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Six New Genera in the Chaetognath Family Sagittidae

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SIX NEW GENERA IN THE CHAETOGNATH FAMILY SAGITTIDAE

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ABSTRACT The following six new genera of Sagittidae, with type species listed in parentheses, are proposed: *Adhesisagitta* (*Sagitta hispida* Conant, 1985), *Demisagitta* (*Sagitta demipenna* Tokioka and Pathansali, 1963), *Decipisagitta* (*Sagitta decipiens* Fowler, 1905), *Tenuisagitta* (*Sagitta tenuis* Conant, 1986), *Abacisagitta* (*Sagitta pulchra* Doncaster, 1903), *Oculosagitta* (*Sagitta megalophthalma* Dallot and Ducret, 1969).

INTRODUCTION

While reviewing recently (Bieri, In Press) the genera of the chaetognath family Sagittidae, I noticed that some genera are heterogeneous and therefore neither parallel nor symmetrical with the other genera of the family. Among the asymmetries are differences in fin ray distribution, body proportions, body texture, and the shape and structure of the seminal vesicles. To correct these heterogeneous assemblages I propose the following new genera:

Sagittidae Tokioka, 1965

Adhesisagitta, new genus
Figure 1

Type species — *Sagitta hispida* Conant, 1895, by monotypy and present designation.

Name — From the Latin "adhaesus", clinging to, referring to the habit of this "quasi-planktonic" species of clinging to the substrate.

Definition — Corona ciliata long, extending from just anterior to eyes to well posterior on trunk but not reaching ventral ganglion; intestinal diverticula present; lateral fins completely rayed; body rigid; seminal vesicles slightly swollen at anterior end when mature, but not forming distinct knob; ovaries moderately long and narrow with ova irregularly spaced rather than in a single row; mouth appearing sutured or buckled by 4 rod-like structures or bars about 1/3 as long as distance between them; species can cling to vertical substrate.

Species included — One, *Sagitta hispida*.

Discussion — Published drawings and descriptions of this species are not consistent with one another in several critical features. Figure 1 is a composite of the drawings of Pierce (1951), Tokioka (1955), Michel (1984), McLelland (1989), and my own observations. In distinguishing *Adhesisagitta* from *Sagitta* and *Ferrosagitta* the structure of the seminal vesicle and variations in its appearance at different stages of maturity are important and are best illustrated by Tokioka (1955). Although perhaps not of generic significance, the space between the seminal vesicle and the tail fin is about 1/2 the length of the vesicle. Pierce shows the vesicle in contact with the tail fin, and Michel, although stating in her text that it is widely separated from the tail fin, illustrates it as rather close, as does McLelland. The irregular arrangement of the ova is distinctive. Although the number of chaetognath species examined with SEM now exceeds 17 (Thuesen et al 1988), *A. hispida* is the only species found to have well developed bars or buckles across the mouth. They are shown exceptionally clearly in the SEM photograph of Cosper and Reeve (1970). It is also the only sagittid known to cling habitually to the walls of glass aquaria (H. Michel, pers. comm.) and to eel grass (McLelland, pers. comm.), a behavior that may be related to its hyper-neritic distribution (Pierce, 1951). The conjectured buckles may function as adhesive organs. *Adhesisagitta* is distinguished from the possibly closely related genera *Sagitta* (sensu Tokioka) and *Ferrosagitta* not only by the mouth buckles but also by its clinging ability, shape of the seminal vesicles, and the irregular arrangement of the ova.

Demisagitta, new genus
Figure 2

Type species — *Sagitta demipenna* Tokioka and Pathansali, 1963, by montypy and present designation. Tokioka (1965) placed *S. demipenna* in *Aidanosagitta* Tokioka and Pathansali, 1963

Name — From the trivial name of the type species, referring to the short or "half" posterior fin, which is limited to the tail.

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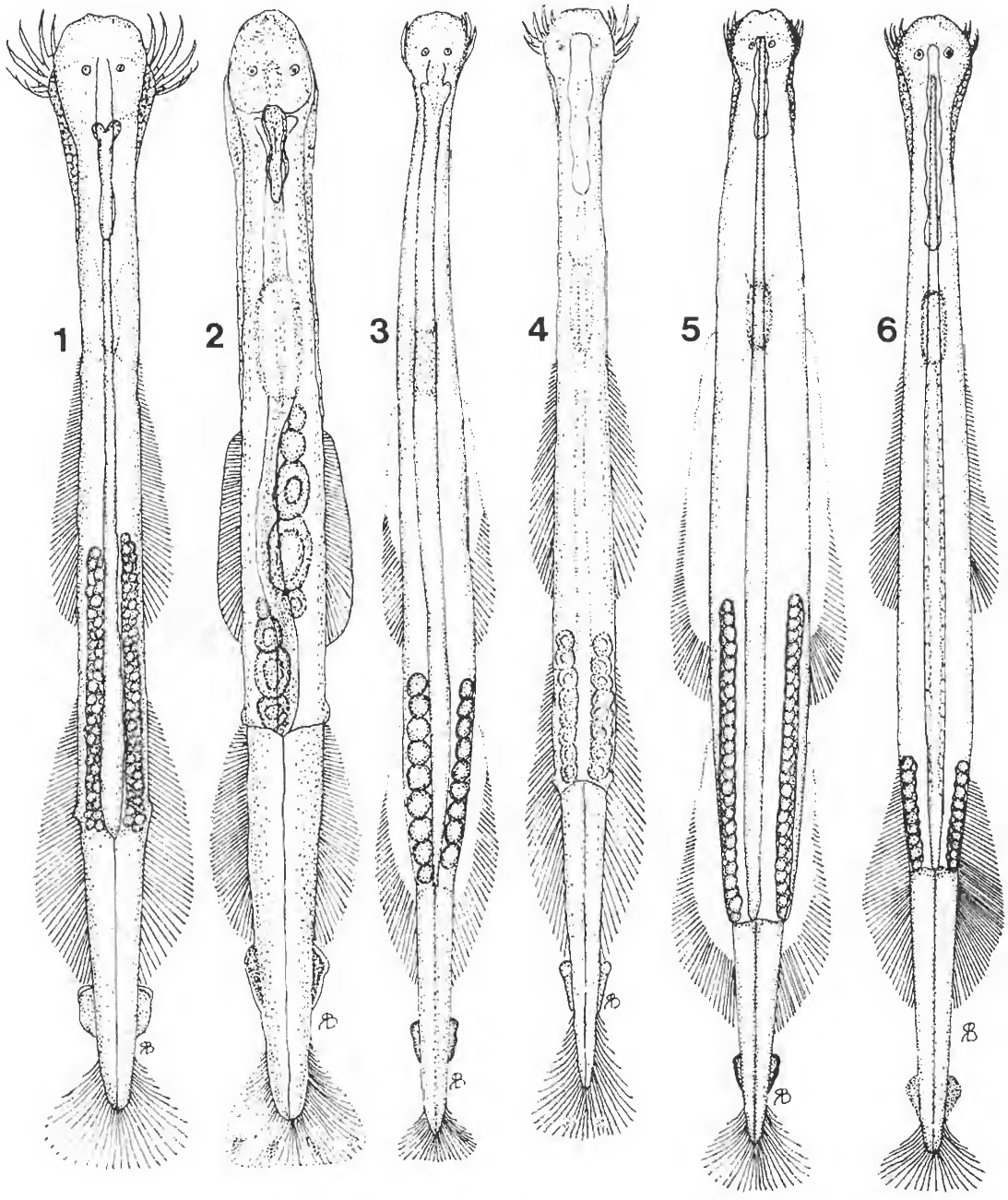

Figures 1—6. Composite and schematic habitus drawings of Chaetognatha, in dorsal view. (1) *Adhesisagitta hispida*, based on Pierce 1951, Tokioka 1955, Michel 1984, McLelland 1989, and the author's observations. (2) *Demisagitta demipenna*, based on Tokioka and Pathansall 1963, Pathansall 1974, and Alvariño 1967. (3) *Decipisagitta decipiens*, based on Pierrot-Bults 1979, McLelland 1989, and the author's observations. (4) *Tenuisagitta tenuis* based on Pierce 1951, Mclelland 1980, and the author's observations. (5) *Abaciasagitta pulchra*, based on Tokioka 1966, Alvariño 1967, and the author's observations. (6) *Oculosagitta megalophthalma*, based on Dallot and Ducret 1969, and Michel 1984.

Definition — Very similar to *Aidanosagitta* as defined by Tokioka (1965). Corona ciliata beginning posterior to eyes; intestinal diverticula present; lateral fins completely rayed, rays at anterior ends of fins perpendicular to body wall; body very stiff and rigid, wider than in *Aidanosagitta*, more like *Spadella* and *Pterosagitta*; tail relatively long; seminal vesicle situated just behind posterior fin and separated from tail fin, no external differentiation of anterior glandular part; mature ovaries reaching ventral ganglion, ova in single row, so large that they crowd and distort gut, maturing asynchronously; posterior fin extending anteriorly only to level of transverse septum.

Species included — One, *Demisagitta demipenna*.

Discussion — No other species of Sagittidae has the posterior fin limited to the tail. This remarkable feature clearly separates *D. demipenna* from all other known sagittids and requires modification of the usual textbook definition of Sagittidae. If *D. demipenna* were to lose the anterior fin and develop a pair of large hair fans, it would fit into the genus *Pterosagitta*, which demonstrates the close affinity of the Pterosagittidae to the Sagittidae. The occurrence of a "demi-fin" in the relatively short, wide-bodied, and heavily muscled genera *Pterosagitta* and *Spadella* as in *Demisagitta* argues for a specialized form of locomotion associated with the short, powerful muscles and the short, stiff "demi-fin."

Discussion — Erection of this genus leaves *Mesosagitta* with a single species, *M. minima* (Grassi, 1881). Of the four species listed above, only two were recognized as valid by Pierrot-Bults in her 1979 review of the group. *Decipisagitta batava* may have been described from deformed specimens of *Sagitta setosa*. It has not been reported since the original description by Bierstecker and van der Spoel (1966), who said that small intestinal diverticula, show in their figure 2, are "usually present." No other chaetognath has been reported with diverticula "usually present"; they are either present or absent. Although possibly due to poor preservation, this type of preservational artifact has not been reported previously (Bieri, 1989). The other three species of *Decipisagitta* are mesoplanktonic, whereas *D. batava* is epiplanktonic, which is also anomalous. However, the original description is so well done that the species should be retained pending further study.

Although Pierrot-Bults synonymized *Sagitta neodecipiens* Tokioka (1959) with S. decipiens Fowler (1905), there are very significant differences in the arrangement of the fin rays as shown by Tokioka (1959) in his original description of *S. neodecipiens* and in *S. decipiens* as drawn by Pierrot-Bults from the lectotype and paralectotype. In view of these striking differences and the differences in the eye pigments, *S. neodecipiens* should be retained as a valid species.

Decipisagitta, new genus
Figure 3

Type species — *Sagitta decipiens* Fowler, 1905.

Name — From the trivial name of the type species.

Definition — Agreeing mostly with Tokioka's (1965) definition of *Mesosagitta*. Corona ciliata beginning on neck and extending posteriorly onto anterior part of trunk; intestinal diverticula present; fin rays diagonal to body wall rather than perpendicular as in *Mesosagitta*, rays completely appressed, not irregularly spaced, missing in some areas of both lateral fins; more of posterior fin on trunk than on tail; seminal vesicles separated from posterior fin; maximum body width rather spread out; between 1/3 and 1/2 of trunk length anterior to transverse septum, in contrast to *Mesosagitta* in which less than 1/4 of trunk is anterior to transverse septum; no marked constriction of tail at transverse septum as in *Mesosagitta*; body muscles weakly developed, stronger than in *Flaccisagitta* but weaker than in *Serratosagitta*, stronger and more opaque than in *Mesosagitta*; mature ovaries approaching but usually not reaching ventral ganglion, relatively long and narrow with ova in single row.

Included species — Four: *Decipisagitta decipiens*, *D. sibogae*, *D. neodecipiens*, and possibly the doubtful species, *D. batava*.

Tenuisagitta, new genus
Figure 4

Type species — Sagitta tenuis Conant, 1896.

Name — From the trivial name of the type species.

Definition — Corona ciliata very elongate, extending from just anterior to eyes to well onto trunk; intestinal diverticula absent; lateral fins completely rayed, rays completely appressed; body rather transparent with longitudinal muscles of moderate strength, weaker than in *Sagitta* but stronger than in *Mesosagitta*; seminal vesicles simple but with circular process at anterior end that becomes ovoid when fully mature; ovary variable, in small species with ova arranged in single row and maturing synchronously, in large species with ova arranged in double row and sometimes maturing asynchronously.

Species included — As presently understood, six species: *Tenuisagitta tenuis*, *T. setosa*, *T. friderici*, *T. euneritica*, *T. peruviana*, *T. popvicci*.

Discussion — Although *Tenuisagitta* bears a strong superficial resemblance to *Parasagitta*, the two genera differ in several significant features, including the presence in *Parasagitta* of intestinal diverticula, and large vacuolated gut cells containing NH4+ rather than Na+ resulting in a lower body density in *Parasagitta* than in *Tenuisagitta* (Bone et al., 1987). All included species of

Tenuisagitta are epiplanktonic and more or less neritic.

Abaciasagitta, new genus
Figure 5

Type species — *Sagitta pulchra* Doncaster, 1903, by monotypy and present designation.

Name — From the Latin "ab", off, away from, plus "acia", thread, referring to the partial lack of rays in the lateral fins.

Definition — Corona ciliata very long, extending from just anterior to eyes to well onto trunk; intestinal diverticula absent; lateral fins with conspicuous rayless zones, especially large in posterior fins, much larger than in *Zonosagitta*; head not as wide as maximum body width which is at about midlength; body muscles weaker and more translucent than in *Zonosagitta*; anterior fins flat-sided and broadest near posterior end; seminal vesicle in two parts rather than forming bulb as in *Zonosagitta*; ovary very long, reaching from midbody to ventral ganglion when mature, ova viewed dorsally usually in a single row; tail about 1/5 as long as head and trunk combined.

Species included — One, *Sagitta pulchra*.

Discussion — Tokioka (1965) included *S. pulchra* in his new genus *Zonosagitta*. Alvarino (1967), on the other hand, excluded it from her "bedoti group" (= *Zonosagitta*), stating that "This species is not included in any group." In view of the fin differences as well as differences in the body muscles and the seminal vesicles, this species merits its own genus.

Oculosagitta, new genus
Figure 6

Type-species — *Sagitta megalophthalma* Dallot and Ducret, 1969, by monotypy and present designation.

Name — From the Latin "oculus", eye, referring to the importance the authors of *S. megalophthalma* placed on the size of the eye pigment.

Definition — Corona ciliata very long, extending from just anterior to eyes to well back onto trunk but not reaching ventral ganglion; intestinal diverticula absent; lateral fins completely rayed, all rays appressed one to another; body moderately firm; head barely wider than maximum body with which is at about 1/3 of trunk length anterior to transversed septum; body width tapering gradually towards head and tail, without marked constriction at transverse septum; seminal vesicle simple, ovoid, touching tail fin but widely separated from posterior fin; ova reaching only to anterior end of posterior fin (mature specimens may not yet be known), ova in double row or irregularly spaced when viewed dorsally; gut with large vacuolated cells in middle two-thirds easily visible in dorsal view, these cells may line the entire gut in juveniles.

Species included — One: *Sagitta megalophthalma*.

Discussion — In their original description Dallot and Ducret discussed Tokioka's genera and Alvariño's groups and decided that *S. megalophthalma* did not fit into any of the extant genera or groups. Although somewhat similar to *Sagitta bipunctata* and vaguely reminiscent of *Mesosagitta minim*, the species does not fit in any sagittid genus and therefore merits its own genus. The large, heavily pigmented eyes, large head, slender body, small collarette, and long series of vacuolated gut cells set it off from all other known species of Sagittidae.

A Note on the Figures

The figures are composites of figures published by several different authors as noted with modifications based on the author's experience. The separation of the fin rays, which are actually closely appressed, is much exaggerated. Particular attention has been given to body proportions, relative head width, location of seminal vesicles, extent of ovary and arrangement of ova, and disposition of the fins in relation to the ventral ganglion and transverse septum. A less than successful attempt has been made to indicate the stiffness of the body musculature by the degree of shading. The author is personally well acquainted with all the type species from well preserved formalin specimens with the exception of *Demisagitta demipenna* and *Oculosagitta megalopthalma*.

References Cited

Alvariño, A. 1967. The Chaetognatha of the Naga Expedition (1959-1961) in the South China Sea and the Gulf of Thailand. *Naga Rep.* 4(2):1—197.

Bieri, R. 1989. Krohnitellidae and Bathybelidae, new families in the phylum Chaetognatha; the rejection of the family Tokiokaispadellidae and the genera *Tokiokaispadella*, *Zahonya*, and *Aberrospadella*. *Proc. Biol. Soc. Wash.* 102(4):973—976.

In Press. Systematics of the Chaetognatha. *In* : Q. Bonê, A.C. Pierrot Bults, and H. Kapp, (eds), *The Biology of the Chaetognatha*. University Press, Oxford.

Biersteker, R. H., & S. van der Spoel. 1966. *Sagitta batava* n. sp. from the Scheldt Estuary, the Netherlands (Chaetognatha). *Beaufortia* 14(167):61—69.

Bone, Q., C. Brownlee, G. W. Bryan, G. R. Burt, P. R. Dando, M. I. Liddicoat, A. L. Pulsford, & K. P. Ryan. 1987. On

the differences between the two indicator species of chaetognath, *Sagitta setosa* and *S. elegans*. *J. Mar. Biol. Assoc. U.K.* 67:545-560.

Conant, F. S. 1985. Description of two new chaetognaths (*Spadella schizoptera* and *Sagitta hispida*). *Ann. Mag. Nat. Hist.* (6)16:288-292.

_____. 1896. Notes on the chaetognaths. *Ann. Mag. Nat. Hist.* (6)18:201-214.

_____. Cosper, T. C., & M. R. Reeve. 1970. Structural details of the mouthparts of a chaetognath as revealed by scanning electron microscopy. *Bull. Mar. Sci. Gulf. Caribb.* 20:441-445.

Dallot, S., & F. Ducret. 1969. Un chaetognathe mésoplanctonique nouveau: *Sagitta megalophthalma* sp. n. *Beaufortia* 17:13-20.

Doncaster, L. 1903. Chaetognatha, with a note on the variation and distribution of the group. *Fauna Geogr. Maldive-Laccadive Archipel.* 1:209-218.

Fowler, G. H. 1905. Biscayan plankton collected during a cruise of the H.M.S. Research, 1900. III. The Chaetognatha. *Trans. Linn. Soc. London (Zool.)* 10(3):55-87.

Grassi, B. 1881. Intorno ai Chaetognati. *Rend. R. Ist. Lombardo Sc. Lett.*, (2) 14:199-214.

McLelland, J. A. 1980. Notes on the northern Gulf of Mexico occurrence of *Sagitta friderici* Ritter-Zahoney (Chaetognatha). *Gulf Res. Rept.* 6(4):343-348.

_____. 1989. An illustrated key to the Chaetognatha of the northern Gulf of Mexico with notes on their distribution. *Gulf Res. Rept.* 8(2):145-172.

Michel, H. B. 1984. Chaetognatha of the Caribbean Sea and adjacent areas. NOAA Tech. Rep. NMFS 15, U.S. Dept. of Commerce. 33 pp.

Pathansali, D. 1974. Chaetognatha in the coastal waters of peninsular Malaysia with descriptions of two new species. *Fish. Bull. No. 2, Minist. Agric. Rural Develop. Malaysia*, 29 pp.

Pierce, E. L. 1951. The Chaetognatha of the west coast of Florida. *Biol. Bull.* 100:206-228.

Pierrot-Bults, A. C. 1979. On the synonymy of *Sagitta decipiens* Fowler. 1905, and *Sagitta neodecipiens* Tokioka, 1959, and the validity of *Sagitta sibogae* Fowler, 1906. *Bull. Zool. Mus. Univ. Amst.* 6:137-143.

Ritter-Záhony, R. von. 1911. Revision der Chaetognathen. *Dtsch. Südpol. Exped.* 1901-3. 13(1):1-71.

Thuesen, E. V., S. Nagasawa, R. Bieri, & T. Nemoto. 1988. Transvestibular pores of chaetognaths with comments on the functions and nomenclature of the vestibular anatomy. *Bull. Plankton Soc. Jpn.* 35:133-141.

Tokioka, T. 1955. Notes on some chaetognaths from the Gulf of Mexico. *Bull. Mar. Sci. Gulf Caribb.* 5:52-65.

_____. 1959. Observations on the taxonomy and distribution of chaetognaths of the North Pacific. *Publ. Seto Mar. Biol. Lab.* 7:349-456.

_____. 1965. The taxonomical outline of Chaetognatha. *Publ. Seto Mar. Biol. Lab.* 12:335-357.

_____. 1966. Phylum Chaetognatha. Pages 181-190 in: I. Yamazi, Illustrations of the Marine Plankton of Japan. Hoikusha Publ. Co., Osaka, Japan.

_____ & D. Pathansali. 1963. Another new chaetognath from Malay waters, with a proposal of grouping some species of *Sagitta* into subgenera. *Publ. Seto Mar. Biol. Lab.* 11:119-123.

Robert Bieri died on July 31, 1990 after a lengthy bout with cancer. He was Professor Emeritus of Environmental Studies at Antioch College in Yellow Springs, Ohio, where he taught for 30 years. He previously held posts at the Scripps Institution of Oceanography and the Lamont-Doherty Geological Observatory of Columbia University. His numerous expeditions included excursions to the Arctic Ocean, the Pacific Coast of Mexico, the Caribbean Sea, the Mediterranean Sea, and the Boreal North Atlantic. He spent two sabbatical years in Japan and three months in Ecuador as a visiting scientist at the Instituto Oceanographico de la Armada. He made numerous contributions to the knowledge of chaetognath biology and systematics, and will be greatly missed as a reviewer and contributor to ***Gulf Research Reports.***

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Notes on Some Chaetognaths from Pine Cay, Turks and Caicos Islands (British West Indies)

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NOTES ON SOME CHAETOGNATHS FROM PINE CAY, TURKS AND CAICOS ISLANDS (BRITISH WEST INDIES)

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ABSTRACT Seven species of planktonic Chaetognatha — *Ferosagitta hispida, Flaccisagitta enflata, F. hexaptera, Krohnitta pacifica, Sagitta bipunctata, Serratosagitta serratodentata,* and *Pterosagitta draco* — were present in plankton samples collected in waters north of Pine Cay, Turks and Caicos Islands, British West Indies. In addition, the epibenthic species *Spadella cephaloptera, Paraspadella nana,* and *P. schizoptera* were present, the latter two species associated mainly with shallow clumps of the coralline alga, *Neogoniolithon* sp., and with sponge-algal communities. One specimen of *S. cephaloptera* was collected at 35 m from a sand bottom north of the fringing reef adjacent to Pine Cay. Meristic data for *F. hispida* and for the three epibenthic species are provided.

Introduction

Water surrounding small islands in the British West Indies is primarily oceanic in nature, with little dilution from terrestrial freshwater sources. Consequently, the near-shore plankton community is composed largely of species associated with oceanic currents.

Detailed information on the chaetognath population structure in the southern Bahamas and British West Indies is sketchy. Investigations of planktonic chaetognath distribution in the tropical western Atlantic were published by Ritter-Záhony (1910), Suárez-Caabro (1955), Colman (1959), Alvariño (1969), and more recently Michel *et al* (1976). Distribution of the epibenthic family Spadellidae in the Bahamas was discussed by Owre (1972), who also mentioned four planktonic chaetognath species from surface qualitative samples collected at diverse stations among the islands. Michel (1984), in a synopsis of chaetognaths of the Caribbean Sea and adjacent waters, provided an identification key and illustrations of species occurring in the region. The purpose of this paper is to document three epibenthic species occurring at Pine Cay and planktonic species from nearby waters.

Materials and Methods

Chaetognaths from near-shore waters in the vicinity of Pine Cay (Figure 1) were examined from collections made in April 1988, November 1988, and April 1989. Several methods were used for collecting planktonic specimens (Table 1), including towing a 0.5 m, 500 µm mesh net from a skiff, pulling an Ockelmann epibenthic dredge (sled) both from a skiff and along the beach by hand, and using an illuminated plexiglass plankton trap at night. Epibenthic specimens were collected by gently hand washing substrata (e.g., algae clumps, sponges) in a weak formalin-seawater solution. Attached animals that became dislodged were captured on a 0.5 mm sieve. Epibenthic specimens were also collected using a hand-operated PVC yabby pump and sock-net of 0.5 mm mesh size. Samples were fixed in 10% formalin-seawater. Chaetognaths removed from the samples were identified to species, counted, and assigned to a stage of maturity based on the four stages of gonadal development reviewed by Alvariño (1965). Total numbers and maturity stages of chaetognaths sorted from the plankton samples are presented in Table 2. Numbers and stages of maturity of chaetognaths from the various epibenthic collections are presented in Table 3; some meristic values are provided in Table 4.

Results and Discussion

Planktonic species (Table 2)

With the exception of the primarily neritic *Ferosagitta hispida* collected only in epibenthic samples (Table 1), the planktonic species are all oceanic and found in the epipelagic strata. However, *Flaccisagitta hexaptera*, considered rare in surface waters, is most often associated with the lower epiplankton from about 50 to 200 m. All are cosmopolitan except *Serratosagitta serratodentata* and *Ferosagitta hispida*, which are tropical Atlantic species (Pierrot-Bults 1974; Alvariño 1965). Illustra-

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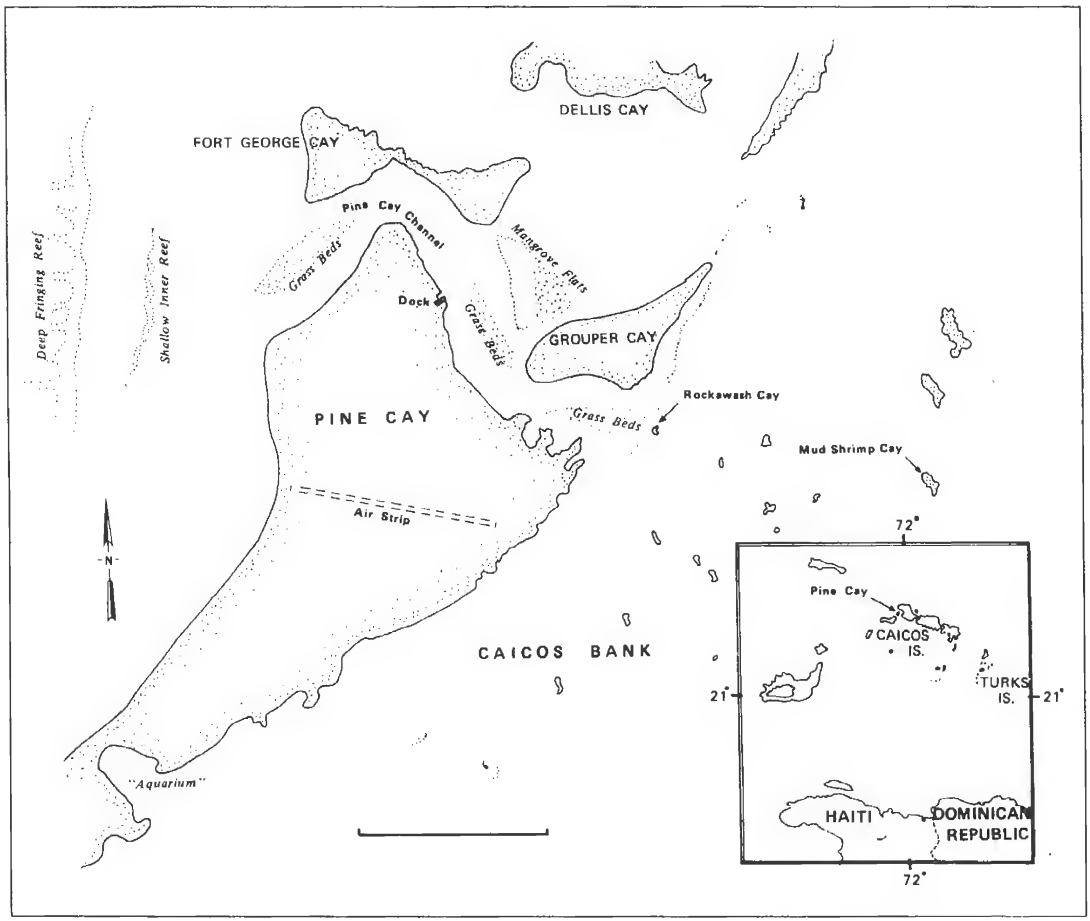

Figure 1. Map showing locations of collecting sites in the vicinity of Pine Cay, Turks and Caicos Islands, British West Indies. Scale = 1 km.

tions and descriptions were published by Alvariño (1969), Michel (1984), and McLelland (1989). The following list presents synonyms and ecological notes for the seven planktonic species:

Ferosagitta hispida (Conant, 1895)
Sagitta hispida, Conant 1895
Sagitta gloriae, Almeida-Prado 1960
Parasagitta hispida, Tokioka 1965
Ferosagitta hispida, Kassatkina 1971

Ecology and distribution: This species is common in neritic, tropical and subtropical waters near continents and islands of the Atlantic ocean (Boltovskoy 1981; Michel 1984). It was very abundant in the nearshore waters around Pine Cay, especially over the grass beds in the channel (Ockelmann dredge collections), but absent in surface net collections made over the fringing reef in April 1988. A near-bottom distribution was also noted for the species by Owre (1972) from Bahamian collections and supports the idea of Robert Bieri (pers. comm. 1989) that *F. hispida* might be considered "quasi-planktonic;" that is, spending some of its time attached or associated with substrata such as blades of the sea grass *Thalassia*.

Flaccisagitta enflata (Grassi, 1881)
Sagitta Enflata (sic), Grassi 1881
Sagitta flaccida, Conant 1896

TABLE 1

Benthic and epibenthic collection data from various sites around Pine Cay.

collection	location	date	time	approx. depth (m)	substrate	method	Total Specimen
A	Mud Shrimp Cay	4/8/88	—	1	*Neogoniolithon*	formalin wash	12
B	Rock-a-wash Cay	10/30/88	--	1	gray sponge	formalin wash	7
C	Pine Cay dock	11/2/88	2000	2	silt	dredge	2
D	NE grass beds	11/2/88	--	2	Thalassia	dredge	111
E	North beach	11/9/88	--	3	sand	dredge	33
F	NE grass beds	11/10/88	--	2	Thalassia	dredge	32
G	Fringing reef	11/4/88	--	35	sand	hand net	1
H	Fringing reef	11/5/88	--	4	rubble	yabby pump	10
I	Ft. George Cay	11/8/88	--	1	Neogoniolithon	formalin wash	5
J	Ft. George Cay	11/8/88	--	1	soft algae	formalin wash	25
K	NE grass beds	4/7/89	1830	2	Thalassia	dredge	5
L	Fringing reef	4/9/89	--	4.5	rubble	yabby pump	15
M	Ft. George Cay	4/10/89	1700	1	Neogoniolithon	formalin wash	1
N	NE grass beds	4/11/89	1400	3	Thalassia	dredge	2
O	Fringing reef	4/12/89	1100	10	sand	yabby pump	3
P	Aquarium	4/12/89	2200	0.5	silt	light trap	5
Q	North beach	4/12/89	2215	0.5	sand	dredge	1
R	Rock-a-wash Cay	4/13/89	1400	1	Neogoniolithon	formalin wash	27
S	Rock-a-wash Cay	4/13/89	1400	1	sponge	formalin wash	48
T	NE beach	4/14/89	--	10	grass-algae	dredge	5
U	North beach	4/14/89	1800	4	sand	dredge	11
V	North beach	4/14/89	--	15	sand-grass	dredge	50
W	Fringing reef	4/16/89	0900	4	rubble	yabby pump	67

Sagitta gardineri, Doncaster 1903
Sagitta brachycephala, Moltschanoff 1907
Sagitta inflata, Ritter-Záhony 1908
Sagitta australis, Johnston 1909
Flaccisagitta enflata, Tokioka 1965

Ecology and distribution: Flaccisagitta enflata, a very common species in oceanic and coastal waters, is epiplanktonic in tropical and temperate regions throughout the world (Alvariño 1965; Boltovskoy 1981). It was the most abundant chaetognath in surface tow collections from Pine Cay made in April 1988.

Flaccisagitta hexaptera (d'Orbigny, 1843)
Sagitta hexaptera d'Orbigny, 1843
Sagitta magna, Langerhans 1880
Sagitta longidentata, Grassi 1881
Sagitta hexaptera f. *magna*, Germain and Joubin 1916
Flaccisagitta hexaptera, Tokioka 1965

Ecology and distribution: Flaccisagitta hexaptera, an oceanic, epiplanktonic species in tropical and temperate regions (Alvariño 1965), occurs in the deeper epipelagic to upper mesopelagic zones (100-500 m) in warm seas (Owre 1960; David 1963). The single specimen collected was not expected in our samples, because the species is seldom found in shallow coastal waters.

Krohnitta pacifica (Aida, 1897)
Krohnia pacifica, Aida 1897
Krohnitta subtilis (partim), Ritter-Záhony 1910
Krohnia kerberti, Oye 1918
Eukrohnia pacifica, Michael 1911
Krohnitta mutabbii, Alvariño 1969
Krohnitta pacifica, Tokioka 1939

Ecology and Distribution: Krohnitta pacifica, a semineritic, epiplanktonic species, is known from tropical and subtropical seas (Furnestin 1966; Boltovskoy 1981). It is common along oceanic-coastal water fronts (Pierce and Wass 1962; Almeida-Prado 1968; McLelland, 1984).

Pterosagitta draco (Krohn, 1853) Ritter-Záhony, 1911
Sagitta draco, Krohn 1853
Pterosagitta mediterranea, Costa 1869
Spadella draco, Langerhans 1880
Pterosagitta besnardi, Vannucci and Hosoé 1952

TABLE 2

Chaetognaths present in surface plankton tows made in the vicinity of the fringing reef north of Pine Cay.

species	maturity stage	4/7/88 0800-0825	4/18/88 0808-0911
Flaccisagitta enflata	I	4	124
	II	-	4
	III	-	1
F. hexaptera	I	-	1
Krohnitta pacifica	I	-	5
	II	-	11
	III	-	5
Pterosagitta draco	I	2	26
	II	-	1
Sagitta bipunctata	II	-	1
Serratosagitta serratodentata	I	13	16
	II	5	8
	III	3	3

Ecology and distribution: Pterosagitta draco is an oceanic species, epiplanktonic to upper mesoplanktonic in tropical and subtropical areas (Owre 1960; Alvariño 1965), and has been found associated with mixed water along continental shelf regions (Pierce 1962; Pierce and Wass 1962; Saint-Bon 1963; McLelland 1984).

Sagitta bipunctata Quoy and Gaimard, 1827
Sagitta californica, Michael 1913
Sagitta atlantica, Gray 1922
Sagitta hispida (non Conant), Burfield and Harvey, 1926
Sagitta multidentata, Hsü 1943

Ecology and distribution: This oceanic species is epiplanktonic to upper mesoplanktonic in temperate to tropical waters (Owre 1960; Alvariño 1965; Legaré and Zoppi 1961), where it is considered an indicator of high-salinity, oceanic water (Pierce 1953; Grant 1963).

Serratosagitta serratodentata (Krohn, 1853)
Sagitta serrato-dentata, Krohn 1853
Sagitta serratodentata, Langerhans 1880
Spadella serratodentata, Grassi 1883
Sagitta serratodentata serratodentata, Pierrot-Bults 1974
Serratosagitta serratodentata, Tokioka 1965

Ecology and distribution: An epiplanktonic, oceanic form, the subspecies described by Pierrot-Bults is widespread in tropical and sub-tropical Atlantic waters. It was collected near the surface at three stations in the Bahamas by Owre (1972). As is the case for the other planktonic species reported here, the presence of *S. serratodentata* in coastal waters indicates the influence of offshore currents.

Epibenthic species (Figure 2, Table 3)

Most specimens of *Paraspadella nana* and *P. schizoptera*, of the family Spadellidae (Tokioka 1965), were taken from shallow water (1-1.5 m) algal-sponge-coral washings at Fort George Cay across the channel from Pine Cay, and at Rockawash and Mud Shrimp Cays, two islets on the shallow Caicos Banks east of Pine Cay (Fig. 1). Additional specimens of *P. schizoptera* were collected with the yabby pump from sediment samples at the shallow fringing reef northwest of Pine Cay. One specimen of *Spadella cephaloptera* was taken from a bag of sand collected by Cherie Heard (4 Nov. 1988) from 110-120 ft (35 m) on a silt-sand bottom near the seaward edge of the fringing reef northwest of Pine Cay.

The specimens of *P. nana* greater than 1.80 mm were all mature or nearly so (Table 4). Meristic characters fell within ranges published by Owre (1963, 1972) for Caribbean specimens. The species (Fig. 2f-i) is easily identified by its small size, two wide lateral adhesive processes emerging anterior to the seminal vesicles, and large ova that bend the gut into an "S" shape. Two mature specimens had the peculiar hernia midway between the seminal vesicles and tip of the tail noted by Owre (1963). Specimens of *P. schizoptera* (Fig 2a-e), 1.41-4.00 mm, were identified mainly by the presence of four thin, elongate digitate adhesive processes. Also notable are the elongate anterior teeth that protrude prominently outward when the hooks are extended (Fig. 2d). Paired lateral fins, described by Conant (1895) and Michel (1984) from animals of up to 4.6 mm, were not observed on any Pine Cay specimens. The two "pairs" of lateral fins described by some authors are not apparent during early growth as seen in Feigenbaum's (1976) developmental study of the species. The lateral fin should be considered as a single structure constricted into anterior and posterior lobes by the protruding genital receptacular apparatus ("funnels"), which becomes prominent as the animal approaches maturity (H.B. Michel, pers. comm. 1989). For this reason we chose to adopt Bowman and Bieri's (1989) revision of Spadellidae systematics which divided the family into two genera based on the presence or absence of adhesive organs (*Paraspadella* and *Spadella*, respectively), and discounted the presence of true paired lateral fins. By definition, the species *nana*, *pulchella*, *hummelinki*, *schizoptera*, and *anops*, all possessing adhesive organs, now belong to the genus *Par-*

Table 3

Chaetognaths present in benthic and epibenthic collections made near Pine Cay (Table 1). Numbers and maturity stages.

Species	Mat Stage	COLLECTIONS A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	
Spadella cephaloptera	II	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paraspadella nana	I	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	2	-	-	-
	II	-	1	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	2	4	-	-	-
	III	5	5	-	-	-	-	-	-	-	6	-	-	-	2	-	-	-	1	5	-	-	-
	IV	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	7	-	-	-
Paraspadella schizoptera	I	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	3	-	-	-	-
	II	1	1	-	-	-	-	-	1	2	2	-	3	-	-	1	-	-	5	5	-	-	-
	III	2	-	-	-	-	-	-	-	2	2	-	3	-	-	2	-	-	-	7	-	-	-
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
Ferosagitta hispida	I	-	-	-	20	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
	II	-	-	-	84	21	32	-	-	-	-	5	-	-	-	-	2	-	-	-	4	8	32
	III	-	-	-	7	11	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	3	8
	IV	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Flaccisagitta enflata	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-

aspadella. Bowman and Bieri's revision rectified an earlier proposal by Salvini-Plawen (1986), which based the systematics partly on the numbers of lateral fin pairs.

Paraspadella nana and *P. schizoptera* are both common in shallow waters of the Bahamas and southeastern Florida (Owre 1972; Michel 1984). *Paraspadella schizoptera* has also been reported from Japan (Yosii and Tokioka 1939), 70-100 m. off New South Wales, Australia (Mawson 1944), and Soldier Key, Florida (Owre 1963). The Japanese record has been designated as a new species, *P. caecafera*, by Salvini-Plawen (1986) based on its lack of anterior fins and presence of intestinal diverticula. Two other species of the genus not found in this study, *P. pulchella* (Owre, 1963), and *P. hummelincki* (Alvariño, 1970), have been reported from the Bahamas and surrounding waters, although the latter is probably a synonym of the former (Owre 1973), and therefore, likely occur in the Turks and Caicos Islands. The three epibenthic species are listed with synonyms and ecological notes:

Spadella cephaloptera (Busch, 1851)
Sagitta cephaloptera, Busch 1851
Spadella cephaloptera, Ritter-Záhony 1911

Ecology and distribution: This species has a cosmopolitan distribution in temperate and tropical seas and is abundant in shallow waters of the Bahamian islands and in southern Florida (Owre 1972; Michel 1984). Owre (1972) reported it to be associated with a variety of substrata including sand bottoms and Thalassia sea grass in waters ranging in depth from 0.5 to 15 m. Surprisingly, only a single specimen was collected during this study, one from a sand bottom at 35 m.

Paraspadella nana (Owre, 1963)
Spadella nana, Owre 1963
Gephyrospadella nana, Salvini-Plawen 1986

Ecology and distribution: This species was described from specimens associated with mixed algae and turtle grass (*Thalassia testudinum*) at 5-8 feet off Soldier Key, Florida (Owre 1963). Owre (1972) indicated that it might be associated with plant growth on sandy bottoms in the Bahamas, where it was found at 19 of 36 stations in depths of 1 to 10 meters. In our study, it was consistently found associated with the coralline alga, *Neogoniolithon* sp., and with sponge-algal communities in shallow water.

Table 4

Meristic values of some chaetognaths from Pine Cay, Turks and Caicos Islands.

SPECIES	Total Length mm	% Tail	Hooks	Ant. Teeth	Post. Teeth	Mat. Stage	No. Specimens
Ferosagitta hispida							
	6.80	27.6	8	6	10	II	1
	7.60	26.7	7	5	10	III	1
	7.70	25.8	8	-	-	III	1
	8.50	27.2	8	7	14	IV	1
	8.60	27.9	7	7	12	IV	1
	8.70	25.4-26.9	7-8	5-7	11	III	2
	8.90	26.3	8	6	10	III	1
	9.30	26.3-27.9	7.8	6	12	IV	2
Spadella cephaloptera							
	2.40	48.6	10	4	-	II	1
Paraspadella nana							
	1.20	50.9	7	1	-	I	1
	1.36	48.4	8	2	-	II	1
	1.50	48.5-51.5	8	2	-	I-II	2
	1.60	47.3	8	2	-	II	1
	1.70	48.1-50.5	8	2-3	-	II	2
	1.74	51.9	8	3	-	I	1
	1.80	48.8-50.0	7-8	2-3	-	II-III	3
	1.85	48.8	8	2	-	II	1
	1.87	49.4	8	2	-	III	1
	1.89	50.0	8	3	-	III	1
	1.90	52.9	8	2	-	II	1
	1.91	48.3-49.4	8-9	2	-	III	2
	1.94	46.6-50.0	8	2	-	III	2
	1.96	47.2-49.0	7	2	-	III	2
	2.00	48.4-53.8	8	2-3	-	III-IV	7
	2.08	48.9-50.0	7-9	2-3	-	III	2
	2.10	46.9-52.1	8-9	2-3	-	III-IV	5
	2.13	46.4-49.5	8	2-4	-	III	2
	2.16	49.1	8	3	-	III	1
	2.20	48.0-51.0	8	3	-	III-IV	4
	2.26	48.7	7	2	-	III	1
	2.30	44.3	7	1	-	III	1
	2.32	47.4-49.1	7-8	2	-	IV	3
	2.42	47.1	8	2	-	IV	1
	3.20	50.0	10	4	-	III	1
	3.50	49.0	9	5	-	III	1
Paraspadella schizoptera							
	1.41	48.4	8	3	-	I	1
	1.50	49.3	7	2	-	I	1
	1.56	45.1	8	1	-	I	1
	1.60	47.9	8	3	-	I	1
	1.70	46.1	-	-	-	I	1
	1.80	50.0	8	2	-	II	1
	1.90	52.3	8	2	-	II	1
	2.00	48.9	8	2	-	II	1
	2.02	48.9	8	3	-	II	1
	2.10	48.5	9	2	-	II	1
	2.30	48.5-50.9	8-10	2-3	-	II	5
	2.40	42.2	8	3	-	II	1
	2.46	48.2	8	3	-	II	1

Table 4 (Continued)

SPECIES	Total Length mm	% Tail	Hooks	Ant. Teeth	Post. Teeth	Mat. Stage	No. Specimens
	2.49	48.7	9	3	-	III	1
	2.50	48.7	9	3	-	II	1
	2.60	49.2-50.4	8	2-3	-	II-III	2
	2.68	47.8	9	3	-	II	2
	2.77	45.2	8	3	-	III	1
	2.86	47.7	9	3	-	II	1
	2.88	49.6	9	1	-	II	1
	2.90	45.8-48.5	9-10	2-3	-	II-III	2
	2.92	45.2	9	3	-	III	1
	2.95	46.3	8	4	-	III	2
	3.10	45.0-43.4	9	3	-	III	2
	3.20	48.3	9	2	-	II	1
	3.30	46.7-49.0	9-10	3-4	-	II-III	2
	3.40	49.0	9	2	-	III	1
	3.44	50.0	8	3	-	III	1
	3.50	40.1-49.4	9-10	3	-	III-IV	2
	3.60	47.9-50.3	9-10	3	-	III	2
	3.70	47.6-47.8	9-10	3	-	III	2
	4.00	47.3	9	4	-	IV	1

Paraspadella schizoptera (Conant, 1895)
Spadella schizoptera, Conant 1895
Paraspadella schizoptera, Salvini-Plawen 1986
Paraspadella schizoptera, Bowman and Bieri 1989

Ecology and distribution: Originally, *P. schizoptera* was described from three specimens collected with a plankton net "at rising tide" from Bimini in the Bahamas (Conant 1895). It has since been found associated with mixed algae off Soldier Key, Florida (Owre 1963), and sandy bottoms from 0.5 to 10 meters in the Bahamas and Biscayne Bay, Florida (Owre 1972). It was present in nine collections from Pine Cay in waters of 1 to 10 m and associated with coralline algae, sponges, and rubble bottoms.

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REFERENCES CITED

Aida, T. 1897. Chaetognaths of Misaki Harbor. *Annot. Zool. Jpn.* 1:13-21.

Almeida-Prado, M.S. de. 1960. A new species of *Sagitta* from the southern Brazilian coast. *Acad. Bras. de Cienc.* 32(2):275-280.

_____. 1968. Distribution and occurrence of Chaetognatha off Cananeia and Santos Coast. *Bol. Inst. Oceanogr., Sao Paulo* 17(1):33-55.

Alvariño, A. 1965. Chaetognaths. *Ann. Rev. Oceanogr. Mar. Biol.* 3:115-194.

_____. 1969. Los quetognatos del Atlántico. Distribucion y notas esenciales de sistemática. *Trab. Inst. esp. Oceanogr.* 37. 290 pp.

_____. 1970. A new species of *Spadella* (benthic Chaetognatha). Stud. Fauna Curaçao and Other Caribb. Isls. 125(34):73-89.

Boltovskoy, D. 1981. Chaetognatha. In: Atlas del zooplankton del Atlántico Suboccidental. D. Boltovskoy, Ed., *Publ. Inst. Nac. Invest. y Des. Pesc.* (INIDEP), Argentina. pp. 759-791.

Bowman, T.E., and R. Bieri. 1989. *Paraspadella anops*, new species, from Sagittarius Cave Grand Bahama Island, the second troglobitic chaetognath. *Proc. Biol. Soc. Wash.* 102(3):586-589.

Burfield, S.T., and J.W. Harvey. 1926. The Chaetognatha of the Sealark expedition. *Trans. Linn. Soc. Lond.* Ser. 2 (Zool.) 19(1):93-119.

