

Redescription of the clam shrimp *Lynceus gracilicornis* (Packard) (Branchiopoda, Conchostraca, Lynceidae) from Florida, with notes on its biology

JOEL W. MARTIN, BRUCE E. FELGENHAUER and LAWRENCE G. ABELE

Accepted 21 October 1985

Martin, J. W., Felgenhauer, B. E. & Abele, L. G. 1986. Redescription of the clam shrimp *Lynceus gracilicornis* (Packard) (Branchiopoda, Conchostraca, Lynceidae) from Florida, with notes on its biology.—*Zool. Scr.* 15: 221–232.

Clam shrimps of the family Lynceidae differ markedly from all other families of the Conchostraca. The biology and morphology of the genus *Lynceus* are poorly known. In North America the genus is represented by four species: *L. brachyurus*, *L. mucronatus*, *L. brevifrons* and *L. gracilicornis*. The last species, previously known from two localities in Texas, is reported from an ephemeral pond in north Florida. Among the characters distinguishing *L. gracilicornis* from North American congeners are dimorphic male claspers and a broad, straight rostral margin. Females are distinct in having a smoothly rounded, distal rostral margin. External and internal morphology are described using light and scanning electron microscopy. Scanning electron microscopy reveals the presence of frontal setose sensory fields and a small rostral pit in both sexes. Numerous setal types are described from the claspers and posterior thoracopods. Internal structures include a large anterior hepatopancreas, C-shaped gut and large paired gonads ventro-lateral to the gut.

Joel W. Martin, Bruce E. Felgenhauer & Lawrence G. Abele, Department of Biological Science, Florida State University, Tallahassee, FL 32306, U.S.A.

Introduction

The conchostracan genus *Lynceus* Müller, 1776 is known from ephemeral ponds or streams and occasionally lakes on all continents except Antarctica (Tasch 1969; Mattox 1957, 1959; Belk 1982). Four species occur in North America: *L. brachyurus* Müller, *L. mucronatus* (Packard), *L. brevifrons* (Packard) and *L. gracilicornis* (Packard). These are distinguished with some difficulty, as many of the characters employed by Packard (1883) (and also Daday 1927) appear to be variable.

Lynceus gracilicornis was originally described from Texas (Packard 1871) and until now was known only from that state. Unfortunately, Packard gave no illustrations, left no type series, and failed to note the type locality. In 1883 Packard published an illustration of a male and gave a type locality as Waco, Texas, although the actual type locality is Bosque County, Texas (see Geiser 1933; Lynch 1964). Daday (1927) illustrated *L. gracilicornis* based on specimens in the Museum of Natural History in Berlin, reported as being from Dallas, Texas. Forro & Brtek (1983) noted that Daday deposited three specimens in the Hungarian Natural History Museum; the locality of these is given as Dallas, Texas. Forro & Brtek also noted that the type series of *L. gracilicornis* is not among the branchiopod types in the Zoologisches Museum, Berlin.

In April 1984 we collected a large number of conchostracans from an ephemeral pond in Leon County, Florida. Comparison of this material with Texas specimens kindly supplied by Dr Denton Belk convinced us that our material is conspecific with *L. gracilicornis*. Below we redescribe this species, which is the first record of the family from the southeastern United States, and provide notes on its morphology and biology.

Material and methods

Conchostracans were collected on 4 and 9 April 1984, from a shallow (<1.0 m) ephemeral pond in Leon County, Florida (Fig. 2A). The pond is located within the boundaries of the Ponderosa Trailer Park on state road 20, 4.6 miles south of its intersection with Highway 90. On 9 April the water temperature was 24°C; air temperature was 25°C. Water in the pond was clear but dark colored (tannic). In addition to clam shrimp, the pond contained aquatic insects, frog tadpoles and several large anostracans (*Streptocephalus seali* Ryder, 1879). Highest densities of conchostracans were found in shallow grassy areas of the pond, although individuals could also be seen swimming over bare patches of sand. Density was estimated by repeated sweeps through the grass inside a 0.5 m² quadrat. In the laboratory animals were maintained in plastic 8 l buckets and one 15 l aquarium. Specimens to be illustrated were preserved in 10% formalin for 24 h and transferred to 70% ethanol. Animals were illustrated with the aid of a Wild M-5 stereoscope and M-11 compound microscope, both equipped with camera lucida. Specimens used for scanning electron microscopy (SEM) were fixed in 3% glutaraldehyde at room temperature for 3 h in 0.1 M phosphate buffer and post-fixed in 2% osmium tetroxide an additional 2 h before dehydration in a graded ethanol series. Specimens were then critical-point dried, mounted on stubs and coated with 10–20 nm of gold-palladium for observation in a Cambridge S4-10 and JEOL 100CX II TEMSCAN at accelerating voltages of 10–30 kV.

Terminology follows that of Sars (1896), Linder (1945), Tasch (1969) and McLaughlin (1980).

Results

Family Lynceidae Stebbing, 1902
Genus *Lynceus* Müller, 1776

Lynceus gracilicornis (Packard, 1871)

Limnetis gracilicornis Packard, 1871: 113; 1883: 298 (key), 302, fig. 3b.
Lynceus gracilicornis; Daday 1927: 89–94 (675–680), fig. 166; Mattox 1959: 580 (key).

Diagnosis

Lynceus with dimorphic male claspers, that of right side markedly larger than that of left; male rostrum terminating distally in broad straight border, female rostrum longer than that of male and produced distally into smoothly rounded apical border; flagella of second antennae with 16–22 segments; carapace lacking growth lines, completely enclosing rostrum when closed; both sexes with sensory fields on either side of, and rostral pit on midline of, rostral carina.

Description

The above characters are traditionally used to identify species of *Lynceus* and serve to separate *L. gracilicornis* from the other known North American forms (*L. brachyurus*, *L. mucronatus* and *L. brevifrons*). There appears to be variability within species in this family, particularly in the shape of the rostrum and outline of the carapace. In addition, some characters may change significantly with ontogeny (e.g. see Retallack & Clifford 1980). Few detailed descriptions exist for other species of *Lynceus*; it is possible that some of the characters described below may apply also to other species or to all members of the family.

