Acta Botánica Mexicana (1994), 26:11-19

MORPHOLOGY AND VARIATION OF THE DIATOM *AULACODISCUS MARGARITACEAUS* (BACILLARIOPHYTA)

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ABSTRACT

Numerous specimens of the diatom *Aulacodiscus margaritaceus* Ralfs were found in the stomach contents of Atherinid fishes from the Gulf of California. This species was studied by light and scanning electron microscopy. The general morphology is consistent with earlier descriptions: the valve presents fairly coarse, loculate areolae closed by cribra on the outside and open to the inside by large foramina. However, externally the valve shows rather large granules lying on the porose cribra. Their density is variable, but in larger specimens the granules are densely distributed. There are tubular, external processes near the margin of the valve. The number of these processes may vary from 4 to 6 (4 to 10 in specimens of the type material), and it is common to find them broken. The processes end internally in horse-shoe shaped slits. On the internal valve surface hyaline rays sometimes run from the valve center to the rimoportulae. Comments are provided on the variability of this species, as well as on the origin of the external large granules.

RESUMEN

Se encontraron numerosos individuos de la diatomea *Aulacodiscus margaritaceus* Ralfs en el contenido estomacal de peces aterínidos del Golfo de California. Estos especímenes fueron estudiados con microscopios de luz y electrónico de barrido. La morfología general se ajusta a descripciones que se han hecho previamente, presentando valvas gruesas, areolas loculadas cerradas por cribra en el exterior y abiertas por dentro en un foramen. Sin embargo, externamente la valva presenta gránulos grandes de origen silíceo en los cribra, cuya densidad es variable, y por lo general es mayor en los individuos más grandes.Hay procesos externos tubulares cerca del margen de la valva; el número de estos procesos puede variar de 4-6 (4-10 en especímenes del material tipo) y es común encontrarlos rotos. Los procesos terminan internamente en un hendimiento en forma de herradura. En la superficie interna de la valva corren rayos hialinos del centro de la valva a las rimoportulas. Se discute la variabilidad de esta especie, así como el origen de los gránulos externos.

INTRODUCTION

The diatom genus *Aulacodiscus* Ehrenberg comprises heavily silicified solitary species, having a circular outline, and a number of conspicuous processes close to the valve margins. Most species form part of the benthic community, mainly living on sandy substrates. Taxonomic revisions of the genus have been previously done (Rattray 1888, Burke & Woodward 1963-1974), and also some authors have reported the general morphology of various species of *Aulacodiscus* by light microscopy, but especially by electron microscopy (e.g. Ross & Sims 1970, Venkateswarlu & Round 1973, Holmes & Mahood 1980, Sims & Holmes 1983).

Therefore, at present the basic and characteristic structures of the species of *Aulacodiscus* are fairly well-known (Ross & Sims 1974, Round et al. 1990); species of the group "kittonii" have been extensively studied by Sims & Holmes (1983). Morphological variation has been also noted and discussed (Holmes & Mahood 1980). In this paper, further morphological observations are made on a common temperate-subtropical benthic species, *Aulacodicus margaritaceus* Ralfs, and comments are given on the morphological variation of this species as well as on the presence of peculiar large "granules" lying externally on the porose cribra.

