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On the anatomy of a new species of *Oxypolella* (Nemertini) and further notes on *Oxypolella bergendali* Cantell 1975

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Abstract

The anatomy of a new species of heteronemertean from the Mediterranean, *Oxypolella banyulensis* sp. nov., is described and illustrated. The species is characterized by having a dermis comprising subepidermal longitudinal muscle fibres arranged in characteristic piles, a three-layered proboscis with four main regions, one ciliated pit in the frontal organ, two dorsal nerves and a thin inner circular muscle layer. Further notes on *Oxypolella bergendali* are given.

Keywords: *Heteronemertea*, *Mediterranean*, *Oxypolella banyulensis* sp. nov., *Oxypolella bergendali*

Introduction

Many nemertines from the Mediterranean were first described by Bürger (1895) in his monograph in *Fauna und Flora des Golfes von Neapel*. Since that time new morphological characters have been verified as important for the taxonomy of nemertines and they need careful descriptions.

In this paper the anatomy of *Oxypolella banyulensis* sp. nov. from a bottom with both corals and mud just outside Laboratoire Arago, Banyuls-sur-Mer, France is described. Bergendal (1902, 1903) described *Oxypolella punnetti* and *Oxypolella alba* from the Swedish west coast; Cantell (1972) described *Oxypolella bergendali* from the Swedish west coast; and Senz (1993) studied the new species *Oxypolella histriana* from the Mediterranean area.

From the same locality (le coralligènes des Albères) where *Oxypolella banyulensis* was found Cantell (1988, 1996) has studied *Cerebratulus hepaticus* Hubrecht 1879 and *Leucocephalonemertes aurantiaca* (Grube 1855).

Abbreviations used in figures

The following abbreviations are used in the figures: BR, brain; CL, cephalic lacuna; CO, cerebral sensory organ; DC, dermal connective tissue layer; DG, dorsal ganglion; DM, dermal musculature; FM, foregut musculature; GD, gonoduct; GO, gonad; IC, body wall inner circular musculature; MO, mouth; PR, proboscis.

Material and methods

The nemertine upon which the following description is based was collected near the Laboratoire Arago, Banyuls-sur-Mer, France. Tubs were filled with material (e.g. corals and also mud) and then left standing without aeration, which resulted in nemertines emerging from the substratum to creep up towards the surface of the sea water (Cantell 1975). The body length was measured with a drawing compass during normal extension. Living worms were observed during normal extension and then anaesthetized with MS 222 before fixation. Bouin's fluid was used as a routine fixative, followed by Heidenhain's iron-haematoxylin-eosin. Descriptions are based on serial sections of one specimen cut transversely.

Systematics

Class ANOPLA
Subclass HETERONEMERTEA
Family Valencinidae Gibson
Genus *Oxypolella* Bergendal, 1902

Diagnosis

Heteronemertea without lateral horizontal cephalic slits but with a transverse furrow encircling the back of the head; proboscis with three muscle layers (outer longitudinal, middle circular, inner longitudinal), without muscle crosses; rhynchocoel wall circular muscles not interwoven with body wall musculature; proboscis pore subterminal, ventral; dorsal fibrous core of cerebral ganglia branched only at rear into dorsal and ventral points; nervous system with one or two dorsal nerves; dermis with gland cells and gelatinous connective tissue intermingled and also with distinct circular fibres; caudal cirrus absent; cephalic glands well developed or none; frontal organ present or none; eyes absent; cerebral sensory organs small; sexes separate.

Gibson (1994) has given a diagnosis for the genus *Oxypolia* Punnett, 1901 which shares a lot of similarities with the genus *Oxypolella*.

***Oxypolella banyulensis* sp. nov.**
 (Figures 1–13)

Holotype

A 54 mm long and 1 mm wide specimen from the type locality. Series of transverse sections through the anterior body, mid-intestinal region and posterior region. The specimen is deposited in the Museum of Evolution, Uppsala, Sweden, Cat. No. Nemertini 14.

Figure 1. Anterior region of *Oxypolella banyulensis* sp. nov., dorsal aspect. Scale bar: 0.05 mm.

