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Ecology of *Pherusa* sp. (Polychaeta, Flabelligeridae)

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ABSTRACT

Pherusa sp. is an endolithic species which burrows into hard substrates (loess) with a range of cohesion from 0 to 254.6 kg. cm^{-2}. The burrow is a tube which is closed posteriorly. The shape of the tube reflects in saggital section the position of the animal inside it. The wall of the burrow is lined with aragonite. The lining is thickest near the opening of the tube. A dorsal shield on the first 3 chaetigers function as a lid to the burrow when the animal is withdrawn. During feeding the two palps and the branchiae play a very important role. The food reaches the mouth by different prostomial ciliary grooves. As with many other boring marine animals, *Pherusa* sp. is a microphaga and detritous feeder. Waste products and gametes are discharged to the sea through the two nephridiopores located in the head near the inner line of branchiae. The first 36 segments of the body are longer and thicker than the rest which resembles a tail. The anus is located on the terminal end of the tail which is reflexed, making the body U-shaped. The mouth is ventral with respect to the anus. The intertidal population studied inhabits a loess which on the exposed surface presents a large and dense stratum of coralline algae. Endolithic species such as *Polydora* sp., *Themiste petricola, Lithophaga patagonica,* etc., surround the holes of *Pherusa sp.* The density of the species in the intertidal loess of Santa Elena, province of Buenos Aires, Argentina was 14 specimens in a quadrant of 100 cm^2. The species shows indirect development and some of its larval stages can be collected by washing the epilithic coralline algae from November to February. *Pherusa sp.* shows characteristics of tubicolous animals. The gradient of cohesion (0 to 254.6 kg. cm^{-2}) suggests that this species possesses a physical as well as chemical mechanism for burrowing. The presence of acid mucopolysaccharides in the tegument gland secretion confirms this deduction. The lining of the tube, thicker around the aperture could indicate a function of consolidation of the burrow in substrates of low cohesion, but this thickening was also present in high cohesion substrates. The aragonite lining deposited by *Pherusa sp.* on the burrow walls contributes to loess particles cementation and rock hardness increase.

RÉSUMÉ

Écologie de *Pherusa* sp. (Polychaeta, Flabelligeridae)

Pherusa sp. est une espèce endolithique qui perfore les substrats durs (loess). La perforation consiste en un tube fermé dans la partie postérieure dont la forme, en section sagittale, indique la position de l'animal à l'intérieur du tube. La paroi du tube est couverte d'aragonite dont l'épaisseur augmente autour de l'ouverture du tube. Une plaque dorsale sur les trois premiers segments de l'animal ferme l'ouverture du tube lorsque l'animal se rétracte. Pendant l'alimentation, les deux palpes et les branchies jouent un rôle très important. Les aliments arrivent à la bouche par plusieurs sillons ciliés

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du prostomium. Comme beaucoup d'animaux marins sédentaires, *Pherusa* sp. est microphage et mangeur de détritus. Les déchets et les gamètes sont libérés dans la mer par les néphridiopores situés dans la tête, près de la ligne interne des branchies. Les 36 premiers segments du corps du ver sont plus longs, plus larges et plus hauts que les autres lesquels réssemblent d'ailleurs à une queue. L'anus se trouve postérieurement, il se replie sur le corps formant un "u". Il en résulte que la bouche est ventrale par rapport à l'anus. La population intertidale étudiée habite un loess qui présente, sur la surface exposée, une strate dense et peuplée d'algues corallines. Des espèces endolithiques comme *Polydora* sp., *Themiste petricola, Lithophaga patagonica,* etc., entourent les trous de *Pherusa* sp. La densité de l'espèce à Santa Elena (Argentine) atteint 14 spécimens dans un carré de 10x10 cm L'espèce étudiée montre un développement indirect et quelques stades larvaires peuvent être recueillis en lavant les algues corallines epilithiques de novembre à février. *Pherusa* sp. présente les caractéristiques des animaux tubicoles. Le gradient de cohésion (0-254,6 kg. cm^{-2}) suggère que cette espèce possède un mécanisme physique et un autre chimique pour perforer les substrats durs. La présence de mucopolysaccharides acides dans la sécrétion des glandes du tégument conforte cette déduction.

