Emschermannia ramificata—a new genus and species of solitary entoproct from the Kara Sea, Russia

ANASTASIA O. BORISANOVA
Faculty of Biology, Moscow State University, 1-12 Leninskie Gory, Moscow, Russia 119991. E-mail: borisanovaao@mail.ru

Abstract
A new genus and species of solitary entoproct, Emschermannia ramificata, is described from the Kara Sea. It is an epibiont of the nephtyid polychaete Aglaophamus malmgreni, collected from 25–472 m depth. The species is about 250–300 μm long, with 8–10 tentacles, and buds are formed from a frontal area of the calyx. The calyx and stalk are not separated from each other by a cuticular septum, and a star-cell complex is absent. Emschermannia ramificata attaches to a substratum via a basal plate from which pseudostolons grow. Zooidal morphology conforms to that of the Loxosomatidae, but the attachment structure is unique among solitary entoprocts; it resembles basal plates and stolons of colonial entoprocts, but pseudostolons of Emschermannia serve only for attachment, not for budding. Overall, the morphology of Emschermannia may be considered intermediate between that of solitary and colonial forms, with relevance to evolutionary development within Entoprocta.

Key words: Entoprocta, new taxon, intermediate morphology, polychaete epibiont, Aglaophamus

Introduction
The current classification of Entoprocta was offered by Emschermann (1972). He recognized two orders—Solitaria, with the one family Loxosomatidae, and Coloniales, with the suborders Astolonata (family Loxokalypodidae) and Stolonata (families Barentsiidae and Pedicellinidae). Loxosomatidae comprises solitary species with a budding area on the calyx, a stalk attached to a substratum by a muscular sucking disc or a differentiated foot with a foot gland and a foot groove that can degenerate after attaching (Nielsen 1989), and no cuticular septum and star-cell complex between the calyx and stalk. Loxokalypodidae includes colonial entoprocts with features that are intermediate between solitary and colonial forms. Loxokalypus zooids resemble those of solitary species but they are connected by non-septate basal plate (Emschermann 1972). Suborder Stolonata comprises species with a cuticular septum between calyx and stalk. Zooids in Pedicellinidae and Barentsiidae arise from a stolon; those in Urnatellidae are on a basal disc (Brien 1959; Nielsen 1964). The present paper describes a new genus of solitary Entoprocta with an attachment structure similar to that of colonial species.

Material and methods
Benthic samples containing entoprocts were collected using a Sigsby trawl at several locations in the central plateau and St Anna Trough of the Kara Sea during Expedition 59 of RV Akademik Mstislav Keldysh in September–October 2011. Specimens of Entoprocta were found at depths of 25–472 m on parapodia and in the groove between the notopodia and the neuropodia of Aglaophamus malmgreni (Polychaeta: Nephtyidae).

Collected material was fixed and stored in 4% formaldehyde. Individual entoproct specimens were imaged using a Leica MZ6 and Leica DM2500. For scanning electron microscopy, the fixed material was dehydrated in an ethanol and acetone series, critical-point-dried and examined using a JEOL JSM 6380 SEM. Type material was deposited in the Zoological Museum of Moscow State University (ZMMU). For light microscopy, the samples were dehydrated in an ethanol series of increasing concentration, in 96% ethanol mixed with acetone and in pure
acetone. The dehydrated samples were embedded in epoxy resin (Epon-Araldite). Thick sections (3 µm) were cut on an Ultramicrotome Leica EM UC6 and stained with 1% toluidine blue.

Systematics

_Emschermannia_ gen. nov.

**Diagnosis.** Zooids comprising calyx and stalk that are not separated from each other by a star-cell complex and cuticular septum. Budding area located on calyx. Zooids attached to substratum by basal plate from which pseudostolons grow. The basal plate may be reduced so that the zooid arises directly from pseudostolon.

**Type species.** _Emschermannia ramificata_ sp. nov.

**Etymology.** _Emschermannia_ is named in honor of Dr Peter Emschermann, who provided the modern classification of Entoprocta.