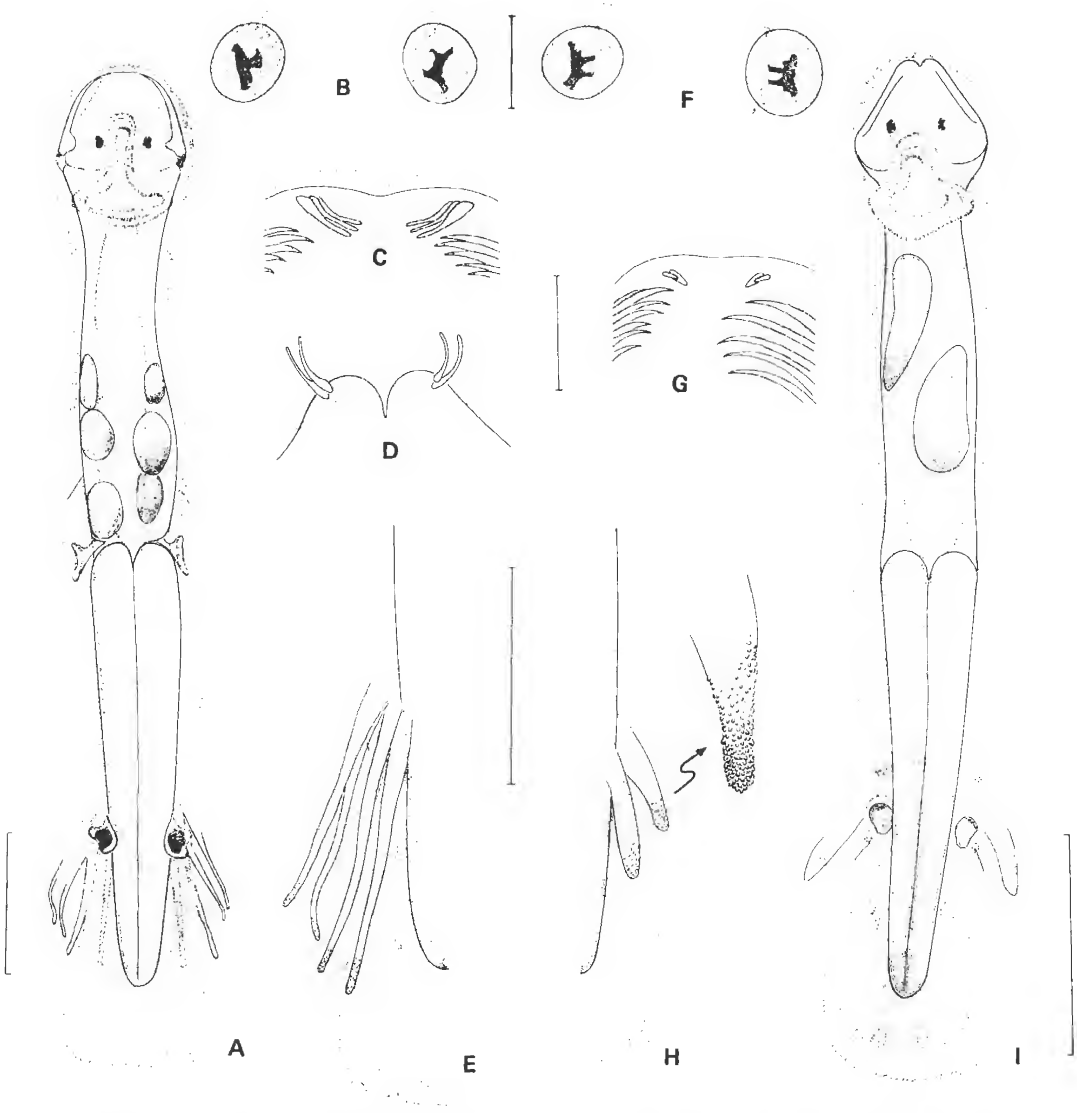

Figure 2. A-E, *Paraspadella schizoptera*. F-I, *Paraspadella nana*. A, I, whole animal, dorsal view; B,F, left and right eyes; C,G, anterior teeth with hooks retracted, ventral view; D, protruding anterior teeth when hooks are extended, ventral view; E,H, detail of adhesive processes, ventral view. Scales: A,E,H,I = 0.5 mm; B-D,F,G = 0.1 mm.

Busch, W. 1851. Beobachtungen über Anatomie und Entwicklung einiger wirbellosen Seethiere. Chaetognatha. Berlin, 4:93-100.

Colman, J.S. 1959. The "Rosaura" expedition 1937-38. Chaetognatha. *Bull. Br. Mus. (Nat. Hist.) Zool.* 5(8):219-253.

Conant, F.S. 1895. Description of two new chaetognaths (*Spadella schizoptera* and *Sagitta hispida*). *Ann. Mag. Nat. Hist.*, Ser.6, 16:288-292.

Costa, A. 1869. Di un nuovo genere di Chetognati. *Ann. Mus. Zool. Reale Univ. Napoli.* 5:54.

David, P.M. 1963. Some aspects of speciation in the Chaetognatha. In: Speciation in the Sea (symp.). J.P. Harding & N. Tebble, Eds., *Publs. Syst. Assoc.* 5:129-143.

Doncaster, L. 1903. Chaetognatha, with a note on the variation and distribution of the group. *Fauna Geogr.* Maldive-Laccadive Archip. 1:209-218.

d'Orbigny, A. 1843. Voyage dans l'Amerique meridionale, Mollusques, Paris, 5(10):140-144.

Feigenbaum, D.L. 1976. Development of the adhesive organ in *Spadella schizoptera* (Chaetognatha) with comments on growth and pigmentation. *Bull. Mar. Sci.* 26(4):600-603.

Furnestin, M.L. 1966. Chaetognathes des eaux Africaines. *Atl. Rep. Sci. Résult Dan. Exp. Coast Trop. West Afr.* 9:105-135.

Germain, I. & L. Joubin. 1916. Chétognathes provenant des campagnes des yachts *Hirondelle* et *Princesse-Alice* (1885-1910). *Résult. Camp. Sci. Monaco* 49:1-118.

Grant, G.C. 1963. Investigations of inner continental shelf waters off lower Chesapeake Bay. Part IV. Descriptions of the Chaetognatha and a key to their identification. *Chesapeake Sci.* 4(3):107-119.

Grassi, B. 1881. Intorno in chetognati. *Reale Inst. Lombardo Sci. Let. Rend.*, Ser. 2, 14(6):193-213.

_____. 1883. I Chetognati. Fauna Flora Golf. Neapel, 5:1-126.

Gray, B.B. 1922. Notes on species of 7 collected during a voyage from England to Australia. *Proc. R. Soc. Queensl.* 34:171-180.

Hsu, F. 1943. Species of *Sagitta* from China. *Sinensia*, Shanghai 14(1-6):129-139.

Johnston, T.H. 1909. An Australian chaetognath. *Rec. Aust. Mus.* 7:251-256.

Kassatkina, A.P. 1971. New neritic species of chaetognaths from the Possjet Bay of the Sea of Japan. *Issled. Fauny Morei* 8:265-294.

Krohn, A. 1853. Nachtragliche Bemerkungen über den Bau der Gattung *Sagitta* nebst der Beschreibung einer neuen Arten. *Arch. Naturgesch.* 19(1):1-286.

Langerhans, P. 1880. Die Wurmfauna von Madeira. *Aeitschr. Wiss. Zol.* 34:132-136.

Legaré, J.E.H., & E. Zoppi 1961. Notas sobre la abundancia y distribution de Chaetognatha in las aguas del oriente de Venezuela. *Bol. Inst. Oceanogr.* 1(1):1-25.

Mawson, P.M. 1944. Some species of Chaetognath genus *Spadella* from New South Wales. *Trans R. Soc. S. Aust.* 68(2):327-333.

McLelland, J.A. 1984. Observations on chaetognath distributions in the northeastern Gulf of Mexico during the summer of 1974. *Northeast Gulf Sci.* 7(1):49-59.

_____. 1989. An illustrated key to the Chaetognatha of the northern Gulf of Mexico with notes on their distribution. *Gulf Res. Rept.* 8(2):145-172.

Michael, E.L. 1911. Classification and vertical distribution of the Chaetognatha of the San Diego Region. *Univ. Calif. Publ. Zool.* 8(3):21-186.

_____. 1913. *S. californica*, sp. n. from the San Diego region. *Univ. Calif. Publ. Zool.* 11(5):p.125.

Michel, H.B. 1984. Chaetognatha of the Caribbean Sea and adjacent areas. *NOAA Tech. Rep. NMFS* 15, U.S. Dept of Commerce. 33 pp.

_____. M. Foyo, & D.A. Haagensen. 1976. Caribbean zooplankton. Part I - Siphonophora, Heteropoda, Copepoda, Euphausiacea, Chaetognatha, and Salpidae. publ. by Office of Nav. Res., Dept. of Navy, U.S. Govt. printing office, Washington, D.C. 549 pp.

Moltschanoff, L.A. 1907. Die Chaetognathen des Zoologischen Museums der Kaiser Academie der Wissenshaften in St. Petersburg. *Ann. Mus. Zool. Acad. Sci. St. Petersburg.* 12:203-212.

Owre, H.B. 1960. Plankton of the Florida Current. Part VI. The Chaetognatha. *Bull. Mar. Sci.* 10(3):255-322.

_____. 1963. The genus *Spadella* (Chaetognatha) in the western North Atlantic Ocean, with descriptions of two new species. *Bull. Mar. Sci. Gulf Caribb.* 13(3):378-390.

_____. 1972. The genus *Spadella* and other Chaetognatha. *Sarsia* 49:49-58.

_____. 1973. A new chaetognath genus and species, with remarks on the taxonomy and distribution of others. *Bull. Mar. Sci.* 23(4):948-963.

Oye, P. 1918. Untersuchungen über die Chaetognathen des Javameeres. *Contr. Faune Indes Néerl.* 4:1-61.

Pierce, E.L. 1953. The Chaetognatha over the continental shelf of North Carolina with attention to their relation to the hydrography of the area. *J. Mar. Res.* 12(1):75-92.

_____. 1962. Chaetognatha from the Texas coast. *Publ. Inst. Mar. Sci., Univ. Tex.* 8:147-152.

_____. & M.L. Wass. 1962. Chaetognatha from the Florida Current and coastal water of the southeastern Atlantic states. *Bull. Mar. Sci.* 12(3):403-436.

Pierrot-Bults, A.C. 1974. Taxonomy and zoogeography of certain members of the "*Sagitta serratodentata*-group" (Chaetognatha). *Bijdr. Dierkd.* 44(2):215-234.

Quoy, J., & P. Gaimard. 1827. Observations zoologiques faites a bord de l'Astrolabe in Mai 1826 dans le detroit de Gibraltar. *Ann. Sci. Nat. (Zool.)* 10:230-232.

Ritter-Záhony, R. Von. 1908. Chaetognathen. *In:* Zoologische ergebnisse der expedition S.M.S. Pola in das Östliche Mittelmeer 1890-1894. Denk. Akad. wiss. Wien., Bd. 84., S. 789.

_____. 1910. Westindische Chätognathen. *Zool. Jahrb. Abt. Allg. Zool. Physiol. Tierre*, Suppl. 11:133-143.

_____. 1911. Revision der Chätognathen. Dtsch. Sudp. Exped. 13:1-71.

Saint-Bon, M.C. de. 1963. Les Chaetognathes de la Cote d'Ivoire (especes de surface). *Rev. Trav. Inst. (Scient. Tech.) Pêch. Marit.* 27(3):301-346.

Salvini-Plawen, L. v. 1986. Systematic notes on *Spadella* and on the Chaetognatha in general. *Z. Zool. Syst. Evolutionforsch.* 24:122-128.

Suárez-Caabro, J.A. 1955. Quetognatos de los Mares Cubanos. *Mem. Soc. Cub. Hist. Nat.* 22(2):125-180.

Tokioka, T. 1939. Chaetognatha collected chiefly from the bays of Sagami and Suruga, with some notes on the shape and structure of the seminal vesicles. *Rec. Oceanogr. Works Jpn.* 10(2):123-150.

_____. 1965. The taxonomic outline of Chaetognatha. *Publ. Seto Mar. Biol. Lab.* 12(5):335-357.

Vannucci, M., & K. Hosoé. 1952. Resultados cientificos do cruzeiro de "Baepandi" e do "Vega" a Ilha da Trinidade. Chaetognatha. *Bol. Inst. Oceanogr.* Sao Paulo 3(1-)9:5-30.

Yosii, N., & T. Tokioka. 1939. Notes on Japanese *Spadella* (Chaetognatha). *Annot. Jpn.* 18(4):267-273.

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STUDIES ON THE CRUSTACEA OF THE TURKS AND CAICOS ISLANDS, BRITISH WEST INDIES I. FOUR NEW MARINE ISOPOD CRUSTACEANS FROM THE VICINITY OF PINE CAY.

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ABSTRACT Four undescribed species of shallow-water marine isopods were recently collected in the vicinity of Pine Cay in the western Caicos Islands. These are described and include the anthurid *Licranthura tuberculata*, possessing a tuberculate third article of the antenna and a rounded distolateral angle of the uropodal exopod; the anthurid *Mesanthura spongicola*, which has a distinctive color pattern, distinctly attenuated body, and 5-7 spines on the third article of the mandibular palp; the paranthurid *Califanthura minuta*, a tiny (1.6 mm) species having a reduced, triangular uropodal exopod; and the stenetriid asellote *Stenetrium caicosensis*, which has a pronounced lobe on the merus of pereopod 1 in the male.

Introduction

The fauna of the Turks and Caicos Islands, British West Indies, is poorly documented, especially for many marine invertebrate groups including the Isopoda. During the course of participating in the Turks and Caicos Coral Reef Ecology Program sponsored by the Oakleigh L. Thorne Foundation, the second author collected isopods from a variety of shallow-water marine habitats, mainly around Pine Cay and Fort George Cay. Fine mesh kicknets, yabby pumps, an Ockelmann dredge, and light traps were all used in this collection, with SCUBA at the deeper stations. Four undescribed marine species found during the survey and their descriptions are the subject of this report. While the marine isopods of the general Caribbean and Bahamian region have been broadly dealt with in Kensley and Schotte (1989), this is the first of a series of reports (see Schotte and Heard 1991, Schotte *et al* 1991) dealing with isopods specifically from the Turks and Caicos Islands.

Results

Family Anthuridae
Licranthura tuberculata, new species
Figs. 1-3

Material. HOLOTYPE, USNM 243474, female tl 3.2 mm, PARATYPE, USNM 243475, male tl 3.2 mm, from yellow sponge, 37-40 m, 10 Nov 1988.

Description. Female: Body slender, about 12 times longer than wide. Faint red-brown pigmentation dorsally on pereonites 2-6. Body proportions: C < 1 > 2 = 3 < 4 with 5 or 6 distal plumose setae. Uropodal endopod = 5 > 6 > 7 < P. Pleonites short, free, 1-5 of similar length, pleonite 6 dorsally demarked. Telson widening to posteriorly rounded serrate/crenulate margin.

Cephalon with well pigmented eyes. Antennular peduncle with basal article widest; flagellum of 3 articles, first very short, terminal article bearing 2 aesthetascs. Antennal peduncle with article 3 having 4 teeth on mesial margin, dorsal surface with several small tubercles plus stronger distal tooth; article 4 offset at right angle on article 3, short, about two-thirds length of article 5; flagellum of 8 setose articles. Mandibular palp of 3 articles, articles 1 and 3 subequal, each about half length of article 2; article 3 bearing 3 distal spines; incisor of 3 blunt cusps; lamina dentata having 5 serrations; molar absent. Maxilla having 5 distal spines. Maxilliped with endite short, blunt; palp of 5 articles, article 1 very short, articles 2-4 subequal, about as long as wide, article 5 very small.

Pereopod 1 more robust than pereopods 2 and 3, articles squat; carpus triangular, lacking free anterior margin; propodus roughly rectangular, posterior margin straight, bearing few simple setae, 2 fringed setae anterodistally; dactylus having several blunt corneous tubercles on posterior surface, unguis short, squat, with bifid accessory spine at base. Pereopods 2 and 3 similar, carpus with anterior margin barely free; propodus with strong toothed posterodistal spine; unguis almost three-fourths length of rest of dactylus. Pereopods 5-7, carpus with free anterior margin shorter than posterior margin, with toothed posterodistal spine; propodus with toothed posterodistal spine; unguis about two-thirds length of rest of dactylus. Pleopods similar, pleopod 1 slightly larger than following, both rami having opercular function, endopod longer and narrower than exopod, each roughly ovate, with margin serrate to crenulate; exopod

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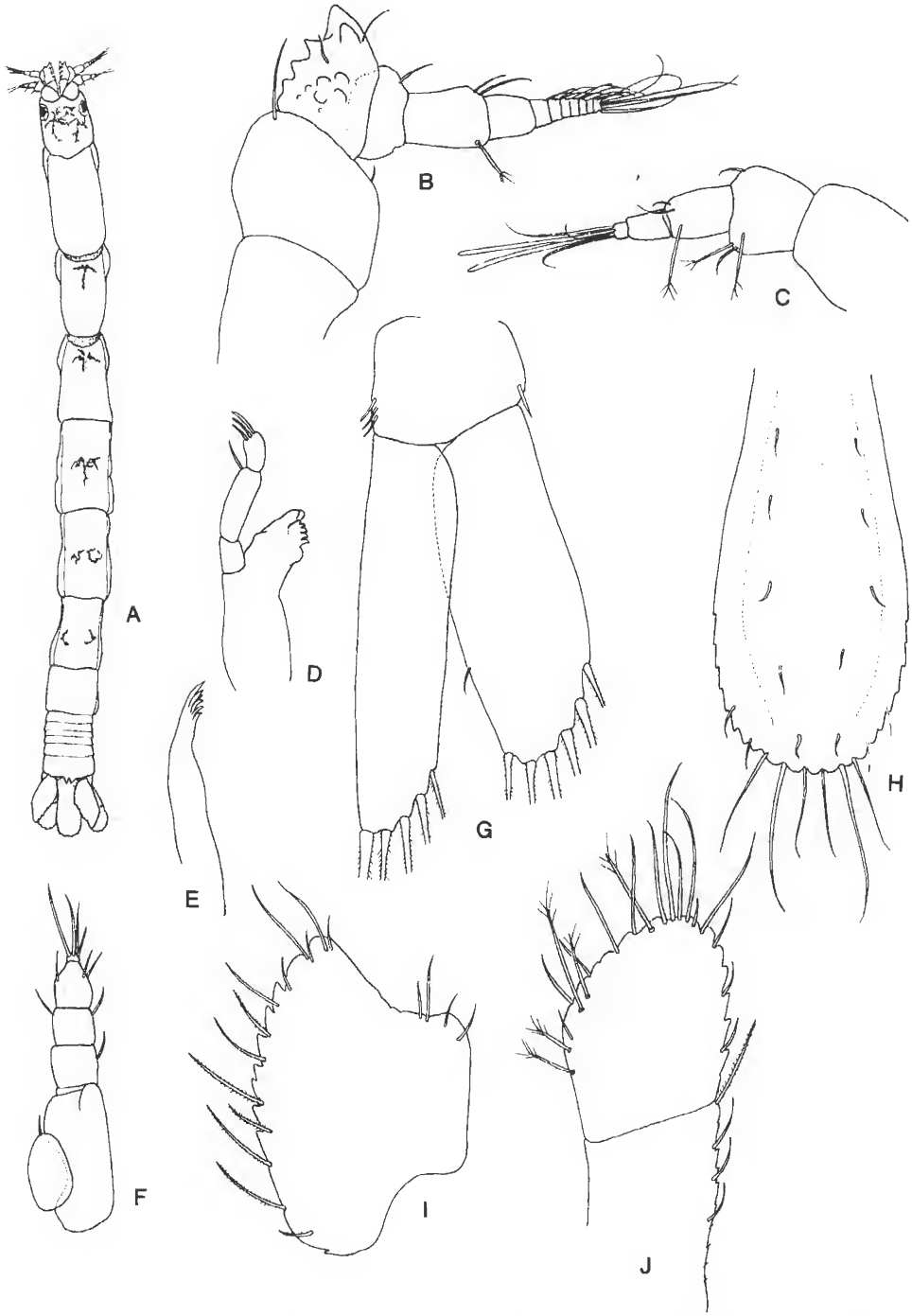

Fig. 1. ***Licranthura tuberculata*, new species, female: A, dorsal view; B, antenna; C, antennule; D, mandible; E, maxilla; F, Maxilliped; G, pleopod 1; H, telson; I, uropodal exopod; J, uropodal endopod and protopod.**

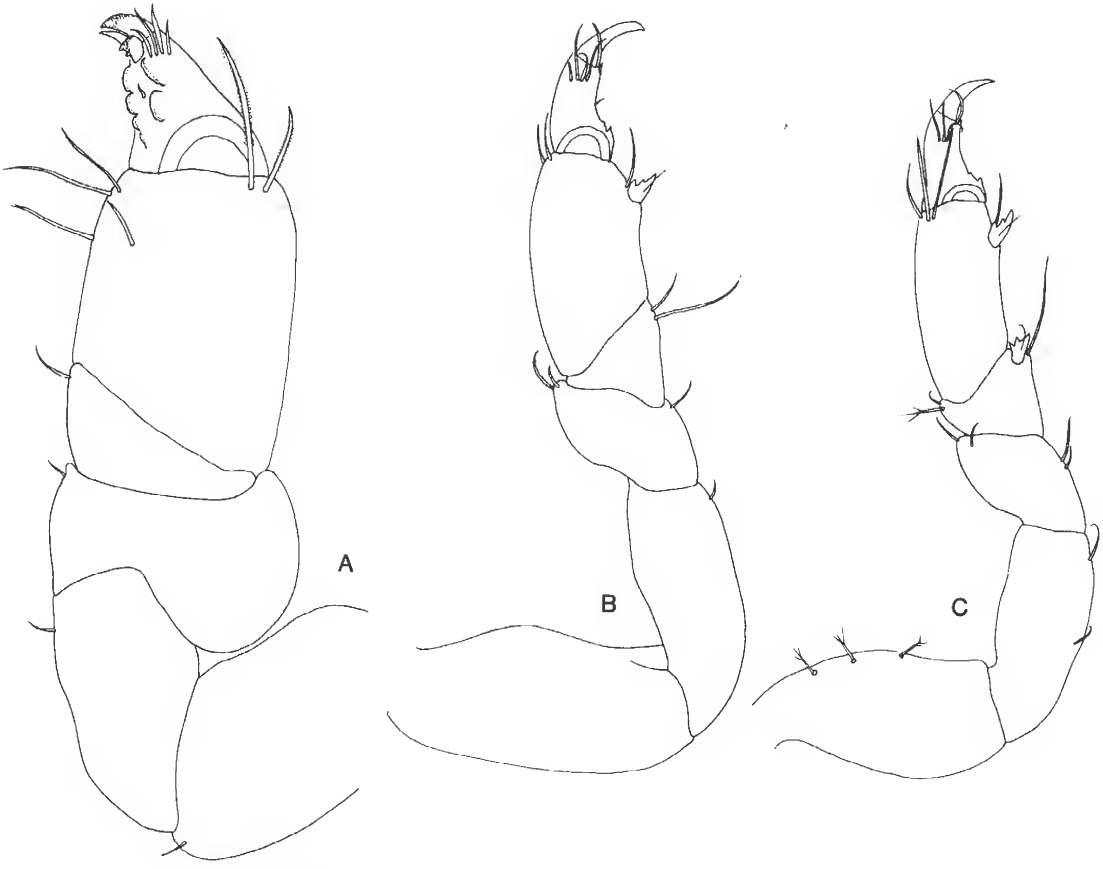

Fig. 2. ***Licranthura tuberculata*, new species, female: A, pereopod 1; B, pereopod 2; C, pereopod 7.**

laterally broadened, distally emarginate, with lateral lobe bluntly triangular, lateral margin serrate and setose.

Male: Body similar to female; eyes enormously enlarged, dorsally almost contiguous. Antennular flagellum of about 9 aesthetascs-bearing articles. Antennal peduncle article 3 having 4 distal acute tubercles, article 4 offset at right-angle on article 3; flagellum of 7 setose articles. Pereopod 1, propodal width slightly more than twice anterior length, with few simple and fringed setae posterodistally; dactylus with low blunt tubercles on posterior surface, unguis about half length of rest of dactylus, with short squat accessory spine. Pleopod 2, exopod of 2 articles, proximal about half length of distal article; endopod with copulatory stylet articulating in proximal half of mesial margin, reaching slightly beyond apex of ramus.

Remarks. The present species differs from *L. amyle* Kensley and Schotte, 1987, from Belize, the type and only other species in the genus, in having fewer teeth on the mesial margin of the third antennal peduncle article, a posteriorly more rounded telson, and a blunt (as opposed to an acute) distolateral lobe on the uropodal exopod.

Etymology. The specific epithet refers to the tuberculate nature of the third antennal peduncle article.

Mesanthura spongicola, new species
Fig. 4

Material. HOLOTYPE, USNM 243479, non-ovig. female total length (tl) 6.5 mm, PARATYPE, USNM 243480, 14 non-ovig. females tl 5.3 - 6.5 mm, GCRL 1149, 3 non-ovig. female 5.3-6.5 mm, in yellow tube sponge (*Verongia* sp.) on fringing reef, off Pine Cay, 25 - 28 m, 11 Nov 1989. PARATYPES, USNM 243481, 2 non-ovig. females tl 4.3 & 4.8 mm, in sponge on outer

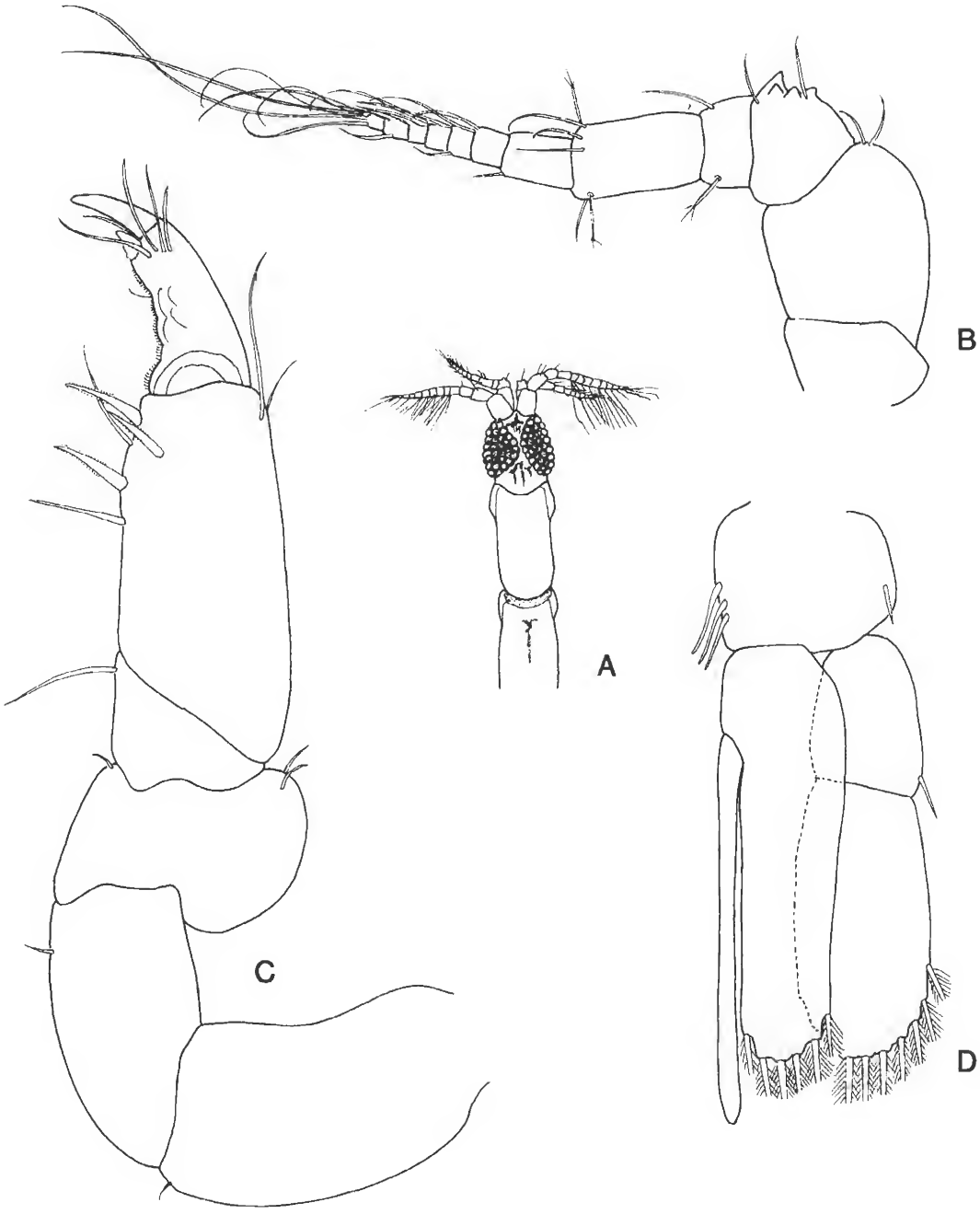

Fig. 3. ***Licranthura tuberculata*****, new species, female: A, pereopod 1; B, pereopod 2; C, pereopod 7.**

fringing reef, off Pine Cay, 12 m, 4 Nov 1989. PARATYPES, USNM 243483, 2 non-ovig. females tl 3.2 & 5.8 mm, in *Verongia* sp. off outer reef, Pine Cay, 20 m, 31 Oct 1988.

Description. Female: Body proportions, C = 1 = 2 > 3 < 4 > 5 > 6 > 7 < P. Pleonite 6 dorsally free, posterior margin bilobed. Telson with posterior margin broadly rounded, with 2 pairs of short and long apical setae mesially. Antennular flagellum of 4 articles, subterminal article with 1 aesthetasc, terminal article with 2 aesthetascs. Antennal flagellum of 4 setose articles. Mandibular palp of 3 articles, article 2 longest and broadest, with single strong distal seta, article 3 having 5 - 7 distal spines; lamina dentate with 5 serrations; molar reduced to rounded boss. Maxilla with 6 distal spines. Maxilliped lacking endite, palp of 3 articles, terminal article semicircular in outline, with 7 setae on mesial margin. Pereopod 1 subchelate, carpus triangular, posterodistally rounded; propodus moderately expanded, length about 2.5 times greatest width, palm sinuous, bearing few setae; unguis subequal in length to rest of dactylus. Pereopod 2, propodus with anterior length almost 3 times greatest width, with posterior margin bearing numerous scales plus tricuspid posterodistal spine; dactylus with 2 low proximal teeth on posterior margin, unguis about half length of rest of dactylus. Pereopods 4 - 7, carpi with anterior margin shorter than posterior, with short posterodistal spine; propodi with fringed scales on posterior margin plus 2 stout fringed setae and tricuspid spine posterodistally; unguis about one-third length of rest of dactylus. Pleopod 1 exopod operculiform, about 3.5 times wider than endopod, latter shorter than exopod, with 6 distal plumose setae. Uropodal endopod distally rounded, length about 1.5 times basal width; exopod reaching beyond base of endopod, apically acute, with shallow distal emargination in lateral margin.

Color pattern. Red-brown patches of chromatophores on dorsum of cephalon, all pereonites, pleon, telson, and uropods, those on pereonites and pleon having elongate unpigmented median area.

Remarks. Of the eight known species of *Mesanthura* from the western North Atlantic, *M. spongicola* is most similar to *M. bivittata* Kensley, 1987, from Belize and *M. looensis* Kensley & Schotte, 1987, from the Florida Keys. The new species can be separated from *M. bivittata* by the presence of 5 - 7 spines on article 3 of the mandibular palp and pereopods 2 - 6 each having a stout tricuspid sensory spine at the posterodistal angle of the propodus. The distinctly more elongate body form and the dorsal pigment pattern distinguish *M. spongicola* from *M. looensis*. Pereonite 7 of *M. spongicola* has the pigment patch in a thick irregular U-shape, whereas the pigment in this area in *M. looensis* is in the shape of an acute triangle or tapers anteromedially.

Collection data indicate that *M. spongicola* is associated with, and lives in a yellow tube sponge, *Verongia* sp. Although numerous benthic and epibenthic samples, which represented a variety of substrata and over 10 other species of sponges, were taken along the fringing reef-face off Pine Cay, *M. spongicola* was found to occur only with the yellow tube sponge. Specimens were found in six of the eight specimens of *Verongia* examined during the fall (Oct-Nov) of 1988 and 1989; however, during the spring (April- May) of 1989 and 1990 no specimens of *M. spongicola* were found in over 20 yellow tube sponges from the same collecting area. Of the approximately 30 described species of *Mesanthura*, only three, viz. *M. albinotata* Thompson, 1951, *M. bipunctata* Thompson, 1951, and *M. protei* Kensley, 1980, have been collected with, or found in sponges (See Negoescu & Wägele 1984).

Etymology. The specific epithet, meaning 'sponge dweller', refers to the fact that all the specimens of this species were taken from sponges.

Family Paranthuridae
Califanthura minuta, new species
Fig. 5

Material. HOLOTYPE, USNM 243271, ovig. female tl 1.6 mm, PARATYPES, USNM 243272, 2 non-ovig. females tl 1.6 mm, off Pine Cay, inner fringing reef, in coarse sand and rubble, 1.5 m, 3 Nov 1988. PARATYPE, USNM 243273, non-ovig. female cl 1.6 mm, off Pine Cay, in coarse sand and rubble, 5 m, 16 Nov 1989. PARATYPE, GCRL 1148, 1 non-ovig. female, 1.6 mm, off Pine Cay, back of fringing reef in coarse sand and rubble, 4 m, 16 Apr 1989.

Description. Body proportions: C < 1 = 2 < 3 < 4 > 5 > 6 > 7. Cephalon with low rounded rostrum; eyes well pigmented, consisting of 6 - 8 ommatidia each. Pereonite 7 about one-sixth length of pereopod 6, lacking legs. Pleonites 1 - 5 fused; pleonite 6 dorsally indistinguishably fused with telson. Latter tapering posteriorly to broadly rounded posterior margin. Antennular peduncle with basal article longest and broadest; article 2 shorter than article 3; flagellum of 2 short articles, distal article bearing several simple setae plus 2 aesthetascs. Antennal peduncle with article 3 about half length of article 4, which in turn about half length of article 5; flagellum consisting of single setose article. Maxilla having about 12 distal serrations. Pereopod 1, carpus distally rounded; propodus broad, expanded, with rounded lobe at proximal end of palm, having 3 stout basally situated setae on mesial surface, palm with lateral convex flange bearing few setae. Pereopod 2, propodus barely inflated, with 4 short spines on posterior margin. Pereopod 6, carpus with anterior margin shorter than posterior, latter bearing 2 distal spines on posterior margin; propodus about 2.5 times longer than wide, with single strong posterodistal spine. Pleopod 1, endopod elongate, slender, with 3 distal plumose setae; exopod broad, operculiform, with about 8 plumose setae on laterodistal margin. Uropodal endo-

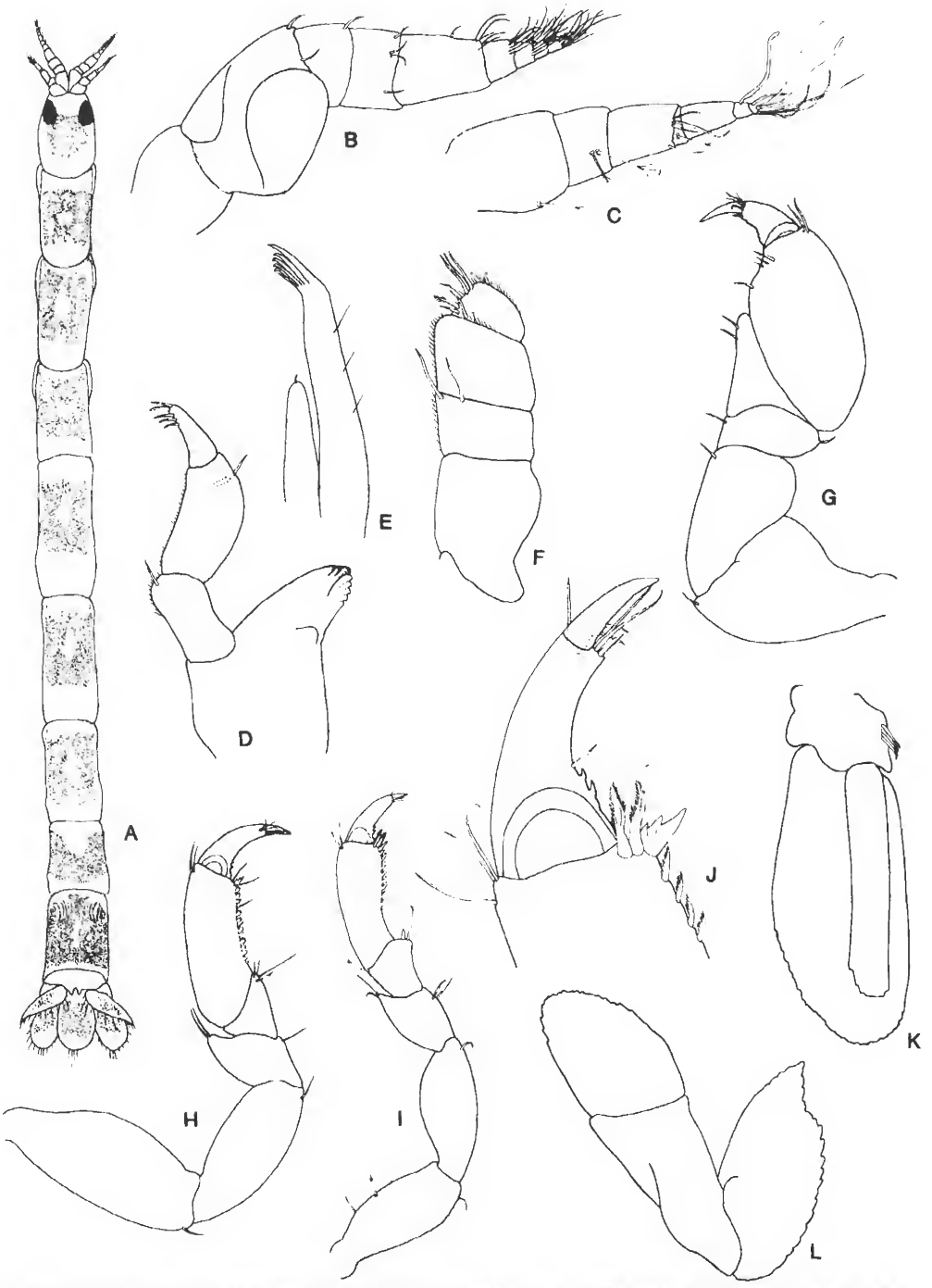

Fig. 4. ***Mesanthura spongicola*****, new species; A, Non-ovigerous female in dorsal view; B, antenna; C, antennule; D, mandible; E, maxilla; F, maxilliped; G, pereopod 1; H, pereopod 2; I, pereopod 7, distal propodus and dactylus; K, pleopod 1; L, uropod.**

pod ovate, distal margin setose; exopod short, narrowly triangular, distally acute, barely reaching level of mesiodistal margin of protopod.

Remarks. Poore (1984) clarified the diagnoses of four seemingly closely related paranthurid genera that lack a seventh pereopod in the adult, of which *Califanthura* is one. The five previously decribed species of *Califanthura* are characterized by having pleonites 1-5 fused and generally lacking dorsal folds marking this fusion (see Poore 1984:699). None of these possesses a short triangular uropodal exopod and an evenly tapering telson, nor are any of them mature at the small size (1.6 mm) seen in *C. minuta*.

Etymology. The specific epithet, the Latin for little or tiny, refers to the small size (1.6 mm) of the adult.

Family Stenetriidae
Stenetrium caicosensis, new species
Figs. 6-7

Material. HOLOTYPE, USNM 243476, male tl 5.0 mm, PARATYPES, USNM 243477, 2 males tl 4.3 - 5.0 mm, 5 ovig. females tl 3.9 - 4.5 mm, 11 juvs., GCRL 1150, 1 male 4.3 mm, 1 ovig. female 4.8 mm, Fort George Cay, *Neogoniolithon* washings, 0.5 m, 18 Apr 1988. PARATYPE, USNM 243478, male tl 5.2 mm, Crab Hole Cay, Caicos Bank off Pine Cay, 15 Apr 1988.

Description. Male: Body about 3.5 times longer than greatest width. Cephalon with dorsolateral eyes large, well pigmented; anterolateral lobe acutely triangular; frontal margin faintly concave; rostrum rectangular, anterior margin truncate. Anterolateral lobes of pereonites 1-3 acute, of 4-7 right-angled to rounded; posterolateral lobes of pereonites 6 and 7 acute. Pleotelson wider than long, lateral margins each with 4 serrations, posteriormost forming strong tooth; posterior margin between uropodal bases gently convex. Antennule with basal article widest and longest, article 2 about half length of 3; flagellum of 11 articles, single aesthetasc on each of 8 distal articles. Antenna almost as long as body, peduncle articles 1 and 2 short, subequal, latter with setose scale, article 3 very short, articles 4 and 5 slender, elongate, subequal, each longer than 3 proximal articles together. Mouthparts typical of genus, as figured. Maxilliped endite with 6 coupling hooks on mesial margin. Pereopod 1 of mature male with posterior surfaces of ischium, merus, carpus, propodus and dactylus bearing dense elongate setae; merus with broad apically subacute lobe produced from distal half of posterior margin; carpus subequal in length of merus (excluding posterior lobe); propodus anterior length about 2.5 times greatest width, with distally directed spine-like process in distal half of posterior margin; dactylus curved, club-shaped, reaching to base of propodus, lacking distal claw or unguis. Pereopods 2 - 7 similar, meri with anterodistal angle produced and bearing stout seta; carpi roughly rectangular, with few short spines on posterior margin; propodi subequal in length to, about half width of carpus, with 6 spines on posterior margin; dactyli biunguiculate, 2 ungui equally strong; slender accessory spines on posterior margin. Pleopod 1, rami tapering, distally rounded, distolateral margins setose. Pleopods 2-4 typical of genus. Uropod with basis slightly shorter than endopod; exopod three-fourths length of endopod.

Female: Pereopod 1, basis bearing 5 stout distal setae on anterior margin; ischium with few setae on posterior surface; merus with anterodistal angle produced, bearing stout seta; carpus with numerous setae on posterior surface, anterodistal angle produced into acute lobe; propodus with palm separated from posterior margin by strong fringed spine, palm bearing 5 slender fringed setae; dactylus bearing row of short fringed spines on posteriodistal margin, unguis about one-fourth length of rest of dactylus. Pleonal operculum longer than basal width, subapically slightly pinched, distally rounded.

Color pattern. Red-brown scattering of chromatophores between eyes, on pereonites 1 and 2, broad band on 3, absent on 4, broad band on 5, scattering on 6 and 7, broad basal band with lateral lobes on pleon.

Remarks. Of the four Caribbean species of *Stenetrium* having reniform eyes (See Kensley & Schotte 1989:100), *S. caicosensis* most closely resembles *S. bowmani* Kensley, 1984, from Belize and Mexico, especially in the shape of the cephalon and pleon. The two species can easily be separated, however, by the color pattern (the chromatophores are more evenly and densely spread over the dorsum of *S. bowmani*), by the number of coupling hooks on the maxillipedal endite (four in *S. bowmani*, six in *S. caicosensis*), by the shape of pereopod 1 of the male (*S. bowmani* possesses an expanded propodus with a trilobed palm, while *S. caicosensis* has a broad lobe on the posterior surface of the merus), and by the more strongly produced acute anterodistal lobe on the carpus of pereopod 1 of *S. caicosensis*.

Etymology. The specific name is derived from the type locality, viz. the Caicos Islands.

