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AN ILLUSTRATED KEY TO THE CHAETOGNATHA OF THE NORTHERN GULF OF MEXICO WITH NOTES ON THEIR DISTRIBUTION

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ABSTRACT A key is provided to facilitate the identification of 24 species in nine genera of Chaetognatha occurring in the northern Gulf of Mexico. Included are the deep-water species, *Eukrohnia proboscidea*, *E. calliops*, *Mesosagitta sibogae*, and *Sagitta megalophthalma*, all recent additions to the known fauna of the region. Meristic data, brief descriptions, ecological notes, Gulf of Mexico records, and illustrations are also presented.

INTRODUCTION

Chaetognaths (arrow worms) have long been recognized as a significant trophic link between the vast numbers of marine copepods and larger predators, including many commercially important species of fish (Heydorn 1959; Reeve 1966; Nagasawa and Marumo 1981). Certain species are associated with discrete physio-chemical conditions and have, thus, become useful as hydrological indicators in areas of inter-mixing water masses. Some species have gained recognition as vectors in the life cycles of marine parasites (Pearre 1979; Boltovskoy 1981; Jarling and Kapp 1985).

The chaetognath fauna of the Gulf of Mexico is known from various ecological studies concerned with the population structure in continental shelf and open-ocean plankton communities, but few of these works have included detailed descriptions of the animals or dealt with the entire reported fauna of the Gulf. However, descriptions of all species known to occur in the Gulf of Mexico were included in a recent work by Michel (1984) on chaetognaths of the Caribbean Sea and adjacent areas.

The present work, limited in scope to the northern Gulf of Mexico, attempts to facilitate the identification of common species of chaetognaths one might expect to encounter in plankton samples from coastal and offshore waters of the region. The key also includes some rare species recently obtained from deep-water collections.

Prior to 1988, 21 species representing 11 genera were recorded from the Gulf of Mexico. Of those, one is excluded from this key, the monospecific *Bathobelos typhlops* Owre, a rare, extremely deep-dwelling species known only from a single specimen collected in the central Gulf (Owre 1973). Recently, the deep-water species *Mesosagitta sibogae* Fowler, 1906, *Eukrohnia*

calliops McLelland, 1989, *E. proboscidea* Fumestin and Ducret, 1965, and *Sagitta megalophthalma* Dallot and Ducret, 1969, were added to the Gulf fauna (McLelland and Perry 1989), increasing the number of species to 25. At this writing, the fairly common epibenthic family Spadellidae has yet to be reported in the Gulf of Mexico; thus, only the planktonic species of Chaetognatha are considered in this key.

There are, worldwide, currently about 125 described species of the phylum Chaetognatha belonging to two orders and six families of which the Sagittidae is the most diverse. In his 1965 publication, Tokioka introduced a detailed phylogeny based on morphological similarities in which he arranged the 65 then recognized species into classes, orders, sub-orders, and families and restructured the former genus *Sagitta* into nine genera. Acceptance for Tokioka's proposal, especially the latter point, has been slow to gain support among specialists even though numbers of newly described species continue to mount. Recent systematic works such as those of Kassatkina (1971, 1982), Casanova (1985), and Salvini-Plawen (1986), have expanded upon Tokioka's original proposal. Accordingly, this work conforms to the revised taxonomy of the phylum, including the restructuring of the former genus *Sagitta*, in order to better account for differences among the distinct "groups" within the Sagittidae.

MATERIALS AND METHODS

Chaetognath specimens (from 5-10% buffered formalin samples) were examined unstained under stereoscopic dissecting and compound microscopes. Using an ocular micrometer, total length measurements (excluding the caudal fin) were made and percentages of tail segment to total length (T%) were calculated. Ranges of hooks and teeth recorded in Table 1

TABLE 1
Meristic values of chaetognaths from the northern Gulf of Mexico

Species	Total Length (mm)	% Tail Segment	Number Hooks	Number Anterior Teeth	Number Posterior Teeth	Number Specimens	Source of Specimens
<i>Eukrohnia bathyantartica</i>	16.2	25.6	12	--	12	1	E
<i>E. bathypelagica</i>	5.6-5.9	24.3-25.3	9-10	--	1-5	2	B,E
	7.2-8.8	25.6-27.3	9	--	2-4	4	E
	9.0-10.6	22.6-26.5	8-9	--	2-7	8	E
	11.6-12.6	24.5-29.2	8-10	--	6-12	6	B,E
<i>E. calliops</i>	8.4	26.7	11	--	9-10	1	E
	10.4-11.7	22.3-31.0	11-13	--	7-15	3	E
	12.6-15.0	21.7-29.3	12-13	--	12-13	4	E
	16.2-18.4	24.8-27.0	12-13	--	15-19	4	E
	21.5	24.9	12	--	21	1	E
<i>E. fowleri</i>	5.2-5.3	18.2-24.1	9-10	--	4-5	2	B
	7.0	19.0	12	--	10	1	B
	10.7-11.8	20.0-20.9	10-12	--	6-12	3	E
	13.6-14.4	22.4-24.0	11	--	12	3	E
	26.6-28.5	21.3-23.0	11-13	--	20-27	3	E
<i>E. proboscidea</i>	10.6	24.2	10	--	8	1	E
<i>Krohnitta pacifica</i>	3.5-5.0	23.7-31.4	8-10	11-13	--	6	A
	5.3-5.8	29.1-32.1	9	13	--	4	D
	6.4-7.0	28.1-30.0	9	14	--	2	D
<i>K. subtilis</i>	7.6-9.3	31.4-37.8	8	10-11	--	5	A,B
	9.8-10.4	34.7-35.0	7	10	--	2	B,E
	11.2-12.8	31.4-40.1	7-9	10-12	--	11	A,B,E
	13.9-14.2	31.0-40.4	7-8	9-12	--	3	E
<i>Pterosagitta draco</i>	3.7-4.9	37.1-39.5	7	4	6	3	B,D
	5.1-5.9	37.6-41.4	9	6-7	12-14	8	B,D
	6.2-7.2	37.8-41.8	8-10	6-8	13-16	15	B,D
<i>Caecosagitta macrocephala</i>	3.5	39.7	10	3	6	1	B
	5.1-6.5	26.7-37.7	10-12	3-7	8-22	8	B,E
	7.5-10.5	27.7-37.6	10-13	6-10	17-24	11	B,E
	13.2	32.7	12	6	29	1	E
	14.6	33.9	9-11	8	30	1	E
<i>Ferosagitta hispida</i>	6.9-9.4	23.6-28.3	7-8	7-9	10-13	5	A
	11.6-13.9	23.5-27.0	6-8	5-9	10-14	8	D,F
	16.4-16.5	26.8-27.8	7	8-9	12	2	C
<i>Flaccisagitta enflata</i>	6.5-7.9	17.9-18.0	9-11	6	8	2	D
	10.1	17.9	9	7	10	1	F
	14.0-17.2	15.4-18.5	8-9	7-9	10-16	5	D,F
	18.1-19.9	14.9-15.8	8-9	7-11	12-16	4	D,F
<i>F. hexaptera</i>	9.1	22.1	9-10	3	3	1	A
	14.1-17.0	16.4-23.4	7-9	3-4	3-8	4	A,D,E
	20.8-28.3	14.1-22.9	6-9	3-6	1-9	6	A,D,E
	30.6-32.6	16.7-22.0	6-7	2-3	2-6	4	A,D,E
	38.4-44.0	16.7-18.8	6-7	3-4	3-6	3	A,E
	48.8-53.0	18.1-19.3	4-6	4	4-6	2	E
	59.2	16.2	6	4	5	1	E

TABLE 1 (Continued)
Meristic values of chaetognaths from the northern Gulf of Mexico