INTRODUCTION

The first objective of the "Bioturbations of the Buenos Aires Loess" program initiated in 1987, was to establish the relationship between the endolithic macrofauna and the characteristics of the hard substrate (AMOR *et al*, 1991). The second goal was to determine the role of the endolithic fauna in the deterioration of the intertidal loess of Santa Elena beach in the province of Buenos Aires, Argentina. The results of this study on the ecology of *Pherusa* sp. contribute to the knowledge of how *Pherusa* sp. leads to deterioration of the loess.

MATERIALS AND METHODS

The adults of *Pherusa* sp. are endolithic and were collected during low tide on the rocky beach of Santa Elena (37°56'02" S; 58°11'35" W) in the province of Buenos Aires, Argentina.

The shoal consists of a bank 5 m high with a shelf with drainage channels (Fig. 1a). Tubes were found on the sides of small pools located within coralline algae at the mid-tide level (Fig. 1b). Rock samples were collected using a hammer and chisel and transported to the laboratory in buckets of seawater. In the laboratory the sanples were divided according to the study objectives: a) Direct observation of the worms within the rock in order to study their feeding behaviour. The samples were placed in plastic boxes containing sea-water of 32 P.S.U. salinity and kept at 24 °C which was similar to the environmental conditions. The worms were fed microscopic algae from cultures. Observations on feeding behaviour were made under a stereomicroscope. b) Adults were separated from their tubes and fixed with neutral 10 % formalin for staining with Alcian blue (MARTOJA & MARTOJA, 1967). c) The heads of a group of animals were fixed in Bouin's fluid, stained with Ehrlich's hematoxylene-eosin, and cut into sections 5 µm thick. d) The anterior region of the body was fixed in 2.5 % glutaraldehyde in Millonig's phosphate buffer adjusted to 970 milliomsmoles for scanning electron microscopic examination. Following dehydration in alcohol and acetone, the material was dried in liquid carbon dioxide in a critical point drier, coated with gold palladium and observed in a JEOL microscope. e) Fractions of the tube lining were separated from the rock and their mineral composition was determined using a Philips DRX x-ray diffractometer model PW 1011/00 with a copper tube, wavelength 1.5454 A, 18 A, 40 kV, goniometer velocity 2°. min^{-1}, paper speed 1200 mm. h^{-1}.

The pH of the seawater occupying the space between the animal and the wall of the tube was determined using "pHYDRION" pH test papers of two ranges: 0-13 and 3-5.5.

The population density was estimated by sampling at low tide using a systematic sampling plan (KRUMBAIN & GRAYBILL, 1965) which consisted of tracing seven transects perpendicular to the coastline, designated A, AB, BA, B, BC, CB, and C. Transects A, B, and C extended from the top of the bank to the sea. AB, BA, BC, and CB ran from the upper inhabited level of the beach to the sea (Fig. 4c).

The study area was 132 m wide (distance between A and C), the bank 5 m high (levels 1, 2 and 3), the beach 36 m long (from the base of the bank to the sea), and the sampled beach 6 m long (levels 4 and 5). The high tide reaches the bank at level 3. A square frame (10 x 10 cm) was used to count holes with animals at levels 4 and 5.

