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Studies on the Neurosecretory Cycle in the Eyestalk of the Shrimp *Metapenaeus brevicornis* During Ovary Maturation and Spawning

J. MARTIN SANTHA KUMAR

C/- Department of Fisheries
135 Pirie Street
Adelaide 5000, Australia

Abstract

Histological studies of the neurosecretory cells (NSC) in the eyestalk of *Metapenaeus brevicornis* have revealed a secretory cycle regulating the reproductive state such as vitellogenesis, spawning and recovering. High secretory activity of the NSC was observed during spent-recovery and recrudescence. Different modes of release of neurosecretory materials from NSC were observed.

Introduction

It is known that the crustacean eyestalk, brain or supraoesophageal ganglion, thoracic ganglion, and abdominal and visceral ganglion are neurosecretory in function. Induced maturation and spawning by eyestalk ablation is now practiced routinely, although very little is known about the structural and physiological changes that occur in the neuroendocrine system operating under these circumstances.

Smith and Naylor (1972) reported six types of neurosecretory cells (NSC) during intermolt of male and female *Carcinus maenas* based on size, location, appearance and method of secretion of material released from the perikaryon. Studies on the ultrastructure of the sinus gland of the fidler crab *Uca pugnax* revealed five types of neurosecretory axon terminals which are identified on the basis of size, shape and electron density of granules within the axons. The structure and organization and types of neurosecretory cells of the central nervous system of other crustaceans have been studied by neurosecretion, details regarding mean and standard deviation of the ova diameter by considering all ova and stages of ovary maturation are presented in this paper.

The amount of neurosecretory material in the perikarya of the NSC was determined using the five-degree arbitrary scale, as modified by Peter and Gorbman (1968). In order to determine the degree of activity of the NSC, the percentage of cells with few neurosecretory granules was calculated as suggested by Mieszowska and Jasinski (1973). In the present study such cells are termed 'degranulated'.

Results

The NSC present were found to be positive to chrom-alum-hematoxylin-phloxin and stained purple blue irrespective of size. Monthly percentages of degranulated NSC in the eyestalk with stages of secretory cycle on Jasinski's scale and monthly mean ova diameter in relation to the stage of ovarian maturity are shown in Figs. 1, 2 and 3, respectively.

The NSC pathway leading from the medulla terminalis to the medulla externa could be traced (Fig. 4). In the vicinity of the sinuses, discrete groups of large, medium and small NSC were

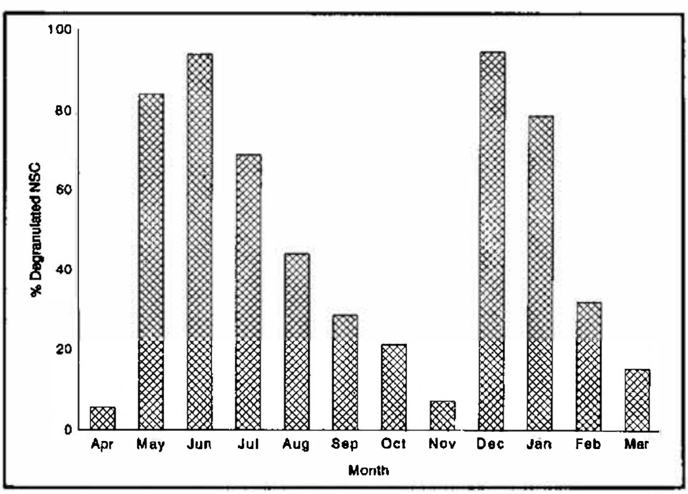

Fig. 1. Monthly percentage of degranulated NSC found in the eyestalks of *Metapenaeus brevicornis*.

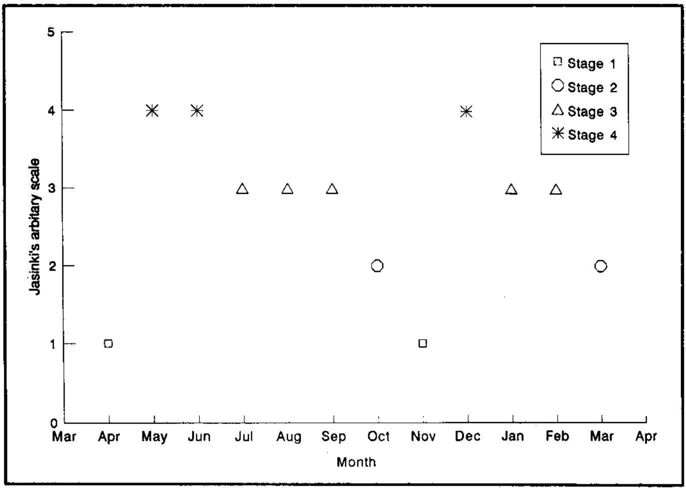

Fig. 2. Stages of neurosecretory cycle in *M. brevicornis* according to Jasinski's scale.