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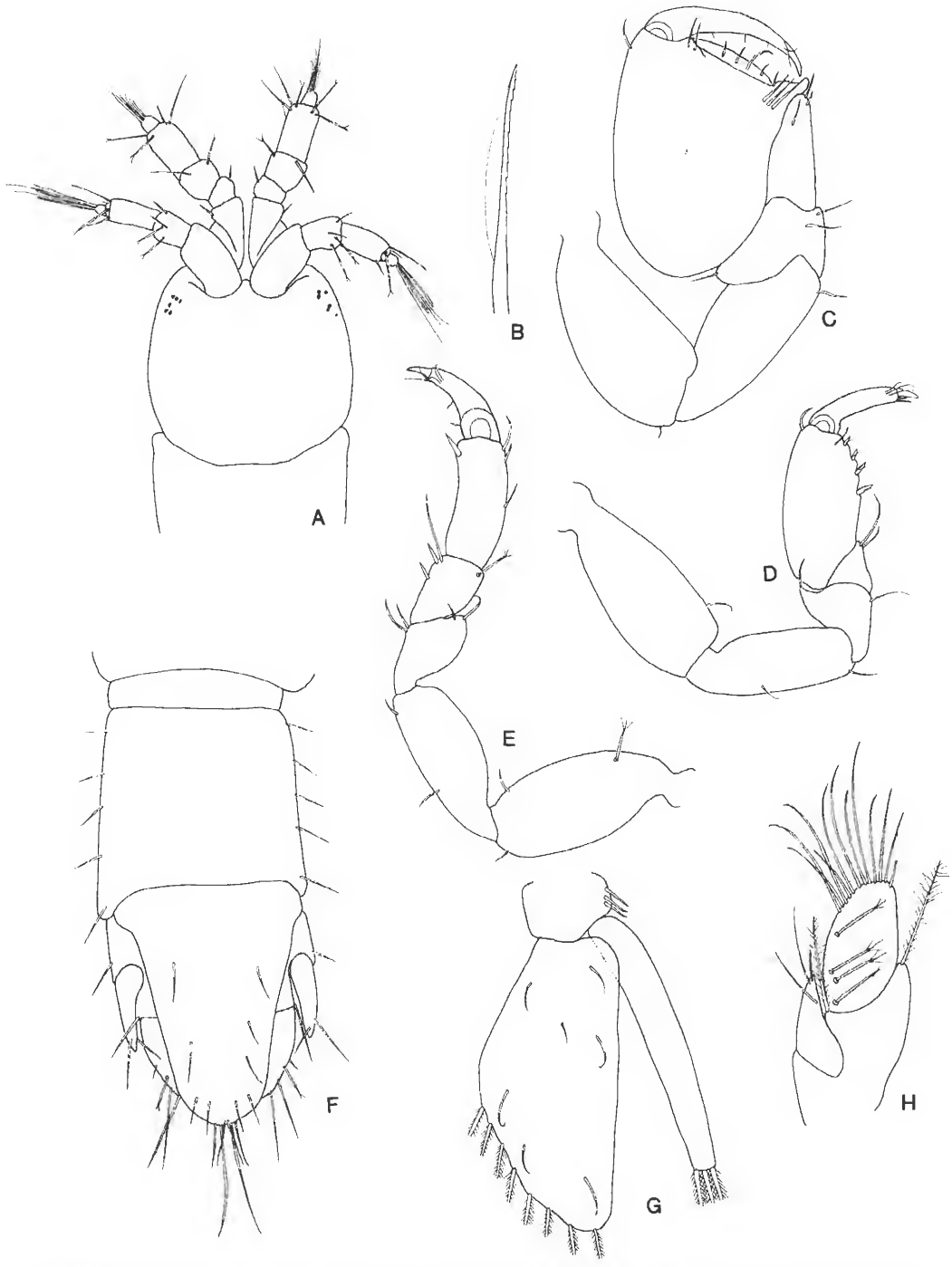

Fig. 5. ***Califanthura minuta*****, new species, female: A, cephalon, antennules, and antennae; B, maxilla; C, pereopod 1; D, pereopod 2; E, pereopod 6; F, pleon and pleotelson; G, pleopod 1; H, uropod.**

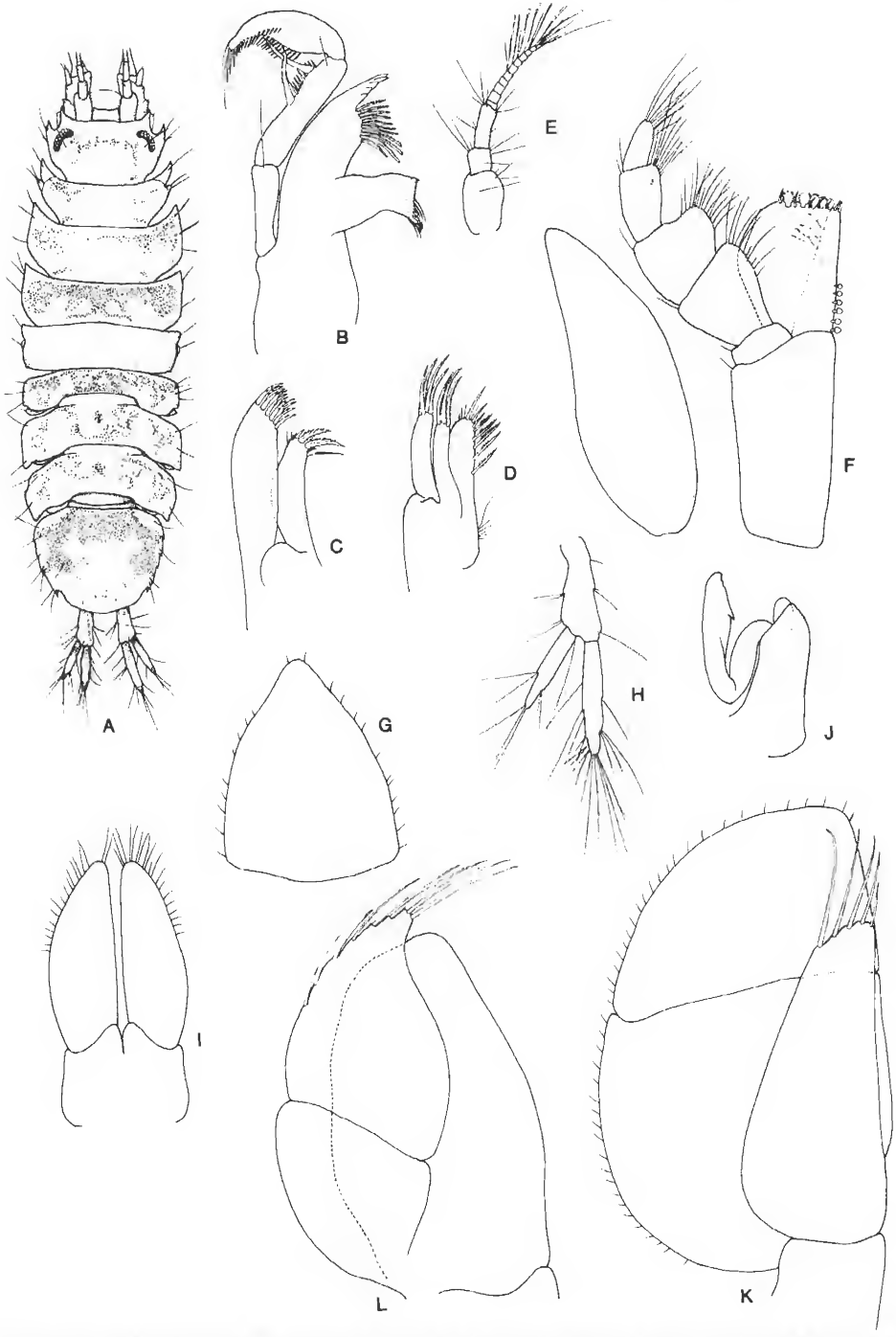

Fig. 6. ***Stenetrium caicosensis*****, new species: A, whole animal in dorsal view; B, mandible; C, maxilla 1; D, maxilla 2; E, antennule; F, maxilliped; G, operculum, female; H, uropod; I, pleopod 1 male; J, pleopod 2 male; K, pleopod 3; L, pleopod 4.**

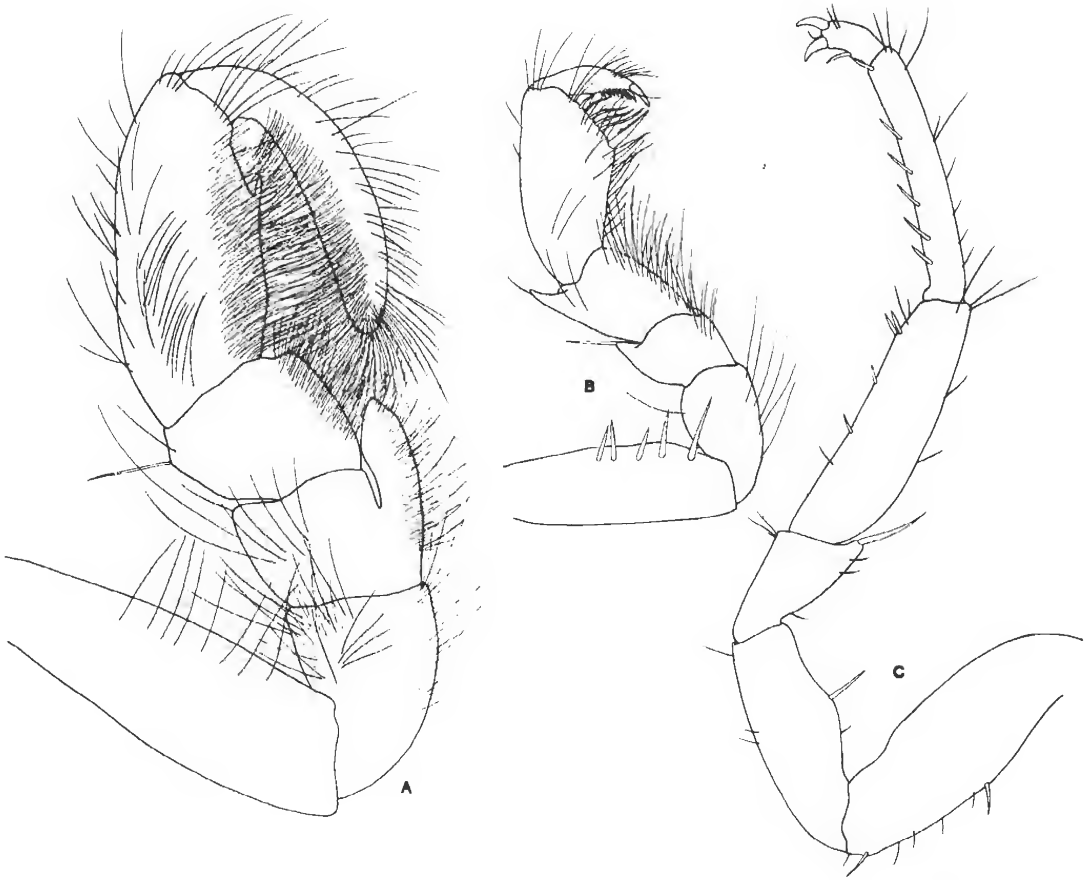

Fig. 7. *Stentrium caicosensis*, new species: A, pereopod 1 male; B, pereopod 1 female; C, pereopod 7.

REFERENCES CITED

Kensley, B. 1980. Anthuridean isopod crustaceans from the International Indian Ocean Expedition, 1960-1965, in the Smithsonian Collections. *Smithson. Contrib. Zool.* 304:1-37.

_____. 1984. The Atlantic Barrier Reef Ecosystem at Carrie Bow Cay, Belize, III. New Marine Isopoda. *Smithson. Contrib. Mar. Sci.* 24:1-81.

_____. 1987. Further records of marine isopod crustaceans from the Caribbean. *Proc. Biol. Soc. Wash.* 100(3):559-577.

_____ & M. Schotte. 1987. New records of isopod Crustacea from the Caribbean, the Florida Keys, and the Bahamas. *Proc. Biol. Soc. Wash.* 100(1):216-247.

_____ & _____. 1989. *Guide to the marine isopod crustaceans of the Caribbean.* Smithsonian Institution Press, Washington, D.C. and London, 308 pp.

Negoescu, I. & J.-W. Wägele. 1984. World list of the anthuridean isopods (Crustacea, Isopoda, Anthuridea). Travaux du Muséum d'Histoire naturelle Grigore Antipa. 25:99-146.

Poore, G. C. B. 1984. *Colanthura, Califanthura, Cruranthura* and *Cruregens*, related genera of the Paranthuridae (Crustacea: Isopoda). *J. Nat. Hist.* 18:697-715.

Schotte, M. & R.W. Heard. 1991. Studies on the Crustacea of the Turks and Caicos Islands, British West Indies. II. *Armadilloniscus steptus*, n. sp (Isopoda: Oniscidea: Scyphacidae) from Pine Cay. *Gulf Res. Rept.* 8(3):247-250.

Schotte, M., R. W. Heard, and B. Kensley. 1991. Records of shallow-water marine isopod crustaceans from the Turks and Caicos Islands, British West Indies. *Gulf Res. Rept.* 8(3): 251-257.

Thomson, J. M. 1951. The fauna of Rottnest Island. X. Anthuridae. *J. and Proc. Royal Soc. West. Australia* 35:1-8.

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STUDIES ON THE CRUSTACEA OF THE TURKS AND CAICOS ISLANDS, BRITISH WEST INDIES. II. *ARMADILLONISCUS STEPTUS*, N. SP (ISOPODA: ONISCIDEA: SCYPHACIDAE) FROM PINE CAY.

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ABSTRACT *Armadilloniscus steptus*, n. sp., the second species of this genus from the Caribbean Sea, is described and distinguished from the other five species from the New World. The new species, collected from the upper intertidal zone on Pine Cay, Turks and Caicos Islands, differs from *A. coronacapitalis*, *A. ellipticus*, *A. holmesi*, *A. lindahli*, and *A. ninae* by the greater degree of tuberculation of the integument, smaller size at maturity, and sexual dimorphism in the structure of the pleon.

Introduction

While participating in the Turks and Caicos Coral Reef Ecology Program, the second author collected isopods from a variety of shallow-water marine habitats, in the vicinity of Pine Cay. These collections contained three species of marine oniscidean isopods, *Ligia baudiniana* H. Milne Edwards, 1840; *Littorophiloscia culebrae* (Moore,1901) and undescribed species of *Armadilloniscus* Ul'yanin, 1875. The description of the last is the subject of this report.

Although the name and a short description of *Armadilloniscus* was published in Russian by Ul'yanin in 1875, Verhoeff (1918) provided a more accessible generic diagnosis, based on his observations (he did not see Ul'yanin's paper) and the definition of Budde-Lund (1885). Vandel (1962) later corroborated and expanded this diagnosis. Verhoeff's diagnosis is based on, among other things, the morphology of the antennae, antenules, and mouthparts. The antenna has a flagellum of four articles and the antennule is minute, consisting of two articles. Both mandibles, though dissimilar in shape, have a setose lobe below the lacinia mobilis; between the lacinia and the molar the setal row consists of stiff setae known as "penicils." Although Verhoeff found two pencils on each mandible, Sutton (1972) states that these may vary in number between species. The internal lobe of the first maxilla (maxillule) is simple with two bundles of setae. Vandel (1970) states that the tergal ornamentation is the most useful character in distinguishing species.

Eight species of *Armadilloniscus* from the USNM collection were examined: *A. aestuarii* Verhoeff, 1930 (from Yugoslavia); *A. coronacapitalis* Menzies, 1950 (California); *A. dalmatinus* Verhoeff, 1901 (Italy and Yugoslavia); *A. ellipticus* (Harger, 1878) (Virginia); *A. heroldii* Verhoeff, 1918 (Switzerland); *A. holmesi* Arcangeli, 1933 (California); *A. lindahli* (Richardson, 1905) (California); and *A. ninae* Schultz, 1984 (Belize). The material of *A. tuberculatus* (Holmes and Gay, 1909) from Baja California is listed as missing at USNM and was not examined, but according to Van Name (1940), it is conspecific with *A. holmesi*. The highly tuberculate dorsum of the new species relates it most closely to the North American *A. coronacapitalis* and *A. ninae*. The new species from Pine Cay, which occurs in marine upper intertidal habitats, is the second to be found in the tropical northwestern Atlantic following *A. ninae* from Belize (Schultz, 1984).

Family Scyphacidae Dana, 1852
Armadilloniscus steptus, new species
Figs. 1, 2

Material.- HOLOTYPE: female, total length (tl) 2.9 mm, USNM 252209, Turks and Caicos Islands, Pine Cay, upper intertidal under slabs of soft carbonate rock, 1 May 1990, coll. R. W. Heard.- ALLOTYPE: male, tl 2.1 mm, USNM 2522210, same collection data as holotype. PARATYPES: 5 males, 3 females (ovig.), 19 juveniles, USNM 252211, same collection data as holotype; 2 males, 1 female (ovig.), Gulf Coast Research Laboratory Museum, GCRL 1147, same collection data as holotype; 1 juvenile, USNM 252212, Pine Cay dock, upper intertidal under dead leaves, 9 Nov 1989, coll. R. W. Heard.

Description. - Body elongate-elliptical, not capable of completely rolling into ball; frontal margin acute, anterolateral lobes of cephalon rounded; cephalon highly sculptured with 5 large tubercles, 2 anterior and 3

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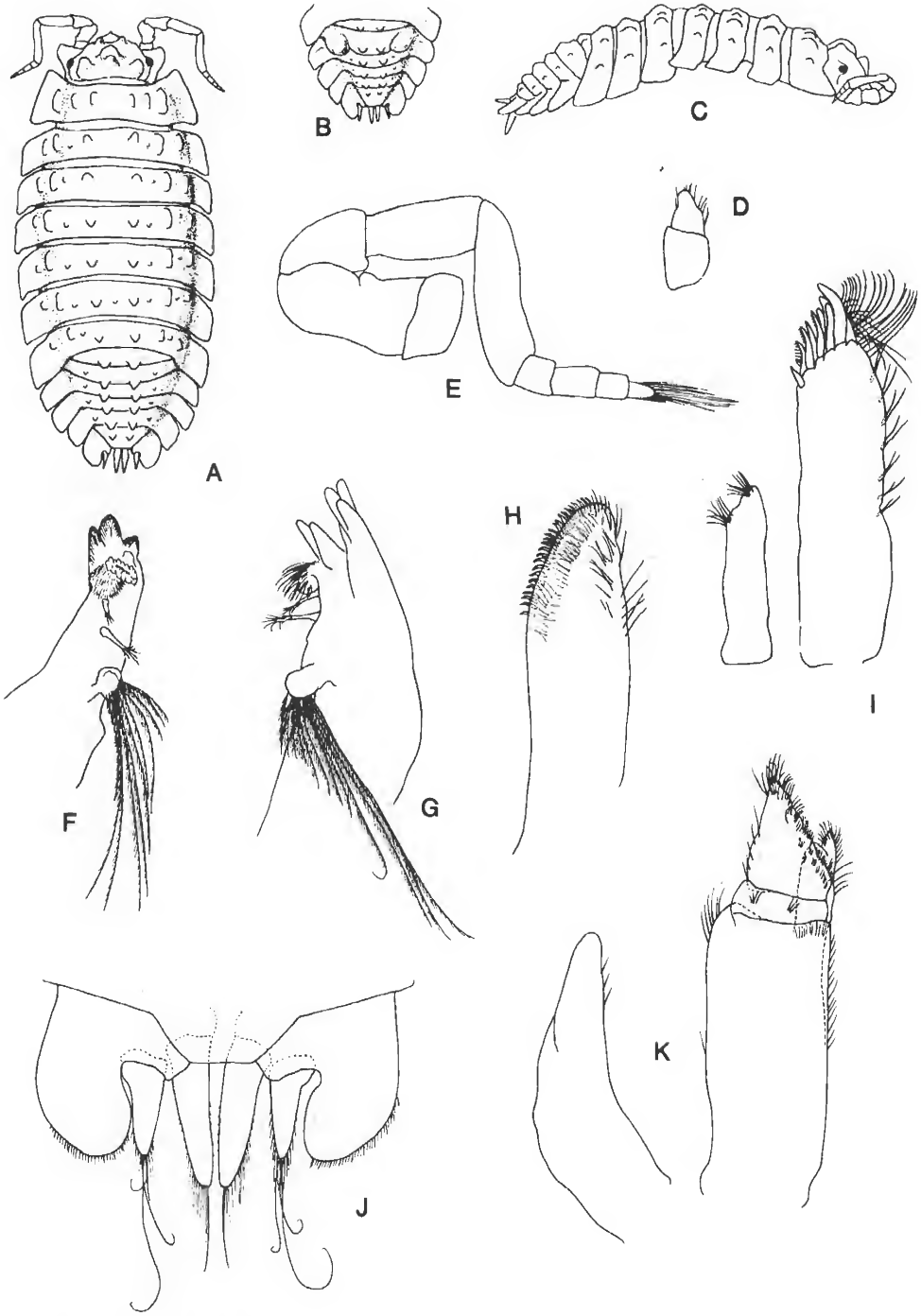

Fig. 1. ***Armadilloniscus steptus*, female: A, Whole animal in dorsal view; C, Lateral view; D, Antennule; E, Antenna; F, Right mandible; G, Left mandible; H, Second maxilla; I, First maxilla; J, Uropods; K, Maxilliped. Male, B: Pleon.**

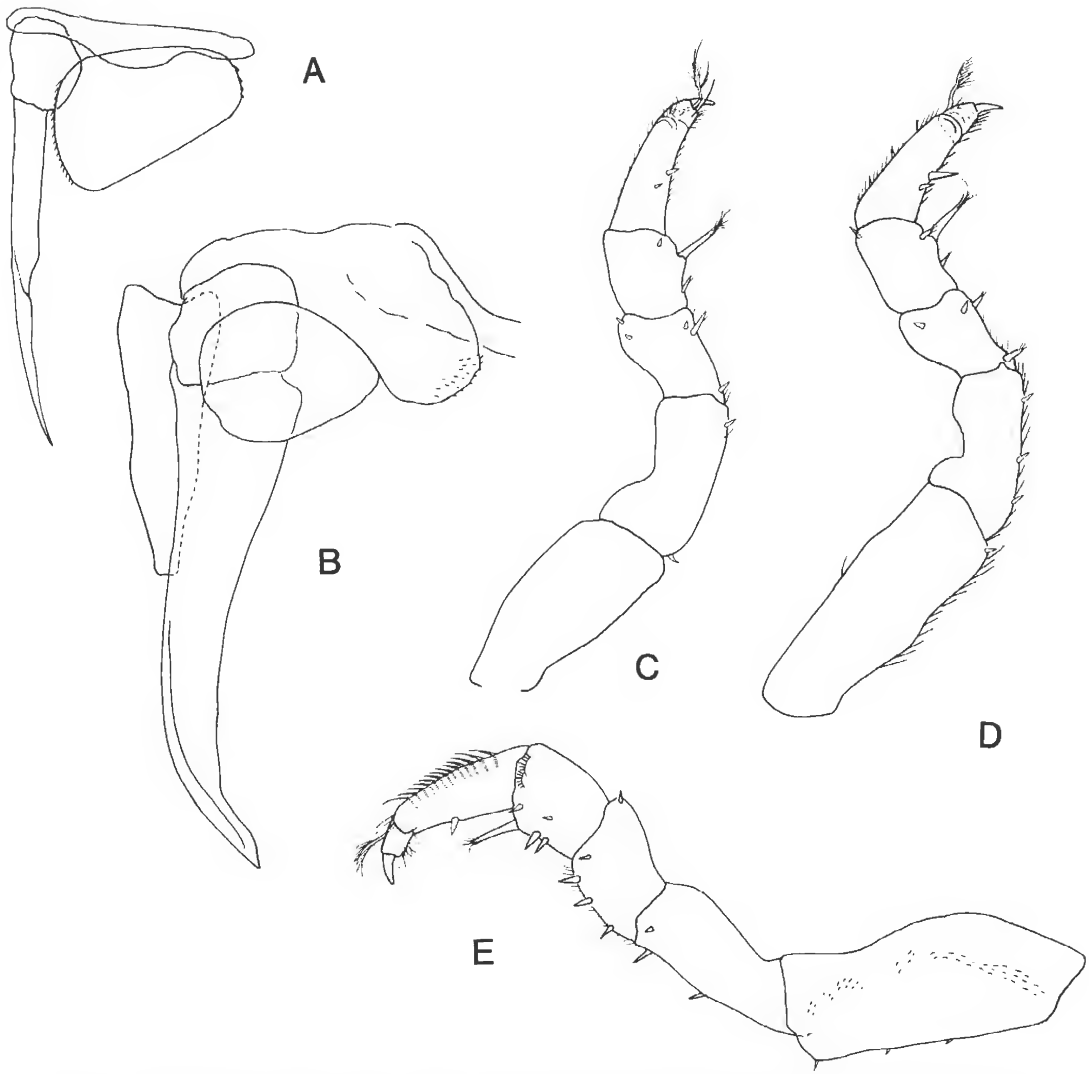

Fig. 2. ***Armadilloniscus steptus,*** **male: A, Pleopod 2; B, Pleopod 1; C, Pereopod 1; D, Pereopod 2; E, Pereopod 7.**

posterior (posteromesial tubercle appearing double). Dorsum covered with tubercles of varying sizes: pereonites each with 4 larger, elongate tubercles and several interspersed smaller ones. Pleonites each with pair of submedial tubercles each flanked by smaller lateral ones. Sexual dimorphism evident in second pleonite having large dorsal swelling on each side only in males; males also smaller in size. Apex of telson truncate. Uropodal endopods flexed ventrally, at least in preserved specimens, uropodal rami unequal, exopod more than half length of endopod. Endopods each with one long seta and several smaller ones; exopods each having 3 long (one extremely long) thin hair-like setae plus others.

Antennule inconspicuous, of 2 articles. Antenna stout, with peduncle of 5 articles, fifth longest, second article with small flange on lateral margin; flagellum of 4 articles.

Left mandible with incisor of 3 cusps; large setose lobe below lacinia mobilis; setal row of 2 stiff setae ("penicils") between lacinia and molar with many long,

plumose setae. Right mandible having incisor of 3 teeth; lacinia a "rosette" of tiny cusps; 2 penicils between setose lobe and molar process. Exopod of maxilla 1 with 10 spines, 4 with spinules, outer margin with several paired setae, anterolateral margin with tuft of numerous long, thin setae; endopod simple with 2 bundles of setae. Maxilla 2 with single row of curved, irregular spines and fringing setae near apex. Maxilliped with setae on endite and on apex and mesial margin of palp.

Pereopods 1, 2, and 7 similar, as figured, each with single large, stiff, tufted seta on inner margin of carpus; all pereopods with one long, flagellate seta ["organe dactylien," of Vandel (1962: 467)], at base of dactyl. Male pleopod 1 endopod apically acute; genital apophysis appearing truncate at apex. Male pleopod 2 having exopod squarish with spinose mesial margin and few spines on lateral border; endopod long, thin and membranous, acute at tip.

Remarks.- *Armadilloniscus steptus* is the only species of the six now known to occur in North and Central America that exhibits sexual dimorphism in the pleon. *Armadilloniscus ellipticus* has produced anterolateral lobes, almost truncate, on the cephalon and very low, poorly defined tubercles on the dorsum. According to Menzies (1950), *A. holmesi* appears almost smooth; the cephalic lobes are long and truncate, and the telsonic apex is rounded, not truncate as in *A. steptus*. Truncate lateral lobes and a rounded apex at the telson are also features of *A. lindahli*. The new species is easily distinguished from *A. coronacapitalis*, which has four large elevated tubercles on the cephalon in the female, a flange on the fourth antennal article, and a large lobe on the carpus of pereopod 7 in the male. It is also a much larger species than *A. steptus* at maturity. *Armadilloniscus ninae*, the other Caribbean species, is far less tuberculate than *A. steptus*. The uropods of *A. ninae* do not appear to be flexed ventrally and it a distinctly larger species (4.3 mm ovigerous females versus 2.2 mm). *Armadilloniscus steptus* has ten curved spines on maxilla 1 as opposed to six in *A. ninae*. The right mandible of *A. steptus* appears to have two penicils, in contrast to three in *A. ninae*. Again, no dimorphism has been noted in structure of the pleon of *A. ninae*.

Etymology. - The specific name is derived from the Greek (steptos = "crowned"), referring to the arrangement of tubercles on the cephalon.

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REFERENCES CITED

Budde-Lund, G. 1885. Crustacea Isopoda Terrestria per familias et genera et species descripta. Hauniae.

Menzies, Robert J. 1950. Notes on California Isopods of the genus *Armadilloniscus*, with the description of *Armadilloniscus coronacapitalis* n. sp. *Proc. Calif. Acad. Sci.* 26 (13): 467- 481.

Schultz, George. 1984. Three new and five other species of Oniscoidea from Belize, Central America (Crustacea: Isopoda) *J. Nat. Hist.* 18: 3- 14.

Sutton, Stephen. 1972. *Woodlice*. 143 pp. London: Ginn & Company.

Ul'yanin, B. N. 1875. (Voyage of Fendtchenko to Turkestan. Crustacea. [*Imperatorskoe obshchestvo Lyubitelei Estestvoznaniya Antropologhii i Etnoghrafii* vol. 2, pt. 6. Moscow (In Russian and Latin.]

Vandel, Albert. 1962. Isopodes Terrestres (Deuxieme Partie). *Faune de France* 66: 417-927.

Vandel, Albert. 1970. Les Isopodes terrestres des iles Rennell et Bellona. The Natural History of Rennell Island, British Solomon Islands: 139 -153.

Van Name, Willard G. A. 1940. Supplement to the American Land and Fresh-water Isopod Crustacea. *Bull. Am. Mus. Nat. Hist.* 77(II): 109-142.

Verhoeff, Karl W. 1918. Zur Kenntnis der Ligidien, Porcellioniden und Onisciden. 24. Isopoden-Aufsatz. Archiv fur Naturgeschichte 82(A): 108-169.

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Studies on the Crustacea of the Turks and Caicos Islands, British West Indies. III. Records of Marine Isopoda from Pine Cay, Fort George Cay, Water Cay, and Adjacent Waters

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STUDIES ON THE CRUSTACEA OF THE TURKS AND CAICOS ISLANDS, BRITISH WEST INDIES. III. RECORDS OF MARINE ISOPODA FROM PINE CAY, FORT GEORGE CAY, WATER CAY, AND ADJACENT WATERS.

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ABSTRACT Between April 1987 and April 1990, 45 species of marine isopods were collected from intertidal and subtidal habitats in the vicinity of Pine Cay, Turks and Caicos, British West Indies. Five species, *Licranthura tuberculata, Mesanthura spongicola, Califanthura minuta, Stenetrium caicoensis*, and *Armadilloniscus stepus*, are known currently only from the northeastern Turks and Caicos Islands. The Turks and Caicos collections represent considerable range extensions for many of the species collected. Four species, *Apanthura cracenta, Mesanthura punctillata, Carpias triton*, and *Munna petronastes*, known previously from the east coast of Central America (Belize), are reported for the first time since their description. This report also presents the first published records from outside of their respective type localities for *Amakusanthura significa, Mexicope kensleyi, Carpias brachydactylus, Carpias serricaudus, Uromunna caribea, Stenetrium monocule*, and *Stenobermuda acutirostrata*. The other species reported, mostly flabelliferans, appear to be widely distributed in the tropical western North Atlantic and their occurrence in the Turks and Caicos was not unexpected.

Introduction

Geologically the Turks and Caicos Islands, which are the northernmost islands in the British West Indies and located approximately 175 km north of Hispaniola, are part of the southeastern Bahamas. With the exception of a few scattered reports dealing with anchialine cave taxa (Buden & Felder 1977, Stock & Vermuelen 1982, Bowman et al 1985, and Kornicker & Iliffe 1985, Yager & Schram 1986), the crustacean fauna of Turks and Caicos Islands is poorly known.

This report and those of Kensley & Heard (1991) and Schotte & Heard (1991), which are published together in this journal number, are the first documentations of the marine isopod fauna of the Turks and Caicos Islands. The reports by Kensley and Heard (1991) and Schotte and Heard (1991) deal with the descriptions of four new marine subtidal species (*Licranthura tuberculata, Mesanthura spongicola, Califanthura minuta, Stenetrium caicosensis*) and a new intertidal oniscidean (*Armadilloniscus steptus*), respectively. The records for these species are also listed in this report. The marine isopods of the general Caribbean region and Bermuda have been treated by Kensley and Schotte (1989).

Materials and Methods

The material recorded herein was collected primarily by the second author along with other participants in the Turks and Caicos Coral Reef Ecology Program, in the environs of Pine Cay, Fort George Cay, Water Cay, and smaller nearby Cays in the northeastern Turks and Caicos Islands (see Figure 1). Subtidal collecting methods included the use of fine mesh kicknets, suction pumps (yabby pumps), an Ockelmann dredge, plankton nets, and light traps. SCUBA was also employed in the collection of subtidal specimens. Algal-coral-sponge washings and sediments were gently eleutriated and sieved before preservation and sorting. Intertidal specimens were collected by hand. The material listed here has been deposited in the collections of the National Museum of Natural History, Smithsonian Institution. Additional material has been also deposited in the Museum of the Gulf Coast Research Laboratory.

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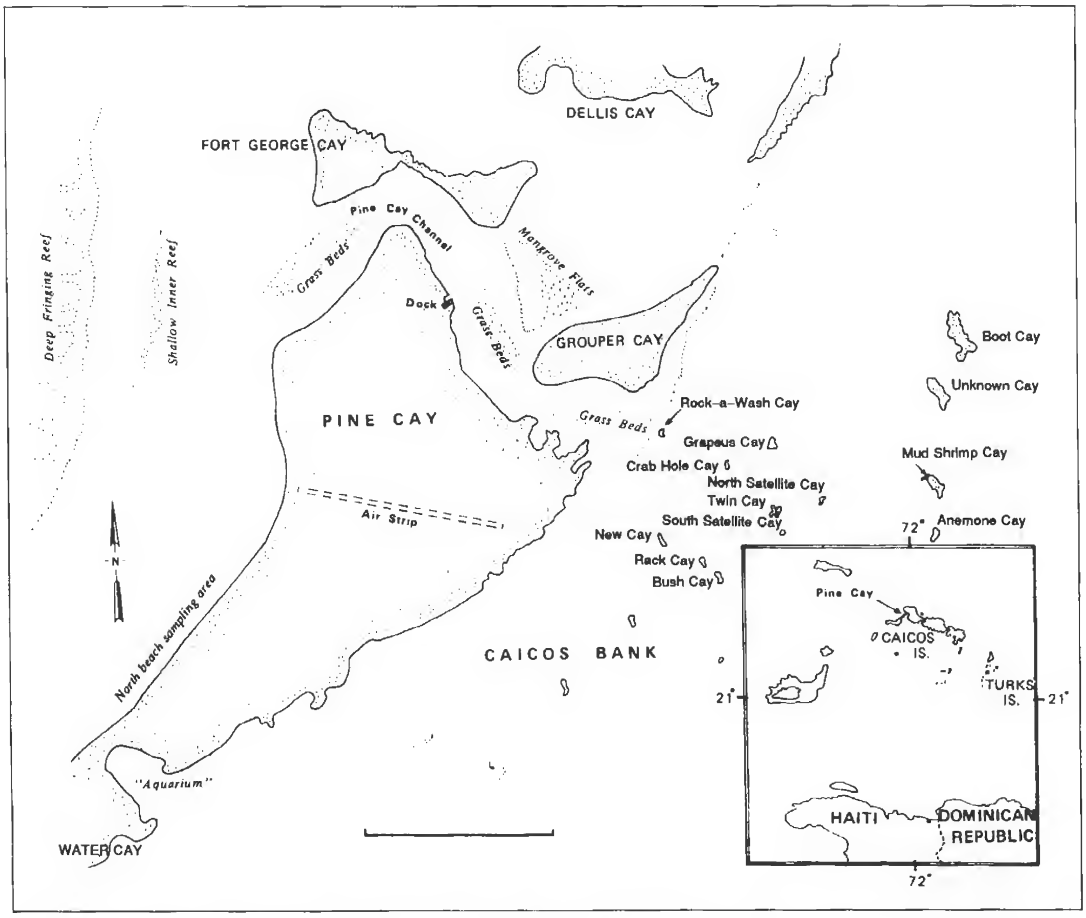

Figure 1. Map showing the collecting sites in the vicinity of the Pine Cay, Turks and Caicos Islands, British West Indies. Scale = 1 km

RESULTS

We identified 45 distinct species of free-living or semi-parasitic marine isopods from collections made between April 1987 and April 1990 in marine habitats on, or in the vicinity of, Pine Cay, Fort George Cay, and Water Cay (Figure 1). These species represented 18 different families belonging to the suborders Anthuridea, Asellota, Flabellifera, Valvifera and Oniscidea. Parasitic species belonging to the suborders Epicaridea and Gnathiidea, and the flabelliferan family Cymothoidae were also collected, but are not treated in this report. The suborders, families, and species are arranged alphabetically in the following taxonomic listing of records.

SUBORDER ANTHURIDEA
Family Anthuridae

Amakusanthura significa (Paul and Menzies, 1971)
Material. 11 females, Pine Cay, rubble bottom inside fringing reef,4-5 m, 9 Apr 1989.
Previous Records. Venezuela.

Apanthura cracenta Kensley, 1984
Material. 3 females, New Cay, 13 Apr 1988. 3 females, Twin Cay, washings, ca. 1 m, 1 Nov 1988. 1 female, Rock-a-Wash Cay, orange sponge washings, 1 m, 30 Oct 1988. 1 female, Rack Cay, *Neogoniolithon* washings, 1 m, 31 Oct 1988. 1 male, 8 females, 8 juv., Rock-a-Wash Cay, 0.5-1 m, 30 Oct 1988. 2 females, inner fringing reef off Pine Cay, rubble bottom, 4-5 m, 3 Nov 1988. 1 female, Twin Cay, Ockelmann dredge, 1 Nov 1988. 1 female, off

Pine Cay, sand patch in outer reef, 33 m, 2 Nov 1988. 3 females, from "lamb's wool sponge" washings, Mud Shrimp Cay, 17 April 1988.
Previous Records. Carrie Bow Cay, Belize

Apanthura cf. crucis (Barnard, 1925)
Material. 1 male (premale), Rack Cay, 12 Apr 1988.
Previous Records for *A. crucis*. St. Croix, U. S. Virgin Islands.
Remarks. As the single specimen is a premale, the change from premale to male is incomplete, making specific identification uncertain.

Elsothistos petrensis Kensley, 1984
Material. 1 female, Pine Cay, *Neogoniolithon* washings, 0.5 m, 16 Apr 1988.
Previous Records. Florida, Belize, U. S. Virgin Islands.

Licranthura tuberculata Kensley & Heard, 1991
Material. 1 male, 1 female, deep fringing reef, from yellow sponge, 37-40 m, 10 Nov 1988.
Distribution. off Pine Cay, Turks and Caicos Islands

Malacanthura sp.
Material. 1 female, off Pine Cay, deep fringing reef, from "bread sponge", 37 m, 10 Nov 1988.
Remarks. This form may represent an undescribed species, but a larger series of specimens is needed for study before it can be properly described.

Mesanthura fasciata Kensley, 1982
Material. 1 female, off Pine Cay, inner fringe reef, rubble bottom, 4-5 m, 3 Nov 1988. 1 female, same station, 4 April 1989.
Previous Records. Looe Key, Florida; Coszumel, Mexico; Carrie Bow Cay, Belize; Puerto Rico; Jamaica.

Mesanthura pulchra Barnard, 1925
Material. 1 female, New Cay, 13 Apr 1988. 1 female, off Water Cay, algae at reef top, 3-4 m, 18 Apr 1988. Ft. George Cay, in *Neogoniolithon* washings, 0.5 m, 18 Apr 1988. 1 female, Crab Hole Cay, 15 Apr 1988. 1 female, Mud Shrimp Cay, washings, ca. 1 m, 14 Apr 1988; 1 female, Twin Cay, from algae-sponge washings, 1 - 1.5 m, 1 Nov 1988. 1 female, South Satellite Cay, *Porites*-algae-sponge washings, 1-1.5 m, 11 Nov 1988.
Previous Records. Florida (Egmont Key, Looe Key, & Dry Tortugas); Puerto Rico; Carrie Bow Cay, Belize; U.S. Virgin Islands (St. Thomas and St. John's); Cozumel, Mexico.

Mesanthura punctillata Kensley, 1982
Material. 1 ovig. female, New Cay, 13 Apr 1988. 1 ovig. female, Mud Shrimp Cay, ca. 1 m, 14 Apr 1988. 1 ovig. female, Ft. George Cay, *Neogoniolithon washings*, 8 Nov 1988;
Previous Records. Carrie Bow Cay, Belize, 0.2-20 m.

Mesanthura spongicola Kensley & Heard, 1991
Material. 1 female, off Pine Cay, outer reef, on *Verongia*, 21 m, 31 Oct 1988. 18 females, off Pine Cay, on *Verongia*, 25-28 m.
Distribution. Off Pine Cay, Turks and Caicos Islands

Family Hyssuridae

Xenanthura brevitelson Barnard, 1925
Material. 1 male, 32 females, Mud Shrimp Cay, ca. 1 m, 14 Apr 1988. 5 males, 12 females, 1 juv., Mud Shrimp Cay, in algae and associated carbonate substratum, 0.5 - 1 m, 8 Apr 1988. 1 male, 4 females, Rock-a-Wash Cay, from *Neogoniolithon* washings, 16 Apr 1988. 2 males, 6 females, Twin Cay, Ockelmann dredge, ca. 1 m, 1 Nov 1988.
Previous Records. Off Georgia, 20-145 m; off Florida, 8-10 m; Gulf of Mexico; St. Thomas, U.S. Virgin Islands, 50-60 m.

Family Paranthuridae

Califanthura minuta Kensley & Heard, 1991
Material. 3 females, off Pine Cay, inner fringing reef, in coarse sand rubble, 1.5 m, 3 Nov 1988. 1 female, off Pine Cay, inner fringing reef, in coarse sand and rubble, 5 m, 16 Nov 1989.
Distribution. Pine Cay, Turks and Caicos Islands

SUBORDER ASELLOTA
Family Incertae Sedis

Mexicope kensleyi Hooker, 1985
Material. 1 female, 1 juv., Rack Cay, sponge washings, 12 Apr 1988. 2 females (1 ovig.), Rock-a-Wash Cay, *Neogoniolithon* washings, 0.5 m, 16 Apr 1988. 1 male, 1 female, Rack Cay, 1-1.5 m, 31 Oct 1988. 2 males, 2 females (1 ovig.), Rock-a-Wash Cay, *Neogoniolithon* washings, 1-1.5 m, 30 Oct 1988. 1 male, off Pine Cay, deep fringing reef, sand-rubble bottom, 9-10 m, 11 Nov 1989.
Previous Records. Florida Middle Grounds, Gulf of Mexico, 30 m.

Family Janiridae

Carpias algicola (Miller, 1941)
Material. 1 male, Rack Cay, *Neogoniolithon* washings, 11 Apr 1988. 2 males, Rock-a-Wash Cay, *Neogoniolithon* washings, 1-1.5 m, 16 Apr 1988. 8 males, 2 females, patch reef off Water Cay, algae scrapings, 3-4 m, 18 Apr 1988.
Previous Records. Looe Key, Florida, 1-1.5 m; Yucatan, Mexico; Carrie Bow Cay, Belize, 0-2 m; Puerto Rico; Jamaica; Venezuela; Indo-West Pacific.

Carpias brachydactylus (Pires, 1982)
Material. 1 male, 4 females (2 ovig.), Rack Cay, 12 Apr 1988. 1 female, New Cay, 13 Apr 1988. 3 males, 11 females (6 ovig.), Crab Hole Cay, 15 Apr 1988. 1 male, 1 female (ovig.), Mud Shrimp Cay, 17 Apr 1988. 1 female, algal mat on patch reef off Water Cay, 3-4 m; 18 Apr 1988. 2 males, 4 females (1 ovig.), Crab Hole Cay, from algae and sponge washings, 1-1.5 m, 4 Nov 1988. 3 males, 3 females (ovig.), 2 juv., Rack Cay, from orange sponge washings, 1-1.5 m, 31 Oct 1988. 3 males, 7 females (3 ovig.), South Satellite Cay, *Porites*-algae-sponge washings, 1-1.5 m, 11 Nov 1988.
Previous Records. Puerto Rico, 1.5 m.

Carpias serricaudus (Menzies and Glynn, 1968)
Material. 5 males, 4 females (2 ovig.), Rack Cay, 12 Apr 1988. 3 males, 8 females (3 ovig.), Crab Hole Cay, 15 April 1988. 1 male, patch reef off Water Cay, algae scrapings, 3-4 m, 18 Apr 1988. 5 males, 3 females (ovig.), Rack Cay, 31 Oct 1988.
Previous Records. Puerto Rico.

Carpias triton (Pires, 1982)
Material. 21 males (4 subadults), 44 females (17 ovig.), Rack Cay, 12 April 1988. 13 males, 14 females (6 ovig.), Rock-a-Wash Cay, 16 Apr 1988. 10 males, 12 females, Rack Cay, 31 Oct 1988. 6 males, Rock-a-Wash Cay, 30 Oct 1988.
Previous Records. Carrie Bow Cay, Belize, intertidal reef crest.

Family Joeropsidae

Joeropsis rathbunae Richardson, 1902
Material. 15 males, 15 (6 ovig.), 5 juvs., Ft. George Cay, *Neogoniolithon* washings, 0.5 m, 18 Apr 1988. 3 males, 2 females, New Cay, 13 Apr 1988. 1 male, Rock-a-Wash Cay, 1-1.5 m, 30 Oct 1988. 2 males, 4 females (1 ovig.), 3 juv., Twin Cay, algae-sponge washings, 1 Nov 1988. 1 male, 2 females (1 ovig.), Rack Cay, 31 Oct 1988.
Previous Records. Bermuda; Puerto Rico; Florida Keys; Gulf of Mexico. Intertidal to 36 m.

Family Microparasellidae

Microcharon sp.
Material. 3 males, 4 females (3 ovig.), off Pine Cay, inner fringing reef, sand-rubble bottom, 3-4 m, 16 Nov 1989.
Remarks. Our specimens do not appear to represent any of the three species of *Microcharon* Karaman, 1934 previously recorded from the Caribbean area (see Kensley and Schotte 1989). Considerable work and collections are still required to resolve the complexities of this genus.

Family Munnidae

Munna petronastes Kensley, 1984
Material. 2 females (1 ovig.), South Satellite Cay, *Porites*-algae-sponge washings, 1-1.5 m, 11 Nov 1988.
Previous Records. Carrie Bow Cay, Belize, intertidal to 2m.

Uromunna caribea (Carvacho, 1977)
Material. 1 female, Rock-a-Wash Cay, *Neogoniolithon* washings, 16 Apr 1988. 2 males, 2 females (ovig.), Crab Hole Cay, 15 Apr 1988. 3 males, 14 females (12 ovig.), Rack Cay, 12 Apr 1988. 1 female (ovig.), South Satellite Cay, *Porites*-algae-sponge washings, 1-1.5 m, 11 Nov 1988.
Previous Records. Canal de la Belle Plaine, Guadeloupe, in water of 25 ppt.

Family Pleurocopidae

Pleurocope floridensis Hooker, 1985
Material. 6 females, Rack Cay, algae-sponge washings, ca. 1 m, 12 Apr 1988. 3 females, Ft. George Cay, *Neogoniolithon* washings, 0.5 m, 18 Apr 1988.
Distribution. Florida Middle Grounds, Gulf of Mexico, 55 m; Carrie Bow Cay, Belize, 3-10 m.

Family Santildae

Santia milleri (Menzies & Glynn, 1968)
Material. 2 females (ovig.), Crab Hole Cay, 15 Apr 1988. 27 females (17 ovig.), 1 juv., Rack Cay, sponge washings, 12 Apr 1988. 3 females, algal mats on patch reef off Water Cay, 3-4 m, 18 Apr 1988. 1 specimen, Ft. George Cay, algae and sponge washings, 4 Nov 1988. 1 specimen, Rack Cay, 31 Oct 1988.
Distribution. Carrie Bow Cay, Belize, intertidal to 30 m; Puerto Rico, 1.5 m; San Salvador, Bahamas, 6 m; Anguilla; Jamaica; Cozumel, Mexico; Gulf of Mexico; Brazil, 1-6 m..

Family Stenetriidae

Stenetrium caicoensis Kensley and Heard, 1991
Material. 5 males, 15 females (6 ovig.), 9 juvs, Fort George Cay, *Neogoniolithon* washings, 0.5 m, 18 Apr 1988. 1 male, Crab Hole Cay, 15 Apr 1988. 2 males, 11 females (4 ovig.), 1 juv., Ft. George Cay, *Neogoniolithon* washings, 1-1.5 m, 8 Nov 1988. 1 male, Pine Cay, inner fringing reef, sand-rubble bottom, 3-4 m, 5 Nov 1988.
Distribution. Presently known only from Turks and Caicos Islands.

Stenetrium serratum Hansen, 1904
Material. 9 males, 5 females, 19 juvs., Rock-a-Wash Cay, *Neogoniolithon* washings, 16 Apr 1988. 3 females (ovig.), Rock-a-Wash Cay, *Neogoniolithon* washings, 11 Apr 1988. 6 males, 7 females (ovig.), 41 juvs., Rack

Cay, sponge washings, 12 Apr 1988. 2 males, 3 females (ovig.), 14 juvs., New Cay, 13 Apr 1988.
Previous Records. Looe Key, Florida, 0.5-6 m; Jamaica; Puerto Rico, intertidal to 3 m; St. Thomas, U.S. Virgin Islands; Carrie Bow Cay, Belize, intertidal to 15 m.

Stenetrium stebbingi Richardson, 1902
Material. 13 males, 7 females (ovig.), 40 juvs., Ft. George Cay, *Neogoniolithon* washings, 0.5 m, 18 Apr 1988. 22 males, 16 females (ovig.), 26 juvs., Rack Cay, sponge washings, 12 Apr 1988. 2 males, 5 juvs., Mud Shrimp Cay, from algae, 8 Apr 1988. 2 males, 2 juvs., Rock-a-Wash Cay, *Neogoniolithon* washings, 11 Apr 1988. 1 male, 2 females (ovig.), 2 juvs., Rock-a-Wash Cay, *Neogoniolithon* washings, 16 Apr 1988. 1 male, 5 females (ovig.), 6 juvs., Mud Shrimp Cay, lamb's wool sponge washings, 17 Apr 1988. 1 male, Mud Shrimp Cay, ca. 1 m, 14 Apr 1988. 16 males, 20 females (ovig.), 37 juvs., New Cay, 13 Apr 1988. 14 males, 6 females (ovig.), 18 juvs., Crab Hole Cay, 15 Apr 1988. 2 males, 1 female, from algal mat on patch reef off Water Cay, 3-4 m, 18 Apr 1988. 29 males, 9 females (1 ovig.), Twin Cay, from algae-sponge washings, 1-1.5 m, 1 Nov 1988. 1 male, 1 female (ovig.), Rack Cay, on small black sponge, 31 Oct 1988. 1 male, South Satellite Cay, *Porites*-algae-sponge washings, 1-1.5 m, 11 Nov 1988.
Previous Records. Bermuda, 0.5-4 m; Florida Keys, 18.3 m; Bahamas, 5 m; Cuba; Jamaica; U.S. Virgin Islands, 50 m; Carrie Bow Cay, Belize, 0.5-36 m; Gulf of Mexico.

Stenetrium minocule Menzies and Glynn, 1968
Material. 2 males, 6 females (1 ovig.), Pine Cay, inner fringing reef, rubble bottom, 4-5 m, 9 Apr 1989.
Previous Records. Puerto Rico

Stenobermuda acutirostrata Schultz, 1978
Material. 1 male, 1 female, Rack Cay, sponge washings, 12 April 1988. 4 females, Pine Cay, inside fringing reef, rubble-sand substratum, 4-5 m, 9 April 1989.
Previous Records. Off Bermuda, 90 m.