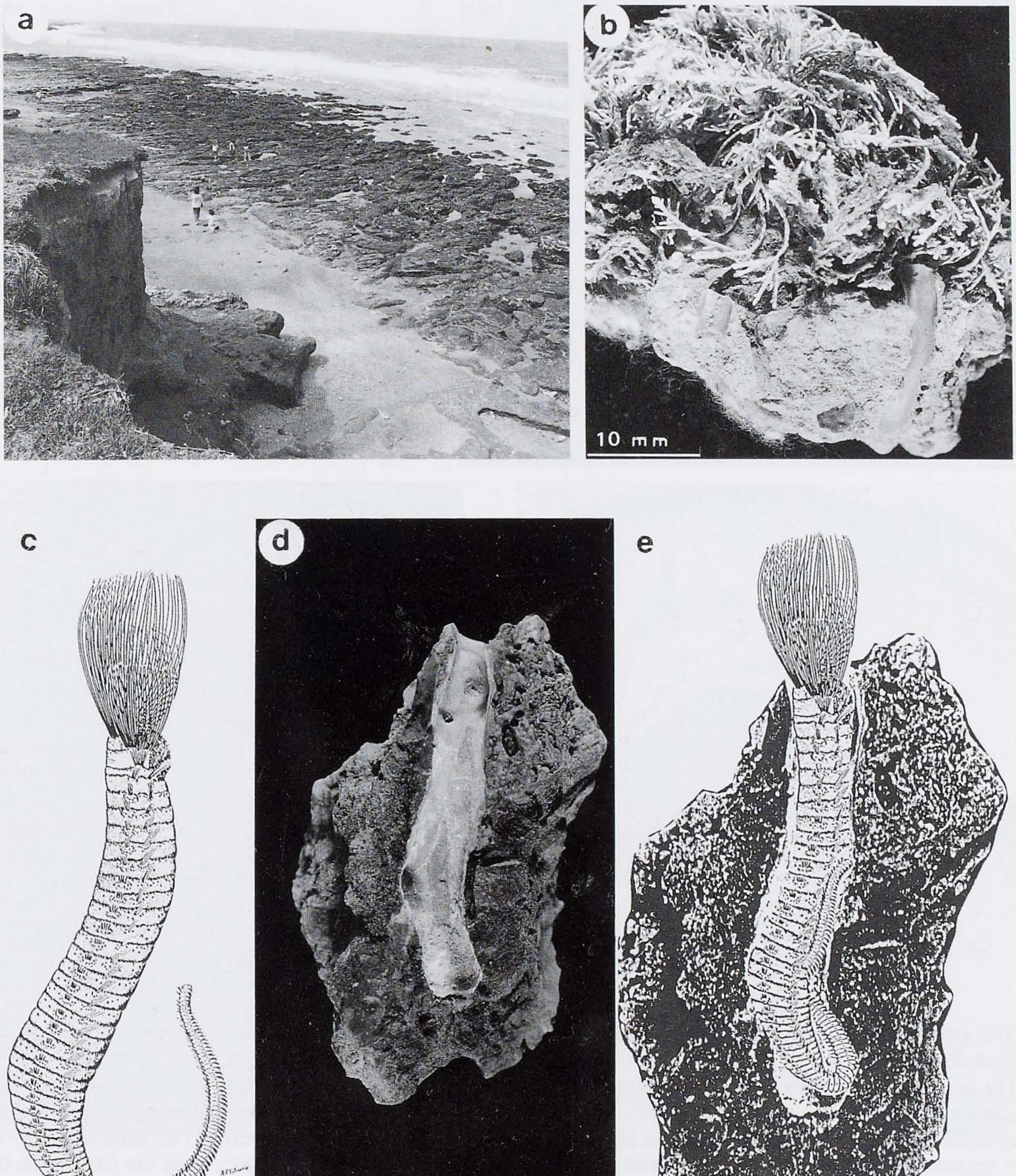

FIG. 1. — *Pherusa* sp.: **a**, general view of the collection area on Santa Elena beach. **b**, view of a rocky sample in the intertidal coralline algae zone with burrows. **c**, lateral view of the worm (drawing). **d**, burrow. **e**, burrow with worm inside it (composed).

RESULTS

Pherusa sp. is an endolithic worm which burrows in hard substrates (Fig. 1c). The substrate in the sampling zone has been described as a loess which is continuously eroded by the sea (AMOR *et al.*, 1991). The cohesion of the loess was found to range from 0 to 254.6 kg. cm^{-2} in its resistance to compression. *Pherusa* sp. is found in loess throughout this range of resistances along with other species such as *Themiste petricola, Polydora* sp., *Lithophaga patagonica, Petricola patagonica* and *Saxicava solida.* This suggests that *Pherusa* sp. and the other species possess a chemical mechanism in addition to a physical mechanism, which permits them to burrow into highly cohesive rock (254.6 kg. cm^{-2}). Preliminary studies indicate that the glands of the tegument of *Pherusa* sp. secreted acid mucopolysaccharides as shown by the Alcian blue technique.

