BEAUFORTIA

INSTITUTE OF TAXONOMIC ZOOLOGY (ZOOLOGICAL MUSEUM)
UNIVERSITY OF AMSTERDAM

Vol. 43, no. 7 June 18, 1993

THE ARCTIC SPECIES *HETEROSTIGMA SEPAR* ÄRNBÄCK-CHRISTIE-LINDE, 1924 (ASCIDIACEA: PYURIDAE) IN THE STRAIT OF GIBRALTAR (SOUTHERN SPAIN)

S.A. NARANJO & J.C. GARCIA-GOMEZ

Laboratorio de Biología Marina, Departamento de Fisiología y Biología Animal. Fac. de Biología. Universidad de Sevilla. Apdo. 1095, 41080 Sevilla, España.

ABSTRACT

The arctic species *Heterostigma separ* Ärnbäck-Christie-Linde, 1924, a component of the interstitial fauna in coastal soft bottoms from Nova Zembla, was found in gravels of Algeciras Bay (Gibraltar Strait, Southern Spain). This new record constitutes the southernmost limit of the geographical range of this species. Some traits of branchial morphology of *H. separ* are studied, and new data are presented to establish the anatomical variability of this species. Furthermore, some aspects of reproduction, life cycle and ecological requirements are provided and discussed. The geographical distribution of european species of this genus is summarized.

INTRODUCTION

The Gibraltar Strait is a zoogeographical highly interesting area, especially from the point of view of the interchange of the species between Atlantic and Mediterranean waters. During the BALGIM cruise organized by the French CNRS, 24 species of deep-sea ascidians were collected at both sides of the Strait of Gibraltar, most of which having true bathyal or abyssal characteristics (Monniot & Monniot, 1988).

The soft bottom ascidians are distributed at all depths from shallow waters to bathyal and abyssal bottoms, but there are only few studies about the abundance and diversity of species in comparison with those of hard bottoms.

Although the water renewal in the Strait of Gibraltar is continuous, there is a conspicuous geographic area (the Algeciras Bay) which supports an important human population. Some large public works (harbours, shipyards and breakwaters) and effluents of anthropogenic origin, have transformed Algeciras Bay into an ecological system very interesting to study from a biomonitoring point of view. For this reason, a multidisciplinary research project of our Marine Laboratory is in progress, financed by local industries and political institutions (see acknowledgments).

During the sampling program, 42 specimens of soft bottom ascidians have been collected. Some