Carapace (Figs. 1A, C, E, 3). Carapace or 'shell' in lateral view ovate to round, in dorsal view slightly more than twice as long as wide to nearly spherical when closed, female often more inflated than male. Outer surface completely smooth lacking growth lines or puncta, dorsally somewhat flattened and slightly depressed medially toward hinge-line; umbo lacking; area of attachment of adductor muscle to carapace visible under light microscopy and surrounded by irregular concentric ovals (maxillary gland; Fig. 1E, *mg*). Carapace, when closed, completely enclosing rostral area in both sexes, forming tight seal around entire animal; carapace border flares slightly; flattened internal surfaces rather than leading edges appressed when closed. Size approximately the same in both sexes, reaching 6.0 mm in carapace length as defined by Saunders & Wu (1984).

Thin membranous sheet extending laterally from approximate area of maxillary somite, originating dorsally as ligament connecting dorsum of body to carapace, attaching to ventral edge of carapace along curved line just dorsal to rounded ventral borders of carapace. Large sac-like maxillary gland (Fig. 1E, *mg*) visible through carapace within space between outer shell surface and inner membrane around attachment site of adductor muscle (Fig. 1E, *ms*).

Rostrum. Male rostrum (Figs. 1A, B, 2B, 3) truncate distally, lacking medial cleft and lacking or with minute antero-lateral spiniform extensions; disto-lateral angle approximately 90° to distal margin (Fig. 1A). Rostral carina (Figs. 1A, B, *rc*) extending nearly to tip of rostrum and extending posteriorly in smooth curve; no indication of a post-orbital cleft. Demarcation between 'head' and 'thorax' a slight indentation (occipital notch; Figs. 1C, 3, *on*). Lateral rostral borders curve proximally, folding slightly over adjacent edge of rostrum; in frontal view lateral margins curve medially at level of second antennae

(Figs. 1A, 2B) then sharply laterally at antennal base. Rostral carina slopes gradually to lateral borders, abuts posteriorly with fusion of lateral borders and orbital region; this abrupt escarpment harboring on either side of rostrum a distinct setose sensory field (see below). Postero-ventral surface of rostrum slopes gently upward toward confluence with descending labrum (Fig. 1B). First and second antennae arise from this posterior rostral surface and extend postero-ventrally and antero-ventrally, respectively. Female rostrum (Figs. 1C, 2C) very different anteriorly from that of male, ventral (distal) border elongated and rounded, not at all truncate; no indication of partitioning of this border into lobes or regions as shown in figures of Daday (1927). Female rostrum otherwise similar to that of male.

Sensory fields. Distinct oval field of short simple setae (sensory field; Figs. 1A, C, 2D, E, 3, *sf*) on either side of base of rostral carina where it arises from orbital region; cuticle underlying these setae thin and membranous, differing from that of surrounding rostral cuticle. Setae extend to just beyond edge of rostral carina and radiate outward from convex cuticular surface of field; setae appear weakly calcified, no apical pore (Fig. 2E, inset).

Rostral pit. Distinct pit along midline of rostrum between sensory fields in both males and females; opening of this pit under high magnification (Figs. 2D, F) appears separated by posterior blunt protuberance into two subequal oval shafts.

First antenna (antennules). First pair of antennae small, reduced to only 2 segments, arising from lateral surface of underside of rostrum (Figs. 1B, 4A); proximal segment short and cylindrical; distal segment 2–3 times as long as proximal and bearing numerous short blunt setae (olfactory papillae; Fig. 4A, *op*), each with apical pore.

Second antenna. Second antennae large, well developed, biramous, lateral and dorsal to first antennae (Figs. 1A–C, 4B). Basal peduncle divided into 2 poorly demarcated cylindrical segments, each with scattered simple setae; basal segment with few plumose setae disto-laterally. Biramous flagella vary in number of segments from 16 to 22; both anterior (*af*) and posterior (*pf*) flagella bear long lightly plumose setae directed posteriorly, anterior ramus bears in addition shorter plumose setae along dorsal edge of each segment (Fig. 4B).

Labrum. Labrum large, well developed, extending ventrally from posterior rostral surface (Fig. 1B). Anterior surface mostly smooth and unarmed, except for ventral (distal) third which is densely setose; setae extend ventrally and posteriorly to terminus of labrum and laterally to posterior labral surface. Posterior surface of labrum complex, with paired excavated areas delimited by distinct ridges (Fig. 4C); surface of posterior labrum with dense covering of short simple setae; those adjacent to mouth region becoming spiniform and creating V-shaped row; area of mouth (*m*), corresponding to this spiniform row, denticulate, bearing minute sclerotized teeth (the 'oral comb' apparatus; Fig. 4C, *oc*).