The burrow of *Pherusa* sp. is a blind-ended tube measuring up to 3 cm in length (Fig. 1d). Sagital cut of the tube indicates the position occupied by the animal. The tube walls are covered with aragonite (Fig. 2). The lining is thicker near the opening than elsewhere in the tube. A dorsal shield on the first 3 chaetigers function as a lid to the burrow when the animal is withdrawn. The seawater lying between the animal and the burrow has a pH of 5.

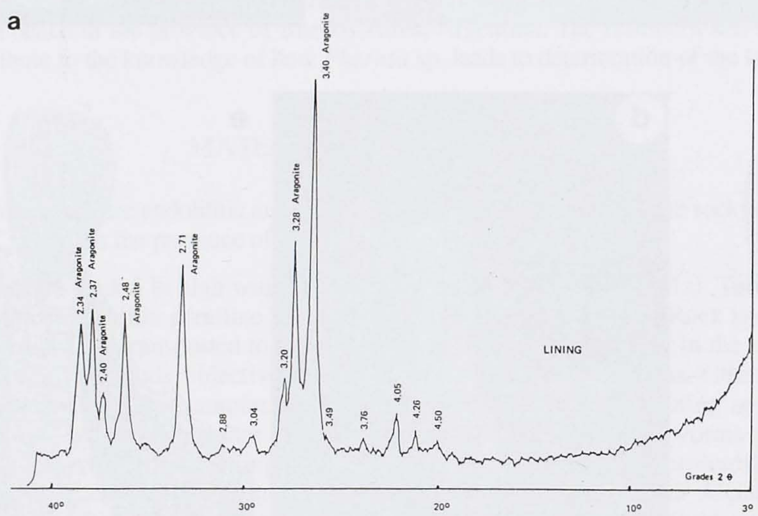

FIG. 2. — *Pherusa* sp.: **a**, diffractogram of the burrow lining.

The structures of the head and the chaetae which participate in feeding are described according to their functional role.

The head of *Pherusa* sp. can be either introverted or extended. It is usually found withdrawn into a chamber formed by a membrane extended in front of the first chaetiger. When the head is introverted, the membrane invaginates with it. The head is protruded followed by the chaetal cage during feeding. The chaetae of the first three segments of the body form the chaetal cage. The length of the chaetae decreases from the first to the third segment, and they are all oriented anteriorly (Fig. 3c). During feeding the chaetae are separated and moved backwards forming a filtering system.

The prostomium consists of the prostomial lobe with four eyes in the base, the ciliary grooves, a solid ridge between the right and the left ciliary grooves, the nuchal organs, the dorsal lip, the two palps and the two pads. The two prostomial tracts of cilia originate at the base of the two dorsal branchiae (Fig. 3a,b and d; Fig. 4a). The ciliated grooves flank the solid medial ridge up and surround the prostomial lobe. These grooves are prolonged as far as the ciliated fossae of the nuchal organs. The ciliated grooves continue to the base of the palps, cross over the pad to each side of the dorsal lip to the mouth. The palps originate in the ventral border of the prostomial lobe.