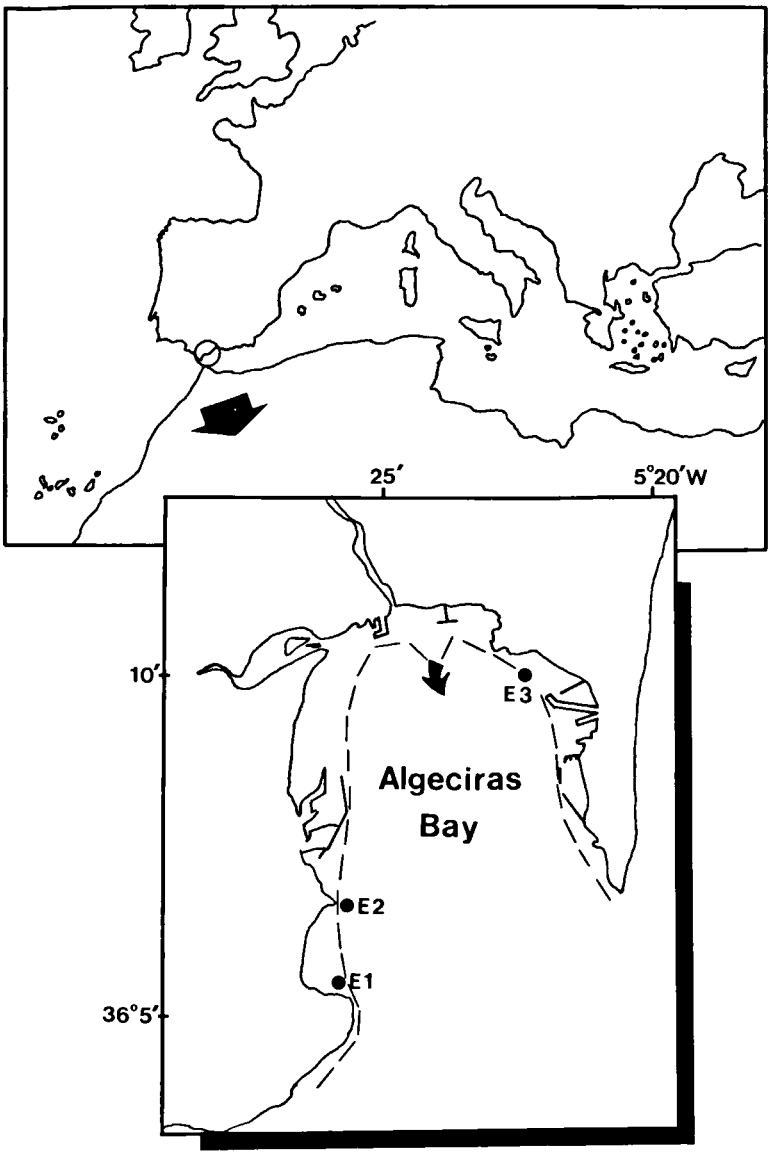

Fig. 1: Map of sampling localities (E1-E3). Lines show the general direction of the major currents in the Algeciras Bay.

of these belong to the genus *Heterostigma* Ärnbäck-Christie-Linde, 1924, and we have attributed them to the species *H.separ*, described by the same author from arctic waters. In spite of the wide geographical separation, no significant differences have been found with the original description.

The anatomical features of this genus place it in a doubtful taxonomic position in the Pyuridae family. Thus, the lack of branchial folds, the unusual morphology of the stigmata and the simplicity of the oral tentacles, confer a certain primitive aspect (Monniot, 1965), and approach this genus to aberrant forms as *Culeolus* Herdman, 1881 or *Eupera* Michaelsen, 1904.

MATERIAL AND METHODS

The animals were collected in Algeciras Bay (5° 24' N; 36° 8' W) at the Mediterranean side of the Strait of Gibraltar (Southern Spain) (Fig. 1). Sta-

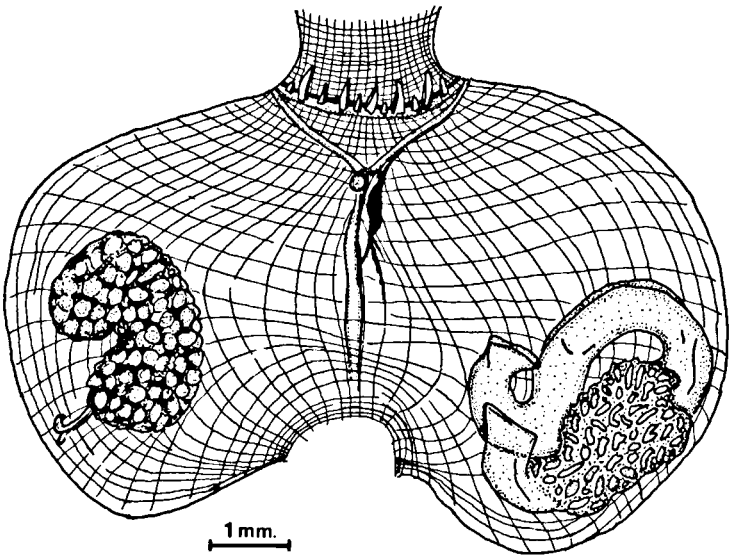

Fig.2: *Heterostigma separ.* Internal side of the mantle with test and branchial sac removed, showing the muscular bands, digestive tract and gonad.

tions: E1, La Ballenera: 15 m, July 1990, 1 sp. 15 mm E2, San García: 26 m, July 1991, 1 sp. 5 mm E3, San Felipe: 4 m, July 1991, 15 sp. 1.5-6 mm; 1 sp. 15 mm.

The three stations are characterized as having soft bottoms with gravels, sand and shell-fragments. The samples were obtained by dredging (stations 1 and 2) and using a air-lift suction sampler (Scuba Diving) (station 3).

RESULTS AND DISCUSSION

Morphological description

In general, the body of adult specimens is rounded to globular shape. The tunic is thin and covered with sand particles, gravel and shell-fragments. The apertures are on widely separated and prolonged siphons that end in four well-developed lobes.

Oral tentacles simple and short, with a broad base and sharp tips. Up to 16 in number of several sizes. No atrial papillae have been observed. Raphe broad, continuous and plain-edged. Dorsal tubercle resembles a small button situated to the right of the elongated dorsal ganglion.