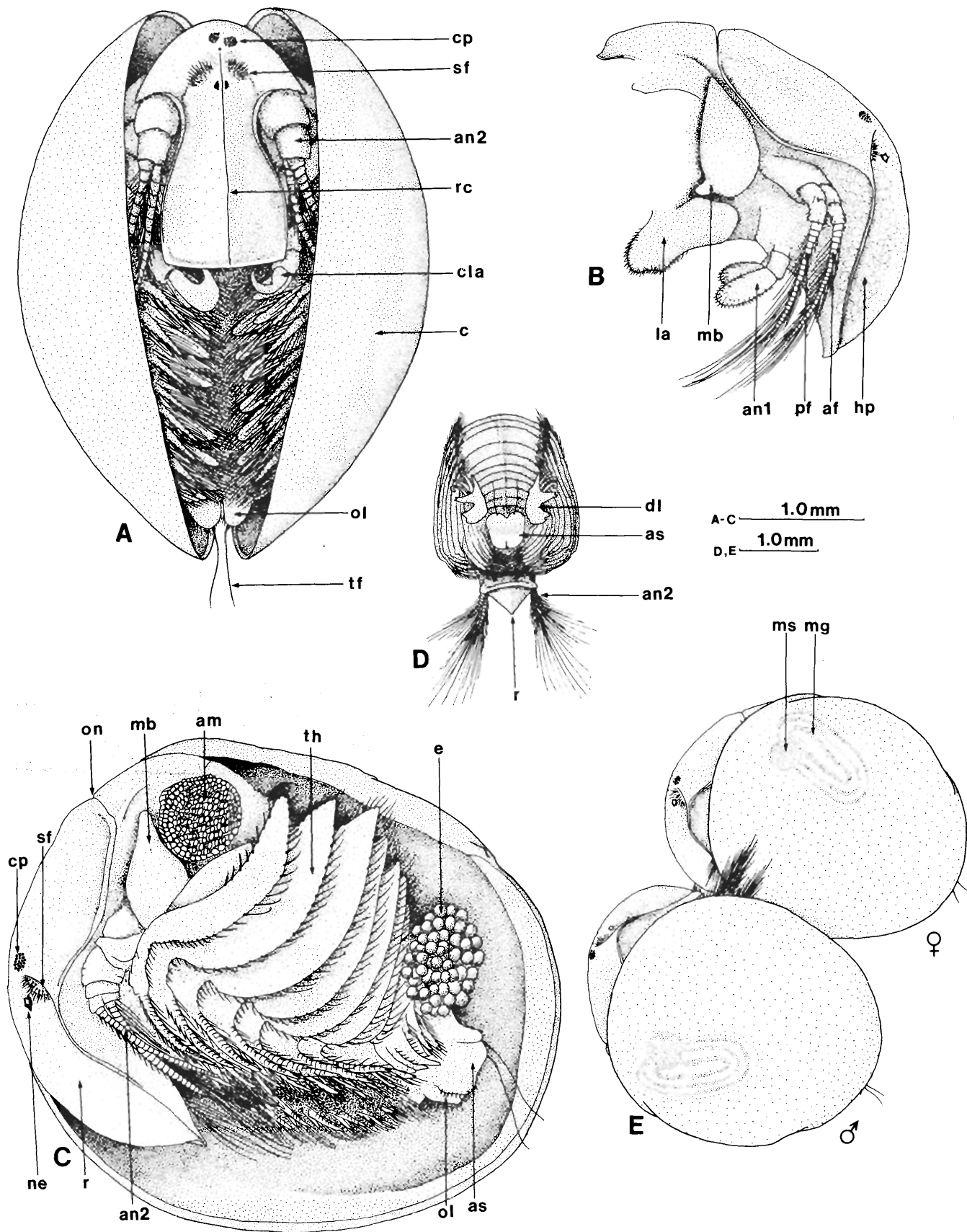


Fig. 1. *Lynceus gracilicornis* carapace and rostral morphology.—A. Ventral view of male.—B. Lateral view of rostral region of male.—C. Lateral view of female with left carapace valve removed.—D. Posterior view of female with carapace removed to show modified exopods of thoracopods and dorsal lamellae for egg carrying.—E. Mating pair.

Mandible. Mandible large, stout, arising just posterior to labrum (Figs. 4D, 7F). Proximal (dorsal) part narrow and conical, distal (ventral) part becoming thick and wide, bending sharply medially to meet cutting edge of opposing

mandible; cutting edge dentate with short stout corneous teeth (Figs. 4D, 7F).

Maxillae. First maxilla (Fig. 4E) small, indistinctly 2-

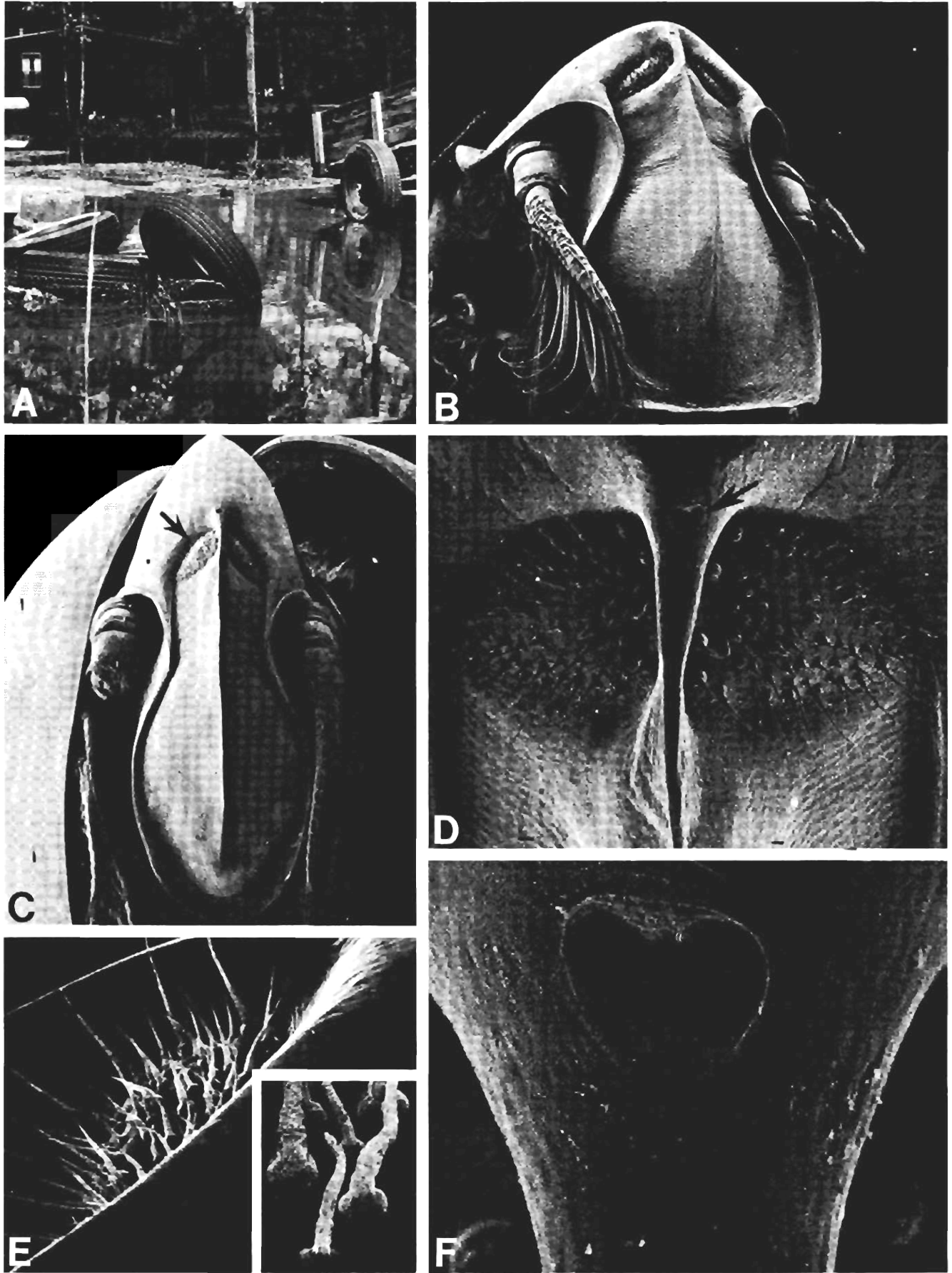


Fig. 2. Florida collecting locality and detailed rostral morphology of *L. gracilicornis*.—A. Area of highest abundance at collection site.—B. Frontal view of male rostrum.—C. Frontal view of female rostrum; sensory field indicated by black arrow.—D. Sensory fields flanking rostral carina and rostral pit; rostral pit indicated by black arrow.—E. Lateral view of sensory field with high magnification of setae (inset).—F. High magnification of rostral pit indicated in D.