SUBORDER FLABELLIFERA
Family Aegidae

Rocinela signata Schioedte and Meinert, 1879
Material. 1 , Pine Cay, rubble bottom, inside inner fringing reef, 3-4 m, 9 Apr 1989. 1 female, same data, 17 Nov 1989.
Previous Records. Florida Keys, Bahamas, widespread throughout Caribbean and Gulf of Mexico, southern California to Panama and Costa Rica.

Family Cirolanidae

Calyptolana hancocki Bruce, 1985
Material. 1 female, off Pine Cay, 4 m, sand-rubble bottom adjacent to inner fringing reef, 5 Nov 1988. 1 male, off Pine Cay, inner fringing reef, sand-rubble bottom, 9-10 m, 11 Nov 1989.
Previous Records. Dominican Republic; Aruba Island; Netherlands Antilles, 43.2 m.

Cirolana parva Hansen, 1890
Material. 6 females, 17 juvs., Ft. George Cay, *Neogoniolithon* washings, 0.5 m, 18 Apr 1988. 1 male, 1 female, 7 juvs., Rack Cay, sponge washings, 12 Apr 1988. 1 female, 1 juv., New Cay, 13 Apr 1988. 4 male, 1 female, 10 juvs., Rock-a-Wash, *Neogoniolithon* washings, 0.5 m, 16 Apr 1988. 1 male, 2 juvs., Crab Hole Cay, 15 Apr 1988. 27 specimens, Twin Cay, algae-sponge washings, 1-1.5 m, 1 Nov 1988. 5 juvs., South Satellite Cay, *Porites*-algae-sponge washings, 1-1.5 m, 11 Nov 1988. 20+ specimens, Rack Cay, algae-sponge washings, 1-1.5 m, 31 Oct 1988.
Previous Records. North and South Carolina; St. Thomas and St. Croix, U.S. Virgin Islands; Andros Is., Bahamas; Puerto Rico; Jamaica; Florida Keys; Dry Tortugas; Barbados; Carrie Bow Cay, Belize; Cozumel, Mexico; Panama; intertidal to 55 m.

Eurydice personata Kensley, 1987
Material. 2 males, 3 females, 3 juvs., Pine Cay, plankton tow off north beach at night, 1.5 m, 30 Oct 1988. 1 juv., off Pine Cay, coarse sand, rubble bottom, inner fringing reef, 4 m, 3 Nov 1988.
Previous Records. Bermuda; off Georgia, 18-27 m; off South Carolina, 34 m; off Miami, Florida; Puerto Rico, 13-17 m; Bahamas, 1-2 m and surface plankton tow; Haiti; Cuba; Venezuela.

Excirolana braziliensis Richardson, 1912
Material. 5 females, 3 juv., Pine Cay, plankton tow at night off north beach, 1.5 m, 30 Oct 1988.
Previous Records. Caribbean to Brazil; Gulf of Mexico; Gulf of California to Chile.

Metacirolana halia Kensley, 1984
Material. 2 females, 2 juvs., Ft. George Cay, *Neogoniolithon* washings, 0.5 m, 18 Apr 1988. 12 females, 5 juvs., Rack Cay, 12 Apr 1988. 1 female Rock-a-Wash Cay, *Neogoniolithon* washings, 16 Apr 1988. 1 male, 8 females, Twin Cay, 1-1.5 m, algae-sponge washings, 1 Nov 1989.
Previous Records. Carrie Bow Cay, Glover's Reef, Belize; Bahamas; Jamaica; Cozumel, Mexico; intertidal to 23 m.

Metacirolana sphaeromiformis (Hansen, 1890)
Material. 9 females, 6 juvs., Ft. George Cay, *Neogoniolithon* washings, 18 Apr 1988.
Previous Records. Looe Key, Florida, intertidal reef crest; St. Thomas, U. S. Virgin Islands.

Family Corallanidae

Excorallana quadricornis (Hansen, 1890)
Material. 1 male, Grapsus Cay, algae-sponge washings, 1-1.5 m, 5 Nov 1988.
Distribution. Bermuda; St. Thomas, U.S. Virgin Islands; Jamaica; Martinique; Belize; Venezuela.

Excorallana tricornis tricornis (Hansen, 1890)
Material. 1 female, off Pine Cay, *Neogoniolithon* washings, 16 Apr 1988. 1 male, 1 female, Mud Shrimp Cay, in "lamb's wool sponge," 17 Apr 1988. 1 juv., Rock-a-Wash Cay, *Neogoniolithon* washings, 11 April 1988. 1 male, 1 juv., Rock-a-Wash Cay, algae-sponge washings, 1-1.5 m, 1 Nov 1988.
Distribution. St. Thomas and St. Croix, U.S. Virgin Islands; Cuba; Puerto Rico; Belize; Gulf of Mexico, intertidal to 55 m.

Excorallana cf. berbicensis Boone, 1918
Material. 1 female, Pine Cay, outer reef, from yellow sponge, 40 m, 5 Nov 1988.
Remarks: Stone and Heard (1989) have discussed some of the taxonomic problems and questionable records from French Guiana and Guadelope for *E. berbicensis*. Until a large series of adult specimens, especially males, from the Turks and Caicos Islands are available for study, the specific status of the Pine Cay material will remain uncertain.
Previous Records for *E. berbicensis*: Guyana (type locality); French Guiana; Guadeloupe.

Family Sphaeromatidae

Paracerceis caudata (Say, 1818)
Material. 1 male, 17 females, 15 juv., on algal mat from patch reef off Water Cay, 3-4 m, 18 Apr 1988. 1 male, 8 females, 1 juv., New Cay, 13 Apr 1988. 1 female, 1 juv., Rock-a-Wash Cay, *Neogoniolithon* washings, 16 Apr 1988. 1 female, Twin Cay, algae-sponge washings, 1-1.5 m, 1 Nov 1988. 1 female, 1 juv., Rack Cay, from small black sponge, 1-1.5 m, 31 Oct 1988.
Previous Records. New Jersey to Florida Keys; Gulf of Mexico; Bermuda; Yucatan to Venezuela; Cuba; Puerto Rico; Bahamas; Jamaica; Haiti; St. Maartens; St. Lucia, 20 cm to 127 m.

Paracerceis edithae Boone, 1930
Material. 1 male, 3 females, Rock-a-Wash Cay, from gray sponge, 1-1.5 m, 30 Oct 1988. 1 male, 2 females, Pine Cay, from sponge on fringing reef, 27-30 m, 17 Nov 1989.
Previous Records. Bahamas, 60-66 m, in vase sponge; Haiti; Puerto Rico, 20-25 m.

Family Limnoriidae

Limnoria platycauda Menzies, 1957
Material. 2 females (ovig.), Twin Cay, 1 Nov 1988.
Previous Records. Cuba; Puerto Rico to Curaçao; Cozumel, Mexico; Belize; Aldabra Atoll, Indian Ocean.

SUBORDER VALVIFERA
Family Idoteidae

Cleantioides planicauda (Benedict, 1899)
Material. 1 female, Pine Cay, in seagrass, 4 m, 9 Nov 1988.
Distribution. Maryland to Florida; Puerto Rico; Panama; Louisiana, Gulf of Mexico.

Erichsonella filiformis (Say, 1818)
Material. 2 males, Rack Cay, sponge washings, 12 Apr 1988. 2 males, 1 female, Pine Cay, New Cay, 13 Apr 1988. 2 males, South Satellite Cay, *Porites*-algae-sponge washings, 11 Nov 1988.
Previous Records. Connecticut to Florida, shallow intertidal to 55 m; Florida, Texas, Gulf of Mexico; Bahamas; Quintana Roo, Yucatan Peninsula, Mexico, 60-109 m.

SUBORDER ONISICIDEA
Family Scyphacidae

Armadilloniscus steptus Schotte and Heard, 1991
Material. 1 juv., Northeastern end of Pine Cay (Boat Dock), upper intertidal under leaves, 9 November 1989. 7 males, 6 females (5 ovig.), 19 juvs., southwestern end of Pine Cay ("Aquarium"), upper intertidal under slabs of soft carbonate rock, 1 May 1990.
Distribution. At present known only from Turks and Caicos Islands (Pine Cay).

Family Ligiidae

Ligia baudiniana H. Milne Edwards, 1840
Material. 1 male, 2 females, Grapsus Cay, supratidal and intertidal, on or under slabs of carbonate rock or shore debris, Nov 1988. 1 female (ovig.), Pine Cay, from dock, 2 Nov 1988.
Previous Records. Bermuda; Bahamas; U.S. Virgin Islands; Antigua; Carrie Bow Cay, Belize; Bonaire; Aruba; Trinidad; Tobago; Gulf of Mexico.

Family Philosciidae

Littorophiloscia culebrae (Moore, 1901)
Material. 3 females, Pine Cay, boat dock, intertidal, under dead leaves, 2 Nov 1988. 7 females (5 ovig.), same location, April 9, 1987. 2 males, 9 females (5-ovig), same location, 9 November 1989.
Previous Records. Florida; U. S. Virgin Islands; Puerto Rico; Belize.
Remarks: This species was listed under the genus *Vandeloscia* Roman, 1977 by Kensley and Schotte (1989).

DISCUSSION

Of the 45 marine isopods reported here, five species, viz. *Licranthura tuberculata, Mesanthura spongicola, Califanthura minuta, Stenetrium caicoensis,* and *Armadilloniscus steptus*, are known currently only from the northeastern Turks and Caicos Islands (see Kensley and Heard 1991 & Schotte and Heard 1991). Our Turks and Caicos collections represent considerable range extensions for many of the species collected. Four species (*Apanthura cracenta, Mesanthura punctillata, Carpias triton*, and *Munna petronastes*, known previously from the east coast of Central America (Belize), are reported for the first time since their description. This report also presents the first published records from outside of their respective type localities for *Amakusanthura significa* (Venezuela), *Mexicope kensleyi* (eastern Gulf of Mexico), *Carpias brachydactylus* (Puerto Rico), Carpias serricaudus (Puerto Rico), *Uromunna caribea* (Guadeloupe), *Stenetrium monocule* (Puerto Rico), and *Stenobermuda acutirostrata* (Bermuda). Due to inadequate material or taxonomic problems, the specific status of four taxa, *Apanthura cf. crucis, Malacanthura* sp., and *Microcharon* sp. and *Excorallana cf. berbicensis*, will require further study. The other 26 species listed, mostly flabelliferans, appear to be widely distributed in the tropical western North Atlantic and their occurrence in the Turks and Caicos was not unexpected. With exception of the five species described from the Pine Cay area (see Kensley & Heard 1991, Schotte & Heard 1991), refer to Kensley & Schotte (1989) for illustrations, keys, diagnoses, and taxonomic and zoogeographic references for the other species reported herein.

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REFERENCES CITED

Bowman, T. E., J. Yager, and T. M. Iliffe. 1985. *Speonebalia cannoni*, n. gen., n. sp., from the Caicos Islands, the first hypogean leptostracan (Nebaliacea: Nebaliidae). *Proc. Biol. Soc. Wash.* 98(2):439-446.

Buden, D. W., and D. L. Felder. 1977. Cave shrimps in the Caicos Islands. *Proc. Biol. Soc. Wash.* 90(1):108-115.

Kensley, B. and R. W. Heard. 1991. Studies on the Crustacea of the Turks and Caicos Islands, British West Indies. I. New marine isopod crustaceans from the waters surrounding Pine Cay. *Gulf Res. Rept.* 8(3): 237-246.

Kensley, B. & M. Schotte. 1989. *Guide to the Marine Isopod Crustaceans of the Caribbean.* Washington, D. C. and London, Smithsonian Institution Press, 308 pp.

Kornicker, L. S., and T. M. Iliffe. 1985. Deeveyinae, a new subfamily of Ostracoda (Halocyprididae) from the marine cave on the Turks and Caicos Islands. *Proc. Biol. Soc. Wash.* 98(2):476-493.

Schotte, M. and R.W. Heard. 1991. Studies on the Crustacea of the Turks and Caicos Islands, British West Indies. II. A new species, *Armadilloniscus steptus*, (Isopoda: Oniscidea) from Pine Cay. *Gulf Res. Rept.* 8(3):247-250.

Stock, J.H., and J. J. Vermuelen. 1982. A representative of the mainly abyssal family Pardaliscidae (Crustacea, Amphipoda) in cave waters of the Caicos Islands. Bijdragen tot de Dierkunde 52(1):332-344.

Stone, I., and R. W. Heard. 1989. *Excorallana delaneyi*, n. sp. (Crustacea: Isopoda: Excorallanidae) from the northeastern Gulf of Mexico, with observations on adult characters and sexual dimorphism in related species of *Excorallana* Stebbing, 1904. *Gulf Res. Rept.* 8(2):199-211.

Yager, J., and F. R. Schram. 1986. *Lasionectes entrichoma*, new genus, new species, (Crustacea: Remipedia) from anchialine caves in the Turks and Caicos, British West Indies. *Proc. Biol. Soc. Wash.* 99(1):65-70.

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Haustorius jayneae, a New Species of Haustoriid Amphipod from the Northern Gulf of Mexico, with Notes on Its Ecology at Panama City Beach, Florida U.S.A.

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HAUSTORIUS JAYNEAE, A NEW SPECIES OF HAUSTORIID AMPHIPOD FROM THE NORTHERN GULF OF MEXICO, WITH NOTES ON ITS ECOLOGY AT PANAMA CITY BEACH, FLORIDA U.S.A.

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ABSTRACT A new species of sand-burrowing amphipod, *Haustorius jayneae*, is described from the swash zone and shallow subtidal sands along the north Florida and Mississippi Gulf coasts. It is most similar to *H. canadensis* from the American Atlantic coast, differing primarily in the presence of a distinct anterodistal spinous lobe on pereopod 6, article 5; a longer row of distal marginal spines on pereopod 7, article 4; and fewer proximal spines on the peduncle of uropod 1. A revised key to the known species of *Haustorius* is included and information on the ecology of *H. jayneae* n. sp. at Panama City Beach, Florida, is reviewed.

INTRODUCTION

Taxonomic and zoogeographic studies of Gulf of Mexico Haustoriidae are scarce. A lack of keys for Gulf material, a reflection of the underdeveloped state of knowledge about the family in the region, has limited workers to the use of keys and guides written primarily for Atlantic coast material. As a result, government and private environmental assessment reports often provide species lists in which citations are limited to genera, or where species are listed which do not occur in the Gulf of Mexico.

Existing knowledge of the Gulf Haustoriidae is reported primarily in papers which describe new species (Pearse, 1908; Robertson and Shelton, 1978; Robertson and Shelton, 1980; Thomas and Barnard, 1984; Foster, 1989) and in several ecological papers which have reported undescribed species and recognized them as such (Thomas, 1976; Shelton and Robertson, 1981). Foster (1989) reviewed the history of haustoriid studies in the Gulf and listed the known species.

Among the numerous taxonomic problems associated with the Haustoriidae, questions concerning the type genus *Haustorius* Muller, 1775 are particularly significant. Three species are currently recognized in the genus. The type species, *Haustorius arenarius* (Slabber, 1769), is distributed in the northeastern Atlantic and has also been reported from the Gulf of Mexico (Pearse, 1912), although Croker (1967) considered such early records to be the result of erroneous identifications. The remaining two species, *Haustorius canadensis* Bousfield, 1962 and *Haustorius algeriensis* Mulot, 1967, are distributed in the northwestern Atlantic and along the North African coast in the Mediterranean Sea, respectively.

Five additional haustoriid species originally assigned to the genus *Haustorius* have since been placed in other genera. These include the Gulf of Mexico species *Pseudohaustorius americanus* (Pearse, 1908) and the North Atlantic species *Acanthohaustorius spinosus* (Bousfield, 1962), both removed from *Haustorius* by Bousfield (1965). In addition, the northern Pacific species *Eohaustorius washingtonianus* (Thorsteinson, 1941), *E. eous* (Gurjanova, 1951), and *E. cheliferous* (Bulycheva, 1952) were removed from *Haustorius* by Barnard (1957).

A number of undescribed haustoriid species are known to occur in the Gulf of Mexico. Bousfield (1970) indicated that at least ten undescribed species of Haustoriidae occur in the region, although the number of species in the type genus was not reported. In addition, recent studies have resulted in the reporting of a "long-rostrate" *Haustorius* species from North Carolina (Bousfield, 1965; Fox and Bynum, 1975). Although no formal description was published, this form is included in the key provided in this paper.

Ecological reports with reference to *Haustorius* in the northern Gulf of Mexico are numerous. For example, in the area between Cape San Blas, in the Florida Panhandle, and Mississippi Sound, the genus has been reported by Saloman (1976), Saloman and Naughton (1977;1978), Saloman et al. (1982), Taylor (1987), and Heard and Stuck (1988). Thomas (1976) also reported an undescribed species of *Haustorius* from Barataria Bay, Louisiana, occuring in fine sand from the drift line to a depth of 1 -2 meters, and Robertson and Shelton (1980) found an undescribed species in a similar habitat on the Texas coast.

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METHODS

Material for this study came from several locations along the coasts of Florida and Mississippi. These include St. Andrew Bay, Panama City Beach, Cape San Blas, and Perdido Key, Florida, as well as Horn and Ship Islands, Mississippi. In all localities, amphipods were collected in the swash zone and from tidal pools with suction devices (yabby pumps), push nets, or coring tools. See Saloman (1976) and Heard and Stuck (1988) for detailed information on localities, methodology, sedimentology, and associated fauna.

Margins of the antennae and uropods are referred to as dorsal and ventral in the text, as opposed to anterior and posterior, because of their orientation along the main axis of the body.

Haustoriidae Stebbing, 1906
Haustoriinae Bousfield, 1965
Haustorius Muller, 1775
Haustorius jayneae, new species
Figures 1 - 4

Haustorius new species: Saloman and Naughton, 1977, pp. 359-362

Haustorius species: Saloman and Naughton, 1978, pp. 67-68

Material Examined

Holotype: Female, 6.0 mm, SAB-e, St. Andrew Bay, Florida, West Pass, medium sand in wave pool above swash, 25 °C, 28 ppt, 14 Oct. 1989, USNM 250725, coll. J. M. Foster.

Paratypes: Female, 8.0 mm, SAB-a, GCRL 1141; female, 5.3 mm, SAB-b, USNM 250726; male 5.0 mm, SAB-c, USNM 250727; male, 4.0 mm, SAB-d, USNM 250728; male, 6.0 mm, SAB-f, USNM 250729; male, 7.0 mm, SAB-g, GCRL 1141; male, 5.0 mm, SAB-h, USNM 250730; female, 7.0 mm, SAB-i, USNM 250731; female, 7.0 mm, SAB-j, USNM 250732; male, 6.0 mm, SAB-k, USNM 250733, Panama City Beach, Florida, moderately sorted fine sand, swash zone, 18.0 °C, 32.70 ppt, 4 Feb. 1975, coll. C. H. Saloman. Male, 5.5 mm, CSB-a, USNM 250734; male, 6.0 mm, CSB-b, USNM 250735; female (ovg), 5.0 mm, CSB-d, USNM 250736; female, 5.0 mm, CSB-f, USNM 250737; female, 7.0 mm, CSB-g, USNM 250738, Cape San Blas, Florida, wet, intertidal fine sand with shell hash, 27.5 °C, 29 ppt, 27 Sept. 1987, coll. J. M. Foster. Male, 7.5 mm, CSB-c, USNM 250739; Cape San Blas, Florida, longshore tidal pool on moderate energy beach in fine sand, 16.8 °C, 30 ppt, 11 Mar. 1989, coll. J. M. Foster. Male, 6.0 mm, PK-d, USNM 250740; female 6.0 mm, PK-e, USNM 250741; female, 7.0 mm, PK-f, USNM 250742, Perdido Key, Florida, swash zone in medium sand, 23 July 1987, coll. R.W. Heard. Male, 10.0 mm, MISS-a, USNM 250743; female, 10.0 mm, MISS-b, USNM 250744; female, 8.0 mm, MISS-c USNM 250745, Ranger Lagoon, Horn Island, Mississippi Sound, swash zone, 25 Jan. 1989, coll. R. W. Heard.

Additional Material: 5 males, 9 females, 4 juveniles, USNM 250746; 4 males, 8 females, 1 juvenile, GCRL 1142, St Andrew Bay, Florida, West Pass, medium sand in wave pool above swash zone, 14 Oct. 1989, coll. J. M. Foster. 4 males, 5 females, 7 juveniles, USNM 250747; 31 males, 42 females (1 ovg.), 73 juveniles, USNM 250748; 7 males, 7 females (1 ovg.), 9 juveniles, GCRL 1143, Perdido Key, Florida, subtidal sand, 4-6 Oct. 1989, coll. R. W. Heard. 2 males, 1 female (ovg.), 2 juveniles, USNM 250749; 1 male, 1 female, GCRL 1144, Horn Island, Mississippi Sound, swash zone sand, 25 Jan. 1990, coll. R. W. Heard. 7 males, 4 females (3 ovg.), USNM 250750; 8 males, 3 females (2 ovg.), GCRL 1145, Ship Island, Mississippi Sound, subtidal sand, 12 July 1988, coll. R. W. Heard. 2 males, 2 females, USNM 250751; 1 male, 1 female, GCRL 1146, Ship Island, Mississippi Sound, swash zone sand, 12 July 1988, coll. R.W. Heard.

Diagnosis

Antenna 1, accessory flagellum 4-5 segmented. Rostrum short, subacute, wide at base, not exceeding midpoint of antenna 1, peduncle 1. Pereopod 5, article 6, anterior margin with 3-4 spine groups. Pereopod 6, article 4, posterior margin markedly oblique proximally, bearing 3-4 spines distally; article 5 subquadrate with distinct anterodistal spinous lobe. Pereopod 7, coxal plate with setae on posterodistal margin only; article 4, proximal margin sharply set off from posterior margin, posterior margin with 1 spine group, distolateral marginal spines extending half length of distal margin. Uropod 1, peduncle, dorsolateral margin with 1-2 proximal spines, proximal and distal spines only. Telson cleft one-third distance to base.

Description

Paratype male SAB-f, 6.0 mm, Panama City Beach, Florida

Head - Broadest medially, rostrum blunt, wide at base; slightly exceeding anterolateral apices, extending one-quarter of dorsally visible length of antenna 1, peduncle 1; antennal sinuses markedly convave.

Antenna 1 - Peduncle article 1 and 2 subequal, article 3 two-thirds length of article 2; peduncle 1, dorsolateral margin lined with plumose setae, ventrolateral margin with 4 pilose spines; peduncle 2 widened distally, dorsal margin with a row of plumose setae interspersed with shorter simple setae, lateral surface with mixed plumose

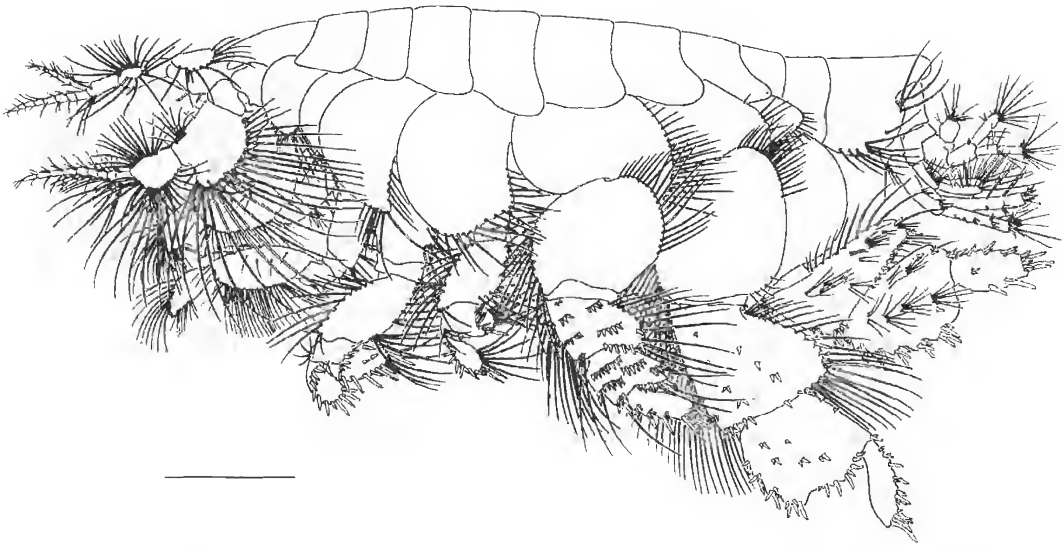

Figure 1. ***Haustorius jayneae*** **n. sp.. Lateral view of adult female (6.0 mm) from St. Andrews Bay, Florida. Scale = 1.0 mm.**

and simple setae; peduncle 3, ventral margin with row of long pilose spines inserted near articulation with flagellum; flagellum with 9 articles, each with short simple setae inserted terminally, several with aesthetsacs; accessory flagellum 4 segmented.

Antenna 2 - Peduncle 4 expanded ventrally to form deep lobe with broadly rounded distal projection, ventral margin with 22 spines inserted laterally and a row of densely plumose setae inserted medially along margin, 5 plumose spines on proximal half of ventral margin, lateral surface with row of 5 setae near proximal dorsal margin, medial surface with oblique row of 6 setae across width of article, dorsal margin with distolateral row of plumose setae, ventral margin with 2-3 thin pilose spines distally in sinus formed by distal lobe of article; article 5 slightly over half length of article 4, with strongly convex ventral lobe, ventral margin lined with long plumose setae, distoventral corner with cluster of plumes, several thin spine-like setae and 1 thick pilose spine, distolateral margin with row of thinner, shorter plumose setae and scattered slender, simple setae; distal half of dorsal margin with row of plumose setae; flagellum of 10 articles, article 1 longest, with distoventral row of plumose setae, article 2 half length of article 1 and bearing 1 distoventral plumose seta, article 3 with 1 distoventral plumose seta, remaining articles with groups of simple terminal setae.

Upper Lip - Broad, apex flattened, corners abruptly rounded.

Lower Lip - Inner lobes extending two-thirds length of outer lobes, truncate distally and finely pilose; outer lobes broadly rounded, pilose around margins, both lobes with numerous short spines along inner distal margin.

Mandible - Right side, incisor bifid, raker row of 10 distally serrate blades; molar triturative with 1 projecting plumose seta; palp article 2 with marginal and facial row of short simple setae, article 3 with 17 pectinate spines in comb row, 14 - 15 distally tapered, minutely pectinate terminal spines. Left side, lacinia mobilis short, conical.

Maxilla 1 - Inner plate with 10 sparsely plumose marginal setae; outer plate with 4 stout, smooth, blunt and 12 slender, minutely serrate, subacute distal spines; palp article 2 with marginal and apical plumose setae, and tapered terminal spines with recurved tips; bailer lobe large and densely setose.

Maxilla 2 - Inner plate linguiform, slender, with plumose marginal setae and oblique row of plumose facial setae; outer plate large, lunate, outer margin lined with fine setae, 14 stout, distally tapered comb spines medially, inner margin with 30 - 32 sparsely plumose setae distally, lined with minutely plumose setae proximally.

Maxilliped - Inner plate with 11 inner marginal setae, proximal setae short and finely pectinate on both edges, distal setae longer, plumose, apical margin with 2 blunt, stout spines, aboral surface with 2 penicillate setae and a row of distal spines, oral surface with transverse row

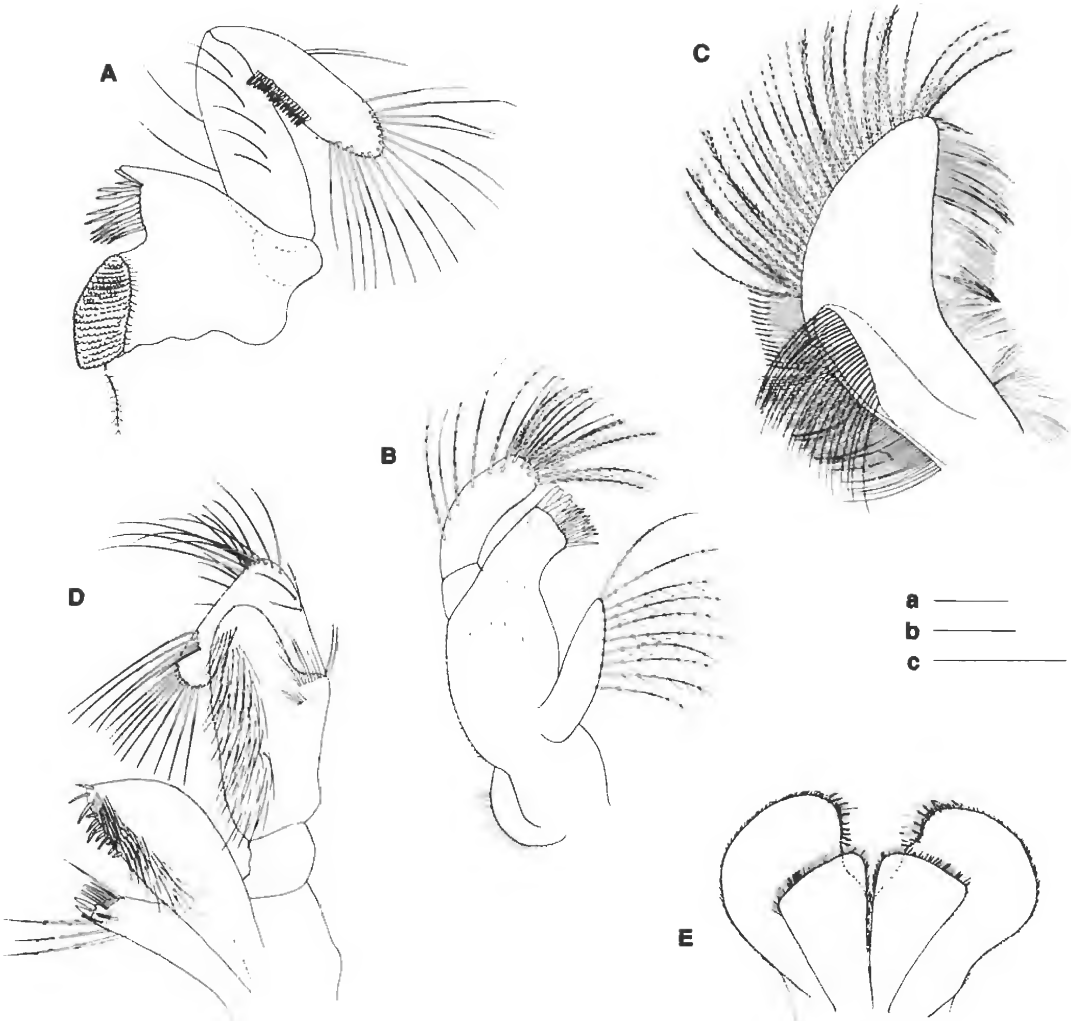

Figure 2. ***Haustorius jayneae*** **n. sp., paratype male SAB-f (6.0 mm): (A) mandible; (B) maxilla 1; (C) maxilla 2; (E) lower lip. Adult male (6.0 mm), St. Andrew Bay, Florida: (D) maxilliped. Scales: a = 0.2 mm (B-C, E); b = 0.2 mm (A); c = 0.4 mm (D).**

of distal spines; outer plate slightly broader than inner with 12 recurved spines and numerous transerve rows of setae; palp article 3 with expanded distally, dense transverse rows of setae on inner margin, article 3 geniculate with long serrate setae and simple setae on distal margin, 9 elongate spines terminally, aboral surface with central row of simple setae.

Coxal Plates - Plates 1-4 increasing in size with each successive plate, combined ventral margins forming a gentle curve.

Gnathopod 1 - Coxa deeper than wide, gently concave posteriorly with 6 plumose posterior marginal setae, posterovental angle with 3 long, plumose setae, anterodistal margin with a row of simple setae, increasing in length distally; article 2 narrowed proximally with long, widely spaced simple setae on posterior margin; article 5, posterior margin with dense clusters of long simple setae along lateral and medial surfaces; article 6 one-half length of article 5, anterodistal margin with 6 - 7 transverse rows of long, distally recurved, finely pectinate setae, posterodistal margin with 5 row of shorter, distally recurved, finely pectinate setae, posterodistal margin with 5 rows of distally recurved, finely pectinate setae; article 7 one-quarter length of article 6, projecting nail subequal in length to article 7.

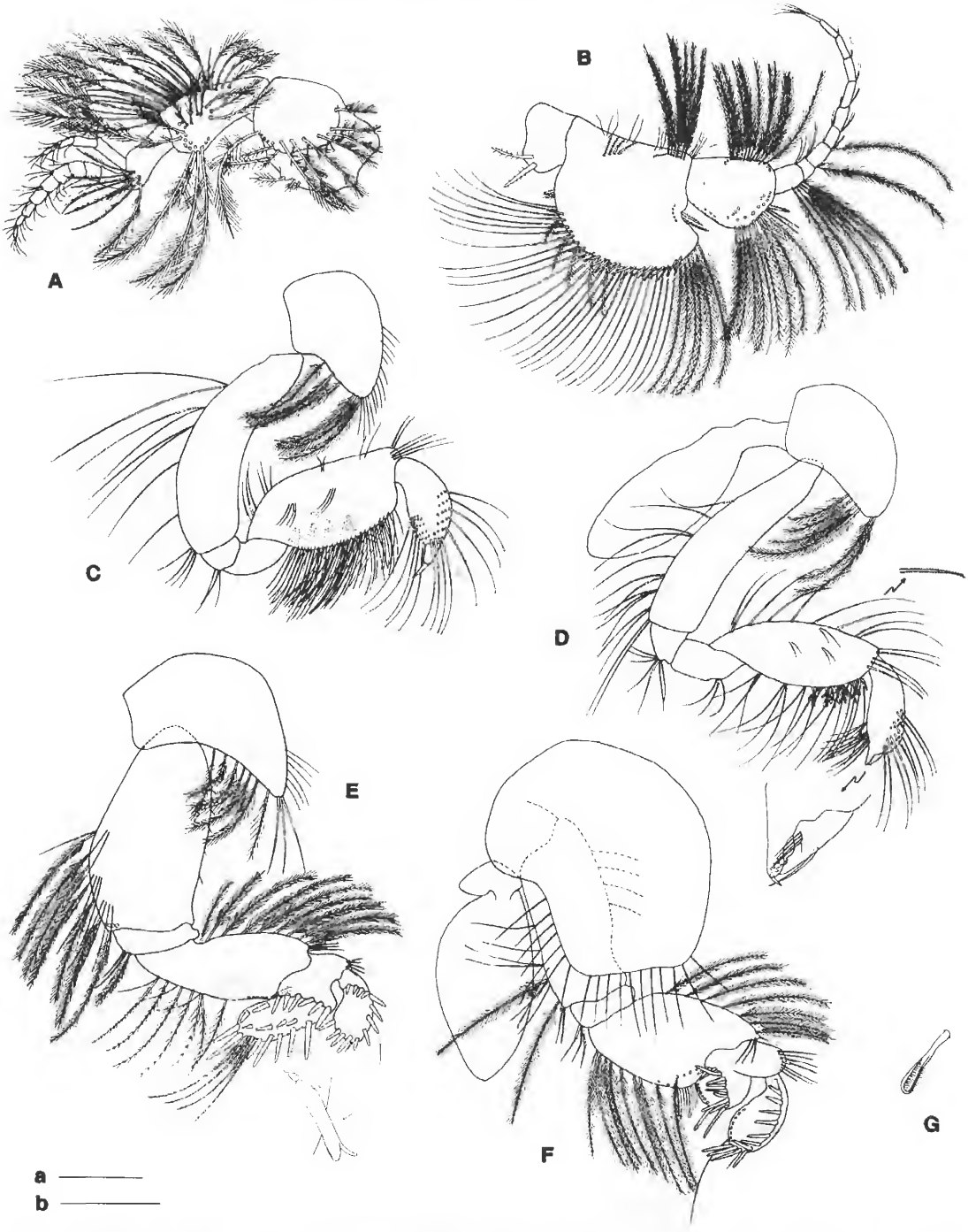

Figure 3. ***Haustorius jayneae*** **n. sp., paratype male SAB-f (6.0 mm): (A) antenna 1; (B) antenna 2; (C) gnathopod 1; (D) gnathopod 2; (E) pereopod 3; (F) pereopod 4; (G) spatulate comb spine from gnathopod 2, article 5. Scales: a = 0.5 mm (E-F); b = 0.5 mm (A-D), 0.08 mm (G).**

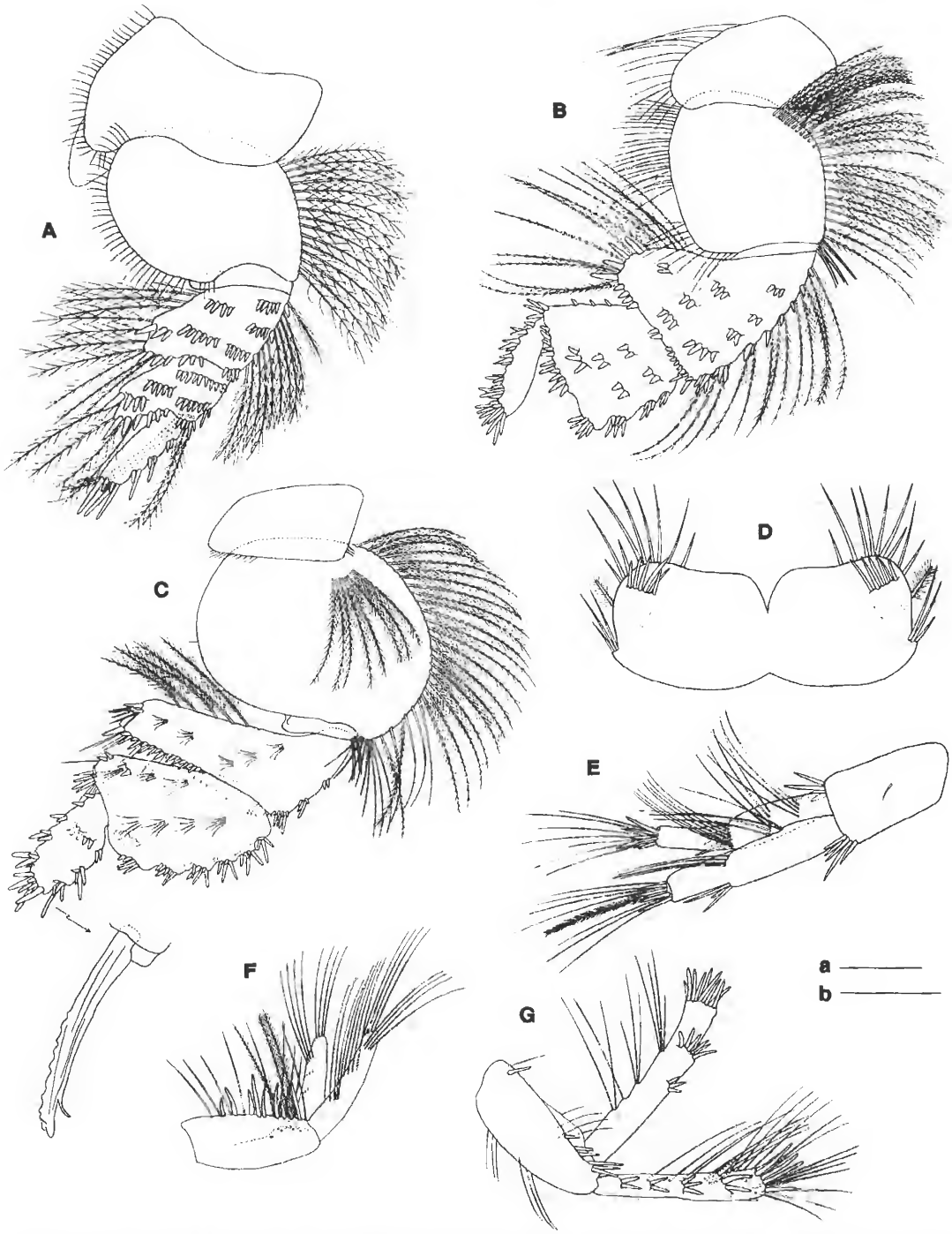

Figure 4. ***Haustorius jayneae*** **n. sp., paratype male SAB-f (6.0 mm): (A) pereopod 5; (B) pereopod 6; (C) pereopod 7; (D) telson; (E) uropod 3; (F) uropod 2; (G) uropod 1. Scales: a = 0.5 mm (A-C); b = 0.2 mm (D), 0.4 mm (E-G).**

Gnathopod 2 - Coxa deeper than wide, anterior margin convex, posterior margin nearly straight, with 6 plumose setae distally, anterodistal margin with 6 simple setae; article 2 slightly narrowed proximally with row of evenly spaced clusters of long simple setae on posterior margin; article 5, anterior margin with evenly spaced groups of minutely pectinate setae, outer lateral surface with scattered simple setae, anterodistal margin with cluster of 5 minutely pectinate setae, posterior margin with 3 - 5 groups of medially inserted, spatulate comb spines on distal half, row of simple setae along entire margin; article 6, anterior margin with 6 - 7 transverse rows of long, distally recurved, minutely pectinate setae, posterior margin with distal cluster of minutely pectinate setae, posterodistal margin strongly produced, dactyl toothed on flexor surface, closing on posterodistal process of article 6 to form chelate gnathopod.

Pereopod 3 - Coxa strongly convex anteriorly, posterior margin with 7 plumose setae, posterodistal angle with 3 long, simple setae, anterodistal margin with 6 shorter simple setae; article 2, distal half of posterior margin with several groups of simple setae along lateral surface, long plumose setae and several thin simple setae, posterodistal margin with 5 plumes and 1 short simple seta, anterior margin with 5 short, scattered setules; article 4, anterior margin lined with 9 plumose setae, anterodistal angle with a cluster of 3 simple setae, posterior margin with 6 groups of long plumose setae and short simple setae proximally, distal portion of posterior margin with a dense cluster of much longer plumose setae and 3 short simple setae; article 5 with a cluster of 5 - 6 simple setae on anterodistal margin, posterior lobe ovate, lined with 15 stout spines, some with accessory setules, lateral surface of lobe with 4 stout spines, posterior margin with 4 - 5 long plumose setae; article 6 subrectangular with 13 stout spines and 1 small seta on anterior and distal margins, posterior margin bare.

Pereopod 4 - Coxa broad, anterior margin strongly convex, posterior margin with strongly angular lobe, lined with simple setae; article 2 short with 4 short simple setae on anterior margin, posterior margin with 6 simple setae and 2 long plumed setae, posterodistal angle with 2 minutely pectinate setae; article 3 with 3 posterodistal minutely pectinate setae; article 4 lined with posterior marginal plumose setae and several scattered simple setae, posterodistal angle with 8 simple setae and a lateral row of 4 plumose setae, anterior margin lined with plumose setae, anterodistal angle with 2 simple and 3 minutely pectinate setae; article 5 with posteriorly directed circular lobe fringed with 11 stout spines and 7 long simple setae; article 6 with 11 stout anterior marginal spines, 7 long simple posterodistal marginal setae and 1 distal marginal setule.

Pereopod 5 - Coxa broad, posterior lobe slightly deeper and narrower than anterior, posterior margin lined with simple setae; article 2, posterior margin lined with simple setae, anterior margin lined with plumose setae with several short setules proximally; article 4 with plumose setae on posterior margin, anterior margin with 3 stout marginal spines interspersed in a row of plumose setae, anterodistal margin with a cluster of 4 spines, distal margin with a row of 6 spines, lateral surface with 6 clusters of 3 - 6 stout spines, medial surface with clusters of plumose setae; article 5, distomedial margin with cluster of long plumose setae, posterior half of distal margin with a row of 6 stout spines, posterodistal margin lined with plumose setae, anterior margin with 1 cluster of 2 spines, anterodistal angle with cluster of 5 spines, lateral surface with 4 clusters of 4 - 10 stout spines; article 6 naked posteriorly, anterior margin with 3 clusters of 2 - 4 stout spines, terminally with 3 long and 2 short spines and 1 short plumose setule.

Pereopod 6 - Coxa rounded posteriorly, posterior margin lined with simple setae; article 2 subquadrate, posterior margin lined with simple setae proximally and distally, bare gap in center (present on most specimens), anterior margin with row of plumose setae and with row curving across lateral surface proximally, anterodistal margin with 3 long, pectinate setae; article 4 subtrianglular, longer than broad, anterior margin lined with dense plumose setae occuring in medially placed diagonal rows, marginal spines stout, short, occuring in groups of 1 to 4, medial anterodistal angle with 1 long spine and numerous plumed setae, lateral anterodistal angle with 1 long spine, distolateral margin with 8 spines in row extending about one-quarter length of margin, center distal margin with a group of 2 spines, posterior distolateral margin with row of 4 spines, posterior margin with 4 stout spines and a row of plumose setae, proximal section of margin narrowing abruptly, lateral surface with clusters of 2 - 4 spines; article 5 subquadrate, slightly wider than long with defining lobe at anterodistal angle, anterior margin with 3 groups of 3 - 6 spines, anterodistal lobe with 5 spines, distal margin with central row of 12 spines, posterodistal angle with cluster of 4 spines, posterior margin with 3 spines, lateral surface with 5 groups of 1 - 3 spines, article 6 naked anteriorly, posterior margin with 5 groups of 2 - 5 spines, terminal spines 10.

Pereopod 7 - Coxa small, posterior lobe subacute, with simple setae on distal margin; article 2 ovate, with a cluster of proximal plumose facial setae, anterior margin lined with plumed setae, distal half of margin with 4 distally tapered pectinate setae, anterodistal angle with 9 pectinate setae, posterior margin with scattered short setules, or bare; article 4 much broader than long, proximal and distal margins nearly parallel posteriorly, widening anteriorly, anterior margin twice length of posterior with 2 groups of 2 - 4 spines, anterodistal angle with 8 spines, proximal margin lined with plumose setae, posterior margin with cluster of 1 long and 2 short stout spines, 1 long plumose setae (broken off), 5 pectinate setae, posterodistal angle with 1 stout spine, distomedial margin with row of 16 spines, distolateral margin with row of 10 spines extending over half the length of distal

margin, lateral and medial surfaces with scattered clusters of long setae; article 6, posterior margin with distal cluster of 2 stout spines and 1 pectinate seta, posterodistal angle with 2 short lateral spines, row of 4 longer medial spines, cluster of simple setae on medial margin, posterior facial spines 2, anterior marginal spines in 6 groups of 5 - 7 spines each, medial surface with oblique row of 4 spines near anterodistal margin, lateral and medial surfaces with numerous clusters of simple setae; article 6 anterior marginal spines in 3 groups of 2 - 4 spines each, posterior marginal spines in 4 groups of 1 - 4 spines each, medial surface with 1 group of 3 spines, lateral surface with 1 group of 2 spines, terminal spines 7.

Pleopods - Pleopod 1, outer ramus with 15 segments, inner with 12; pleopod 2, outer ramus with 17 segments, inner with 12; pleopod 3 outer ramus with 16 segments, inner with 13.

Pleosome - With characteristics of the genus.

Uropod 1 - Ventromedial margin of peduncle with 2 clusters of simple setae, dorsal margin with 1 simple seta and 1 stout spine proximally, 3 stout spines distally, interramal area with 3 spines; outer ramus shorter than inner with lateral spine groups 2-2-3-4, medial surface with 5 groups of long simple setae, increasing in number distally, terminal spines 6; inner ramus, ventrolateral marginal spines on distal half in 2 groups of 3 - 7 spines each, dorsal margin with 4 groups of simple setae, terminal spines 9.

Uropod 2 - Dorsolateral margin of peduncle with a row of slender spines of varying lengths interspersed with long simple setae, dorsomedial margin of peduncle with distal cluster of long plumose setae; outer ramus slightly longer than inner, lateral surface with 3 clusters of long simple setae, terminal group of long setae; inner ramus similar.