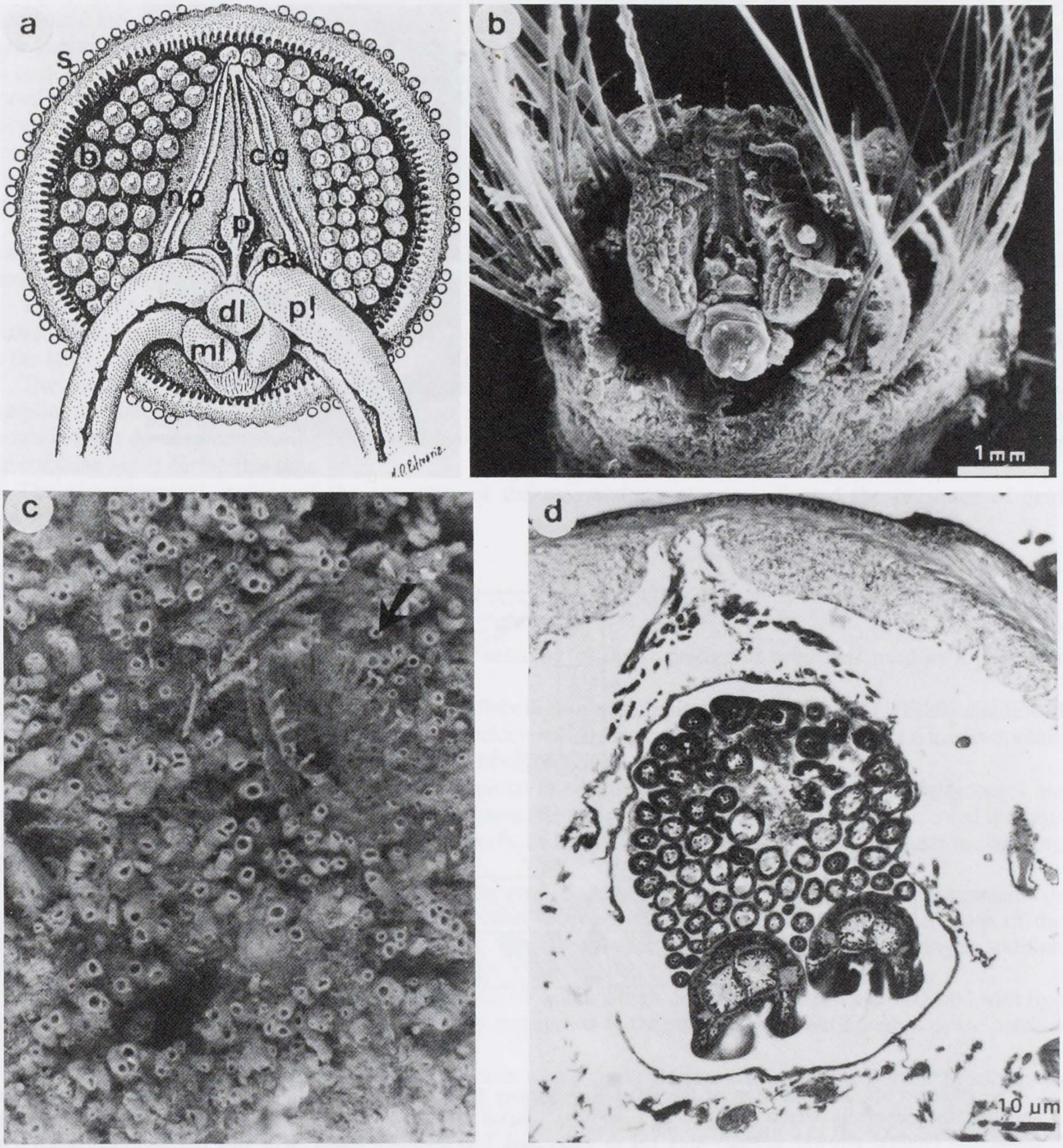

FIG. 3. — *Pherusa* sp.: **a**, schematic frontal view of head; P, prostomium; PL, palp; DL, dorsal lip; CG, ciliary groove; NP, nephridiopore; ML, median lip; S, chaeta. **b**, head evaginated with the buccal capsule extruded (palps cut). **c**, the chaetae of the first three segments are separated like fans in this worm shown on the rock. **d**, branchiae impel food particles to the ciliary grooves.