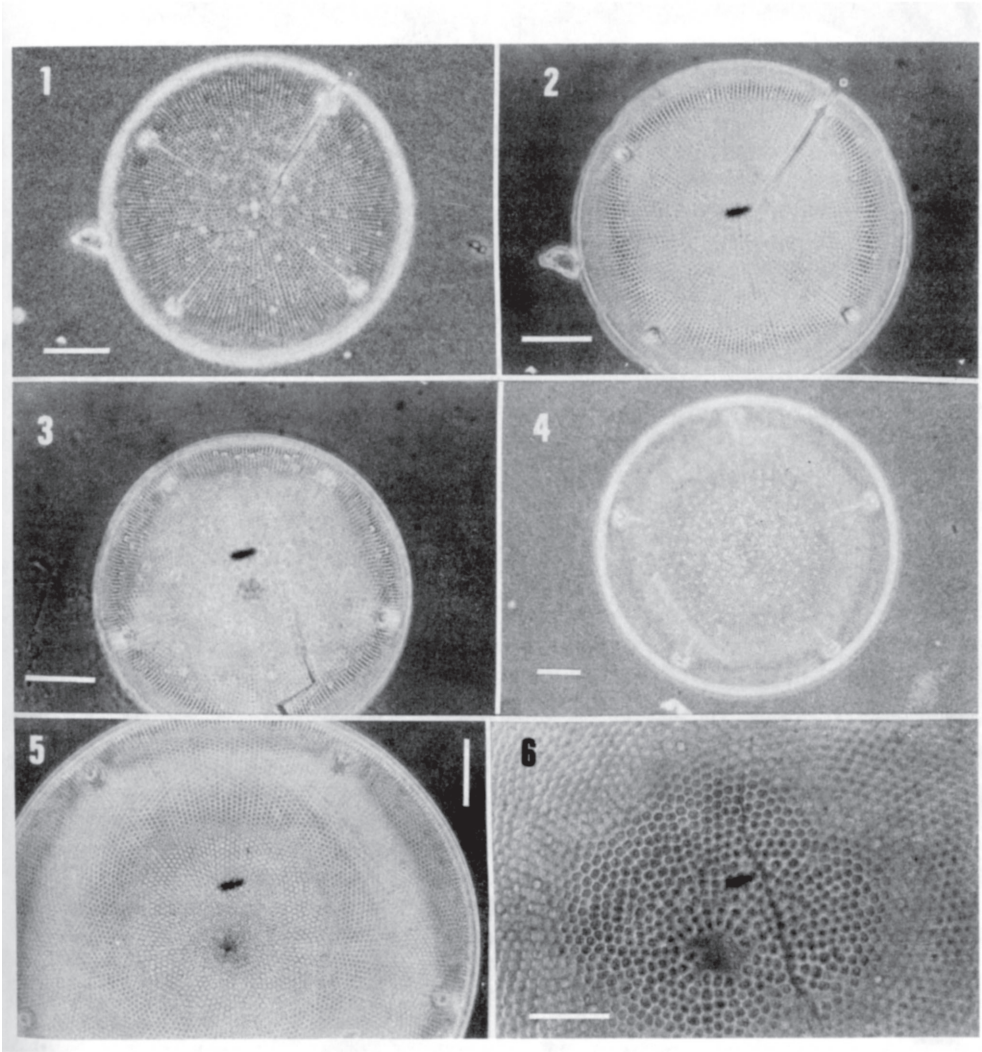
MATERIAL AND METHODS

The material studied was obtained from stomachs of fishes (Atherinids) collected on 8-March-89 from the Gulf of California, in a shallow embayment (El Sargento, Sonora, Mexico). A total of 94 specimens of *Aulacodiscus margaritaceus* was encountered in a single fish (3.4 cm length). The diatoms were cleaned using conventional methods (Hasle 1978); most specimens of the species studied were only loose valves. Permanent mounts were prepared to allow observations by Light Microscopy (LM, Zeiss M phase contrast). Also cleaned material was analysed by SEM (JEOL JMS-35, operated at 24 kv). Morphometric data such as the number of processes, valve diameter (um), areola density (number/10 um), and relative granule density (number of large granules/number of areolae) were obtained through LM. In addition, type material was studied to confirm correct identification: two slides from the British Museum (Natural History), BM 66929 and BM 66935 from the Ralfs Collection. Terminology follows that proposed by Ross & Sims (1970), Anonymous (1975) and Ross et al. (1979).