Uropod 3 - Peduncle with 9 (5 medial, 4 lateral) spines; rami subequal, inner ramus with distal group of 3 spines on medial margin, 2 groups of long simple setae on lateral margin, terminally with 5 spines, numerous long, simple setae, 1 plumed seta; outer ramus 2-segmented, proximal segment with 2 dorsomarginal and 1 dorsodistal groups of simple setae, 6 distoventral spines, distal segment slightly shorter than proximal segment, thinner, with 7 terminal spines, numerous long simple setae.

Telson - Cleft one-third distance to base, lobes subrectangular with small proximolateral lobes bearing 3 spines, distal margin with 9 spines, submarginal cluster with 6 spines, dorsal surface with 1 long and 1 short penicillate seta on each lobe.

Holotype Female SAB-e, 6.0 mm, St. Andrew Bay, Florida

Similar to male except for the following:

Oostegites - Slender, increasing in length posteriorly on pereopods 2 - 4, very small on pereopod 5, marginal setae elongate, simple.

Distribution

Haustorius jayneae occurs along sand beaches from Cape San Blas, Florida (Gulf County) to Mississippi Sound. It inhabits tidal pools and the swash zone seaward to a depth of two meters; however, most individuals occur in depths less than one foot.

Ecology

At Panama City Beach, Florida, monthly densities of *Haustorius jayneae* and its distribution across the nearshore zone were studied for a period of years by Saloman (1976) and Saloman and Naughton (1977;1978;1984). The swash zone population was shown to be the greatest in March and April of 1974-1975 with similar peaks during May and June of 1976. In a series of stations, beginning in the swash zone, extending through a series of sand bars, and terminating at a depth of 9.1 meters, *H. jayneae* occurred primarily in the swash zone and on the first sand bar (5.5% and 8.8% of all organisms collected, respectively). No specimens were recovered from the 9.1 meter station. This conforms to the pattern observed by Sameoto (1969) for *H. canadensis* at Sippewisett, Massachusetts, in that greatest densities are found in areas of complete saturation at low tide, such as sand bars. Juveniles were present during all months and ovigerous females were present in all samples examined except those from January and May.

The study area displayed an annual temperature variation of 19.0 to 32.1 °C and had an average salinity of 31.8 ppt. The sediments consisted of 99-100% quartz sand (Saloman, 1976). During a later nine month study in the same area, *H. jayneae* comprised 16.5% of the total population of organisms recovered from the swash zone, 55% of the Crustacea and 99% of the Amphipoda. At the first sand bar, *H. jayneae* comprised 34.1% of all organisms, 47% of Crustacea, and 93% of Amphipoda. May and June were peak population periods (Saloman and Naughton, 1984).

Saloman et al. (1982) investigated the macroinfauna of vegetated and unvegetated sediments within St. Andrew Bay and reported an undescribed *Haustorius* from four localities. While those specimens were not available for study, one of the stations conformed to the type locality of *H. jayneae*. The locality, at West Pass of St. Andrew Bay, was unvegetated 100% sand.

Etymology

This species is named in honor of Jayne E. Foster, whose patience and support for this project are greatly appreciated.

Variation

Within the samples examined from four locations on the northern Gulf coast, *H. jayneae* showed minor intra-

specific variation (Table 1). Minor variations were observed in the number of accessory flagellum segments, spination of the pereopods, and the spination of the dorsolateral margin of the peduncle of uropod 1. There was also a trend toward an increase in the number of spines in all areas with increasing animal size. This variability is to be expected in highly spinous fossorial forms such as the Haustoriidae (Thomas and Barnard, 1984).

Remarks

Haustorius jayneae is most closely related to *H. canadenis* Bousfield, 1962 from the American Atlantic coast. Major morphological differences between it and other known species are shown in the key and in Tables 2 and 3.

KEY TO THE KNOWN SPECIES OF *HAUSTORIUS*
(Modified from Bousfield, 1973)

TABLE 1

Intraspecific Variation in Selected Characters of *Haustorius jayneae*

	Size Groupings of Paratypes				
Character	4.0–5.0mm	5.1–6.0mm	6.1–8.0mm	8.41–10.0mm	Overall Range
	Range (Mean)				
Antenna 1, # accessory flagellum segments	4 (4.0)	4 (4.0)	4–5 (4.1)	4–5* (4.5)	4–5
Mandible palp 3, # comb spines	11–17 (13.0)	12–20 (16.1)	16–20 (16.6)	22–23 (22.5)	12–23
Pereopod 5, article 4, # posterodistal spines	5 (5.0)	5–8 (6.4)	5–9 (6.8)	6–7 (6.5)	5–9
Pereopod 5, article 6, # anterior marginal spine groups	3 (3.0)	3 (3.0)	3–4** (3.3)	3 (3.0)	3–4
Pereopod 6, article 4, # posterodistal spines	5–6 (5.3)	4–8 (6.3)	6–9 (7.6)	6–10 (8.0)	4–10
Pereopod 7, article 4, # long medial posterior marginal spines	1 (1.0)	1 (1.0)	1 (1.0)	1 (1.0)	1
Pereopod 7, article 4, # posterodistal spines	6–8 (6.8)	6–11 (8.6)	9–18 (12.0)	9–10 (9.5)	6–18
Pereopod 7, article 5, # anterior marginal spine groups	6 (6.0)	6–7 (6.3)	6–7 (6.4)	7 (7.0)	6–7

* Two specimens, MISS-b and MISS-c had 5 segments
** One specimen, PK-f had 4 groups

TABLE 2

Comparison of *Haustorius jayneae* and *Haustorius canadensis*

Character	*H. canadensis*	*H. jayneae*
Rostrum	Acute, less broad basally	Subacute, triangular, wide at base
Pereopod 5, article 6	4–5 anterior marginal spine groups	3, occasionally 4 spine groups
Pereopod 6, article 4	Long posterior margin before proximal narrowing, 6 posterior spines	Shorter posterior margin, more distal point of proximal narrowing, segment triangular, 3 posterior spines
Pereopod 6, article 5	Anterior margin rounded gently to distal margin without clear anterodistal angle, 6 spine groups along curve	Article subquadrate with a distinct anterodistal defining lobe, lobe with a cluster of 3 spines, distal and anterior spines present
Pereopod 7, coxal plate	Setae along entire posterior margin	Setae on posterodistal margin only
Pereopod 7, article 4	Spines on distolateral margin limited to posterior one-fourth of margin, closely spaced	Spines on distolateral margin more widely spaced and extending at least one-half length of margin
Uropod 1, peduncle	3–4 proximal spines, and 1–2 proximal setae	1–2 proximal spines and occasionally 1 proximal seta

1. Uropod 1, dorsolateral margin of peduncle lined throughout out with stout spines; pereopod 7, article 4, proximal margin rounding, continuous with posterior margin; EUROPEAN SPECIES.....2

Uropod 1, dorsolateral margin of peduncle with proximal and distal groups of spines; pereopod 7, article 4, proximal margin sharply set off from posterior margin; AMERICAN SPECIES..... 3

2. Accessory flagellum 4+ segmented; pereopod 7, posterior margin of article 4 with 3-4 stiff spine groups ..... *H. arenarius* (Slabber)

Accessory flagellum 3-segmented; pereopod 7, proximal and posterior margin of article 4 lined continuously with long stiff setae ..... *H. algeriensis* Mulot

3. Rostrum very long, extending to the end of antenna 1, peduncle segment 1 ..... *Haustorius* "long rostrate form"

Rostrum short, not exceeding midpoint of antenna 1, peduncle segment 1 4

4. Pereopod 6, article 5, anterodistal angle broadly rounding; pereopod 7, coxal plate with setae along entire posterior margin, article 4, distolateral marginal spines limited to posterior quarter of distal margin ..... *H. canadensis* Bousfield

Pereopod 6, article 5, anterodistal angle with defining lobe bearing a spine cluster; pereopod 7, coxal plate with setae on posterodistal margin only, article 4, distolateral marginal spines extending to mid-margin ..... *H. jayneae* n. sp.

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TABLE 3

Comparison of Selected Characters of the Known Species of *Haustorius*

Character	*H. jayneae*	*H. canadensis* Bousfield, 1962	*H. arenarius*[2] (Slabber, 1769)	*H. algeriensis*[1] Mulot, 1967
Antenna 1, # accessory flagellum segments	4–5	4	3–5	3–4
Rostrum length relative to dorsally exposed peduncle of antenna 1	20%	20%	Less than 20%	Undetermined
Shape of rostrum	Subacute	Acute	Subacute	Undetermined
Maxilla 2, outer plate, distal shape	Subacute	Subacute	Acute	Sharply rounded
Pereopod 5, article 4, # anterior spines	2–4	4	4	1
Pereopod 5, article 6, # anterior marginal spine groups	3–4	4–5	3–4	3
Pereopod 6, article 4, width as % length	75%	67%	70%	66–70%
Pereopod 6, article 5, shape of anterodistal margin	Anterodistal lobe with spine group	Broadly rounded without lobe	Angular, but without lobe	Rounded
Pereopod 7, article 4, distolateral spine locations	Posterior to center of distal margin	Posterior distal margin	Posterior and center of distal margin	Posterior distal margin
Uropod 1, peduncle spine locations	Proximal and distal only	Proximal and distal only	Entire margin	Entire margin

[1]Derived from Mulot (1967) and Bellan-Santini (1989)
[2]Based upon material from U.S. National Museum and British Museum of Natural History and Lincoln (1979)

REFERENCES CITED

Barnard, J.L. 1957. A new genus of haustoriid amphipod from the northeastern Pacific Ocean and the southern distribtution of *Urothoe varvarni* Gurjanova. *Bull. S. Calif. Acad. Sci.* 56: 81-84.

Bellan-Santini, D. 1989. Family Haustoriidae. In: The Amphipoda of the Mediterranean. Part 2. Gammaridea (Haustoriidae to Lysianassidae) (S. Ruffo, ed.). *Mem. Inst. Oceanographique*, Monaco, No. 13: 365-384.

Bousfield, E.L. 1962. New haustoriid amphipods from the Canadian Atlantic region. *Bull. Nat. Mus. Canada* 183: 63-75.

Bousfield, E.L. 1965. Haustoriidae of New England (Crustacea: Amphipoda). *Proc. U.S. Nat. Mus.* 117(3512): 159-240.

Bousfield, E.L. 1970. Adaptive radiation in sand-burrowing amphipod crustaceans. *Chesapeake Sci.* 11(3): 143-154.

Bousfield, E.L. 1973. *The shallow water gammaridean amphipods of New England.* Comstock Pub. Associates, 312 pp.

Bulycheva, A I. 1952. Novye vidy bokoplavov (Amphipoda: Gammaridea) iz Japonskogo Morja. Akad. Nauk SSSR, Trudy Zool. Inst. 12: 195-200.

Croker, R.A. 1967. Niche diversity in five sympatric species of intertidal amphipods (Crustacea: Haustoriidae). *Ecol. Mono.* 37(3): 173-200.

Foster, J.M. 1989. *Acanthohaustorius uncinus*, a new species of sand-burrowing amphipod from the northern Gulf of Mexico, with notes on its ecology (Haustoriidae: Haustoriinae). *Gulf Res. Rept.* 8(2): 189-197.

Fox, R.S. and K.H. Bynum. 1975. The amphipod crustaceans of North Carolina estuarine waters. *Chesapeake Sci.* 16(4):223-237.

Gurjanova, E. 1951. Amphipoda-Gammaridea of the seas of the USSR and adjoining waters - Keys to the fauna of the USSR. *Zool. Inst. Acad. Sci. USSR*, No. 41, 1029 pp. (in Russian)

Heard, R.W. and K. Stuck. 1988. Study of the composition and dynamics of the brackish and marine macroinvertebrates

of Horn and Ship Islands, Mississippi, and Perdido Key, Florida. Final Report, Contract No. CX1600-3-0005, Department of Interior, National Park Service.

Hopkins, T.S., Valentine, J.F. and L.B. Lutz. 1989. An illustrated guide with key to selected benthic invertebrate fauna of the northern Gulf of Mexico. Alabama-Mississippi Sea Grant Consortium, MASGP-87-010, 163 pp.

Lincoln, R.J. 1979. *British marine Amphipoda: Gammaridea.* British Museum (Natural History), 658 pp.

Mulot, M. 1967. Description d'*Haustorius algeriensis* n. sp. (Amphipoda: Haustoriidae). *Bull. Soc. Zool. France* 92(4): 815-826.

Pearse, A.S. 1908. Descriptions of four new species of amphipodous Crustacea from the Gulf of Mexico. *Proc. U.S. Nat. Mus.* 34(1936): 369-379.

Robertson, P.B. and C.R. Shelton. 1978. Two new species of haustoriid amphipods (Crustacea: Amhipoda) from the northwestern Gulf of Mexico. *Contrib. Mar. Sci.* 21: 47-62.

Robertson, P.B. and C.R. Shelton. 1980. *Lepidactylus triarticulatus* n. sp., a new species of haustoriid amphipod from the northern Gulf of Mexico. *Gulf Res. Rept.* 6(4): 415-420.

Saloman, C.H. 1976. The benthic fauna and sediments of the nearshore zone off Panama City Beach, Florida. U.S. Army Corps of Engineers Res. Center, Interservice Support Agreement No. 76-10, 256 pp.

Saloman, C.H. and S.P. Naughton. 1977. Effect of Hurricane Eloise on the benthic fauna of Panama City Beach, Florida, U.S.A. *Mar. Biol.* 42 (4): 357-363.

Saloman, C.H. and S.P. Naughton. 1978. Benthic macroinvertebrates inhabiting the swash zone of Panama City Beach, Florida. *Northeast Gulf Sci.* 2: 65-72.

Saloman, C.H. and S.P. Naughton. 1984. Beach restoration with offshore dredged sand: effects on nearshore macroinfauna. NOAA Administration Tech. Memo., NMFS-SEFC-133, 20 pp.

Saloman, C.H., Naughton, S.P., and J.L. Taylor. 1982. Benthic faunal assemblages of shallow water sand and seagrass habitats, St. Andrew Bay, Florida. U.S. Fish Wildl. Ser., Div. Ecolog. Ser., Panama City, Florida, 565 pp.

Sameoto, D.D. 1969. Comparative ecology, life histories, and behavior of intertidal sand-burrowing amphipods (Crustacea:Haustoriidae) at Cape Cod. *J. Fish. Res. Bd. Canada* 26(2): 361-388.

Shelton, C.R. and P.B. Robertson. 1981. Community structure of intertidal macrofauna of two surf-exposed Texas sandy beaches. *Bull. Mar. Sci.* 31(4): 833-842.

Taylor, J.L. 1987. Michigan Avenue sewer outfall environmental monitoring study. Fina Report to Panama City, Florida Engineering Department, Taylor Biological Company, Lynn Haven, Florida.

Thomas, J.D. 1976. A survey of gammarid amphipoda of the Barataria Bay, Louisiana region. *Contrib. Mar. Sci.* 20: 87-100.

Thomas, J.D. and J.L. Barnard. 1984. *Acanthohaustorius pansus*, a new species of sand-burrowing amphipod from Looe Key Reef, Florida Keys, with redescription of *A. bousfieldi* Frame, 1980 (Amphipoda: Haustoriidae). *Proc. Biol. Soc. Wash.* 97(4): 909-926.

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New Sandhoppers (Crustacea: Amphipoda) from the Gulf Coast of the United States

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NEW SANDHOPPERS (CRUSTACEA: AMPHIPODA) FROM THE GULF COAST OF THE UNITED STATES

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ABSTRACT Three species of sand-burrowing semi-terrestrial amphipod crustaceans are newly described from sandy beaches of the North American coast of the Gulf of Mexico. They (and two related species from the open Atlantic coast of North America) are removed from the genus *Talorchestia* Dana 1853, and placed in a new genus, *Americorchestia*. *Americorchestia salomani*, new species, and *A. heardi*, new species, occur from northwestern Florida to the Mississippi Delta. They are morphological counterparts of the well-known sandhoppers from the open Atlantic coast, *A. megalophthalma* (Bate) and *A. longicornis* (Say) respectively. *Americorchestia barbarae*, new species, related to *A. salomani*, occurs on open beaches west of the Mississippi Delta. Sandhopper species of the Gulf coast are smaller, have different food resources available to them, and are exposed to different physical and biological survival factors than their counterparts from the North Atlantic coastal region.

Introduction

The intertidal talitrid amphipod fauna of the North American Atlantic region has been generally known for some time (e.g. Holmes, 1904; Bousfield, 1958, 1973). From the coast of the Gulf of Mexico, studies on palustral talitrids, beach fleas, and landhoppers of the genera *Uhlorchestia*, *Chelorchestia*, *Tethorchestia*, *Platorchestia*, and *Talitroides* have been made principally by Shoemaker (1936), Bousfield (1984), and Bousfield and Heard (1986). However, very few records and no detailed studies have been made on primary sandhoppers of this region. This hiatus is now being filled on the basis of material collected personally from various Gulf coast beaches since 1963, and specimens on loan from other sources. In this material, that had provisionally been assigned to the genus *Talorchestia* (sens. lat.), the writer has identified three distinct new species of sandhoppers. Analysis of the systematics and distributional-ecology of these and related species form the basis of this report.

Systematics

Family Talitridae Stebbing 1906 emend Bulycheva 1957

Taxonomic commentary: Bousfield (1984) divided the family into four semi-phyletic but essentially pragmatic (morphological-ecological) groups. His study encompassed the primitive palustral group, the more advanced landhopper group, and the most advanced beachflea group. The sandhopper group was left untreated, but like the other three groups, it appears to be polyphyletic, and comprised of at least two major subgroups. In his initial treatment of the sandhopper group, based mainly on North American Pacific species, Bousfield (1982) more fully defined some of the existing genera including *Orchestoidea* Nicolet, *Megalorchestia* Brandt, and *Talitrus* Bosc. He formally proposed the new genera *Trinorchestia*, with a single northwestern Pacific species, and *Pseudorchestoidea*, consisting mainly of slender-bodied, tropical and warm-temperate species, and hinted that other species groups would be formally recognized later. Most of these undesignated species groups have, until very recently, been lumped under the name *Talorchestia* Dana. Morino and Miyamoto (1988), however, have restricted this name quite properly to a group of slender-bodied tropical Indo-Pacific species of which *T. gracilis* Dana is the type. The writer has therefore elevated the group of relatively large, stout-bodied, North American Atlantic species, also formerly assigned to the genus *Talorchestia*, to a newly proposed genus, *Americorchestia*, as described and keyed below.

KEY TO NORTH AMERICAN GENERA OF SAND-BURROWING TALITRIDAE*

1. Gnathopod 1 (both sexes), propod with distinct palm, dactyl not projecting past it in male; uropods 1 & 2, peduncles and rami weakly spinose, margins with 0-4 spines only; uropod 3 short, ramus cylindrical, tapering, apex sub-acute..... *Platorchestia* Bousfield

*Genera *Megalorchestia*, *Pseudorchestoidea*, *Platorchestia*, *Talorchestia* and *Americorchestia*, partly after Bousfield, 1982.

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Gnathopod 1, palm of propod lacking in female, lacking or small and greatly surpassed by dactyl in male; uropods 1 & 2, peduncles and rami usually very strongly spinose, margins with 5-15 spines (rarely fewer); uropod 3, ramus laterally compressed, not tapering, apex rounded.....2.

2. Gnathopod 1 (both sexes), propod lacking distinct palm, but (in male) may have a small postero-distal blister greatly surpassed by the dactyl; telson usually short, wider than long, apex entire, rarely notched.....3.

Gnathopod 1 in female, palm of propod lacking, in male, with small but distinct palm, in addition to a postero-distal tumescence or blister; telson slightly longer than broad, apically notched .....4.

3. Pleopod rami very reduced, 1-3 segmented, shorter than basally broadened peduncles; peraeopod 5, dactyl normal in size and form; peraeopods 6 & 7 stout, heavily spinose, subequal in length .....*Megalorchestia* Brandt (N. Pacific coast).

Pleopod rami slightly reduced, multi-segmented (4-12 segments) peduncles slender; peraeopod 5, dactyl very shortened and basally swollen, nail minute; peraeopods 6 & 7 slender, normally spinose, P7 distinctly the longer .....*Pseudorchestoidea* (Central Pacific coast).

4. Body small, slender (males 11-14 mm); uropod 1, outer ramus usually lacking marginal spines; uropod 2, rami subequal, weakly spinose; uropod 3, ramus shorter than peduncle.....*Talorchestia* Dana (Caribbean shores and Indo Pacific).

Body large, robust (males 14-25 mm); uropod 1, outer ramus usually with numerous stout marginal spines; uropod 2, outer ramus distinctly the shorter, strongly spinose; uropod 3, ramus usually longer than peduncle.....*Americorchestia* (N. Atlantic and Gulf Coasts)

Americorchestia, new genus

Talorchestia Stebbing, 1906, p. 257 (partim)
Barnard, 1969, p. 472 (partim)
Bousfield, 1973, p. 162 (partim)

Component species

Americorchestia longicornis (Say, 1817) - TYPE SPECIES
A. heardi, new species
A. megalophthalma (Bate, 1862)
A. salomani, new species
A. barbarae, new species

Diagnosis

Medium to large, heavy bodied, large eyed, strongly sexually dimorphic, fossorial talitrids. Eyes usually very large, often bulging from the lateral head margins.

Antenna 1: Short, not reaching peduncle 5 of antenna 2, peduncular segment 2 not longer than 3.

Antenna 2 (male): Strongly developed, elongate, distal flagellar segments often toothed.

Buccal mass: Medium-deep, not prognathous.

Mandible: Left lacinia 5-dentate.

Maxilliped: Palp, segments 2 & 3 short, broad, spinose, segment 2 with pronounced disto-medial lobe, segment 4 lacking.

Coxa 1: Short, with inner spinose "shelf" anterior to junction with basis; coxae 2-4 medium-deep, hind marginal cusps weak.

Gnathopod 1: Strong, spinose, fossorial; propod (male) with small but distinct palm, exceeded by dactyl, postero-distal "blister" or tumescence conspicuous on propod and carpus, faint or lacking on merus; propod (female) totally lacking palm, distal segments without postero-distal tumescence.

Gnathopod 2 (male): Very strongly subchelate, powerful; palm of propod oblique, convex, or with tooth-like prominence near hinge.

Gnathopod 2 (female): Small, basis broadly expanded anteriorly; propod mitten-shaped, shorter than carpus; merus usually lacking posterior lobe.

Peraeopods 3 & 4: Dactyls slender, 4th contricted behind.

Peraeopod 5: Short; coxa broad, shallow; basis broad; segments 4, 5, and 6 subequal, 4 slightly expanded or thickened behind, 5 & 6 may have anterior marginal club-shaped spines; dactyl not shortened or modified.

Peraeopods 6 & 7: Elongate, sub-equal; bases broad, rounded behind, regular; dactyls slender, smooth.

Pleon plates 1-3: Regular, hind corners weakly acuminate.

Pleopods: Rami multi-segmented, little shortened or modified; peduncle slightly broadened, esp. basally, outer margin spinose.

Uropods 1 & 2: Stout, ramal margins strongly spinose.

Uropod 1: Pre-peduncle short, rami and peduncles subequal, outer ramus marginally spinose, ramal apical spines may be spade-shaped.

Uropod 2: Outer ramus distinctly the shorter.

Uropod 3: Ramus laterally compressed, longer than peduncle, rounded apically, margins spinose.

Telson: Short, broad, apically notched, distally spinose.

Coxal gills: Small, sac-like on P3-5, longer but sinuous on P2 and P6.

Brood plates-Medium-broad, margins with numerous simple setae.

Etymology

A combining form denoting generic endemicity to North America.

Relationships

Americorchestia differs from other genera of sand hoppers by characters provided in the generic key (below). It is clearly separable from *Talorchestia* Dana (as revised by Morino & Miyamoto 1988) in the large heavy body, short peduncular segment 2 of antenna 1, elongate dactyls of peraeopods 3 & 4, subequal peraeopods 6 & 7, spinose broadened pleopod peduncles, heavily spinose uropod rami that are markedly unequal in uropod 2, and elongate ramus of uropod 3 (longer than peduncle).

In balance of character states, *Americorchestia* appears most closely similar to *Trinorchestia* and to the "*Talorchestia*" *sinensis* group of the northwestern Pacific region. It is less closely related to other primary sandhopper genera such as *Pseudorchestoidea*, *Talorchestia*, and *Megalorchestia*. It is remote from *Talitrus*, *Orchestoidea*, and other undesignated groups that are centred mainly in the southern hemisphere, and from beachhopper groups such as *Platorchestia* that may secondarily be classified as sandhoppers (see Bousfield 1982).

KEY TO NORTH AMERICAN ATLANTIC SPECIES OF AMERICORCHESTIA*

1. Peraeopod 5, segment 6 distinctly longer than 5, with 4-6 (5) groups of anterior marginal spines, segment 4 subtriangular, widest distally; pleon plate 1, lower margin continuous with hind margin; eyes not bulging from sides of head (viewed dorsally); uropod 2, inner margin of outer ramus lacking spines; pleopod rami weak, 10-segmented ..... *longicornis* group 2.

   Peraeopod 5, segment 6 not distinctly longer (usually shorter) than segment 5; segment 4 sub-rectangular, not broadening distally; pleon plate 1 with weakly acuminate hind corner; eyes very large, prominently bulging from sides of head; uropod 2, inner margin of outer ramus usually armed with short spines; pleopods normally developed, not reduced ..... *megalophthalma* group 3.

2. Peraeopod 5, segment 6 about 1/3 longer than 5, anterior marginal spines long, similar to those of segment 5; uropod 2, marginal spines of outer ramus very long, about twice width of ramus ..... *A. longicornis* (Say, 1818) (fig. 7B).

   Peraeopod 5, segment 6 about 1/6 longer than 5, anterior marginal spines much shorter than in segment 5; uropod 2, marginal spines of outer ramus short, not more than 1 1/2 times width of ramus ..... *A. heardi*, new species (figs. 5, 6)

3. Peraeopod 5, segment 5 with acuminate spines; uropod 2, inner margin of outer ramus smooth; uropod 3 ramus short, broad, about 2 1/2 times width; coxa 5, posterior lobe acute below; uropod 1, marginal spines of outer ramus about twice width of ramus ..... *A. megalophthalma* (Bate, 1862) (fig. 7A).

   Peraeopod 5, segment 5 with blunt-tipped (club-shaped) anterior marginal spines; uropod 2, inner margin of outer ramus armed with a few short spines; uropod 1 marginal spines of outer ramus about equal to width of ramus; coxa 5, posterior lobe rounded below; uropod 3 ramus longer, tip less blunt, weakly armed ..... 4.

4. Peraeopod 5, segment 6 more than 2/3 length of segment 5, anterior margin with 3 pairs of acuminate spines; uropod 2, inner margin of outer ramus with 3-4 short weak spines; uropod 3, ramus with 3-4 subapical spines only ..... *A. barbarae*, new species (figs. 3,4)

   Peraeopod 5, segment 6 less than 2/3 segment 5 anterior margin with 2 pairs of blunt-tipped (slender) spines; uropod 2, inner margin of outer ramus with 2 spines, length about half width of ramus; uropod 3, ramus with 6+ sub-apical spines ..... *A. salomani*, new species (figs. 1, 2)

*Both sexes and larger immatures.

Americorchestia salomani, new species (Figs. 1, 2)

Talorchestia sp. - Bousfield, 1970, p. 150 (partim)

Material Examined

Panama City, Florida, open sand beach at HW level, August 6, 1938 - HOLOTYPE male, 16.0 mm., USNM NO. 161453.

The following material, ELB coll., is housed in CMN collections, Ottawa: Horn I., Miss., outer beach coarse to medium sand at HW level, March 23, 1967 - ALLOTYPE female ov., 15 mm.; *Ibid* - 12 males, 8 females; Dauphin I. outer beach, Miss., at HW, April 4, 1978 - 3 females; Gulf Shores (Florida), on steep medium coarse sand beach at HW level - 2 males, 10 females ov.; St. Andrews State Park, outer beach west of jetty at HW level, March 17, 1977 - 6 specimens (males and females

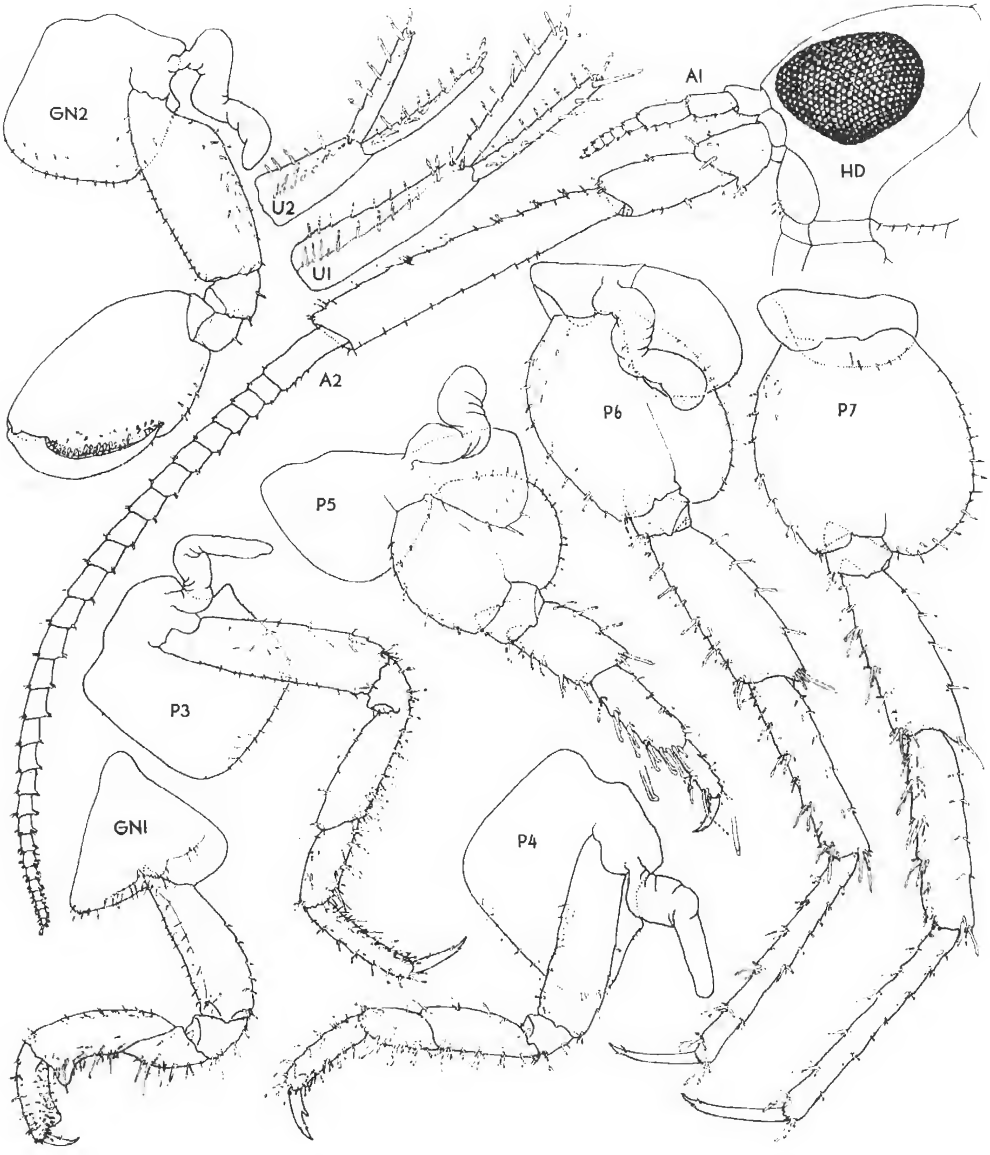

Figure 1. ***Americorchestia salomani*, new species. Male, 16.0 mm. Near Panama City, Florida, August 6, 1938.**

photographed); St. Andrews Bay near Alligator Pt., in sand at HW level, March 18, 1977 - 15 adult specimens; Panama City beach, in fine white surf-exposed sand at HW level, April 20, 1966 - several adult specimens; St. Joe, Florida, outer beach, in white sugar sand at HW level, March 21, 1977 - several specimens, including mature males; Alligator Pt, Co., Florida outer sand beach at HW level, March 21, 1977 - numerous adult specimens.

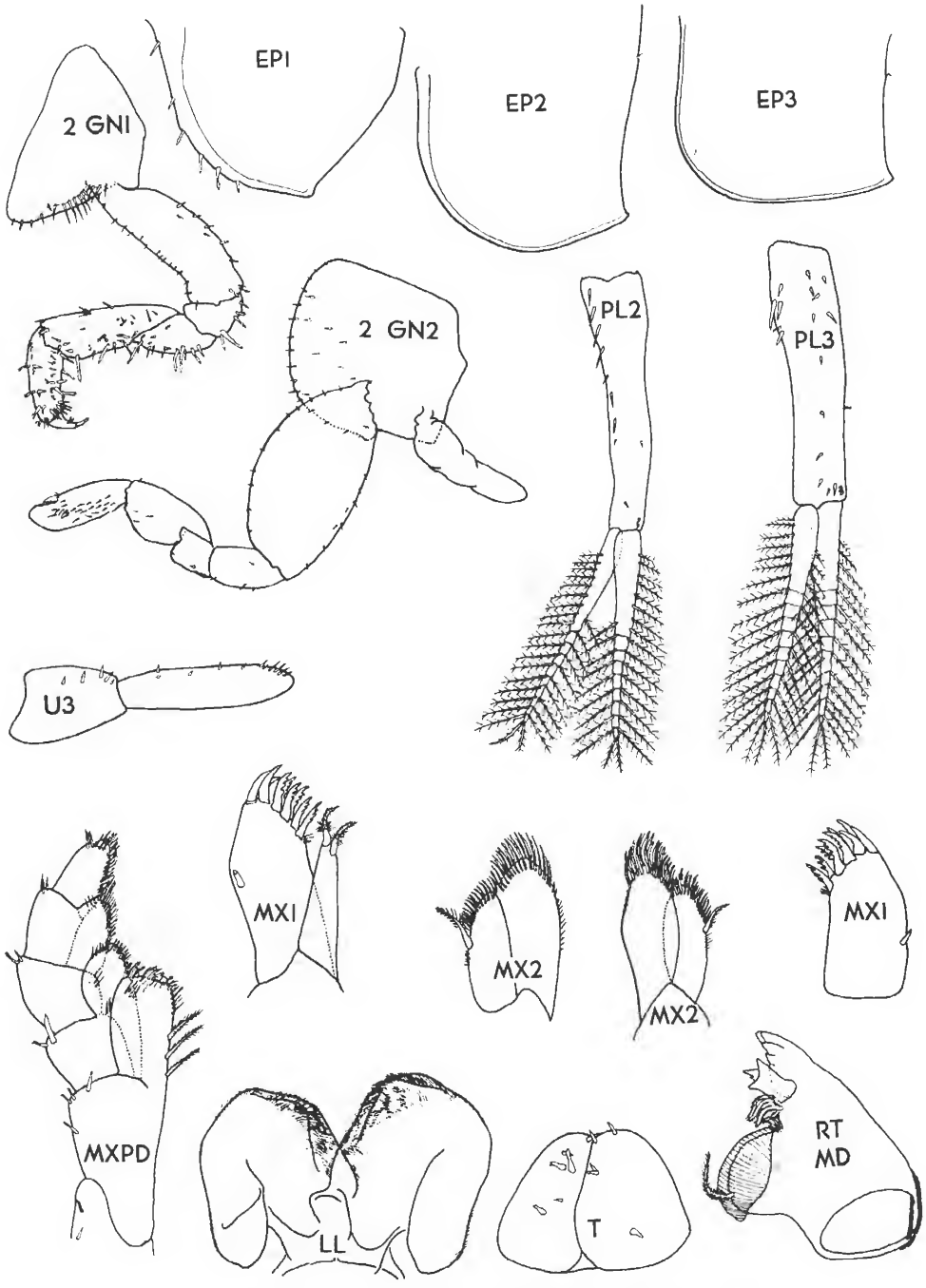

Figure 2. ***Americorchestia salomani*, new species. 1. Male, 16.0 mm. Near Panama City, Florida. 2. Female, 15.0 mm. Horn Island, Miss., March 23, 1967.**

Diagnosis

(Male, 16.0 mm)

A slender, medium-sized member of the *megalophthalma* group. Eyes very large, subrectangular, bulging laterally from head margin.

Antenna 1: Flagellum 6-segmented.

Antenna 2: Peduncle 4 distinctly less than half length of segment 5, flagellum about 28-segmented, distal segments weakly toothed.

Maxilliped: Inner plate with weak distal inner marginal setae and 3 stout medial marginal setae; segment 4 minute, vestigial.

Gnathopod 1: Palm short, vertical, tumescent lobe subacute.

Gnathopod 2: Propod slightly broadening distally, palm oblique, distinctly convex.

Peraeopod 4: Distinctly shorter than 3, segment 6 distinctly the shorter in peraeopod 4.

Peraeopod 5: Coxa wide, shallow, anterior lobe very gently rounding below; basis broader than wide, strongly rounded behind; segment 4 broadened, subrectangular; segment 5 nearly 1/3 longer than 6, anterior margin with 5-6 groups of club-tipped spines.

Peraeopods 6 & 7: Slender, subequal in length; basis of P6 ovate, of P7 slightly broader, hind margin with numerous short spines.

Pleopod: Peduncles with single row of outer marginal spines, marginal spines short; rami closely subequal, each with 9-10 distal free segments.

Pleon plate 1: With acuminate hind corner, plate 3 virtually smooth.

Uropod 1: Rami and peduncle subequal in length, marginal spines short, about equal to width of ramus; paired apical spines with spade-shaped tips.

Uropod 2: Rami longer than peduncle, armature about as in 1, inner margin of outer ramus with 2 short spines distally.

Uropod 3: Ramus slender, about 1/3 longer than peduncle, with 5-6 slender postero-apical spines.

Telson: Narrowing to slightly notched apex, each lobe

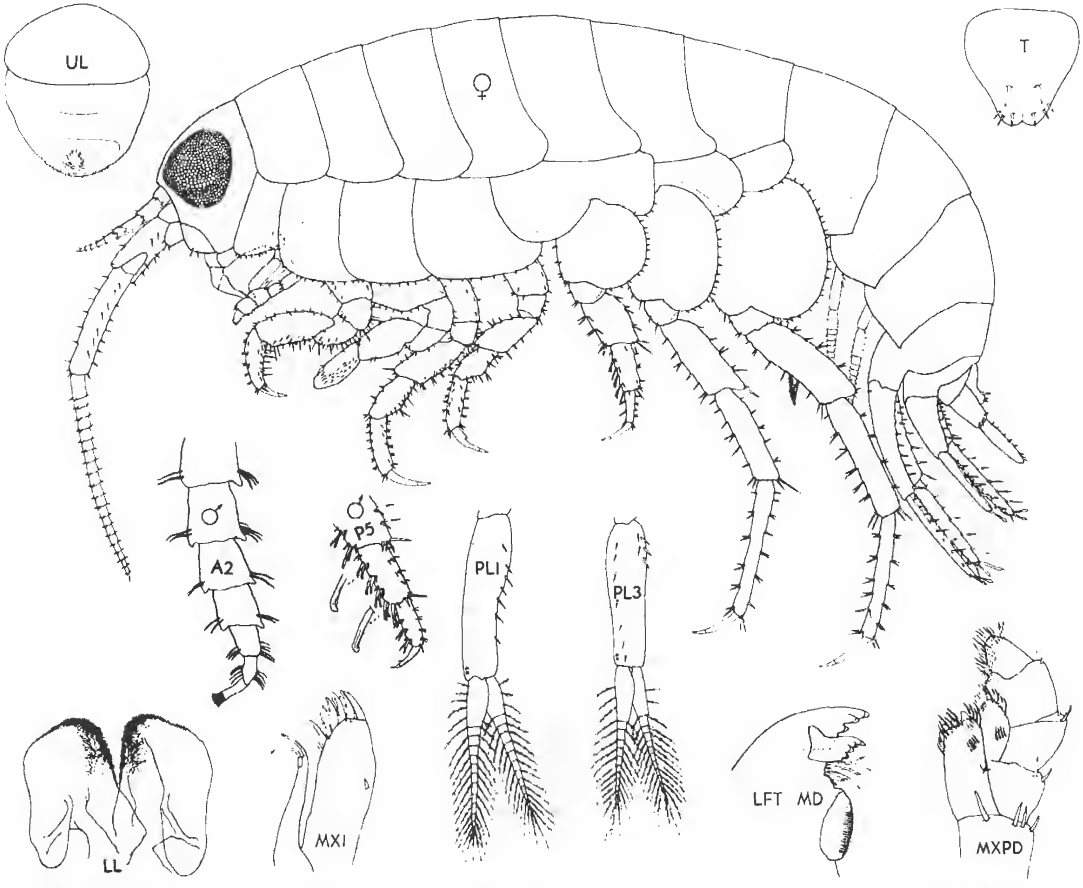

Figure 3. ***Americorchestia barbarae*, new species. Female, 13.0 mm. West of Sabine Pass, Texas, March 31, 1967.**

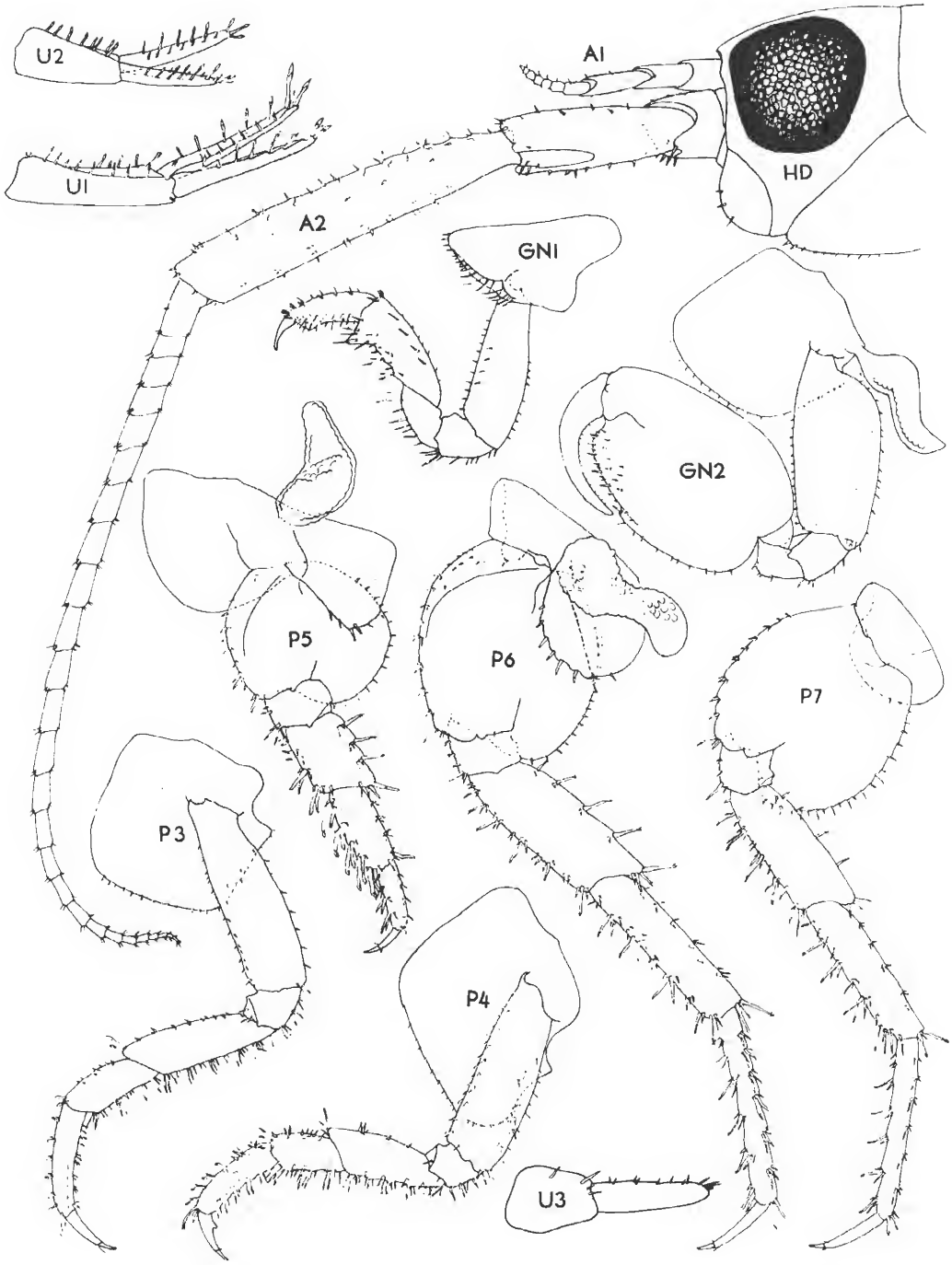

Figure 4. ***Americorchestia*** **barbarae, new species. Male, 14.0 mm. West of Sabine Pass, Texas, March 31, 1967.**

with 2 apical and 3 subapical short spines.

(Female ov., 15.0 mm)

Gnathopod 1: Carpus and propod nearly straight, not arched, propod little narrowing distally; dactyl curved.

Gnathopod 2: Basis strongly expanded anteriorly, width greater than half its length; merus slightly bulging posterodistally.

Brood plates: On peraeopods 2-4 little broadened, each with 15-20 marginal simple setae.

Etymology

Named in honour of Dr. Carl H. Saloman who has pioneered studies on population biology of sand-burrowing marine and estuarine organisms in the west Florida region.

Distributional Ecology

A. salomani burrows in sand at or near the HW level of surf exposed beaches, from the Appalachicola region of western Florida to the barrier islands of the Mississippi Delta.

Americorchestia barbarae, new species (Figs. 3, 4)

Material Examined

Sand beach about 10 miles west of Sabine Pass, Galveston Co., Texas, burrowing near HW level in somewhat silty sand, E. L. and Barbara Bousfield coll., March 31, 1967 - HOLOTYPE male, 14.0 mm., ALLOTYPE female br. II, 13.0 mm., slide mounts; *Ibid* - 1 subadult male, 6 subadult females, 1 immature female (PARATYPES), all in CMN collections, Ottawa.

Diagnosis

(male, 14.0 mm)

A relatively small and slender member of the *megalophthalma* subgroup. Eyes very large, bulging laterally, slightly narrowing below.

Antenna 1: Flagellum 7-segmented.

Antenna 2: Peduncle 4 about half length of segment 5, flagellum about 25-segmented, distal segments very weakly toothed.

Maxilliped: Inner plate with weak distomedial marginal setae, segment 4 lacking.

Gnathopod 1: Palm very short, oblique, tumescence shallow.

Gnathopod 2: Propod not broadening distally, margins subparallel, palm oblique, strongly convex.

Peraeopod 4: Slightly shorter than 3, segment 6 subequal.