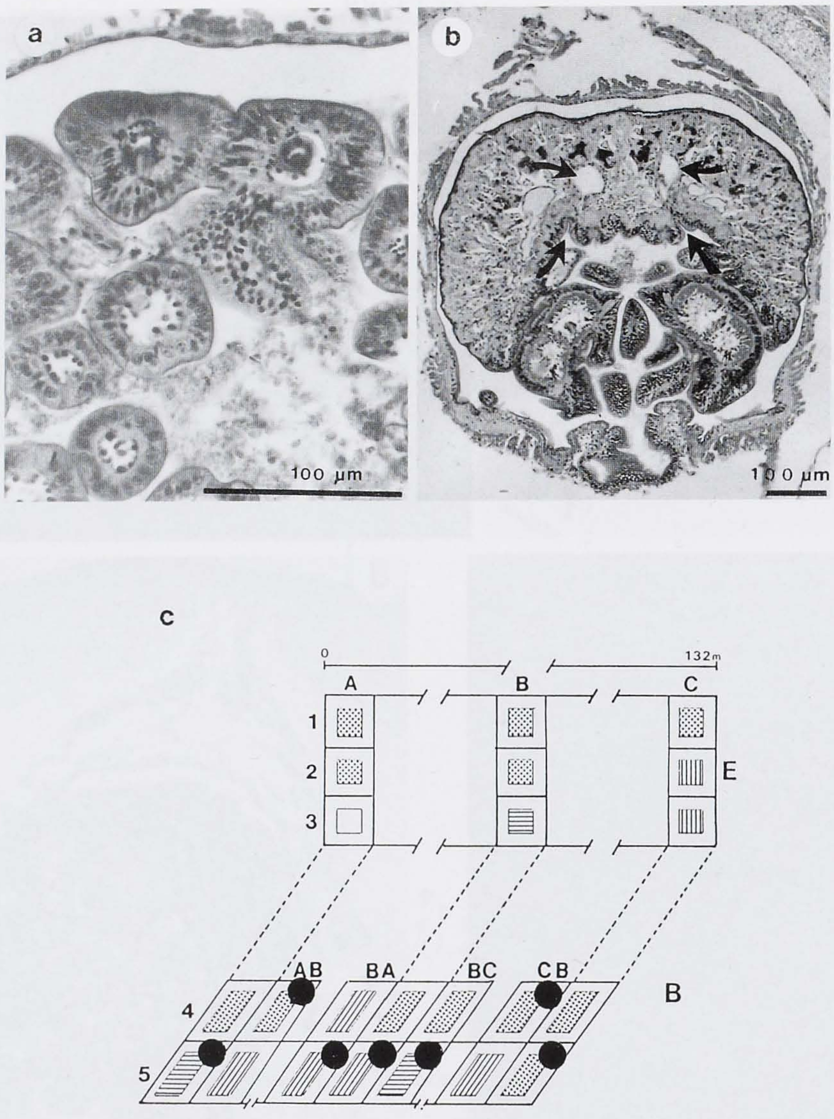

FIG. 4. — *Pherusa* sp.: **a**, beginning of the left ciliary groove on the branchial membrane. **b**, a section of the head showing the nephridia which also act as gonoducts (dorsal arrows) and the nephridiopores which also acts as gonopores (ventral arrows). **c,** study area 132 m wide; bank 5 m high (E); beach 36 m long (B); sampled beach 6 m long (comprised levels 4 and 5); transects A, AB, BA, B, BC, CB, and C; dotted pattern, low cohesion; vertical striped, medium cohesion; horizontal striped, high cohesion; plain, presence of *Pherusa sp*.

They are extensible, retractable, deciduous and rounded distally. The palp is horseshoe shaped with a ciliated almost straight base in the centre of which there is a ciliated slit (the ciliated groove of the palp) and a cavity separated by a septum. This separation of the cavity disappears towards the end of the palp. The circular and longitudinal muscles and the fluid-filled cavities of the palp form a hydrostatic skeleton. When the animal feeds, the ciliated base of the palps sweeps across the chaetal cage. The captured particles are moved by the cilia towards the medial groove. The ciliary current of the groove, which transports the particles, is rapid and arrives at the mouth passing between the dorsal and medial lips of each side.

