Temora Baird, 1850

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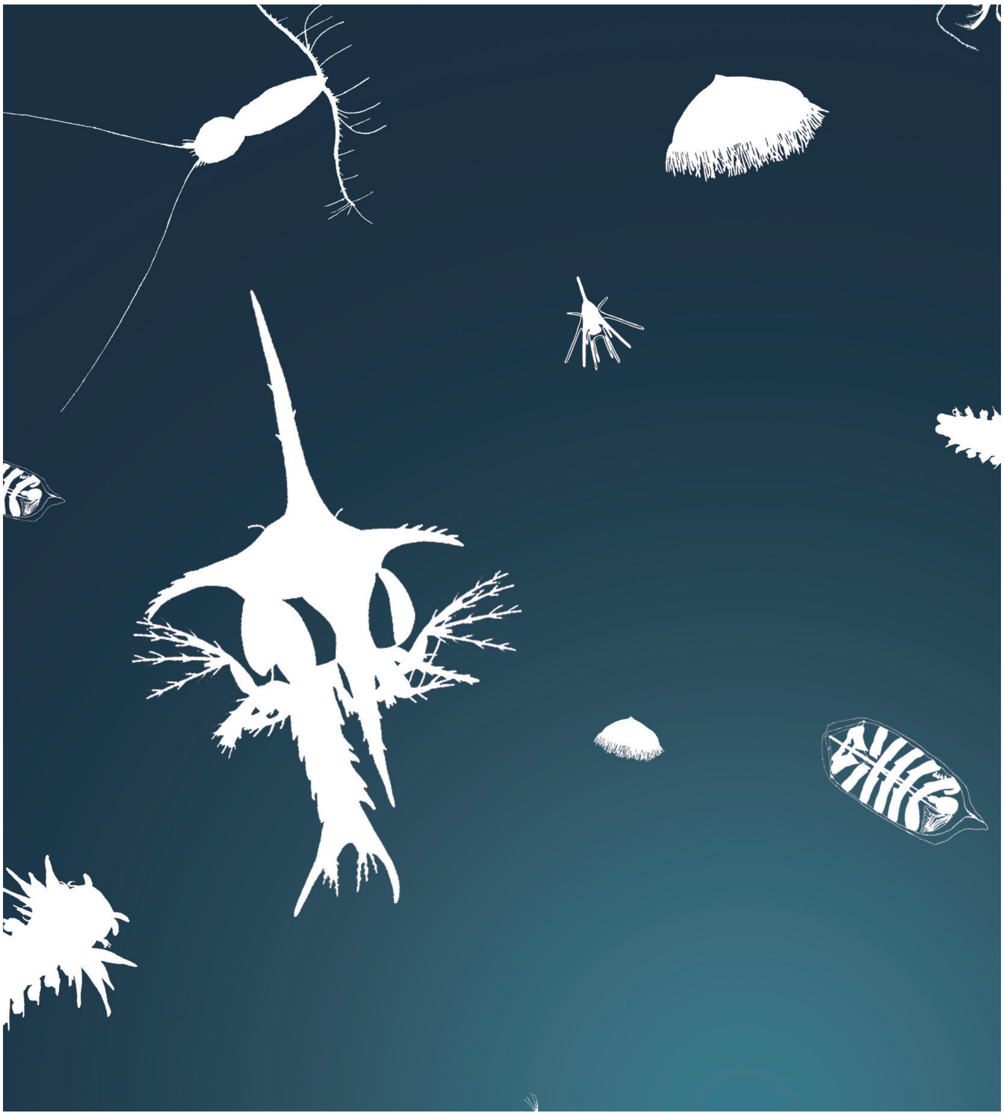

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Contents

Copepoda

Order: Calanoida

Superfamily: Diaptomidae

Family: Temoridae Giesbrecht, 1893

Genus: Temora Baird, 1850

Author: Iole Di Capua

1 Summary

Temorids are one of the most abundant calanoid copepod families of meso-zooplankton communities worldwide. They usually occur in coastal and neritic waters; they may also be present in epipelagic oceanic zones, as well as in brackish areas. The adults of all species are more than 1 mm in body length and are efficiently captured by mesozooplankton standard nets with a 200 µm meshes. This leaflet presents taxonomic keys with diagnostic morphological characters to distinguish between female and males of the most abundant species of the *Temora* genus under a stereomicroscope. Information on biological and ecological traits is also presented.