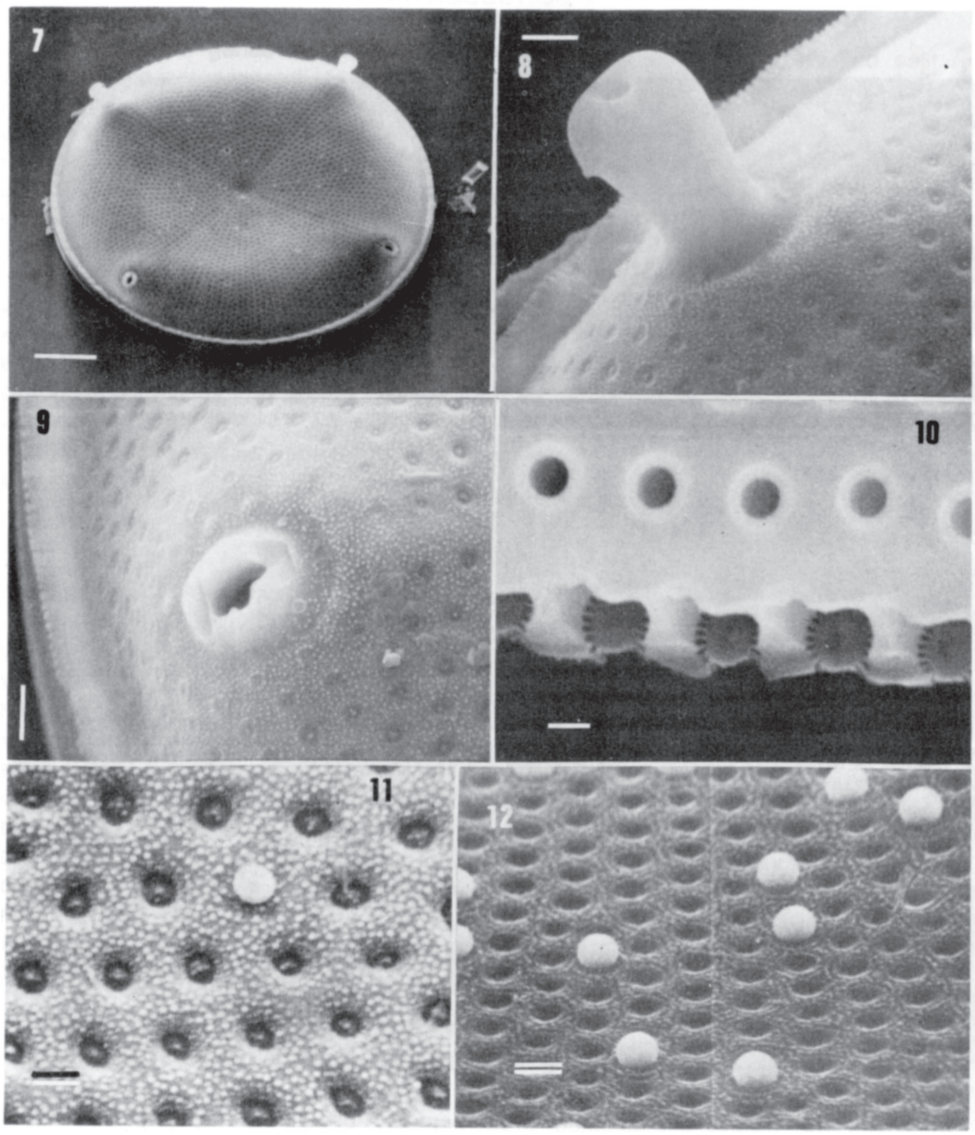
OBSERVATIONS

A description of combined LM and SEM observations shows specimens of *Aulacodiscus margaritaceus* with circular valves, flat or slightly convex, having a diameter from 186 to 365 m (Figs. 1-6, 7, 15, 16). The center of the valves is slightly depressed (Figs. 7, 15).

There are four to six well-defined marginal processes (Figs. 1, 2, 4, 7, 15, 16). They are external, tubular openings of the rimoportulae (Figs. 8, 15) and they often appear broken (Fig. 9).



Figs. 1-6. *Aulacodiscus margaritaceus*, LM. Fig. 1. A valve with four processes, hyaline rays run from the centre to the processes, BF. Fig. 2. The same valve slightly enlarged, PhC. Fig. 3. A valve with five processes, BF. Fig. 4. Another valve having five processes and showing a high density of granules, PhC. Fig. 5. Detail of a valve with five processes, BF. Fig. 6. Central part of a valve showing large granules, BF. Scale bars= 50 m, Figs. 1-5; = 20 m, Fig. 6. BF = bright field, PhC = phase contrast.