The branchiae of *Pherusa* sp. arise from an achaetous segment between the first chaetiger and the head during the pelagic larval stage. They surround the prostomium in adults. They are filiform, contractile and ciliated along their length with an unusual distribution of cilia. There are between 80 and 90 branchiae divided into two groups on each side of the prostomium. The two groups are united dorsally by a pair of branchiae (Fig. 3a,b, and d). The dorsal branchiae are longest. The ciliated branchiae produce movement of the water and particles in suspension in the space limited by the chaetae of the first chaetiger. Food particles are concentrated and moved to the base of the two dorsal branchiae (Fig. 3d; Fig. 4a). The food particles are transported by the ciliary current of the prostomial grooves to the mouth. *Pherusa* sp. is a microphage and detritus feeder and feeds by day similar to other boring marine animals.

The two nephridiopores of *Pherusa* sp. are located in the branchial membrane near the internal line of branchiae and on each side of the prostomial ciliated grooves (Fig. 4b). Waste products and gametes are discharged through these pores.

The first 36 segments of the body are longer and wider than the rest which resembles a tail. The anus is located on the terminal portion. The tail is reflexed to give the body a U-shaped appearance. The mouth is ventral to the anus.

The population inhabits a loess which is covered with a dense growth of coralline algae. By systematically sampling the intertidal population, the density at Santa Elena was estimated to be 14 ind./100 cm^2. The species shows indirect development during November to February. Some of the larval stages can be collected by washing the coralline algae during this time.

The histochemical studies of the secretion of the tegumentary glands indicated the presence of acid mucopolysaccharides (Alcian blue at pH 5).

DISCUSSION AND CONCLUSION

The paper by SPIES (1975) on the functional anatomy of the flabelligerid head was used as a basis for interpretation of the head.

Studies on the ecology of endolithic species of flabelligerids are limited. BLEAKNEY *et al.* (1980) mentioned *Flabelligera affinis* living in vacant burrows of the pelecypod *Zirfaea crispata.* This species is not a true endolithic worm since it does not burrow; it is a typical worm of cryptopfauna crevices.

Pherusa sp. is similar to a typical tubiculous animal in which the mouth, branchiae and nephridiopores are found in the anterior end. The anus is located at the posterior end of the body but the reflexed tail located the anus near the open end of the tube. All apertures of the body are at approximately the same level and near the opening of the tube.

The slightly acidic pH of the seawater within the tube could account for the absence of other organisms or ectoparasites on the body or within the tube. The acid mucopolysaccharids detected in the secretions of the tegumentary glands support the idea that *Pherusa* sp. possesses a chemical mechanism for burrowing in addition to a physical one.

Population density was estimated from 14 samples in which a high density, 14 burrows in 100 cm^2 with live animals was found in only seven suggesting that the population in the study area is distributed in dense patches of worms.

The lining of the tube is thicker around the aperture which could aid in establishing the burrow in substrates of low cohesion, but this thickening was also present in high-cohesion substrates.

The aragonite lining of the tube of *Pherusa* sp. could contribute to the cementation of the rock and increase its hardness in the same way as the calcite deposits of the burrow walls of *Lithophaga patagonica, Petricola patagonica,* and *Saxicava solida* which also inhabit the same area.

REFERENCES

AMOR, A., LOPEZ ARMENGOL, M.F., IÑIGUEZ RODRIGUEZ, A.M. & TRAVERSA, L.P., 1991. — Intertidal endolithic fauna and it's relationship to the mineralogical, physical and chemical characteristics of the substrate. *Mar. Biol.*, **111** : 271-280.

BLEAKNEY, J.S., ROBINSON, S.M. & WAUGH, J.C., 1980. — Endolithic fauna of vacated *Zirfaea crispata* L. burrows in Blomidon shale, minas basin, Nova Scottia. *Proc. N.S. Inst. Sci.*, Nova Scotia, **30** : 55-63.

KRUMBAIN, W.C. & GRAYBILL, F.A., 1965. — *An introduction to statistical models in geology*. Mc Graw Hill Book Co., New York, 475 pp.

MARTOJA, R. & MARTOJA-PIERSON, M., 1967. — *Initiation aux techniques de l'histologie animale*. Masson et Cie., Paris, 345 pp.

SPIES, R.B., 1975. — Structure and function of the head in flabelligerid polychaetes. *J. Morph.*, **47** : 187-208.