J. mar. biol. Ass. India, 1992, 34 (1 & 2) : 222-230

STUDIES ON THE COMMON ROCKY EGYPTIAN CHITON *ACANTHOPLEURA GEMMATA* (MOLLUSCA : POLYPLACOPHORA) IN THE NORTHWESTERN RED SEA

FATHEY EL-SAYED SOLIMAN AND TITO NAEIM HABIB

Department of Zoology, Faculty of Science, Sohag, Assiut University, Egypt

ABSTRACT

In the present study on *Acanthopleura gemmata* (Blainville, 1825), rectification of the species name, its distribution and abundance in the northwestern part of the Red Sea, and the intraspecific variation within intermittent subpopulations have been achieved. Within each natural population, two forms, one banded and the other non-banded have been distinguished. The main differences in shell characters, girdle elements and radula features of the two forms have been investigated.

INTRODUCTION

THE POLYPLACOPHORAN *Acanthopleura gemmata* is one of the commonest in the rocky intertidal area in the Indo-Pacific province (Ferreira, 1986). Several studies on polyplacophorans have been carried out on the coastline of the Red Sea (Fretter, 1937; Gunnar and Rupert, 1981; Iredale and Hull, 1923, 1927). In these studies ten species of chitons have been recorded, but their identification and description were to some extent poor, as most of the authors agreed that the largest and most common species are those related to genus *Acanthopleura*. Savigny (1827) restricted and classified the common large Egyptian chiton under the name of *Oscabrion* sp. Abd El-Moneim (1983) made an extensive study on the morphology and macroanatomy of the common banded Egyptian chiton and named it as *Acanthopleura spiniger*. But he did not recognized that every *Acanthopleura* species population has two forms, one with banded girdle (which he described) and the other with unbanded girdle that he neglected.

In this study the distribution and abundance of the two forms along the Egyptian coastline has been recorded and morphometric data on specimens from several populations including the two forms, have been obtained to evaluate, if these forms are intraspecific varieties or they are distinctly two different species.

The authors wish to express their gratitudes to Prof. Dr. Ahmed A. El-Samahy, Vice-President of Assiut University (Sohag), Dr. Mohammed M. Ibrahim, Dean of Faculty of Science (Sohag) for providing facilities during the course of this study. They also thank to all members of the Department of Zoology for their valuable help and encouragment. Special thanks to Mr. Khalaf Aly and Mr. Mohammed Ibrahim for their good assistance.

MATERIAL AND METHODS

Sampling was carried out along the coasts of the Northwestern part of the Red Sea; from north of Marsa Alam City to north of

..da City, Egypt (Fig. 1), during December 1986 to January 1989. Collections were done at 10-20 km intervals and where the coast is accessible for sampling. The specimens were collected from the supralittoral to the lower mid inter-tidal zones during the low tide at day time, using a sharp knife to release the specimens from the big rocks, dead coral blocks and large stones. To lift the stones

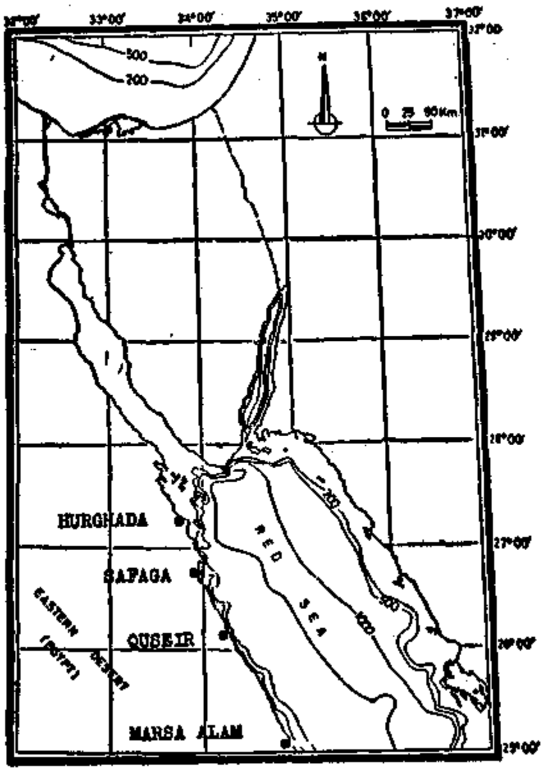

FIG. 1. The study area along the coast of the northeastern part of the Red Sea.

a stick with three metal hooks was used and both the rocks and coral blocks were returned back to their original position to maintain the chiton populations unharmed.