_Emschermannia ramificata_ sp. nov.  
(Figs 1–4)

**Material examined.** _Holotype:_ ZMMU No. Uk-7, from central plateau of Kara Sea, 73°43.05’ N, 79°23.38’ E, 29 m, September–October 2011. _Paratypes:_ ZMMU No. Uk-8), five specimens from the same locality. _Other material:_ ZMMU No. Uk-9, three specimens from central plateau of Kara Sea, 73°10’ N, 79°51’ E, 25 m. ZMMU No. Uk-10, three specimens from central plateau of Kara Sea, 74°17’ N, 79°37’ E, 33 m. ZMMU Uk-11, two species from St Anna trough of Kara Sea, 77º12’ N, 78º07’ E, 119 m. ZMMU Uk-12, four species from St Anna trough of Kara Sea, 78º00’ N, 74º53’ E, 364 m, all September–October 2011.

**Etymology.** Latin _ramus_, branch, and _facio_, make, alluding to the unusual branched attachment structure of this species.

**Description.** Solitary, with single zooids attached to substratum by basal plate and short or long, usually branched, pseudostolons. Total length of body from end of stalk to base of tentacles 250–300 µm (Table 1). Calyx length 160–200 µm, width at broadest part 130–160 µm. Calyx laterally compressed, with 8–10 tentacles, facing distally or slightly distofrontally in contracted state. Tentacle crown of calyx with developing larvae directed distofrontally. Sensitive papillae absent. Stomach rounded without lobes. No cuticular septum between calyx and stalk (Fig. 2D). Stalk shorter than calyx, slightly extended at base, 80–110 µm long, 30–60 µm wide. Attachment structure an expanded basal plate from which sterile appendices (pseudostolons) grow out in different directions; these structures unequal, ranging from 50 to 600 µm long and 25–40 µm wide. Long pseudostolons usually growing from basal plate in opposite directions (Figs 2C, 4C); short pseudostolons growing from basal plate in any direction, also originating from long pseudostolons. Basal plate may be reduced in some specimens such that zooid arises only from creeping pseudostolon (Fig. 4B). In other specimens basal plate can attain diameter > 100 µm. Two unusual specimens of _Emschermannia_ were found among solitary forms (Fig. 3). Each of these specimens had two zooids arising from one attachment structure. In one case, both zooids arising from the basal plate, and in the other case one zooid arose from the basal plate and the other zooid from a pseudostolon.

**TABLE 1.** Measurements (µm) of seven preserved specimens of _Emschermannia ramificata_ gen. et sp. nov. The asterisk signifies the holotype.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>1*</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length</td>
<td>296</td>
<td>272</td>
<td>335</td>
<td>165</td>
<td>245</td>
<td>281</td>
<td>261</td>
</tr>
<tr>
<td>Calyx length</td>
<td>183</td>
<td>178</td>
<td>188</td>
<td>107</td>
<td>171</td>
<td>170</td>
<td>162</td>
</tr>
<tr>
<td>Calyx width</td>
<td>142</td>
<td>160</td>
<td>157</td>
<td>79</td>
<td>129</td>
<td>141</td>
<td>127</td>
</tr>
<tr>
<td>Stalk length</td>
<td>113</td>
<td>94</td>
<td>147</td>
<td>58</td>
<td>88</td>
<td>111</td>
<td>99</td>
</tr>
<tr>
<td>Stalk width</td>
<td>44</td>
<td>57</td>
<td>67</td>
<td>34</td>
<td>29</td>
<td>59</td>
<td>58</td>
</tr>
<tr>
<td>Length calyx/length of stalk</td>
<td>1.6</td>
<td>1.9</td>
<td>1.3</td>
<td>1.84</td>
<td>1.94</td>
<td>1.27</td>
<td>1.6</td>
</tr>
<tr>
<td>Length/width of calyx</td>
<td>1.3</td>
<td>1.1</td>
<td>1.2</td>
<td>1.35</td>
<td>1.3</td>
<td>1.2</td>
<td>1.27</td>
</tr>
</tbody>
</table>
Reproduction. Buds formed from median frontal area of calyx, several (up to 8) buds (Fig. 4A) are developing simultaneously, with new buds lying above older ones. Large buds with 8 tentacles and well-developed foot with foot gland and foot groove (Fig. 4D). Buds attached to the calyx by tip of foot, which is turned away from substratum. Developed buds 150–160 μm long, calyx length c. 80 μm, calyx width c. 60 μm.

