pectinidae are more or less functional hermaphrodites, protandry being very common (*Hinnites distorta* and *Chlamys varia*) exceptions not lacking. *Pecten maximus* (Mason, 1958), *Aequipecten tehuelchus* (Christiansen and Olivier, 1971), *C. opercularis* (Coe, 1945) are hermaphrodites throughout life, without sexual reversal. There are other species which are dioecious throughout life including *Chlamys tigerina*, *C. striata* and *C. furtiva* (Reddiah, 1962), *Placopecten magellanicus* (Posgay, 1950), *Patinopecten yessoensis* (Yamamoto, 1953), *Hinnites multirugosu*s (Yonge, 1953) *Placopecten magellanicus* (Bourne, 1964; Naidu, 1970). In *Amusium laurenti* the gonad has well differentiated female and male portions. Each follicle contains elements of only one sex.

The genus *Amusium* has several representatives in tropical waters of the world. *Amusium papyraceum* from Venezuela shows a pattern similar to the one we found for *A. laurenti*, with a major spawning peak in June–July (summer), and two minor spawning events in December–January and March–April (Salaya and Penchaszadeh, 1980). *Amusium pleuronectes* from the Philippines also reproduce throughout the year, with one major peak and one minor peak (Del Norte, pers. comm.). But in the dioecious *Amusium balloti* from Western Australia, there is a single annual spawning that coincides with rising benthic sea temperatures during the summer; there has been no evidence of partial spawning or regression of pre-spawning developmental stages (Heald and Caputi, 1981).

The other important species in Venezuelan, *Euvola ziczac*, another functional hermaphrodite, typically has a period of gonadal growth that correlates with a period of temperature increase from 23 °C to 25.5 °C (December to

April), while massive spawning occurs when temperatures are above 26 °C (Brea, 1986; Vélez et al., 1987), as we also found in *Amusium laurenti*.

Even though there seems to be a relation between bottom water temperature and spawning events in several Pectinidae, its effect is still not clear and further studies must be performed to better understand this relation.

Acknowledgments

We would like to thank Iraima Verkaik, Oriana Farina and Jennifer Herrera, who assisted with microscope observations; Gustavo Rodríguez and Luís José González, who assisted with the collection of the scallops and the histological work. We thank Claudia Penaloza for correcting the final manuscript. This work was supported by a Decanato de Investigación grant to ciencias Marinas group, University Simón Bolívar.

References

Abbott, T. (1974) *American Seashells*, Van Nostrand Reinhold Company, New York, 663 pp.

Bourne, N. (1964) Scallops and the offshore Fishery of the Maritimes. *Fisheries Research Board of Canada Bulletin* **145**, 1–60.

Brea, J. (1986) *Variaciones energéticas estacionales en la composición bioquímica de Pecten ziczac (Lineus, 1753) en relación con el metabolismo energético, reproducción y crecimiento*. Lic. Biol. Tesis. Escuela de Ciencias, Universidad de Oriente, Cumaná, Venezuela, 75 pp.

Christiansen, H.E. and Olivier, S.R. (1971) Sobre el hermafroditismo de *Chlamys tehuelcha* d'Orb., 1846 (Pelecypoda, Philibranchia). *Anales de la Sociedad Científica Argentina* **191**, 115–127.

Coe, W.R. (1943) Development of the primary gonads and differentiation of sexuality in *Teredo navalis* and other pelecypod molluscs. *Biological Bulletin* **84**(2), 178–186.

Coe, W.R. (1945) Development of the reproductive system and variation in sexuality in *Pecten* and other pelecypod molluscs. *Transactions Connecticut Academy of Arts and Sciences* **36**, 673–700.

Díaz, J.M. and Puyana, M. (1994) *Moluscos del Caribe Colombiano*, COLCIENCIA y Fundación Natura Colombia, Santa Fe de Bogotá, Colombia, pp. 291+LXXIV.

Heald, D.I. and Caputi, N. (1981) Some aspects of growth, recruitment and reproduction in the southern saucer scallop, *Amusium balloti* (Bernardi, 1861) in Shark Bay, Western Australia. *Fishery Research Western Australia* **25**, 1–33.

Llana, Ma E.G. and Aprieto, V.L. (1980) Reproductive Biology of the Asian Moon Scallop *Amusium pleuronectes*. *Fishery Research Journal of Philippines* **5**(2), 1–10.

Mason, J. (1958) The breeding of the scallop, *Pecten maximus* (L.) in Manx Waters. *Journal Marine Biological Association UK* **37**, 653–671.

Naidu, K.S. (1970) Reproduction and breeding cycle of the giant scallop *Placopecten magallanicus* (Gmelin) in Port au Port Bay, Newfoundland. *Canadian Journal of Zoology* **48**, 1003–1012.

Novoa, D., Mendoza, J., Marcano, L. and Cárdenas, J.J. (1998) Atlas pesquero marítimo de Venezuela. MAC-SARPA-Congepesca. Caracas, Venezuela, 197 pp.

Penchaszadeh, P. and Salaya, J.J. (1983) Reproduction and Gonadal changes in Laevicardium laevigatum (Mollusca: Bivalvia: Cardidae) of Golfo Triste, Venezuela. *The Veliger* **25**(4), 343–346.

Posgay, J.A. (1950) Investigation of the sea scallop, *Pecten grandis*. In *Third Report on Investigations of Methods of Improving the Shellfish Resources of Massachusetts*, Mass. Department of Natural Resources, Division of Marine Fisheries, pp. 24–30.

Reddiah, K. (1962) The sexuality and spawning of Manx Pectinids. *Journal of the Marine Biological Association, U.K.* **42**, 683–704.

Salaya, J.J. and Penchaszadeh, P.E. (1979) Pesquería de la vieira, *Pecten papyraceus* (Mollusca-Bivalvia), en Venezuela. In: J.B. Higman (ed.), *Proceeding of the Thirty – First Annual Gulf and Caribbean Fisheries Institute*. Miami, USA, pp. 105–126.

Salaya, J. J. and Penchaszadeh, P.E. (1980) Contribución al conocimiento de la reproducción de la vieira *Pecten papyraceus* en Golfo Triste, Venezuela. In *Actas II. Simposio de la Asociación Latinoamericana de Acuicultura*, México, pp. 846–870.

Vélez, A., Alifa, E. and L. Freites (1993) Inducción de la reproducción en la vieira *Euvola (Pecten) ziczac* (Mollusca: Bivalvia). Maduración y desove. *Caribbean Journal of Science* **29**, 209–213.

Waller, T.R. (1991) Evolutionary relationships among commercial scallops (Mollusca: Bivalvia: Pectinidae). In S. Shumway (ed.), *Scallops: Biology, Ecology and Aquaculture*, Elsevier, New York, pp. 1–72.

Yamamoto, G. (1953) Ecology of the scallop *Pecten yessoensis* Jay. *Scientific Reports of Tôhoku University*, Series 4, 20, II-32.

Yonge, C.M. (1951) Studies on the pacific coast Mollusks. III. Observations on *Hinnites multirugosus* (Gale). *University of California Publication, Zoology* **55**(8), 409–420.