

Revisiting the *Cephalodella* trophi types

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Abstract The six trophi types proposed by Wulfert (Archiv für Hydrobiologie 31:592–636, 1937) are used as one main character to identify *Cephalodella* species, although these trophi types were just based on the trophi of 31 species described after light microscopy findings. Given the 160 species nowadays valid and the possibility of examining trophi with scanning electron microscopy it is questionable if the definitions of the six types might or rather have to be improved in order to facilitate species identification. Here, a new even simpler definition scheme is proposed to identify the six trophi types.

Keywords Trophi types · *Cephalodella* · Species identification

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Introduction

Wulfert (1937) recognized the value of the trophi of *Cephalodella* species for their determination given the very low variation of trophi morphology within taxa. This is in contrast to the higher variation that can be found in size, overall habitus or toe shape apart from eyespots mainly used to describe species at that time; just strikingly different trophi like those of *Cephalodella megalcephala* (Glascott, 1893) and *Cephalodella mira* Myers, 1934 were described in detail before 1937. Based on a subset of 31 species with well described trophi, out of about 100 species known at that time, Wulfert proposed six trophi types that categorize the diversity of the slightly different trophi. In 1938 he developed a determination key that, apart from the existence and position of the eyes, habitus and sizes, uses his trophi types as main characters (Wulfert, 1938). A trophi type was now assigned to nearly all keyed species and often more detailed information was lacking.

This system was adopted nearly unchanged by later keys (Koste, 1978; Nogrady et al., 1995). But nonetheless, some discrepancies can be found regarding the trophi types in the keys: e.g. *Cephalodella pseudeva* Berzins, 1976, *Cephalodella gisleni* Berzins, 1953 or *Cephalodella gobio* Wulfert, 1937 were assigned to type B or A; *Cephalodella apocoela* Myers, 1924 albeit redescribed with fanned manubrial ends by Wulfert (1940) keyed as A, *Cephalodella fluviatilis* (Zavadovsky, 1926) stated as type C or A;

Cephalodella theodora Koch-Althaus, 1961 keyed as type A, B or D; or *Cephalodella lindamayae* Koste & Shiel, 1986 and *Cephalodella boettgeri* Koste, 1988 without having any extension of the manubrial end described as type B.

In addition to these discrepancies, there is a mismatch between the 31 species used originally to define the trophi types and the 160 species that are nowadays valid (Segers, 2007). Furthermore, the examination of the trophi with scanning electron microscopy (SEM) has become widely used in the meantime. Given this, one can question if the definitions of the six types might or rather have to be improved in order to facilitate species identification. Especially, as the decision for one trophi type leads to different subsets of *Cephalodella* species and thus potentially to misidentifications. Alternatively, the diversity might be too high and consequently real differences between types so small that the categories cannot be used anymore.

Materials and methods

Trophi appearing in the figures were prepared by isolating them for SEM with SDS/DTT solution modified after Kleinow et al. (1990): 0.1 g 1,4-Dithio-DL-Threit(ol) (DTT) dissolved in 5 ml stock solution; stock solution: 5.2 g sodium dodecylsulphate (SDS) and 0.24 g NH_4HCO_3 in 100 ml distilled water. After decomposition of the surrounding tissue with SDS/DTT trophi were rinsed with distilled water. The air-dried trophi were afterwards sputtered with gold. SEM was performed with a Zeiss DSM 940, operated at 10 kV. Additional information about trophi was drawn from Wulfert (1938), Koste (1978), Nogrady et al. (1995) and the references therein.

Results

A simpler definition scheme was found sufficient to identify the six trophi types by light microscopic findings (Fig. 1). It uses a hierarchical set of five questions. First it is determined if the manubrial ends are extended, e.g. crutched, fanned or loop shaped (question Q1). Positively answered it is trophi type C if the manubrial ends are loop-shaped, otherwise it is trophi type B (question Q1b). However, it must be

noted that the loop must be nearly closed and not only slightly loop shaped as in *C. sterea minor* Donner, 1950 for example (Fig. 2, here are diverse manubrial ends of trophi belonging to type B illustrated). Given a negative answer to question 1, it is next asked if the manubrial possess dorsal as well as ventral basal lamellae and the rami numerous teeth as well as caudally attached broom-like subunci (or pleural rods if following De Smet, 2001) to identify trophi type D (Q2). The manubrial clava that is very characteristic, even in SEM, is depicted in Fig. 3.

