THE STRUCTURE OF SUCKERS OF NEWLY HATCHED SEPIA OFFICINALIS, LOLIGO VULGARIS, AND OCTOPUS VULGARIS

H. Schmidtberg

VIE MILIEU, 1997, 47 (2) : 155-159

THE STRUCTURE OF SUCKERS OF NEWLY HATCHED *SEPIA OFFICINALIS, LOLIGO VULGARIS,* AND *OCTOPUS VULGARIS*

H. SCHMIDTBERG

Institut für Spezielle Zoologie und Vergleichende Embryologie, Hüfferstr. 1, D-48149 Münster

SEPIA OFFICINALIS
LOLIGO VULGARIS
OCTOPUS VULGARIS
NEWLY-HATCHED
SUCKERS

ABSTRACT. – Scanning and transmission electron microscope studies allow a comparison of the state of differentiation of the suckers of the newly-hatched benthic *Sepia officinalis* Linné, 1758, and planktonic *Loligo vulgaris* Lamarck, 1798, and *Octopus vulgaris* Cuvier, 1797. These analyses may help to correlate the differences in the suckers with the divergent developmental types of the three species and give further information about the functional morphology of the suckers at hatching.

SEPIA OFFICINALIS
LOLIGO VULGARIS
OCTOPUS VULGARIS
FRAÎCHEMENT ÉCLOS
VENTOUSES

RÉSUMÉ. – Nos études en microscopie électronique à balayage et à transmission permettent de comparer l'état de différenciation des ventouses chez les animaux fraîchement éclos, soit benthiques (*Sepia officinalis* Linné, 1758) soit planctoniques (*Loligo vulgaris* Lamarck, 1798; *Octopus vulgaris* Cuvier, 1797). Ces analyses pourraient aider à définir d'éventuelles corrélations entre différences de structures au niveau des ventouses et les différences de type de développement parmi les trois espèces, tout en apportant de nouvelles informations sur la morphologie fonctionnelle des ventouses au moment de l'éclosion.

INTRODUCTION

Behavioural observations on the post-embryonic life of cephalopods show that the suckers even of hatchlings perform a remarkable variety of functions (Boletzky 1974, 1977, 1979, 1987). A detailed morphological and histological study of the suckers of postembryonic cephalopods, however, is lacking. In this paper the suckers of three cephalopods of different developmental types (Fioroni 1977) are analysed and an attempt is made to compare the differentiation and the functional morphology of the suckers of *Sepia officinalis, Loligo vulgaris,* and *Octopus vulgaris* at hatching.

MATERIAL AND METHODS

Newly-hatched specimens of *S. officinalis* (dorsal mantle length (dml) approximately 8 mm), *L.vulgaris* (dml : 3 mm), and *O. vulgaris* (dml : 1,5 mm) were obtained from the western Mediterranean Sea (Banyuls-sur-Mer, France). The dorsal mantle length was measured on SEM-pictures. The tissue was fixed with Bouin's solution or in 2 % OsO_4 dissolved in 0.5 % $K_2Cr_2O_7$ in 70 % seawater. The material for transmission electron microscopy was dehydrated in ethanol and embedded in Spurr's medium (Spurr, 1969). Ultrathin sections were stained with lead citrate (Reynolds, 1963). Material for scanning electron microscopy was dehydrated in ethanol, critical point dried with CO_2 and coated with gold. In *S. officinalis* the most highly differentiated suckers on the outer rows of all four arms and the suckers of the middle region of the tentacle club were examined. In *L. vulgaris* the developmental state of the arms – compared with *S. officinalis* – is quite different at hatching; thus, only the largest suckers on the base of the ventral arms and on the tentacles were analysed. In *O. vulgaris* the central one of the three suckers on each arm was investigated, because it shows the highest differentiation on the outer surface of the infundibulum.

