JOURNAL OF CRUSTACEAN BIOLOGY, 6(2): 214–226, 1986

UPOGEBIA AFFINIS (SAY): ITS POSTLARVAL STAGE DESCRIBED FROM LOUISIANA PLANKTON, WITH A COMPARISON TO POSTLARVAE OF OTHER SPECIES WITHIN THE GENUS AND NOTES ON ITS DISTRIBUTION

Bryan L. Andryszak

ABSTRACT

The first postlarval stage of *Upogebia affinis* (Say) is, for the first time, completely described. It is easily distinguished in the plankton by its rounded, densely setose rostrum and the strongly asymmetric fingers of its chelipeds, resembling those of the adult. Morphological characters which are most useful in distinguishing postlarvae of *U. affinis* from those of other species include: rostrum shape, spination, and setation; number of antennule endopod segments; number of antennal segments and nature of antennal scale; relative lengths of cheliped fixed and movable fingers; telson distal margin shape and spination.

Seventeen postlarval specimens of *U. affinis* were identified from 1,320 plankton samples collected between June 1983 and August 1984 from 10 stations located approximately 10 km southwest of Calcasieu Pass, Louisiana, in the northern Gulf of Mexico. Postlarvae were rarely observed, although zoeal stages were regularly encountered. Postlarvae were collected more commonly at night, especially near the surface. Daytime occurrences were exclusively near the bottom.

Zoeal stages of Atlantic and Gulf coast specimens of *U. affinis* were essentially identical except for slight size differences, suggesting that Atlantic coast postlarvae would be similar morphologically but slightly larger than those from the Gulf of Mexico.

The burrowing mud shrimp *Upogebia affinis* (Say) is a common inhabitant of muddy substrates. It lives in estuaries, mud flats, shallow bays, and other intertidal to shallow subtidal (to 36 m) regions of the western Atlantic, ranging from Massachusetts to Brazil (Felder, 1973; Rabalais *et al.*, 1981; Williams, 1984). The cryptic behavior of suspension-feeding adults, which rarely venture from their 30–50 cm deep burrows (Williams, 1984), makes the individuals difficult to collect. Consequently, documented occurrences and collection of *U. affinis* are infrequent (Rabalais *et al.*, 1981). The planktonic zoeal stages, however, are seasonally abundant during their spring through summer reproductive period (Williams, 1984; Sandifer, 1973).

Several descriptions of the early life history stages of species of *Upogebia* from around the world have been undertaken, especially of the more abundant zoeal stages. References to early larval studies on the genus may be found in Gurney (1939, 1942). More recent noteworthy studies include those by Webb (1919); Gurney (1924, 1937, 1938); Hart (1937); Dakin and Colefax (1940); Kurian (1956); Heegaard (1963); Shenoy (1967); Kurata (1970); Sandifer (1973); Ngoc-Ho (1977, 1981).

Fewer descriptions of the postlarval stage(s) of species of *Upogebia* exist. These include *U. deltaura* and *U. stellata* (Webb, 1919); *U. danai* (Gurney, 1924); upogebiid larvae, *Upogebia* sp. IV, *Calliadne* (*Gebiopsis*) sp. (Menon, 1933, 1940; as cited by Ngoc-Ho, 1977); *U. pugettensis* (Hart, 1937); *U. savignyi* (Gurney, 1937); *U. pusilla* (Dolgopolskaya, 1969; as cited by Ngoc-Ho, 1977); *U. kempi* (Shenoy, 1967); *U. darwini* (Ngoc-Ho, 1977).

This paper describes the first postlarval stage of *Upogebia affinis* and its distribution in neritic waters of Louisiana. This stage is compared with those of three other species to identify distinguishing morphological characters among the postlarval stages of *Upogebia*.

Materials and Methods

Macrozooplankton samples were collected from nearshore waters of the northern Gulf of Mexico, approximately 10 km southwest of Calcasieu Pass and south of Cameron, Louisiana (29°39′52.2″N, 93°26′34.8″W). Nine stations within a study area of approximately 60 km² were sampled from June 1983 through August 1984 during the months of June to September, November, March, and May to August.

An opening-closing 60-cm diameter bongo net was used to collect macrozooplankton. The nets used were 333-μm and 505-μm mesh Nitex with quick-release cod ends. Selected water column parameters were measured during zooplankton net tows using a Hydrolab® sensor which was mounted on the bongo net frame. This system provided real-time physical water column data as well as a reliable indication of towing depth during sampling. All tows were of 1-min duration and were collected at a speed of about 1 m/s (Wolff *et al.*, 1983).

The contents of the bongo net cod ends were washed through concentrating funnels (300-μm mesh) and then preserved in a 10% solution of 40% prebuffered (pH = 8) formaldehyde and sea water. Preserved zooplankton samples sat undisturbed for at least 7 days to allow for fixation and changes in organisms' volumes. They were then transferred to 2% sodium borate buffered formaldehyde for permanent storage.

Postlarval *Upogebia affinis* were dissected and the appendages illustrated. Whole specimens were drawn at 50× using a Wild M5A dissecting microscope with camera lucida. Appendages were illustrated at either 250× (pereiopods, tail fan, pleopod, frontal region) or 400× (antenna, mandible, maxilla, maxillipeds) and checked for details at 1,000× using a Leitz Laborlux® 12 binocular compound microscope with camera lucida. A series of permanent slides was made for future reference using Pro-Texx® mounting medium following a dehydration series of distilled water to ethanol stained with Rose Bengal through pure xylene. Three voucher specimens were deposited in the National Museum of Natural History, Smithsonian Institution (USNM 221337).

Results

Larvae of three species of *Upogebia* are known from the Gulf of Mexico (Ngoc-Ho, 1981). Of these, only *U. affinis* occurs in coastal waters of the northern Gulf (Felder, 1973; Rabalais *et al.*, 1981; Williams, 1984). The remaining two species, *Upogebia* sp. A and *Upogebia* sp. B, are known only from Mexican waters (Ngoc-Ho, 1981). All zoeal stages of *Upogebia* collected in this study are identified as *U. affinis* (Sandifer, 1973). Since *U. affinis* is the only species of the genus known to occur in the immediate vicinity of where the specimens described herein were collected, it is reasonable to assume that these postlarvae are those of *U. affinis* (Darryl Felder, personal communication).