Branchial sac without folds and six internal longitudinal vessels. In the anterior part of the branchial wall there are at least four transversal rows of infundibula . They are formed by an extended stigma spirally coiled. This kind of stigma is irregularly cut back under longitudinal vessels. In the posterior part of the branchial sac there are 7 to 14 straight protostigmata. They are situated under the rows of infundibula and transversally extended. The first order transversal vessels are between the spiral stigmata rows, dividing the anterior part of the branchial wall into square fields. The second and third order transversal vessels are well developed and cross the spiral stigmata in radial form.

The morphology of the digestive tract are shown in Fig. 2. The oesophagus is of a remarkable width. The stomach is short and covered by hepatic papillas. The intestine forms a wide loop having a thick ridge on its surface. The rectum is short and a thick ledge is observed on its end, which gives it a bilobed aspect.

This species presents a single hermaphroditic bean-shaped gonad on the right side of the body. It is formed by an ovary surrounded by globular

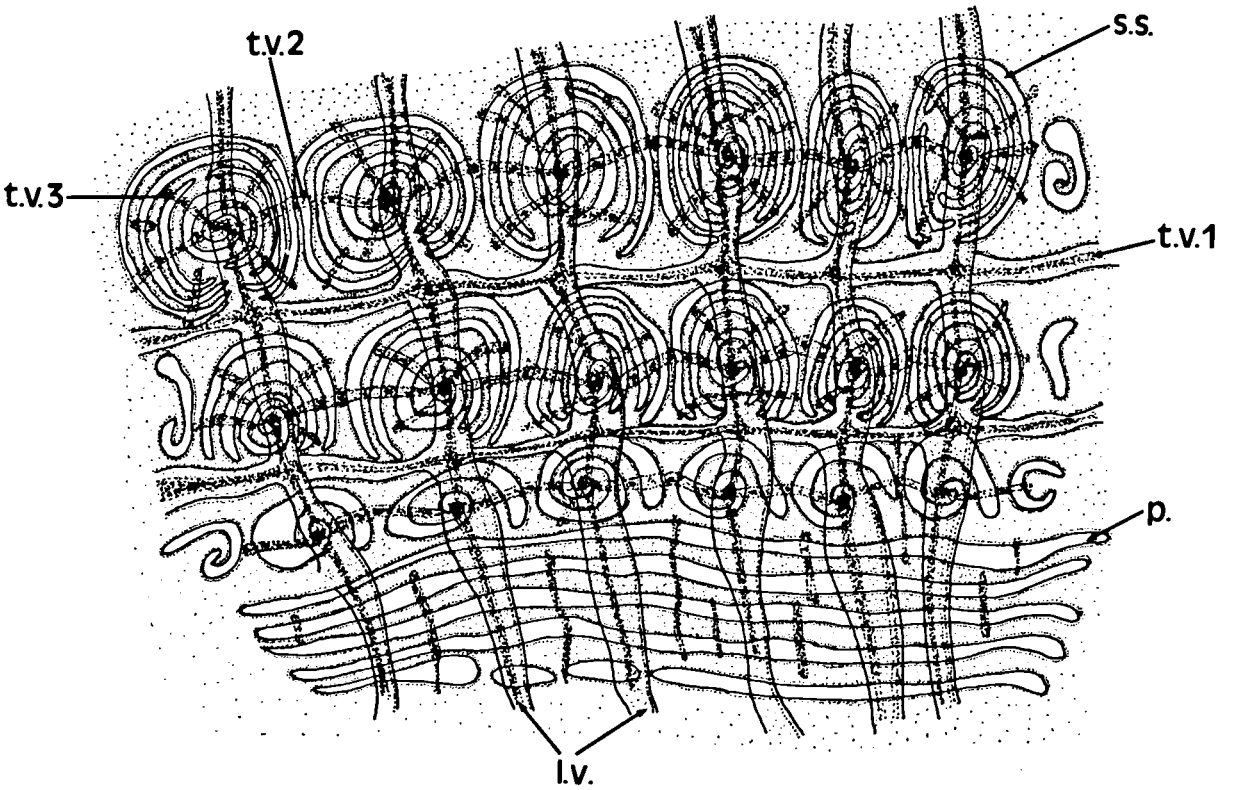

Fig.3: Part of the branchial sac. l.v.: longitudinal vessels; p: protostigma; s.s.: spiral stigmata; t.v. 1, 2 and 3: transverse vessels of first, second an third order.

spermatic vesicles. Both ovary and testis open at the end of the gonad by a short duct. They end in a big brood pouch that fills most of the atrial cavity on the right side.