The collected specimens were kept in labelled plastic container containing sea water. Some of the collected specimens were preserved in 10% formalin in sea water, while the others were left for observing and recording the natural colour of the shell valves and girdle. Morphometric characters were measured using a vernier calliper with a minimum limit of 0.1 mm.

In the field, just before removing the specimens from rocks and stones, the whole length and width of each specimen, the total length of the shell valves, and the width of the fourth valve were measured. In the laboratory, the previous field data were repeated on preserved specimens. Besides, the absolute measurements of the anterior and posterior valves after disarticulating them from their individuals, diameters and distributions of ocelli on the surfaces of shell valves, upper-surface and lower surface girdle elements (spinelets and scales) and the teeth of the radular organ were recorded. The latter were measured using a Binocular Research Microscope provided with micrometer eyepiece. Drawings and photographs were made using a Camera Lucida and Photo-camera, attached to the above mentioned microscope.

Results

Acanthopleura gemmata (Blainville, 1825)

General body form

The collected specimens were oval in shape, roundbacked and bilaterally symmetrical. The average width/length of the adult specimens is 0.6 (SD = $\pm$ 0.1, n = 131). No sexual dimorphism was recorded in the investigated specimens although there was two colour patters within the species populations. (Fig. 2 and 3 a, b).

Shell

As in all Polyplacophora, the shell is made up of eight articulated overlapping calcareous plates or valves which are very thick and robust. The anterior plate (I) which overhangs the mouth and the posterior plate (VIII) which overhangs the anal aperture, are semicircular, while the six intermediate plates (II-VII) are roughly rectangular (Fig. 4 a, b). The eight valves arranged in a single continuous series forming a solid oval armour over the dorsal body wall (Fig. 3 a, b). A transverse section of one of the plates (Fig. 5) reveals several layers, two of which are of special taxonomic interest. These are the tegmentum or outer layer which may be differently coloured

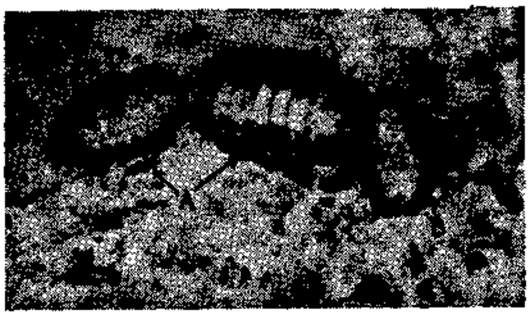

FIG. 2. *Acanthopleura gemmata* (Blainville, 1825): a. Banded form and b. Non-banded form.

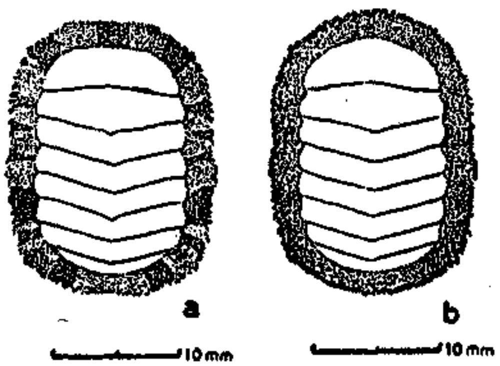

FIG. 3. *Acanthopleura gemmata*: a. Banded form and b. Non-banded form.

and sculptured, and the whitish innermost non-porous layer, 'the articulamentum' which is an intercalation within the hypostracum. The articulamentum serves for a better insertion of the shell plates in the perinotum. Examination of the tegmentum of the plates showed a grayishgreen to grayishbrown colour, the tegmentum of the anterior shell plate has only one anterior region, while that of the intermediates have one median (jugum) and two lateral areas (Fig. 4 a). Each of the latter has two regions which are not always easily distinguishable, but sometimes can be defined into an inner small triangular part (pleura) and an outermost smaller rectangular part (lateral). The tegmentum of the posterior plate (VIII) has almost a raised central apex (mucro) and divided into two areas, one is upper to the mucro (central) and the other postmucro (posterior).