Figures 2–7. *Oxypolella banyulensis* sp. nov. Scale bars: 0.05 mm. (2) Transverse section through the dermis in the region of the cephalic lacuna. (3) Transverse section through the dermis in the region of the foregut to show the distinct circular fibres. (4) Transverse section through the dermis in the mid-intestinal region to show the zone of fibrillated connective tissue. (5) Transverse section through the brain posterior to the region where the dorsal ganglia are separated from the ventral ganglia. (6) Transverse section through the cephalic lacuna. (7) Transverse section through the foregut to show the musculature lateral to the foregut.

Type locality

On bottom with both corals and mud just outside Laboratoire Arago, Banyuls-sur-Mer, France. This worm crept out from the mud.

Etymology

The specific name *banyulensis* refers to Banyuls-sur-Mer, the area where the nemertean was found.

External features

The worm is 54 mm long and 1 mm wide. In cross-section its anterior portion is round, while the midgut is flatter.

Figures 8–13. *Oxypolella banyulensis* sp. nov. Scale bars: 0.05 mm. (8) Transverse section through region 1 of the proboscis. (9) Transverse section through region 4 of the proboscis. (10) Transverse section through the region of the mouth. (11) Transverse section through the brain where the dorsal ganglia are separated from the ventral ganglia. (12) Transverse section through the anterior brain where ventrolateral nerves lead from the brain. (13) Transverse section through the reproductive region.

The shape of the head is shown in Figure 1. The head, which is not discernible from the rest of the body, is bluntly rounded anteriorly. Slightly anterior to the mouth a furrow appears around the body. There are no cephalic furrows. The proboscis pore is situated between the mouth and the anterior tip, somewhat closer to the latter. The rounded posterior end of the body lacks a caudal cirrus. The worm is sticky. At contraction the posterior half is thickened.

The anterior third of the body has a white colour but the posterior two-thirds of the body is yellow-white. Eye spots are absent.

Body wall

The epidermis is about 220 μm tall in the foregut region but about 110 μm tall in the reproductive region. It contains an abundance of oblong and oval glands containing homogeneous and coarse granular secretion. The epidermal basement membrane is thin.

Dermis (Figures 2, 3) is characterized by well-developed circular muscle fibres and connective tissue fibres especially in the anterior body. The outermost dermal musculature consists of a compact circular layer of fibres with very distinct subepidermal longitudinal muscle fibres arranged in characteristic piles. Inside the compact portion of the circular fibres there is an inner portion composed of dispersed sturdy fibres, dermal glands and longitudinal fibres embedded in the gelatinous connective tissue. There is a very thin layer of connective tissue between the muscular and dermal zones (except in the reproductive zone).

In front of the mouth there are few dermal glands and groups of longitudinal muscle fibres embedded in the connective tissue.

In the foregut region the dermis occupies about one-half to one-third of the zone between the epidermal basement membrane and the outer circular muscle layer. Dermis is filled with plenty of glands and only single longitudinal muscle fibres in the connective tissue. The subepidermal longitudinal muscle fibres, which are arranged in characteristic piles, are distinct both in the foregut region and also in front of the mouth (Figures 2, 3).

In the reproductive region the dermis occupies about one-third of the zone between the epidermal basement membrane and the outer circular muscle layer. There are few dermal glands and few subepidermal longitudinal muscle fibres (about one to two rows of muscle fibres). The connective tissue inside the dermal glands form a distinct zone of fibrillated connective tissue (about half of the dermal zone) (Figure 4).

Body musculature

The body musculature consists of (1) the outer longitudinal muscle layer, (2) the outer circular muscle layer, (3) the inner longitudinal muscle layer, (4) the inner circular muscle layer and, in addition, (5) a variety of muscle fibres, single or in bundles, which cross the body in various directions.

Where the dorsal ganglia separate from the ventral ganglia there are thin horizontal muscle fibres ventral to the rhynchocoel (Figure 5). Both in the posterior brain region and also in the anterior mouth region the horizontal muscle fibres are distinct and spread out fanwise.

The outer circular muscle layer, which is especially thin anterior to the mouth, extends posteriorly from the cephalic lacuna. Posterior to the dorsal lobes, the outer circular muscle layer widens to include the cerebral organs.