Variability of the branchial features

After the description of this species by Ärnbäck-Christie-Linde (1924) based on Nova Zembla specimens, Monniot & Monniot (1963) completed it from the study of animals from Roscoff. However, the appearance in the Algeciras Bay of several specimens having a wide range of sizes, allow us to confirm and furher complete the observations, particularly those relating to the branchial structure.

As in the other species of *Heterostigma*, the branchial structure shows a variable aspect in accordance with age (Monniot, 1965). All studied specimens of *H.separ* from Algeciras Bay show six well-developed internal longitudinal vessels, but the number of transversal rows of infundibula varies from 4 in smallest animals (2 mm or less) to 6 in the largest ones. On the other hand, like the specimens from Nova Zembla, those from Algeciras Bay have up to 8 longitudinal rows of spiral stigmata, and those in the first and eighth rows are reduced or incipient, irregularly coiled.

The number of whorls of spiral stigmata is higher at the upper rows, with 9 to 10 whorls in the biggest ascidians, and generally in telescopical disposition. In the rest of the transversal rows the spirals present 4 to 8 whorls. This range of variation includes those observed in the specimens from Nova Zembla and Roscoff, with 5 to 7 and 6 to 10 spiralturns respectively.

The stigmata nearest to the protostigmata are reduced showing an incipient degree of spiralization (2 to 3 whorls only) (Fig. 3). However, the

Fig.4: Scheme of disposition in the bottom. A: adult, B: young.

specimens from Nova Zembla and Roscoff mostly show stigmata with similar morphology, but this character can be considered as geographic variability.

In agreement with Monniot & Monniot (1963), we think that the protostigmata figured by Ärnbäck-Christie-Linde belong to an aged or abnormal animal, since in all ascidians examined by us the protostigmata show a regular disposition and morphology.

The number of protostigmata varies according to the branchial development, which is in relation with the ascidian age. The small specimens have 5 to 6 protostigmata on the right side, and 8 to 10 on the left one. The biggest specimens show up 12 or 14 protostigmata on the left side, and smaller numbers on the right side because of the brood pouch development.

Of all the known species of the genus *Heterostigma*, *H.reptans* and *H.separ* show the greatest number of common features. Monniot (1965) proposed a taxonomic key of this genus on the basis of the most obvious characters. In agreement with that author, one of the principal differences is that *H.separ* presents spiral stigmata regularly cut back under longitudinal vessels. In the Algeciras Bay specimens this character is very variable, even in the branchial sac of a single animal, where the stigmata cutting back degree may decrease at the upper transversal rows. However, the presence of a fourth well-developed row of infundibula in *H.separ*, together other differences (greatest number of whorls in spiral stigmata, presence of well-developed second and third order transversal vessels, and different morphology of digestive tube and gonad), confirms the taxonomic identity of both species.

Ecological remarks

Heterostigma separ, like the remaining species of the genus, lives in soft bottoms of the type clubbed "sables à Amphioxus" (Pérès & Picard, 1964), characterized by coarse sand and fine gravel, together with small shell-fragments. Their success in this kind of habitat implies the development of internal anatomical features reflecting a high degree of adaptation to the mesopsammic life. Accordingly, body size is decreased due to the organic simplification by the reduction and disappearance of the left gonad, which absence is compensated by a major development of the digestive tract, avoiding the loss of symmetry on the left side (Monniot, 1965). Also a spacious brood pouch is developed involving the eggs and larval protection. Both developments constitute important evolutionary advan-

