

Zeitschrift: Bollettino della Società ticinese di scienze naturali

Herausgeber: Società ticinese di scienze naturali

Band: 87 (1999)

Artikel: Symbiotic relations between bacteria and cephalopods

Autor: Grigioni, Sveva / Boucher-Rodoni, Renata / Tonolla, Mauro

DOI: <https://doi.org/10.5169/seals-1003287>

Nutzungsbedingungen

Die ETH-Bibliothek ist die Anbieterin der digitalisierten Zeitschriften auf E-Periodica. Sie besitzt keine Urheberrechte an den Zeitschriften und ist nicht verantwortlich für deren Inhalte. Die Rechte liegen in der Regel bei den Herausgebern beziehungsweise den externen Rechteinhabern. Das Veröffentlichen von Bildern in Print- und Online-Publikationen sowie auf Social Media-Kanälen oder Webseiten ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. [Mehr erfahren](#)

Conditions d'utilisation

L'ETH Library est le fournisseur des revues numérisées. Elle ne détient aucun droit d'auteur sur les revues et n'est pas responsable de leur contenu. En règle générale, les droits sont détenus par les éditeurs ou les détenteurs de droits externes. La reproduction d'images dans des publications imprimées ou en ligne ainsi que sur des canaux de médias sociaux ou des sites web n'est autorisée qu'avec l'accord préalable des détenteurs des droits. [En savoir plus](#)

Terms of use

The ETH Library is the provider of the digitised journals. It does not own any copyrights to the journals and is not responsible for their content. The rights usually lie with the publishers or the external rights holders. Publishing images in print and online publications, as well as on social media channels or websites, is only permitted with the prior consent of the rights holders. [Find out more](#)

Download PDF: 13.02.2026

ETH-Bibliothek Zürich, E-Periodica, <https://www.e-periodica.ch>

Symbiotic relations between bacteria and cephalopods

Sveva Grigioni¹, Renata Boucher-Rodoni¹, Mauro Tonolla² and Raffaele Peduzzi²

¹ Laboratoire de Biologie des Invertébrés marins,
URA 699 CNRS, Muséum national d'Histoire naturelle, 55 rue Buffon, 75005 Paris
² Cantonal Institute of Bacteriology, Microbial Ecology (University of Geneva), CH-6904 Lugano

INTRODUCTION

Chronic heterotrophic symbiosis is known from many invertebrate taxa, including cephalopods. The symbionts can be intracellular or extracellular, and entertain with the host parasitic, commensal or mutualistic relationships. The transmission from one generation to the other is either hereditary (vertical), or non-hereditary (horizontal), the infection occurring after birth.

In cephalopods, two types of symbiosis are now well documented: the sepiolid *Euprymna*/luminous bacterium *Vibrio fisheri* association, and the accessory nidamental glands/microbial community symbiosis.

(1) Many cephalopods are bioluminescent, and in some species of sepiolids and loliginids the light is emitted by extracellular symbiotic bacteria, which live in the crypt of a light organ located on the ink sac. In this case, the host provides an adequate environment for the heterotrophic bacterium, and the host derives luminescence from the bacteria. At birth, the sepiolid is aposymbiotic and acquires free-living *Vibrio fisheri* from the surrounding sea water within hours (WEI & YOUNG, 1989; MCFALL-NGAI & RUBY, 1991, 1998; MONTGOMERY & MCFALL-NGAI, 1994). Only some tissues of the light organ are influenced by the presence of *Vibrio*, which induce light organ morphogenesis (DOINO & MCFALL-NGAI, 1995).

(2) As far as the accessory nidamental glands (ANG) microbial community symbiosis is concerned, we know that these organs harbour a dense bacterial community, colourless in immature animals, which becomes red-orange in mature females (BLOODGOOD, 1977). Sequencing of bacterial 16S DNA has allowed to show that various bacteria species are present in the ANG of *Loligo pealei* (BARBIERI *et al.* 1996). ANG symbiotic bacteria are present in sepioids and in myopsid squids, but their role is not yet totally understood. The ANG are closely associated with nidamental glands and oviduct, and their role might be to coat the eggs with bacteria in charge of protective antimicrobial activity (BARBIERI *et al.*, 1997). In agreement with this suggestion, similarities in the microbial community of both ANG and egg cases were shown. As far as the transmission is concerned, bacterial colonization of ANG is thought to occur after hatching (LUM-KONG & HASTINGS, 1992; KAUFMAN *et al.*, 1998).

In this paper, we investigate the presence of symbi-

otic bacteria in different organs of the sepioid *Sepia officinalis*, the nautiloid *Nautilus macromphalus* and of the octopod *Eledone* *sp.* the sepioid *Sepia officinalis* is known to harbour symbiotic bacteria in the ANG, and Schipp *et al.* (1985) suggest the presence of bacteria in the pericardial appendages of *Nautilus*. In *Eledone* no symbiotic association is known so far.

MATERIAL AND METHODS

***Sepia officinalis*:** 8 adult specimens were collected in the English Channel (Luc-sur-mer). Various organs were obtained by aseptic dissection: the accessory nidamental gland (ANG); the nidamental gland, the anterior and posterior renal sac, the heart, the branchial heart, the gills, the digestive gland, the blood, the pericardial gland, the spermatophore.