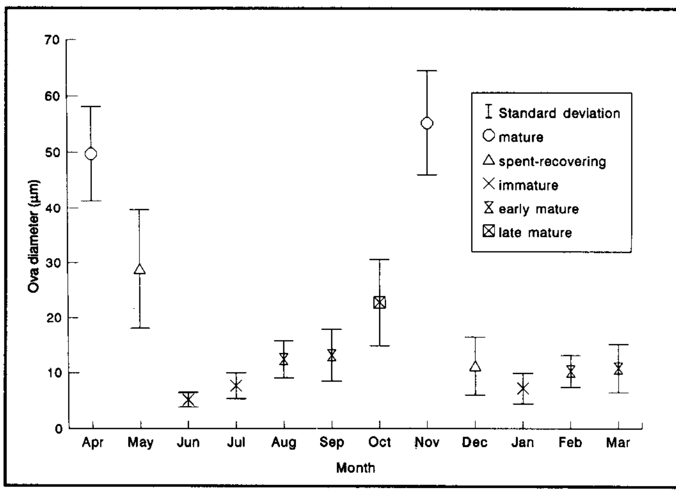

Fig. 3. Monthly mean ova diameter and ovary maturation stages of *M. brevicornis*.

Fig. 4. Longitudinal section of eyestalk showing lamina ganglions (LG), medulla externa (ME), medulla interna (MI), medulla terminalis (MT) and NSC (arrow), 40X.

observed (Figs. 5-6). Some of the large NSC were oval with centrally located nucleus and chromatin. The medium size NSC were round with an oval nucleus. Small NSC were also round.

Cyclic secretory activities were observed. The NSC exhibited remarkable stages during the cycle. A high secretory stage with prominent discharge and maximum percentage of degranulated cells was observed during May, June, December and January (Figs. 1, 5, 6). In April and November the NSC were compactly arranged, densely filled with granules and the minimum percentage of degranulated NSC was recorded (Fig. 7). The NSC population was loose, but filled with neurosecretory material during September, October and March (Fig. 8). During July, August and February the NSC exhibited prominent nuclei (Fig. 9).

On the other side of the medulla externa, two small groups of NSC with all three types of cells were located (Figs. 10-11). Some cells exhibited degenerative structures. Purple blue granules were noticed in the pathway to the sinus gland (Fig. 12). Both axonal and peripheral discharges of neurosecretory material were also observed (Fig. 13).

Fig. 5. Longitudinal section of eyestalk showing release of neurosecretory material (arrow) and degeneration of NSC (D), 240X.

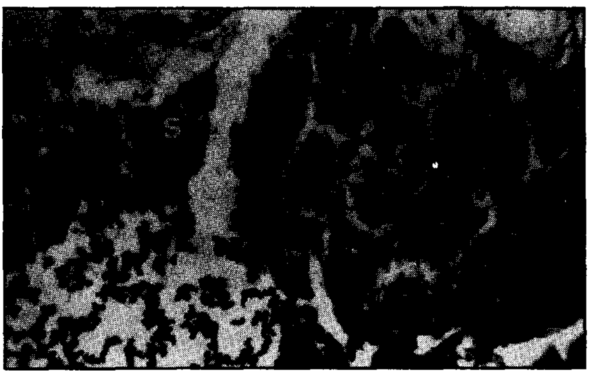

Fig. 6. Magnified view of Fig. 5 showing different size and shape of NSC type: large type (L), medium (M) and small (S). The arrow showing degranulated cells and vacuole (V), 400X.

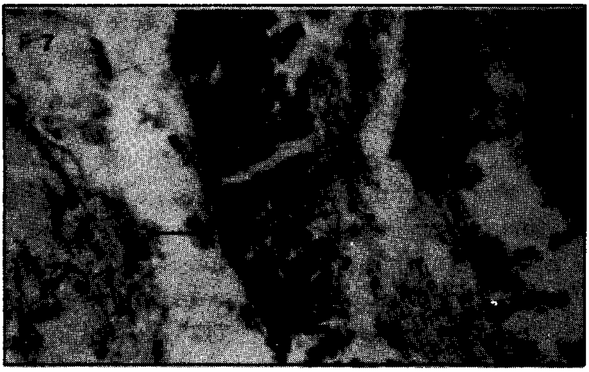

Fig. 7. Longitudinal section of eyestalk showing compactly arranged, densely filled NSC. The nucleus is not clear, 400X.