The morphology of all four zoeal stages of *Upogebia affinis* observed in this study is very consistent between Sandifer's (1973) original description and specimens collected from Chesapeake Bay. The only consistently observed difference between Louisiana and Chesapeake Bay zoeae is that the Louisiana zoeae are slightly (about 0.2 mm) smaller. Therefore, it is suspected that postlarvae of *U. affinis* from the northern Gulf of Mexico are similar morphologically but slightly smaller than those from the Atlantic coast.

Webb (1919) and Shenoy (1967) describe the first two to three postlarval stages of laboratory-reared specimens of *Upogebia deltaura, U. stellata,* and *U. kempi.* They note the occurrence of first postlarvae which have sparsely setose thoracic appendages and which subsequently molt into more setose second postlarvae. The less setose first postlarvae either develop from individuals which metamorphosed after three rather than four zoeal stages (Webb, 1919), or molt into second postlarvae that are either fringed or unfringed. The unfringed second postlarvae are believed to develop into fringed third postlarvae (Shenoy, 1967). All seventeen postlarvae of *U. affinis* examined and described herein have a degree of setation

Table 1. Collection data for postlarvae of *Upogebia affinis* from neritic Louisiana waters (10–11 m depth) during the period June 1983 through August 1984.

Sample	Latitude	Longitude	Date (m/d/y)	Time (local)	Depth (m)	Temperature (°C)	Salinity (‰)	Dissolved oxygen (mg/l)	Number of specimens
1/M18N/B/3/5	29°39′52.2″	93°26′34.8″	6/4/83	0315	8.7[B]	26.0	27.9	0.9	1
1/M18N/S/2/5[A]	29°39′52.2″	93°26′34.8″	6/4/83	0315	1.0	26.9	16.6	7.6	4
1/M18D/B/2/3	29°39′52.2″	93°26′34.8″	6/4/83	0705	8.6[B]	26.3	23.0	4.2	1
1/M18D/B/2/5	29°39′52.2″	93°26′34.8″	6/4/83	0705	8.6[B]	26.3	23.0	4.2	2
7/M18N/S/3/5	29°39′52.2″	93°26′34.8″	5/23/84	2040	1.0	24.9	12.8	8.7	2
7/M18TN/8/2/3	29°39′52.2″	93°26′34.8″	5/23/84	2040	1.0	24.9	12.8	8.7	1
7/M18D/B/1/3	29°39′52.2″	93°26′34.8″	5/23/84	1135	8.0[B]	24.2	23.0	6.7	1
10/M18N/S/3/3	29°39′52.2″	93°26′34.8″	8/21/84	2145	1.1	30.1	29.3	6.4	1
10/M18N/S/3/5	29°39′52.2″	93°26′34.8″	8/21/84	2145	1.1	30.1	29.3	6.4	2
4/DND/B/3/5	29°40′39.6″	93°28′12.6″	9/8/83	1655	8.6[B]	27.8	23.7	5.7	1
10/DWN/S/3/5	29°40′09.0″	93°28′48.0″	8/21/84	2032	1.0	30.0	29.3	5.5	1

[A] Three specimens deposited in the National Museum of Natural History, Smithsonian Institution (USNM 221337).
[B] Sample collected about 1 m above bottom.

that resembles that of some of the second postlarvae described by Webb (1919) and Shenoy (1967). However, they are believed to be first postlarvae for two reasons: (1) Their size is in close agreement with those of first postlarvae of other species; (2) They are very similar morphologically to one another. It is very unlikely that only later stage postlarvae would be collected in the plankton, especially since the first postlarvae of congeners are known to demonstrate a tendency to settle down and burrow into sand or mud (Webb, 1919; Shenoy, 1967).

Zoeal stages of *Upogebia affinis* were frequently collected from June 1983 through August 1984. However, a total of only 17 postlarvae of *U. affinis* were collected from late May through early September and predominantly from station M18 (Table 1). Postlarvae were collected more frequently at night than during the day; those collected at night were mostly found near the surface, whereas daytime occurrences were exclusively near the bottom.

Postlarva Description

Carapace length (mean of 10 specimens measured from tip of rostrum to dorsal median articulation with first abdominal segment): 1.34 mm.

Total length (mean of 10 specimens measured from tip of rostrum to tip of telson): 3.90 mm.

Carapace (Fig. 1A–C) approximately 1.25 times longer than wide. Cervical groove barely visible. Rostrum broad, short, bluntly tipped; with 3 or 4 pairs of equally spaced spines along lateral borders, becoming smaller posteriorly; distal two-thirds fringed with sparsely plumose stout setae. Each outer orbital angle terminating as stout supraorbital spine with tuft of 4–6 setae near base. Eyes small, reaching to distal edge of rostrum. Low raised ridge supporting regularly spaced setae extending from each outer orbital angle along dorsal surface of gastric region. Carapace dorsal and lateral surfaces sparsely setose. Ventral and posterior carapace margin fringed with regularly spaced setae from near outer orbital angle to median articulation with first abdominal segment.

Antennule (Fig. 2C) with peduncle 3-segmented; basal segment with 2 long dorsal setae, line of 5–7 ventral finely plumose setae, several other scattered setae; second segment with 2 long sparsely plumose setae, usually 4 short setae along distal margin; third segment with 2, rarely 3, lateral setae, tuft of 3 small terminal