Figs. 7-12. *A. margaritaceus*, SEM. Fig. 7. Valve having four processes, two of them broken, and a low density of large granules. Fig. 8. Detail of one process. Fig. 9. Another process broken from its base. Fig. 10. Valve broken showing the wall: the foramina inside and the loculate areolae outside. Fig. 11. Detail of the areolae. There are small granules all over and one large granule on the cribrum. Fig. 12. A profile of the areolae showing the large granules on the cribra. Scale bars= 50 m, Fig. 7; = 5 m, Figs. 8, 9, 12; = 2 m, Figs. 10, 11.

The valves show coarse (Fig. 6) loculate areolae closed by cribra on the outside (Fig. 11) and open to the inside by foramina (Fig. 10). Apparently, the density of the areolae does not change significantly within a same valve (e.g. center, middle and margin). A number of rather large granules, presumably siliceous, are present on the valve (Figs. 1, 4, 6), lying on the porose cribra (Figs. 11, 12). Other, much smaller, and widespread granules are present on the external wall of the valve, but not on the cribra (Fig. 11). The relative density of the large granules varies between the specimens, but in general the larger specimens have a higher density of granules (Figs. 13, 14).

Internally, the center of the valve shows a small hyaline area from which rays run to the rimoportulae (Fig. 17). The rimoportulae have a horse-shoe shaped slit and are almost flush with the internal layer of the wall (Fig. 18).

The valves with a larger diameter have a higher number of processes; the largest valve measured (365 m) had 6 processes (Table 1, Fig. 19). In contrast, the relative density of large granules (number of granules/number of areolae) showed a weak trend with valve diameter (some larger valves had a higher density of these granules, Table 1), but not with the number of processes.

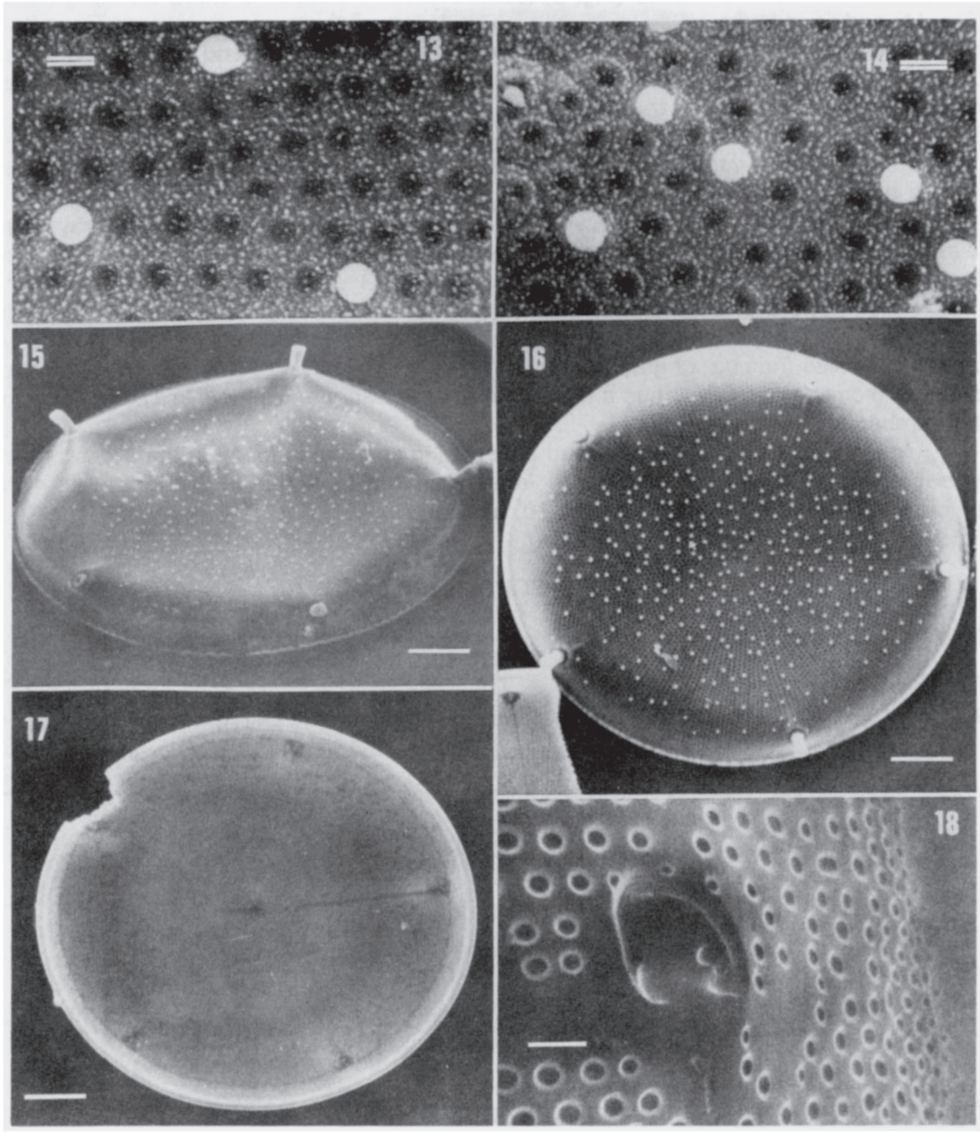
In Fig. 19, the variation observed observed in specimens found in the slides of the type material is shown. The specimens varied from 143 to 427 m in diameter, with 4 to 10 processes (one having 8, one with 10, none of 9).