RESULTS

Beside the differences in the arrangement of the suckers on the various arms and within one arm there exist species-specific differences in number and size : *S. officinalis* (Fig. 1 A) exhibits

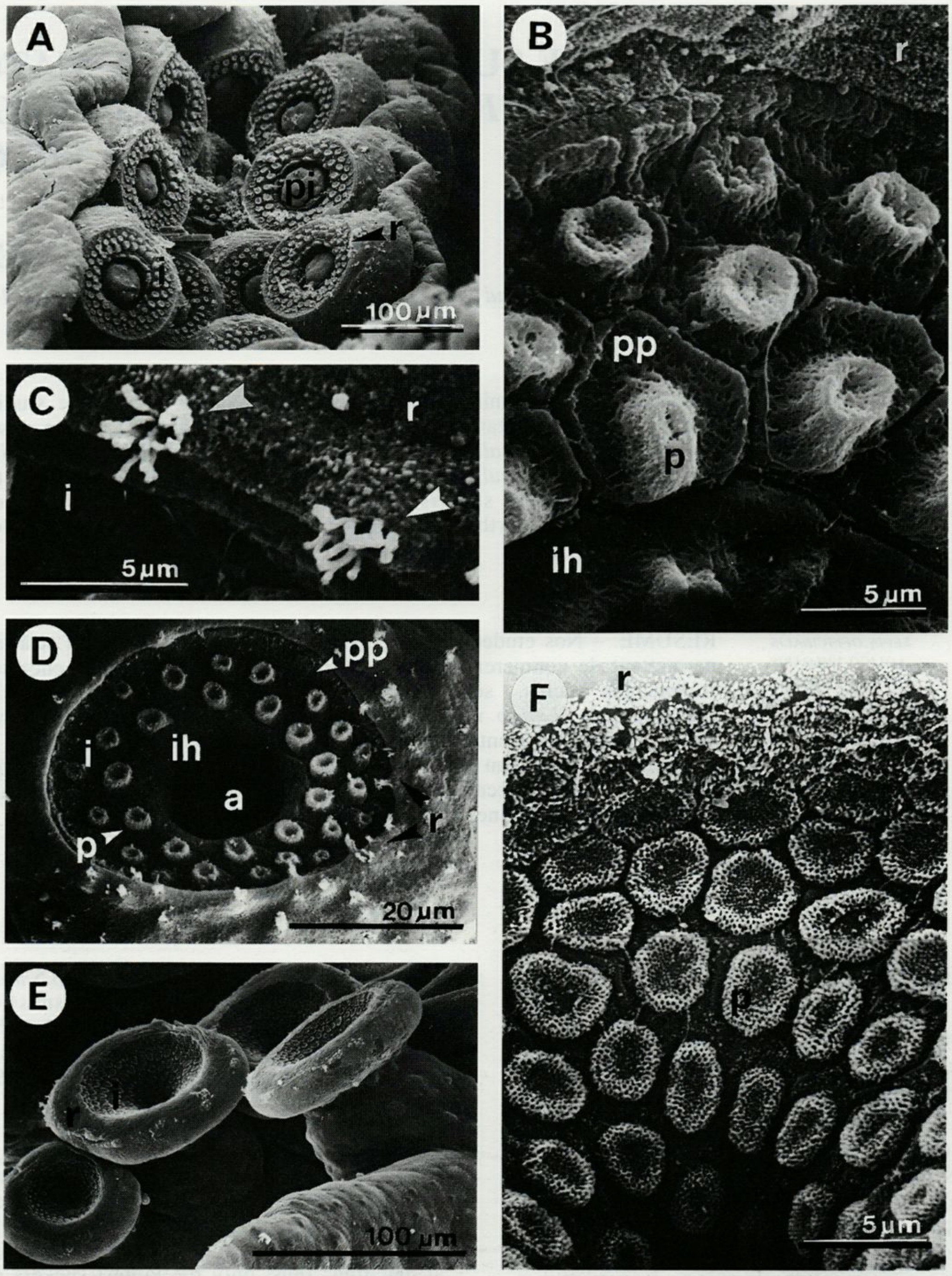

Fig. 1. – A, Four longitudinal rows of arm suckers of *S. officinalis.* B, Polygonal processes with pegs cover the infundibulum of a sucker of *S. officinalis.* C, On the outside of the suckers tufts of cilia emerge through pores (arrow head), here on the rim of a sucker of the cuttlefish. D, In the squid the infundibulum is endowed with two rings of polygonal processes with small pegs. E, In *O. vulgaris* the infundibulum is encircled by a rather plain rim. F, The infundibulum of a sucker of *O. vulgaris* at higher magnification shows almost rounded flat pegs with small pores. a acetabulum, i infundibulum, ih inner horny ring, p peg, pi piston epithelium, pp polygonal process, r rim.

adult-like morphology at hatching with a high number of suckers which develop during an intensive phase of growth in late embryogenesis (Fioroni 1977). In the less developed paralarvae of *L. vulgaris* (Fig. 1 D) and *O. vulgaris* (without this phase) only a small number of suckers is present. For example, in *O. vulgaris* only three suckers are present on each arm (Fig. 1 E), but the suckers are relatively large compared with the short arms (Nolte & Fioroni 1983).