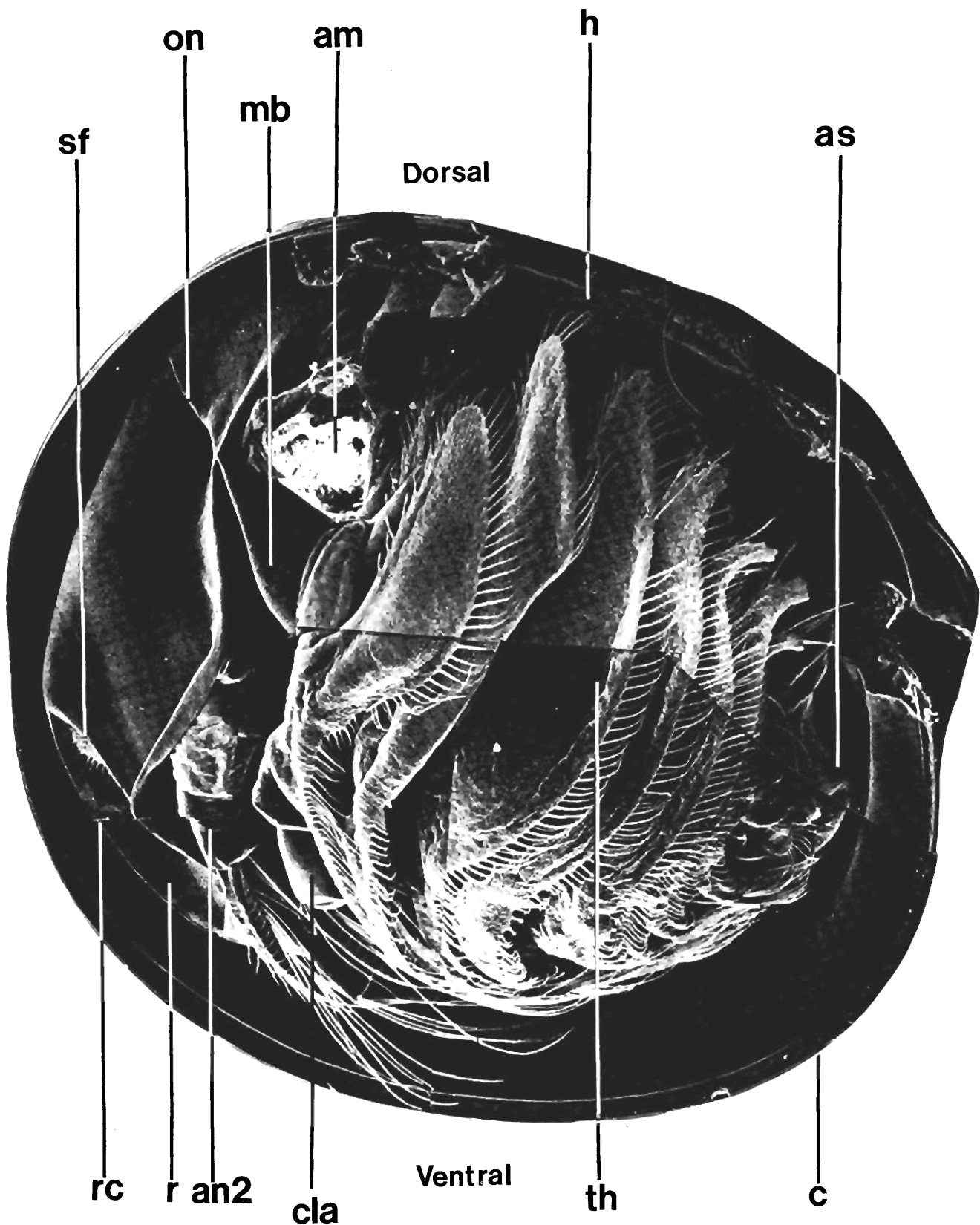


Fig. 3. SEM montage of male *L. gracilicornis*, $\times 60$

segmented; basal segment unarmed, distal segment with short serrate and simple setae and longer plumose setae. Second maxillae absent.

Thoracopods. Basic lynceid thoracopod (=phyllopod) thin, flat, divided into many lobes and endites (Fig. 5). Exopod large and flat, divided into narrow ventral lobe (*exv*) and broader lanceolate dorsal lobe (*exd*), each with

numerous long plumose setae. Endopod typically divided into 6 distinct lobes or endites, variously named by different authors [as the coxal lobe differs morphologically and functionally from the distal endites we have retained Sars' (1896) term for it, although the remaining endites are numbered 1-5 in the more conventional proximal to distal arrangement (Fig. 5)]. First and second endites short and broad; third through fifth narrow and digiform.