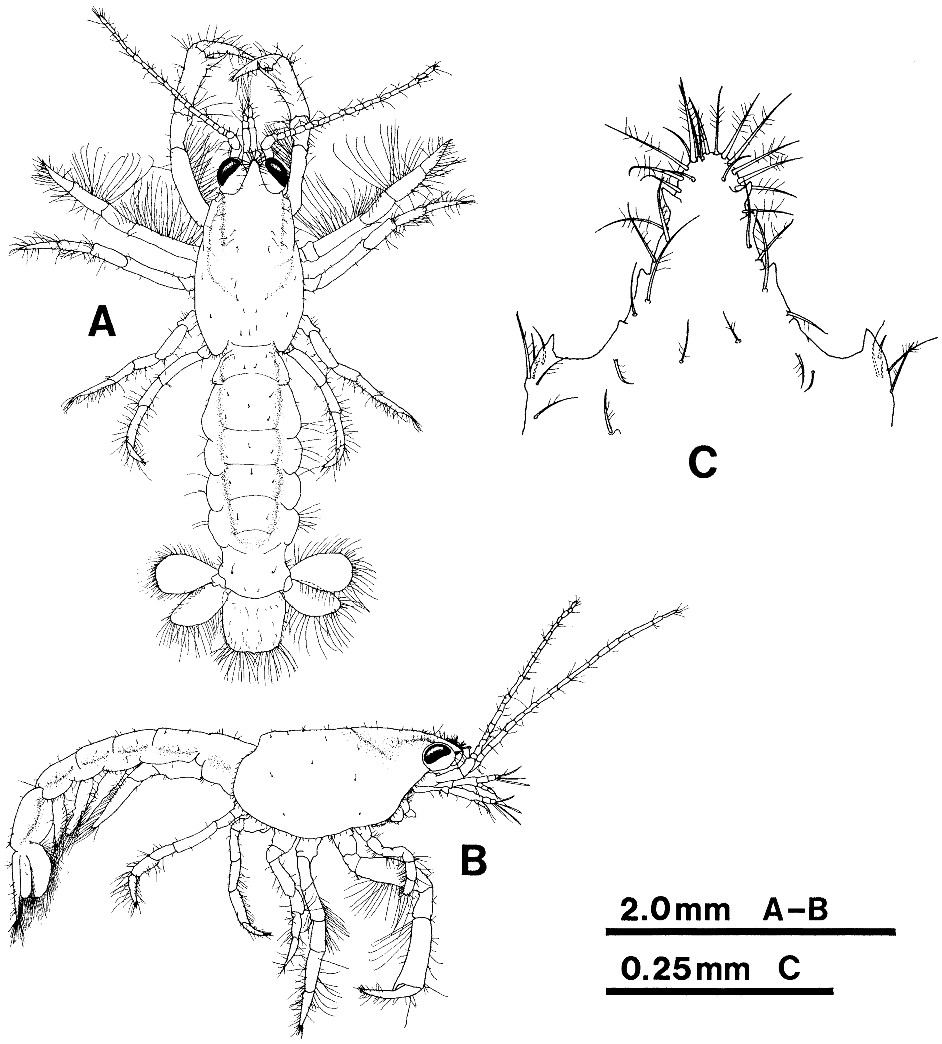

Fig. 1. *Upogebia affinis* (Say), postlarva. A, dorsal view; B, lateral view (left side thoracic and abdominal appendages excluded); C, frontal region.

setae. Exopod 3-segmented with 2 terminal, 1 subterminal aesthetascs; 2–4 terminal, 3 or 4 subterminal simple setae. Endopod 3-segmented with 1 + 1 + 4 (proximal to distal) simple setae.

Antenna (Fig. 2A) consisting of 23–27 segments; first 2 segments with ventral row of fine plumose and simple setae, segment 2 with small distal dorsal spine (vestigial scale) and distal ventral knob plus row of 4 or 5 long finely plumose setae. Flagellum setose throughout length.

Mandible (Fig. 2D) as illustrated, with 2-segmented palp; basal segment with 1 finely plumose proximal seta; distal segment with 15 stout plumose setae.

Maxillule (Fig. 2E) having protopodite base with 1 long simple seta; coxal endite with about 24 long similar slightly plumose setae; basal endite with 2 lateral marginal setae, 5 stout bristled terminal setae, 15 slender terminal setae. Endopod unsegmented without setae, rarely with 1 small plumose seta at base.

