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Synchronous development of the ovary and the female accessory sex glands of a crustacean, *Squilla holoschista*

M DEECARAMAN and T SUBRAMONIAM*
Department of Zoology, Sir Theagaraya College, Madras 600 021, India
*Department of Zoology, University of Madras, Madras 600 005, India

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Abstract. Based on the histology of the female accessory sex glands (cement glands) and the sequential appearance of their secretory products, four stages have been distinguished in the development of the cement glands in *S. holoschista*. This paper describes the various stages in ovarian development and correlates them to the cement glands activity. A further correlation between the ovarian and cement glands activity has been shown by statistical analyses. A possible endocrine mechanism regulating the synchronous activity of the ovary and cement glands is proposed.

Keywords. Female accessory sex glands (cement glands); Ovary; synchronous activity; *Squilla*.

1. Introduction

In recent years, much attention has been paid to the study of accessory sex glands of arthropods (Adiyodi and Adiyodi 1974). Many male insects utilise their secretion for spermatophore formation, sperm maturation, activation and transportation, formation of mating plug, egg maturation, oviposition, alteration of the mating behaviour, and also for production of fecundity-enhancing and receptivity-inhibiting substances (Leopold 1976; Gillot and Friedel 1977). Among arachnids, the Scorpionidea and the Pseudoscorpinoidea possess complex accessory reproductive glands, whose main function in the male is to form the chitinous spermatophore. Accessory sex glands of the crustacea have not been studied in any great detail. Specialized male accessory sex glands have been described from three crustacean groups (Fryer 1960; Wolfe 1971; Deecaraman and Subramoniam 1980a). Some female crustaceans possess cement glands which secrete a dense mucoid substance necessary for agglutination and also for holding the eggs together after laying (Yonge 1937; Lloyd and Yonge 1940; Mason 1970).

In some decapods, Lloyd and Yonge (1940) reported synchronous development of the ovigerous setae and ovary. A relationship between cement glands development and ovarian maturation is known to exist in crayfishes (Stephens 1952). In *S. mantis*, for instance, Do-chi (1975) recorded a cyclic activity of the cement glands correlated to vitellogenesis. Recently, Deecaraman and Subramoniam (1980b) reported four stages in the activity of the cement glands of *S. holoschista*. This paper deals with the developmental stages of the ovary in relation to the developmental stages of female accessory sex glands (cement glands) in *S. holoschista*.

2. Materials and methods

S. holoschista, used in the present study, was collected from the Madras coast. For routine histological studies, the ovaries and cement glands were fixed in Bouin's fluid and 10% neutral buffered formaldehyde. Sections (6 μm thick) were stained in haemotoxylin of Delafield, Ehrlich, Mallory's and Mason's.

From histological and squash preparations, the cement glands and ovaries were classified into four stages depending upon their size, and the presence or absence of cytoplasmic inclusions. The oocytes and cement glands were measured taking the average of their longest and shortest axes. For each stage of the ovarian and cement glands development, 50 measurements were made and the average calculated and plotted in the histogram. The data obtained were subjected to statistical analyses.

3. Results

The cement glands are found as dense white patches in the mature female on the ventral side of the sixth, seventh and eighth thoracic segments. In the spent female, the cement glands are shrunken and not visible externally. To follow the sequential changes in the structure and chemical composition of the cement gland, its growth was divided into four stages (Deecaraman and Subramoniam 1980b), a categorization also used in the present study.

3.1 *Ovarian development stages*

The ovarian development of *S. holoschista* has been arbitrarily divided into four stages based on oocyte diameter and histological characteristics, which compared well with developmental stages of the cement glands.

3.1a *Stage I:* In this stage, the ovary is thin, fragile and white-to-cream coloured, with black pigments over its surface. Each oocyte measures 8.58 μm in diameter and is elliptical in shape. The nucleus (4 μm across) occupies a major portion of the oocyte. The ooplasm which is scarce forms a thin rim over the nucleus. The chromatin granules are found towards the inner surface of the nucleus (figure 1). This stage corresponds to the first developmental stage of cement glands.