In *S. officinalis* the outer surface of the infundibulum of the arm suckers shows rings of polygonal processes which are provided with a projecting peg, each with a concave surface (Fig. 1 B). The processes and the pegs are covered with small pores. They decrease in size from the center of the infundibulum to its periphery. Here the processes lack pegs or only little pegs are formed. The distal half of the inner horny ring, where the processes are fused, has blunt projections, while the remaining half is smooth. The diameter of the infundibulum of the most highly differentiated suckers on the tentacle club is larger than that of the arms. Their whole inner horny ring is still smooth.

In the arm suckers of *L. vulgaris* the infundibulum is endowed with fewer and smaller pegs whose concave upper surface is well marked (Fig. 1 D). At the edge of the infundibulum small processes without pegs are prominent. Like in *S. officinalis* the cuticle forming a peg contains a system of canals penetrated by microvilli (Fig. 2 B, see Haas 1989). The inner horny ring is smooth and has no teeth. In general, the infundibulum of the tentacles resembles that of the arm suckers.

In *O. vulgaris* (Fig. 1 F) the infundibulum possesses very flat but numerous pegs which are already endowed with minute pores. Like in the two decapod species the concavity on the upper surface of the pegs is obvious. The infundibulum is encircled by a plain rim. The circumferential marginal folds which surround the infundibulum in suckers of adult animals are not yet present.

In the suckers of the cuttlefish large cells exist below the epithelium of the piston (Fig. 2 C). They seem to have no contact with nervous tissue. Similiar cells are found in the squid but they are not as conspicuous as in *S. officinalis.* Nevertheless, in both decapods numerous nerve fibres exist beneath the infundibulum and the rim of the muscular wall and a thick nerve bundle in the peduncle can be traced into the brachial nerve. In *O. vulgaris* nerve fibres appear in the walls of the acetabulum and infundibulum and run along the extrinsic muscular system of the sucker. In the subacetabular region a concentration of nerve fibres can be observed. In all species investigated, ciliated cells are common on the rim but rare at the lateral regions of the sucker (Fig. 1 C). Ciliated cells were not observed in the piston or in the