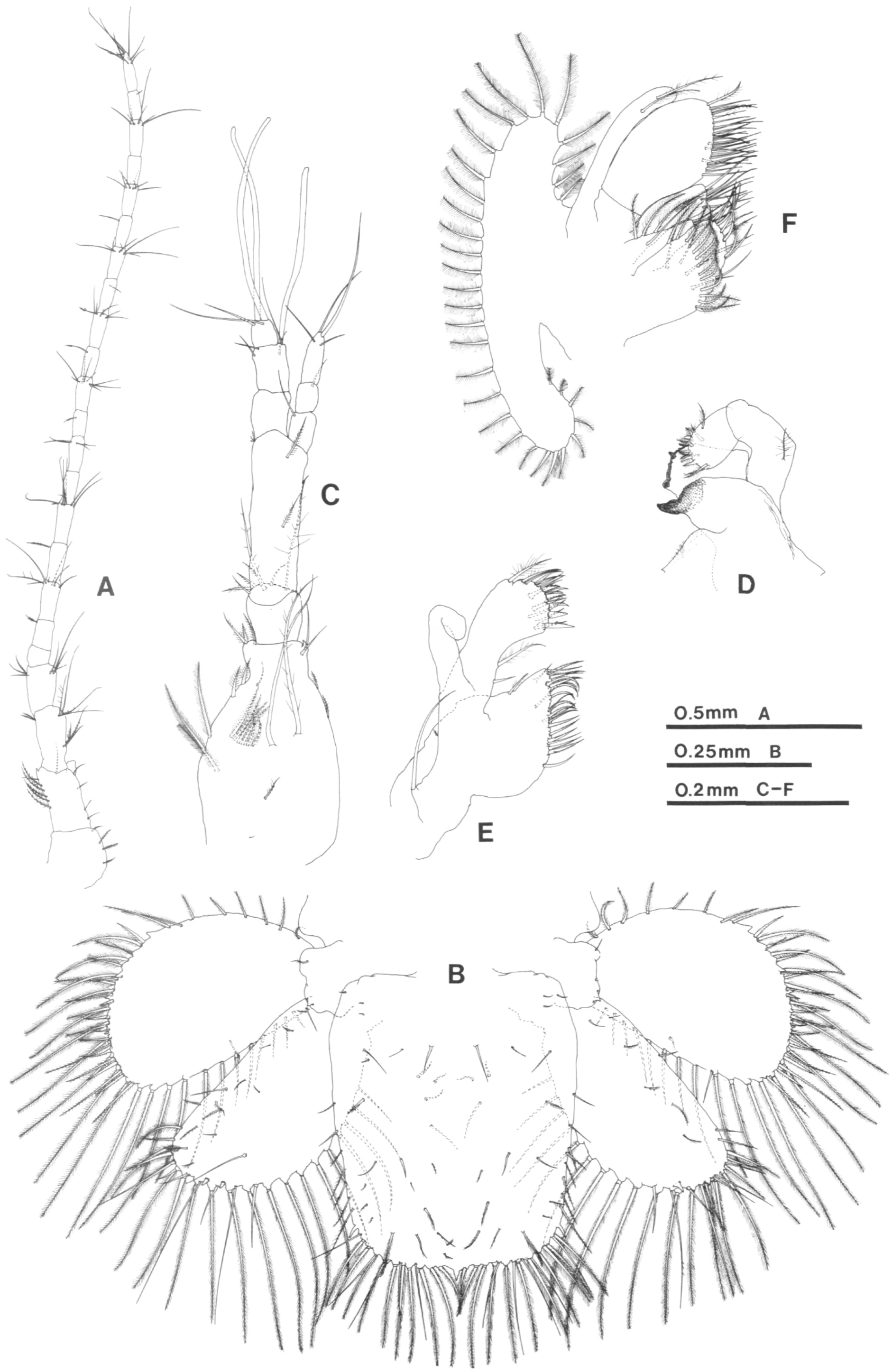

Fig. 2. *Upogebia affinis* (Say), postlarva. A, antenna; B, tail fan; C, antennule; D, mandible; E, maxillule; F, maxilla.

Maxilla (Fig. 2F) having coxal endite bilobed, with band of about 17 subterminal densely plumose setae and 11 terminal sparsely plumose setae on proximal lobe, distal lobe with 4 marginal and 2–4 terminal setae. Basal endite bilobed; proximal lobe with 1 subterminal and 7–10 terminal setae; distal lobe with about 28 terminal setae. Endopod unsegmented with 2 subterminal plumose setae. Scaphognathite bearing 28–35 densely plumose setae.

Maxilliped 1 (Fig. 3A) with coxal and basal endites bearing about 14 and 32 densely plumose setae, respectively. Endopod fringed with 6–8 long inner sparsely plumose setae, 2 or 3 short outer plumose setae, 1 terminal densely plumose seta. Exopod with 4 or 5 outer subterminal and 2 terminal plumose setae. Protopodite with small proximal externally directed lobe.

Maxilliped 2 (Fig. 3B) having coxal and basal endites together with about 11 sparsely plumose setae. Endopod 4-segmented; first segment with about 21–30 inner plumose setae and 1 outer simple seta, third and fourth segments with 9–11 and 9 or 10 sparsely plumose setae, respectively. Exopod unsegmented and naked, rarely with 1 terminal or 1 lateral sparsely plumose seta.

Maxilliped 3 (Fig. 3C) with small coxal endite. Coxa and basis together with about 16 plumose setae. Exopod small, unsegmented, naked, rarely with 1 small midlateral seta. Endopod 5-segmented with many densely plumose setae on proximal 2 segments, many somewhat less plumose and sparsely plumose setae on distal 3 segments.

Pereiopod 1 (Fig. 4A) well developed with similar, equal chelae; movable finger about 3 times length of fixed finger. Coxa-basis with assorted plumose setae. Ischium with 1 inner spine and 2 inner rows of long plumose setae extending through entire length of merus. Merus with 3 or 4 small inner marginal spines, 1 large outer dorsal distal marginal spine. Carpus with 4 large distal marginal spines. Propodus with inner row of 5–7 long plumose setae, 2 strong distal dorsal marginal spines, 2 or 3 blunt teeth near base of fixed finger. Dactylus with many simple setae, 3–6 blunt teeth spaced from proximal articulation with fixed finger to midpoint of inner dactylus margin, few small spines near tip.

Pereiopod 2 (Fig. 4B) having coxa with stout dorsal distal marginal spine. Coxa, basis, ischium sparsely setose. Merus with 1 smaller proximal inner marginal spine, 1 stout distal outer marginal spine, 1 small distal dorsal marginal spine, 2 inner rows of long densely plumose setae. Carpus with row of long densely plumose setae, 1 stout inner and 1 stout outer marginal spine. Propodus with inner row of long densely plumose setae, outer row of plumose setae. Dactylus with plumose setae on outer lateral surface, simple setae on inner lateral surface, small tubercles distally to near tip.

Pereiopods 3 and 4 (Figs. 4C, D) similar in size and shape. Pereiopod 3 with outer distal meral spine; inflated carpus bearing dorsal distal marginal knob; dactylus with 1 stout proximal dorsal spine, few scattered tubercles; long sparsely plumose setae on carpus, propodus, and dactylus. Pereiopod 4 without spines on merus or carpus; propodus with 1 distal dorsal spine; dactylus with 3 proximal dorsal spines; setation similar to pereiopod 3.

Pereiopod 5 (Fig. 4E) similar in size and setation to pereiopods 3 and 4. No spines on any segment except dactylus, with 1 inner subapical spine.

Pleopods (Fig. 3D) present on abdominal segments 2–5; all similar in size and shape. Coxae of pleopods 1 and 2 rarely with 1 or 2 plumose setae. Endopods of pleopods 1–4 bearing 11–15, 11–14, 12–14, 12 or 13 densely plumose setae, respectively. Exopods of pleopods 1–4 bearing 23–27, 24–26, 24–27, 25–28 densely plumose setae, respectively.