3.1b *Stage II:* The ovary is faint yellow in colour. The black pigmentation which was conspicuous over the surface of the ovary in stage I is now much reduced. The oocytes are larger (27.12 μm) in diameter but the nucleus is smaller (3 μm). The ooplasm now occupies more space than the nucleus and is provided with yolk granules. The chromatin granules are still visible. This stage corresponds to the second stage of development of the cement glands.

3.1c *Stage III:* The ovary which is yellow and large extends profusely on either side of the thoracic and abdominal segments and forms lateral diverticulae. The oocyte measures 45.62 μm in diameter; the nucleus is very much reduced and measures only 2 μm. At this stage, the oocytes lose their spherical shape; the ooplasm occupies more space and is filled with yolk granules and globules. This stage is comparable to the third stage of development of the cement glands.

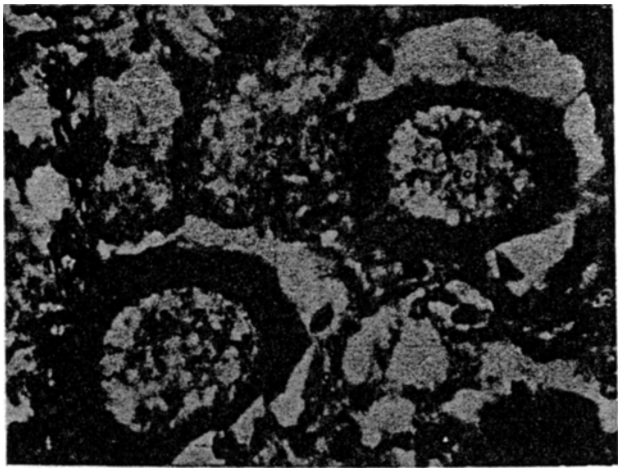

Figure 1. Transverse section of the ovary to show the oocytes at stage I. Stained in Ehrlich's haematoxylin (× 1125).

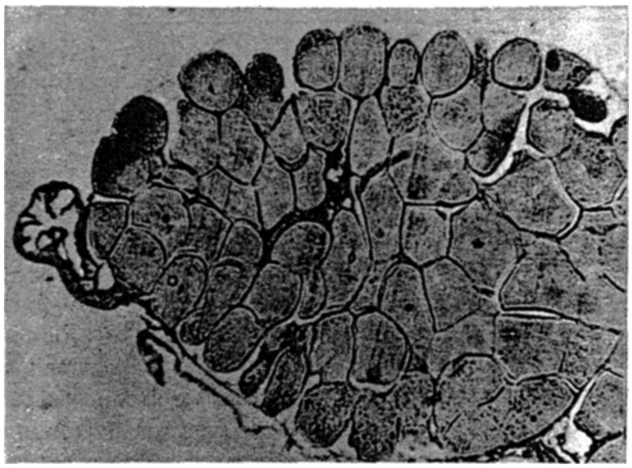

Figure 2. Transverse section of the ovary to show the oocytes at stage IV. Stained in Ehrlich's haematoxylin (× 250).

3.1d *Stage IV:* The ovary is bright golden yellow; the oocytes measure 53.42 μm and the nucleus only 2 μm in diameter (figure 2). The cytoplasm is filled with yolk granules and globules. This stage corresponds to the fourth stage of development of the cement glands.

The data obtained from the developmental stages of ovaries and cement glands were subjected to statistical analyses. The analysis of variance (*f*-tests) reveals significant growth between all the stages of oocytes as well as cement glands (table 1). Table 2 shows that growth in the means of the oocyte as well as cement glands for any pair of stages is significant, suggesting synchronous development of both the organs (figure 3).

Table 1. Growth in the stages of oocytes and cement glands (50 samples of each stage).

Material		Stages			
		I	II	III	IV
Mean and standard deviation.					
Oocytes		8.58±1.787	27.12±2.312	45.62±6.786	53.92±5.791
Cement glands	A	14.38±1.925	20.92±1.432	24.24±3.240	35.05±4.668
	B	13.64±4.500	16.72±2.940	32.16±2.962	29.52±2.844

Value of *f* observed: oocytes, 6.975; cement glands A, 233.24; cement glands B, 290.55;
Value of *f* calculated in all cases was 2.67.