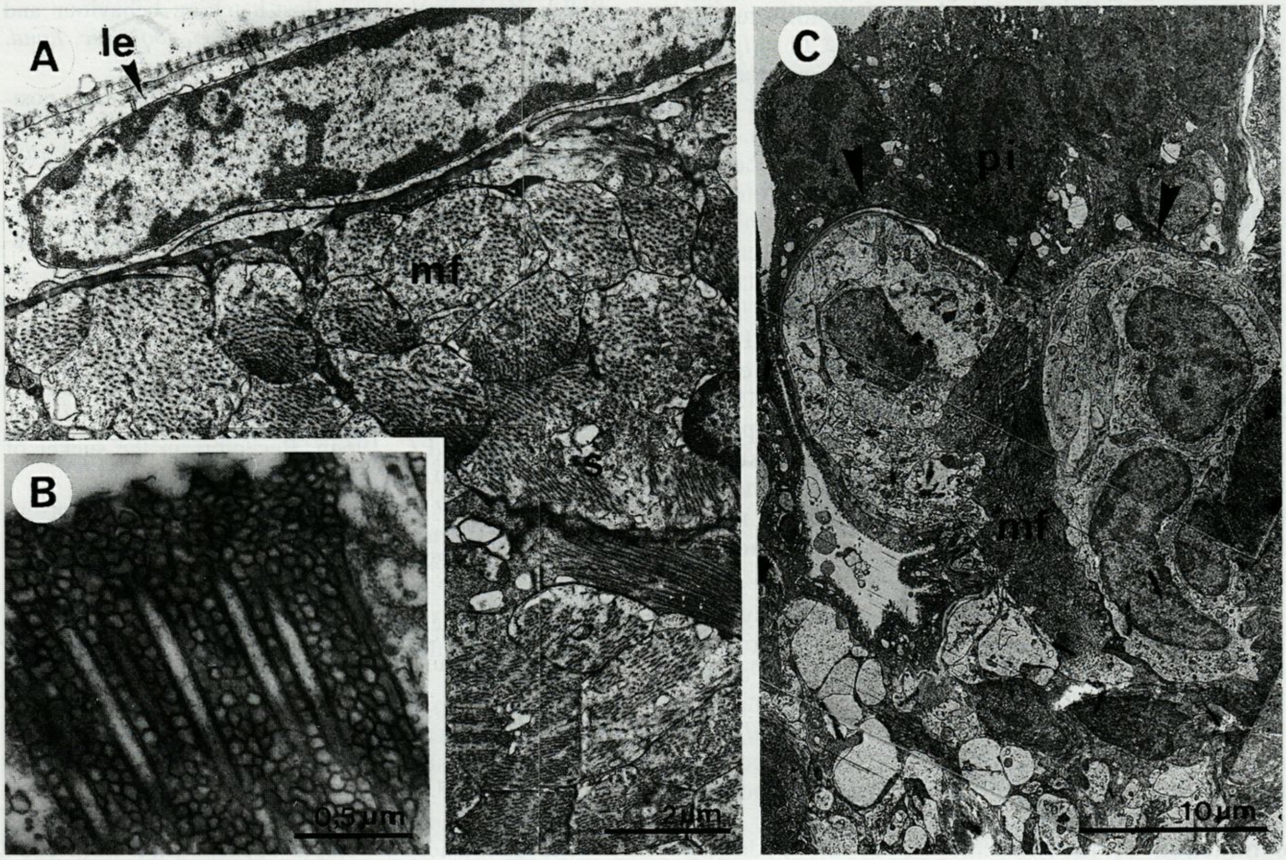

Fig. 2. – A, The main sphincter muscle of a sucker of *S. officinalis* with densely packed muscular fibres. B, The cuticle of the pegs of all investigated specimens – here in *L. vulgaris* – is formed by a system of canals which are penetrated by microvilli. C, In *S. officinalis* large cells (arrow head) below the piston epithelium seem to lack nervous tissue. le lateral epithelium, mf muscular fibres, pi piston epithelium, s main sphincter muscle.

epithelium of the infundibulum (Graziadei, 1964a, 1964b).

In *S. officinalis* the intrinsic muscular tissue of the sucker walls and the peduncle is well differentiated (Fig. 2 A). The suckers of *L. vulgaris* possess highly developed muscular tissue (circular and longitudinal muscular fibres) in the peduncle but lack well-differentiated muscle in the sucker wall. In *O. vulgaris* the acetabulum roof includes radial muscle fibres which extend between an inner and outer fibrous connective tissue (Kier & Smith 1990). But they are not as densely packed as the corresponding fibres in the suckers of the cuttlefish. Nevertheless, radial, circular, and meridional fibres are differentiated in the infundibulum and acetabulum wall. No well marked sphincter muscle can be found at hatching stage but thick extrinsic muscular bundles attach the sucker to the arm.

DISCUSSION

In general, the main features of the outer surface of the sucker show an obvious resemblance to those of the adult suckers (Nixon & Dilly 1977). Even in the hatchlings the infundibulum is provided with pegs : *S. officinalis* and *L. vulgaris* are endowed with a relatively small number of tall pegs, whereas in *O. vulgaris* many flat pegs appear on the surface of the infundibulum. The pegs may provide friction to aid suction adhesion of the suckers of the hatchlings. In addition, the epidermis of the rim and the lateral regions are dotted with ciliated cells which probably enable the hatchlings to respond to chemical and tactile stimuli from the environment (Graziadei 1964a, 1964b; Graziadei & Gagne 1976). A typical subacetabular ganglion was not observed in the two decapods (Guérin 1908; Martoja & May 1956). The large cells below the epithelium of the piston may secrete the collagenous connective tissue of the subacetabular region (Haas 1989). In the subacetabular region of *O. vulgaris*, however, nerve fibres exist and may establish the connection to the prospective subacetabular ganglion.