Species	Total Length (mm)	% Tail Segment	Number Hooks	Number Anterior Teeth	Number Posterior Teeth	Number Specimens	Source of Specimens
<i>F. lyra</i>	12.5-14.3	17.7-20.0	7-9	5-6	6-9	3	A,B
	20.3	15.0	8	6	10	1	E
	22.7-25.7	14.9-17.6	3-9	3-7	2-10	11	A,B,E
	26.0-29.0	13.3-16.0	3-7	6-8	2-10	6	A,B,E
	30.8-34.7	15.0-15.5	3-8	7-8	3-10	3	A,B
<i>Mesosagitta decipiens</i>	8.2-10.1	22.8-32.2	6	7-9	13-17	8	B,E
	11.0-12.6	19.4-26.3	6-7	7-9	14-20	8	B,E
	12.9-13.3	21.2-24.4	6	8-9	19	3	B,E
<i>M. minima</i>	3.8	22.2	7	2	4-5	1	A
	5.0-5.3	16.5-20.5	7-8	3-5	7-12	6	A,D
	6.1-6.8	15.7-19.8	7	3-4	9-11	3	A,D
<i>M. sibogae</i>	10.6-11.8	19.4-27.4	6	8-9	14-17	6	E
	12.4-13.7	17.5-22.9	6	7-9	15-18	7	B,E
	14.0-14.2	20.0-23.6	6	7-9	16-17	3	B,E
	14.8-14.9	21.0-21.9	6	8-9	17	3	B,E
	16.3	21.1	6	9	19-20	1	E
<i>Sagitta bipunctata</i>	4.6	27.3	8	5	9-10	1	A
	8.5-9.6	24.6-26.4	10	5-7	13-17	5	B
	10.0-11.3	24.1-26.0	9-11	6-7	13-15	4	F
	12.3-13.0	25.3-26.4	9-10	5-6	10-15	2	E
<i>S. helenae</i>	6.4	26.5	8	9	7	1	D
	11.3-14.6	23.4-27.6	7-8	11-18	12-14	3	C
	15.5-15.9	21.8-25.4	8	15-19	14-15	4	A,D
	17.2-19.2	23.2-24.3	7	15-16	12	2	D
<i>S. friderici</i>	6.0-7.9	25.0-30.4	7-8	5-8	13-17	22	A,C
	8.1-11.6	25.7-30.2	7-8	6-8	14-19	10	A,C
	12.4-13.7	27.8-29.8	8-9	7-9	17-22	9	A,C
<i>S. megalophthalma</i>	6.8	25.9	7	5	13	1	E
	7.5	24.5	8	6	17	1	E
	10.0	25.6	7-8	8	21	1	E
	11.9-12.1	22.5-28.9	7	7-8	19-21	2	E
<i>S. tenuis</i>	4.8	31.3	8	6	11	1	A
	5.3-5.9	24.6-32.2	7-8	5-6	12-14	8	A,D
	6.0-6.8	25.7-28.6	7-8	5-7	10-16	8	A,D
<i>Serratosagitta serratodentata</i>	5.3-6.4	22.9-28.4	6-8	6-8	10-15	3	A
	6.9-7.9	23.9-26.0	7-8	8-10	16-19	3	F
	8.6-9.7	23.0-24.5	6	9-10	15-20	4	F
	10.0-10.6	25.6-27.2	5-6	9-10	16-20	4	E
<i>Solidosagitta planctonis</i>	8.4	21.0	8-9	5	10-11	1	E
	11.4-11.8	26.1-29.9	10	6-8	14-15	2	E
	16.0-16.4	23.5-24.4	8-9	9-10	17-20	2	E

represent those observed in a single set from either side of the head. The meristic values in the table are based on observations of specimens ranging in size from juvenile to adult from the northern Gulf of Mexico collections listed below. This list is referred to by letter under the "Source of Specimens" column in the table.

- A. U.S. Bureau of Land Management (BLM-SUSIO), 1974; northeastern Gulf of Mexico continental shelf and slope, MAFLA lease tracts (see McLelland 1984); 12 stations, 0–256 m, 54 samples; collected by R.A. Woodmansee, Gulf Coast Research Laboratory (GCRL).
- B. U.S. Dept. of Energy (LBL-OTEC), 1978; Mobile OTEC site (29°N, 088°W), 0–1000 m, 10 samples; collected by J.P. Steen, Jr., GCRL.
- C. NOAA R/V Oregon II, winter cruise, 1975; Mississippi River delta region, surface samples; collected by J.P. Steen, Jr., GCRL.
- D. Louisiana Dept. of Wildlife and Fisheries (LWF), Louisiana Offshore Oil Port Study (LOOP), 1981; over continental shelf south of Timbalier Bay, Louisiana; collected by R. Ganzcak, LWF.
- E. MARFIN Geryon cruises – August and November, 1987 and February, 1988; northern Gulf of Mexico continental slope, 5 sites; 200–677 m; collected by Harriet Perry, GCRL (See McLelland and Perry 1989).
- F. Personal collections of J.A. McLelland from various locations around the Mississippi Sound barrier islands.

Deep-water Collections. The OTEC samples (see B above) were collected during four cruises made between June 15 and October 31, 1978, under Subcontract LBL 4714602, Lawrence Berkeley Laboratory, for the U.S. Department of Energy Contract No. W-7405-ENG-48. Closing plankton nets (0.75 m, 202 μ m mesh) equipped with Niskin double-trip devices were used.

General Morphology

The general features by which most chaetognaths are identified are depicted in Figure 1. Chaetognaths are bilaterally symmetrical enterocoelous coelomates characterized by three body segments – head, trunk, and tail – separated by transverse septae. All chaetognaths display lateral and caudal stabilizing fins, a head armed with chitinous grasping spines (hooks), transparent to semi-opaque bodies, and a lack of excretory and circulatory systems. The nervous system features a primary cerebral ganglion in the head connected to two dorsal eyes, and one large trunk ganglion on the ventral surface. The mouth and anus, both ventral, are connected by a straight digestive tube. As protandric

Figure 1. General diagram of a chaetognath showing diagnostic characteristics.

hermaphrodites, chaetognaths feature two oblong ovaries in the trunk segment opening dorso-laterally at the tail-trunk septum and two testes in the tail segment which are connected by minute sperm ducts to exterior seminal vesicles.

This key is primarily intended for the identification of well-preserved adult animals and is based on easily observed external features and some internal features such as mature ovaries. Therefore, caution must be taken when juveniles or sub-adults are examined. It is advisable for one to first become familiar with the

adult forms in a given sample before attempts are made to identify immature specimens. Illustrations for this work were prepared using preserved specimens at hand. Because quality specimens of all species were not available, some whole-animal illustrations were omitted. The reader is referred to Michel (1984) and Alvario (1969) for additional illustrations, especially for the genus *Eukrohnia*.