Table 2. Showing further significant growth of oocytes and cement glands.

	Oocytes stages	*t* (observed)
A	Stage first oocytes	20.4674
B	Stage second oocytes on third	15.0231
C	Stage third oocytes on fourth	5.5063
	Cement glands stages	
A	Stage first A type gland on second	11.731
B	Stage second A type gland on third	3.7935
C	Stage third A type gland on fourth	11.4905
D	Stage first B type of gland on second	3.9039
E	Stage second B type of gland on third	9.9203
F	Stage third B type of gland on fourth	13.050

Value of *t* (expected) in all cases was 1.96.

4. Discussion

The present study has shown a relationship between stages in development of the ovary and stages in the activity of cement glands, suggesting a close synchrony in the function of these two organs in *S. holoschista*. Similar synchrony in development of the cement glands and ovary has been reported in crayfish and *S. mantis* by Lloyd and Yonge (1940), Stephens (1952) and Do-chi (1975). Experiments involving eyestalk ablation and thoracic ganglia extract injection have indicated hormonal influences in development of the ovary and cement glands in *S. holoschista* (Deecaraman and Subramoniam 1979). Identical results were also obtained by Stephens (1952) in different species of *Procambarus*. In the Crustacea, the ovarian hormone influences the appearance of permanent as well as temporary (blood-related) secondary sexual characters (Lloyd and Yonge 1940; Adiyodi and Adiyodi 1970; Mason 1970). Further,

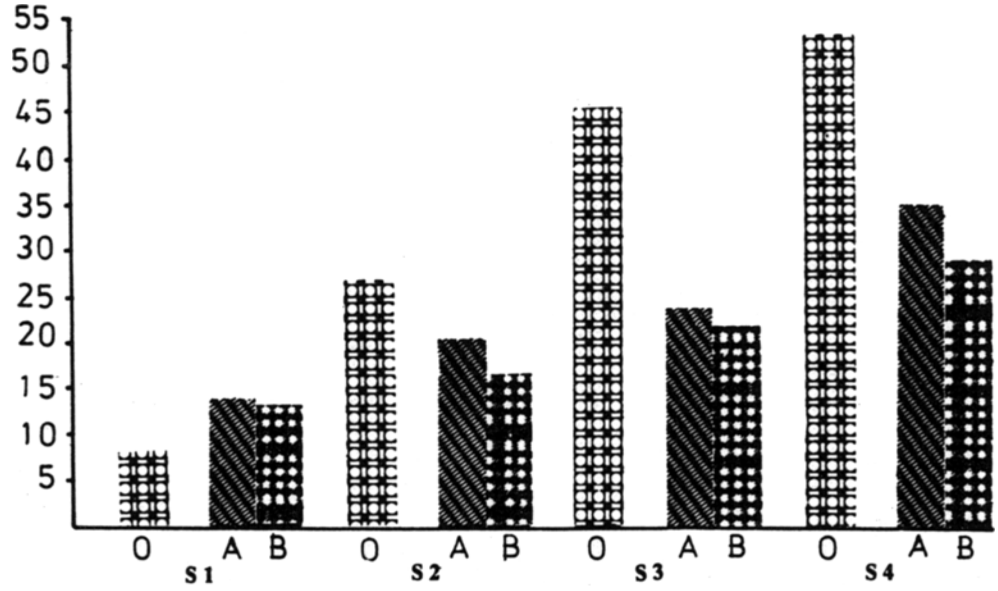

Figure 3. Histograms representing comparative developmental stages of oocytes and A and B type of cement glands. Stages—1, 2, 3 and 4.

these temporary secondary sexual characters appear only during the breeding season as they are apparently under the control of a hormone produced by the maturing ovary (Adiyodi 1978). Activity of cement glands in stomatopod crustaceans, correlated to ovarian maturation may be considered as a temporary secondary sexual character (Deecaraman 1980c). But in view of the parallel development of the ovaries and cement glands it is unlikely that an ovarian hormone may be involved in the initiation of cement gland development. The synchronous development of the ovaries and cement glands in *S. holoschista* suggests that endocrine regulatory mechanisms exist that serve to correlate cyclic development of the ovaries and cement glands.

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