***Nautilus macromphalus*:** 9 adult specimens were collected in New Caledonia. Various organs were analysed: the gills, the heart, the pericardial appendages, the digestive gland, the renal appendages.

***Eledone* *sp.*:** 3 adult specimens were collected in the Mediterranean (Banyuls-sur-mer). The organs analysed were the renal sac, the coelomic liquid, the branchial heart, the gills.

Samples for **PCR analysis** were stored in TE buffer pH8 (10 mM tris/HCl pH7.2, 1mM EDTA) at -20°C until use. Total DNA extraction was performed by classic phenol purification and ethanol precipitation after 10mg/ml Lysozyme and 10mg/ml Proteinase K digestion. DNA was resuspended in 50µl of TE and stored at -20°C.

The amplification primers are listed in table 1. We used the universal bacterium-specific 27F-1385R or UNIL-UNIR, which produced almost the entire 16S rRNA gene fragment and the eubacteria specific EUB-UNIL pair. Two other amplification primer pairs were used: the AMOR-AMOF pair specific for ammonifying bacteria (amplification of the gene coding for the ammonia-monoxygenase), and the NARGF-NARGR pair specific for denitrifying bacteria (amplification of the gene coding for the nitrate reductase).

PRIMER	SEQUENCE
27F	5'GAGTTTGATCCTGGCTCAG3'
1385R	5'GCCACACATGTTCCGG3'
UNIR	5'ATGGTACCGTGTGACGGCGGTGA3'
UNIL	5'ATTCTAGAGTTGATCATGGCTCA3'
EUB	5'GCTGCCTCCCGTAGGAGT3'
AMOR	5'AGACTCCGATCCGGACTACG3'
AMOF	5'TGGGGCATAACGCATCGAAAG3'
NARGF	5'TTACTTCAAACAGAAGGGTGAAACCTTT3'
NARGR	5'TTCGCTTATCGCGCTTCAATGAT3'

Tab. 1 - Amplification primers sequences.

PCR was conducted with dNTP, *Taq* polymerase and buffer (Eurogentec S.A.) in a Thermojet Thermocycler (EquiBio, Belgium) with a denaturing step at 94°C for 5 min, 32 cycles of 94°C (30 sec), 55°C (30sec) and 72°C (1 min) and a final elongation step of 72°C for 7 min. For amplification with NARGF-NARGR primers, Kloos *et al.* (1995) protocol was followed. Length of PCR products was controlled by electrophoresis in 1.5% agarose gel.

RESULTS AND DISCUSSION

Several organs were tested for bacterial symbiosis based on PCR amplification, in three species of cephalopods, *Sepia officinalis*, *Nautilus macromphalus*, *Eledone* sp., using 4 different primer pairs. The results obtained are presented in table 2.

Table 2. Results of PCR amplifications of different bacterial strains from various organs of three cephalopods. *: positive results; **: highly positive results; -: negative results; nd: not done. ANG: accessory nidamental gland; Ant.RS: anterior renal sac; BH: branchial heart; Coel.Liq.: coelomic liquid; DG: digestive gland; NG: nidamental gland; P.App: pericardial appendages; P.Gl: pericardial gland (branchial heart appendages); Post.RS: posterior renal sac; Renal App: renal appendages; Sperm: spermatophore.

(A) *Sepia officinalis*

Primers\ organs	Gills	BH	Heart	Blood	NG	ANG	Sperm	P.Gl	DG	Ant.	Post.	RS	RS
Universal bact.	*	-	*	-	-	**	-	-	-	-	*	**	
EUB	*	-	*	-	-	**	-	-	-	-	**	**	
bAMO	-	-	-	-	nd	-	nd	-	nd	-	*		
NAR-G	nd	nd	nd	nd	nd	*	nd	-	nd	-	-	-	

(B) *Nautilus macromphalus*

Primers\ organs	Gills	BH	Heart	P.App	DG	Renal App
Universal bact.	**	-	-	**	-	**
EUB	nd	-	-	**	-	**
bAMO	-	-	-	-	nd	*
NAR-G	nd	nd	nd	nd	nd	-

(C) *Eledone* sp.

Primers\ organs	Gills	BH	Coel.Liq	Renal Sac
Universal bact.	*	-	-	-
EUB	**	-	-	-
bAMO	*	-	nd	-
NAR-G	nd	nd	nd	nd

As expected the accessory nidamental glands of *Sepia officinalis* give highly positive results (universal bacteria, eubacteria, NAR-G). But also some other organs of this species appear to harbour dense bacteria populations, in particular the renal sacs (universal bacteria, eubacteria, bAMO).

The presence of symbiotic bacteria in the pericardial appendages of *Nautilus* was suggested by Schipp *et al.* (1985), based on electron microscopy observations. This is confirmed here: the results obtained with universal bacteria and eubacteria specific primers are highly positive. In addition, this species also appears to have, like *Sepia*, bacteria associated to the renal appendages. In both species, the excretory organs harbour among eubacteria, ammonifying bacteria.