Table 1: Morphometric data of some specimens (n=10) of *Aulacodiscus margaritaceus.*

Specimen	Diameter (µm)	Number of processes	Relative density of granules		
			Center	Middle	Margin
1	266	4	1:5-10	1:20-25	----
2	275	4	1:5-10	1:20-25	1:30
3	224	4	1:10-15	1:25-30	----
4	264	4	1:5-10	1:15-20	----
5	219	5	1:10-15	1:10-15	1:15-20
6	351	5	1:5-10	1:15-20	----
7	275	5	1:5-10	1:15-20	1:30
8	285	5	1:15-20	1:15-20	1:25-30
9	294	5	1:15-20	1:15-20	1:30
10	365	6	1:10-15	1:10-15	1:25

DISCUSSION

General descriptions of species of *Aulacodiscus* have shown well-defined characteristics. The processes near the valve margin are a very conspicuous feature, even when seen by light microscopy. Regarding *Aulacodiscus margaritaceus*, Ross & Sims (1970) provided an earlier description using SEM, and the present study confirms the particular



Figs. 13-18. *A. margaritaceus*, SEM. Fig. 13. Low density of large granules in a valve. Fig. 14. Higher density of large granules in another valve. Fig. 15. Valve with five processes, one broken. Fig. 16. Same valve showing the high density of granules. Fig. 17. Internal view of a valve with a conspicuous hyaline ray from the centre to one rimoportula. Fig. 18. Detail of a rimoportula. Scale bars= 50μm, Figs. 15-17; = 5μm, Figs. 13, 14, 18.

morphology of the species, except for finding large granules lying on the cribra. This characteristic was not found by Ross & Sims (1970), and they only observed the smaller granules on the valve surface (not on the cribra); their material came from Chile. Examination of the type material (collected from guano of the Gulf of California), revealed the presence of specimens having the large granules, which density was also variable.

The great intraspecific variability in *Aulacodiscus margaritaceus* is evident. The number of processes, the valve diameter and the relative density of the large granules on the valve are conspicuously varying characters. This variation is noticeable in specimens of the type material (Fig. 19), where specimens ranged from 143 to 427 m in diameter and had up to 10 processes. Holmes & Mahood (1980) also documented variation in *A. kittonii* (even showing valves with no process), but they mentioned that this variant is very rare, about 0.5 % of the population analized. In *A. margaritaceus*, the variability could have led some authors to propose taxonomic varieties (eleven varieties, following Rattray 1888), and perhaps some of them are merely forms or morphotypes.