The taxonomic key distinguishing the four genera of the family Temoridae, established by Giesbrecht (1893), presented here is modified from Boxshall and Halsey (2004). It is also based on the extensive information presented in Razouls *et al.* (2005–2020).

This is a new leaflet, and includes HD-stereomicroscope images of *Temora longicornis* and *T. stylifera* for the first time. These are species reported from both the ICES area and the Mediterranean Sea.

2 Introduction

The family Temoridae was established by W. Giesbrecht (1893), consisting of one marine genus (*Temora* Baird, 1850) and three brackish- and freshwater genera (*Eurytemora* Giesbrecht, 1881; *Heterocope* Sars, 1863; *Epischura* Forbes, 1882). Oliveira (1947) described three genera (*Lahmeyeria*, *Ganchosia*, and *Manaia)* considered *genera inquirenda* by Boxshall and Halsey (2004).

The genus *Temoropia* was redefined by Schulz (1986) and it is transferred to the Fosshageniidaea family by Boxshall and Halsey (2004). Vives and Shmeleva (2007), however, keep this genus in the Temoridae family.

The Temoridae family was placed in the Diaptomidae superfamily by Andronov (1974) and Park (1986).

The genus *Temora* was established by Baird (1850) for *Cyclops longicornis,* synonyms of *Temora longicornis*.

Temora species are the most abundant calanoids of zooplankton communities in coastal and estuarine waters (Boxshall and Halsey, 2004). *Temora* spp. represent more than 35% of total copepod, are spread over a broad latitudinal range worldwide, and are present from estuarine to coastal and neritic waters, including the epipelagic oceanic areas (Furnestin, 1968; Razouls, 1973; Gaudy, 1984; Kouwnberg, 1994; Siokou-Frangou, 1996; Halsband and Hirche, 2001; Di Capua and Mazzocchi, 2005; Carotenuto *et al*., 2006; Brylinski, 2009; Daan, 1989; Van Ginderdeuren, 2014; Zingone *et al*., 2019).

Temora species are tolerant of a wide range of environmental variables. Several studies have reported on the effects of increased temperature on different life history traits (body size, developmental time, and hatching success) of *T. longicornis* and *T. stylifera* (Kiørboe *et al*., 1988; Ianora *et al*., 1989; Ianora, 1998; Ianora *et al*., 1995; Halsband-Lenk *et al*., 2002; Devreker *et al*, 2005; Dzierzbicka-Glowacka *et al*., 2011). The results of many studies conducted during the last two decades indicate that *Temora* species can be considered a sentinel copepod for assessing the effects of global warming on the marine ecosystems (Molinero *et al*., 2005; Semmouri *et al*., 2019).

The genus *Temora* includes five species: *Temora stylifera* (Dana, 1849), *T. discaudata* Giesbrecht, 1889, *T. turbinata* (Dana, 1849), *T. longicornis* (Müller, 1792) and *T. kerguelensis* (Wolfenden, 1911).

Most *Temora* species have a sex ratio (female/male) of around 1. The reproductive biology and mating behaviour of *Temora* species has been intensively studied by several authors (Castellani and Luca, 2003; Maps *et al*., 2005). Langhoff *et al*. (2018) highlighted the way in which the male *T. longicornis* detects the different chemical compound ratios of pheromone trails released by females. All *Temora* species are free-spawners; unlike other genera of the Temoridae family which are predominantly egg-carrying.

The developmental stages of *T. stylifera* have been described in details by Carotenuto (1999); *T. stylifera* and *T. longicornis* were both successfully reared in the laboratory. The first two naupliar stages in both species are very similar; from NIII they have almost the same number of segments and setae, but the two species display differences in certain morphological details. These include the caudal spine, and the ratio of anterior to posterior parts of the body.

Despite their global distribution, abundance, and the many studies conducted on the biology and ecology of *Temora* species, there is only limited information available on this genus at a molecular level. At the time of writing (December 2020) there are 80 nucleotide sequences deposited in Genbank. Those include 32 sequences for *T. longiconis*, 17 sequences for *T. stylifera*, 16 sequences for *T. discaudata,* and 15 sequences for *T. turbinata*, relative to mitochondrial COI gene and ribosomal genes (mainly 18 S).