If it should not be of type D it is asked in the next two questions whether it is one of the so far monotypic trophi types f (Q3) or E (Q4). Here, trophi type F is defined by rami that are bent backwards so that the trophi is only a little longer than the fulcrum. The trophi type E is characterized by its unique rami and the dorsally located manubria with dorsally attached lamellae that could either belong to the clava or the unci, which are otherwise not present. The rami (viewed laterally) consist of a less conspicuous ventral subbasal chamber proximately in line with the fulcrum and distally bent at right angle towards the dorsal side and a more prominent basal chamber bending upwards from the fulcrum on and connecting apically to the subbasal chamber. If all questions before are negatively answered the trophi in question is of trophi type A. Note that trophi of type A can but need not to be as fragile as in *Cephalodella auriculata* (Müller, 1773) (Fig. 4). Given the definitions behind the questions, it should also be possible to identify the trophi type of a given *Cephalodella* species without working through them. However, the hierarchical questions clarify which trophi types might be confused.

Discussion

A simpler definition scheme for the *Cephalodella* trophi types than originally developed by Wulfert (1937) is proposed here, because in the way they presently are used these types try to define even those traits not present in all members with a given trophi type-like, e.g. the presence of alulae, pleural rods or rami teeth. This is believed to cause the confusions existing in the literature and could lead to problems during identification of *Cephalodella* species. The detailed descriptions of the types are due to the fact that Wulfert (1937, 1938) wanted to describe the