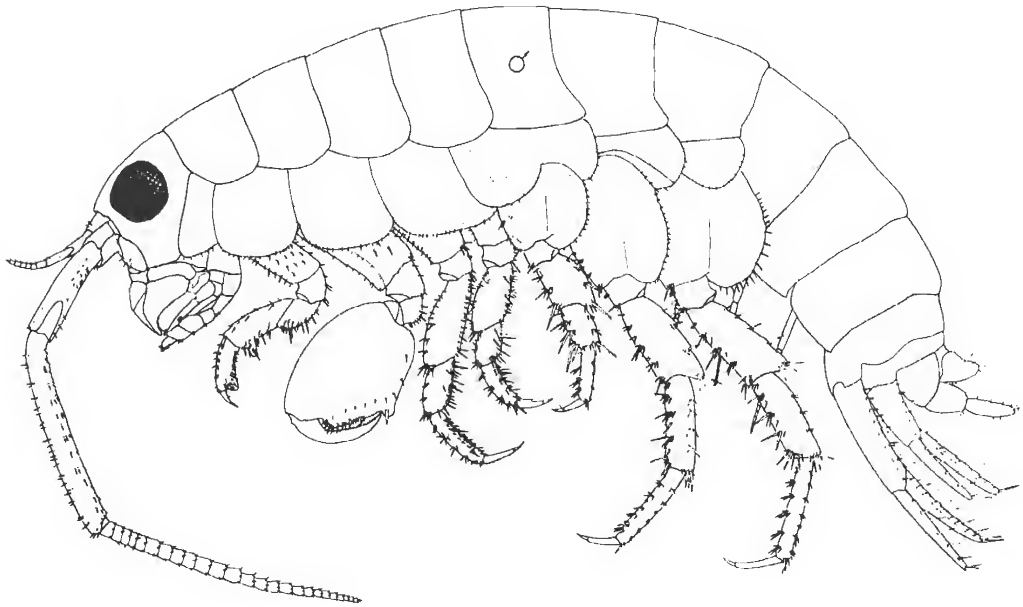

Figure 5. ***Americorchestia heardi*, new species. Male, 16.0 mm. Horn Island, Miss., April 4, 1944.**

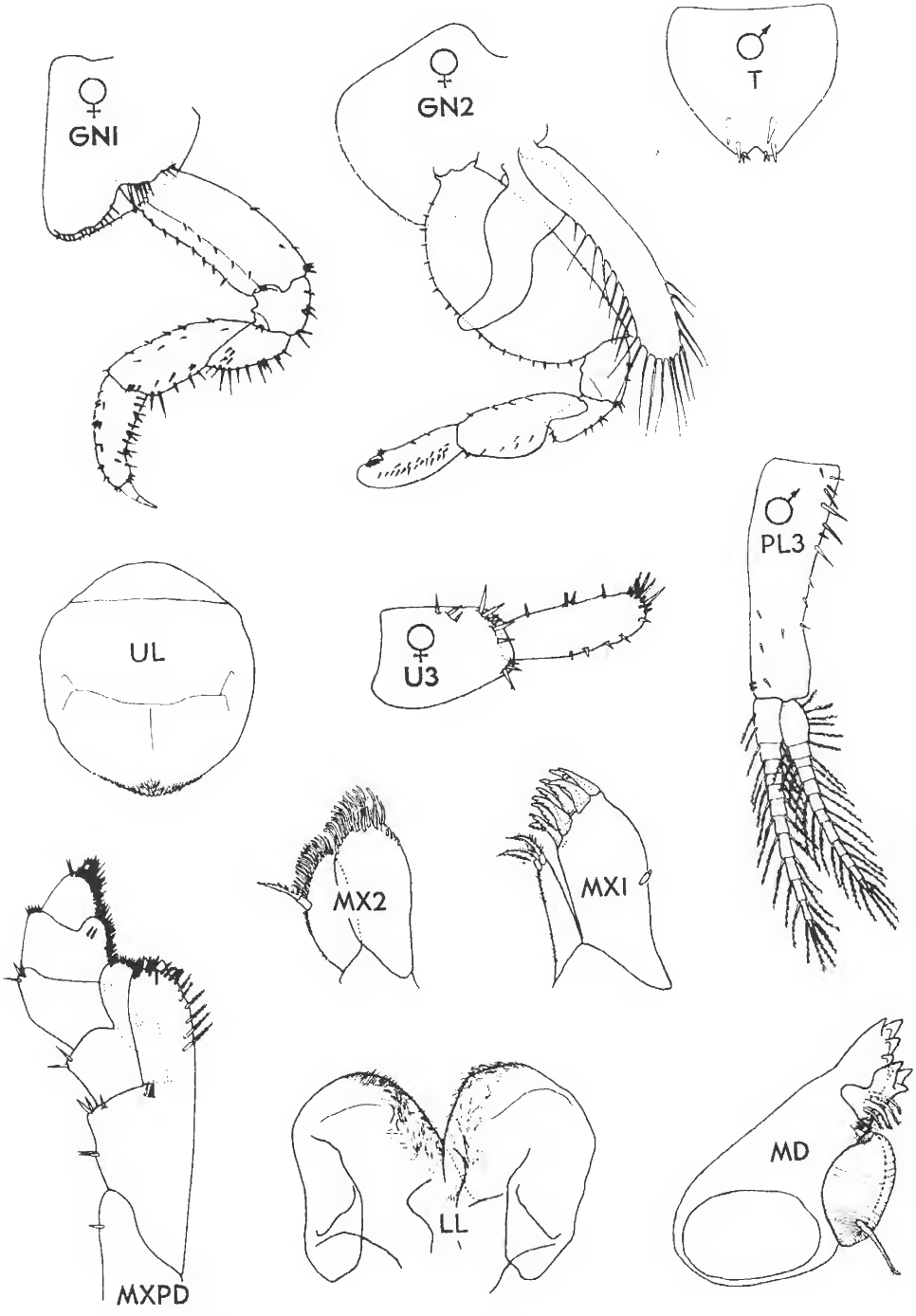

Figure 6. ***Americorchestia heardi*, new species. Horn I., Miss. 1. Male, 16 mm. 2. Female ov., 12.0 mm.**

Peraeopod 5: Coxa shallow distinctly wider than deep, lower margins rounded; basis smoothly rounded behind; segment 4 slightly broadened, subrectangular, distinctly longer than wide; segment 5 with 4-5 groups of anterior marginal club-spines; segment 6 slightly shorter than 5.

Peraeopods 6 & 7: Closely subequal in length; basis of P7 much broader, marginal spines minute; dactyls much longer than P5.

Pleopod: Peduncles with single row of outer marginal spines; rami subequal, each with 10-12 distal free segments.

Pleon plate 3: With 2-3 minute posterior marginal spines, hind corner acuminate.

Uropod 1: Rami longer than peduncle, marginal spines short, about equal to width of ramus: paired apical spines with spade-shaped tips.

Uropod 2: Rami longer than peduncle, armature similar, but slightly stronger than in uropod 1, inner margin of outer ramus with 3-4 short spines.

Uropod 3: Ramus slender, about 25% longer than peduncle, posterior margin weakly spinose, with 3-4 subapical spines only.

Telson: Narrowing to slightly notched apex, each lobe with 3 apical, and 1 stronger dorsal subapical, spines.

(Female, 13.0 mm)

Antenna 1: Slightly exceeding penduncle 4 of A2.

Antenna 2: Peduncle 4 more than half length of peduncle 5, flagellum 18-20 segmented, distal segments not toothed.

Gnathopod 1: Propod slightly arched, narrowing distally, dactyl nearly straight.

Gnathopod 2: Basis moderately expanded in front, width about half its length; merus lacking any trace of postero-distal lobe.

Brood plates: Not developed.

Etymology

Named in honour of my late wife, Barbara Bousfield, whose help was vital to the success of our field expeditions to the southeastern and Gulf coasts of the United States.

Distributional Ecology

Known only from the type locality, west of the Mississippi delta, but probably occurring along the entire Gulf coast of Texas. The entrance to the burrow is oval-shaped, similar to that of some species of *Megalorchestia*.

Taxonomic Commentary

The spade-shaped apical spines of uropods 1 and 2 resemble those of the American Pacific genus *Pseudorchestoidea*.

Americorchestia heardi, new species (Figs. 5, 6)

Talorchestia sp. - Bousfield, 1970, p. 150 (partim)

Material Examined

Horn Island., Miss., opp. old U.S. Army Biological Station, in sand at HW level, April 20, 1944 - HOLOTYPE male 16.0 mm, ALLOTYPE female ov. 12.0 mm. USNM No. 222855.

Little Deer I., west end, medium fine sand at HW level, ELB coll., March 23, 1967 - 2 females ov., CMN coll.,; Ibid, April 10, 1978 - 2 males, 1 female. CMN collections; Belle Fontaine Beach, Miss., HW sand above muddy sand flats, ELB coll., March 24, 1967 - several specimens including males; Pensacola Point, at Fair Pt. in sand at HW level, ELB coll., March 23, 1977 - numerous adults, including males. Cedar Key, Florida, public beach, in sand at HW level, ELB coll., April 16, 1966 - many females and immatures but no adult males.

Diagnosis

(male, 16.0 mm)

A relatively small member of the longicornis group. Eyes medium large, subrotund, not bulging laterally from head margin.

Antenna 1: Flagellum 7-segmented.

Antenna 2: Peduncle slightly incrassate, longer than flagellum, peduncular segment 4 about half length of segment 5: flagellum about 25-segmented, distal segments very weakly toothed.

Maxilliped: Inner plate with 6+ stout inner marginal plumose setae; segment 4 lacking.

Gnathopod 1: Propod slightly curved, palm vertical, tumescence prominent, sharply rounded, dactyl slightly exceeding palm.

Gnathopod 2: Propod slightly broadening distally, palm oblique, irregular, with low prominence near hinge, and rounded process and single stout spine at postero-distal angle.

Peraeopod 4: Segments 4 & 5 distinctly smaller than in peraeopod 3.

Peraeopod 5: Anterior coxal lobe medium deep, broadly rounded below; basis broad, smoothly rounded behind; segment 4 broadening distally; segment distinctly shorter than 6, with 3-4 groups of simple, stout, anterior marginal spines; dactyl strong, simple.

Peraeopods 6 & 7: Strong, subequal, distal segments not elongate; basis of 6 ovate, of 7 broad, with subacute posterior proximal corner, hind margin with numerous medium spines.

Pleopods: Slightly reduced in size; peduncles broad-

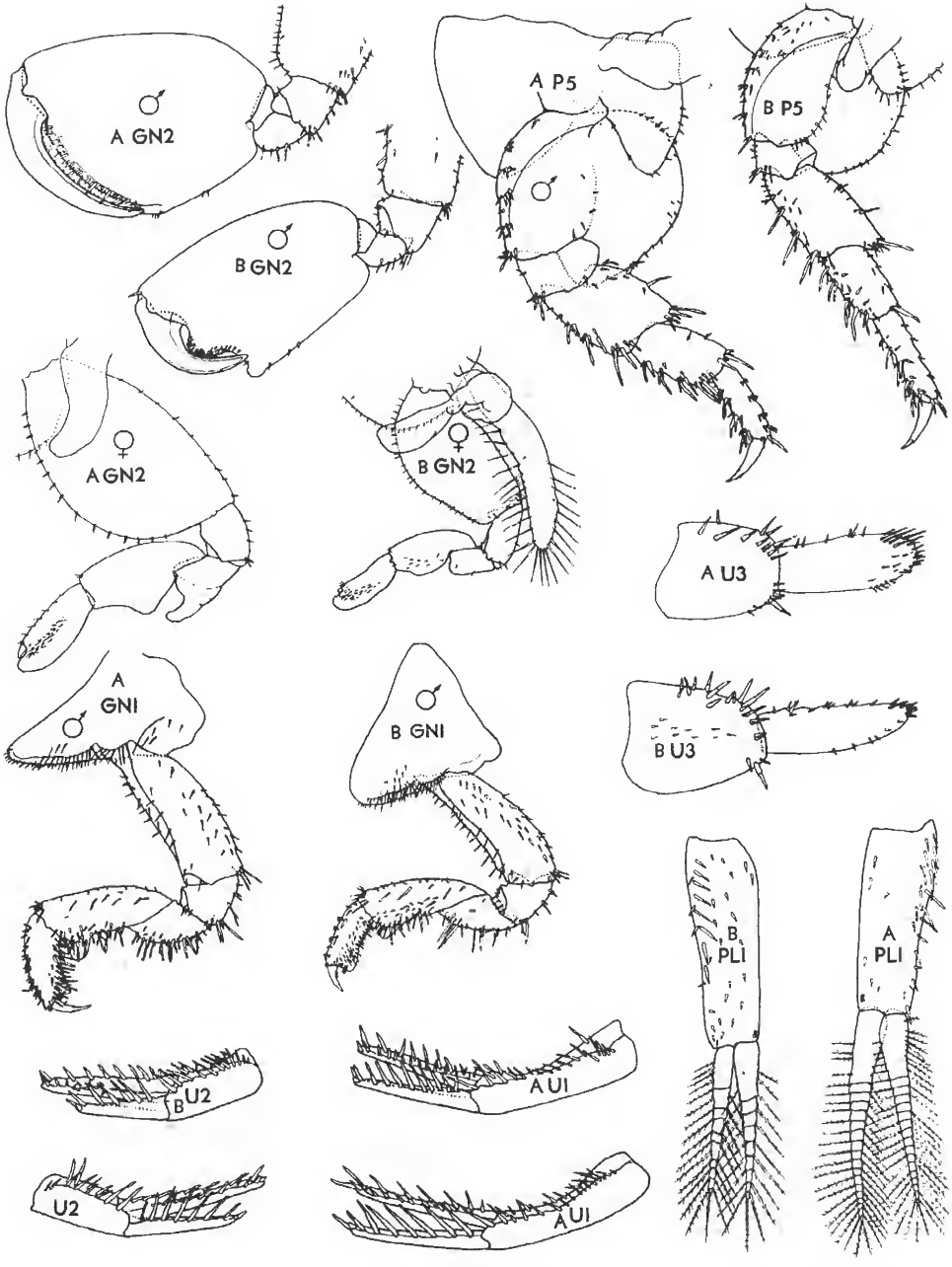

Figure 7. A. *Americorchestia megalophthalma* (Bate) Lockeport Beach, N.S. Male, 22.0 mm., Female, 18.0 mm. B. *Americorchestia longicornis* (Say). Lingan Beach, N.S. Male, 23.0 mm., Female ov., 20 mm.

ened proximally, outer margin proximally with diverse slender spines; rami subequal, each with 10-11 segments, basal segment short.

Pleon plate 3: Smooth behind, hind corner acuminate.

Uropod 1: Rami slightly shorter than peduncle, apical spines simple, outer marginal spines of outer ramus medium strong, longer than width of ramus.

Uropod 2: Rami much longer than peduncle, inner margin of outer ramus lacking spines, outer marginal and terminal spines simple.

Uropod 3: Ramus slightly longer than peduncle, upper and lower margins spinose, apex with stout spines.

Telson: Short, narrowing to notched apex, each lobe with minute apical spines and 2 subapical dorsal spines.

(Female ov., 12.0 mm)

Gnathopod 1: Propod curved, narrowing distally; dactyl short, slightly curved.

Gnathopod 2: Basis evenly broadened in front, width slightly more than half its length; merus slightly tumescent postero-distally.

Brood plates: On peraeopods 2-4 little broadened, margins distally lined with about 20 simple setae.

Etymology

Named in honour of Dr. Richard W. Heard, whose contributions to the systematics, ecology, and parasitology of Gulf coast crustaceans have been outstanding.

Distributional Ecology

Burrowing at HW drift line of surf-protected sand beaches, in somewhat lowered salinities, from western Florida to Louisiana, east of the Mississippi Delta.

Distributional - Ecological Commentary

Basic information on the distributional ecology and life histories of Talitridae, including sandhoppers, has been summarized by Wildish (1988). The Florida "thumb", marked by non-terrigenous (coralline) sand beaches, and subtropical marine temperatures, poses a significant post-Pleistocene biogeographic "barrier" to populations of igneous sand-burrowing temperate-zone amphipod groups such as haustoriids and sandhoppers (Bousfield, 1970). Thus the northern big-eyed sandhopper, *A. megalophthalma*, is dominant on surf-exposed sand beaches of Atlantic Canada to southern New England (less commonly southward to Georgia (Bousfield, 1973). This species (Fig. 7A) has a large, powerfully fossorial body that can burrow deeply (>60 cm.), and also presumably more easily handle larger food items. Sandhoppers feed, mainly nocturnally, directly on wavecast wrack that consists primarily of dead plant material. The beach wrack on northern surf-exposed beaches is composed mainly of large fucoid algae (*Ascophyllum*), kelp (*Laminaria*) and some *Chondrus*. Summers are relatively short and cool but winters are severe, usually accompained by heavy shore icing and deeply penetrating frost action in the upper berm. The berm may also be heavily denuded of sand by winter storms.

Along the Gulf coast, the eastern Gulf sandhopper, *A. salomani*, is regionally endemic and separated by the Mississippi delta from its taxonomic and ecological counterpart, the western Gulf sandhopper, *A. barbarae*. Both species have smaller, less powerful, but more agile bodies than *A. megalophthalma*. Their food supply is more limited since the sea wrack of open Gulf beaches consists mainly of turtle grass (*Thalassia*) and small algae (*Sargassum*, etc), seldom in large quantities. On Gulf beaches, rapid saltation away from nocturnal predators such as the ghost crab (*Ocypode*) that does not occur north of Cape Cod, may be a more important survival factor than deep-burrowing ability. Moreover, relatively shallow burrowing by the desiccation-prone sandhoppers is presumably sufficient to avoid the effects of both light winter frosts, on the one hand, and, on the other, the lethally high daytime summer surface temperatures that characterize sand beach microclimates in the Gulf region. Also, except for the effects of sporadic hurricanes, wave-denudation of the berm sand along Gulf beaches is presumably less severe year-round than it is along the open North Atlantic coast.

Similarly in the *longicornis* group, the common Atlantic sandhopper, *A. longicornis* (Fig. 7B), occurs on outer beaches (with *A. megalophthalma*), but is dominant on inner protected beaches, from the Gulf of St. Lawrence to northern Florida (Bousfield, 1973). It is common on estuarine beaches, in summer salinities as low as $3^{0}/_{00}$ and tends to hide under logs and other objects and burrow less deeply than does *A. megalophthalma* (see Bousfield, 1958). In these habitats, it may subsist on dead eel grass (*Zostera*), *Sargassum*, and organic material of terrestrial origin. It complemental species, the common Gulf sandhopper, *A. heardi*, is endemic to protected sand beaches east of the Mississippi Delta. A counterpart species might occur on protected beaches or in lagoons west of the Delta, especially along the coasts of southwestern Louisiana and southeastern Texas, but has not yet been found.

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The writer is indebted to several interested colleagues and their marine laboratories who contributed to the success of the field operations. These include Dr. R. W. Heard, Gulf Coast Research Laboratory, Ocean Springs, Mississippi and Dauphin Island Sea Lab, Alabama; Dr. W. Fletcher, U.S. Environmental Protection Agency Environmental Research Laboratory, Gulf Breeze, Florida; Dr. Carl Saloman, NOAA Marine Station, Panama City, Florida; Dr. R.L. Livingstone and colleagues, Florida State University, Tallahassee; and Dr. W.D. Burbanck, Emory University, Atlanta, Georgia. I am grateful to Drs. T.E. Bowman, J.L. Barnard, and the late C.R. Shoemaker, Smithsonian Institution, Washington, D.C., for the loan of regional specimens.

ABBREVIATIONS FOR FIGURES

A1-2 - antennae 1-2
EP1-3 - pleon side plates 1-3
LFT - left
GN1-2 - gnathopods 1-2
HD - head
LL - lower lip
RT - right
T - telson
UL - upper lip
U1-3 - uropods 1-3
♂ - male
♀ - female
MD - mandible
MX1 - maxilla 1
MX2 - maxilla 2
MXPD - maxilliped
P1 - peraeopods 1-7
PL1-3 - pleopods 1-2

REFERENCES CITED

Barnard, J. L. 1969. The Families and Genera of Marine Gammaridean Amphipoda. *Bull. U.S. Nat. Museum*, No. 271, 535 pp.

Bousfield, E. L. 1958. Distributional Ecology of the terrestrial Talitridae (Crustacea: Amphipoda) of Canada. *Tenth Intern. Congr. Ent., Proc. for 1956* 1:883-898.

_____. 1970. Adaptive Radiation in sand-burrowing amphipod crustaceans. *Ches. Sci.* 11(3):143-154.

_____. 1973. *Shallow-water Gammaridean Amphipoda of New England.* Cornell Univ. Press, Ithaca, N.Y., 312 pp.

_____. 1982. The amphipod superfamily Talitroidea in the north-eastern Pacific region. 1. Family Talitridae; systematics and distributional ecology. *Pub. Biol. Oceanogr., Natl. Mus. Nat. Sci.*, 11:1-73.

_____. 1984. Recent advances in the systematics and biogeography of landhoppers (Amphipoda: Talitridae) of the Indo-Pacific Region. *Bernice P. Bishop Mus., Spec. Publ.* 72:171-210.

_____ and R.W. Heard. 1986. Systematics, distributional ecology and some host-parasite relationships of *Uhlorchestia uhleri* (Shoemaker) and *U. spartinophila*, new species (Crustacea: Amphipoda), endemic to salt marshes of the Atlantic coast of North America. *J. Crust. Biol.* 6(2):264-274.

Holmes, S. J. 1904. The Amphipoda of Southern New England. *Bull. U.S. Bur. Fish.* 24:459-529.

Morino H., and H. Miyamoto. 1988. Redefinition of *Talorchestia* (Amphipoda: Talitridae) with description of a new species from the tropical West Pacific. *Jour. Crust. Biol.* 8(1):91-98.

Shoemaker, C. R. 1936. The occurrence of the terrestrial amphipods *Talitrus alluaudi* and *Talitrus sylvaticus* in the United States. *Jour. Wash. Acad. Sci.* 26(2):60-64.

Stebbing, T. R. R. 1906. Amphipoda. I. Gammaridea. *Das Tierreich* 21:1-806.

Wildish, D. J. 1988. Ecology and natural history of aquatic Talitroidea. *Can. Jour. Zool.* 66:2340-2359.

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Design and Operation of a Small Tank System for Ovarian Maturation and Spawning of *Penaeus vannamei*

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DESIGN AND OPERATION OF A SMALL TANK SYSTEM FOR OVARIAN MATURATION AND SPAWNING OF *PENAEUS VANNAMEI*

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ABSTRACT Ovarian maturation and spawning of *Penaeus vannamei* was accomplished in a 120 l (30 gal) tank as well as in a 800 l recirculating system consisting of six aquaria plumbed into a common biofilter. Pond reared animals stocked one per tank were fed a diet consisting of commercial pellets, squid, and bloodworms. Temperature was maintained at 28°C and salinity between 28 and 32 ppt. Presence of black shields between aquaria, males, eggs in the water, and other females in the aquaria were not required for ovarian maturation. Thirty-six of 78 females held in the small tank system spawned. The smallest female which spawned was 25.9 g. After unilateral eyestalk ablation by enucleation, female *P. vannamei* molted in 3-16 days and spawned in 7-20 days. Up to four spawns occurred before the next molt which occurred 15-35 days after ablation.

Introduction

The white legged shrimp of the Central American Pacific Coast, *Penaeus vannamei* or "vanna whites," have become the species of choice for culture in the Americas. One recurring problem in the aquaculture of this species has been the variable seed supply. Postlarval abundance off Ecuador has determined the economics for both wild and hatchery produced seedstock. The yearly abundance of postlarvae off Ecuador is determined by ocean temperatures linked to the "El Niño" for which no predictive models are available. Maturation of *P. vannamei* in captivity is difficult but obtainable (Boeing 1988). Production of this shrimp species is low due to low mating success, low egg fertilization and a low hatching rate (Boeing 1988). Finally, there is a perception among commercial farmers that the quality of hatchery produced postlarvae is not as good as wild larvae and consequently, they sell for less (Montealegre 1989). Commercially, the majority of maturation tanks are over 3.8 m (15 ft) in diameter (Ogle 1991) and due to a requirement for feeding fresh feeds, operation of a maturation facility can be expensive. Research on ovarian maturation of marine penaeid shrimp has been limited due to the time, cost and difficulty of replication associated with large tank systems. Few research institutions have the facilities to accomplish shrimp maturation and few commercial facilities are willing to conduct replicated experiments in production tanks. For these reasons, a closed recirculating system was developed using small tanks to experimentally determine factors influencing ovarian maturation of *P. vannamei*. The objective was to conduct replicable experiments with minimal space and expense for a large number of factors that might influence egg production and egg quality. It is recognized that studies on mating will still require large tanks (Ogle 1991), although *in vitro* fertilization might be accomplished with the small tank systems. Finally, the small tank system allows close control of individual animals, controlled breeding and pre-screening of animals for reproductive performance.

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Materials and Methods

The system (Fig. 1) consisted of six 120 l (30 gal) aquaria plumbed in common to an external trickling biofilter. A 2.54 cm (1 in) hole was drilled in the upper left corner of one end of each aquaria to provide an overflow. A thruhull fitting was fabricated from a polyvinyl chloride (PVC) male adaptor and a PVC (slip threaded slip) threaded through the hole in the aquarium. A 15 cm (6 in) length of 2.54 cm (1 in) PVC pipe having a number of 1.27 cm (1/2 in) holes was wrapped with fiberglass window screen secured with silicone sealant. This pipe, capped on one end and inserted into the male adaptor, constituted an internal screened overflow. A length of PVC pipe directed the water from the overflow down through an egg collector into a common collection trough. The egg collectors were fabricated from plastic 473 ml (16 oz) beverage bottles. The bottles had 5.08 cm (2 in) square holes cut in the side and covered with 180 micron nitex secured with silicone sealant. Waste water from the trough cascades into a downflow submerged trickling filter. The filter consisted of a 83 l (22 gal) white, round plastic trash container filled with a filter

media of clam shells (*Rangia* sp.). A 20 cm (8 in) PVC pipe extended from the bottom of the container to just above the top of the container. This pipe housed a submersible pump (Little Giant, Oklahoma City, OK, Model NK-1) which provided filtered water through a 1.27 cm (1/2 in) vinyl hose to an overhead manifold. The 213 cm (7 ft) manifold was constructed of 10 cm (4 in) PVC pipe capped at both ends. A thruhull fitting of 3.8 cm (1 1/2 in) PVC was constructed from a male adaptor and a tee inserted into one end cap to provide for overflow of the manifold. Excess water was directed back into the top of the trickling filter by a length of PVC pipe. Two 2.54 cm x 91 cm (1 in x 3 ft) slots were cut into the top of the manifold pipe. The slots allowed positioning of air line tubing which was used as siphons to supply water to each aquaria. A piece of 1.9 cm (3/4 in) PVC pipe filled with sand and capped at both ends to which the air line tubing was attached with plastic wire-ties was used as a weight to secure the siphons in the manifold. Each aquarium received water having a flow rate of 690 ml/min. Each aquarium was aerated with a single airstone and covered with plexiglass. A plastic clothespin was glued to the top of the covers to secure cards used to record data for each tank.

Settled estuarine water of at least 18 ppt was evaporated to 32 ppt by heating to 80°C and provided the natural seawater for the system. Total volume of the entire system was approximately 1100 l (300 gal). Groups of six aquaria were contained in a common water table 214 cm x 106 cm x 15 cm (84 in x 42 in x 6 in) deep filled with 287 l (75 gal) of freshwater. Water temperature was generally maintained by regulating room air temperature. Additionally, each water table was equipped with a thermostatically controlled 100-watt titanium heater (Glow-Quartz, Mentor, Ohio). A submersible pump (Little Giant Model p-AAA) positioned at the opposite end of the water table from the heater provided water circulation to ensure equal temperature distribution. Six complete systems of six tanks each were located in a 3 m x 9.4 m room. Lighting was provided by eight 40-watt cool white fluorescent bulbs located overhead in the room. A mechanical timer controlled the lights and was

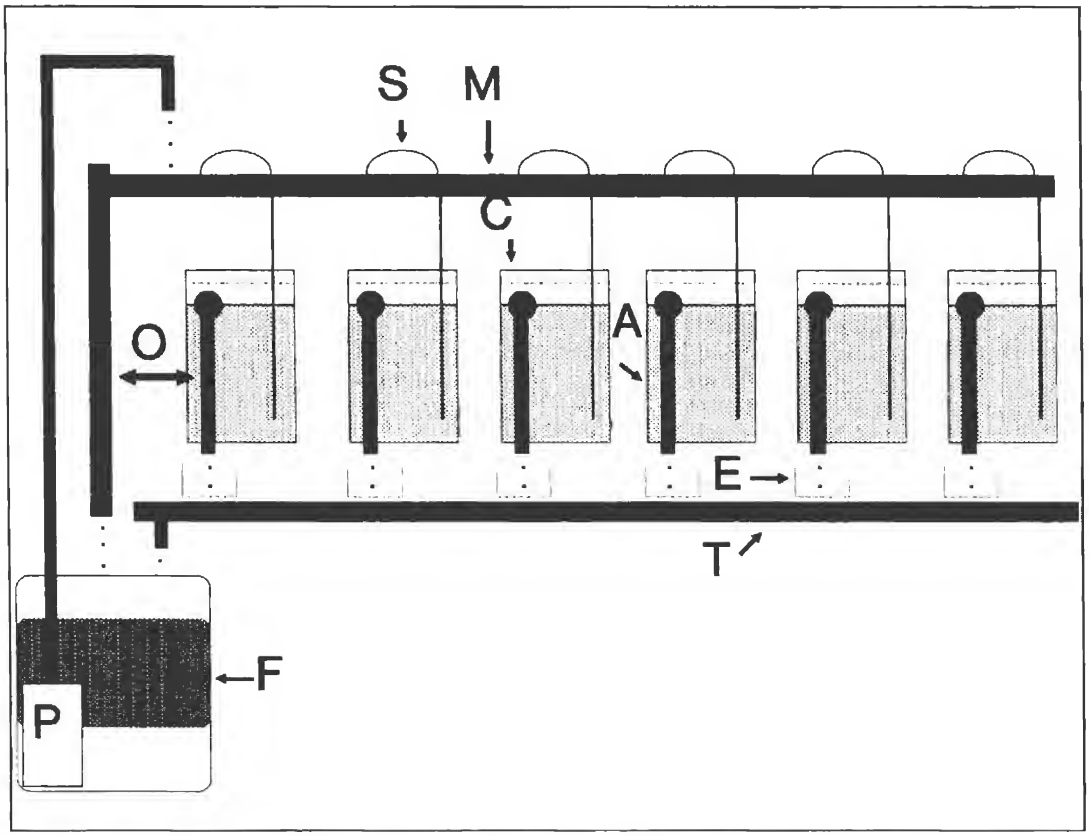

Figure 1. A cross-section diagram of the small tank system used to achieve ovarian maturation and spawning of *Penaeus vannamei:* S siphon, M manifold, C cover, A aquaria, E egg collector, F filter, P pump, T trough, and O overflow.

used to provide a photoperiod of 14L:10D hours.

Initial efforts to achieve ovarian maturation of *P. vannamei* involved the use of black shields between aquaria, placing males in the system, placing two females in each aquaria and adding shrimp eggs from another tank to each system. An additional study investigated the effect of eyestalk ablation 5 and 10 days after molting. The left eyestalk was ablated by enucleation. In a final experiment of five separate trials, an artificial seawater mix (Marine Environment, San Francisco, CA) was compared to natural sea water. A reverse osmosis filter (Nimbus, San Diego, CA) was used to purify the well water for mixing with artificial sea salt.

Water samples were analyzed weekly for pH, total ammonia, nitrite, nitrate, temperature and salinity. Ammonia and pH were determined by using an Orion pH/ion analyzer with appropriate electrode. Nitrite and nitrate levels were determined by titration (EPA 1983). Salinity and temperature were determined with a refractometer and mercury thermometer, respectively.

A standard management procedure involved the replacement of filter media for each study, cleaning the system and refilling with freshly filtered well water. Artificial salt was mixed and allowed to circulate at least three days before animals were stocked. Female *P. vannamei* of at least 30 g body weight that have never undergone ovarian maturation were used. A commercial shrimp grower pellet was fed until the animals molted, at which time the shrimp were started on a maturation diet consisting of squid in the morning, bloodworms at noon and maturation pellets in the evening. The left eyestalk was ablated five days after their first molt. Tanks were cleaned daily by siphoning and replacing part of the water. Egg collectors were added in the evenings commencing with the ablation of the animal and checked for eggs the following morning. If spawning did not occur, animals were discarded after their fourth molt.

(Use of trade names does not imply endorsement.)

RESULTS

Water temperature during the initial studies was maintained at 28°C and salinity between 28-32 ppt. Total ammonia ranged from 0.01 ppm to 0.22 ppm, pH ranged from 8.16 to 7.41, nitrite peaked at 1.12 ppm and nitrate increased to a high of 118.4 ppm.

Presence of black shields between aquaria, males, eggs in the water and other females in the aquaria were not required for maturation. Of the 27 animals held in the preliminary study, 13 spawned while not subjected to the above conditions. Twelve animals either died or were lost from jumping out of the tanks; the remaining animals never spawned. The average size of the females that did not spawn was 35.7 g, the average size of the females that did spawn was 38.2 g and the smallest female that spawned was 25.9 g. Five of the 10 animals that were ablated five days after molting spawned. Eight of the 15 animals that were ablated ten days after molting spawned. After unilateral eyestalk ablation, female *P. vannamei* molted in 3-16 days and spawned in 7-20 days. Up to four spawns occurred before the next molt which occured 15-35 days after eyestalk ablation. In five subsequent studies (Table 1), 19 of 29 females spawned in artificial seawater and 14 of 22 spawned in natural estuarine water. Spawning occurred an average of 12.4 days past eyestalk ablation for shrimp maintained in artificial seawater and 9.3 days past ablation for shrimp maintained in natural estuarine water. In the artificial seawater, 31.6% of the females spawned within the same molt cycle that ablation occurred, whereas 64.3% of the animals held in natural water spawned in the same cycle. The second molt occurred in 13.4 days for both groups.

DISCUSSION

This is the first account of which the author is aware for the maturation and spawning of *P. vannamei* in a small tank system utilizing artificial seawater and recirculation. Maturation of the penaeid shrimp, *P. monodon*, has been recorded (Beard and Wickins 1980) for a small tank and spawning of *P. merguiensis* was accomplished in 32 l of water (Beard et al. 1977). Caillouet (1973) achieved ovarian development of *P. duorarum* in a 300 l system. Maturation and spawning of a single female, *P. vannamei*, was accomplished at a commercial venture (King James Shrimp) in large tanks utilizing an artificial seawater (Bob Brick, personal communication) in 1977. A majority of commercial maturation facilities utilize some recirculation of water in large tanks averaging over 3.6 m (15 ft) in diameter (Ogle 1991). Tanks used for penaeid shrimp maturation can range from 500 l to 50 m^3 (Primavera 1984; Muthu and Laxminarayana 1982). The system described here, patterned after a system used for production of mysid shrimp for bioassay, (Burke and Walker 1988) enables relatively inexpensive replication of maturation experiments under controlled conditions.

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TABLE 1

Comparison of reproductive performance of female *P. vannamei* maintained in artificial seawater and natural seawater.

	Marine Environment				Pure Bay Water		
System Number	1	2	3	Avg.	1	2	Avg.
Females/System	9	10	10	29	13	9	22
% Spawn	88.9	60	50	65.6	75	50	63.7
% No Spawn	0	0	30	10.3	8.3	0	4.5
% Dead	11.1	40	20	24.1	16.7	50	31.8
Spawn DPA*	11.4	14.8	11	12.4	8.2	10.4	9.3
PER CENT SPAWN DURING MOLT CYCLE							
Cycle 1	75	16.7	60	31.6	66.7	60	64.3
Cycle 2	25	66.7	40	63.1	33.3	40	35.7
Cycle 3	---	16.6	---	5.3	0	0	0
INTERMOLT DURATION IN DAYS							
Cycle 1	12.5	13.2	14.6	13.4	13.8	10.4	13.4
Cycle 2	---	13.0	16.3	15.5	33	---	---
Cycle 3	---	---	20.3	20.3	15	---	---
WATER QUALITY							
pH							
Minimum	7.73	7.78	7.93		7.61	7.69	
Maximum	7.94	8.05	8.02		8.07	7.95	
TOTAL AMMONIA (ppm)							
Mimimum	0.0205	0.0092	0.0075		0.002	0.0182	
Maximum	0.0483	0.0724	0.108		0.183	0.347	
NITRITE (ppm)							
Minimum	0.0183	0.0138	0.0382		0.00363	0.0286	
Maximum	0.0749	0.0957	1.67		0.188	0.493	
NITRATE (ppm)							
Minimum	5.74	1.71	0.62		1.15	0.10	
Maximum	19.9	21.7	22.5		39.9	16.2	

*days past ablation

REFERENCES CITED

Beard T. W. and J. F. Wickins. 1980. Breeding of *Penaeus monodon* Fabricius in laboratory recirculation systems. *Aquacult.* 20(2):79-89.

Beard, T. W., J. F. Wickins, and D. R. Arnstein. 1977. The breeding and growth of *Penaeus merguiensis* de Man in laboratory recirculation systems. *Aquacult.* 10(3):275-289.

Boeing, P. L. and S.A. Semacua. 1988. Hatchery differences in the culture of *Penaeus vannamei, Penaeus stylisrostris*, and *Penaeus monodon*. Brazilian Aquaculture Conference.

Burke, D. and W. W. Walker. 1988. The culture of *Mysidopsis bahia* under modified greenhouse conditions. Seatec. Nov. 88, Pensacola, FL. (Abstr.)

Caillouet, C. W. Jr. 1973. Ovarian maturation induced by eyestalk ablation in pink shrimp, *Penaeus duorarum* Burkenroad. *Proc. World Maricult. Soc.* 3:205-225.

EPA, 1983. Chemical analysis for water and waste. EPA-625-16/74/003. Revised March 1983.

Muthu, M. S., and A. Laxinarayana. 1982. Induced maturation of penaeid prawns- a review. *Proceedings of the symposium on coastal aquaculture Part I: Prawn culture.* The Marine Biological Association of India pp. 16-27.

Ogle, J. T. 1991. Captive maturation and reproduction of *Penaeus vannamei* based upon a survey. *Gulf Res. Rept.* 8(3):295-297.

Primavera, J.H. 1985. A review of maturation and reproduction in closed thelycum penaeids. In Y. Taki, J.H. Primavera and J.A. Llobrera (eds.) *Proc. First Intl. Conf. Cult. Penaeid Prawns/Shrimps.* Aquaculture Department Southeast Asian Fisheries Development Center, pp. 47-64.

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Food Preference of *Penaeus vannamei*

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FOOD PREFERENCE OF *PENAEUS VANNAMEI*

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ABSTRACT The preference of *Penaeus vannamei* for 15 food items used in maturation was determined. The foods in order of preference were ranked as follows: *Artemia*, krill, Maine bloodworms, oysters, sandworms, anchovies, Panama bloodworms, Nippai maturation pellets, Shigueno maturation pellets, conch, squid, Salmon-Frippak maturation pellets, Rangen maturation pellets and Argent maturation pellets.

Introduction

There is a paucity of published prawn preference papers. Studies have been undertaken to determine the distribution of potential prey from the natural shrimp grounds (Hilderbrand 1954, 1955, Williams 1955), but whether shrimp distribution is influenced by prey distribution is uncertain. Some information on the natural diets of penaeids is available from analyses of the shrimp foregut contents (Broad 1962, Dall 1968, Rubright 1978). Even in some aquaculture ponds, the natural benthos may comprise the majority of the shrimp's diet despite the presence of artifical feeds (Rubright 1978, Anderson *et al.* 1987, Reymond and Lagardere 1990).

Some species of shrimp feed selectively and exhibit dietary preferences. Karim and Aldrich (1970) found that *Penaeus setiferus* exhibited a greater selectivity than *Penaeus aztecus*, but both preferred live *Artemia* over five artificial diets. *P. durorum* evidenced an increase in consumption of artificial diets as the content of *Artemia* increased (Sick and Baptist 1973). Hysmith *et al.* (1972) found that *P. aztecus* preferred chopped fish (whiting) over fish meal pellets, with soybean meal pellets the least preferred of the three. Meyers and Zein-Eldin (1972) indicated that, given a choice, shrimp prefered odiferous rations. Quarberg (1974) found that when *P. aztecus* were offered arthropods, the insect larvae were selected over the insect nymphs which, in turn, were preferred over the adults. Dead arthropods were consumed more than live arthropods but this may have been due more to the ability of live arthropods to escape capture than to preference. He also reported that natural benthos were preferred over artificial rations. When several different artificial feeds were offered, Quarberg found that Purina Marine ration, Ralston Purina trout chow and M-G 32 were consumed more often than M-G 28, Domino catfish feed and co-op fish feed. He found that the rations were not necessarily chosen for preference, but may have been chosen due to the stability and density of the pellets. Hardin (1981), working with *P. stylirostris*, noted that one marine ration which included fish meal was preferred over another artificial diet made with soybean. In another study, six commercially prepared artificial diets were tested against a control of chopped fish, with the fish the most preferred (Anon. 1972). Of the six artificial diets, a high density basal diet was most preferred, while a basal diet substituting soybean meal for fish meal was least preferred (Anon. 1972).

At present, fresh or frozen natural products are used as the primary feeds for controlled maturation of penaeid shrimp, and studies have been conducted on some of these foods. Hill and Wassenberg (1987) noted that *Penaeus esculentes* consumed animal matter in the following order of preference: the prawn *Metapenaeus bennettae*, the bivalve *Donax deltoides*, the bivalve *Perna canaliculus*, and the prawn *P. longistylus*. Brown *et al.* (1979) found that *P. setiferus* consumed mussels more readily than oysters. Ogle (1991), in a survey of maturation facility managers utilizing *Penaeus vannamei*, noted that squid was the most commonly used natural food (94%) followed by bloodworms (64%) and oysters (43%). This use pattern was apparently due to availability and cost, not necessarily because of shrimp preferences. As little was known regarding the preference of *P. vannamei* for the various feeds being used in maturation, the following study was conducted.

Materials and Methods

The feeding preference of *P. vannamei* was determined for 15 food items (Table 1). Each treatment (ration) was evaluated in duplicate 1-m diameter tanks, with five individually weighed shrimp in each tank. Shrimp ranged in size from 7.6 g for the first week to a

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TABLE 1

Ranking of food items offered to *Penaeus vannamei* in order of decreasing preference, with preference established on the basis of consumption.

1.	*Artemia sp.*
2.	Krill (*Euphausia superba*)
3.	MAINE BLOODWORMS (*Glyceria dibranchia*)
4.	OYSTERS (*Crassostrea virginica*)
5.	SANDWORMS (*Nereis virens*)
6.	ANCHOVIES (*Anchoa mitchilli*)
7.	PANAMA BLOODWORMS (*Americonuphis reesei*)
8.	NIPPAI MATURATION PELLETS
9.	SHIGUENO MATURATION PELLETS
10.	CONCH (*Strombus gigas*)
11.	SQUID (*Lolliguncula brevis*)
12.	SALMON & Frippak maturation pellets
13.	RANGEN MATURATION PELLETS
14.	Argent maturation pellets

Series 1 Experiments—capitalized, Series 2 Experiments—not capitalized.

final size of 11.1 g for week 14. The tanks were filled to a depth of 22 cm with natural baywater obtained from the Mississippi Sound. The water was adjusted to 16 ppt using Instant Ocean artificial sea salt and maintained at a temperature of 26±3°C. Aeration was provided by one airstone/tank. Prior to being stocked into experimental tanks, shrimp were held in a 8,000-l raceway where they were maintained on a commercial shrimp grower pellet (Zeigler Bros., Inc., Gardner, PA).

Each trial lasted five days, as a longer experiment period resulted in poor water quality. Since addition of a filter also removed food particles, the water was left unfiltered. Food was offered daily in the afternoon, at rates of 15% of shrimp body weight for fresh foods and 3.5% for dry feeds. Several hours after feeding, the lights were turned off until the following morning. Observations on consumption of feed items were routinely continued into the evening, with checks made by flashlight.

Each experiment was duplicated, with two different foods being offered in each tank during each five-day trial. All foods were kept frozen and natural foods were chopped into small pieces, weighed and allowed to thaw shortly before placement in tanks. All feed items were placed on opposite sides of the tanks. The feeds were placed in reverse order for each duplicate tank and placement was alternated daily in all tanks. The feed item in each tank consumed to the largest extent was considered to be the preferred food for that tank (Table 2). After all experiments were conducted, foods were compared and ranked according to the number of times each food was selected. The proportion of each food that was consumed was determined visually after an 18-hour period or when one food was completely consumed. If the relative consumption could not be clearly determined in a given tank, the two food items would be removed and reweighed for actual consumption. In cases where both foods were totally consumed, the first food consumed entirely was noted as the preferred food. Pellets were counted and examined for wholeness before being placed in the tanks and again immediately before removal from the tanks. When two sets of similarly shaped and colored pellets were offered, each set was alternately dyed using Aquashade.

TABLE 2

Series I. Combinations of 11 food items tested over a 10-week period.

	Tank 1	Tank 2	Tank 3	Tank 4	Tank 5	Tank 6
Week 1	**Maine** Squid	**Conch** Squid	Nippai **Maine**	Shigueno **Panama**	**Sandworms** Shigueno	
Week 2	**Sandworms** Squid	Conch **Maine**	**Anchovies** Rangen	Conch **Shigueno**	Salmon **Sandworms**	
Week 3	**Sandworms** Anchovies	Rangen **Nippai**	**Salmon** Rangen	**Anchovies** Panama	**Shigueno** Squid	
Week 4	**Oysters** Sandworms	**Oysters** Salmon	**Squid** Rangen	Oysters **Maine**	**Nippai** Shigueno	
Week 5	**Oysters** Nippai	**Anchovies** Conch	Anchovies **Oysters**	Anchovies **Maine**	**Anchovies** Squid	Salmon **Shigueno**
Week 6	**Anchovies** Shigueno	Salmon **Conch**	Rangen **Shigueno**	Rangen **Conch**	**Panama** Nippai	**Panama** Squid
Week 7	**Maine** Rangen	Shigueno **Maine**	**Panama** Rangen	**Panama** Conch	**Anchovies** Nippai	**Nippai** Squid
Week 9	**Oysters** Conch	Nippai **Sandworms**	**Oysters** Shigueno	Salmon **Panama**	Conch **Nippai**	Salmon **Squid**
Week 10	**Maine** Sandworms	**Sandworms** Panama	Salmon **Maine**	**Oysters** Panama	**Maine** Panama	

Results based on two replicates for 5 days. Preferred food in bold.

Nippai, Rangen, Shigueno—Maturation pellets. Maine and Panama—Bloodworms.

Water in the tanks was swirled; food, debris and detritus were allowed to settle and were daily siphoned off the bottom. The tanks were devoid of any substrate to ensure complete removal of food and provide an unobstructed view of the food as it was being consumed. At the termination of each five-day trial, the water and shrimp were replaced. Each set of shrimp was used only once in the preference experiments.

Any dead shrimp were removed in the mornings and new shrimp were weighed, added to the tanks and feed rates adjusted.

Two series of experiments were conducted. In the first series, every combination of 11 food items were compared in paired tests (Table 1). Although several trials were conducted simultaneously with the available tanks, 10 weeks were required to test the 55 combinations of the 11 food items. A second series of four food items was subsequently tested and added to the preference table. The second series of experiments followed the same procedure as the first series, with the exception that not all combinations were compared. A food item was compared to the established table based upon expected performance. Based upon results of the first test, the food would be compared to another food ranking higher or lower until its ranking was established.

RESULTS

Adult frozen brine shrimp was the most preferred food of *P. vannamei* (Table 1). In general, fresh foods were preferred over artificial pellets. Nippai maturation pellets were the most preferred of the artificial diets.

In the first series, the rankings were consistent in all combinations. A food item would be less acceptable than all items above it in ranking and more acceptable to all items below it in ranking. Since this consistency was established in series 1, it was considered unnecessary to compare the food items in series 2 to every other item. This facilitated the updating of the table without an inordinate amount of experimental testing. The preferences are not ranked as to strength of preference. In some trials, one item was consumed to a slightly greater extent on only one of the five days. This was still ranked as

preferred. In only one case, Frippak maturation pellets and salmon, no true preference was detected. Therefore, these two items were equally ranked. (Table 1).

After the foods were presented into the tanks, shrimp were observed picking up the first food with which they made contact. As the shrimp continued around the tank, this food would be discarded for the next food group, but in most cases the shrimp eventually consumed most of one food type.

During this study, we noted that when shrimp were offered a preferred food, this often seemed to stimulate the animals to consume a less preferred food. The shrimp would then consume more of the less preferred food than normal, even if this food had a low preference ranking. Also, the shrimp would consume 30 per cent of their body weight per day for the entire five-day trial period if fed two greatly preferred foods. If two foods were found to be less palatable, the shrimp would consume very little of either.

DISCUSSION

Squid are the most utilized food item for facilities maturing *P. vannamei* (Ogle 1991), but in the present study, squid were not well liked and ranked below two artificial maturation pellets. However, squid are readily available, inexpensive and promote maturation and spawning more than other natural food items used alone (Chamberlain 1988).