Among seven *de novo* assembled transcriptomes for calanoids, Semmouri *et al*. (2019) carried out the first transcriptome analysis on *T. longicornis* to study the response to a thermal stressor. Russo *et al*. (2020), using a high-throughput sequencing approach, generated a *de novo* assembled transcriptome of adult *T. stylifera* females. There is, however, no genomic or transcriptomic information available for *T. kerguelensis*.

3 Distribution

Table 1 and Figure 1 contain information on the vertical and geographic distribution of *Temora* species reported for the ICES regions and the Mediterranean Sea.

Temora discaudata is an epipelagic species (depth range 0–100 m) commonly present in coastal waters of tropical to warm-temperate areas. *T. discaudata* is not reported in ICES area and in the Mediterranean Sea is reported only for the Levantine basin. It is also reported, however, in the Black Sea as well as in Indo-Pacific areas (predominantly in the western sector) and in the Indian Ocean.

Temora kerguelensis is reported only for Subantarctic areas.

Temora stylifera is an epipelagic species (depth range 0–100 m) present only in the ICES subareas of Bay of Biscay and Iberian Coast (Portugal, Vigo, Bilbao and Urdaibai estuaries in Spain, Bay of Biscay, Arcachon Bay in France), and the Azores. *T. stylifera* is warm-temperate species; it is restricted to the Atlantic Ocean from 40°N to 35°S along the American coasts, and from 45°N to 5°S in the eastern Atlantic including the Mediterranean Sea.

Temora turbinata is an epipelagic species (depth range 0–50 m) mainly present in coastal and estuarine waters. *T. turbinata* is reported in the ICES area, and is widespread in tropical and subtropical waters.

Temora longicornis is an epipelagic species (depth range 0–200 m) present in all ICES areas. This species is one of the main calanoid copepods in mesozooplankton communities in the coastal and neritic water of the northern hemisphere, and its distribution extends into the Mediterranean Sea and into tropical waters.

4 Morphological description

Temoridae

The body of a Temoridae is divided into a round prosome with a shield shape, and a slender urosome. The main diagnostic characters are 6-segmented prosome, comprised of cephalosome and 5 free pedigerous somites, or 5-segmented prosome due to the fusion of fourth and fifth pedigerous somites to form double-somite. The urosome is typically 3-segmented in females with 2 free abdominal somites, and 5-segmented in males. P5 in males is always prehensile.

Genital apparatus comprising common genital aperture located in the middle on ventral surface of genital double-somites. Urosome 5-segmented in male; comprising genital somites and 4 free abdominal somites, single genital aperture located ventrolateral.

Caudal rami often elongated with similar longitude to the rest of the urosome, armed with up to 6 setae.

Rostrum either divided into two small rostral filaments or absent. Naupliar eye present. Antennule with 24- or 25-articles in female; 20- or 23-articles in male, asymmetric and generally geniculate in right side.

Swimming legs 1 to 4 are biramous (P1–P4), typically with 3-articulated exopods; endopods typically 1- or 2-articulated. Exopods sometimes 2-articulated due to fusion of the first and second articles. Inner seta on basis of P1 absent.

Temora

In all *Temora* species the prosome is short, round, and typically widest, while the head is vaulted dorsally; remarkably dilated with a posterodorsal prominence. Rostrum divided in two slender filaments. Small naupliar eye is present and visible. Female genital segment short and protuberant ventrally flattened. Caudal rami narrow and elongate (6 times as long as it is wide), sometimes asymmetrical, setae comparatively short and of the usual number, one is on the outer border some distance from others. Antennules slender and elongate, 24-articulated in female, last 2 articles fused, geniculate on right in male. Second antenna exopod 7-articulated, scarcely longer than endopod. Mouthparts with normal structure. Swimming legs with endopods small and 2-articulated; exopodal articles 1 and 2 of P2–P4 partly fused in female; exopodal article 3 with 3 outer edge spines and 1 terminal coarsely toothed spine.

The main diagnostic characters for identification of the females of the different species are mainly based on the presence/absence of strong spines on the last segment of the prosoma and on caudal rami differences. For *T. longicornis* and *T. turbinata*, however, the different anal segment length is another important character to consider. Finally the not natatory leg 5 is an additional diagnostic character, for females as well as for *Temora* males. Female P5 small and simple, not natatory, 3-articulated, first two simple, last article dentate terminally. Usually without an endopod; 2–3-articulated with common basal article. Male P5 not natatory and asymmetrical, left leg much larger, 4-articulated, article 2 produced on inner edge into a long curved thumb-like process, which opposes the 2 terminal articles; right leg 3-articulated, terminal article incurved, claw-like. Usually P5 is without an endopod; larger than those of the female and prehensile, often pincer-like on one side, 2–4-articulated with common basal article.