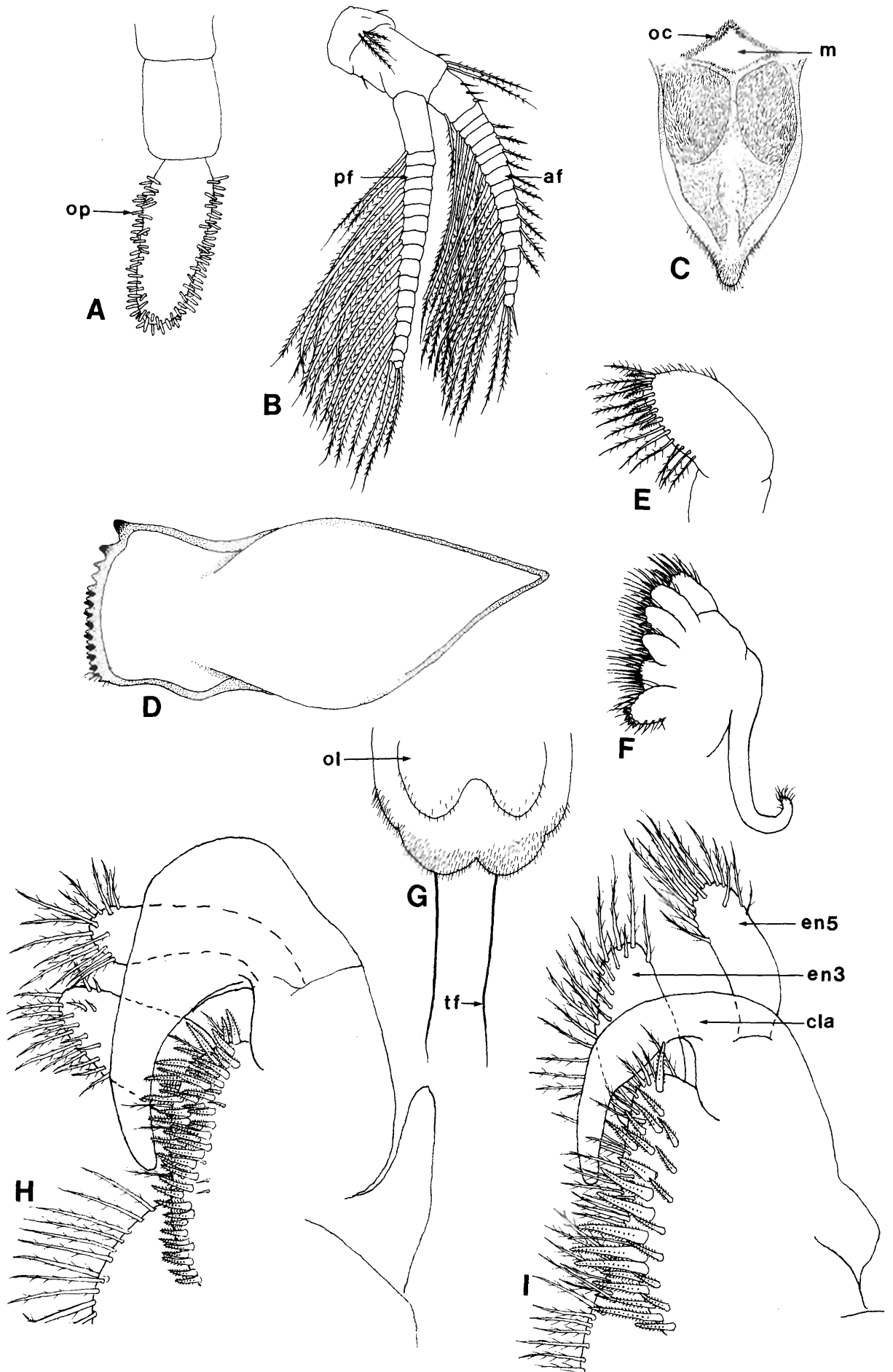


Fig. 4. Various anterior and trunk appendages of *L. gracilicornis*.—A. First antenna with olfactory papillae.—B. Second antenna.—C. Posterior view of labrum.—D. Frontal view of mandible.—E. First maxilla.—F. Posterior thoracopod of female with modified egg-carrying dorsal lobe of exopod.—G. Ventral view of anal somite with opercular lamellae extending posteriorly from penultimate somite.—H. Right clasper of male, terminal portion.—I. Left clasper of male, terminal portion.

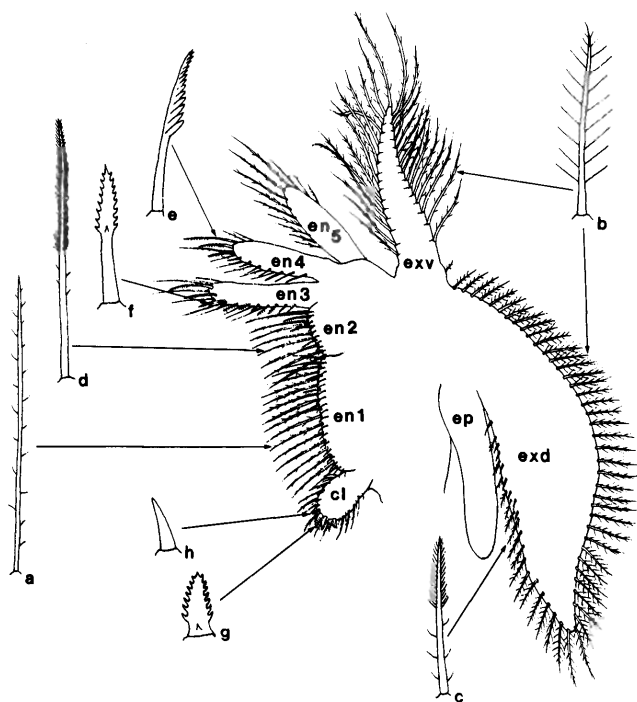


Fig. 5. Schematic generalized lynceid thoracopod with various setal types. Location of a given setal type is not meant to be inclusive or exclusive of its presence, but represents area of highest likelihood of occurrence. Lower case letters *a-h* refer to setal types (see text).

Endite 5 (Fig. 5, *en5*) articulates with appendage and therefore differs from all other endites. Epipod (*ep*) a smooth unarmed dorsal lobe posterior to dorsal lobe of exopod.

Male first thoracopods. Male first thoracopod modified as a clasping appendage (Figs. 1A, 3, 4H, I, 7A, *cla*), as in all known lynceids; fourth endite enlarged as claw-like process. Reduced second endite with numerous smooth 'sensory' setae, each with apical pore (Figs. 7C, D), and several heavy cuspidate spines (Figs. 4H, I, 7A, B). Other portions of thoracopod (exopod, coxal lobe and first endite) unmodified, although reduced in size. Thoracopods strongly dimorphic; right clasper large with wide heavy terminal claw (Fig. 4H) and many serrate spines on second endite, left clasper with narrow slender terminal claw and fewer spines and setae (Figs. 4I, 7A).

Body. No demarcation between thoracic and abdominal regions; postcephalic portion often termed 'trunk'. Trunk somites with no dorsal spines or setae, mostly smooth; exception in females on penultimate (pre-anal) somite, which bears pair of large dorsal lamellae (Fig. 1D, *dl*) which support, with modified last two thoracopods, the egg mass in ovigerous individuals.