Larvae. Some specimens with larvae developing in atrium (Figs 2B, 4B). Up to 5 embryos at different stages observed in one calyx.

Ecology. Emschermannia ramificata is an epibiont on the polychaete Aglaophamus malmgreni. Specimens of E. ramificata are most often in the groove between notopodia and neuropodia but they can also be found on the
parapodium itself and on the body surface beneath parapodia. The number of specimens on a single polychaete varies from several zooids to several dozen zooids, and separate specimens of *A. malmgreni* bear more than 50 entoprocts. Usually entoprocts are on parapodia of the anterior part of the worm’s body, but when the quantity of epibionts is great they also occur in the middle part of the body.

**FIGURE 2.** *Emschermannia ramificata* gen. et sp. nov., light micrographs: A, lateral view of holotype specimen; B, specimen with developed larvae in the atrium; C, specimen with long pseudostolon threads; D, longitudinal thin section through the calyx and stalk. Abbreviations: b, bud; in, intestine; la, larva; o, oocyte; ps, pseudostolon; s, stalk; st, stomach. Scale bars: 100 µm.

**Discussion**

The solitary mode of life and the general organization of zooids of *E. ramificata* correspond to that found in the Loxosomatidae. As in other members of this family, *Emschermannia* zooids have no septum between the calyx and the stalk, and buds with a well-developed foot and foot gland form on the calyx. The attachment structure of *Emschermannia* is unique to solitary forms and is similar to the attachment structures of colonial entoprocts.
FIGURE 3. *Emschermannia ramificata* gen. et sp. nov., light micrographs: A, B, specimens showing two zooids attached to the basal plate, with pseudostolons visible; C, higher magnification of the inset box in B, showing the place of connection (arrow) with the basal plate of the pseudostolon of one of the zooids. Abbreviations: b, bud; bp, basal plate; ps, pseudostolon. Scale bars: 50 µm.
Zooids of *Emschermannia ramificata* attach to a substratum surface via an expanded basal plate similar to the basal disc in Loxokalypodidae (Emschermann 1972). Thin stolon-like threads grow on the basal plate in different directions. They are here called pseudostolons because of their external resemblance to stolons of colonial forms. Unlike real stolons in the Pedicellinidae and Barentsiidae (Emschermann 1972; Wasson 2002), pseudostolons of *E. ramificata* do not serve for budding, only for attachment to the substratum. Two specimens were found, however, with a pair of zooids arising from one attachment structure such that they resembled miniature colonies (Fig. 3). It is not possible to confirm without histological sections level if these are genuinely colonial, resulting from budding of the attachment structure, or if they resulted from the accretion of two separate individuals. If it turns out that these are real colonies, then *Emschermannia* cannot be regarded as a member of Loxosomatidae but should be classified in its own new family (Emschermanniidae).
Emschermannia ramificata combines typical features of solitary species with an attachment structure peculiar to colonial species. Thus E. ramificata could be regarded as a kind of an intermediate between solitary and colonial entoprocts. Among earlier described species, Loxokalypus was regarded as an intermediate form of entoproct (Emschermann 1972). Loxokalypus is a colonial form that lives as an epibiont on the polychaete Glycera nana. It comprises small colonies with zooids arising from a common basal plate. New buds form on the stalk of the maternal zooid, then fold off while remaining connected to it via the basal plate; budding from the calyx was not described. In other respects, zooids maintain the organization of solitary forms, there being no cuticular septum between calyx and stalk, and muscles pass from stalk to calyx (Emschermann 1972).