The size range of female body length is from less than 1 mm to 2 mm. The males are smaller than females, with body length from 0.6 mm to 1.9 mm (Table 1).

The furcal rami have the same length as the anal segment. This latter is very long, of almost the same length as the three preceding segments. The last thoracic segment is rounded on both sides.

The A1 show robust straight spines on the 8th, 10th and 11th article. The articles 8–11 are strongly reduced. The second of the 4 articles from the articulation is very long, the last very short, the penultimate is elongated and seems articulated.

P5 seems to differ from that of *T. longicornis* and *T. turbinata*. On the right leg, the second article is enlarged and carries an external distal robust spine; the last article is foliar and characteristic. The endopodite is present as a long article resembling a stick, as long as the left leg. The left leg is very short and in the form of a stick.

Temora kerguelensis was described from just two male specimens collected in Subantarctic areas; these showed differences from *T. longicornis* and *T. turbinata* but no figures were reported by the authors (Wolfenden, 1911).

5 Taxonomic Key

Key to Temoridae genera

Four genera can be distinguished based on the key to genera reported by Boxshall and Halsey (2004), using mainly the differences in the P5 swimming leg:

1. Female swimming P5 with proximal exopodal article produced medially into spinous process, distal article armed with 2 setae; male P5 without inner process on basis of left leg.. ***Eurytemora* Giesbrecht, 1881**

   Female P5 without spinous inner process on proximal exopodal article; male P5 typically with inner process on basis of left leg... **2**

2. P1 to P4 endopods with 2 articles... ***Temora* Baird, 1850**

   P1 to P4 endopod with 1 article.. **3**

3. Female P5 terminating in a long apical spine; male urosome symmetrical.................. .... ***Heterocope* Sars G.O., 1863**

   Female P5 without long apical spine; male urosome usually asymmetrical................ .... ***Epischura* S.A. Forbes, 1882**

Key to *Temora* species present in the ICES regions

Females (modified from Wilson, 1932)

1. Lateral angles of fifth article of prosome pointed **2**
   Lateral angles of fifth segment of prosome rounded **3**

2. Caudal rami symmetrical and 6 times longer than wider…………………..................
   ……………………………………………....... ***Temora stylifera* (Dana, 1849)**
   Caudal rami asymmetrical...................................... ***Temora discaudata* Giesbrecht, 1889**

3. One terminal caudal seta conspicuously thickened.. ***Temora turbinata* (Dana, 1849)**
   One terminal caudal seta not conspicuously thickened...
   .... ***Temora longicornis* (Muller, 1792)**

Males (modified from Wilson, 1932)

1. Lateral angles of fifth article of prosome pointed **2**
   Lateral angles of fifth segment of prosome rounded **3**

2. P5 asymmetrical, left part forms a large claw, bend in right terminal hook does not extend to distal border of right segment 2, bend at about proximal 1/5.......................
   .... ***Temora stylifera* (Dana, 1849)**

   P5 asymmetrical, left terminal segment (including stout terminal spine) longer than penultimate segment, bend in right terminal hook extends beyond distal border of left segment 2, bend at about proximal 1/3.........***Temora discaudata* Giesbrecht, 1889**

3. P5 left terminal segment longer than penultimate segment; armed with 2 stout terminal spines and 2 sub-terminal spines................ ***Temora turbinata* (Dana, 1849)**

   P5 left terminal segment shorter than penultimate segment; armed with 1 stout terminal spine, 2 small inner distal spines, and 1 terminal plumose seta......................
   .... ***Temora longicornis* (Muller, 1792)**

6 Tables

Table 1. Comparative table presenting the dimensions and ecological traits of *Temora* species. Each species in the table is linked with its corresponding Alphia ID, a unique numerical identifier given to each taxon listed in the World Register of Marine Species (http://www.marinespecies.org).