The inner longitudinal muscle layer in the cephalic region is arranged as thick bundles of fibres above and below the cephalic lacuna (Figure 6). In the cephalic lacuna there are

Table I. Morphological comparison between the species of *Oxypolella* and *Oxypolia*.

Species	1	2	3	4	5	6
<i>Oxypolella alba</i> Bergendal, 1903	2	?	+	?	?	?
<i>Oxypolella punnettii</i> Bergendal, 1902	3	?	—	+	?	3–5
<i>Oxypolella bergendali</i> Cantell, 1972	4	2	+	+	—	8
<i>Oxypolella histriana</i> Senz, 1993	3	1	+	—	?	?
<i>Oxypolella banyulensis</i> sp. nov.	4	2	+	+	+	2
<i>Oxypolia beaumontiana</i> Punnett, 1901	1	2	—	—	?	4–11

(1) Number of regions in proboscis. (2) Number of dorsal nerves. (3) Presence (+) or absence (—) of body wall inner circular muscle layer. (4) Presence (+) or absence (—) of frontal organ. (5) Subepidermal longitudinal muscle fibres in characteristic piles. (6) Number of efferent ducts in the excretory system.

transverse muscle fibres dorsal and ventral of the lacuna passing through the inner longitudinal muscle layer. Laterally the transverse muscle fibres form radial muscle fibres. There are also dorsoventral and oblique muscle fibres passing through the cephalic lacuna. In the brain region there are a lot of longitudinal muscle fibres especially dorsally (Figure 5). In the mouth and the anterior foregut region the thicker dorsolateral parts of the inner longitudinal muscle layer are about five times as thick as the outer circular muscle layer, and in the reproductive region about two to three times as thick as the outer circular muscle layer. Here both layers are thinner.

Where the dorsal lobes are separated, they are detached from the circular muscle layer of the rhynchocoel thin dorsoventral and oblique muscle fibres. The dorsoventral muscle fibres also occur in the anterior mouth region.

Dorsally in the mouth region tangential muscle fibres separate from the circular muscle layer of the rhynchocoel to form a very thin inner circular muscle layer (Figure 7). The inner circular muscle layer occurs only in the anterior foregut region.

Connective tissue

The connective tissue is most abundantly developed in the mid-intestinal region lateral to the rhynchocoel and the dorsal vessel and alongside the intestine. Just posterior to the gonadal region the intestine is surrounded by a thick layer of connective tissue (laterally 253 μm). The connective tissue is fibrous.

Proboscis apparatus

The rhynchodaeum opens from the subterminal proboscis pore and forms a tubular chamber lined by an epithelium composed of cuboidal and columnar cells. The epithelium has long cilia anteriorly. The circular muscle layer, which appears just anterior to the region where the rhynchodaeum has penetrated the outer circular muscle layer, forms a muscle sphincter in the anterior brain region.

The wall of the rhynchocoel contains a thin circular muscle layer and inside it an even thinner longitudinal muscle layer. The diameter of the rhynchocoel diminishes towards the rear. In the foregut region there are muscle crossovers between the outer circular musculature and the rhynchocoel circular musculature. The rhynchocoel reaches nearly to the end of the worm.

The proboscis insertion is situated in front of the mouth at the level just behind the ventral brain commissure.

The proboscis is divisible into four main regions. The first region (Figure 8) adjoins the insertion and is characterized by a high outer epithelium (110 μm), a thick outer longitudinal muscle layer (132 μm), a thick but uneven nerve plexus (22 μm), a thin circular muscle layer (11 μm), a thin inner longitudinal muscle layer (3 μm) and a thin connective tissue layer below the flat epithelium.

The second region is characterized by having an especially thick circular muscle layer. The second region has an outer epithelium (55 μm), an outer longitudinal musculature (220 μm), a circular muscle layer (198 μm) and an inner longitudinal muscle layer (one row of muscle fibres).

At the change to the third region the outer longitudinal muscle layer widens at the expense of the circular muscle layer. The third region is characterized by an outer epithelium (44 μm), an outer thicker longitudinal muscle layer (550 μm), a circular muscle

layer (22 μm), an inner longitudinal muscle layer (22 μm) and a thickened connective tissue membrane (33 μm) below the flat epithelium.