GULF OF MEXICO CHAETOGNATHA species list

Class Sagittoidea Claus and Grobben, 1905

Order Phragmophora Tokioka, 1965

Family Eukrohnidae Tokioka, 1965

Eukrohnia Ritter-Zahony, 1909

E. bathyantarctica David, 1958

E. bathypelagica Alvario, 1962

E. calliops McLelland, 1989

E. fowleri Ritter-Zahony, 1909

E. hamata (Möbius, 1875)

E. proboscidea Furnestin and Ducret, 1969

Order Apheragmophora Tokioka, 1965

Family Krohnittidae Tokioka, 1965

Krohnitta Ritter-Zahony, 1910

K. pacifica (Aida, 1897)

K. subtilis (Grassi, 1881)

Family Pterosagittidae Tokioka, 1965

Pterosagitta Costa, 1869

P. draco (Krohn, 1853)

Family Sagittidae Claus and Grobben, 1905

Bathybelos Owre, 1973

B. typhlops Owre, 1973

Caecosagitta Tokioka, 1965

C. macrocephala (Fowler, 1905)

Ferosagitta Kassatkina, 1971

F. hispida (Conant, 1895)

Flaccisagitta Tokioka, 1965

F. enflata (Grassi, 1881)

F. hexaptera (d'Orbigny, 1843)

F. lyra (Krohn, 1853)

Mesosagitta Tokioka, 1965

M. decipiens (Fowler, 1905)

M. minima (Grassi, 1881)

M. sibogae (Fowler, 1906)

Sagitta Quoy and Gaimard, 1827

S. bipunctata Quoy and Gaimard, 1827

S. helenae Ritter-Zahony, 1910

S. friderici Ritter-Zahony, 1911

S. megalophthalma Dallot and Ducret, 1969

S. tenuis Conant, 1896

Serratosagitta Tokioka and Pathansali, 1963

S. serratodentata (Krohn, 1853)

Solidosagitta Tokioka, 1965

S. planctonis (Steinhaus, 1896)

KEY TO THE CHAETOGNATHA OF THE NORTHERN GULF OF MEXICO

1. a. One pair of lateral fins 2
- b. Two pairs of lateral fins 10
2. a. Lateral fins extending onto trunk segment; one set of teeth 3
- b. Lateral fins limited to tail segment (Fig. 4); two sets of teeth genus *Pterosagitta* *P. draco*
3. a. Lateral fins extending to ventral ganglion genus *Eukrohnia* 4
- b. Lateral fins not extending to ventral ganglion genus *Krohnitta* 9
4. a. Eyes with pigment 5
- b. Eyes without pigment 7
5. a. Apical gland-cell complex bilobate and protruding, causing head to appear pointed (Figs. 2B,E); hook tips bent inward at 45–90° angles (Figs. 2D,G); transverse musculature extending past posterior edge of ventral ganglion 6
- b. Apical gland not prominent, a single lobed mass (Fig. 3B); hook tips straight (Fig. 3E), transverse musculature even with posterior edge of ganglion *E. fowleri*

6. a. Eye pigment small, elongate or "U" shaped, in posterior region of eye (Fig. 2F) *E. proboscidea*
 b. Eye pigment large, lunate, encompassing most of median portion of eye (Fig. 2C) *E. calliops*
7. a. Number of hooks greater than 11, hook tips straight *E. bathyantartica*
 b. Number of hooks less than 11, hook tips bent inward 8
8. a. Hooks stout, nearly straight; tail less than 25% of body length *E. hamata*
 b. Hooks slender, gently curved; tail usually greater than 25% of body length *E. bathypelagica*
9. a. Outer margin of hooks obtusely angled (Fig. 5G); mature ovaries elongate, may extend past edge of lateral fins (Fig. 5E) *K. pacifica*
 b. Outer margin of hooks evenly rounded (Fig. 5D); mature ovaries compact, not extending past edge of lateral fins (Fig. 5A) *K. subtilis*
10. a. Body flaccid, highly transparent; trunk musculature inconspicuous genus *Flaccisagitta* (Fig. 7) 11
 b. Body rigid, translucent; trunk musculature prominent 13
11. a. Anterior fins long, inserted close to ventral ganglion, connected to posterior fins by raised portion of body cuticle; caudal fin bilobate (Fig. 7D) *F. lyra*
 b. Anterior fin short, rounded, well separated from ventral ganglion and posterior fins; caudal fin not bilobate 12
12. a. Two to four elongate, thin anterior teeth which sometimes protrude anteriorly (Fig. 7C) *F. hexaptera*
 b. Four to eight short, wide, overlapping anterior teeth *F. enflata*
13. a. Hooks finely serrate on inner margins as seen under 100X magnification (Fig. 11B) genus *Serratogitta* *S. serratodentata*
 b. Hooks not serrate 14
14. a. Collarete absent or indistinct 15
 b. Collarete distinct 18
15. a. Eyes without pigment; anterior fins entirely rayed, emerging at a point well separated from ventral ganglion (Fig. 6B) genus *Caecosagitta* *C. macrocephala*
 b. Eyes with pigment; anterior fins with anterior rayless zone, emerging at or near ventral ganglion genus *Mesosagitta* 16
16. a. Tail segment less than 22% of total body length; mature ovaries compact, with three to five large ova (Fig. 8D) *M. minima*
 b. Tail segment usually greater than 22% of total body length; mature ovaries elongate with numerous small ova 17
17. a. Seminal vesicles located approximately equal distance from posterior fins and caudal fin (Fig. 8A); maximum body length at maturity less than 15 mm *M. decipiens*

- b. Seminal vesicles adjacent to caudal fin and well separated from posterior fins (Fig. 8B); maximum body length at maturity may reach 20 mm *M. sibogae*
18. a. Gut diverticulae present* 19
- b. Gut diverticulae absent genus *Sagitta* 20
19. a. Posterior fins triangular with prominent rayless zone; walls of gut tube lined with large vacuolar cells (Fig. 10D) genus *Solidosagitta* *S. planctonis*
- b. Posterior fins rounded, completely rayed; no large vacuolar cells associated with gut tube (Fig. 11E) genus *Ferosagitta* *F. hispida*
20. a. Posterior fins well separated from seminal vesicles 21
- b. Posterior fins contacting the seminal vesicles 22
21. a. Anterior fins emerging posterior to ventral ganglion by a distance of about half the length of the ganglion; large vacuolar cells lining middle third of gut tube (Fig. 10A) *S. megalophthalma*
- b. Anterior fins emerging level with posterior edge of ventral ganglion; no large vacuolar cells associated with gut tube (Fig. 9A) *S. bipunctata*
22. a. Anterior teeth numerous (8–18), elongate, protruding outward in an overlapping, fan-shaped arrangement (Fig. 9D) *S. helenae*
- b. Anterior teeth less numerous (6–9), short, lying flat against head 23
23. a. Mature ovaries with large ova which are few in number and arranged in one row (Fig. 9F) *S. tenuis*
- b. Mature ovaries with small, numerous ova arranged in double rows (Fig. 9H) *S. friderici*

* Gut diverticulae are often undeveloped and thus difficult to see in immature specimens.

EUKROHNIA BATHYANTARCTICA

David, 1958

Diagnosis

Body length at maturity unknown but probably greater than 20 mm. Hooks 11–14. Teeth usually 11–16. T% 19–25. No eye pigment. No collarete. No gut diverticulae. Fins extending from anterior end of ventral ganglion to anterior third of tail segment. Mature ovaries short with small ova. Seminal vesicles ovoid, adjacent to lateral fins. Hooks gently curved with straight tips.

Ecology

Oceanic, bathyplanktonic, probably cosmopolitan. The most deep-living species of the genus in the Gulf of Mexico, occurring at depths to 2800 m (Fagetti 1968). Collected from great depths in the Antarctic and Caribbean Seas (David 1958; Fagetti 1968; Owre 1972,

1973). Listed as meso- to bathyplanktonic (>500–600 m) in the Florida Straits off Miami (Stepien 1980).

Gulf of Mexico records

Open ocean – Fagetti (1968), Owre (1973), McLelland and Perry (1989).

Remarks

One specimen (16.2 mm), an immature individual, was obtained from the bottom net sample (677 m) at Area 5 of the February, 1988 Geryon cruise (Table 1). It was undoubtedly a stray from deeper waters upwelled in the region. It had no denticulate hooks, a feature noted by Owre (1973) for 14 smaller (7.5–12.0 mm) Caribbean specimens. Fagetti (1968) failed to find denticulate hooks on any of her 11 specimens (11.5–20.0 mm) from the Gulf of Mexico and Caribbean Sea.

Figure 2. A-D, *Eukrohnia calliops*. E-G, *E. proboscidea*. (A) whole animal, ventral view; (B) head, dorsal view; (C) eyes; (D) hook with tip variations; (E) head, dorsal view; (F) left eye; (G) hook tip variations. Scales: A = 1.0 mm; B, E = 0.5 mm; C, D, F, G = 0.1 mm.

Figure 3. *Eukrohnia fowleri*. (A) immature specimen, ventral view; (B) head, dorsal view; (C) eyes; (D) adult hook; (E) hook tip variations; (F) juvenile hook. Scales: A, B = 1.0 mm; D = 0.5 mm; C, F = 0.1 mm; E = 0.05 mm.