Taxon name	Alphia ID	Female total length (mm)	Male total length (mm)	Distribution	Habitat
Temora stylifera, Dana, 1849	104879	0.9–2.1	0.8–1.9	Epipelagic Neritic	Cosmopolitan
Temora discaudata, Giesbrecht, 1889	220898	1.1–2.1	1.5–1.9	Epipelagic Neritic	Cosmopolitan
Temora turbinata Dana, 1849	104880	0.9–1.7	0.8–1.7	Epipelagic Coastal-estuarine	Cosmopolitan
Temora longicornis Müller, 1792	104878	0.8–1.7	0.6–1.7	Epipelagic Neritic	Cosmopolitan
Temora kerguelensis Wolfenden, 1911	345887	-	2	Epipelagic Neritic	Restricted to Subantarctic

Table 2. Comparative summary of morphological characters for the fourth prosome segment, caudal rami, caudal setae and anal segment in the female *Temora* species.

Female	Th4	CR	Cs	AS
T. stylifera	Pointed	Symmetrical	-	-
T. discaudata	Pointed	Asymmetrical	-	-
T. turbinata	Rounded	Symmetrical	Thickened	Shorter than previous
T. longicornis	Rounded	Symmetrical	Slim	Longer than previous

Table 3. Comparative summary of morphological characters for the fourth prosome segment, fifth leg and terminal segment in the male *Temora* species.

Male	Th4	P5	P5 left terminal segment
T. stylifera	Pointed	Asymmetric	Enlarged, like a leaf
T. discaudata	Pointed	Asymmetric	Irregular, like a stick
T. turbinata	Rounded	Asymmetric	Longer than penultimate article
T. longicornis	Rounded	Asymmetric	Shorter than penultimate article

7 Figures

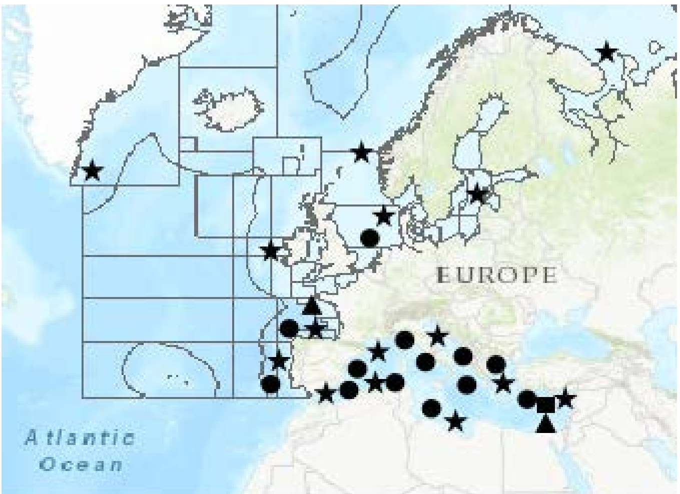

Figure 1. Distribution of *T. longicornis* (★) T.*stylifera* (●) *T. turbinata* (▲) and *T. discaudata* (■) in the ICES regions and Mediterranean Sea.