Anal somite. Terminal (anal) somite (Figs. 1C, 3, 8F, *as*) wide, cylindrical, with terminal anus; ventrum of somite covered by two opercular lamellae (Figs. 4G, 8F, *ol*) which extend posteriorly from penultimate somite. Dorsum of anal somite with pair of long hair-like processes termed telsonal filaments (Figs. 1A, 4G, *tf*); telson possibly represented by small dorsal protuberance which gives rise to these filaments. Alternatively, small outgrowth of cuticle on posterior margin of anal somite

(Figs. 8D, F) possibly homologous to telson in other conchostracans. Posterior border of anal somite and opercular lamellae of penultimate somite minutely setose (Fig. 4G).

Thoracopod morphology

Setation of the thoracopod (Fig. 5) is diverse; setal types referred to herein are designated in Fig. 5 by lower case letters. As is the case in most crustaceans, the following setal types are not always discrete as there are many setae transitional between any two described setae. The first and second endites of the endopod bear numerous long, sparsely pappose setae (type *a*). Similar to the pappose setae but with longer and denser setules are the plumose setae (type *b*) of the ventral and dorsal lobes of the exopod. On the posterior edge of the dorsal exopod and on many of the endites are stout pappose-spinose setae (type *c*) intermediate between pappose or plumose setae and the longer spinose setae (type *d*) found on the more ventral endites. There are two distinct serrate setal types. The first (type *e*) has flexible lamellar-like setules arising from the distal half of the setal shaft. The second (type *f*) has rigid, short, curved dentations also on the distal half of the shaft. A modified form of the latter type are the short serrate setae (type *g*), found exclusively on the coxal lobe, which also may bear short simple spiniform setae (type *h*).

Not all setal types can be found consistently on any given thoracopod. For example, type *f* serrate setae are found only on endites 3, 4 and 5 on thoracopods posterior to thoracopod 4. Serrate setae of type *e* are rare and are found on endites 3 and 4 usually on thoracopods 6–8. In addition, long simple setae, not shown in Fig. 5, may be present on endites 1, 2 or 3. Sars (1896) noted the presence in *L. brachyurus* of a distinctive setal type termed by him a "peculiar bifid spine" on the fourth endite (his second endite) of males only. We noted no such setal type as pictured in his plate XX fig. 9b, and observed no sexual dimorphism in setal types or location.

The actual shape of the thoracopod is not flat, as illustrated. Instead the dorsal and ventral lobes of the exopod are strongly recurved posteriorly, so that the entire appendage is folded longitudinally into a V-shape. In lateral view (Figs. 1C, 3) the ventral and dorsal lobes of the exopod are visible, whereas the coxal lobe, epipod and endites lie medial to the exopod and are thus hidden from view.

With the exception of the male first thoracopod, the lynceid thoracopods are similar and become smaller in size in an anterior to posterior direction (Fig. 6.) The ventral endites (3–5) become shorter and more similar to the basal endites and coxal lobe, while both lobes of the exopod diminish in size until they are completely lost in thoracopod 10 (Fig. 6I).

There are two exceptions to this gradual reduction in size with retention of original form. In females the posterior three thoracopods have modified dorsal lobes curved laterally and bearing minute simple setae on the distal border (Figs. 1D, 4F). These modified exopods, in addition to the dorsal lamellae of the posterior female body (Fig. 1D, *dl*), facilitate support of the egg mass. The second exception occurs on the pre-anal (pre-telsonal)



Fig. 6. Male *L. gracilicornis*, thoracopods 2-10.—A. Thoracopod 2.—B. Thoracopod 3.—C. Thoracopod 4.—D. Thoracopod 5.—E. Thoracopod 6.—F. Thoracopod 7.—G. Thoracopod 8.—H. Thoracopod 9.—I. Thoracopod 10.

somite. On this somite the appendages are represented by a pair of small thin ventral flaps, the opercular lamellae (Figs. 1A, C, 3, 4G, *ol*), which extend posteriorly beneath the telson.

Internal morphology

Because of the thin transparent nature of the lynceid cuticle, much of the internal morphology can be seen