EUKROHNIA BATHYPELAGICA* Alvaríño, 1962*Diagnosis**

Body length at maturity 20–23 mm. Hooks 7–10. Teeth 17–22 (mature). T% 24–29. No eye pigment. No collarette. No gut diverticulae. Lateral fins extending from middle of ventral ganglion to posterior third of tail segment. Ovary tips have coiled appearance before becoming fully mature. Seminal vesicles oval, separated from lateral and caudal fins. Hook tips bent inward at 45–90° angles.

Ecology

Oceanic, meso- to bathyplanktonic, probably cosmopolitan; inhabits cold, deep waters from 200 to 1400 m. Recorded from the North Pacific (Alvaríño 1962) and Atlantic oceans (Ducret 1965; Owre 1973).

Gulf of Mexico records

Open ocean – Owre (1973), McLelland and Perry (1989).

Remarks

Numerous specimens were found in the OTEC (200–800 m) and in the Geryon (200–677 m) samples, but none were mature. They probably were strays from a deeper population offshore. The smallest specimen (5.6 mm) from the OTEC samples did not have denticulate hooks; however, denticulations were present on the two ventral-most pairs of hooks of three specimens (7.2, 7.2, and 7.8 mm) from the Geryon samples. Denticulate hooks have been observed on small specimens of this species by Owre (1973) and Nagasawa and Marumo (1979). All specimens had the characteristic hook tip deflection (an abrupt bend of approximately 45 degrees).

***EUKROHNIA CALLIOPS* McLelland, 1989**
(Figs. 2A–D)

Diagnosis

Body length at maturity 15–22 mm. Hooks 11–13. Teeth up to 21. T% 21–31. Eyes large with dark, lunate pigment cups (Fig. 2C). Paired apical gland at anterior tip of head. Distinct neck. No collarette. No gut diverticulae. Lateral fins broadly rounded at posterior ends, tapering anteriorly, extending from anterior third of ventral ganglion to posterior third of tail segment; fin rays present only in outer-most posterior edge. Caudal fin large, broadly triangular. Mature ovaries short; ova large, round, in two rows. Seminal

vesicles ovoid-elongate, separate from caudal fin, anterior third overlapped by posterior edge of lateral fins. Hook tips sharply deflected inward (Fig. 2D).

Figure 4. *Pterosagitta draco*. Whole animal, ventral view. Scale = 1.0 mm.

Ecology

Oceanic, mesoplanktonic, probably hypoplanktonic along the continental slope in the northern Gulf of Mexico.

Gulf of Mexico records

McLelland (1989), McLelland and Perry (1989).

Remarks

One hundred and eighty-three (183) specimens were collected at four sites from 200 to 677 m over the Northeast Gulf continental slope in August, 1987, and February, 1988 (MARFIN Geryon cruises). Tokyo Bay (Japan) specimens of a closely related species, *E. kitoui* Kuroda, 1981, on loan from Kazunori Kuroda, were compared to the Gulf of Mexico specimens and found to be substantially different (McLelland 1989). No denticulate hooks were found on any specimens from either species.

***EUKROHNIA FOWLERI* Ritter-Zahony, 1909**
(Figs. 3A–F)

Diagnosis

Body length at maturity 34–40 mm. Hooks 9–13. Teeth up 30. Head wide with conspicuous neck. Eye pigment small, in center of eye (Fig. 3C). In well preserved specimens, thick band of epidermal tissue encircles body at ventral ganglion. Lateral fins with rays only in posterior third. Ovaries short; ova large, few in number, in two rows. Seminal vesicles ovoid, separated from caudal fin. Hooks gently curved with straight tips (Figs. 3D,E), appearing reddish in preserved specimens. Three to four ventral-most pairs of hooks strongly denticulate in small specimens (Fig. 3F).

Ecology

Oceanic, meso- to bathyplanktonic, cosmopolitan; abundant at depths greater than 600 m (Ducret 1965; Alvarino 1969). Epiplanktonic in polar seas, but submerged to colder waters in tropics (Fraser 1952; Boltovskoy 1981).

Gulf of Mexico records

Open ocean – Every (1968), Fagetti (1968), McLelland (1989), McLelland and Perry (1989).

***EUKROHNIA HAMATA* (Mobius, 1875)**

Diagnosis

Body length at maturity 35–43 mm. Hooks 8–9. Teeth up to 25. T% 19–24. No eye pigment. Head small with distinct neck. No collarette. No gut diverticulae. Fins narrow, extending from middle of ventral ganglion to seminal vesicles, with rays only in posterior third. Mature ovaries with small ova arranged in four rows. Seminal vesicles ovoid, adjacent to lateral fins and apart from caudal fin. Tips of hooks bent inward at sharp angle (60–90°).

Ecology

Oceanic, cosmopolitan, epiplanktonic in cold-water regions, submerged to deeper depths toward the tropics (Ducret 1965; Boltovskoy 1981).

Gulf of Mexico records

Open ocean – Pierce (1954).

Remarks

No specimens were found in northern Gulf collections. Pierce's specimens, collected at 495–749 m, were possibly *E. bathypelagica* or *E. bathyantartica*, species unknown at the time of his work.

EUKROHNIA PROBOSCIDEA

Furnestin and Ducret, 1965
(Figs. 2E–G)

Diagnosis

Length at maturity 18–30 mm. Hooks 10–13. Teeth 8–25 (15–25 when mature). T% 20–31. Apical gland bilobate. Eye pigment light brown in color, elongate, situated in posterior region of eye (Fig. 2F). No collarette. No gut diverticulae. Lateral fins extending from posterior edge of ventral ganglion to midpoint of tail segment; rays only in posterior half and outer edge. Mature ovaries short; ova up to 14, in two rows. Mature seminal vesicles ovoid-elongate with anterior third overlapped by lateral fins; well separated from caudal fin. Hook tips bent sharply inward (Fig. 2G).

Ecology

Oceanic, meso- to bathyplanktonic in tropical and subtropical Atlantic. Type material from 1000 and 1100 m off southwest African coast (Furnestin and Ducret 1965). Four specimens reported from 739 to 2072 m in Caribbean Sea (Owre 1973; Michel et al. 1976).

Figure 5. A-D, *Kohnnitta subtilis*. E-G, *K. pacifica*. (A) whole animal, ventral view; (B) head, ventral view; (C) right eye; (D) hooks; (E) whole animal, ventral view; (F) right eye; (G) hooks. Scales: A, E = 1.0 mm; B = 0.5 mm; D, G = 0.1 mm; C, F = 0.05 mm.

Gulf of Mexico Records

McLelland (1989), McLelland and Perry (1989).

Remarks

The single specimen collected at Area 5 during the 1988 Geryon cruise constitutes a new record for the Gulf of Mexico (see McLelland 1989). At 10.6 mm, it is the smallest yet recorded for the species. Its position at 29°N, 084°W and depth of 677 m extends the range of the species vertically, northward, and westward where it is considered a stray from a Caribbean population.

KROHNITTA PACIFICA (Aida, 1897)
(Figs. 5E-G)

Diagnosis

Body length seldom longer than 7 mm. Hooks 8–10. Teeth 11–14. T% 23–32. Eye pigment small, round (Fig. 5F). No collarette. No gut diverticulae. Lateral fins extending from seminal vesicles to a point midway between ventral ganglion and trunk-tail septum; gently curved, narrow, with rayless zone comprising about half of fin area. Caudal fin spatulate, often continuous with lateral fins. Mature ovaries long, may reach ventral ganglion; ova round or cuboidal, in one row. Seminal vesicles small, oval, usually overlapped by lateral and caudal fins. Hooks flat, highly transparent, light brown in color, outer edges obtusely angled (Fig. 5G).

Ecology

Semi-neritic, epipelagic, cosmopolitan in tropical and subtropical seas (Fumestini 1966; Boltovskoy 1981). Often associated with outer coastal regions of mixed water (Pierce and Wass 1962; Almeida-Prado 1968; McLelland 1978, 1984).

