Chaetognatha

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Chaetognatha

Order: Phragmophora and Aphragmophora

Genera: Eukrohnia, Krohnitta, Pterosagitta, and Sagitta

1 Summary

There are currently two recognized orders of chaetognaths: (i) Phragmophora, with the planktonic genera Eukrohnia, and Heterokrohnia; the bentholanktonic genus Archeterokrohnia; and the benthic genera Spadella, Paraspadella, Hemispadella, Calispadella, Bathyspadella, and Xenokrohnia; and (ii) Aphragmophora, with the planctonic genera Krohnitta, Pterosagitta and Sagitta. In this leaflet, the genus Sagitta is not divided into several genera. This taxonomic division is based on revisions by Ritter-Zahony (1911) and Tokioka (1956). More recent information can be found in Bone et al. (1991), Casanova (1999), and Pierrot-Bults (2017).

This is a major revision of ICES Identification Leaflets for Plankton No. 1 (Fraser, 1939; revised by Fraser, 1957). It covers the 28 of the 41 planktonic species recognized in the ICES Area. Excluded are 12 species of the very deep living genus Heterokrohnia and Sagitta abyssicola, all occurring below approximately 2000 m.

2 Introduction

Chaetognaths are strictly marine, and are traditionally considered to be carnivorous, or in deeper layers, detritivorous. In laboratory experiments, they feed mainly on copepods. To catch their prey, they dart suddenly over short distances, hence their common name "arrow worms" (Reeve, 1964; Feigenbaum, 1992). Field studies revealed substantial prey loss of more than 50% in the guts of sampled chaetognaths in tows of longer than 2 minutes duration (Baier and Purcell, 1997). However, recent publications have argued that chaetognaths are mainly osmotrophic, feeding by gulping water through their guts, since the majority of sampled chaetognaths are found without food in their guts (Duvert et al., 2000; Casanova et al., 2012). The main predators of chaetognaths are fish.

Two orders of chaetognaths are recognized. However, earlier morphological research has shown that the order Phragmophora, with the genera Spadella, Paraspadella, Hemispadella, Calispadella, Bathyspadella, and Xenokrohnia, the bentholanktonic Archeterokrohnia and the planktonic Eukrohnia and Heterokrohnia, is paraphyletic; while the order Aphragmophora, with the planktonic genera Pterosagitta, Krohnitta, and Sagitta is monophyletic (Casanova and Duvert, 2002). This conclusion is supported by more recent molecular research (Gasmi et al., 2014), which indicated that the diversity of Chaetognatha is the result of mosaic evolution. Moreover, chaetognaths have mostly evolved by simplification of their body plan, and their history shows numerous convergent events of losses and reversions.

At present, approximately 120 species are recognized. However, recent molecular studies have revealed groupings within species (Peijnenburg et al., 2006; Miyamoto et al., 2010, 2012), indicating that cryptic species may exist. Around 70 species are planktonic. Forty-one pelagic species are recorded in ICES area. Of these, 12 species belonging to the genus Heterokrohnia (H. angeli, H. biscayensis, H. curvichaeta, H. davidi, H. discoveryi, H. furnestinae, H. heterodonta, H.
involucrum, H. mirabilis, H. mirabiloides, H. murina, and H. rubra), and Sagitta abyssicola are not covered in this leaflet, since they mainly occur below approximately 2000 m. Furthermore, in this leaflet, the genus Sagitta is not subdivided into several genera suggested by Bieri (1991), pending further investigations (the new genus names can be viewed in the link to WoRMS in Section 7).