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REFERENCES CITED

Anderson, R.K., P.L. Parker and A.Lawrence. 1987. A 13C/12C tracer study of the utilization of presented feed by a commercially important shrimp *Penaeus vannamei* in a pond growout system. *J. World Aquacult. Soc.* 18(3);148-155.

Anonymous. 1972. Sea Grant Annual Report 1970-71. TAMU SG 72-104, p. 24-29.

Broad, A.D. 1963. Environmental requirements of shrimp. Pp. 86-91 in: C.M. Tarzwell (ed.) *Bio. Problems in Water Pollution.* U.S. Div. Water Supply Pollution Control (Third Seminar 1962).

Brown, A., Jr., J. McVey, B.S. Middleditch and A.L. Lawrence. 1979. Maturation of white shrimp (*Penaeus setiferus*) in captivity. *Proc. World Maricul. Soc.* 10:435-444.

Chamberlain, G.W. 1988. Stepwise investigation of environmental and nutritional requirements for reproduction of penaeid shrimp. Ph.D. Dissertation, Texas A&M Univ., College Station, Texas. 210 pp.

Dall, W. 1968. Food and feeding of some Australian penaeid shrimp. *FAO Fisheries Rept.* 2(57):251-258.

Hardin, M.P. 1981. Considerations of diet, stocking density, distribution, population estimation and economics in the pond culture of blue shrimp (*Penaeus stylirostris* Stimpson). M.S. Thesis, Texas A&M Univ., College Station, Texas. 168 pp.

Hildebrand, H.H. 1954. A study of the brown shrimp (*Penaeus aztecus* Ives) ground in the western Gulf of Mexico. Publ. *Inst. Mar. Sci.* 3(2):233-266.

Hildebrand, H.H. 1955. A study of the fauna of the pink shrimp (*Penaeus duorarum*, Burkenroad) ground in the Gulf of Campeche. *Publ. Inst. Mar. Sci.* 4(1):169-232.

Hill, B.J. and T.J. Wassenburg. 1987. Feeding behavior of adult tiger prawns, *Penaeus esculentus*, under laboratory conditions. *Aust. J. Mar. Freshw. Res.* 38:183-90.

Hysmith, B.T., J.R. Booth, H. Cook and W.L. Mies. 1972. A study of the effects of feeding synthetic diets to brown shrimp (*Penaeus aztecus*). *Proc. World Maricul. Soc.* 3:365-388.

Karim, M. and D.V. Aldrich. 1970. Influence of diet on the feeding behavior, growth and thermal resistance of postlarval *Penaeus aztecus* and *P. setiferus*. Texas A&M Univ. Sea Grant Program, Report No. TAMU-SG-70-226. 80 pp.

Meyers, S.P. and Z.P. Zein-Eldin. 1972. Binders and pellet stability in development of crustacean diets. *Proc. World Maricul. Soc.* 3:351-363.

Ogle, J.T. 1991. Standard conditions for captive maturation and reproduction of *Penaeus vannamei* based upon a survey. *Gulf Res. Rept.* 8(3):295-297.

Quarberg, D.M. 1974. Report on the culture of brown shrimp, *Penaeus aztecus*, in ponds receiving thermal effluent from a power plant. M.S. Thesis. Texas A&M Univ., College Station, Texas, 225 pp.

Reymond, H. and J.P. Lagardere. 1990. Feeding rhythms and food of *Penaeus japonicus* Bate (Crustacea, Penaeidae) in salt marsh ponds: role of halophilic entomofauna. *Aquacult.* 84:125-143.

Rubright, J.S. 1978. An investigation into the role of meiofauna in the food chain of a shrimp mariculture pond system. M.S. Thesis. Texas A&M Univ., College Station, Texas. 66 pp.

Sick, L.V. and G. Baptist. 1973. Effects of selected physical and nutritional factors on rates of pelleted diet ingestion by postlarval penaeid shrimp. *J. Elisha Mitchell Sci. Soc.* 89(3):161-165.

Williams, A.B. 1955. A contribution to the life histories of commerical shrimp (Penaeidae) in North Carolina. *Bull. Mar. Sci. Gulf Caribb.* 5(2):116-146.

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Maturation of *Penaeus vannamei* Based Upon a Survey

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MATURATION OF *PENAEUS VANNAMEI* BASED UPON A SURVEY

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ABSTRACT Captive maturation and reproduction of *Penaeus vannamei*, a popularly cultured penaeid shrimp, was first achieved in 1977. Based upon interviews of 18 facility managers, average conditions are as follows: tank diameter of 4.6 m (15 ft), 100% water exchange with recirculation, temperature 27-29°C, salinity 28-32 ppt, and a photoperiod of 13-14 hours of light. Broodstock are predominately wild, undergo unilateral eyestalk ablation by enuculation, and are stocked at five per square meter with a 1:1 sex ratio. *Penaeus vannamei* at most facilities are fed squid, pellets and bloodworms four times daily and 3-7% of the females are found to be mated per night and 50% of the eggs are expected to hatch. Most facility managers anticipate some misplaced and some melanization of spermataphores.

Introduction

Although *Penaeus vannamei* is the most popularly cultured shrimp in the Americas, maturation research has been fairly recent and the species was not matured and reproduced in captivity until 1977 (Aquacop 1979). Effects of diets on maturation were studied by Chamberlain and Lawrence (1981). Maturation in earthen ponds (Yano and Wyban 1987), mating behavior (Yano *et al.* 1988) and hormone treatment (Yano and Wyban 1987, 1988, Yano *et al.* 1988) were also studied. Problems with the melanization of the male spermatophore have been discussed by Chamberlain *et al.* (1983), Leung-Trujillo and Lawrence (1985, 1987), and Salvador *et al.*(1988). The performance in maturation facilities has been reported on by Aquacop (1983), Gomez and Arellano (1987), Wyban *et al.* (1987), McGovern (1988), Ashmore (1988), and Oyama *et al.* (1989). Due to the proprietary nature and competition of the commercial facilities, little information is available as to what constitutes an "industry standard" for maturation of *P. vannamei*. Therefore, a survey was undertaken based upon interviews of maturation facility managers in the Americas and Carribean basin involved with this species of shrimp.

Materials and Methods

While attending the 19th Annual World Aquaculture Society Conference and Exposition, January 2-9, 1988 in Honolulu, Hawaii, interviews were conducted with 18 managers of maturation facilities utilizing *P. vannamei* broodstock. A survey form was used to standardize questions, although the survey form was not compatible with all responses. The responses were grouped into catagories and averaged. Individual responses are not presented in order to comply with concerns of some respondents over the proprietary nature of some information. Not all questions were answered by all respondents, therefore, the averages represent a mean of responses to a particular question and may not add up to 100% for a category. No indication will be made as to which questions were considered sensitive and not answered.

Results

Average conditions under which *P. vannamei* were being matured in 1988 (Table 1) consisted of the use of 4.6 m (15 ft) diameter or greater round tanks which have 100% exchange of recirculated water, with temperatures of 27-29°C, salinity of 28-32 ppt, oxygenated by airstones and the use of artifical illumination with a photoperiod of 13-14 hours daylight. Animals are predominately wild and stocked at five per square meter with a 1:1 sex ratio. Females undergo unilateral eyestalk ablation by enuclation. Three to seven per cent mated females were detected per night by sourcing, with 50% fertilization and some spermatophores were noted to be melanized or misplaced. A combination of feeds were used by all facilities, with squid used by almost all. Pellets were the second most common feed item, with bloodworms ranking third. It should be noted that even though some facilities operated without the use of bloodworms in the diet, all respondents indicated that they would have used bloodworms had they been available to their facility.

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TABLE 1

Maturation of *Penaeus vannamei*
a survey of 18 lab managers

SYSTEM	%	ANIMALS	%	FEEDING	%
Tank Diameter		Broodstock		Times per Day	
≤ 12	33	**wild**	**61**	2	8
14	11	captive	39	3	38
≤ 15	**50**			**4**	**54**
		Eyestalk Ablation			
Daily Turn Over		**enuculate**	**61**	Food	
1x	**44**	cauterize	28	bloodworms	64
2x	17	not ablated	6	**squid**	**94**
5–6x	11			pellets	71
9–12x	22	Male/Female Ratio		oysters	43
		1:1	**81**	shrimp	29
Water System				fish	21
Flow Through	44	Stocking Density		mussel	14
Recirculating	**56**	≤ 5	38	clam	14
		> 5	**56**		
Aeration					
Airstones	**65**	Mated Female/Night			
Airlifts	29	< 3%	7		
		3–7%	**73**		
Parameters		> 10%	20		
Temp. 27–29°C	78				
Sal. 28–32 ppt	44	Fertilization			
Activated Carbon	28	< 50%	27		
EDTA	11	**> 50%**	**73**		
Lighting		Spermatophores			
Natural Light	33	misplaced			
Photoperiod (13–14)	**54**	none	8		
		some	**84**		
Lights Out		a lot	8		
Morning	15	melanized			
Afternoon	**23**	none	23		
Evening	**23**	**some**	**69**		
		a lot	8		

Bold type indicates average conditions

DISCUSSION

Even though Johnson and Fielding (1956) produced larvae from captive stocks of *Penaeus setiferus* in ponds, routine maturation of penaeids was not achieved until 1975 (Aquacop 1975). A number of penaeid shrimp species have now been routinely matured in captivity. The state of knowledge concerning the published research of shrimp maturation has been adequately reviewed by Muthu and Laxinarayana (1982), Primavera (1985) and Chamberlain (1985).

This survey and summary of conditions, while based upon a small number of respondents, is useful in providing a beginning toward that which can be considered an "industry standard" in 1988 for captive maturation of *P. vannamei*.

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REFERENCES CITED

Aquacop. 1975. Maturation and spawning in captivity of penaeid shrimp: *Penaeus merguiensis* de Man, *Penaeus japonicus* Bate, *Penaeus aztecus* Ives, *Metapenaeus ensis* de Hann, and *Penaeus semisculcatus* de Haan. *Proc. World Maricult. Soc.* 6:123-129.

Aquacop. 1979. Penaeid reared brood stock: closing the cycle on *P. monodon*, *P. stylirostris* and *P. vannamei*. *Proc. World Maricult. Soc.* 10:445-452.

Aquacop. 1983. Penaeid larval rearing in the Centre Oceanologigue du Pacifique. p. 123-127. In: J.P. McVey (ed.), *CRC Handbook of Mariculture. Vol. I. Crustacean Aquaculture*. CRC Press, Boca Raton, FL.

Ashmore, S.B. 1988. Nauplii production results from a commercial *Penaeus vannamei* maturation facility in Hawaii. *J. World Aquacult. Soc.* (Abstract) 19(1):15A.

Chamberlain, G.W. 1985. Biology and control of shrimp reproduction. p. III1-III41. In: G.W. Chamberlain, M.G. Haby and R.J. Miget (eds.), *Texas Shrimp Farming Manual*. Texas Agricultural Extension Service publication of invited papers presented at the Texas Shrimp Farming Workshop on 19-20 Nov. 1985 in Corpus Christi, Texas.

Chamberlain, G.W. and A.L. Lawrence. 1981. Maturation, reproduction, and growth of *Penaeus vannamei* and *P. stylirostris* fed different natural diets. *J. World Maricult. Soc.* 12(1):209-224.

Chamberlain, G.C., S.K. Johnson and D.H. Lewis. 1983. Swelling and melanization of the male reproductive system of captive adult penaeid shrimp. *J. World Maricult. Soc.* 14:135-136.

Gomez, L. and E. Arellano. 1987. Maturation in captivity of *Penaeus vannamei* in the Escuela Surperior Politecnica del Litoral. *J. World Aquacult. Soc.* (Astract) 18(1):14A.

Johnson, M.C. and J.R. Fielding. 1956. Propagation of the white shrimp, *Penaeus setiferus* (Linn.), in captivity. *Tulane Stud. Zool.* 4(6):175-190.

Leung-Trujillo, J.R. and A.L. Lawrence. 1985. The effect of eyestalk ablation on spermatophore and sperm quality in *Penaeus vannamei*. *J. World Maricult. Soc.* 16:258-266.

Leung-Trujillo, J.R. and A.L. Lawrence. 1987. Observations on the decline in male viability of *Penaeus setiferus* under laboratory conditions. *Aquacult.* 65(3-4):363-370.

McGovern, K.M. 1988. Management strategies for *Penaeus vannamei* broodstock. *J. World Aquacult. Soc.* (Abstract) 19(1):51A.

Muthu, M.S. and A. Laxinarayana. 1982. Induced maturation of penaeid prawns - a review. *Proc. Symposium on Coastal Aquacult.* The Mar. Biol. Assoc. of India, pp. 16-27.

Oyama, R., R. Deupree, M. Edralin, J. Sweeney and J. Wyban. 1989. Individual female *Penaeus vannamei* performance under long term maturation system conditions. *J. World Aquacult. Soc.* (Abstract), 20(1):61A.

Primavera, J.H. 1985. A review of maturation and reproduction in closed thelycum penaeids. pp. 47-64. In: Y. Taki, J.H. Primavera and J.A. Llobrera (eds.) *Proc. First Intl. Conf. Culture of Penaeid Prawns/Shrimps*. Aquaculture Department, Southeast Asian Fisheries Development Center.

Salavdor, J.A., B. Jaramillo, Z. Romero, H. Lucien-Brun and D.O.C. Lee. 1988. A comparative analysis of sperm quality, between wild caught males and unilaterally eyestalk ablated regenerated males in a commercial *Penaeus vannamei* maturation facility. *J. World Aquacult. Soc.* (Abstract) 19(1):61A.

Wyban, J.A., C.S. Lee, J.N. Sweeney and W.R. Richards. 1987. Observations on development of a maturation system for *Penaeus vannamei*. *J. World Aquacult. Soc.* 18(3):198-200.

Yano, I. and J.A. Wyban. 1987. Induced ovarian maturation and spawning of *Penaeus vannamei* by hormone treatment. *J. World Aquacult. Soc.* (Abstract) 18(1):29A.

Yano, I. and J.A. Wyban. 1987. Maturation of *Penaeus vannamei* in earthen ponds. *J. World Aquacult. Soc.* (Abstract) 18(1):29A.

Yano, I., R.A. Kanna, R.N. Oyama and J.A. Wyban. 1988. Mating behaviour in the penaeid shrimp *Penaeus vannamei*. *Mar. Biol.* 97:171-175.

Yano, I., B. Tsukimura, J.N. Sweeney and J.A. Wyban. 1988. Induced ovarian maturation of *Penaeus vannamei* by implantation of lobster ganglion. *J. World Aquacult. Soc.* 19(4):204-209.

Yano, I. and J.A. Wyban. 1988. Induced ovarian maturation and spawning of *Penaeus vannamei*. *J. World Aquacult. Soc.* (Abstract) 19(1):75.

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A Method to Construct Low-Cost Ponds for Aquaculture

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A METHOD TO CONSTRUCT LOW-COST PONDS FOR AQUACULTURE

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ABSTRACT A 100 m² pond was constructed using a vinyl liner supported by hog wire panels shackled together in a circle. The construction was completed in one afternoon at a total cost of $612.00.

Introduction

Shrimp aquaculture in the United States is growing. In 1985, there were 17 farms with an expected production of 226,796 kg (Pruder *et al.* 1985). These farms utilized dirt ponds ranging from 26 m² to 809 ha and produced yields of 567 kg to 2,268 kg per ha. In 1989, there were 35 farms with an expected production of 907,184 kg (Rosenberry 1989). Although the size of ponds being utilized has decreased, yields have increased. Experimental yields of 9,120 kg/ha/crop (Wyban *et al.* 1988) to 12,680 kg/ha/crop (Sandifer *et al.* 1988) have been achieved. Such yields demand a high degree of management requiring small ponds that are expensive to build. The high water exchange and supplemental aeration required to sustain such yields result in a high water velocity requiring gravel, granite or solid walls to prevent pond erosion.

Vinyl-lined tanks and ponds (Bray *et al.* 1990, Pruder pers. comm.) recently have been shown to allow satisfactory growth of a marine shrimp, *Penaeus vannamei*. The use of vinyl-lined raceways has been reported (Salman *et al.* 1983) and are available commercially (Fastank, Antrim, N. Ireland). Completely self-supporting tanks up to 7 m in diameter are also available (Funny Pool, Settler Textilwerke, Graz, Austria). The use of metal (Woods, et al. 1981) and wood (Anon 1989) for supporting vinyl liners in above ground pools have been reported. These supports are available commercially in round (Aquatic Ecosystems, Inc., Apopka, Fla.) or square configurations (Modutank, Inc., Long Island, N.Y.). Plastic and metal wall supports are also readily available as 3.6 m diameter plastic swimming pools from major discount retailers.

An important consideration in the use of vinyl-lined tanks is the cost-per-unit volume. Although small tanks are readily available at low costs, larger tanks are more difficult to support structurally and are often expensive to construct. In an effort to lower the cost of constructing vinyl lined tanks, experimental use of hog wire panels as a means of supporting the tank was employed. A 100 m² tank was constructed at a total cost of $612.00.

Materials and Methods

A vinyl-lined pond was constructed using hog wire for wall panels. Hog wire is available in 81.3 cm by 4.6 m panels constructed of 4-gauge wire. Vertical wires are equally spaced every 20.3 cm. Eleven horizontal wires are unequally spaced increasing from 5.08 cm at the bottom to 15.24 cm at the top. This is ideal for supporting vinyl tanks as expansion force increases with depth and more support is needed at the bottom. Any number of these panels can be connected together by overlapping panels 20.3 cm and securing them with 0.3 cm cable clamps to form a self supporting circle. A pond of 100 m² surface area required 8 panels. Unlike other lined tanks, no berming was required at the inside perimeter. Dirt under the tank was contoured to produce a slope toward the tank center with no loss of depth at the periphery. A permalon liner (Aquatic Ecosystems, Inc., Apopka, Fla.) prefabricated for the diameter was purchased and installed. The tank required four hours to assemble and cost $612.00.

Discussion

The use of hog wire panels for inexpensive pond construction should prove to be a benefit for aquaculture of a variety of animals. For shrimp aquaculture, it would allow production in areas where normal dirt pond construction is either impossible or too expensive. This type of pond can be readily disassembled and moved if necessary.

Further studies to determine the upper size limit of ponds constructed using the described technique is encouraged.

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References Cited

Anonymous. 1989. Construction of a plywood and liner tank. Sea Grant Advisory Brochure. UNIHI-Seagrant-AB-04. 12 pp.

Bray, W.A., A.L. Lawrence and J.R. Leung-Trujillo. 1990. Salinity and substrate influence on growth of 1 to 15 g *Penaeus vannamei*. (Abstract). World Aquacult. Soc. 90. June 10-14, 1990. Halifax, N.S., Canada.

Pruder, G., J. Wyban and J. Ogle. 1985. U.S. marine shrimp farming consortium: Current status of domestic producers. USDA marine shrimp farming project 85-CRSR-2-2537. 24 pp.

Rosenberry, B. 1989. Shrimp farming in the United States, bonanza or black hole? Shrimp Farming in the USA, Fish Farming Expo-III, Dec. 1989. 10 pp.

Salman, S.E., A. Al-Ahmed and A.S.D. Farmer. 1983. An inexpensive and simple raceway design. *J. World Maricult. Soc.* 14:86-95.

Sandifer, P.A., J.S. Hopkins and A.D. Stokes. 1988. Intensification of shrimp culture in earthen ponds in South Carolina: Progress and prospects. *J. World Aquacult. Soc.* 19(4):218-226.

Woods, L.C., J.H. Kerby, M.T. Huish, G.M. Gafford, and W.L. Rickards. 1981. Circular tank for intensive culture of hybrid striped bass. Prog. Fish-Cult. 43(4):199-200.

Wyban, J.A., J.N. Sweeney and R.A. Kanna. 1988. Shrimp yields and economic potential of intensive round pond systems. *J. World Aquacult. Soc.* 19(4):210-217.

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Pattern and Coloration of *Periclimenes rathbunae* from the Turks and Caicos Islands, with Comments on Host Associations in Other Anemone Shrimps of the West Indies and Bermuda

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PATTERN AND COLORATION OF *PERICLIMENES RATHBUNAE* FROM THE TURKS AND CAICOS ISLANDS, WITH COMMENTS ON HOST ASSOCIATIONS IN OTHER ANEMONE SHRIMPS OF THE WEST INDIES AND BERMUDA

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ABSTRACT The commensal shrimp *Periclimenes rathbunae* Schmitt, 1924, lives in association with the sea anemones *Condylactis gigantea* Weinland, 1860, and *Stichodactyla* (= *Stoichactis*) *helianthus* Ellis, 1767, in the Turks and Caicos Islands, British West Indies. We describe its pattern and coloration in life. Published reports of distribution and host acceptance by *P. rathbunae* and three of its congeners (*P. anthophilus* Holthuis and Eibl-Eibesfeldt, 1964; *P. pedersoni* Chace, 1958; and *P. yucatanicus* Ives, 1891) are reviewed. The last two species are recorded for the first time from the Turks and Caicos, and the association of *P. yucatanicus* with *Stichodactyla helianthus* on the Caicos Bank is a new host record. Finally, we offer the first direct evidence that *P. yucatanicus* leaves the host anemone temporarily to "clean" fishes, discounting a previous suggestion of its role as a noncleaning mimic of *P. pedersoni*.

INTRODUCTION

The commensal shrimp *Periclimenes rathbunae* Schmitt, 1924, lives in association with sea anemones in shallow waters of the West Indies. Schmitt (1924) and later Holthuis (1951) based descriptions on preserved specimens from which the pattern and coloration had been extinguished. In this report we extend the range of the species to the Turks and Caicos Islands (British West Indies), provide a description of the pattern and coloration in life, summarize what is known about distribution, and discuss host associations. We also describe the distribution and host associations of three congeners (*P. anthophilus* Holthuis and Eibl-Eibesfeldt, 1964; *P. pedersoni* Chace, 1958; and *P. yucatanicus* Ives, 1891), report a new host association (*P. yucatanicus* with the sea anemone *Stichodactyla helianthus* Ellis, 1767), and offer the first direct evidence that *P. yucatanicus* may be a "cleaner" of fishes.

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MATERIALS AND METHODS

Periclimenes rathbunae was collected at depths of 1-3 m in the vicinity of Pine Cay (~21°53'N, 72°05'W). Specimens collected on the fringing reef were always associated with the anemone *Stichodactyla* (= *Stoichactis*) *helianthus*. Dunn (1981) discussed taxonomic problems of the genus *Stichodactyla*; our nomenclature follows hers. The shrimp were photographed at an image size of 1/1 or 1/2, then captured in plastic bags. Photographs of a typical adult and juvenile are presented in Figures 1 and 2. In the laboratory we recorded pattern and coloration under a dissecting microscope. Notes were made of six adults and three juveniles. Specimens were fixed while still alive in 10% formalin-seawater and identified from characters in Chace (1972, pp. 29-31, 38). Preservation was in 70% ethanol. We collected several *P. rathbunae* from the anemone *Condylactis gigantea* Weinland, 1860, on the Caicos Bank. These differed from the others in pattern and coloration. The unique characters of one specimen (an ovigerous female) are in boldface in the description below. *Periclimenes pedersoni* and *P. yucatanicus* were observed over two years in shallow waters of the Caicos Bank or during dives on the fringing reef off Pine Cay and Providenciales. Specimens were collected intermittently and preserved for identification.

RESULTS

PERICLIMENES RATHBUNAE ADULTS (Figure 1) — Protopodites of pleopods clear with orange spots; **or orange spots separated intermittently by white spots; some orange spots with darker centers**; exopods and endopods clear or Ova olive green. Pereopod 3 clear except for red spots on basis; **or propodus and carpus washed with white**; other preopods clear with orange and white spots, the latter smaller and irregular in shape; **or with extensive white, either as a patternless wash or rows of closely spaced spots**. Pereopods 4 and 5 with a white stripe extending strongly as a dorsal line from ischium through most of merus; junctions of ischium and merus appear white-banded; **or propodus and carpus covered almost completely with white; merus and ischium clear with one or two rows of small white spots nearly opposite larger orange spots, the latter with darker centers**. Coloration may be strongest on last two pereopods, followed in descending order by pereopods 2 and 1. Pereopod 2 with transverse rows of orange (or russet) and white spots giving the appearance of bands. First and second maxillipeds clear; third maxilliped with orange **or russet** spots. Eyestalks with longitudinal white stripes, **or as closely spaced spots**, and interspersed with orange spots. Antennular peduncle with orange and white spots extending onto stylocerite, some white spots in a thin longitudinal line from base of eyestalks to proximal portion of outer antennules giving the appearance of white stripes. Posterior portion of outer antennules with orange spots, anterior edges clear; **or outer antennules clear and washed strongly with white**; inner antennules clear, **or clear and russet**. Antennal scale orange- and white-spotted for a short distance on dorsolateral surface, then clear. Antennae clear with several faint orange **or russet** bands. Cornea orange ringed with white **or pale gold with an orange band**. Ventrum with prominant white pattern extending from telson into ventroposterior portion of carapace. Ventral surfaces of abdominal somites orange-spotted. Ventrolateral portion of first somite with faint pattern of white spots similar to ventroposterior portion of third somite; second somite with white ventral patches anteriorly and posteriorly, the white circumscribed with orange spots; **or with circular white spots merging strongly into an ellipse**. Midlateral areas of

Figure 1. Adult female *Periclimenes rathbunae* (ovigerous) photographed 19 April 1989 on *Stichodactyla helianthus*. Fringing reef, Pine Cay, Turks and Caicos Islands. Image size 1/1, depth 3 m.

somites clear; second and third somites marked with a large saddle clear in center with solid or interrupted orange edges extending anteriorly (or clear anteriorly); entire saddle edged faintly in white; or posterior portion of saddle consisting of white spots mingled with larger orange spots having darker centers; fourth and fifth somites clear with spots similar to those second and third somites but with the pattern outlined in small white spots. Sixth somite with orange and white dorsal spots extending to proximal surfaces of outer uropods; inner uropods and telson clear; or anterior section of telson and uropods with common white band; outer uropods terminating in orange spots with one or two white spots in no evident pattern; or with large white spots on outer edges and a row of russet spots with darker centers around inner edge. Carapace clear with partial dorsal saddle of orange and white spots extending onto rostrum; midlateral sections clear with orange and white spots, the former dominant. In life, the overall appearance is olive green with chelae of pereopod 2 orange- and white-banded. The same banded appearance is evident in life, but the shrimp is clear with no hint of olive.

PERICLIMENES RATHBUNAE JUVENILES (Figure 2) — Protopodites of pleopods clear; exopods and endopods clear. Pereopods 1 and 2 clear; pereopod 3 clear except for russet spots on basis and coxa; pereopods 4 and 5 clear with orange spots; all pereopods devoid of white. Sixth abdominal somite clear; ventral surfaces of first five somites with faint, parallel, longitudinal russet stripes. First and second maxillipeds clear; third maxilliped with orange spots. Antennular peduncle clear. Outer antennules with orange spots; inner antennules clear. Antennae clear with several faint orange bands. Cornea dark. Anterior portions of uropods and telson with faint russet wash; otherwise clear. Carapace clear except for a pattern of russet spots extending onto dorsal surface of rostrum; midlateral areas of carapace clear with orange and white spots, the former dominant. In life, the overall appearance is clear with russet or orange spots, occasionally with a faint green iridescence. The characteristic pattern becomes increasingly more developed and complex with age, and white is the last color to appear.

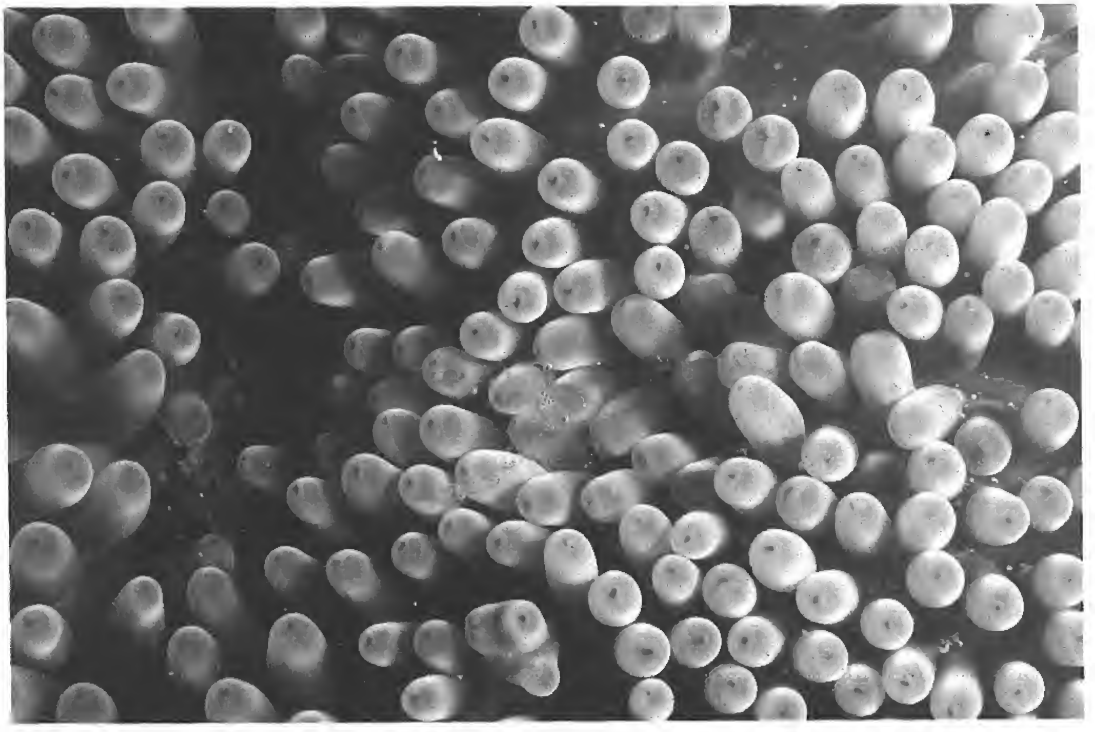

Figure 2. Juvenile *Periclimenes rathbunae* photographed 16 November 1989 on *Stichodactyla helianthus*. The nearly transparent shrimp is positioned near the center of the photograph and facing left. Fringing reef, Pine Cay, Turks and Caicos Islands. Image size 1/2, depth 2.7 m.

DISCUSSION

COMMENTS AND OBSERVATIONS — *P. rathbunae* — The above descriptions suggest that the pattern and coloration of *P. rathbunae* are age-dependent, but also influenced by the host. Mahnken (1972) ascribed to *P. yucatanicus* a limited capacity to match the coloration of its host anemone, but we could find no additional information on the subject with respect to other anemone shrimps of the genus *Periclimenes*.

The tentacles of *S. helianthus* ordinarily are green to olive, and the column ranges from dark olive to almost brown. The coloration of *C. gigantea* is variable: the tentacles can be uniformly white, cream, or various shades of tan, occasionally tipped with red, pink, or lavender. The column, which is just as variable, can be cream, tan, or orange. Specimens of *P. rathbunae* collected from *S. helianthus* and observed *in vitro* were transparent, tinted slightly with olive. The more intense olive appearance in nature is attributable not to inherent coloration, but to light transmitted through the shrimp from the surface of the anemone. The *C. gigantea* from which *P. rathbunae* were collected on the Caicos Bank had cream-colored tentacles. The shrimp were transparent and without any background coloration of note; in other words, similar to the unconfirmed specimen in Figure 3. These observations indicate that *P. rathbunae* can modify its overall coloration to match that of the host, but such capacity is limited.

Schmitt (1924, 1936) made no mention of habitat when describing *P. rathbunae* and was unaware that the species is a symbiont. Before Schmitt's descriptions, Duerden (1900, p. 166) had written that in Jamaica *Stichodactyla helianthus* is host to "a small, brightly-coloured Crustacean," perhaps *P. rathbunae*. Manning (1970) found *P. rathbunae* in Dominica associated with a sea anemone described as *Stoichactis* sp. Colin (1978, p. 344) depicted what appears to be an adult *P. rathbunae* among the tentacles of *S. helianthus*. The shrimp, photographed in color off Puerto Rico, was described simply as "an unidentified specimen of *Periclimenes*." An unidentified shrimp shown in another photograph (Colin 1978, p. 193) is possibly a juvenile *P. rathbunae*. Mercado and Capriles (1982) recorded *P. rathbunae* as a symbiont of both *S. helianthus* and *Homostichanthus duerdeni* Carlgran, 1900, in Puerto Rico. R.N. Mariscal (1979, pers. commun. to Dunn 1981, p. 81) reported having seen *P. rathbunae* on *S. helianthus* in the British Virgin Islands. Hermkind et al. (1976) observed "*P. c.f. rathbunae*" to be a common symbiont on *Lebrunia danae* Duchassaing and Michelotti, 1860, at Grand Bahama. These and other known host associations of *P. rathbunae* and three of its congeners are summarized in Table 1. We keyed three shrimps collected by M.R. Dardeau at Carrie Bow Cay, Belize, to *P. rathbunae* (host unknown).

All *P. rathbunae* observed by us in the Turks and Caicos have been associated with *S. helianthus*, except those on the Caicos Bank. At Bonaire two of us (Manstan and Spotte) photographed shrimps that appear to be *P. rathbunae* on *C. gigantea* (Figure 3). The specimens were not collected. Criales (1984) listed *Bunodosoma granulifera* Leseur, 1817, *C. gigantea*, and *S. helianthus* as hosts of *P. rathbunae* in Santa Marta, Colombia. Captive *P. rathbunae* will accept *C. gigantea* if *S. helianthus* is unavailable. An adult female captured at Pine Cay in April 1989 and placed in a laboratory aquarium with three *C. gigantea* immediately accepted one as host. At Curacao, Criales (1980) reported finding a single *P. rathbunae* on the gorgonian *Eunicea tourneforti* Milne-Edwards and Haime, 1857. Mahnken (1972) collected shrimps similar to *P. rathbunae* (perhaps undescribed) from *Bartholomea annulata* Duchassaing and Michelotti, 1866, and other (unnamed) species of anemones in the U.S. Virgin Islands. Criales (1980) wrote that *P. rathbunae* "... has been reported living in association with several sea anemones (Holthuis 1951, Chace 1972) ...." Neither author cited, however, mentioned a host. Holthuis (1951, p. 60) stated that the single specimen deposited in the U.S. National Museum (Schmitt 1936) had been collected at Bonaire "under stones." According to Chace (1972, p. 38), "Most of the documented specimens in the [U.S. National Museum's] collection were taken from coral reefs in 1-5 feet of water; one specimen was found on a dead coral flat and one along a rock-studded sandy beach."

COMMENTS AND OBSERVATIONS — *P. anthophilus, P. pedersoni, P. yucatanicus* - Of anemone shrimps of the genus *Periclimenes* indigenous to the Western Hemisphere, *P. anthophilus* is the most limited in its host associations (Table 1). Nizinski (1989) found *P. anthophilus* at Bermuda associated only with *C. gigantea*, despite the presence of *B. annulata*. The shrimp sighted by Sargent and Wagenbach (1975) at Bermuda occupied *C. gigantea* exclusively. In their original description of *P. anthophilus*, Holthuis and Eibl-Eibesfeldt (1964) remarked that this shrimp was observed on *C. gigantea* and *Actinia bermudensis* McMurrich, 1889, but never *B. annulata*. To our knowledge, *P. anthophilus* is restricted to Bermuda waters. Criales and Corredor (1977) did not observe *P. anthophilus* at Santa Marta and St. Vincent (we assume St. Vincent and the Grenadines). Criales (1984) later claimed to have seen the species associated with *B. annulata* and *C. gigantea* at Santa Marta, but the vagueness of her descriptions leads us to question their validity.

Periclimenes pedersoni and *P. yucatanicus* seem more plastic in their host acceptance. Early records of these species did not include mention of hosts (Table 1). At Santa Marta, *P. pedersoni* associates with *Aiptasia*

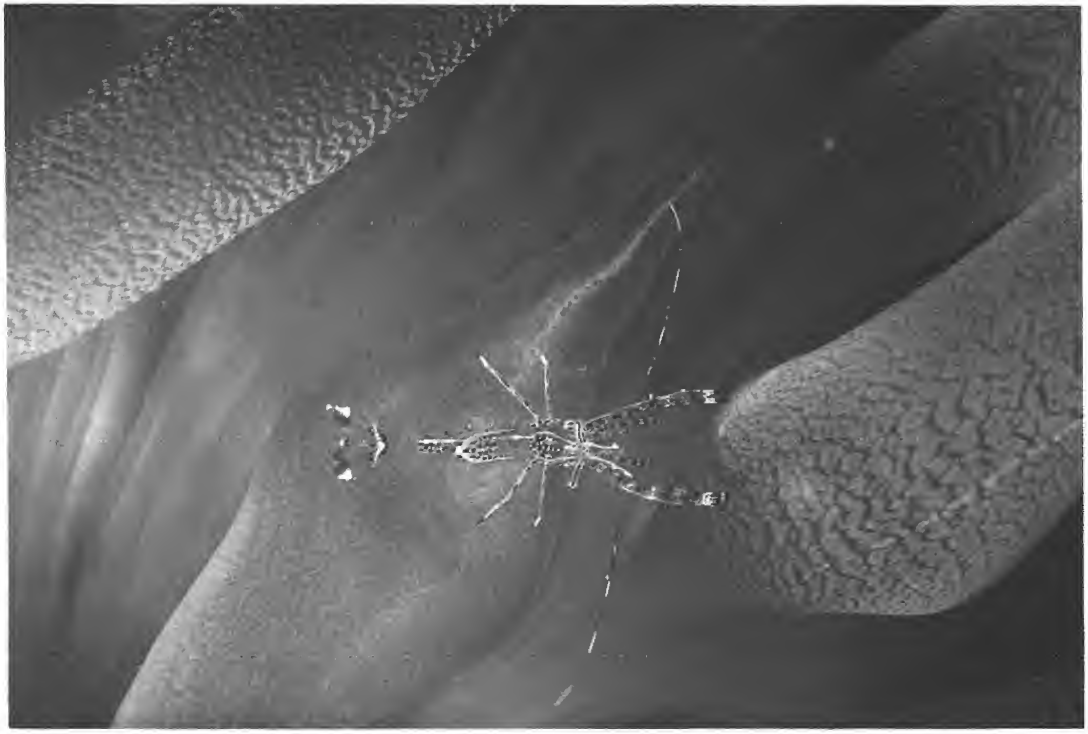

Figure 3. ***Periclimenes* c.f. *rathbunae* photographed April 1982 on *Condylactis gigantea*. Bachelors Beach, Bonaire, Netherlands Antilles. Image size 1/2, depth 6 m.**

pallida Verrill, 1864 (Criales 1984), *B. annulata* (Criales 1984, Criales and Corredor 1977), and *L. danae* (Criales 1984, Criales and Corredor 1977). Criales (1984) also listed *B. granulifera*, *Cerianthus* sp., and the medusa *Cassiopea xamachana* Bigelow, 1892, as hosts of *P. pedersoni* at Santa Marta. At St. Vincent, Criales and Corredor (1977) reported *P. pedersoni* in association with *B. annulata*, *C. gigantea*, and *Heteractis lucida* Duchassaing and Michelotti, 1860. Both shrimps are found commonly on *B. annulata* in the U.S. Virgin Islands (Mahnken 1972). Mahnken (1972) also reported finding *P. yucatanicus* on the medusa *Cassiopeia* [*sic*] sp. and two "large green anemones" (*S. helianthus*?). Limbaugh et al. (1961) stated that in the Bahamas, Virgin Islands (presumably the U.S. Virgin Islands), and Puerto Rico, *P. yucatanicus* associates with *B. annulata* and *C. gigantea*. Specimens of *P. pedersoni* collected by these authors in the Bahamas, Antigua (Antigua and Barbuda), and Virgin Islands (presumably U.S.) were always associated with *B. annulata*. One of us (Spotte) has observed *P. pedersoni* and *P. yucatanicus* on *B. annulata* at Coki Beach, St. Thomas (U.S. Virgin Islands). One of us (Spotte) has photographed a shrimp that resembles *P. yucatanicus* on the corallimorpharian *Rhodactis sanctithomae* Duchassaing and Michelotti, 1860, off Rocher du Diamont, Martinique, French West Indies. The shrimp was not collected.

Chace (1958) recorded *P. pedersoni* in the collections of the U.S. National Museum from Lyford Cay (New Providence Island, Bahamas), Hog Island (Nassau Harbor, Bahamas), and St. John (U.S. Virgin Islands). Chace (1972, p. 38) listed specimens from Antigua and Tortola (British Virgin Islands). Only the Antigua specimens are known to have been associated with a host (*B. annulata*).

Chace (1972, p. 38-39) noted the origins of *P. yucatanicus* deposited at the U.S. National Museum. Specimens from St. Christopher ("St. Kitts;" St. Christopher-Nevis), had been recovered from *B. annulata*; those from Peter Island (British Virgin Islands) were recorded simply as having been found "on the usual anemone." Hosts for the remaining material are unknown (Table 1). Specimens from Horseshoe Island (Florida Keys) in the possession of M.R. Dardeau keyed to *P.*

yucatanicus. They had been collected from *C. gigantea*. Other specimens in the Dardeau collection from Carrie Bow Cay (Belize) were keyed by us to *P. pedersoni* and *P. yucatanicus* (hosts unknown). At Santa Marta, *P. yucatanicus* associates with *A. pallida* (Criales and Corredor 1977), *B. annulata* (Criales 1984, Criales and Corredor 1977), *C. gigantea* (Criales 1984), *L. danae* (Criales 1984), and *C. xamachana* (Criales 1984, Criales and Corredor 1977). At St. Vincent, *P. yucatanicus* is found on *B. annulata* and *C. gigantea* (Criales and Corredor 1977). Hermkind et al. (1976) found *P. pedersoni* and *P. yucatanicus* associated with *L. danae* at Grand Bahama. These authors also saw anemone shrimps hosted by *B. annulata*, but referred to them simply as "*Periclimenes* spp."

Our Turks and Caicos collections have been made on the Caicos Bank and offshore fringing reef, both localities in the vicinity of Pine Cay. On the reef, *B. annulata* and *C. gigantea* are occupied by *P. pedersoni* and *P. yucatanicus*; sometimes the same *B. annulata* hosts both species. On the reef, *B. annulata* is the more common anemone. The reverse is true on the Caicos Bank. There both *B. annulata* and *C. gigantea* are occupied by *P. yucatanicus*, but *P. pedersoni* has not been seen. An ovigerous *P. yucatanicus* was recovered 12 April 1988 from *S. helianthus* on the Caicos Bank. This appears to be a new host record. One of us (Manstan) photographed shrimp that probably were *P. pedersoni* on *L. danae* at a depth of 25 m on the outer reef off Providenciales. The specimens were not collected.

"CLEANING" — Mahnken (1972) never observed *P. rathbunae* in the act of "cleaning" fishes, and neither have we. So far as we can judge, the species has no "cleaning dance" comparable with that of *P. anthophilus*, *P. pedersoni*, and *P. yucatanicus* (Limbaugh et al. 1961, Mahnken 1972, Sargent and Wagenbach, 1975). During these "dances" the shrimp positions itself in a prominant location (e.g., near the tip of one of its host's tentacles), faces the prospective client, rocks sideways, and lashes its antennae (Limbaugh et al. 1961). We add to this the observation that the first and second pairs of pereopods are held together tightly and stretched out as a single unit in front of the shrimp. Holthuis and Eibl-Eibesfeldt (1964) observed this last behavior in *P. anthophilus* and without experimentation or further discussion termed it "fright posture." Sargent and Wagenbach (1975) described the cleaning behavior of *P. anthophilus*, but did not mention "fright posture." In our opinion this designation is inaccurate.

Of anemone shrimps found in the West Indies and Bermuda, only *P. anthophilus* and *P. pedersoni* had been observed previously to leave the host and board client fishes, often entering the opercular cavity and mouth (Limbaugh et al. 1961, Sargent and Wagenbach, 1975). However, *P. pedersoni* on the west coast of Florida reportedly neither associates with anemones nor cleans fishes (Limbaugh et al. 1961). Holthuis and Eibl-Eibesfeldt (1964) did not observe *P. anthophilus* to clean fishes, but Sargent and Wagenbach (1975) described its cleaning behavior in detail. A literature search yielded no direct evidence of cleaning by *P. yucatanicus*. Limbaugh et al. (1961) never observed this species to clean fishes, nor did Criales and Corredor (1977) or Mahnken (1972). According to Limbaugh et al. (1961), contact with fishes that paused near the host anemones was fleeting, and the shrimp did not leave the substratum. they suggested that *P. yucatanicus* mimics other cleaners (presumably *P. pedersoni*), a possibility rejected by Mahnken (1972). We can now state that *P. yucatanicus* possesses what appears to be a full repertoire of cleaning behaviors, including leaving the substratum and boarding the client.

On 19 April 1989, one of us (Spotte) observed cleaning by an adult *P. yucatanicus*. The incident occurred off Pine Cay on the Caicos Bank in water 1.5 m deep. The shrimp, which was associated with a *C. gigantea*, was seen cleaning a Nassau grouper (*Epinephelus striatus* Bloch, 1792) about 15 cm in length. The grouper was at least 10 cm from the anemone. The shrimp was first noticed as it was backing out of the grouper's left opercular cavity, which it had entered until its entire body disappeared from view. The shrimp then walked down the fish's back to the caudal peduncle, paused for slightly more than a minute, and proceeded up the left side of the fish. During this time it paused every few seconds and appeared to be picking objects from the grouper's skin with its chelipeds. After about three minutes it dropped off the fish, returned to the anemone, and the fish swam away. The shrimp was collected and its identity confirmed.