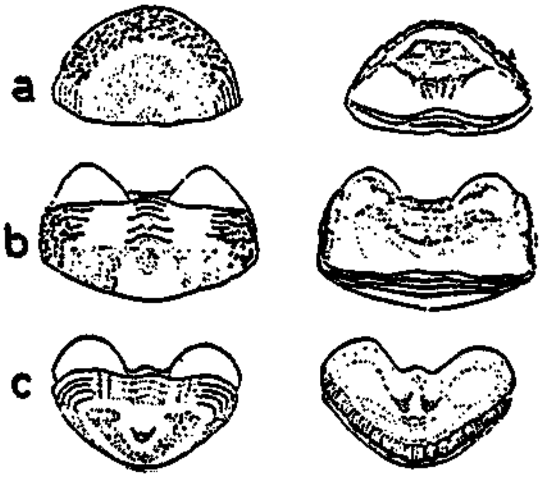

FIG. 4. Dorsal (left row) and ventral (right row) views of: a. The anterior valve, b. intermediate valve and c. posterior valve of both forms of *Acanthopleura gemmata*.

Anterior valve and postmucro area of posterior valve are similarly sculptured with round to elongate granules, in addition to a number of longitudinal white streaks on the anterior valve (Fig. 4 a).

Central areas of the intermediate and the posterior valves are almost featureless, but the pleural ones have smaller to obsolete (vestigial) granules, and thin, well-defined, transverse lamellae appressed across jugal areas of the intermediate valves.

In small specimens, mucro of the posterior valve is central, but somewhat posterior in larger individuals, while postmucro is strongly convex in both small and large specimens.

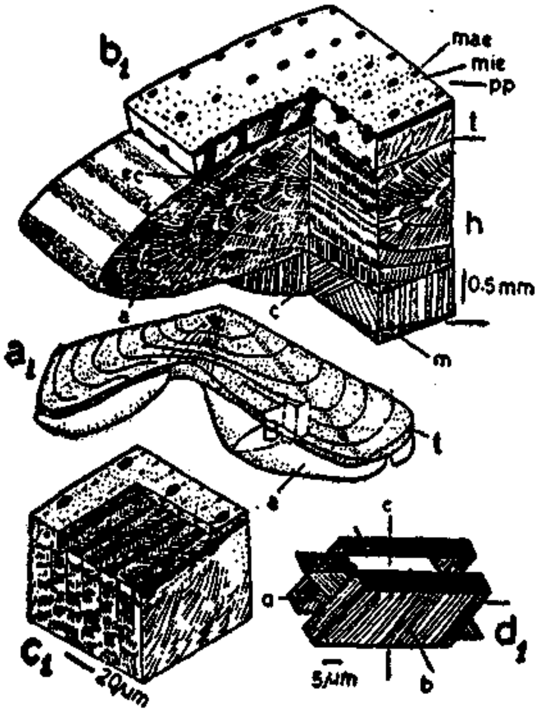

FIG. 5. Morphology of an intermediate shell valve (after Hass, 1976) : a_1. whole plate, b_1. block diagram showing the shell layers, c_1. block diagram of the tegmentum and d_1. crossed lamellar structure of the hypostracum with crystallographic axes (a, b, c). a - articulamentum, c - crossed lamellar structure of the hypostracum, ec - esthete canal, h - hypostracum, m - myostracum, mae - macresthete, mie - micresthete, t - tegmentum and pp - pro-periostracum.

The averages of the tegmental length and width of valve I and VIII, are 0.52 (± 0.06 and 0.46 (± 0.07) respectively, the mean of the tegmental widths of valve I/VIII is 1.0 (± 0.08).

Occasionally, even without the aid of magnification, one can detect small dully pigmented to darkish glossy dots on the dorsal side of the shell plates in both banded and unbanded forms called ' micrethetes and macrethetes ', having a similar distribution patterns (Fig. 4, 5). These are perforations containing a terminal caps of a highly sensitive nervous epidermal stands, round to oval in shape, range from 43.4 to 73.4 μm in diameter, randomaly distributed on the anterior valve, postmucro area of the posterior valve, and the anterior parts of lateral areas of each intermediate shell valve.

The articulamentum of each shell valve including the two forms is larger than the tegmentum. Its colour varies from brown to bluish brown. As we proceed, extensions of the articulamentum (insertion laminae) are preserted on the anterior edge of anterior valve, on the posterior edge of posterior valve, and on the posteriolateral edges of intermediate shell valve (Fig. 4 b).