Gulf of Mexico records

Coastal – Cuba: Suárez-Caabro (1955). Florida: Ritter-Zahony (1910), Pierce (1951), Smith (1955). Northeast Gulf: Mulkana and McIlwain (1973), McLelland (1978, 1984). Texas: Pierce (1962), Adelman (1967). Mexico: Vega-Rodriguez (1964, 1965), Mostajo (1978).

Open ocean – Kolesnikov (1966), Alvarino (1969 – as *K. mutabii*), Michel et al. (1976).

Remarks

According to Owre (1960), Ritter-Zahony's (1910) specimens of *K. subtilis* were probably *K. pacifica*. Owre (1973) considers *K. mutabii* Alvarino, 1969 to be a synonym of *K. pacifica*.

Figure 6. *Caecosagitta macrocephala*. (A) head, ventral view; (B) immature specimen, ventral view. Scales: = 1.0 mm.

KROHNITTA SUBTILIS (Grassi, 1881)
(Figs. 5A–D)

Diagnosis

Body length at maturity 12–16 mm. Hooks 7–9. Teeth 9–12. T% 31–40. Eye pigment small, three-pointed (Fig. 5C). No collarette. No gut diverticulae. Fins semi-circular, delicate, almost totally rayless, extending from seminal vesicles to 2/3 distance from septum to ventral ganglion. Ovaries short, not extending past edge of lateral fins; ova round or oval, in two rows. Seminal vesicles small, rounded, touching lateral and caudal fins. Hooks clear, highly transparent, cutlass shaped (Fig. 5D).

Ecology

Oceanic, lower epipelagic to mesopelagic, cosmopolitan in tropical to temperate waters (Alvariño 1965; Boltovskoy 1981). Usually reported as mesopelagic (200–400 m) in tropical and subtropical seas (Furnestin 1957; Owre 1960; Matlin 1974). Not common in near-shore coastal waters.

Gulf of Mexico records

Coastal – Cuba: Suárez-Caabro (1955). Florida: Maidana and Mostajo (1980). Northeast Gulf: McLelland (1978, 1984). McLelland and Perry (1989). Texas: Pierce (1962). Mexico: Vega-Rodriguez (1964, 1965), Mostajo (1978).

Open ocean – Pierce (1954), Kolesnikov (1966), Kolesnikov and Alfonso (1966), Every (1968), Fagetti (1968).

Remarks

This species reaches a greater length at maturity than *K. pacifica* and is narrower, more transparent, and inhabits deeper strata.

PTEROSAGITTA DRACO Krohn, 1853
(Figs. 4, 12H)

Diagnosis

Mature body length 7–10 mm. Hooks 7–10. Anterior teeth up to 8. Posterior teeth up to 16. T% 37–42. Eye pigment small, elongate (Fig. 12H). Voluminous collarette extending onto tail segment, becoming continuous with lateral fins, possessing lateral tufts or bristles (seen on well preserved specimens). Gut diverticulae present. Tail segment constituting almost half of body length. Lateral fins entirely rayed, confined to tail segment. Ova large, in two rows; mature ovaries may extend full length of trunk cavity. Seminal vesicles

elongate, contacting lateral fins and lying close to caudal fin.

Ecology

Oceanic, epipelagic, cosmopolitan in tropical and subtropical areas (Owre 1960; Alvariño 1965). Apparently tolerates mixed water along continental shelf regions (Pierce 1962; Pierce and Wass 1962; Saint-Bon 1963; McLelland 1984).

Gulf of Mexico records

Coastal – Cuba: Suárez-Caabro (1955). Florida: Alvariño (1969), Maidana and Mostajo (1980). Northeast Gulf: Alvariño (1969), McLelland (1978, 1984), McLelland and Perry (1989). Texas: Pierce (1962). Mexico: Vega-Rodriguez (1964, 1965).

Open ocean – Central Gulf: Pierce (1954), Kolesnikov (1966), Kolesnikov and Alfonso (1966), Every (1968), Alvariño (1969), Owre (1973), Michel et al. (1976), Mostajo (1978).

CAECOSAGITTA MACROCEPHALA (Fowler, 1905)
(Figs. 6A,B)

Diagnosis

Body firm, opaque, with conspicuously large head. Body length at maturity 20–22 mm. Hooks 10–13, reddish in color. Anterior teeth 3–10. Posterior teeth up to 30. T% 26–40. No eye pigment. No collarette. No gut diverticulae. Anterior fins short, completely rayed, separated from ventral ganglion by about half their length. Posterior fins longer and wider than anterior fins, with small rayless zone at anterior end; length equally divided over trunk and tail segment. Seminal vesicles oval, separated from posterior and caudal fins. Ovaries may reach ventral ganglion when mature, containing small ova in multiple rows.

Ecology

Oceanic, cosmopolitan, meso- to bathypelagic in all oceans (Alvariño 1965; Boltovskoy 1981).

Gulf of Mexico records

Coastal – Northeast Gulf: McLelland and Perry (1989).

Open ocean (as *Sagitta macrocephala*) – Pierce (1954), Every (1968), Fagetti (1968), Owre (1973), Michel et al. (1976).

Remarks

Most specimens have dark granular material in the

wall of the gut which may be red or orange pigmented in fresh specimens (Alvariño 1967). Several specimens, all immature, were examined from the OTEC (200–1000 m) and Geryon (200–677 m) samples.

***FEROSAGITTA HISPIDA* (Conant, 1895)**
(Figs. 11E, 12G)

Diagnosis

Body length at maturity 8–12 mm. Hooks 6–8. Anterior teeth 5–9. Posterior teeth 10–14. T% 23–28. Head large, conspicuous. Eye pigment square to bean-shaped (Fig. 12G). Collarete extending 1/2 to 2/3 distance from neck to ventral ganglion. Gut diverticulae present. Lateral fins entirely rayed; anterior fins emerging at posterior edge of ventral ganglion; posterior fins extending to seminal vesicles. Mature ovaries may extend past midpoint of anterior fin; ova round, in two rows. Ripe seminal vesicles large, oval to rectangular, separated from caudal fin by half their length.

Ecology

Neritic, epipelagic, in inshore tropical-subtropical Atlantic waters (Alvariño 1965; Reeve 1966). Indicates presence of inshore water when collected offshore (Owre 1960; Pierce and Wass 1962; Ducret 1968; Michel et al. 1976).

Gulf of Mexico records (*As Sagitta hispida*)

Coastal – Cuba: Suárez-Caabro (1955). Florida: Pierce (1951), Smith (1955), Hopkins (1966), Kelly and Dragovich (1968), Maidana and Mostajo (1980). Northeast Gulf: Mulkana and McIlwain (1973), McLelland (1978, 1984). Texas: Pierce (1962), Adelmann (1967). Mexico: Vega-Rodriguez (1964, 1965), Suárez-Caabro and Gomez-Aguirre (1965), Mostajo (1978).

Open ocean – Kolesnikov (1966), Every (1968), Alvariño (1969).

Remarks

The genus *Ferosagitta* Kassatkina, 1971 was created to separate the similar species *F. ferox*, *F. hispida*, and *F. robusta* from the former genus *Parasagitta* Tokioka, 1965 (See Kassatkina 1982).

***FLACCISAGITTA ENFLATA* (Grassi, 1881)**
(Figs. 7A, 12B)

Diagnosis

Body length at maturity 18–25 mm. Hooks 8–11.

Anterior teeth 6–11. Posterior teeth up to 16. T% 14–18. Eye pigment star-shaped (Fig. 12B). No collarete. No gut diverticulae. Anterior fins short, narrow, well separated from ventral ganglion, rayed only on outer posterior edges. Posterior fins large, rounded, 2/3 length on trunk, rayed only on outer posterior edges. Mature ovaries may reach anterior fins; ova rounded, varying in size, in 2–3 rows. Seminal vesicles small, rounded, contacting caudal fin. Mature testes with conspicuously compacted "V" shaped cluster of material at posterior end of tail segment.