Emschermann (1972) presented a scenario for entoproct evolution. Emschermannia should be added to this schema as an intermediate between solitary (Solitaria) and colonial forms (Coloniales). Emschermannia would be proximal to Loxokalypodidae in this evolutionary scheme because it is closer morphologically to Loxosomatidae than to Loxokalypus. It is possible to assume that the transition from a solitary to a colonial way of life was correlated with a shift of the budding zone from the calyx to the stalk and then to attachment structures such as a basal disc or stolons. It should be noted that colonial Loxokalypus has only a basal disc while solitary Emschermannia forms a basal disc as well as short pseudostolons. Therefore it seems possible that Loxokalypodidae is not the ancestral form of all colonial entoprocts but a lateral branch, and that entoprocts similar to Emschermannia give rise to two independent branches of colonial entoprocts—Astolonata with an attachment structure in the form of a basal disc, and Stolonata with an attachment structure in the form of a creeping stolon (Fig. 5).

The evolution of Stolonata had to be accompanied by the following transformations: loss of calyx budding, reduction of the basal plate, growth of the stolon and formation of the septum and star-cell complex between calyx and stalk. These are dominant features of colonial entoprocts. The most primitive representative of Stolonata seems to be Loxosomatooides, which is now included in the Pedicellinidae (Emschermann 1972; Wasson 2002). Loxosomatooides forms small colonies whose zooids still resemble solitary species (Annandale 1915; Marcus 1939; Wood 2005). The calyx of Loxosomatooides is separated from the stalk by a septum and a canopy-shaped structure composed of multiple cells situated at the calyx-stalk junction, but a distinct star-cell complex is not present (Schwaha et al. 2010). Loxosomatooides zooids are attached to the substratum by an expanded pad from which creeping stolons grow (Wood 2005; Schwaha et al. 2010). This pad may be homologous to the reduced basal plate of Emschermannia. According to these features, Loxosomatooides would constitute a primitive form of Stolonata and perhaps should be split off from Pedicellinidae as a separate family. This suggestion is partially supported by molecular data (Fuchs et al. 2010), according to which Loxosomatooides is the sister group to a clade including Barentsia and Pedicellina.

It should be noted that entoprocts intermediate between solitary and colonial forms (Emschermannia, Loxokalypus) live as epibionts of polychaetes, as do most Loxosomatidae (Nielsen 1964). Obviously the solitary

**FIGURE 5.** Scheme of a possible manner of colonial entoproct evolution. See text for explanation.
ancestor of these intermediate stages was also an epibiont of Polychaeta. In light of this, it is worth considering *Loxosomella varians*, which lives on the parapodia and gills of different nephtyid polychaetes (Nielsen 1964, 1989; Emschermann 1993). This species is interesting in exhibiting variability in stalk shape and in the structure of the attachment area that can be expanded. Emschermann (1993, fig. 18e) illustrated *L. varians* as having a branching adhesive plate. We can hypothesize that during evolution this plate gradually increased in dimensions and give rise to a basal plate with thin stolons dispersing in different directions, as in *Emschermannia*.

**Acknowledgements**

This research was supported by a grant from the Russian Scientific Fund (#14-50-00029). The author is very thankful to Dr V.V. Malakhov for his valuable advice. The author is grateful to the P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences (IO RAS) and especially to A.A. Vedenin for providing samples and taxonomic identification of the polychaete species.

**References**


http://dx.doi.org/10.1007/BF00346772

http://dx.doi.org/10.2307/1542225

http://dx.doi.org/10.1016/j.ympev.2010.04.009


http://dx.doi.org/10.1080/00785326.1964.10416272


http://dx.doi.org/10.1186/1742-9994-7-7


http://dx.doi.org/10.1007/s10750-004-7909-x