Insertion teeth irregularly spaced, sometimes fused together. On valve I, these are divided into nine to twelve teeth by eight or eleven slits, seven to eleven poorly defined teeth on valve VIII, resulting from incomplete slits, particularly towards the midline; teeth of posterior valve often recurved forwards and fused anteriorly to put an extension beyond buttressing, transverse and round ' callus '. The intermediate shell valves are similar in both forms in having two lateral insertion teeth on each side. Slit formula (not always clearly determinable) are nearly constant in the two forms, 7/11-1-6/10. In midline, the mean of the insertion plate length/tegmental length is 0.19 (in both forms). Anterior extensions of the articulamentum on the intermediate and anal valves are termed ' sutural laminae ' each of which is well developed and covered by the valve in front. In the two forms, these are subtriangular on valve II to subrectangular on valve VIII. The sutural laminae of each of intermediate valves are separated from each other by a smooth semicircular groove (jugal sinus). Sinus plate is mostly smooth. The ratio of sinus width/width of sutural lamina of valve VIII are equal in both forms 0.86.

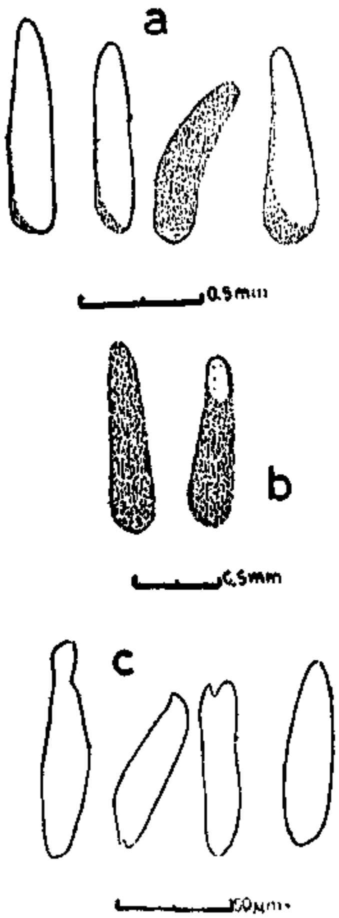

FIG. 6. Girdle elements : a. Girdle upper surface spinelets of the banded form, b. Girdle upper surface spinelets of non-banded form and c. Needle like elements of the two forms.

Girdle

Girdle is thick, flexible, muscular, wide, often banded in most individuals exhibiting the common form, unbanded in few individuals exhibiting another form (Fig. 3 a, b). it encircles the shell valves which studded with white to dark gray, brown, or black spinelets. The latter are pointed, blunt, straight to curved, somewhat conical (Fig. 6, 7) and measure 1.1 mm ($\pm$0.2) in length and 0.2 mm ($\pm$ 0.04) in width, with smaller to minute spinelets between them.

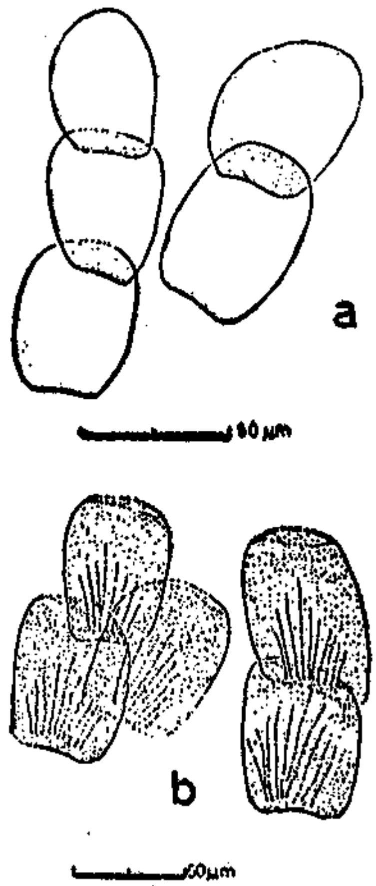

FIG. 7. Girdle lower surface scale of *A. gemmata* : a. in the banded form and b. in the non-banded form.

In some individuals of the two forms, pointed; crystaline, and needle-like elements (Fig. 6 c), with diameters of 70×20 μm are present. These are found isolated or in clusters interspersed amidst spinelets. Girdle bridges often free from spinelets or any other elements.

Undersurface paved with imbricate, transparent to black scales in the common form (Fig. 7 a) and only black in the second form, rectangle to squarish in both forms, about 56×41 µm. These scales have radiating striations from the basal edge of each scale towards the outer margin in specimens of the second form only (Fig. 7 b). Gills are similar in both forms, with 52-70 plumes on each side.