As far as *Eledone* is concerned, the only positive result concerns the gills and might be fortuitous. Preliminary results with in situ hybridization do not reveal the presence of bacteria in the gill tissues of *Eledone* (unpubl. res.). Accordingly, the positive result obtained with PCR is considered as doubtful. The origin of the bacteria present in the gills of the three taxa might be environmental, since these organs are in contact with external sea water.

Thus, bacterial symbiotic associations appear to concern several organs of *Sepia* and *Nautilus*, whereas no significant association could be identified, so far, in *Eledone*. This might be related to a different buoyant system. *Eledone* is a benthic species with no need for buoyancy. *Sepia* and *Nautilus* live in the sea water column and both have a chambered shell, either internal (*Sepia*) or external (*Nautilus*), playing an important part in the regulation of buoyancy by accumulating gas, mainly N₂, in the chambers. Due to these shelled species low excretion rates compared to non shelled ones, it was suggested that the origin of N₂ accumulation might be the result of protein catabolism end-product (NH₄⁺) recycling by symbiotic bacteria (BOUCHER-RODONI & MANGOLD, 1994). The results obtained here are in agreement with this hypothesis, since only the two shelled species *Sepia* and *Nautilus* appear to harbour symbiotic bacteria, including ammonifying or denitrifying strains. In parallel to in situ hybridization aimed to localize the bacteria within the tissues, the specific identification by 16S rRNA sequencing of the bacteria present in the various organs of *Sepia* and *Nautilus* is currently underway and should confirm if some of them could effectively be involved in the Nitrogen cycle.

Acknowledgements

The authors thank Dr. Joel Henri (Univ. Caen) and Pascale Joannot (Aquarium of Nouméa) for providing biological samples. This work was supported by a an international grant from CNRS (PICS N° 743). The first author was the grateful recipient of a grant for Junior Researcher from the Swiss National Science Foundation, followed by a FEMS fellowship for young scientist (1998).

REFERENCES

BARBIERI E., GULLEDGE J., MOSER D. & CHIENG C.C., 1996. New evidence for bacterial diversity in accessory nidamental gland of the squid (*Loligo forbesi*). *Biol. Bull.*, 191: 316.

BARBIERI E., BARRY K., CHILD A. & WAINWRIGHT N., 1997. Antimicrobial activity in the microbial community of the accessory nidamental gland and egg cases of *Loligo pealei* (Cephalopoda: Loliginidae). *Biol. Bull.*, 193: 275-276.

BLOODGOOD R. A., 1977. The squid accessory nidamental gland: ultrastructure and association with bacteria. *Tissue & Cell* 9, 2: 197-208.

BOUCHER-RODONI R. & MANGOLD K., 1994. Ammonia production in cephalopods, physiological and evolutionary aspects. *Mar. Fresh. Behav. Physiol.*, 25: 53-60.

DOINO J.A., & MCFALL-NGAI M.J., 1995. A transient exposure to symbiosis-competent bacteria induces light organ morphogenesis in the host squid. *Biol. Bull.*, 189: 347-355.

KAUFMAN M.R., IKEDA Y., PATTON C., VAN DYKHUIZEN G. & EPEL D., 1998. Bacterial symbionts colonize the accessory nidamental gland of the squid *Loligo opalescens* via horizontal transmission. *Biol. Bull.* 194: 36-43.

KLOOS K., FESEFELDT A., GLIESCHE C.G. & BOTHE H., 1995. DNA-probing indicates the occurrence of denitrification and Nitrogen fixation genes in *Hyphomicrobium*. Distribution of denitrifying and Nitrogen fixing isolates of *Hyphomicrobium* in a sewage treatment plant. *FEMS Microbiol. Ecol.*, 18: 205-213.

LUM-KONG A. & HASTINGS T.S., 1992. The accessory nidamental glands of *Loligo forbesi* (Cephalopoda: Loliginidae): characterization of symbiotic bacteria and preliminary experiments to investigate factors controlling sexual maturation. *J. Zool. Lond.*, 228: 395-403.

MCFALL-NGAI M.J. & RUBY E.G., 1991. Symbiont recognition and subsequent morphogenesis as early events in an animal-bacterial mutualism. *Science* 254: 1491-1494.

MCFALL-NGAI M.J. & RUBY E.G., 1998. Sepiolids and Vibrios: when first they meet. *Bioscience*, 48(4): 257-265.

MONTGOMERY M.K. & MCFALL-NGAI M.J., 1994. Bacterial symbionts induce host organ morphogenesis during early postembryonic development of the squid *Euprymna scolopes*. *Development*, 120: 1719-1729.

SCHIPP R., MARTIN A. W., LIEBERMANN H. and MAGNIER Y., 1985. Cytomorphology and function of pericardial appendages of *Nautilus* (Cephalopoda, Tetrabranchiata). *Zoomorphol.*, 105:16-29.

WEI S.L. & YOUNG R.E., 1989. Development of symbiotic bacterial bioluminescence in a nearshore cephalopod, *Euprymna scolopes*. *Mar. Biol.*, 103: 541-546.