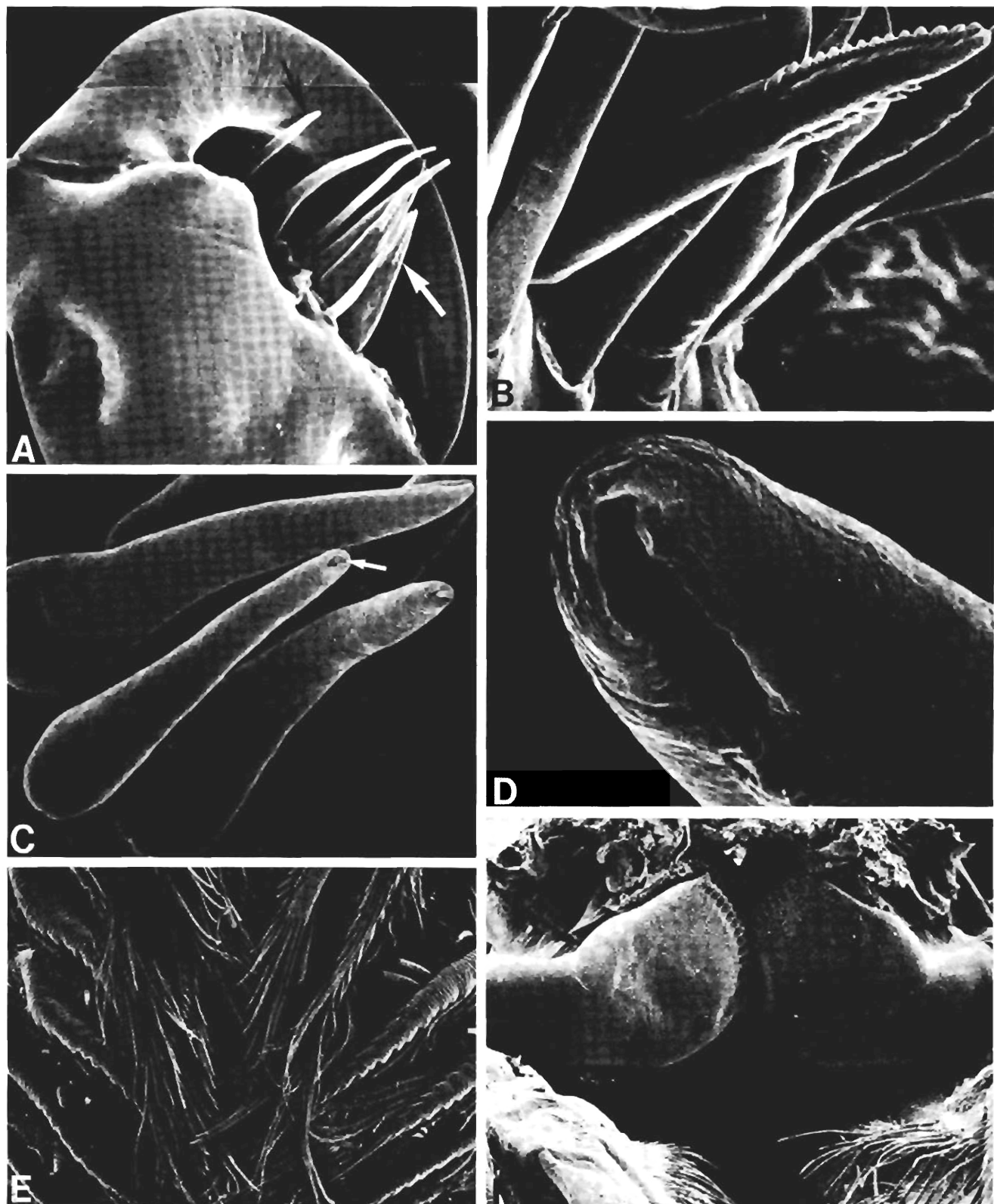


Fig. 7. *Lynceus gracilicornis*, SEM of male clasper and feeding appendages.—A. Terminal portion of left clasper.—B. Cuspidate spines indicated by white arrow in A.—C. Simple pore setae indicated by black arrow in A.—D. High magnification of apical end of a pore seta, as indicated by white arrow in C.—E. Ventral view of confluence of ventral thoracopod endites.—F. Mandibles *in situ*.

using transmitted light with the compound microscope, without dissection. The internal features of the rostrum, including musculature, hepatopancreas and eye structure, are often clearly visible. Unfortunately, internal characters of the trunk somites are obscured by the thoracopods and can be seen only by dissection or sectioning.

Rostrum. The internal components of the rostrum

include the hepatopancreas, compound and naupliar eyes and the associated musculature. The hepatopancreas (Figs. 1B, 8A, *hp*) is a large lobular organ filling almost completely the ventral part of the rostrum. It does not extend dorsally much beyond the region of the compound eye (*cp*) and extends postero-ventrally into the dorsal part of the labrum. In all respects the hepatopancreas of *L. gracilicornis* resembles that of *L. brachyurus* illu-

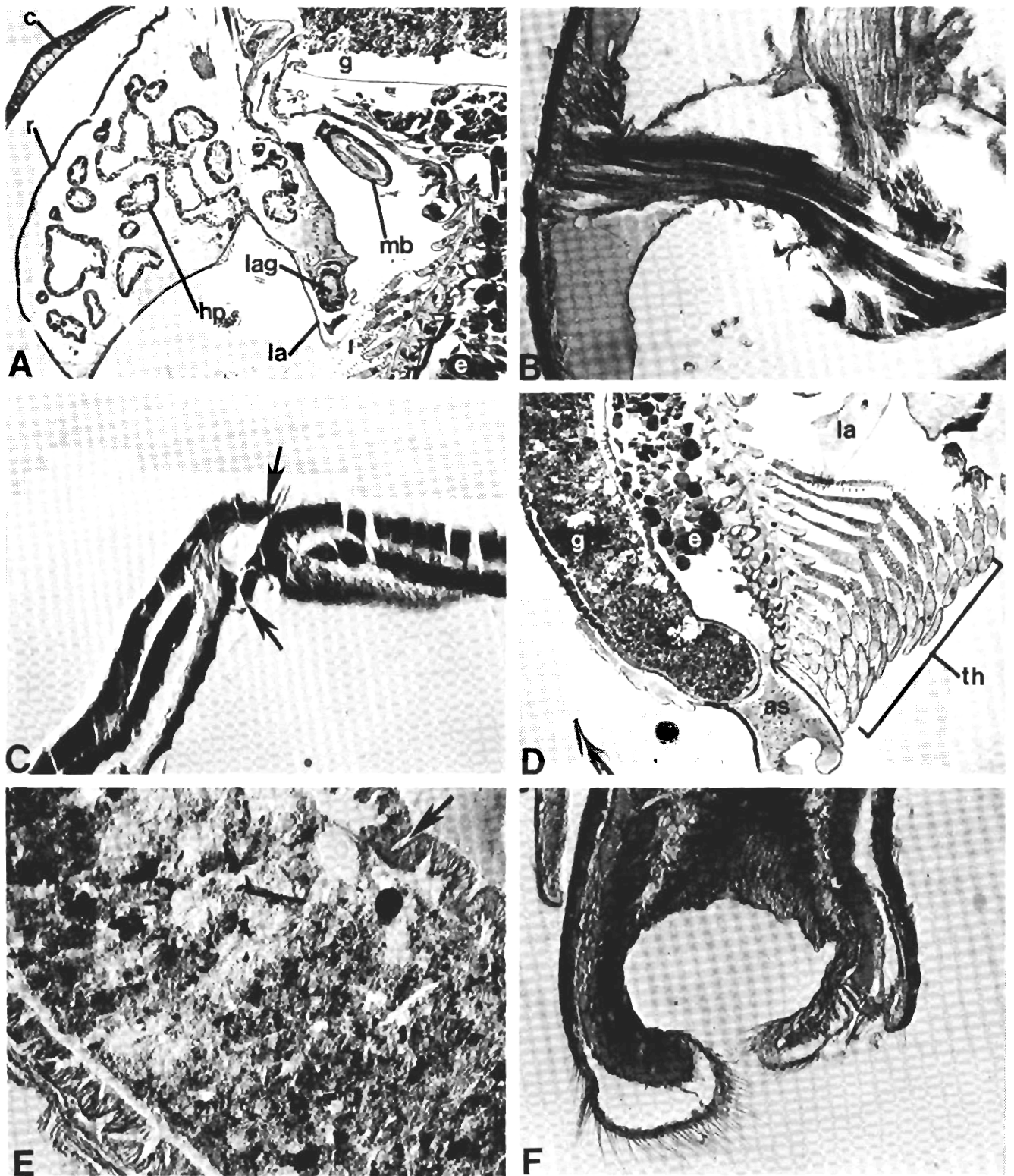


Fig. 8. *Lynceus gracilicornis*, internal morphology.—A. Rostral and labral region; black arrow denotes direction of food passage from mandibles (*mb*) through esophagus and into midgut (*g*).—B. Attachment of adductor muscle to lateral carapace wall.—C. High magnification of hinge region showing interlocking grooves and ridges; upper arrow indicates overreaching flap of left valve; lower arrow indicates 'lip' region of right valve.—D. Posterior region of trunk with gut and gonads visible.—E. High magnification of detrital material in gut; arrow indicates infolding of absorptive gut wall.—F. Longitudinal section through anal somite, with ventral opercular lamella at far right.