Radula

In both the forms; radula averaging 39% of specimen length (range 35-49%, SD = 1.73%, n = 18); extends within the radular sac. The teeth of the radula are arranged in 63 successive transverse rows of mature teeth (range 45-85, SD = 1.6%, n = 18). Each row is 'stepped' or V-shaped, with each tooth anterior to the next most distal tooth one.

among them from station 5 (Fig. 1). The width of the median tooth at anterior blade is 110 µm; first lateral teeth about 500 µm long, 320 µm wide at anterior blade; L_2 pair or the major lateral teeth (the main working teeth) bear highly magnetized dark caps, each has a relatively broad unicusped blunt black blade with its pointed and thin end, directed towards the radular center. It measures 360 µm in greatest width. Also the major lateral teeth have a tubercle of about 200 µm long as a nearly triangular knob in shape, protruding from the inner edge at a level close to the head; outer marginal teeth is 370 µm high and 260 µm wide (length/width 1.4).

Distribution and Abundance

The species are confined to the intertidal zone, from the upper neap tide to lower neap tide, especially at the mean water tide level. The data show that the highest densities

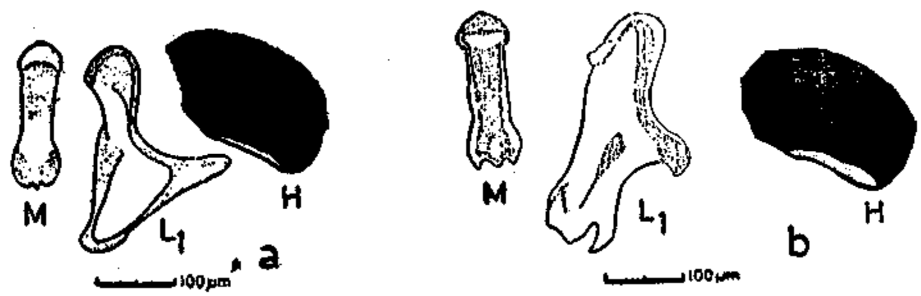

FIG. 8. Radula structure of *A. gemmata*: a. banded form, b. non-banded form L_1, H and M are: first lateral, head of major lateral and median tooth respectively.

As in all polyplacophorans, there are eight lateral teeth (L_1 to L_8) on each side of the median or 'central' tooth (M). The teeth are attached to an elastic radular membrane. The L_2 and L_5 pairs are the most elongate ones.

Radular features (Fig. 8) rather constant in both forms with no significant difference

occur in north stations, especially stations 7 (18.3/m²), while decrease in northernmost stations (0.1/m²) near to the mouth of the Suez Gulf (Fig. 9).

Remarks

The two forms in *Acanthopleura* species are extremely similar in radula features, but some differences in their structures are also noted

(Fig. 8 a, b). The central tooth which has a nearly rod-like shape with a proximal broad triangular base of attachment, supported by three basal knobs (teeth) and a sharp broad blade in the banded form, but in the unbanded one the base of attachment supported by one basal knobs (teeth) and free and provided with a sharp narrow blade.

The Major lateral tooth: provided with a tetragonal inner edge in the unbanded form rather than one pointed end in the banded form.

Discussion

The genus *Acanthopleura* comes under the subfamily Acanthopleurinae (Van Belle, 1983),