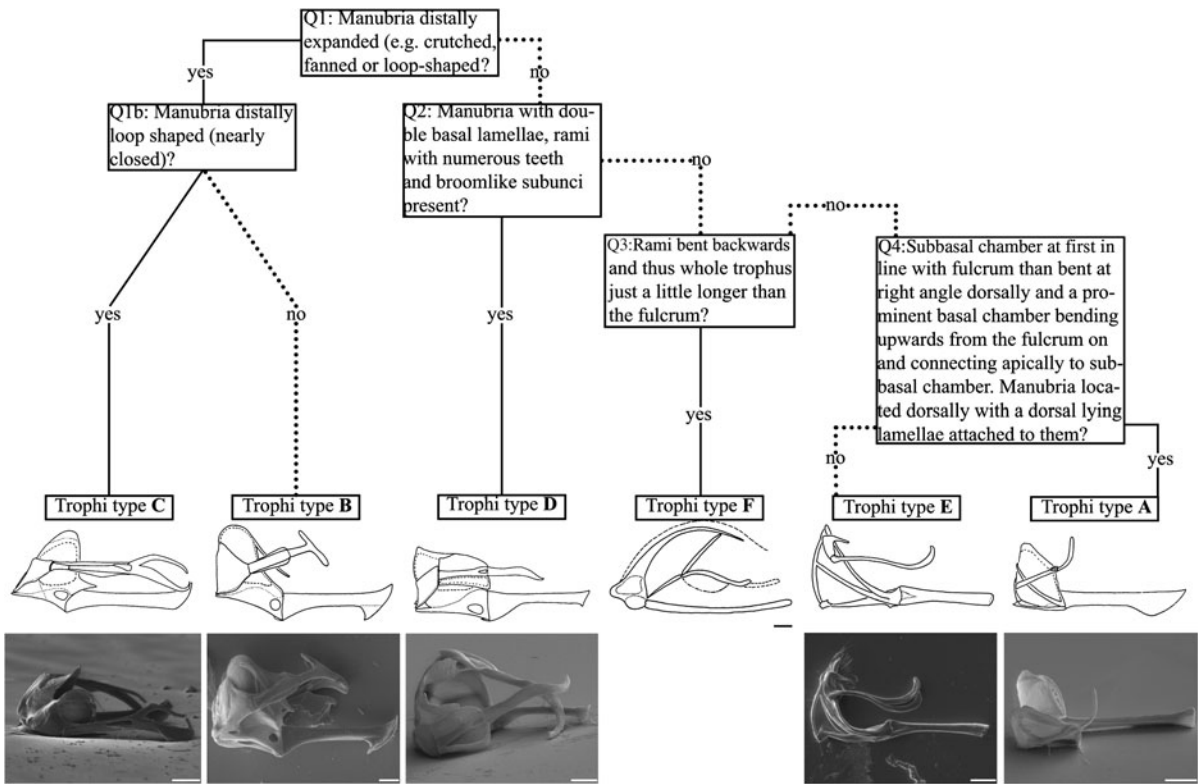


Fig. 1 Hierarchical question (q) scheme to determine the trophi type of a given *Cephalodella* species. Types are exemplified by line drawings (lateral view) and SEM pictures (if available, lateral or dorso-lateral view) of a *Cephalodella* species with trophi of that type: *Cephalodella catellina* (Müller, 1786), type C; *Cephalodella gibba* (Ehrenberg,

1830), type B; *Cephalodella ungulata* Ahlrichs & Fischer, 2006, type D; *C. mira* (redrawn after Koste (1970); details (dashed lines) are additionally present in Myers (1934) and details (dashed/dotted lines) are only present in Koste (1970)), type F; *C. megalcephala*, Type E and *C. auriculata*, type A. Scale bars 5 µm

Fig. 2 SEM pictures of *Cephalodella* species with trophi type B and rather diverse manubrial ends (lateral view): **A** *Cephalodella hyalina* Myers, 1924; **B** *Cephalodella rigida* Donner, 1950; **C** *C. sterea minor*; **D** *Cephalodella tenuior* (Gosse, 1886). Scale bars 5 µm

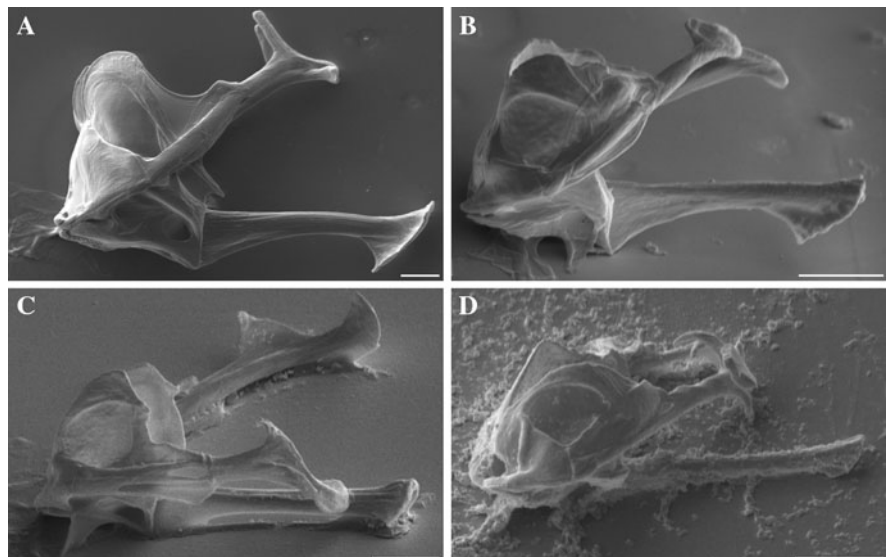


Fig. 3 SEM pictures of *Cephalodella* species with trophi type D illustrating the characteristic manubrial clava (lateral view, except C: caudal view):
A *Cephalodella tinca* Wulfert, 1937;
B *Cephalodella gigantea* Remane, 1933;
C *C. theodora*;
D *C. forficula* (Ehrenberg, 1830). Scale bars 5 μ m