Chaetognaths are bilateral symmetric, protandric hermaphrodites. Adult length varies between ca. 2-140 mm, depending on the species. They have a head, a trunk, and a tail section. The head presents characteristic hooks or bristles, and one or two rows of teeth. Most species have a characteristically shaped eye pigment. One or two pairs of lateral fins are present, plus a tail fin. The testes are situated in the tail section, with seminal vesicles on either side of the tail. The ovaries are situated in the trunk, with the genital openings near the tail septum. Cross-fertilization is believed to be the rule. Sperm packages are deposited on the trunk of another individual, and sperm passes through the genital openings in the seminal receptacles alongside the ovaries until required for fertilization. The black spots in Pterosagitta draco (Figure 6) and Sagitta lyra (Figure 10) are sperm clusters. The fertilized eggs are released in the water, with the exception of a few species of deep-sea Eukrohnia that have brood sacs protruding from the genital openings (Figure 4 shows remnants of brood sacs). Chaetognaths have no true larval stage, although the early juvenile stages have one pair of posterior lateral fins and no anterior fins (Kotori, 1975).

Chaetognath growth and life cycles are largely regulated by temperature. In polar waters, there is a one to two year life cycle, while in temperate waters a spring and an autumn brood are typically produced. In (sub)tropical waters, breeding can occur several times a year (McLaren, 1963). Maximum length varies, since growth stops once the temperature for spawning is reached. In temperate waters, the spring cohort is typically longer than the autumn one, the latter having grown under higher temperatures. When the right spawning temperatures are not reached, the specimens remain sterile and may grow to greater lengths than normal.

For a comprehensive overview of Chaetognatha, see Bone et al. (1991).

### 3 Distribution

Chaetognaths occur in the epipelagic (0–200 m), shallow mesopelagic (200–500 m), deep mesopelagic (500–1000 m), and bathypelagic layers (> 1000 m). They are most abundant in the epipelagic.

Of the 28 pelagic species described in this leaflet, 4 are neritic, i.e. occurring above the continental shelf (Sagitta setosa, S. friderici, S helenae, and S. hispida); 1 is distant neritic in (sub)arctic waters (S. elegans); 1 is distant neritic, associated with oxygen-poor water in the eastern Pacific and eastern Atlantic (S. bierii); and 21 species are oceanic.

The highest diversity of chaetognaths is found in the stratified subtropical layers of the central gyres. In neritic waters, such as the North Sea, only one or two species are usually found, while in neighbouring oceanic waters, around 20 species can be present. Neritic species show restricted distributions, e.g. they can differ on either side of an ocean, while oceanic species occupy large geographical areas. The ICES Area species covered by this leaflet are listed below.

Most species occupy specific vertical layers in the stratified (sub)tropical layers (Pierrot-Bults, 1982). However, some widespread species, e.g. Eukrohnia hamata, Sagitta zetesios, and S. maxima, which occur from ca. 70°N–70°S are deep mesopelagic in latitudes 40°N–40°S in stratified
waters, while at higher latitudes where mixing occurs, they can be found throughout the water column. This is called tropical submergence.

**Eukrohnia bathyantarctica**

Deep-mesopelagic to bathypelagic; described from Antarctic waters, distributed with Antarctic Intermediate Waters to the northwestern Atlantic, and probably coming through the Charlie–Gibbs Fracture Zone in the Mid-Atlantic Ridge to the northeastern Atlantic (Pierrot-Bults, 2008).

**Eukrohnia bathypelagica**

Deep-mesopelagic; recorded in all oceans.

**Eukrohnia fowleri**

Deep-mesopelagic; recorded in all oceans.

**Eukrohnia hamata**

Deep-mesopelagic in all oceans from ca. 40°N to 40°S, but throughout the whole water column at higher latitudes, tropical submergence.

**Eukrohnia macroneura**

Deep-mesopelagic and bathypelagic; recorded in the Atlantic.

**Krohnitta mutabbii**

Described from (sub)tropical western Atlantic waters (Alvariño, 1969); but also found in the Sargasso Sea (Pierrot-Bults and Nair, 2004). Usually synonymized as *K. pacifica*.

**Krohnitta subtilis**

Epipelagic to shallow-mesopelagic; recorded in all oceans from ca. 40°N to 40°S.