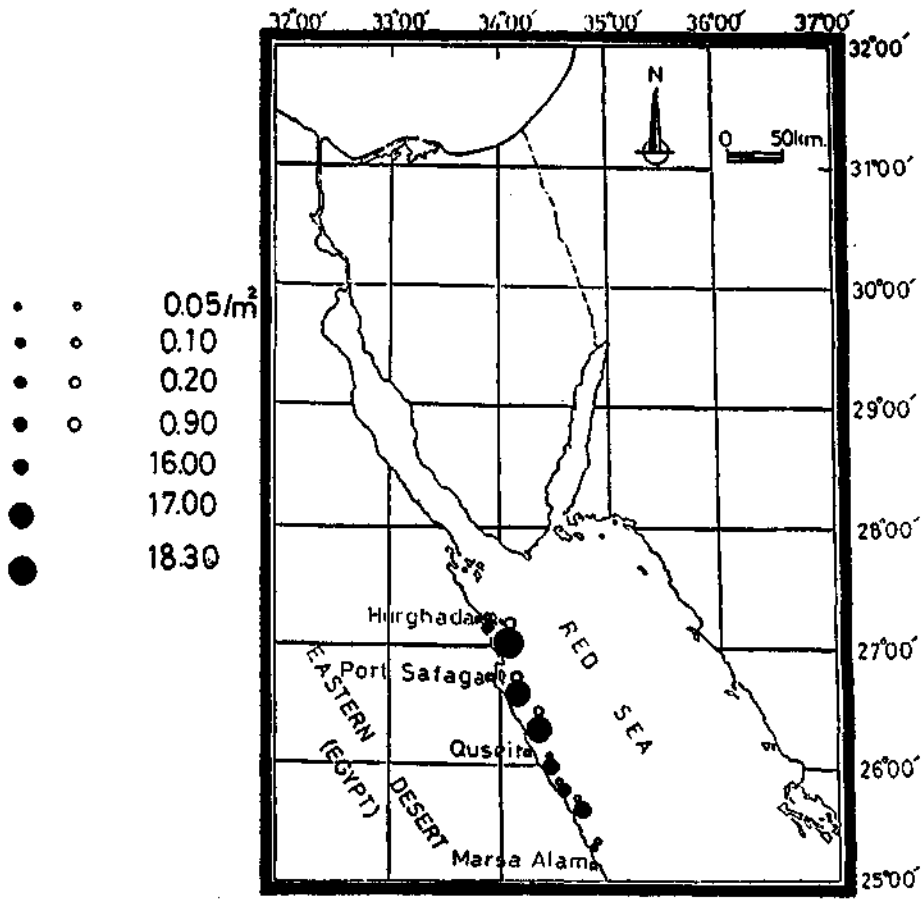

Fig. 9. Distribution and abundance of the banded and non-banded forms of *A. gemmata*. Solid and open circles denote to the banded and non-banded forms respectively.

The 1st lateral teeth: with a concave and a convex base of attachment for the banded and unbanded forms respectively. In the former, there is a basal pointed end towards the outer edge and a stronger sharp blade at the free end.

with the genera *Liolopleura*, *Enoplochiton* and *Squamopleura* suppressed as synonyms.

Acanthopleura attains greatest species diver sity in the Central Indo-Pacific (Ferreira 1986). In the 'fertile triangle' (Briggs, 1974) of the Indo-Malayan region (Ekman, 1953), with a 'center of origin' at Taiwan where five species (*A. spinosa, A. gemmata, A. japonica, A. miles* and *A. loochooana*) have been recognized (Ferreira, 1986). The differential diagnosis of *Acanthopleura* species may be quite difficult at times, particularly when one is faced with species with such a wide geographical distribution.

The commonest chiton species of *Acanthopleura* in the Red Sea was studied by some authors under different names as, *Acanthopleura vaillanti* (Rochebrune, 1882) from the Gulfs of Suez and Aqaba, *A. spiniger* (Abd El-Moneim, 1983; Guirguis, 1978) from north of Hurghada and Qusier, *A. haddoni* (Gunnar and Rupert, 1981; Winckworth, 1927) from Aden and Barim Island, Yemen.

Most of those authors erected their identification of the species on its external morphology and macro-anatomy. Recently, revision of the genus *Acanthopleura* by Ferreira (1986) depending on the morphometric data revealed that the most common species, present virtually everywhere in the tropics is *A. gemmata*.

In this study, all the morphometric data obtained for specimens from different localities along the Egyptian coastline in the Red Sea agree with Ferreira's conclusion on *A. gemmata*, but examination of several *A. gemmata* populations revealed that some diagnostic characters are present among the individuals of the same population, these characters are summarised as follows :

1. There are two coloured forms, one with banded girdle and high density and the other non-banded with low density ; the girdle of the banded form is provided with dark gray, brown, to black spinelets alternating with a white spinelets in between, a character used by Haddon (1886) for the differentiation of the genus *Acanthopleura*, but the girdle of the non-banded form in the same population has only brown to black spinelets.

2. In both forms, posterior valve has well developed insertion teeth with 6-10 slits in between, a single major feature for the differentiation of *A. gemmata* from other species as *A. japonica, A. gaimardi* and *A. hirtosa* in temperate waters (Ferreira, 1986).

3. There are no significant differences in the morphometry between the two forms and that of *A. gemmata* described by Ferreira (1986).

4. The distribution of ocelli (light sensitive organs) are the same in both forms.

5. Lower surface girdle elements (scales) have the same dimensions in both forms, but with a darker colour and some striations in the non-banded form.