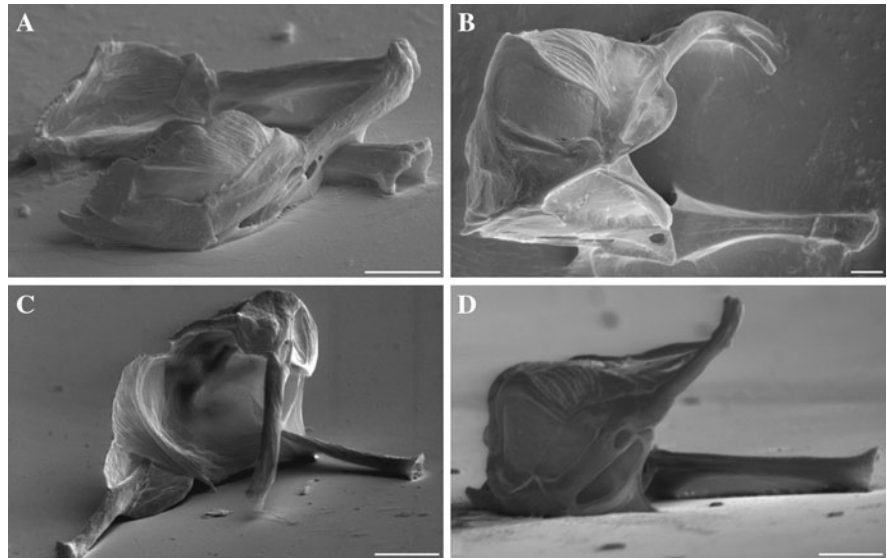
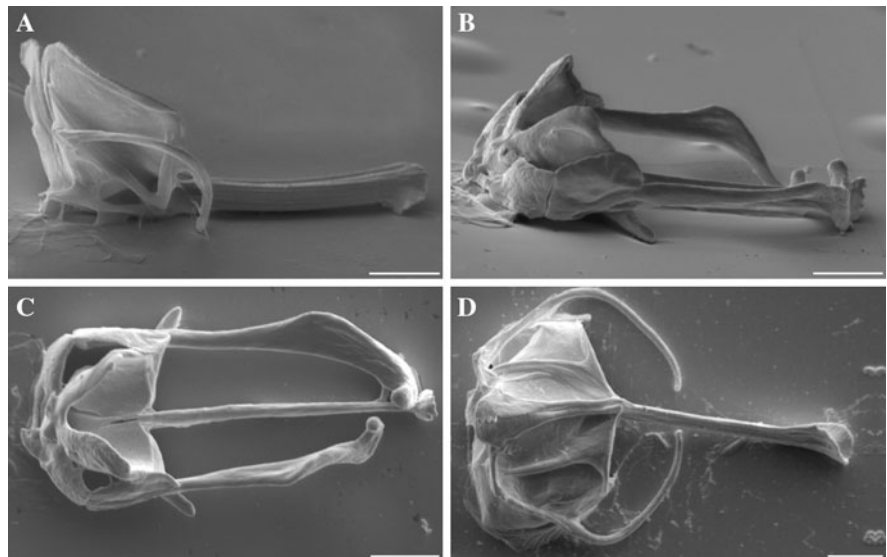


Fig. 4 SEM pictures of *Cephalodella* species with trophi type A:
A *Cephalodella ventripes* (Dixon-Nuttall, 1901) (lateral view);
B, C *C. astricta* (lateral-, dorsal view);
D *Cephalodella hoodii* (Gosse, 1886) (ventral view). Scale bars 5 μ m



trophi of each species in a detailed way as possible, although exhaustive descriptions of the trophi were missing in many cases at that time.

But starting with his work in most cases the trophi of newly described and redescribed species included detailed descriptions of the trophi and thus omitted often to mention a trophi type at all. Only in the case of species descriptions by Myers (1940) and in the case of *C. minora* Wulfert, 1960 are the given descriptions of the trophi not detailed enough to assign the trophi type to the described species without a doubt. And indeed trophi types do not substitute

exhaustive descriptions, as, e.g. can be seen in *C. apocoela* first characterized as type A (Wulfert, 1938) but later found to possess fanned manubrial ends (Wulfert, 1940) or as can be seen in the Fig. 4 displaying amongst others the trophi of *Cephalodella astricta* Myers, 1934, which was not described in detail before. Although its trophi possess dorsal basal lamellae on its manubria and is more robust than the “classical” type A trophi of *C. auriculata*, it still best fits this type.

As they furthermore probably do not reflect monophyletic groups as there are too many possible

transitions between the different types, including SEM findings, it seems justified to remove the details of the given definitions of trophi types and instead to use the proposed simpler definition scheme. Its use should also put the existence of cases with conflicting trophi type assignments as named in the introduction to an end.

A last remark has to be made regarding species so far solely described by Myers as they can potentially still be of the trophi type B if it is stated that their manubrial ends are not crunched as already found for *C. apocolea* (Wulfert, 1940) and *Cephalodella lepida* Myers, 1934 (Wulfert, 1938). Terms like swollen or curved manubrial ends may be indicative of species, that instead of belonging to trophi type A have actually trophi type B with fanned manubrial ends, although these cases are always coded as type A so far.

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