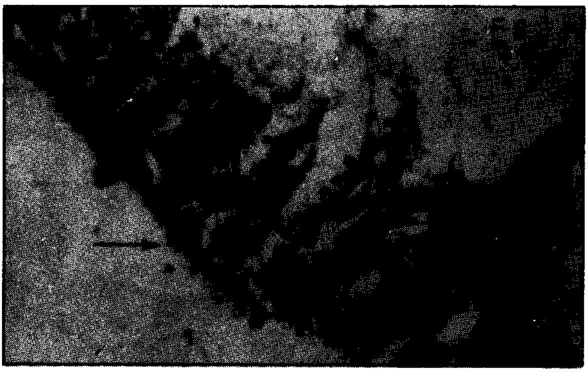

Fig. 8. Longitudinal section of eyestalk showing loosely arranged but densely filled NSC. Nucleus is not clear, 400X.

Fig. 9. Longitudinal section of eyestalk showing small (S) and medium (M) NSC with prominent nuclei and degenerative changes, 400X.

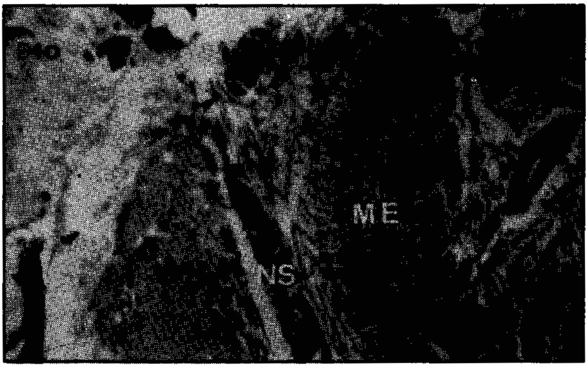

Fig. 10. Longitudinal section of eyestalk showing near medulla externa (ME) two small groups of NSC (arrow), 100X.

Fig. 11. Magnified view of Fig. 10 - small groups of NSC: showing large, medium and small NSC (arrow) with prominent nuclei and degenerative changes (D), 400X.

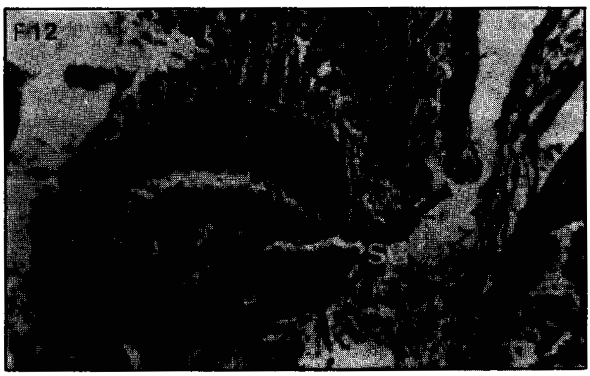

Fig. 12. Longitudinal section of eyestalk showing sinus gland (SG), 100X.

Fig. 13. Longitudinal section of eyestalk showing the axonal (A) and peripheral (P) discharges of neurosecretory material, 100X.

Discussion

The histological study of the eyestalk NSC of *M. brevicornis* clearly indicated two peaks in their secretory activity in one year, which coincided with two reproductive cycles. Their secretory activity was high in May-June and December-January and in the following months it decreased and reached a minimum in November and April when the peak of vitellogenesis occurred.

Matsumoto (1958) reported that seasonal changes in the neurosecretory activity of five species of crabs showed a close relationship with ovarian development. In crustaceans, vitellogenesis was accelerated when the eyestalks were extirpated in mature females (Sehnal 1971). The presence of an ovarian growth inhibitor in the endocrine section of *Sphaeroma serratum* (De Hureaux 1971) and *Crangon crangon* (Kleck-Kawinska and Bomirski 1975) were also reported. Isolation and characterization of a vitellogenesis inhibiting factor from the sinus gland of the lobster *Homarus americanus* was described by Soyez et al. (1987).

In *M. brevicornis,* oocyte development and maturation were observed throughout the year and least neurosecretory activity was noticed when ova diameter was maximum. The initial oocyte development phase and the spent-recovery phase showed high secretory activity in the eyestalk. Thus, the neurosecretory activity possibly controls ovarian maturation. The eyestalk neurosecretory system of other shrimps and crabs shows histological cycles associated with the oocyte development (e.g., Highnam and Hill 1969). The percentage change of degranulated NSC of eyestalks of *M. brevicornis* indicated the degree of secretory activity throughout vitellogenesis suggesting the possible influence on ovulation. It is therefore suggested that the cyclic secretory activity of NSC controls the timing of ovarian maturation and spawning. However, the NSC secretory activity may be stimulated by environmental conditions. The two peak periods of vitellogenesis fell before winter (unpubl. data), and it is therefore possible that temperature coupled with the other environmental factors plays an important role in the rhythmic secretory activity of NSC.

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