6. Measurements of radular teeth are remarkably constant in the two forms with the exception of some differences in their structural features (Fig. 8 a, b).

From the previously mentioned articles, we can conclude that the common Red Sea large chiton species relates to *A. gemmata* described by Ferreira (1986) and the variations of some diagnostic characters of the individuals within their populations may be intraspecific-variations, unless further cytogenetic investigations show otherwise.

Concerning the distribution of *A. gemmata* in the Red Sea, it was recorded by Pears, (1978) and Rochebrune (1882) in the Gulfs of Suez and Aqaba, Abd El-Moneim (1983) and Guirguis (1978) from north of Hurghada and Qusier, Winckworth (1927) from Aden and Barim Island ; Yemen and in Elat, Gulf of Aqaba (Ferreira, 1983). These records may give an indication that the species has an intermittent distribution in the Red Sea, but this study revealed that the species has a continuous distribution pattern, at least in the North-western part of the Red Sea, and where a suitable intertidal habitat is available. The species is always confined to the rocky shores in the intertidal zone 0-2 m. along the Egyptian coastline in the Red Sea, with specimens often exposed at low tide, especially at mean water tide level. Also the density of the species increases as one proceeds from south of Marsa Alam City to northern part of the Red Sea, then decreases again at stations lying north to Hurghada City, and this may agree with the conclusion of Pearse (1983) that the Gulf of Suez environment apparently places extreme physiological stress on northern Red Sea biota.

References

Abd El-Moneim, H. A. 1983. Morphological studies on a marine polyplacophoran species in Egypt *Acanthopleura spiniger* (Sowerby, 1839). MS. Thesis, Assiut University, Egypt. 130 pp.

Blainville, H. D. De 1825. Oscabrion. *Chiton*, 36: 519-55. *In*: F. Cuvier (Ed.) Dictionnaire de Science Naturelles, Paris & Strasbourg, 60 Vols.

Briggs, J. C. 1974. *Marine zoogeography*. Mc Graw-Hill, New York. 475 pp.

Ekman, S. 1953. *Zoogeography of the Sea*. Sidgwick and Jackson, London (1967 edition). 417 pp.

Ferreira, J. A. 1986. A Revision of the Genus *Acanthopleura* Guilding, 1829 (Mollusca: Polyplacophora). *The Veliger*, 28 (3): 221-279.

Fretter, V. 1937. The structure and Function of the alimentary canal of some species of Polyplacophora. *Trans. Roy. Soc. Edinb.*, 59, I, 4: 119-164.

Guirguis, N. A. 1978. Studies of the chitons of the Red Sea at Al Ghardaqa. MS. Thesis, Mansoura University, Egypt. 101 pp.

Gunnar, B. and O. Rupert 1981. *Red Sea coral reefs*. Westerham Press Ltd., Kent, London.

Haddon, A. C. 1886. Report on the Polyplacophora collected by the H.M.S. *Challenger* during the years 1873-1876. *Challenger Reports*, 15 (43): 1-50.

Iredale, T. and A. F. B. Hull 1923. A monograph of the Australian Loricates (Phylum: Mollusca, Order: Loricata). *Australian Zool.*, 4 (4): 256-276.

Pearse, J. S. 1978. Reproductivity periodicities of Indo-Pacific invertebrates in the Gulf of Suez. IV. The Chitons *Acanthopleura haddoni* Winckworth and *Onithochiton lyelli* (Sowerby), and the abalone *Haliotis pustulata* Reeve. *Bull. Mar. Sci.*, 28 (1): 92-101.

——— 1983. The Gulf of Suez: Signs of stress on a tropical biota. *Bull. Inst. Oceanogr. Fish.*, 9: 148-159.

Rochebrune, A. T. De 1882. Diagnoses d'especes nouvelles de la Famille des Chitonidae (Premier supplement). *Bull. Soc. Philomath. Paris*, 6 (7): 190-197.

Savigny, J. C. 1827. Description de L'Egypte. *Histoire Naturelle*, 2: 26.

Van Belle, R. A. 1983. The systematic classification of the Chitons (Mollusca: Polyplacophora). *Informs. Soc. Belge Malacol.*, 11 (1-3): 1-178.

Winckworth, R. 1927. New Species of Chitons from Aden and South India. *Proc. Malac. Soc., London.*, 17: 206-208.