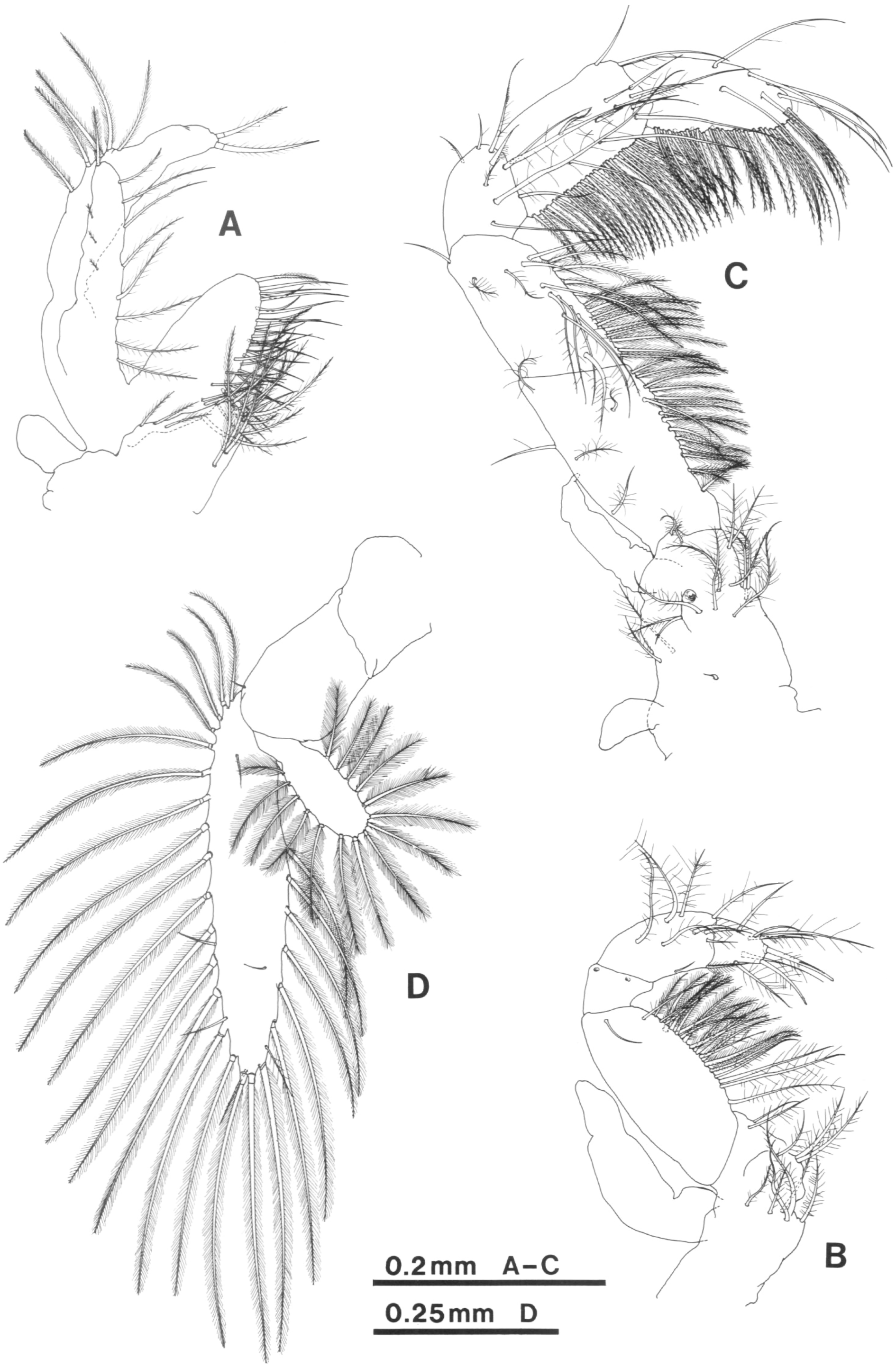

Fig. 3. *Upogebia affinis* (Say), postlarva. A, maxilliped 1; B, maxilliped 2; C, maxilliped 3; D, pleopod.