**Pterosagitta draco**

Epipelagic; recorded in all oceans from ca. 40°N to 40°S.

**Sagitta bierii**

Distant-neritic in the eastern Atlantic and eastern Pacific; associated with oxygen-poor waters.

**Sagitta bipunctata**

Epipelagic; recorded in all oceans from ca. 40°N to 40°S.

**Sagitta decipiens**

Deep-mesopelagic; recorded in all oceans from ca. 40°N to 40°S.

**Sagitta elegans**

Distant-neritic; recorded in (sub)Arctic waters.

**Sagitta enflata**

Epipelagic; recorded in all oceans from ca. 40°N to 40°S.

**Sagitta friderici**

Neritic; recorded on narrow shelves in the northeastern Atlantic and Mediterranean Sea.

**Sagitta helenae**

Distant-neritic epipelagic; recorded in the western Atlantic from 35°N to 30°S.

**Sagitta hexaptera**

Shallow-mesopelagic; recorded in all oceans from ca. 40°N to 40°S.

**Sagitta hispida**

Distant-neritic epipelagic; recorded in the western Atlantic from 35°N to 30°S.

**Sagitta lyra**

Shallow-mesopelagic; recorded in all oceans from ca. 40°N to 40°S.
Sagitta macrocephala  Bathypelagic; recorded in all oceans, including the Arctic and Antarctic.

Sagitta maxima  Deep-mesopelagic to bathypelagic, in all oceans from ca. 40°N to 40°S, but throughout the whole water column at higher latitudes, tropical submergence.

Sagitta minima  Epipelagic; recorded in all oceans from ca. 40°N to 40°S.

Sagitta planctonis  Shallow-mesopelagic; recorded in all oceans from ca. 40°N to 40°S.

Sagitta serratodentata  Epipelagic; recorded in all oceans from ca. 40°N to 40°S.

Sagitta setosa  Neritic; recorded on wide shelves in the North Atlantic, North Sea, and Mediterranean and Black Sea; disjunct distribution.

Sagitta sibogae  Shallow-mesopelagic; recorded in all oceans from ca. 40°N to 40°S.

Sagitta tasmanica  Epipelagic, recorded in transitional waters in the North Atlantic and transitional waters in all oceans in the southern Hemisphere.

Sagitta tenuis  Distant-neritic epipelagic; recorded in the western Atlantic from 35°N to 30°S, and equatorially in the eastern Atlantic.

Sagitta zetesios  Deep-mesopelagic in all oceans from ca. 40°N to 40°S, but throughout the whole water column at higher latitudes, tropical submergence.

4 Main diagnostic features to distinguish chaetognath species

1. Presence or absence of transversal musculature.
2. Presence or absence of teeth rows.
3. Presence of one or two pairs of lateral fins; shape and position of lateral fins.
4. Presence or absence of gut diverticula (Fig.1)
5. Shape of seminal vesicles (Fig. 1)
6. Position of seminal vesicles in relation to the tail fin and the lateral fins.
7. Length of ovaries.
8. Shape of eye pigment.
9. Length of tail section relative to total length.
10. Total length in adults.
5 Taxonomic Key

The following is a key for species identification in the ICES Area. For a more elaborate key, including Archeterokrohnia, and Heterokrohnia, see Casanova (1999).

I. Transversal musculature present................................. Phragmophora

I.a. One long fin on trunk and tail; one row of posterior teeth........ Eukrohnia

1. Diamond-shaped eye pigment (Figure 2a)...................... E. fowleri

2. No eye pigment, but if stained with methylene blue:
   2.a. Completely stained eye spot (Figure 2b)...................... E. hamata
   2.b. Eye spot with some granulates (Figure 2c)............... E. bathypelagica
   2.c. Eye spot colourless in centre (Figure 2d).............. E. bathantarctica
   2.d. No eyes (Figure 5)........................................ E. macroneura