Ecology

Oceanic and semi-neritic, cosmopolitan, epipelagic in tropical and temperate regions (Pierce 1951, 1953; Alvariño 1965; Boltovskoy 1981). Little tolerance for low salinities or persistently high temperature (Pierce 1951).

Gulf of Mexico records (*As Sagitta enflata*)

Coastal – Cuba: Suárez-Caabro (1955). Florida: Pierce (1951), Smith (1955), Hopkins (1966), Kelly and Dragovich (1968), Alvariño (1969), Maidana and Mostajo (1980). Northeast Gulf: Alvariño (1969), Mulkana and McIlwain (1973), Perry and Christmas (1973), Show (1973), McLelland (1978, 1984). Texas: Pierce (1962), Adelmann (1967). Mexico: Vega-Rodriguez (1964, 1965), Suárez-Caabro and Gomez-Aguirre (1965), Mostajo (1978).

Open ocean – Pierce (1954), Kolesnikov (1966), Kolesnikov and Alfonso (1966), Every (1968), Alvariño (1969) Michel et al. (1976).

Remarks

This species is the most commonly reported and easily recognized chaetognath in tropical and subtropical waters.

***FLACCISAGITTA HEXAPTERA* (d'Orbigny, 1843)**
(Figs. 7B,C; 12A)

Diagnosis

Body length at maturity 38–40 mm. Hooks 6–10. Anterior teeth 2–6 (usually 2–4). Posterior teeth 3–8 (usually 3–5). T% 17–20. Eye pigment elongate, T-shaped (Fig. 12A). No collarete. No gut diverticulae. Anterior fins short, rounded, well separated from ventral ganglion; rays only on outer edge. Posterior fins large, rounded, 2/3 length on trunk, with internal, anterior rayless zone. Mature ovaries reach ventral ganglion; ova small, in three rows. Seminal vesicles small, rounded, close to caudal fin.

Figure 7. A, *Flaccisagitta enflata*. B, C, *F. hexaptera*. D, E, *F. lyra*. (A,B,D) whole animals, ventral views; (C) head, dorsal view; (E) head, ventral view. Scales = 1.0 mm.

Figure 8. A, *Mesosagitta decipiens*. B, C, *M. sibogae*. D, *M. minima*. (A) posterior end of body, ventral view; (B, D) whole animal, ventral view; (C) head, dorsal view. Scales = 1.0 mm.

Ecology

Oceanic, cosmopolitan, epipelagic in tropical and temperate regions (Alvariño 1965). Associated with deeper epipelagic zones (100–500 m) in warm seas (Owre 1960; David 1963; Mattlin 1974). Seldom occurs in shallow coastal waters.

Gulf of Mexico records (*As Sagitta hexaptera*)

Coastal – Cuba: Suárez-Caabro (1955). Florida: Alvariño (1969), Maidana and Mostajo (1980). Northeast Gulf: Alvariño (1969), Mulkana and McIlwain (1973), McLelland (1978, 1984), McLelland and Perry (1989 – as *F. hexaptera*). Mexico: Vega-Rodriguez (1964, 1965), Mostajo (1978).

Open ocean – Pierce (1954), Kolesnikov (1966), Kolesnikov and Alfonso (1966), Every (1968), Alvariño (1969), Owre (1973), Michel et al. (1976).

Remarks

This species resembles *F. enflata* but is usually associated with higher salinity and deeper water. One of the largest chaetognaths, it may reach 70 mm in cold waters (Alvariño 1967). Because of its large size, it has been implicated as a predator of larval fish (Alvariño 1980, Thuesen and Bieri 1987).

FLACCISAGITTA LYRA (Krohn, 1853)
(Figs. 7D,E; 12C)

Diagnosis

Body length at maturity 30–38 mm. Hooks 3–9. Anterior teeth 3–8. Posterior teeth up to 10. T% 15–20. Eye pigment elongate, Y-shaped (Fig. 12C). No collarette. No gut diverticulae. Anterior fins emerge near the posterior edge of the ventral ganglion, anterior 2/3 of length rayless. Posterior fins triangular, with large laminate rayless zone. Lateral fins connected by raised portion of body cuticle, or "fin bridge". Caudal fin bilobate on posterior edge. Ovaries long; ova small, in four rows. Seminal vesicles small, oval, situated close to posterior fins. Hooks robust, transparent, with conspicuous flange at base.

Ecology

Oceanic cosmopolitan in tropical and temperate regions (Alvariño 1965). Epipelagic to mesoplanktonic (100–700 m) in open ocean waters (Pierce 1954; Owre 1960; David 1963).

Gulf of Mexico records (*As Sagitta lyra*)

Coastal – Texas: Pierce (1962). Northeast Gulf:

McLelland (1978, 1984), McLelland and Perry (1989 – as *F. lyra*).

Open ocean – Pierce (1954), Kolesnikov and Alfonso (1966), Every (1968), Owre (1973), Michel et al. (1976).

Remarks

As they mature, these animals tend to lose hooks and teeth. Fully mature specimens usually possess 3 hooks (Fig. 7E), 3–5 anterior teeth, and 2–4 posterior teeth.

MESOSAGITTA DECIPIENS (Fowler, 1905)
(Figs. 8A, 12E)

Diagnosis

Body length at maturity 10–14 mm. Hooks 6–7. Anterior teeth 7–9. T% 19–32. Posterior teeth 13–20. Eye pigment elongate, T-shaped (Fig. 12E). No collarette. Gut diverticulae prominent. Anterior fins tapered, emerging level with posterior edge of ventral ganglion, with small rayless zone at anterior end. Posterior fins rounded, equally situated over trunk and tail segments, widest near posterior end, with small rayless zone at anterior end. Mature ovaries with large ova in one row, extending to anterior fins; anterior end of ovaries produced into a sharp point which continues as a fine fiber connected to the body wall (Fig. 8A). Seminal vesicles long and narrow, equidistant from posterior and caudal fins.

Ecology

Oceanic, cosmopolitan in tropical to temperate regions, lower epipelagic to deep mesoplanktonic (David 1963; Alvariño 1965; Fagetti 1972; Pierrot-Bults 1979). Associated with low levels of illumination and temperature (Owre 1960).

Gulf of Mexico records (*As Sagitta decipiens*)

Coastal – Northeast Gulf: McLelland (1978, 1984), McLelland and Perry (1989 – as *M. decipiens*). Mexico: Mostajo (1978).

Open ocean – Kolesnikov (1966), Kolesnikov and Alfonso (1966), Every (1968), Alvariño (1969).

Remarks

Some of the above-mentioned records and ecological notes may be inaccurate because of confusion with *M. sibogae*, a very similar species (see remarks for *M. sibogae*).

MESOSAGITTA MINIMA (Grassi, 1881)
(Figs. 8D, 12D)

Diagnosis

Mature body length 6–7 mm, widest at trunk-tail septum. Hooks 7–8. Anterior teeth 3–5. Posterior teeth up to 12. T% 15–22. Eye pigment small, slightly elongate, T-shaped (Fig. 12D). Small head with distinct neck. No collarette. Gut diverticulae small. Lateral fins delicate with sparse rays on outer margins. Anterior fins slightly separated from ventral ganglion. Posterior fins with 3/4 length on trunk segment. Mature ovaries short, with 3–4 large ova in one row. Seminal vesicles oval, widely separated from posterior fins, contacting caudal fin.

Ecology

Oceanic to semi-neritic, cosmopolitan in tropical and temperate regions where mixing of coastal and oceanic water occurs (Alvariño 1965; Boltovskoy 1981). Not a good hydrological indicator species because of its association with mixed water (Pierce 1953; Pierce and Wass 1962). Epiplanktonic to mesoplanktonic, shows affinity for cooler temperature (Alvariño 1965; Ducret 1968).