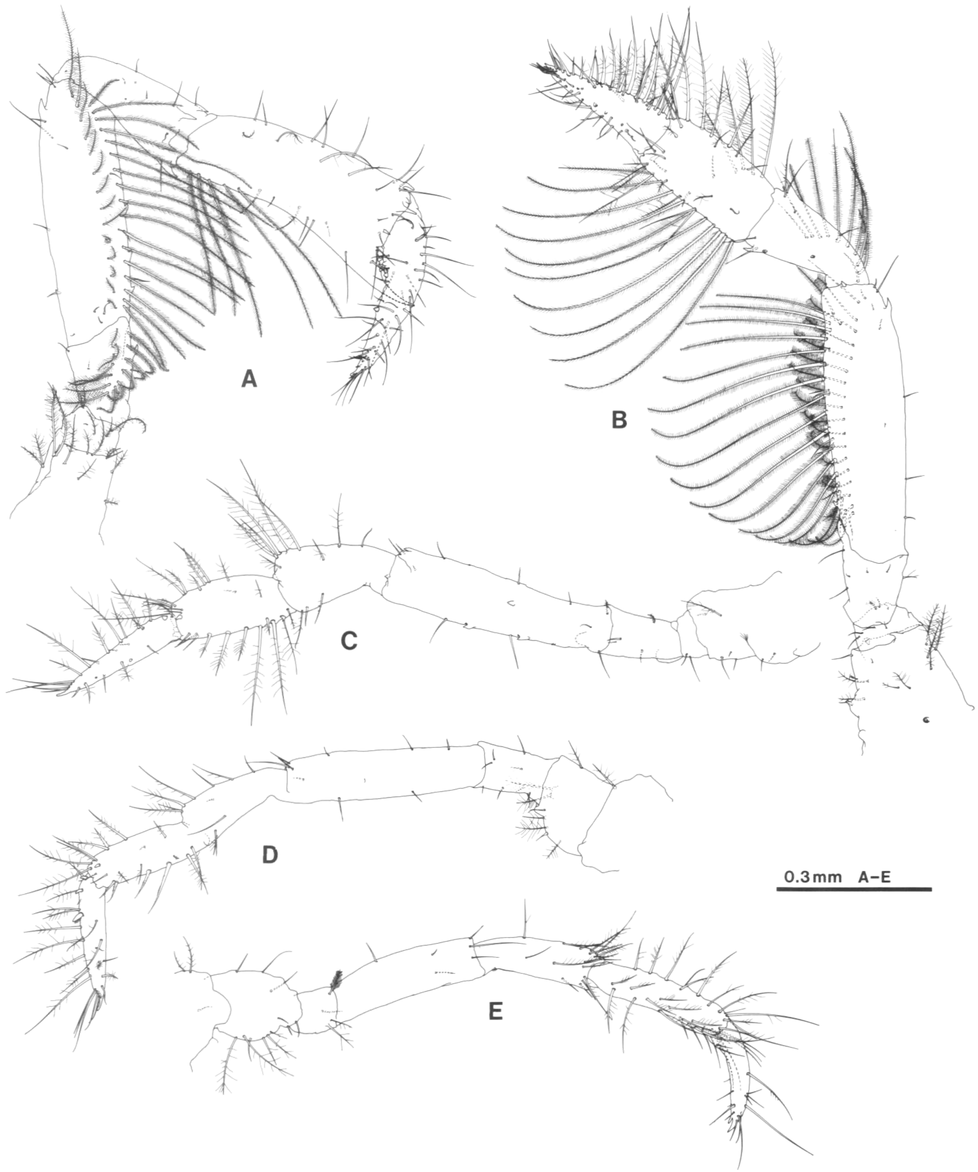

Fig. 4. *Upogebia affinis* (Say), postlarva. A, pereiopod 1; B, pereiopod 2; C, pereiopod 3; D, pereiopod 4; E, pereiopod 5.

Abdomen (Fig. 1A, B) with pleura of segments 1 and 6 smaller than those of segments 2–5. Pleura of segments 2–5 enlarged, rounded, fringed with long setae; however, not sufficiently enlarged to hide conspicuously visible pleopods. Terga of segments 1–6 with few small scattered dorsal setae.

Tail fan (Fig. 2B) with telson length along midline slightly longer than maximum width near base; distal margin nearly straight with 1 terminal median spine and 1 marginal spine near each outer angle; lateral setae fringing outer margin along distal one-half length, becoming longer and more plumose distally; dorsal and

Table 2. Comparison of morphologically important characters for distinguishing first stage postlarvae of *Upogebia affinis* from first postlarval stages of other species described from the coasts of North America and the North Atlantic Ocean based on descriptions and illustrations from different sources.

Species (description source)	Total length (mm)	Rostrum	Antennule segmentation	Antenna
Upogebia deltaura Class A[1] (Webb, 1919)	3.9	Extends even with eyes. Upwardly directed, pointed at tip, with 2 lateral spines, fringed with few setae.	Peduncle: 3 segments. Endopod: 1 segment. Exopod: 3 segments.	23 segments. Small scale vestige on segment 2.
Upogebia deltaura Class B[2] (Webb, 1919)	3.5	Slightly shorter than eyes. Upwardly directed, pointed at tip, with 2 lateral spines,[3] fringed with few setae.[3]	Peduncle: 3 segments. Endopod: 1 segment. Exopod: 3 segments.	20–22 segments. Small scale vestige on segment 2.
Upogebia stellata Class B[2] (Webb, 1919)	4.5	Extends just beyond eyes. Pointed at tip.	Peduncle: 3 segments. Endopod: 1 segment. Exopod: 3 segments.	27 segments.
Upogebia pugettensis (Hart, 1937)	4.0	Extends even with eyes.[3] Obtuse, a number of bristled setae and knobs distally. Lateral teeth nearly obsolete.	Peduncle: not given. Endopod: 1 segment. Exopod: 3 segments.	About 21 segments.[3] Small square scale vestige present.
Upogebia affinis	3.9	Extends even with eyes. Blunt, rounded, with 3 or 4 lateral spines, fringed with many bristled setae.	Peduncle: 3 segments. Endopod: 3 segments. Exopod: 3 segments.	23–27 segments. Minute scale vestige on segment 2.

[1] Metamorphosis into postlarva from fourth zoeal stage.
[2] Metamorphosis into postlarva from third zoeal stage.
[3] Postlarval character illustrated but not described.

ventral surfaces symmetrically setose on either side of midline. Uropod endopods and exopods of nearly equal length, broadly rounded, about three-fourths times telson length; endopods with nearly straight, unarmed outer margin, densely plumose distal and inner margins, dorsal line of widely scattered setae near outer margin, 1 or 2 stout spines near distal median margin; exopods broadly rounded, fringed with setae throughout, one conspicuous (occasionally bifid) spine near anterolateral margin with widely separated progressively smaller spines posteriorly.

Discussion

Planktonic Distribution of Postlarvae of *Upogebia affinis*

Postlarvae of *Upogebia affinis* were rarely observed in macrozooplankton samples. All but two collections of postlarvae were made at station M18 (Table 1). Their paucity and patchy planktonic distribution probably account for why they have not previously been described from Atlantic coastal waters of the United States (Kurata, 1970; Sandifer, 1973). Zoeal stages of *U. affinis* were commonly collected from all stations within the study area during their spring through sum-

Table 2. Continued.

Pereiopod 1	Tail fan
Cheliped: movable finger slightly longer than fixed finger. Propodus: few long inner setae,[3] 1 distal outer dorsal spine, fixed finger with 3 strong teeth. Carpus: 2 distal spines. Merus: several short inner setae. Ischium: almost no setae.	Telson: roughly rectangular, slightly narrowed posteriorly,[3] slightly concave distal margin,[3] fringed with setae, no terminal median spine,[3] 1 spine on each distal lateral margin, few scattered dorsal setae. Uropod: endopod outer margin weakly concave, devoid of setae.
Cheliped: movable finger subequal with fixed finger length. Propodus: few long inner setae,[3] 1 outer distal dorsal spine, fixed finger with 3 strong teeth. Carpus: 2 distal spines. Merus: several short inner setae. Ischium: almost no setae.	Telson: roughly rectangular, slightly narrowed posteriorly,[3] slightly concave distal margin,[3] fringed with setae, no terminal median spine,[3] 1 spine on each distal lateral margin, few scattered dorsal setae. Uropod: endopod outer margin weakly concave, devoid of setae.
Cheliped: movable finger 5 times fixed finger length. Propodus: few long inner, outer setae,[3] no outer distal dorsal spine,[3] fixed finger slightly toothed. Carpus: 2 distal spines.[3] Merus: few short inner setae.[3]	Telson: roughly rectangular, slightly narrowed posteriorly,[3] nearly straight distal margin with slight median sinus bearing medial spine,[3] 1 spine on each distal lateral margin,[3] fringed with setae, dorsal setae form inverted "V" pattern.[3] Uropod: endopod outer margin straight, devoid of setae.
Cheliped: movable finger 4 times fixed finger length.[3] Propodus: inner/outer seta rows,[3] small median distal spine. Merus: inner row setae.[3]	Telson: rectangular, distal margin fringed with setae.
Cheliped: movable finger 3 times fixed finger length. Propodus: long inner plumose setae, 2 distal dorsal spines, fixed finger with 2 or 3 blunt teeth. Carpus: 4 large distal spines. Ischium-merus: 2 rows long inner plumose setae.	Telson: slightly narrowed posteriorly, near straight distal margin fringed with setae, terminal median spine, 1 spine at each outer angle, few scattered dorsal setae. Uropod: endopod outer margin straight, with few scattered setae.