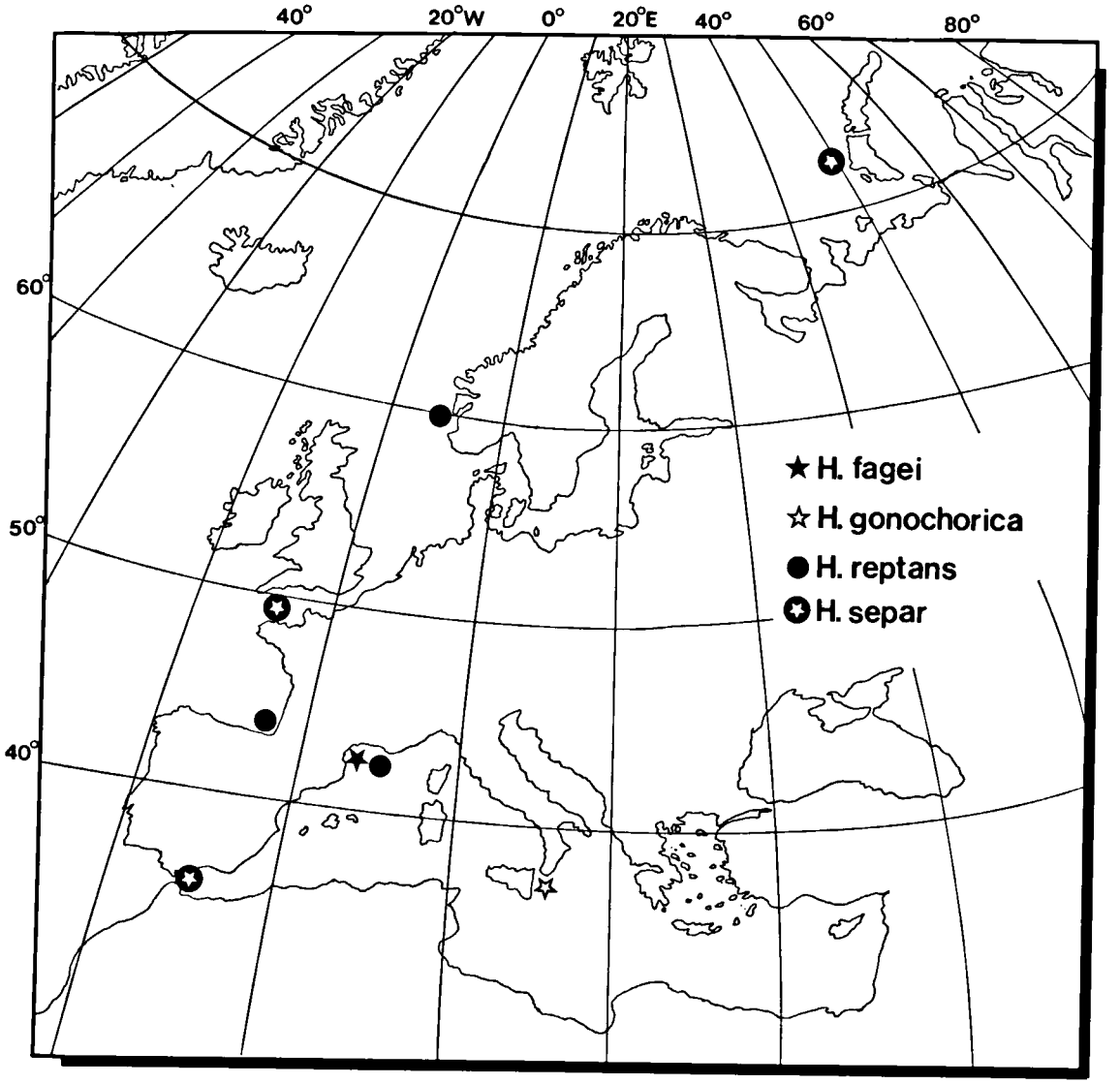

Fig.5: Distribution map of the European species of genus *Heterostigma*.

tages for surviving on motile substrata.

The adults of *H. separ* reach the largest body size within the genus (up to 15 mm). In this species, the sand covering on the tunic is variable. In young specimens the transparent and thin tunic shows a limited capacity for adhering particles of sand, except in the ventral zone particularly on the tip of the rhizoids. In the smallest specimens the tunic is completely naked. The body is enlarged, almost tubular. In loose specimens, the siphons are opposite and very extended. However, the largest specimens are globular, almost spherical, with very close and little developed siphons and a thick tunic totally covered by grains of sand and shell-fragments, resembling some molgulids and styelids of soft bottoms.

According to our observations in specimens from Algeciras Bay, the degree of sand adhesion to the tunic is proportional to the ascidian body size, and, consequently, to its age. So, important morphological and ecological changes occur during the life of this species, since the youngest specimens are interstitial due to their small size and mobility through the particles of sand and

gravel (Fig. 4 B), whereas the biggest ones remain anchored in the sediment, with the rhizoid attached to big particles of gravel and shell-fragments (Fig. 4 A). They are totally covered and protected for many small grains of sand, and specimens displayed spherical morphology.