II. Transversal musculature absent

II.a. One fin on tail section; AT and PT; huge collarette........ Pterosagitta

   P. draco

II.b. One short fin on trunk and tail; one row of long AT.......... Krohnitta

1. Lateral fin almost without fin rays.......................... K. subtilis

2. Lateral fin with fin rays...................................... K. mutabbi

II.c. Two pairs of lateral fins; AT and PT............................ Sagitta

1. AF and PF with fin bridge

   1.a. Body flaccid; no collarette

      1.a.i. Max TL 90 mm; tail 19–25% of TL................. S. maxima
      1.a.ii. Max TL 42 mm; tail 15–17% of TL........... S. lyra

   1.b. Body muscular; collarette present

      1.b.i. Max TL 37 mm; tail 19–21% of TL; PT 10–14 S. planctonis
      1.b.ii. Max TL 45 mm; tail 20–23% of TL; PT 15–22 S. zetesios

2. AF and PF separate; hooks serrated; body needle like; SV with knob and trunk

   2.a. Max TL 13 mm; two appendages on SV knob; PT 12– 20 (Figure 3a)................................................ S. serratodentata
2.b. Max TL 30 mm; protuberances on SV knob; PT 9–15
(Figure 3b)………………………………………………………… S. tasmanica

2.c. Max TL 19 mm; SV knob with one protuberance
(Figure 3c)………………………………………………………… S. bierii

3. AF and PF separate; hooks not serrated

3.a. SV round or ovoid (Figure 1)

3.a.i. Max TL 70 mm; tail 16–20% of TL; body flaccid; AF very 
short, partially rayed; SV touching TF, away from PF;
long OV………………………………………………………… S. hexaptera

3.a.ii. Max TL 25 mm; tail 14–17% of TL; body flaccid; AF very 
short, partially rayed; SV touching TF, away from PF; very 
short OV………………………………………………………… S. enflata

3.a.iii. Max TL 22 mm; tail 29–34% of TL; body muscular; big 
head; no eye pigment; SV touching neither PF nor TF
………………………………………………………… S. macrocephala

3.a.iv. Max TL 30 mm; body firm; fins fully rayed; SV away 
from PF, close to tail fin; GD very small……… S. elegans

3.b. SV with knob and trunk (Figure 1)

3.b.i. Max TL 10 mm; body flaccid; small head; SV touching 
TF, away from PF; very short OV; few large eggs
………………………………………………………… S. minima

3.b.ii. Max TL 14 mm; body flaccid; small head; short AF; OV 
short; no collarette; SV close to or touching both PF and 
TF………………………………………………………… S. setosa

3.b.iii. Max TL 15 mm; body firm; head narrow; AF Medium 
length; SV close to or touching both PF and TF S. friderici

3.b.iv. Max TL 19 mm; body muscular; broad head; collarette 
absent or short; SV touching TF……………… S. bipunctata

3.b.v. Max TL 11 mm; body slender; small head; collarette 
short; SV touching both PF and TF; short 
OV………………………………………………………… S. tenuis

3.b.vi. Max TL 14 mm; body slender; collarette short; broad 
head; SV touching both PF and TF; OV medium length
………………………………………………………… S. helenae

3.b.vii. Max TL 11 mm; body flaccid; broad head; long 
collarette; SV touching PF away from TF; OV medium 
length………………………………………………………… S. hispida
3.c. Pronounced gut diverticula; big eyes with large T-shaped pigment spot

3.c.i. Max TL 30 mm; body slender; medium length ovaries; pronounced SV touching TF, away from PF…  
* S. sibogae

3.c.ii. Max TL 14 mm; body slender; short AF; SV midway between PF and TF; short OV………………….  
* S. decipiens

6  Figures

All figures are from the author of the current leaflet. Figures 4–3, 4–5 and 4–8 are redrawn from Alvariño, 1962; Casanova, 1986; and Alvariño, 1969; respectively.