mer reproductive period. The rarity of planktonic postlarvae is probably due to their strong affinity with a substrate. The observed distribution may be the result of preferred habitat selection by the first postlarval stage. This speculation must await future detailed studies on the behavior and ecology of early postlarval stages of *U. affinis*.

Collection data suggest that postlarvae of *Upogebia affinis* are negatively phototropic prior to settlement. Daytime collections were made exclusively near the bottom, whereas all but one of the more numerous night occurrences were noted near the surface (Table 1). Although maximum water depth in the study area is only 10–11 m, bottom light conditions are typically near total darkness (personal observations with SCUBA). Gurney (1937) noted that the postlarva of *U. savignyi* was free-swimming, especially at night, and could rest for long periods on the bottom.

Hydrographic conditions were typical of nearshore northern Gulf of Mexico waters (Table 1). One hypoxic incident occurred which is a periodic and historically well-documented phenomenon in the region (Dennis *et al.*, 1984). Benthic and pelagic communities must be adapted to periodic exposures to low dissolved oxygen. Mukai and Koike (1984) showed that *Upogebia major* was capable of surviving brief periods of anoxia. It is expected that postlarvae of *U. affinis* may be similarly adapted.

Comparison of Morphology of Postlarvae of *Upogebia affinis* with Other Species of *Upogebia*

Species of *Upogebia* are known to develop through from three to five zoeal stages prior to metamorphosis into the postlarva (Ngoc-Ho, 1977, 1981). One species, *U. savignyi,* is known in which the free larva has been totally suppressed, hatching directly into a postlarva (Gurney, 1937).

Those species of *Upogebia* from the North Atlantic and coastal regions of North America for which the postlarval stage is known include *U. deltaura* and *U. stellata* from Plymouth Sound, England (Webb, 1919), *U. pugettensis* from the coasts of Washington and British Columbia (Hart, 1937), and *U. affinis* from the Gulf coast of North America (herein described).

Webb (1919), in her studies on larval development of *Upogebia deltaura* and *U. stellata,* found that these species passed through either three or four zoeal stages prior to metamorphosis. Consequently, two types of postlarvae were possible for each species: Class A postlarvae, which passed through four (normal) zoeal stages; Class B postlarvae, which passed through only three (abbreviated) zoeal stages. Class A postlarvae were generally larger and more developed than Class B postlarvae by virtue of having passed through one more zoeal stage prior to metamorphosis. By examining the structure of the chelipeds for Class A and Class B individuals of both species, Webb (1919) found that the two species could be easily distinguished from each other. Furthermore, Class A individuals possessed chelipeds that resembled those of adult females, whereas the chelipeds of Class B individuals resembled those of adult males. Thus, she speculated that the secondary sex characters of cheliped morphology, which are distinctive in adults of both species, are also recognizable in their first postlarval stages.

Hart (1937) found that *Upogebia pugettensis* passed through three zoeal stages prior to molting into the postlarva. The postlarva was of adult form. No mention was made of variability in number of zoeal stages or in cheliped structure.

Upogebia affinis consistently passed through four zoeal stages in the plankton; an occasional fifth zoeal stage, observed in laboratory-cultured specimens, was nearly identical to that of the fourth (Sandifer, 1973). Four zoeal stages were consistently observed in the plankton during this study (personal observations). The postlarvae that were examined were apparently of one type and displayed no discernible classes as were observed by Webb (1919).

The postlarva of *Upogebia affinis* is readily distinguishable from the other three species by comparing features of the rostrum, antennule, antenna, first pereiopod, and tail fan (Table 2). The rostra of *U. deltaura* and *U. stellata* are pointed and armed with two lateral spines. The rostrum of *U. pugettensis* is obtuse; lateral teeth are practically nonexistent. *Upogebia affinis* has a blunt rostrum armed with three or four lateral spines. *Upogebia affinis* is the only species listed in Table 2 in which the antennule endopod consists of three segments; the remaining species all have a single antennule endopod segment. Postlarvae of *U. affinis* have antennae that are somewhat different in the number of segments and in the nature of the vestigial antennal scales from those of the other three species. Comparison of the first pereiopods indicates that there are distinct differences in the structure of the cheliped, spination, and arrangement of setae among the four species. Of these characters, the relative lengths of cheliped movable and fixed fingers are most distinctive. Differences in tail fan morphology among the four species are primarily focused on telson setation and spination, and shape and setation of the uropod endopod outer margin. Telson differences are most distinct. In *U. deltaura,* the distal telson margin is slightly concave, it does not have a median spine, and there is one spine on each distal lateral margin. The telson of *U. stellata* has a nearly straight distal margin, a slight median sinus that bears one spine, and one spine on each distal lateral margin. The telson of *U. pugettensis* is rectangular and simply fringed with setae. The telson of *U. affinis* has a nearly straight distal margin produced into a median spine with one spine at each outer angle.