The fourth region (Figure 9) is characterized by having no outer longitudinal muscle layer. The fourth region has an outer epithelium (275 μm), a circular muscle layer (11 μm) and an inner longitudinal muscle layer (121 μm).

Regions 2, 3 and 4 have a thinner nerve plexus (11 μm) than region 1. Below the flat epithelium there is a thin circular muscle layer.

Alimentary canal

The mouth cavity is narrow (Figure 10). Dorsal to the anterior mouth region there are transverse muscle fibres and also medially (below the rhynchocoel) longitudinal muscle fibres. There are distinct radial muscle fibres protruding from the dorsolateral part of the mouth epithelium.

Dorsal to the foregut there is medially a single row of longitudinal muscle fibres but dorsolaterally three to four rows of longitudinal muscle fibres. In the anterior foregut region there is laterally and ventrally a distinct layer of longitudinal muscle fibres (about three to four rows of longitudinal fibres) and outside this thin circular muscle fibres (Figure 7). Posteriorly in the foregut region the longitudinal muscle fibres become fewer (only single muscle fibres). In the foregut region there are also radial muscle fibres.

Between the foregut and the intestine the circular muscle fibres form a muscle sphincter. There are no longitudinal muscle fibres in the region behind the muscle sphincter (the region of the anterior intestine). Very thin dorsoventral muscle fibres occur between the lateral intestinal diverticula. There are no longitudinal muscle fibres around the intestine in the reproductive region.

Blood system

The cephalic lacuna (or commissure) begins in front of the proboscis pore. It gradually increases in diameter and becomes flattened dorsoventrally (Figure 6). It is divided by dorsoventral and oblique muscle fibres into several lacunae (up to six). Approximately where the rhynchodaeum leads inside the outer circular muscle layer the cephalic lacuna divides into two lateral vessels. The rhynchodaeum leads inside the outer circular muscle layer just anterior to the brain. Just behind the separation of the dorsal and ventral ganglia the lateral vessels anastomose by a ventral transverse vascular connective below the proboscis sheath (Figure 11). The vascular connective is ventrally divided by horizontal muscle fibres into a ventral vessel which in front of the mouth is divided into two vessels (Figure 5). They join the lateral vessels somewhat posteriorly.

In the foregut region there are a lot of wide foregut vessels. The dorsal vessel lies along the bottom of the anterior part of the rhynchocoel (Figure 8), then leaves it to run, in the reproductive region, between it and the intestine. Here this vessel is surrounded by a thin circular muscle layer and inside this longitudinal muscle fibres (one to two rows of muscle fibres). In the mid-intestinal region the lateral vessels lie ventrolateral to the mid-intestine.

Nervous system

The fibrous core comprises a large part of the brain. The commissures are broad. Where the dorsal ganglia separate from the ventral, they are approximately three times larger than

the latter (Figure 11). The dorsal lobes are separated in the anterior region of the cerebral organs and lie dorsal to the dorsal ganglia.

In the mass of ganglion cells two types of cells can easily be distinguished, namely a small type and a larger one (about 27 μm). The latter is in a more medial position in the brain. The outer and the inner neurilemma of the brain are thin. The outer neurilemma consists of dispersed fibres and among them in the anterior brain single groups of longitudinal muscle fibres. There are single dispersed circular muscle fibres around the brain.

Anteriorly in the brain there are two nerves leading from the dorsal ganglia in a ventrolateral direction (Figure 12). The ultimate fate of these nerves could not be traced.

From the lateral nerve cords, two foregut nerves separate. They connect with each other by about three commissures in front of the mouth and one below the foregut. The commissure in front of the mouth is the thickest. So far as could be determined, the lateral nerve cords are joined posteriorly by a sub-intestinal commissure situated just in front of the anus.

In front of the brain a dorsal nerve runs between the epidermis and the cephalic lacuna. Behind the brain commissures two dorsal nerves occur medially; one is situated above and contiguous to the outer circular muscle layer (the median dorsal nerve) and the other (the outer dorsal nerve) is situated in the outer longitudinal muscle layer. Just in front of the border between the foregut and the intestine the outer dorsal nerve unites with the median dorsal nerve.

In the reproductive region there are two dorsal nerves, the median dorsal nerve and the outer dorsal nerve.