Figure 1. Seminal vesicles and gut. a: SV round; b: SV ovoid; c: SV knob and trunk, and d: gut diverticula. Drawings not to scale.

Figure 2. Eyes. a: *E. fowleri*; b: *E. hamata*; c: *E. bathypelagica*; and d: *E. bathyantarctica*. Drawings not to scale.

Figure 3. Seminal vesicles (SV). a: *S. serratodentata*; b: *S. tasmanica*; and c: *S. bierii*. Drawings not to scale.
Figure 5. Ventral view of the general morphology of the Chaetognatha. 13: *S. serratodentata*; 14: *S. tasmanica*; 15: *S. bieri*; 16: *S. hexaptera*; 17: *S. enflata*; 18: *S. macrocephala*; 19: *S. elegans*; 20: *S. minima*; 21: *S. setosa*; 22: *S. friderici*; 23: *S. bipunctata*; and 24: *S. tenuis*. 
Figure 6. Ventral view of the general morphology of the Chaetognatha. 25: S. helenae; 26: S. hispida; 27: Sagitta decipiens; and 28: S. sibogae.

7 Links to further information

WoRMS


Eukrohnia
bathyantarctica


Krohnitta mutabbii
as K. pacifica  http://www.marinespecies.org/aphia.php?p=taxdetails&id=266239
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(as Solidosagitta zetesios)
**Molecular information**

Molecular research on several chaetognath species showed that DNA barcoding analysis was highly successful; resolved the species in accordance with morphological traits, and demonstrated relationships between sister species (Jennings et al., 2010; Nair et al., 2015).

Molecular information is available for 21 out of the 28 species described in this leaflet. The information is available from different sources, e.g. cytochrome c oxidase, mitochondrial, and 28S.

<table>
<thead>
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<th>Species</th>
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<td>Krohnitta mutabbi</td>
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<td>Sagitta bierii</td>
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<td>Sagitta friderici</td>
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<tr>
<td>Sagitta hispida</td>
<td>No information available</td>
</tr>
<tr>
<td>Sagitta minima</td>
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Other useful links


8 Abbreviations and Terminology

Abbreviations

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<thead>
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<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>TL</td>
<td>Total length</td>
</tr>
<tr>
<td>TF</td>
<td>Tail fin</td>
</tr>
<tr>
<td>AT</td>
<td>Anterior teeth</td>
</tr>
<tr>
<td>SV</td>
<td>Seminal vesicles</td>
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<tr>
<td>PT</td>
<td>Posterior teeth</td>
</tr>
<tr>
<td>OV</td>
<td>Ovaries</td>
</tr>
<tr>
<td>AF</td>
<td>Anterior fin</td>
</tr>
<tr>
<td>GD</td>
<td>Gut diverticula</td>
</tr>
<tr>
<td>PF</td>
<td>Posterior fin</td>
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</tbody>
</table>

Terminology

Collarette: Loose tissue in the neck region outside the body wall. It can be short, as seen in Sagitta friderici and S. helenae (figures 5.22 and 6.25); it can reach to the anterior fins, as seen in S. zetesios (Figure 3.12); or it can be very long and elaborate, as seen in Pterosagitta draco (Figure 3.6).

Distant neritic: Distribution reaches across the ocean, and is not confined to waters above the continental shelf.
**Gut diverticula:** A bulge in the gut just below the head section. Examples can be seen in *Sagitta decipiens* and *Sagitta sibogae* (figures 6.27 and 6.28).

**Transversal musculature:** The main musculature in chaetognaths is longitudinal. However, in *Eukrohnia* species, there is transversal musculature in the neck region (Figure 4.4).

9 References


Fraser, J.H. 1939. Chaetognatha (revised by Fraser, J.H., 1957). ICES Identification Leaflets for Plankton No. 1. 6 pp. https://doi.org/10.17895/ices.pub.4706


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1 N.B. In this paper, *Sagitta planctonis* and *S. zetesios* are switched.


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