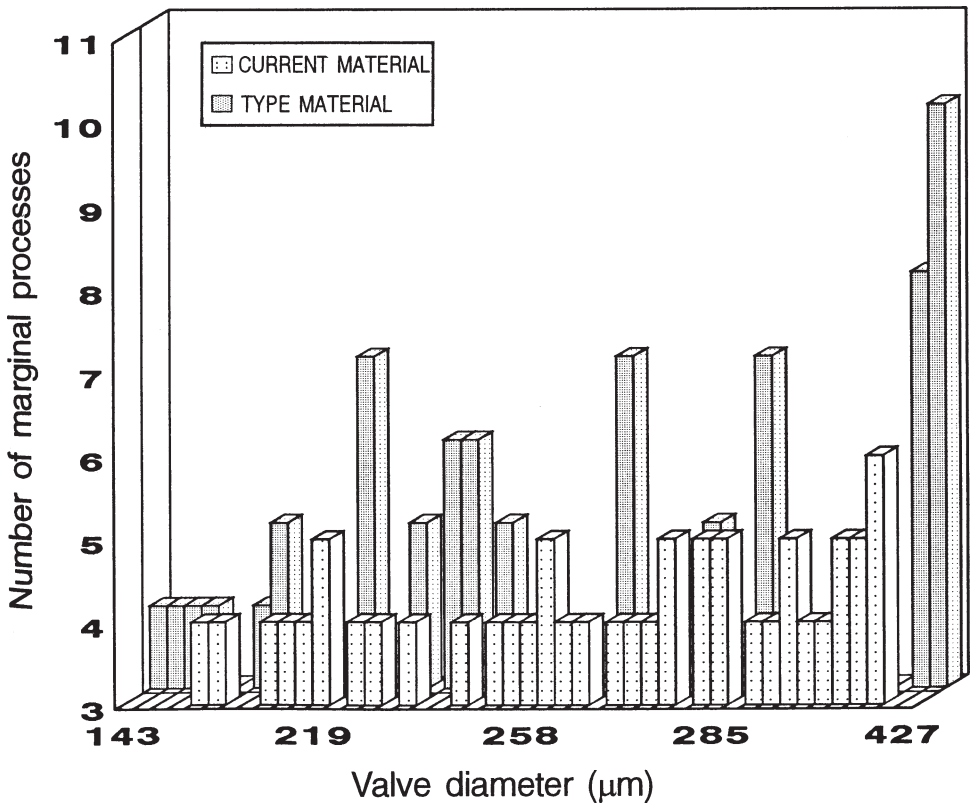


Fig. 19. Valve diameter vs. number of processes in specimens (46) of *Aulacodiscus margaritaceus*, in the current material sampled (30) and the type material (16).

The relation between the number of processes and the valve diameter is not clear, but it is shown that a specimen with six processes had the largest diameter. The density of large granules showes a weak relation with the valve diameter. The presence of these granules offers matter for speculation. One idea of their origin is that they might be produced and released by living cells, perhaps as a response to the excess of silicate, or fluctuating environmental factors.

It is clear that *Aulacodiscus margaritaceus* commonly inhabits the coastal areas of the Gulf of California. It was originally described from a locality in that zone, and has been subsequently recorded there (Licea Durán 1974, Hernández-Becerril 1987). The extension and formation of blooms have not been documented yet. Although the number of specimens found of *A. margaritaceus* was considerable, it can not be compared with blooms produced by other *Aulacodiscus* species, namely *A. kittonii* Arnott, which forms dense blooms along the Pacific coasts of the United States (Lewin 1974, Holmes & Mahood 1980). However, as we did not sample the sediments, we believe that the population studied could be more abundant than documented here.

ACKNOWLEDGEMENTS

The authors thank Patricia Frías G. (Servicio Académico MEB, ICMyL, UNAM) for her skilled assistance when using the SEM, and also Ricardo Mondragón and Sirenia Pozos G. (UME, CINVESTAV-IPN) for giving access to the dark room, and Jorge Lodigiani (UAM-Iztapalapa) for copying the photographic plates. Thanks are especially due to Miss P. Sims (Natural History Museum, London) for loaning the type material. Some comments by Dr. D. G. Mann, Dr. E. F. Stoermer, and Mr. R. Ross are greatly appreciated, as well as others made by Dr. J. Espinoza.

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