Gulf of Mexico records (As *Sagitta minima*)

Coastal – Florida: Maidana and Mostajo (1980). Northeast Gulf: Alvariño (1969), McLelland (1978, 1984), McLelland and Perry (1989 – as *M. minima*). Texas: Pierce (1962). Mexico: Mostajo (1978).

Open ocean – Every (1968), Alvariño (1969), Michel et al. (1976).

MESOSAGITTA SIBOGAE (Fowler, 1906)
(Figs. 8B,C; 12F)

Diagnosis

Body length at maturity 14–20 mm. Hooks 6. Anterior teeth 7–9. Posterior teeth 14–20. T% 19–27. Eye pigment elongate, T-shaped (Fig. 12F). No collarette. Prominent gut diverticulae. Anterior fins tapered, emerging level with posterior edge of ventral ganglion, with small rayless zone at anterior end. Posterior fins rounded, equally situated over trunk and tail segments, widest near posterior end, with small rayless zone at anterior end. Ovaries long, may extend past anterior fin, rounded at distal end; ova uniform in size, in one row. Seminal vesicles situated near caudal fin and widely separated from lateral fins, with a clear, bulbous inflation at anterior end.

Ecology

Oceanic, mesoplanktonic in mid and lower Atlantic latitudes. Probably distributed shallower in the mesopelagic realm than *M. decipiens*; apparently does not migrate diurnally (Pierrot-Bults 1979, 1982).

Gulf of Mexico records

McLelland and Perry (1989).

Remarks

Body length at maturity and seminal vesicle position are the major differences between this species and *M. decipiens*. Pierrot-Bults (1979) resurrected *Sagitta sibogae* after examining the lectotypes of *S. sibogae* and *S. decipiens*. Her detailed redescrptions of both species corrected the inadequacies of Fowler's (1905, 1906) original descriptions. Northeast Gulf specimens were compared to the lectotype of *S. sibogae* (ZMA 525-C, Siboga Exp., sta. 141) on loan from the Zoological Museum of Amsterdam.

SAGITTA BIPUNCTATA Quoy and Gaimard, 1827
(Figs. 9A, 12I)

Diagnosis

Body length at maturity 10–15 mm. Hooks 8–11. Anterior teeth 5–7. Posterior teeth up to 17. T% 24–27. Eye pigment slightly elongate (Fig. 12I). Collarette prominent to level of ventral ganglion, often extending entire length of body. No gut diverticulae. Lateral fins entirely rayed; anterior fin slightly separated from ventral ganglion. Mature ovaries long, may reach level of ventral ganglion; ova round, in one or two rows. Seminal vesicles well separated from posterior fins; anterior portion with clear, bulbous structure which sometimes contains a circular, saw-toothed inset.

Ecology

Oceanic, cosmopolitan in temperate to tropical water (Alvariño 1965). Epiplanktonic to upper mesoplanktonic (Owre 1960; Legaré and Zoppi 1961; Mattlin 1974). An indicator of high salinity, oceanic water (Pierce 1953; Grant 1963).

Gulf of Mexico records

Coastal – Cuba: Suárez-Caabro (1955). Florida: Ritter-Zahony (1910), Maidana and Mostajo (1980). Northeast Gulf: Alvariño (1969), Mulkana and McIlwain (1973), McLelland (1978, 1984), McLelland and Perry (1989).

Figure 9. A, *Sagitta bipunctata*. B, C, D, *S. helenae*. E, F, *S. tenuis*. G, H, *S. friderici*. (A, B, E, G) whole animals, ventral view; (C) head, dorsal view; (D) anterior head, ventral view; (F, H) lateral view of ovaries. Scales = 1.0 mm.

Figure 10. A-C, *Sagitta megalophthalma*. D-F, *Solidosagitta planctonis*. (A, D) whole animals, ventral view; (B, F) heads, dorsal view; (C) left eye; (E) right eye. Scales: A, D = 1.0 mm; B, F = 0.5 mm; C, E = 0.1 mm.

Open ocean – Pierce (1954), Kolesnikov (1966), Kolesnikov and Alfonso (1966), Every (1968), Alvario (1969), Owre (1973), Michel et al. (1976).

Remarks

The anterior teeth are similar in appearance and arrangement to those of *S. helenae* except they are less numerous and shorter.

SAGITTA HELENAE Ritter-Zahony, 1910
(Figs. 9B–D, 12L)

Diagnosis

Body length at maturity 9–13 mm. Hooks 7–8. Anterior teeth up to 19. Posterior teeth up to 15. T% 21–28. Eye pigment square (Fig. 12L). Collarete extending about half way to ventral ganglion. No gut diverticulae. Lateral fins entirely rayed; anterior fins emerge at posterior edge of ventral ganglion; posterior fins contact seminal vesicles. Mature ovaries may extend past ventral ganglion; ova cylindrical, in two rows. Seminal vesicles oval when ripe, contacting posterior and caudal fins.

Ecology

Neritic, epipelagic, in Atlantic tropical-subtropical regions (Alvario 1965; Boltovskoy 1981). Often associated with higher salinity continental shelf waters (Pierce 1951, 1953).

Gulf of Mexico records

Coastal – Florida: Ritter-Zahony (1910), Pierce (1951), Smith (1955), Hopkins (1966), Kelly and Dragovich (1968), Alvario (1969), Maidana and Mostajo (1980). Northeast Gulf: Alvario (1969), Shaw (1973), Mulkana and McIlwain (1973), Perry and Christmas (1973), McLelland (1978, 1984). Texas: Pierce (1962), Adelmann (1967). Mexico: Mostajo (1978).

Open ocean – Every (1968), Alvario (1969).

SAGITTA FRIDERICI Ritter-Zahony, 1911
(Figs. 9G,H, 12J)

Diagnosis

Body length at maturity 9–13 mm. Hooks 7–9. Anterior teeth 5–9. Posterior teeth up to 22. T% 25–30. Eye pigment square (Fig. 12J). Collarete short at neck. No gut diverticulae. Lateral fins entirely rayed; anterior fin tapered, emerging level with posterior edge of ventral ganglion. Mature ovaries may

reach mid-point of anterior fins; ova small, round, in two rows (Fig. 9H). Mature seminal vesicles contacting posterior and caudal fins, possessing anterolateral circular processes.

Ecology

Neritic, epipelagic, widely distributed in coastal waters of Atlantic and adjacent seas (Alvario 1965; Michel et al. 1976). Usually associated with lower salinity, near-shore waters but able to tolerate oceanic salinities (Furnestin 1957; Fraser 1961; McLelland 1980).

Gulf of Mexico records

Coastal – Northeast Gulf: McLelland (1978, 1980, 1984). Mexico: Suárez-Caabro and Gomez-Aguirre (1965), Laguarda-Figueras (1967).

Remarks

Tokioka (1974) considers *S. friderici* and *S. tenuis* to be ecological forms of the same species, with *S. tenuis* being the typical form. He attributes the larger size (up to 19 mm) of *S. friderici* and other "forms" of *S. tenuis* to be characteristic of slower growth rates of "matured individuals" in colder water, whereas the smaller size of individuals in warmer water results from energy being transferred away from body growth toward ovary development to achieve rapid maturation rates. Mature specimens of the two species from the Northeast Gulf, although similar, are readily separated by the methods presented in this key. Sampling evidence seems to indicate overlapping habitats, given the occurrence of both species not only at the same locations, but often in the same sample (McLelland 1978, 1980, 1984).

SAGITTA MEGALOPHTHALMA

Dallot and Ducret, 1969
(Figs. 10A–C)

Diagnosis

Length at maturity up to 19.5 mm. Hooks 7–8. Anterior teeth 5–8. Posterior teeth 13–21. T% 22–29. Eye pigment distinctively large, rectangular (Fig. 10C). Collarete well developed at neck. Gut thickened at anterior end, resembling small diverticulae. Large vacuoles along exterior of gut walls for about 2/3 length of gut tube. Lateral fins completely rayed; anterior fins emerging posterior to ventral ganglion by a distance equal to 1/2 the length of the ganglion. Mature ovaries extending to anterior end of posterior fins; ova round, in three rows. Seminal vesicles ovoid, well separated from posterior fins.