In the populations studied, we have detected young specimens without developed gonads, together with adult specimens containing eggs and larvae into the brood pouch. It shows the coexistence of two different generations, indicating two annual reproduction cycles at a minimum. The production of eggs and larvae have been observed during July. In contrast, the reproduction of specimens from Roscoff occured during September-October (Monniot & Monniot, 1963).

From a biomonitoring point of view. *H.separ* has also been found in soft bottoms characterized by a frequent renewal of the water. In Fig. 1 we show an imaginary line of water circulation based on the free movement of the major currents, having no interruption by coastal public works. In contrast, *H. separ* is absent in semi-enclosed areas where the water is almost stagnant. This is in accordance with the ecological requirements reported for most of the interstitial species, where the existence of bottom currents assure a continuous alimentary supply (Monniot, 1972).

Distribution of the European species of the genus *Heterostigma*

The genus *Heterostigma* includes four European species. Of these, *H.fagei* Monniot & Monniot, 1961 and *H.gonochorica* Monniot,1965, are recorded from the Mediterranean French and Italian coasts, respectively, whereas *H.reptans* Monniot & Monniot, 1963 initially described from Scandinavian coasts, has been collected in the Bay of Biscay and in the Gulf of Marseille (Monniot & Monniot, 1990) (Fig. 5).

The type species of the genus, *H.separ*, was found for the first time in the Arctic (some specimens from Nova Zembla). Monniot & Monniot (1961) recorded this species in Roscoff. The presence of *H.separ* in the Algeciras Bay (Strait of Gibraltar), enlarges its distribution area considerably. It constitutes the southernmost geographical limit and it leads us to assume a very probable presence in nearby Mediterranean waters. In fact, Pérès, in 1958 described *H. separ* var. *mediterraneum* from the Israel coasts. However, in agreement with Monniot & Monniot (1963), we consider the specimen described by Pérès as aberrant, since the branchial features and gonad structure clearly differed from those of this species, and even from those of the other ones of the genus. So, this record must be considered with certain reservations until new specimens be found.

ACKNOWLEDGEMENTS

We thank Dr. C. Monniot for generous help with information and literature and for the loan of material and P. López for valuable suggestions.

We are grateful to CEPSA, Sevillana de Electricidad, Excmo. Ayuntamiento de los Barrios and Mancomunidad de Municipios del Campo de Gibraltar for financial support of this work.

REFERENCES

ÄRNBÄCK-CHRISTIE-LINDE,A.,1924. A remarkable Pyurid Tunicate from Novaya Zembla. Ark. Zool., **16** (15): 1-7.

MONNIOT, C., 1965. Etude systématique et évolutive de la famille des Pyuridae (Ascidiacea). Mem. Mus. Hist. Nat. Paris, XXXVI.

MONNIOT, C. & MONNIOT, F., 1961. Recherches sur les Ascidies interstitielles des gravelles à Amphioxus (2e note). Vie et Milieu, **12**(2): 269-283.

MONNIOT, C. & MONNIOT, F., 1963. Présence à Bergen et à Roscoff de Pyuridae psammicoles du genre *Heterostigma*. Sarsia, **13**: 51-57.

MONNIOT, C. & MONNIOT, F., 1988. Ascidies de chaque côté du seuil de Gibraltar (Campagne BALGIM). Bull. Mus. natn. Hist. nat. Paris, 4, 10, A(3): 415-428.

MONNIOT, C. & MONNIOT, F., 1990. Relationships between deep-sea tunicate populations west and east of the Straits of Gibraltar. Prog. Oceanog., **24**: 289-296

MONNIOT, F., 1965. Ascidies interstitielles des côtes d'Europe. Mem. Mus. Hist. Nat. Paris, XXXV.

MONNIOT, F., 1972. Les ascidies littorales et profundes des sédiments meubles. Smithson. Contrib. Zool., **76**: 119-126.

PERES, J.M., 1958. Ascidies de la bahie de Haifa collectées par E. Gottlieb. Bull. Res. Counc. Israel, **7B**: 151-164.

PERES, J.M. & PICARD, J., 1964. Nouveau Manuel de Bionomie Benthique de la Mediterranée. Recl. trav. stn. mar. Endoume, **47**(31): 5-137.

Received: September 29, 1992