ACKNOWLEDGEMENTS

This study was supported in part by a Department of Energy contract with Texas A&M University, Environmental Engineering Division (contract no. DE-AC96-83P010850). I thank Dr. Charles Giammona and Dr. Roy Hann, Jr., for providing the laboratory space and equipment used in this study. Dr. John Wormuth (Oceanography Department, TAMU), Dr. Gary Wolff (Environmental Engineering Division, TAMU), and the Captain and crew of the Texas A&M University research vessel, *Excellence II,* provided valuable assistance and guidance in the field collecting the samples used in this study. Mr. Stephen Berkowitz, Mr. Chul Park, Ms. Cheryl Shalan, and Ms. Michele Schnitzer provided assistance in collecting and sorting samples in the laboratory. I sincerely thank Mr. Robert Maris (Oceanography Department, Old Dominion University) for his generosity in providing Chesapeake Bay specimens of zoeae of *Upogebia affinis* and reprints of some of the earlier works on larvae of this genus. Finally, I thank Dr. Mary Wicksten (Biology Department, TAMU) for her support and time reviewing the manuscript.

LITERATURE CITED

Dakin, W. J., and A. N. Colefax. 1940. The plankton of the Australian coastal waters off New South Wales. Part I.—Publications of the University of Sydney, Department of Zoology, Monograph No. 1: 1–215.

Dennis, G. D., T. J. Bright, and C. A. Shalan. 1984. Annotated bibliography of hypoxia and other oxygen-depletion literature on the marine environment. Final report. Offshore oceanographic and environmental monitoring services for the strategic petroleum reserve.—Prepared for the Department of Energy. Contract No. DE-AC96-83P010850. Pp. 1–46.

Felder, D. L. 1973. An annotated key to crabs and lobsters (Decapoda, Reptantia) from coastal waters of the northwestern Gulf of Mexico.—Center for Wetland Resources, Louisiana State University, Baton Rouge, Louisiana. Publication No. LSU-SG-73-02. Pp. 1–103.

Gurney, R. 1924. Crustacea. Part IX. Decapod larvae.—British Antarctic Terra Nova Expedition, 1910–1913, Natural History Report, Zoology 8: 37–202.

———. 1937. Notes on some decapod Crustacea from the Red Sea. II. The larvae of *Upogebia savignyi* Strahl.—Proceedings of the Zoological Society of London, Series B, 1937: 98–101.

———. 1938. Larvae of decapod Crustacea. Part V. Nephropsidea and Thalassinidea.—Discovery Reports 17: 291–344.

———. 1939. Bibliography of the larvae of decapod Crustacea.—The Ray Society, London. Pp. 1–123.

———. 1942. Larvae of decapod Crustacea.—The Ray Society, London. Pp. 1–306.

Hart, J. F. L. 1937. Larval and adult stages of British Columbia Anomura.—Canadian Journal of Research, Section D, 15: 179–220.

Heegaard, P. 1963. Decapod larvae from the Gulf of Napoli hatched in captivity.—Videnskabelige Meddelelser fra Dansk Naturhistorisk Forening 125: 449–493.

Kurata, H. 1970. Studies on the life histories of decapod Crustacea of Georgia.—Unpublished report. University of Georgia Marine Institute, Sapelo Island, Georgia. Pp. 1–274.

Kurian, C. V. 1956. Larvae of decapod Crustacea from the Adriatic Sea.—Acta Adriatic 6: 1–108.

Mukai, H., and I. Koike. 1984. Behavior and respiration of the burrowing shrimps *Upogebia major* (de Haan) and *Callianassa japonica* (de Haan).—Journal of Crustacean Biology 4: 191–200.

Ngoc-Ho, N. 1977. The larval development of *Upogebia darwini* (Crustacea, Thalassinidea) reared in the laboratory, with a redescription of the adult.—Proceedings of the Zoological Society of London 181: 439–464.

———. 1981. A taxonomic study of the larvae of four thalassinid species (Decapoda, Thalassinidea) from the Gulf of Mexico.—Bulletin of the British Museum (Natural History), Zoology 40: 237–273.

Rabalais, N. N., S. A. Holt, and R. W. Flint. 1981. Mud shrimps (Crustacea, Decapoda, Thalassinidea) of the northwestern Gulf of Mexico.—Bulletin of Marine Science 31: 96–115.

Sandifer, P. A. 1973. Larvae of the burrowing shrimp, *Upogebia affinis* (Crustacea, Decapoda, Upogebiidae) from Virginia plankton.—Chesapeake Science 14: 98–104.

Shenoy, S. 1967. Studies on larval development in Anomura (Crustacea, Decapoda). II.—Proceedings of the Symposium on Crustacea, Part II: 777–804. Marine Biological Association of India.

Webb, G. E. 1919. The development of the species of *Upogebia* from Plymouth Sound.—Journal of the Marine Biological Association of the United Kingdom 12: 81–135.

Williams, A. B. 1984. Shrimps, lobsters, and crabs of the Atlantic coast of the eastern United States, Maine to Florida.—Smithsonian Institution Press, Washington, D.C. Pp. 1–550.

Wolff, G. A., B. L. Andryszak, J. H. Wormuth, and S. P. Berkowitz. 1983. Zooplankton.—*In:* R. W. Hann, C. P. Giammona, R. E. Randall, eds., Strategic petroleum reserve brine disposal studies in the Gulf of Mexico. Field and laboratory procedures manual. Chapter 10. Department of Energy Contract No. DE-AC96-83P010850.

RECEIVED: 4 February 1985.
ACCEPTED: 8 August 1985.

Address: 4009 Shawnee Circle, Bryan, Texas 77802.

ANNOUNCEMENT

Publication of "Crustaceos decápodos das costas de Galicia. I. Brachyura" (Decapod crustaceans of the Galician coasts. I. Brachyura), by E. González-Gurriarán and M. Méndez G., 1985. Published at Cuadernos da Area de Ciencias Biolóxicas, Seminario de Estudos Galegos, vol. 2. O Castro-Sada, A Coruña: Ediciós do Castro, pp. 1–242.

This book includes the available information on 53 species of Brachyura recorded up to now for Galicia in northwestern Spain. It also takes into account 19 species not previously quoted, but considered to be probable because of the distribution range.

Following an introduction, zoogeographical and morphological considerations, the book offers a systematic list, an identification key, and a description of the different species, along with data on biology, ecology, and distribution. Accompanying the written text there are 81 figures and 63 photographs.

Copies may be obtained by sending $10.00 US payable to Ediciós do Castro (referring to the title of the book).

Address: Ediciós do Castro
O Castro-Sada
A Coruña, Spain