Ecology

Oceanic, mesoplanktonic; reported from the western Mediterranean Sea (holotype from 100–800 m), the Tyrrhenian Sea, and Gulf of Guinea by Dallot and Ducret (1969). A few specimens have been collected in the Caribbean Sea where it is a suspected indicator of North Atlantic water (Michel et al. 1976) and in the Florida Straits (Stepien 1980).

Gulf of Mexico Records

McLelland and Perry (1989).

Remarks

The five specimens from a 200–500 m. Geryon Cruise sample represented a new record for the Gulf of Mexico. They were probably transported in the Loop Current from the Caribbean Sea.

***SAGITTA TENUIS* Conant, 1896**
(Figs. 9E,F; 12K)

Diagnosis

Body length at maturity less than 7 mm. Hooks 7–8. Anterior teeth 5–7. Posterior teeth 10–16. T% 24–32. Eye pigment square (Fig. 12K). Collarete small at neck. No gut diverticulae. Lateral fins entirely rayed; anterior fin tapered, emerging level with posterior edge of ventral ganglion. Mature ovaries usually not reaching anterior fin; ova large, round, few in number, in one row (Fig. 9F). Mature seminal vesicles contacting posterior and caudal fins, possessing anterolateral circular processes.

Ecology

Euryhaline, associated with neritic waters in tropical, subtropical, and temperate Atlantic regions; epipelagic (Alvario 1965).

Gulf of Mexico records

Coastal – Cuba: Suárez-Caabro (1955). Florida: Pierce (1951), Smith (1955), Hopkins (1966), Kelly and Dragovich (1968), Alvario (1969), Maidana and Mostajo (1980). Northeast Gulf: Alvario (1969), Mulkana and McIlwain (1973), Perry and Christmas (1973), McLelland (1978, 1980, 1984). Texas: Pierce (1962), Adelmann (1967). Mexico: Vega-Rodriguez (1964, 1965), Mostajo (1978).

Remarks

Recorded occurrences of *S. tenuis* from Gulf of

Mexico and coastal Atlantic regions may include *S. friderici* owing to Pierce's (1951) placing the two species in synonymy (McLelland 1980). Juveniles and sub-adults of the two species cannot be confidently separated.

SERRATOSAGITTA SERRATODENTATA

(Krohn, 1853)
(Figs. 11A–D)

Diagnosis

Body length at maturity 10–13 mm. Hooks 5–8. Anterior teeth 6–10. Posterior teeth 15–20 (mature). T% 23–28. Eye pigment elongate, T-shaped (Fig. 11D). Collarete vestigial, usually not distinct at neck. No gut diverticulae. Anterior fins emerging at posterior end of ventral ganglion, with small internal rayless zone. Posterior fins "bell" or "guitar" shaped, with internal rayless zone. Mature ovaries extending to anterior fins; ova round to cuboidal, in one row. Seminal vesicles contacting lateral fins, separated from caudal fin, with two anterolateral papillae, or "horns", when mature. Hooks finely serrate on inner margins with serrata being low in profile (Fig. 11B).

Ecology

Oceanic, epipelagic, inhabits tropical and subtropical waters of Atlantic and adjacent seas (Alvario 1965; Boltovskoy 1981). Usually associated with high salinity but has been known to tolerate low salinity coastal water, especially in temperate regions (Pierce and Wass 1962).

Gulf of Mexico records (As Sagitta serratodentata)

Coastal – Cuba: Suárez-Caabro (1955). Florida: Ritter-Zahony (1910), Alvario (1969), Maidana and Mostajo (1980). Northeast Gulf: Alvario (1969), Mulkana and McIlwain (1973), McLelland (1978, 1984), McLelland and Perry (1989 – as *Serratogagitta serratodentata*). Texas: Pierce (1962), Adelmann (1967). Mexico: Vega-Rodriguez (1964, 1965), Mostajo (1978).

Open ocean – Pierce (1954), Kolesnikov (1966), Kolesnikov and Alfonso (1966), Every (1968), Alvario (1969), Michel et al. (1976).

Remarks

According to Pierrot-Bults' (1974) classification, the Gulf population belongs to the Atlantic subspecies *Sagitta serratodentata serratodentata* Krohn, 1853 as opposed to the subspecies *S. serratodentata atlantica* Thompson, 1947, an isolated population in the South Pacific. A compound microscope is usually required to observe hook serrata in smaller specimens.

Figure 11. A-D, *Serratosagitta serratodentata*. E, *Ferosagitta hispida*. (A, E) whole animals, ventral view; (B) hook detail; (C) hook; (D) right eye pigment. Scales: A, E = 1.0 mm; C = 0.1 mm; D = 0.01 mm.

Figure 12. Chaetognath eye pigments, all from right eyes. (A) *Flaccisagitta hexaptera*, (B) *F. enflata*, (C) *F. lyra*, (D) *Mesosagitta minima*, (E) *M. decipiens*, (F) *M. sibogae*, (G) *Ferosagitta hispida*, (H) *Pterosagitta draco*, (I) *Sagitta bipunctata*, (J) *S. friderici*, (K) *S. tenuis*, (L) *S. helenae*. Scales: C, D, E, G, H = 0.01 mm; A, B, I, J, K, L = 0.015 mm; F = 0.02 mm.

SOLIDOSAGITTA PLANCTONIS (Steinhaus, 1896)
(Figs. 10D–F)

Diagnosis

Length at maturity 30–43 mm. Hooks 8–11. Anterior teeth 5–12. Posterior teeth 10–22. T% 20–30. Eye pigment small, square (Fig. 10E). Collarete well developed. Gut diverticulae present. Large vacuoles present in body cavity associated with gut tube. Anterior fins emerging level with posterior end of ventral ganglion, with rayless anterior ends. Posterior fins triangular with rayless interior, 1/3 of length on tail segment. Mature ovaries long; ova small, in three rows. Seminal vesicles oval, situated adjacent to posterior fins, well separated from caudal fin.

Ecology

Oceanic, mesoplanktonic, cosmopolitan in tropical and temperate waters (Alvarino 1965; Terazaki and Marumo 1982). Collected in the Florida Straits at 687 m (Stepien 1980) and throughout the Caribbean Sea down to 3000 m (Michel et al. 1976) where it is considered an indicator of North Atlantic water.

Gulf of Mexico Records

Coastal – Northeast Gulf: McLelland and Perry (1989).

Open ocean – (as *Sagitta zetesios*) Southeast Gulf near Yucatan Straits: Fagetti (1968)

Remarks

Using discriminant and factor analyses on specimens of *Sagitta planctonis* and *S. zetesios* Fowler, 1905, collected from the southwest African coast and Bermuda, Pierrot-Bults (1975) demonstrated that the

species should be considered polytypic with two "formae", *S. planctonis* f. *planctonis* and *S. planctonis* f. *zetesios*, with the latter being associated with deeper, colder water. She showed that both forms, and intermediates between the two, are often present in the same population; thus, no firm barriers exist preventing gene flow between forms. The five immature specimens (8.4–16.4 mm) from the Geryon material corresponded to the form *zetesios*, as described by Pierrot-Bults (1975) and Michel (1984). It is likely that the other form, *S. planctonis* f. *planctonis*, occurs in the Gulf of Mexico since a few specimens were collected in the Caribbean Sea (Michel et al. 1976) and the Florida Straits (Owre 1960). Although Pierrot-Bult's synonymization of the two species is accepted, the legality of the taxon "forma" is questionable; thus, only the species nomenclature, *planctonis*, is retained in this work. The reader is referred to David's (1956) redescrptions of the two species as argument for maintaining the validity of *planctonis* and *zetesios*.

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