In *S. officinalis* the intrinsic muscular system is very well developed and corresponds more or less to the situation in the suckers of the adult. The retardation in the development of the muscular tissue in the wall of the suckers of *L. vulgaris* may be compensated by a well differentiated one in the peduncle which probably plays an important role in the mechanism of attachment: The contraction of the musculature of the peduncle leads to an extension of the acetabulum and thus enlarges the suction effect. In *O. vulgaris* the muscular system of the suckers is more highly differentiated than expected from the outward appearance.

The various developmental stages of the suckers of the hatchlings reproduce almost exactly general morphological differences between the two developmental types (benthic, planktonic) of cephalopods : *S. officinalis* is equipped with highly differentiated suckers which seem to be able to act like the adult ones, whereas the suckers of *L. vulgaris* are less developed. The suckers of the planktonic *O. vulgaris*, however, are more advanced than those of the planktonic squid. This advanced development may be required for the benthic way of life which follows soon after. But the suction process is probably not as effective as in adults because of the still missing marginal fold which is important for forming a tight seal (see Nixon & Dilly 1977). Nevertheless, the suckers of both planktonic cephalopods investigated seem to have a sufficiently effective adhesive function according to the demands in the early postembryonic life.

REFERENCES

BOLETZKY S. V. 1974. The "larvae" of Cephalopoda – a review. *Thalassia Jugos.* **10** : 45-76.

BOLETZKY S. V. 1977. Post-hatching behaviour and mode of life in Cephalopods. *Symp. zool. Soc. Lond.* **38** : 557-567.

BOLETZKY S. V. 1979. Observations on the early post-embryonic development of *Loligo vulgaris* (Cephalopoda, Mollusca). *Rapp. Comm. int. Mer Médit.* 25/26, **10** : 155-158.

BOLETZKY S. V. 1987. Juvenile behaviour. *In* : Cephalopod life cycles. II. Edited by P.R. Boyle, Academic press, London : 45-60.

FIORONI P. 1977. Die Entwicklungstypen der Tintenfische. *Zool. Jb. Anat.* **98** : 441-475.

GRAZIADEI P.P.C. 1964a. Electron microscopy of some primary receptors in the suckers of Octopus vulgaris. *Z. Zellf.* **64** : 510-522.

GRAZIADEI P.P.C. 1964b. Receptors in the sucker of the cuttlefish. *Nature,* Lond. **203**.: 384-386.

GRAZIADEI P.P.C. & GAGNE H.T. 1976. Sensory innervation in the rim of *Octopus* sucker. *J. Morphol.* **150**.: 639-679.

GUÉRIN M.J. 1908. Contribution à l'étude des systèmes cutané, musculaire et nerveux de l'appareil tentaculaire des Céphalopodes. *Arch. Zool. exp. gén.* **4** : 1-178.

HAAS W. 1989. Suckers and arm hooks in Coleoidea (Cephalopoda, Mollusca) and their bearing for phylogenetic systematics. *Abh. naturwiss. Ver. Hamburg* **28** : 165-185.

KIER W.M. & SMITH A.M. 1990. The morphology and mechanics of *Octopus* suckers. *Biol. Bull.* **178** : 126-136.

MARTOJA R. & MAY R.M. 1956. Comparaison de l'innervation brachiale des Céphalopodes *Octopus vulgaris* Lam. et *Sepiola rondeleti* Leach. *Arch. Zool. exp. gén.* **94** : 1-60.

NIXON M. & DILLY P.N. 1977. Sucker surfaces and prey capture. *Symp. zool. Soc. Lond.* **38** : 447-511.

NOLTE K. & FIORONI P. 1983. Zur Entwicklung der Saugnäpfe bei coleoiden Tintenfischen. *Zool. Anz.* **211** (5/6) : 329-340.

REYNOLDS F.S. 1963. The use of lead citrate at high pH as an electron opaque stain in electron microscopy. *J. Cell. Biol.* **17** : 208-212.

SPURR A.R. 1969. A low-viscosity epoxy resin embedding medium for electron microscopy. *J. Ultrastruct. Res.* **26** : 31-43.

Reçu le 26 janvier 1996; received January 26, 1996
Accepté le 30 juillet 1996; accepted July 30, 1996