Outside the outer circular muscle layer a distinct nerve plexus is present (Figure 10).

Sense organs

The present species does not possess eyes. A frontal organ is present and consists of one ciliated pit at the tip of the head. There are few frontal gland cells dorsally and ventrally in the region of the cephalic lacuna.

The cerebral organs, which are 660 μm broad and 550 μm high, lie in their anterior part ventrolateral to the dorsal ganglia. Then the dorsal ganglia turn into the cerebral organs. The cerebral canals, which open in the furrow around the body, lead inwards and then turn backwards and inwards. The posterior part of the cerebral organs does not bulge deep into the lateral vessels, but has the lateral vessels proximally (Figure 10). There is connective tissue between the cerebral organs and the lateral vessels. The posterior part of the ventral fibrous core is situated near the cerebral canal. The posterior part of the cerebral organs has a mass of gland cells.

Excretory system

The nephridial canals are situated in the posterior foregut region. They are situated in the lumen of the lateral blood lacunae. Two pairs of efferent ducts were observed at the posterior end of the nephridial region.

Reproductive system

The large gonads, which have dorsolateral gonoducts, are situated between the lateral pouches of the intestine (Figure 13). They were full of sperm (July).

Further notes on *Oxypolella bergendali*

In the mid-intestinal region only one dorsal nerve (the median dorsal nerve) is present. A frontal organ is present and consists of one ciliated pit in the head. There are ventrolateral nerves from the anterior brain. There is also a fourth region in the proboscis with an outer epithelium, a circular muscle layer and an inner longitudinal muscle layer. Dorsal to the anterior mouth region there are only single longitudinal muscle fibres but dorsal to the posterior mouth region there are dorsomedially single longitudinal muscle fibres and dorsolaterally a lot of longitudinal muscle fibres. The longitudinal muscle fibres surround the foregut both laterally and ventrally.

Discussion

The genus *Oxypolella* belongs to the family Valencinidae (Gibson 1985). Bergendal (1902) erected a new genus *Oxypolella* and according to him the closely related genus *Oxypolia* differs from *Oxypolella* in having no frontal organs, the structure of the dermis and proboscis and the size and situation of the cerebral organs. Especially because of the structure of the dermis Bergendal (1902) erected the genus *Oxypolella*. According to Punnett (1901) there is in *Oxypolia beaumontiana* a fine but well-marked basement membrane in the oesophageal region, beneath which is a well-developed layer of circular muscle fibres. Underneath this again is a thick layer of gelatinous-like connective tissue, which contains a number of small glands. Bergendal (1902) describes in *Oxypolella punnetti* a well-developed basement membrane in the anterior body and no network-like layer in the dermis but instead totally filled with gland cells. There is no frontal organ in *Oxypolia beaumontiana* but one frontal organ in *Oxypolella punnetti*. Punnett (1901) describes in *Oxypolia* one region in the proboscis but Bergendal (1902, 1903) mentions two regions in *Oxypolella alba* and three regions in *Oxypolella punnetti*.

Oxypolella banyulensis differs from *Oxypolella histriana* (Senz 1993) in having two dorsal nerves, musculature around the foregut, a frontal organ with a ciliated pit, horizontal muscle fibres in the brain region and very thin dorsoventral musculature in the intestinal region.

Oxypolella banyulensis shares a lot of similarities with the morphology of *Oxypolella bergendali* but differs in having a distinct subepidermal longitudinal muscle layer with muscle fibres arranged in characteristic piles, two dorsal nerves (outer and median dorsal nerves) in the mid-intestinal region and they are united anterior to the border between the foregut and the intestine. In *Oxypolella bergendali* the subepidermal longitudinal muscle fibres are only dispersed fibres. *Oxypolella banyulensis* has somewhat more developed layers of longitudinal muscle fibres laterally and ventrally around the anterior foregut region.

Bergendal (1902, 1903) briefly described two *Oxypolella* species, *Oxypolella punnetti* and *O. alba*. *Oxypolella alba* differs from *O. punnetti* in having two regions in its proboscis and a weak inner circular muscle layer. *Oxypolella punnetti* has three regions in its proboscis and no inner circular muscle layer.

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