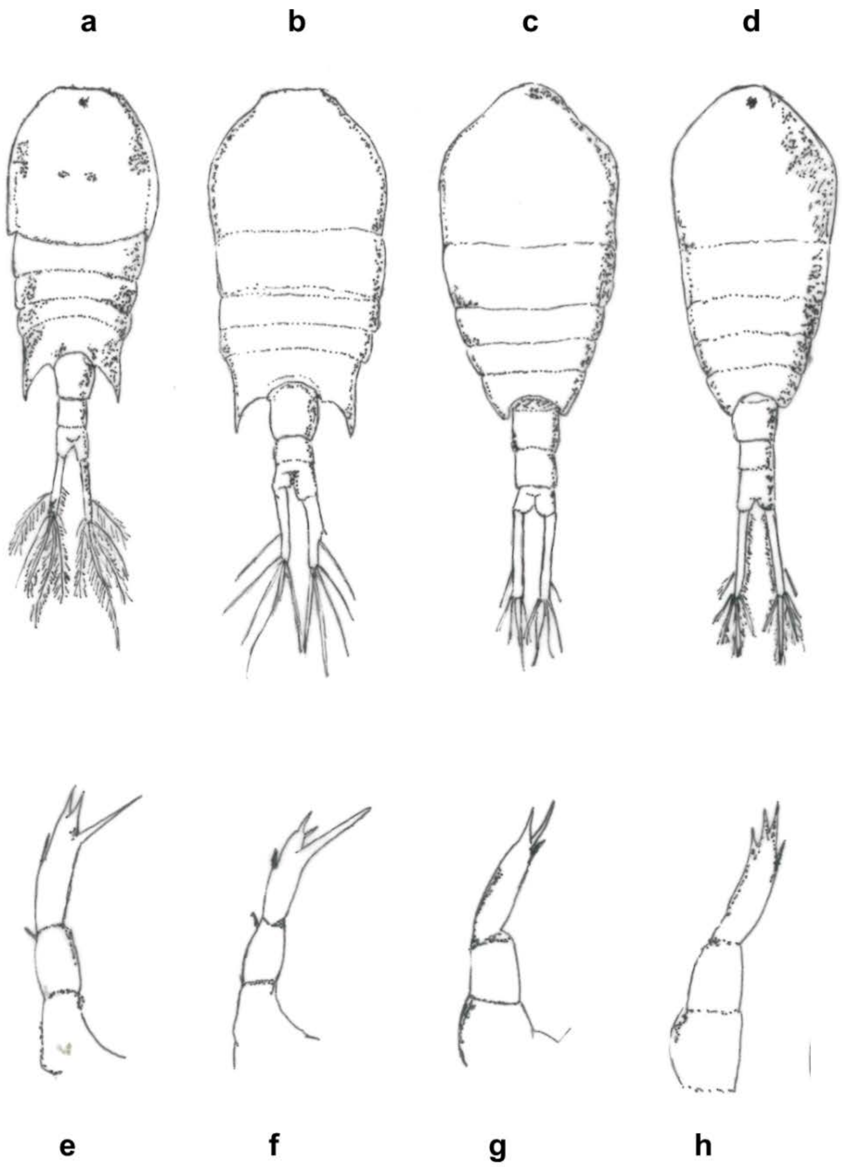

Figure 2. Morphological aspect of adult and fifth swimming legs of female of *Temora stylifera* (a, e), *T. discaudata* (b, f), *T. turbinata* (c, g), *T. longicornis* (d, h).

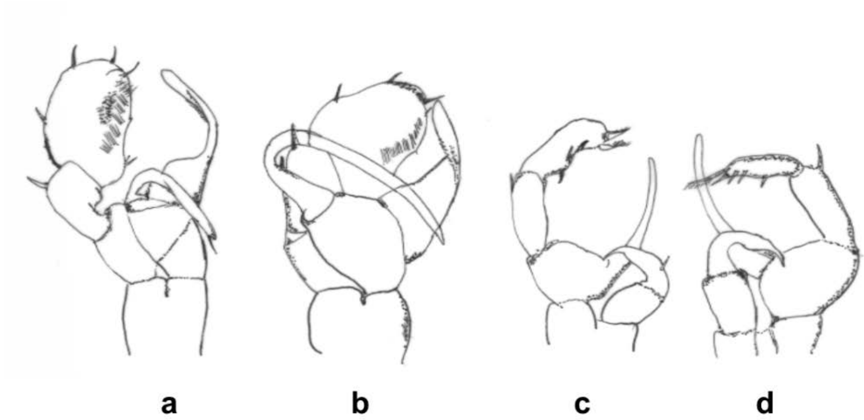

Figure 3. Fifth swimming legs of males of *Temora stylifera* (a), *T. discaudata* (b), *T. turbinata* (c), *T. longicornis* (d).

HD-stereomicroscope images

Figure 4. **HD-stereomicroscope images of *Temora stylifera* adult female, dorsal side (a) showing lateral angles of fifth segment of prosome pointed (arrowed) and symmetrical caudal rami (arrows), lateral side (b), caudal rami (c), urosome and genital segment (d).**

Figure 5. HD-stereomicroscope images of *Temora longicornis* adult female dorsal side (a) showing lateral angles of fifth segment of prosome rounded (arrows) and anal segment longer than previous (arrows), lateral side (b), caudal rami (c), urosome and genital segment (d).

Figure 6. HD-stereomicroscope images of *Temora Stylifera* adult males dorsal side (a) and lateral side (b) and *T. longicornis* dorsal side (c) and lateral side (d).

8 Links to further information

WoRMS

See Table 1.

Molecular information

Temora stylifera	https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=399051
Temora discaudata	https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?mode=Info&id=544695
Temora longicornis	https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?mode=Info&id=261852
Temora turbinata	https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?mode=Info&id=749012

9 Terminology

A1	Antennule	**NI–NVI**	First – sixth naupliar stage
AS	Anal segment	**P1–P5**	Swimming legs 1 – 5
CR	Caudal rami	**Th4**	Fourth prosome segment
Cs	Caudal setae		

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