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TABLE 1

Known and unconfirmed hosts of *Periclimenes anthophilus, P. pedersoni, P. rathbunae,* and *P. yucatanicus.*

HOST	LOCATION	SOURCE
	Periclimenes anthophilus	
Actinia bermudensis	Bermuda	Chace (1972), Holthuis and Eibl-Eibesfeldt (1964)
Bartholomea annulata	Santa Marta, Colombia+	Criales (1984)
Condylactis gigantea	Bermuda	Chace (1972), Holthuis and Eibl-Eibesfeldt (1964), Nizinski (1989), Sargent and Wagenbach (1975)
	Santa Marta, Colombia+	Criales (1984)
	Periclimenes pedersoni	
Aiptasia pallida	Santa Marta, Colombia	Criales (1984)
Bartholomea annulata	Antigua, Antigua and Barbuda	Chace (1972), Limbaugh et al. (1961)
	Bahamas	Limbaugh et al. (1961)
	Pine Cay, fringing reef, Turks and Caicos Islands	This report
	Santa Marta, Colombia	Criales (1984), Criales and Corredor (1977)
	St. Thomas, Coki Beach, U.S. Virgin Islands	This report
	St. Vincent, St. Vincent and the Grenadines	Criales and Corredor (1977)
	U.S. Virgin Islands	Limbaugh et al. (1961), Mahnken (1972)
Bunodosoma granulifera	Santa Marta, Colombia	Criales (1984)
Cassiopea xamachana	Santa Marta, Colombia	Criales (1984)
Cerianthus sp.	Santa Marta, Colombia	Criales (1984)
Condylactis gigantea	St. Vincent, St. Vincent and the Grenadines	Criales and Corredor (1977)
	Pine Cay, fringing reef, Turks and Caicos Islands	This report
Heteractis lucida	St. Vincent, St. Vincent and the Grenadines	Criales and Corredor (1977)
Lebrunia danae	Grand Bahama, Bahamas	Hermkind et al. (1976)

	Providenciales, fringing reef, Turks and Caicos Islands*	This report
	Santa Marta, Colombia	Criales (1984), Criales and Corredor (1977)
Host unknown	Carrie Bow Cay, Belize	M.R. Dardeau, this report
	Florida west coast**	Chace (1972), Limbaugh et al. (1961)
	Hog Island, Nassau Harbor, Bahamas	Chace (1958)
	Lyford Cay, New Providence Island, Bahamas	Chace (1958)
	St. John, U.S. Virgin Islands	Chace (1958)
	Tortola, British Virgin Islands	Chace (1972)
	Periclimenes rathbunae	
Bartholomea annulata	U.S. Virgin Islands*	Mahnken (1972)
Bunodosoma granulifera	Santa Marta, Colombia	Criales (1984)
Condylactis gigantea	Bonaire, Bachelors Beach, Netherlands Antilles*	This report
	Pine Cay, Caicos Bank, Turks and Caicos Islands	This report
	Santa Marta, Colombia	Criales (1984)
Eunicea tourneforti	Curacao, Netherlands Antilles	Criales (1980)
Homostichanthus duerdeni	Puerto Rico	Mercado and Capriles (1982)
Lebrunia danae	Grand Bahama, Bahamas*	Hermkind et al. (1976)
Stichodactyla helianthus	British Virgin Islands*	R.N. Mariscal in Dunn (1981)
	Dominica	Manning (1970)
	Jamaica*	Duerden (1900)
	Pine Cay, fringing reef, Turks and Caicos Islands	This report
	Puerto Rico*	Colin (1978)
	Puerto Rico	Mercado and Capriles (1982)
	Santa Marta, Colombia	Criales (1984)
Host unknown	Antigua, Antigua and Barbuda	Chace (1972)
	Bahía de la Ascensión, Yucatan State, Mexico	Chace (1972)
	Bonaire, Netherlands Antilles	Chace (1972), Holthuis (1951), Schmitt (1936)

	Carrie Bow Cay, Belize	M.R. Dardeau, this report
	Curacao, Netherlands Antilles	Chace (1972), Holthuis (1951), Schmitt (1924, 1936)
	Guadeloupe, French West Indies	Chace (1972)
	Loggerhead Key, Dry Tortugas, Florida*	Chace (1972), Holthuis (1951)
	St. Lucia, French West Indies	Chace (1972)
	Periclimenes yucatanicus	
Aiptasia pallida	Santa Marta, Colombia	Criales and Corredor (1977)
Bartholomea annulata	Bahamas	Limbaugh et al. (1961)
	Pine Cay, fringing reef and Caicos Bank, Turks and Caicos Islands	This report
	Puerto Rico	Limbaugh et al. (1961)
	Santa Marta, Colombia	Criales (1984), Criales and Corredor (1977)
	St. Christopher (St. Kitts), St. Christopher-Nevis	Chace (1972)
	St. Thomas, Coki Beach, U.S. Virgin Islands	This report
	St. Vincent, St. Vincent and the Grenadines	Criales and Corredor (1977)
	U.S. Virgin Islands	Limbaugh et al. (1961), Mahnken (1972)
Cassiopeia [*sic*] sp.	U.S. Virgin Islands	Mahnken (1972)
Cassiopea xamachana	Santa Marta, Colombia	Criales (1984), Criales and Corredor (1977)
Condylactis gigantea	Bahamas, U.S. Virgina Islands, Puerto Rico	Limbaugh et al. (1961)
	Horseshoe Island, Florida Keys	M.R. Dardeau, this report
	Pine Cay, fringing reef and Caicos Bank, Turks and Caicos Islands	This report
	Santa Marta, Colombia	Criales (1984)
	St. Vincent, St. Vincent and the Grenadines	Criales and Corredor (1977)
"large green anemones" (*S. helianthus*?)	U.S. Virgin Islands	Mahnken (1972)
Lebrunia danae	Grand Bahama, Bahamas	Hermkind et al. (1976)
	Santa Marta, Colombia	Criales (1984)

Rhodactis sanctithomae	Martinique, Rocher du Diamont, French West Indies*	This report
Stichodactyla helianthus	Pine Cay, Caicos Bank, Turks and Caicos Islands	This report
Host unknown	Antigua, Antigua and Barbuda	Chace (1972)
	Barbuda, Antigua and Barbuda	Chace (1972)
	Cape Florida, Florida	Holthuis (1951)
—	Cape la Vela, Colombia	Holthuis (1951)
	Carrie Bow Cay, Belize	M.R. Dardeau, this report
	Isla de Cozumel, Yucatan State, Mexico	Chace (1972)
	Long Key, Dry Tortugas, Florida	Holthuis (1951)
	Peter Island, British Virgin Islands	Chace (1972)
	Virgin Gorda, British Virgin Islands	Chace (1972)
	Yucatan State, Mexico	Ives (1891)

†Questionable identification
*Unconfirmed or uncertain identification
**Reported by Limbaugh et al. (1961) not to associate with anemones.

REFERENCES CITED

Chace, F.A. Jr. 1958. A new shrimp of the genus *Periclimenes* from the West Indies. *Proc. Biol. Soc. Wash.* 71:125-130.

Chace, F.A. Jr. 1972. The shrimps of the Smithsonian-Bredin Caribbean expeditions with a summary of the West Indian shallow-water species (Crustacea: Decapoda: Natantia). *Smithson. Contrib. Zool. No. 98*, Smithsonian Institution Press, Washington, 179 pp.

Colin, P.I. 1978. *Caribbean reef invertebrates and plants.* TFH Publications, Neptune City, N.J., 512 pp.

Criales, M.M. 1980. Commensal caridean shrimps of Octocorallia and Antipatharia in Curacao and Bonaire. *Stud. Fauna Curacao* 61:68-85.

Criales, M.M. 1984. Shrimps associated with coelenterates, echinoderms, and molluscs in the Santa Marta region, Colombia. *J. Crust. Biol.* 4:307-317.

Criales, M.M. & L. Corredor. 1977, Aspectos etologicos y ecologicos de camarones limpiadores de peces (Natantia: Palaemonidae, Hippolytidae, Stenopodidae). *An. Inst. Inv. Mar. Punta Betin* 9:141-156.

Duerden, J.E. 1900. Jamaican Actiniara. *Sci. Trans. R. Dublin Soc.* VI(Ser. II):133-220. [pp. 161-166, plate XIV].

Dunn, D.F. 1981. the clownfish sea anemones: Stichodactylidae (Coelenterata: Actinaria) and other sea anemones symbiotic with pomacentrid fishes. *Trans Am. Philos. Soc.* 71 (Part 1):1-115.

Herrnkind, W., G. Stanton, & E. Conklin. 1976. Initial characterization of the commensal complex associated with the anemone, *Lebrunia danae*, at Grand Bahama. *Bull. Mar. Sci.* 26:65-71.

Holthuis, L.B. 1951. A general revision of the Palaemonidae (Crustacea Decapoda Natantia) of the Americas. I. the subfamilies Euryrhynchinae and Pontoniinae. *Allan Hancock Found. Publ. Occas. Pap.* (11):58-60, Plate 17 (p. 235).

Holthuis, L.B. and I. Eibl-Eibesfeldt. 1964. A new species of the genus *Periclimenes* from Bermuda (Crustacea, Decapoda, Palaemonidae). *Senck. Biol.* 45:185-192.

Ives, J.E. 1891. Crustacea from the northern coast of Yucatan, the harbor of Vera Cruz, the west coast of Florida and the Bermuda Islands. *Proc. Acad. Nat. Sci. Phila.* (1891):176-207, Plates V and VI.

Limbaugh, C., H. Pederson, and F.A. Chace Jr. 1961. Shrimps that clean fishes. *Bull. Mar. Sci. Gulf Carib.* 11:237-257.

Mahnken, C. 1972. Observations on cleaner shrimps of the genus *Periclimenes. Sci. Bull. Nat. Hist. Mus. Los Angeles Co.* 14:71-83.

Manning, R.B. 1970. *Mithrax (Mithraculus) commensalis*, a new West Indian spider crab (Decapoda, Majidae) commensal with a sea anemone. *Crustaceana* 19:157-160, Plates 1 and 2.

Mercado, L.M. and V.A. Capriles. 1982. Description of two commensal complexes associated with the anemones, *Stoichactis helianthus* and *Homostichanthus duerdeni* in Puerto Rico. *Carib. J. Sci.* 17:69-72.

Nizinski, M.S. 1989. Ecological distribution, demography and behavioral observations on *Periclimenes anthophilus*, an atypical symbiotic cleaner shrimp. *Bull. Mar. Sci.* 45:174-188.

Sargent, R.C. & G.E. Wagenbach. 1975. Cleaning behavior of the shrimp, *Periclimenes anthophilus* Holthuis and Eibl-Eibesfeldt (Crustacea: Decapoda: Natantia). *Bull. Mar. Sci.* 25:466-472.

Schmitt, W.L. 1924. The macruran, anomuran and stomatopod Crustacea. *In*: Bijdragen tot de Kennis der Fauna van Curacao. Resultaten Eener Reis van Dr. C.J. van der Horst in 1920. *Bijdr. Dierk.* 23:61-81.

Schmitt, W.L. 1936. Macruran and Anomuran Crustacea from Bonaire, Curacao and Aruba. *Zool. Jb. Syst.* 67:363-378, 3 plates.

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Occurrence of Chaceon Larvae in Plankton Samples from Slope Waters of the Northeastern Gulf of Mexico

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OCCURRENCE OF *CHACEON* LARVAE IN PLANKTON SAMPLES FROM SLOPE WATERS OF THE NORTHEASTERN GULF OF MEXICO

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ABSTRACT Geographic, seasonal, and bathymetric distributions of *Chaceon* larvae are described for the northeastern Gulf of Mexico.

Introduction

From 1986 to 1988 a cooperative research project to define geographic, seasonal and bathymetric distribution and abundance of geryonid crabs in the northeastern Gulf of Mexico was carried out by personnel of the University of Florida, the University of South Florida, and the Gulf Coast Research Laboratory (Lockhart *et al.* 1990).

Four seasonal cruises (May 1987, August 1987, December, 1987, and February 1988) were conducted in five distinct geographic sampling areas (Figure 1). Three depth contours (311, 494, and 677 m) were sampled in each area.

Materials and Methods

Plankton tows were made at each depth contour in Areas 1 through 5. Oblique tows were taken with closing nets (1 meter diameter, 333 micron mesh) equipped with Niskin double-trip devices. Deployment rate was approximately 8 meters per minute. Tow depth and duration varied with station depth. The upper 200 meters of the water column were sampled at all depth contours (this was the only portion of the water column sampled at the 311 meter stations). At the 494 and 677 depth contours, bottom tow depth range was 200 to 400 meters and 200 to 500 meters, respectively. Samples were preserved in the field in 5% formalin and taken to Gulf Coast Research Laboratory for analysis.

Samples in May, August, November/December 1987 and February 1988 were taken aboard the Gulf Coast Research Laboratory vessel R/V *TOMMY MUNRO*. An additional set of samples was taken in Area 5 in March 1988 by personnel of the University of South Florida aboard the R/V *SUNCOASTER* (Florida Institute of Oceanography).

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Results

Chaceon larvae occurred infrequently and in small numbers. Larvae of the red crab, *Chaceon quinquedens*, occurred in samples in February. Zoeal stages I, II, and III were identified from samples taken in the upper 200 meters of the water column (Table 1). Zoeae occurred in all areas except Area 4. The fourth zoeal stage and the megalopal stage were not collected.

Zoeae of *Chaceon fenneri* (Stuck *et al.* In manuscript) were more limited in distribution. Seven stage II zoeae were collected in a surface tow in Area 2 in February. All other occurrences were in Area 5 in March 1988; a single stage I zoea and two stage II zoeae were identified from surface samples, and one stage II zoea was taken in a bottom tow.

TABLE 1
Number of zoeae of *Chaceon quinquedens* by area and developmental stage.

Area	Zoea I	Zoea II	Zoea III
5		1	3
3	4	3	
2	6	6	1
1	9	4	1

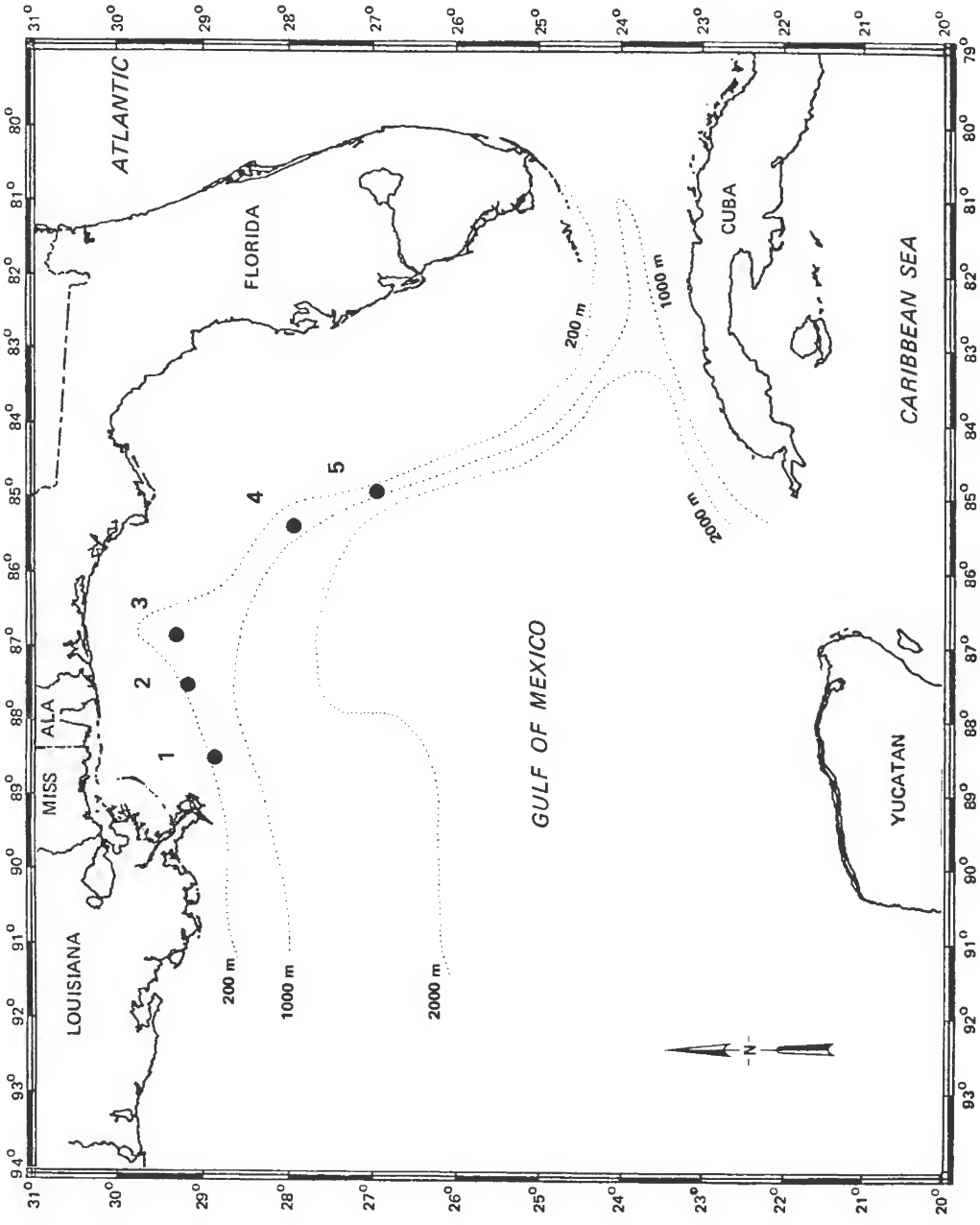

Figure 1. Locations of MARFIN-*Chaceon* sampling areas in the Gulf of Mexico.

DISCUSSION

Reproduction of *C. quinquedens* and *C. fenneri*, based on gross description of the intact ovary and histological examination of ovarian tissue, was discussed by Erdman *et al.* (In press) and Perry *et al.* (1989) for the eastern Gulf of Mexico. Both species exhibit an annual reproductive cycle. Oviposition in the red crab, *C. quinquedens*, begins in May with a brooding period of nine months. These data are similar to the data of Ganz and Hermann (1975) who suggest the same cycle for red crab in New England waters, though the timing of events occurs earlier in the Gulf of Mexico. Oviposition in the golden crab, *C. fenneri*, begins in late summer and the eggs are carried for six months. Reproduction of *C. fenneri* (Erdman *et al.* In press) corroborates the data of Hinsch (1988) for the eastern Gulf of Mexico, and was similar to that reported by Erdman and Blake (1988) for the Atlantic waters off southeast Florida.

Although oviposition occurs earlier in the red crab, hatching of larvae coincides in both species. Zoeae of *C. quinquedens* and *C. fenneri* occurred in plankton samples in February and March taken from slope waters of the eastern Gulf of Mexico. With a single exception, all larvae were taken in surface tows.

Field evidence (presence of egg remnants on pleopods), histological data, and the occurrence of larvae of both species support an annual cycle of reproduction for these species in the Gulf of Mexico with hatching of eggs in the late winter/early spring.

ACKNOWLEDGEMENTS

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REFERENCES CITED

Erdman, R.B. and N.J. Blake. 1988. Reproductive ecology of female golden crabs, *Geryon fenneri* Manning and Holthuis, from southeastern Florida. *J. Crust. Biol.* 8:392-400.

Erdman, R.B., N.J. Blake, W.J. Lindberg, F.D. Lockhart, H.M. Perry, and R.S. Waller. Comparative reproduction of the deep sea crabs *Chaceon fenneri* and *Chaceon quinquedens* (Brachyura: Geryonidae) from the northeast Gulf of Mexico. *Int. J. Invert. Repro. Dev.* (In press)

Ganz, A.R. and J.F. Hermann. 1975. Investigations into the southern New England red crab fishery. Rhode Island Dept. Nat. Res., Div. Fish. Wildl., Mar. Fish. Sect. 78pp.

Hinsch, G.W. 1988. Morphology of the reproductive tract and seasonality of reproduction in the golden crab *Geryon fenneni* from the eastern Gulf of Mexico. *J. Crust. Biol.* 8(2):254-261.

Lockhart, F.D., W.J. Lindberg, N.J. Blake, R.B. Erdman, H.M. Perry, and R.S. Waller. 1990. Distributional differences and population similarities for two deep-sea crabs (Family Geryonidae) in the northeastern Gulf of Mexico. *Can. J. Fish. Aquat. Sci.* 47(11):2112-2122.

Perry, H.M., R. Waller, C. Trigg, T. McBee, R. Erdman, and N. Blake. 1989. Harvest potential of the deep sea red crab, *Chaceon quinquedens*, and distribution of the genus in the Gulf of Mexico. Final Report to NOAA, National Marine Fisheries Service, Marine Fisheries Initiative (MARFIN) Project NA89WC-H-MF021, 24 pp.

Stuck, K.C., H.M. Perry, L.M. Stuck, and A.A. Barrett. Larval development of the golden crab, *Chaceon fenneri* (Manning and Holthuis, 1984) (Decapoda: Brachyura: Geryonidae) reared in the laboratory. *Proc. Biol. Soc. Wash.* (In submission)

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Success of Juvenile Striped Bass in Two Bay Systems in Mississippi: 1980-1984

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SUCCESS OF JUVENILE STRIPED BASS IN TWO BAY SYSTEMS IN MISSISSIPPI: 1980-1984

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ABSTRACT Success of a striped bass (*Morone saxatilis*, Walbaum) stocking program in the Biloxi Bay and St. Louis Bay systems in Mississippi was investigated by monitoring the occurrence of juveniles in bag seine collections in the Biloxi, Tchouticabouffa, Jourdan, and Wolf Rivers. A total of 554 juvenile striped bass were collected during the study. Hydrographic data and stomach analyses indicate that neither water conditions nor food was a limiting factor to juvenile striped bass survival. Appearance of juveniles subsequent to the stocking of Atlantic coast fry and fingerlings coupled with lateral line scale count data indicate that all juveniles collected were of Atlantic coast origin, originating from stocked fry and fingerlings. Absence of juvenile striped bass in samples when stocking did not take place indicates either

Introduction

Striped bass (*Morone saxatilis* - Walbaum) were indigenous to all major river systems along the Mississippi Gulf coast until the early 1950s (Wailes 1854, Pearson 1938, Raney and Woolcott 1955, Cook 1959, and McIlwain 1976). According to McIlwain (1976), the last recorded catch of a native striped bass in Mississippi (prior to any stocking efforts) occurred in the West Pascagoula River in 1967. Reasons for the decline of native striped bass in Mississippi are speculative, ranging from dam construction, to poor water quality, to pesticide pollution (Nicholson et al., 1986).

In 1969, a program was initiated to reestablish the striped bass population along the Mississippi Gulf Coast. Since the establishment of the restocking program, over 9 million striped bass fingerlings have been stocked into the tributaries of Mississippi Sound. A recreational fishery has developed as a result of the stocking effort. The size and value of this fishery is not known but the striped bass fishery is a recognizable segment of the total recreational fishery on the Mississippi Gulf Coast (Nicholson et al., 1986). A juvenile striped bass monitoring program was begun in 1973 in an effort to ascertain the effectiveness of stocking efforts and to attempt to document natural reproduction.

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Materials and Methods

Coastal Mississippi rivers which were sampled during 1980 through 1985 include the Biloxi and Tchouticabouffa Rivers of the Biloxi Bay system and the Jourdan and Wolf Rivers of the St. Louis Bay system. In 1980, station locations included estuarine waters, while in 1981-1984 only freshwater locations were sampled. Stations were selected by locating sand beach areas where a beach seine could be used effectively. At least one river mile separated stations, and station beaches were separated by a beach in between when possible. In 1980, 12 stations were sampled primarily on the Tchouticabouffa River, and eight stations were sampled on the Jourdan River. Beginning in 1981, estuarine stations were dropped and riverine stations on the Biloxi and Wolf Rivers were added (Figures 1 and 2).

A 15 x 2 meter bag seine with 6 millimeter bar, knotless, nylon mesh was used to sample ichthyofauna. If more than five striped bass were collected at any one station, five specimens were retained in a buffered formalin solution and later transferred to a 40% isopropyl alcohol solution for subsequent analysis. All other striped bass were counted and released alive. All fish other than striped bass which were collected were placed in plastic bags, held on ice, and later frozen for subsequent analysis. All sampling was conducted immediately following sunset and was usually completed before midnight. Sampling was conducted twice monthly from June through September for an annual total of eight sampling trips per river.

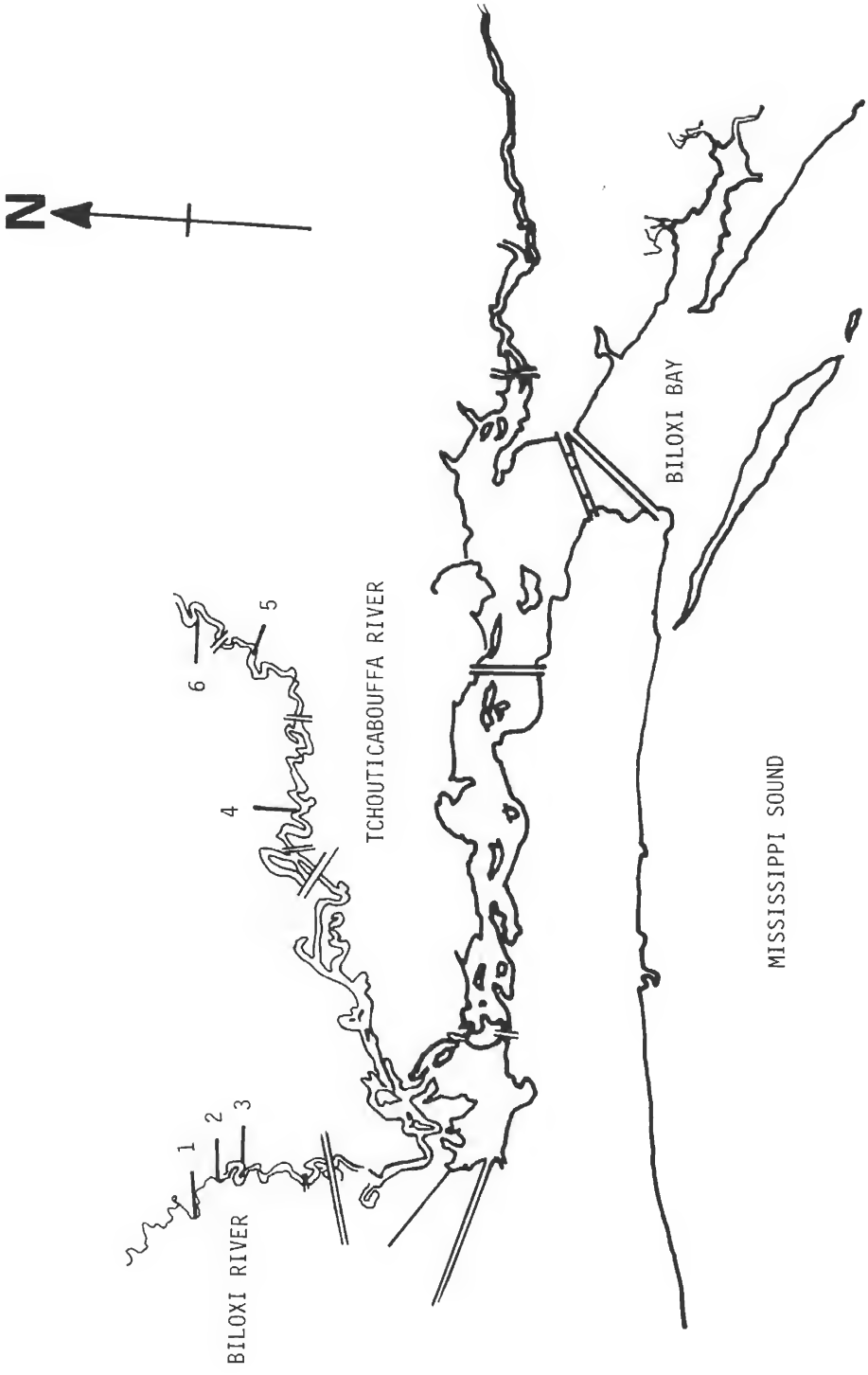

Figure 1. Station locations on the Biloxi and Tchouticabouffa Rivers.

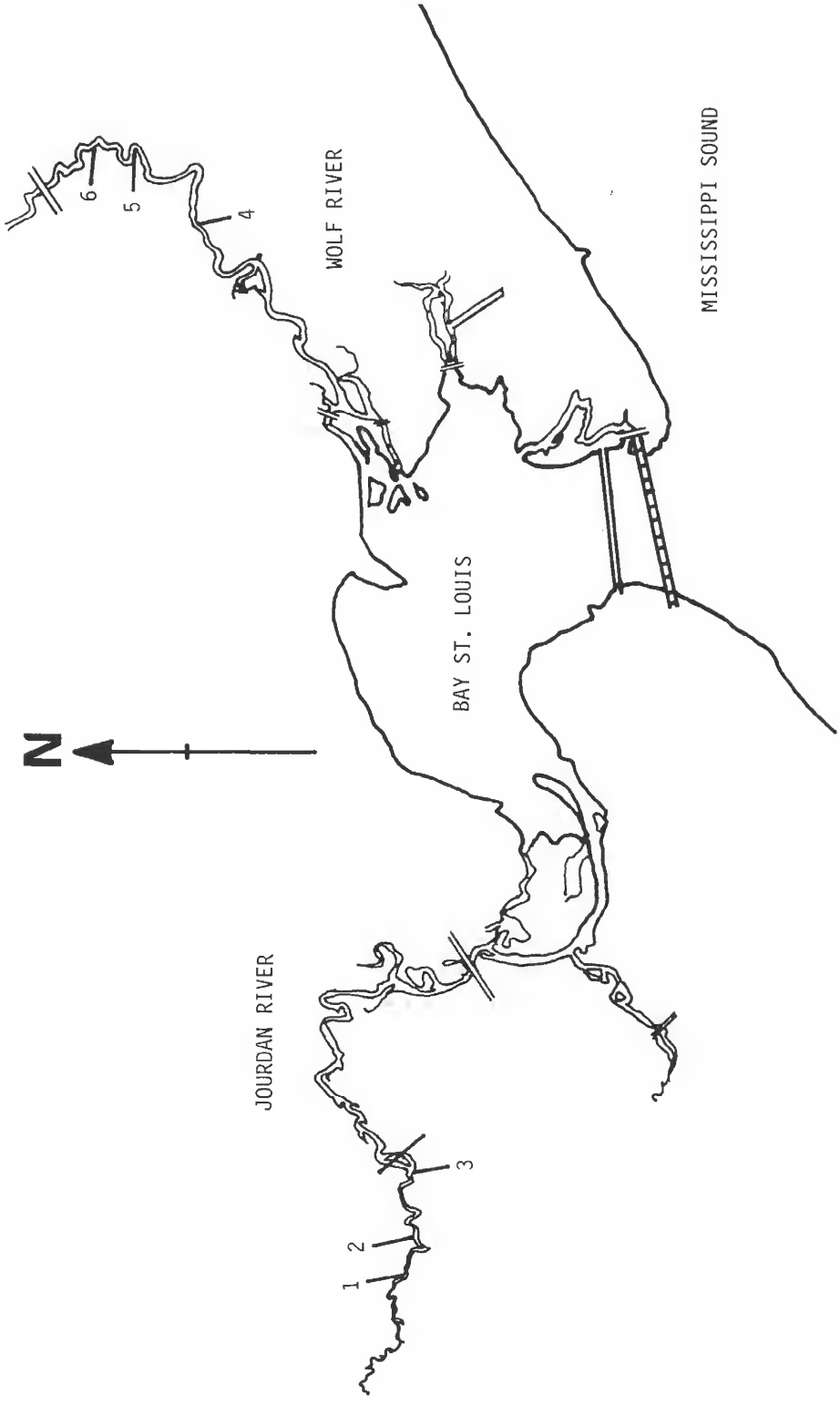

Figure 2. Station locations on the Jourdan and Wolf Rivers.

Growth rates were determined by calculating the difference between average length and weight of fish at the time of stocking with measured length and weight of juvenile striped bass collected over the time the fish were at large.

Food availability for all life stages of striped bass is an important habitat criteria in determining success of stocking activities. Of the juvenile striped bass which were retained and preserved in the 40% isopropyl alcohol solution, 217 were examined for stomach contents. Each stomach was removed, opened with a scalpel, and the contents identified and enumerated under a binocular microscope. Identification of stomach contents was not taken to the species level in most cases.

Lateral line scales, ie. scales with noticeable pores, were counted on all juvenile striped bass specimens retained in collection for the purpose of discriminating between specimens of Atlantic and Gulf of Mexico origin. Counts were made on both sides of the fish under a binocular microscope.

Hydrographic measurements taken concurrently with bag seine hauls, included water temperature (1980-1984), dissolved oxygen (1980-1983), conductivity and pH (1984), and salinity (1980). Instruments used to collect hydrographic data were an A/O Goldberg refractometer, a Yellow Springs Instrument (YSI) Model 51-B oxygen meter, a YSI TSC meter, and an Orion Research Model 221 pH meter.

RESULTS

Biloxi Bay System

A total of 179 juvenile striped bass were collected during the study. Positive collections occurred only during 1980-1982. No juvenile striped bass were collected during 1983 and 1984. Mean total length (TL) ranged from 68.54 millimeters (mm) to 98.02 mm, while mean weight ranged from 6.90 grams (g) to 9.91 g. Growth rates in mm per day and g per day ranged from 0.8 to 2.3 and 0.09 to 0.11, respectively (Table 1).

Measurements of hydrographic parameters for the Biloxi River (Table 2) resulted in temperatures ranging from 18.0° to 32.0°C, with mean values ranging from 25.6°C in 1982 to 27.5°C in 1981. DO values ranged from 4.6 ppm to 8.2 ppm, with mean values ranging from 5.8 ppm in 1981 to 6.9 ppm in 1983. Values for pH, measured only in 1984, ranged from 4.7 to 7.1 with a mean of 5.8.

Measurements of hydrographic parameters for the Tchouticabouffa River (Table 3) resulted in temperatures ranging from 17.5°C to 34.5°C, with mean values ranging from 22.8°C in 1983 to 27.8°C in 1980. DO values ranged from 3.4 ppm to 8.3 ppm, with mean values ranging from 5.1 ppm in 1981 to 6.3 ppm in 1980. Salinity values, measured only in 1980, ranged from 0 parts per thousand (ppt) to 22 ppt. Values for pH, measured only in 1984, ranged from 4.5 to 6.5 with a mean of 5.2.

TABLE 1
Frequency of striped bass, mean total length, mean weight, and growth rates per day for the Biloxi Bay System.

	Frequency	X TL (mm)	X Weight (g)	Growth Rate (mm/day)	Growth Rate (g/day)
1980	43	98.02	9.91	0.8	0.09
1981	63	70.25	6.90	1.3	0.11
1982	73	68.54	7.72	2.3	0.10
1983	0	–	–	–	–
1984	0	–	–	–	–

TABLE 2
Minimum, maximum, and mean values of temperature (°C) and dissolved oxygen (ppm) for the Biloxi River during June through September of 1980 through 1984. Measurements of pH are provided for 1984 only.

	TEMPERATURE			DISSOLVED OXYGEN			pH		
	MIN	MAX	X	MIN	MAX	X	MIN	MAX	X
1980	–	–	–	–	–	–	–	–	–
1981	23.0	32.0	27.5	4.7	6.7	5.8	–	–	–
1982	22.0	28.5	25.6	4.6	8.2	6.6	–	–	–
1983	18.0	22.2	27.0	5.7	8.0	6.9	–	–	–
1984	24.0	28.0	26.3	–	–	–	4.7	7.1	5.8

TABLE 3
Minimum, maximum, and mean values of temperature and dissolved oxygen for the Tchoutlcabouffa River During June through September of 1980 through 1984. Salinity is provided for 1980 and pH for 1984.

	TEMPERATURE			DISSOLVED OXYGEN			SALINITY		pH		
	MIN	MAX	X	MIN	MAX	X	MIN	MAX	MIN	MAX	X
1980	17.5	34.5	27.8	4.0	8.3	6.3	0	22	–	–	–
1981	25.0	30.0	27.6	4.0	6.6	5.1	–	–	–	–	–
1982	23.0	29.0	24.4	3.4	7.2	5.8	–	–	–	–	–
1983	18.5	28.0	22.8	3.8	7.6	6.2	–	–	–	–	–
1984	25.0	29.0	27.6	–	–	–	–	–	4.5	6.5	5.2

St. Louis Bay System

A total of 381 juvenile striped bass were collected from 1980 through 1983. None were collected in 1984. Mean TL ranged from 66.7 mm to 108.9 mm, while mean weight ranged from 4.33 g to 14.27 g. Growth rates in mm per day and g per day ranged from 0.82 to 1.30 and 0.07 to 0.17, respectively (Table 4).

Measurements of hydrographic parameters for the Jourdan River (Table 5) resulted in temperatures ranging from 17.5°C to 33.5°C, with mean values ranging from 23.8°C in 1983 to 27.6°C in 1981. DO values ranged from 4.0 ppm to 9.4 ppm, with mean values ranging from 5.4 ppm in 1981 to 6.5 ppm in 1983. Salinity values, measured only during 1980, ranged from 0 ppt to 15 ppt. Values for pH, measured only during 1984, ranged from 4.8 to 6.8 with a mean of 5.8.

Measurements of hydrographic parameters for the Wolf River (Table 6) resulted in temperatures ranging from 18°C to 31.5°C, with mean values ranging from 21.8°C in 1983 to 27.0°C in 1984. DO values ranged from 5.8 ppm to 8.6 ppm, with mean values ranging from 6.7 ppm in 1981 to 7.5 ppm in 1983. Values for pH, measured only during 1984, ranged from 5.0 to 6.4 with a mean of 5.9.

Description of Stomach Contents

The stomach contents of 217 juvenile striped bass were examined (Table 7). Of the 43 fish examined from the Biloxi Bay system in 1980, 20 contained unidentifiable digested material. Mysid shrimp (*Taphromysis louisiannae*) were found in 16 stomachs, while seven stomachs contained partially digested fish. From the St. Louis Bay system in 1980, all six fish examined contained mysid shrimp; however, two also contained partially digested fish, while one also contained insect larvae.

The stomach contents of 42 juvenile striped bass taken from the Biloxi Bay system in 1981 were examined. Fifteen stomachs were empty, while 18 contained mysid shrimp. Ten stomachs contained partially digested fish, one of which was identified as the bay anchovy (*Anchoa mitchelli*). Insect larvae were found in six stomachs, while amphipods were found in five. Two stomachs contained unidentifiable digested material. The stomach contents of 126 fish were examined from the St. Louis Bay system during 1981. Seventy-two stomachs contained mysid shrimp, while 32 contained unidentifiable digested material. Twenty-one stomachs contained insects and 15 contained amphipods. Five stomachs contained partially digested fish, two of which were of the genus Notropis, and one of which was identified as a hogchoker (*Trinectes maculatus*). Nineteen stomachs were empty.

Lateral Line Scale Counts

All striped bass fry and fingerlings stocked into the Biloxi Bay and St. Louis Bay systems were acquired from hatcheries in South Carolina and Virginia. Barkuloo (1967) used lateral line scale counts to separate striped bass of Atlantic and Gulf of Mexico origins. A total of 332 juvenile striped bass were examined for both right and left side lateral line scale counts in an effort to ascertain if any specimens were of Gulf of Mexico brood stock. The number of lateral line scales on the left side of the fish examined ranged from 46 to 64, while the right side count ranged from 47 to 65. The mean for both sides was 57 (Table 8), indicating that all collected specimens were of Atlantic stock origins.

Other Ichthyofauna

Data for ichthyofauna other than striped bass were collected for survey years 1981 through 1983. In the Biloxi Bay system, a total of 14,415 fish representing 43 species were collected. In the St. Louis Bay system 23,901 fish were collected, representing 40 species. In both cases, the ten most frequent species represented 87% of the total (Tables 9 and 10).

DISCUSSION

The two primary reasons for conducting the striped bass juvenile monitoring program were to assess the survival of juvenile striped bass stocked in the Biloxi and St. Louis Bay systems and to document natural reproduction. In the Biloxi Bay system, numbers of striped bass fingerlings stocked were 411,479 in 1980; 566,070 in 1981, and 85,000 in 1982. All fish during this period were stocked during the months of May or June as Phase I fingerlings, averaging 22.5 mm TL. In 1983 and 1984, all stocked fish were Phase II fingerlings, ranging from 100 to 150 mm TL and were stocked during November. Juvenile striped bass were found in rivers after stocking during early summer and were found to be of Atlantic stock origin. During 1983 and 1984 when stocking of fingerlings occurred in November, juvenile striped bass were not found in the June through September samples. The fact that juveniles collected in 1980-82 were of Atlantic stock origin and corresponded with stocking efforts and the absence of any juveniles in the years of November stocking indicate that either natural spawning did not take place or that eggs or larvae did not survive if spawning did occur.

Data gathered from examining the stomach contents of 217 juvenile striped bass during 1980 and 1981 indicate the occurrence of several types of food items. The mysid shrimp, *Taphromysis louisiannae*, was the

TABLE 4
Frequency of striped bass, mean total length, mean weight, and growth rates per day for the St. Louis Bay system.

	FREQUENCY	X TL (mm)	X WEIGHT (g)	GROWTH RATE (mm/day)	GROWTH RATE (g/day)
1980	6	108.9	14.27	1.12	0.17
1981	215	66.7	4.96	0.82	0.07
1982	115	72.1	4.33	1.30	0.09
1983	45	–	–	–	–
1984	–	–	–	–	–

TABLE 5
Minimum, maximum, and mean values of temperature and dissolved oxygen for the Jourdan River during June through September of 1980 through 1984. Salinity is provided for 1980 and pH for 1984.

	TEMPERATURE			DISSOLVED OXYGEN			SALINITY		pH		
	MIN	MAX	X	MIN	MAX	X	MIN	MAX	MIN	MAX	X
1980	17.5	33.5	26.3	4.2	9.4	6.4	0	15	–	–	–
1981	22.5	32.5	27.6	4.0	6.6	5.4	–	–	–	–	–
1982	23.5	29.0	26.6	4.4	6.9	5.9	–	–	–	–	–
1983	19.0	29.5	23.8	5.3	7.6	6.5	–	–	–	–	–
1984	25.0	28.0	25.2	–	–	–	–	–	4.8	6.8	5.8

TABLE 6

Minimum, maximum, and mean values of temperature and dissolved oxygen for the Wolf River during June through September of 1980 through 1984. Measurements of pH are provided for 1984 only.

	TEMPERATURE			DISSOLVED OXYGEN			pH		
	MIN	MAX	X	MIN	MAX	X	MIN	MAX	X
1980	–	–	–	–	–	–	–	–	–
1981	22.0	31.5	26.8	5.8	8.0	6.7	–	–	–
1982	24.0	29.0	26.2	6.8	8.6	7.2	–	–	–
1983	18.0	28.0	21.8	6.3	8.4	7.5	–	–	–
1984	26.0	29.0	27.0	–	–	–	5.0	6.4	5.9

TABLE 7

Food items found in the stomachs of juvenile striped bass from the Biloxi and St. Louis Bay systems in 1980 and 1981.

YEAR	MYSID SHRIMP	FISH	INSECTS	AMPHIPODS	UNIDENTIFIABLE DISGESTED MATERIAL	EMPTY	TOTAL EXAMINED*
Biloxi Bay System							
1980	16	7	–	–	20	–	43
1981	18	10	6	5	2	15	42
St. Louis Bay System							
1980	6	2	1	–	–	–	6
1981	72	5	21	15	32	19	126

TABLE 8

Frequency of right and left side lateral line scale counts for all juvenile striped bass collected from the Biloxi Bay and St. Louis Bay systems from June through September of 1980 through 1983.

SCALE COUNTS		46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	N
1980	Right						2	1	2	3	6	10	6	3	4	1	2	1				41
	Left						1	1	2	3	6	8	10	6	2		1		1			41
1981	Right						1	1	6	8	10	19	37	22	19	21	9	9	3	1	1	167
	Left					1	2	1	1	4	19	22	21	30	21	22	13	6	2	1		166
1982	Right		1		1	2	3	4	10	7	15	12	12	14	8	6	1	1				97
	Left	1		1		3	4	6	7	8	18	11	16	13	5	2		1				96
1983	Right								3		5	2	3	3	5	3		2	1			27
	Left									3	2	3	6	4	4	2	1	1		1		27

TABLE 9
The 10 most frequent species collected from the Biloxi Bay System, 1981–1983.

GENUS/SPECIES	FREQUENCY	%
Notropis texanus	2,989	24
Notropis venustus	2,748	22
Labidesthes sicculus	1,706	8
Hybopsis amblops	953	8
Micropterus punctulatus	945	7
Lepomis megalotis	890	6
Lepomis macrochirus	772	5
Notropis species	632	5
Leiostomus xanthurus	492	4
Ictalurus punctatus	408	3
TOTAL	12,535	87

TABLE 10
The 10 most frequent species collected from the St. Louis Bay system, 1981–1983.

GENUS/SPECIES	FREQUENCY	%
Notropis venustus	10,196	49
Hybopsis amblops	2,817	14
Notropis texanus	2,669	13
Notropis species	1,778	9
Labidesthes sicculus	726	3
Anchoa mitchelli	701	3
Ictalurus punctatus	593	3
Notropis longirostris	493	2
Notropis petersoni	416	2
Trinectes maculatus	405	2
TOTAL	20,794	87

predominant prey item, occurring in 52% of the stomachs examined. The remainder of the identifiable food items were found in 33% of the stomachs examined, while 25% of the stomachs contained unidentifiable digested material. Sixteen percent of the stomachs examined were empty. These data concur with Nicholson (1983), who stated that juvenile striped bass under 114 mm select small invertebrate organisms, such as the mysid shrimp, amphipods, and insects found in this study. As the fish grow larger, they begin to select soft-rayed fish as their primary food source. Based on the consistency of occurrence of food items and the relatively low frequency of empty stomachs encountered, it appears that forage for juvenile striped bass is not a limiting factor in the Biloxi and St. Louis Bay systems.

Further indications that either natural spawning did not occur or that eggs or larvae did not survive are evidenced in the results of the lateral line scale counts. Of the 332 fish examined from both the Biloxi and St. Louis Bay systems, all scale counts were distributed in concurrence with those reported by Barkuloo (1967) for striped bass from the Atlantic coast. The overall mean lateral line scale count of 57 is comparable to Barkuloo's overall mean of 59. Lateral line scale counts are not as reliable in separating races of striped bass as are newer genetic techniques; however, the technique has been used historically. It is expected that as the genetic technology becomes more refined, it will become a much more available management tool.

When determining the appropriateness of a given river system for stocking of any fish species, it is necessary to be aware of the competitors, predators, and prey species in the river into which fish are stocked. All fish collected while seining for striped bass at riverine locations were enumerated and identified in order to document the faunal complex of both bay systems.

The four most frequently collected species from the Biloxi Bay system (Table 8) and the five most frequently collected species from the St. Louis Bay system (Table 9) were relatively small, soft-rayed species identified by Nicholson (1983) to be primary prey species for juvenile striped bass over 100 mm TL.

Adult fish such as *Micropterus punctulatus* and the various *Lepomis* species could act as predators on juvenile striped bass; however, this has not been documented in Mississippi waters. It is likely that the juveniles of *Micropterus* and *Lepomis* function as competitors with striped bass, utilizing the same river areas (as evidenced by their capture in conjunction with striped bass), and possibly utilizing the same prey species. This possible competition should be minimized as the striped bass grow larger late in their first year, because at that time they begin to school in the open waters of the river, a behavior which is not known or documented for *Micropterus* or *Lepomis* in riverine systems.

The data reported herein on occurrence, growth rates, and stomach analysis for juvenile striped bass support the conclusion that both the Biloxi and St. Louis Bay systems provide suitable habitat for the survival of juvenile striped bass. Nicholson (1983) indicated that the overall goal of anadromous fish activities in Mississippi was to reestablish reproducing populations of striped bass in coastal Mississippi. It is imperative that a monitoring program be conducted concurrently with stocking to determine the degree of stocking success. Stocking of the Biloxi and St. Louis Bay systems during 1980 through 1984 resulted in survival of juvenile striped bass up to about 100 mm TL. Determination of the condition of the adult striped bass stock was beyond the scope of this study; however, data collected during this study support the conclusion that successful natural reproduction did not occur during 1980 through 1984.

REFERENCES CITED

Barkuloo, J. M. 1967. Florida Striped Bass. Fish. Bull. No. 4. Florida Game and Freshwater Fish Commission. 24 pp.

Cook, F. 1959. Freshwater Fishes of Mississippi. Game and Fish Commission (Jackson). 239 pp.

Lukens, R. R. 1988. Habitat Criteria for Striped Bass Stocked in Rivers in the Northern Gulf of Mexico. Gulf States Marine Fisheries Commission Special Report. 53 pp.

McIlwain, T. D. 1976. Striped Bass Rearing and Stocking Program - Mississippi. In: Completion Report Project AFCS-5-3 for 1976 (Gulf Coast Research Laboratory, Ocean Springs, Mississippi).

Nicholson, L. C. 1983. Rearing and Stocking Striped Bass - Mississippi Gulf Coast. Completion Report. Project No. AFCS-7. Gulf Coast Research Laboratory, Ocean Springs, Mississippi.

_____, I. B. Byrd, E. Crateau, J. A. Huff, V. Minton, M. Powell, G. E. Saul, F. Ware, & A. Williams. 1986. Striped Bass Fishery Management Plan. Gulf States Marine Fisheries Commission. Publication No. 16.

Pearson, J. C. 1938. The Life History of the Striped Bass, or Rockfish Roccus saxatilis (Walbaum). U.S. Bur. Fish., Bull. 28:825-851.

Raney, E. C. & W. S. Woolcott. 1955. Races of Striped Bass, Roccus saxatilis (Walbaum), in the Southeast United States. Jour. Wildlife Mgmt. 19(4):444-450.

Wailes, B. L. C. 1854. Report of Agriculture and Geology of Mississippi. Pub. by the State of Mississippi, 332-337.