strated by Sars (1896). The compound eyes (Fig. 1A, C *cp*) are large and situated on either side of the base of the rostral carina, dorsal to the rostral pit. They are very near the outer rostral surface. Often the two compound eyes are asymmetrically arranged, with one noticeably more dorsal than the other (Fig. 1A). The naupliar eye (Fig. 1A, C, *ne*) or ocellus is a trapezoidal structure located ventral and internal to the compound

eyes, just ventral and medial to the sensory fields. Under light microscopy it appears birefringent, with a central light-reflecting quadrangular region. Its structure is similar to that illustrated by Sars (1896) for *L. brachyurus*, but its location differs in the two species. In *L. brachyurus* it is located deeper within the rostrum, almost directly below the compound eyes and dorsal to the sensory fields.

Labrum. The dorsal half of the labrum is usually filled with hepatopancreas (Figs. 1B, 8A). The lower third contains a large glandular structure which we are calling the labral gland (Fig. 8A, *lag*). Its function in lynceids is not known.

Digestive system. The digestive system consists of an anterior hepatopancreas and an enormous simple C-shaped gut (Figs. 8D, E) that takes up almost all of the internal space. Anteriorly there is a short esophagus that extends dorsally from the mouth at the base of the labrum, then posteriorly as it expands to join the midgut. The posterior opening is on the terminal somite (the anal somite of Bowman 1971, but see Schminke 1976). This anus opens postero-ventrally between two lateral lobes of the anal somite. In almost all animals examined the gut was packed with small particles of detritus (e.g. Fig. 8E), but at least one individual contained pieces of arthropod cuticle.

Reproductive system. With light microscopy (Fig. 8D) the gonads of both sexes appear as large paired glandular organs ventral or ventro-lateral to the intestine, and, together with the intestine, completely fill the body somites. According to Linder (1945), the genital opening of the female lynceid is at the base of the 11th somite appendage. Linder also claimed that the vas deferens of the male extends through the telson (anal somite), paralleling the intestine, and opens on either side of the anus via a pair of small openings. Sars (1896) believed that the vas deferens opened laterally or ventro-laterally in a position which corresponded to the same aperture in females. We observed no paired openings on the posterior surface of the anal somite flanking the anus, as Linder (1945) suggested, but neither have we located any lateral openings at the base of the penultimate appendages. The modified last two thoracopods and dorsal lamellae in the female suggest a lateral or even dorsolateral genital opening for the female, but the external aperture of the male reproductive system still awaits discovery.

Biology

Lynceus gracilicornis is a large, robust species that can be seen easily with the naked eye. Living animals are orange to rose in color, with dark maroon shells and yellow to orange eggs in ovigerous females. At least in the Florida locality, the species is abundant, with densities of up to 320 per m². We encountered the highest densities in shallow grassy parts of the pond, with few individuals in deeper water or water over bare sand or mud. The site remains wet over most of the spring and summer, with occasional periods of low water or complete dryness in July and August. It usually fills again in the fall, but no clam shrimps were found during one wet period in September. During winter the area remains dry for months at a time. Because of the great abundance of animals encountered in early April, we feel that this is probably near the season of peak abundance.

Swimming is accomplished by backward propulsion of the foliaceous thoracopods and second antennae. The animal often swims in an upside-down position or on its

side; spiral movement through the water is not uncommon. Copulation was observed in the field and in the laboratory. Males clasp the lower border of the female shell and typically swim holding the female above them (Fig. 1E). Grasping is accomplished via the modified claspers and serrate spines of the first thoracopods, although the exact mode of attachment could not be ascertained. Laboratory pairs were seen to remain together for up to 5 min, during which the pair almost always swam in a slow spiral. Ovigerous females carry up to 200 eggs (usually many more than illustrated in Fig. 1C) in a cohesive mass, which is usually visible through the carapace.

Animals remained alive in the laboratory for 3 weeks before becoming sluggish and dying. We did not attempt to feed them during this period, but observed often the extending and withdrawing of the second antennae, similar to the cirral feeding of barnacles. Unlike other conchostracans, lynceids are known to collect plankton while swimming (Kaestner 1970). *Lynceus gracilicornis* probably feeds in the same manner.

Discussion

Functional morphology

The setose fields on either side of the base of the rostral carina are probably sensory structures. Because of their apparent lack of pores and the flexible nature of the surrounding cuticle of the field, coupled with their proximity to the rostral pit and internal sensory organs, we assume that these fields serve a tactile sensory function. The rostral pit may be a chemoreceptor, although innervation of this area was not ascertained. It would seem likely that these areas and the pore setae of the first antennae constitute the non-visual sensory centers.

The two valves of the carapace are joined dorsally by a true hinge, with the valves slightly overlapping dorsally (Fig. 8C). The medial part of this hinge (not figured) is in a deep longitudinal cleft between the valves. The presence of a true hinge is in contrast to definitions of the Conchostraca that include as an ordinal character the non-hinging nature of the carapace (e.g. Sars 1896). Both Sars (1896) and Linder (1945) were aware of the different nature of the lynceid hinge.

Comparison with other known lynceids

Lynceus gracilicornis is distinguished from almost all other known members of the Lynceidae by the strongly dimorphic male claspers (Figs. 4H, I). Although certain other species of *Lynceus* show slight dimorphism in clasper size, few possess a right clasper which differs in shape from that on the left. In the majority of lynceids the clasper is a thin, smoothly curving, sickle-shaped recurved claw which tapers distally. This is true of the left clasper of *L. gracilicornis* (Fig. 4I), but the right clasper is enormously inflated dorsally (Fig. 4H). The only other lynceids exhibiting a similar inflated clasper are *L. massaicus* Thiele from east Africa, *L. dovei* Daday and *L. decaryi* Gauthier from Madagascar, and *L. aequatorialis* Daday from Venezuela, with a very different clasper (see Daday 1927). The related genus *Lynceiopsis* Daday also posses-

ses an inflated right clasper, but is immediately distinguished from *Lynceus* by the unusual morphology of the second pair of thoracopods (See Daday 1927).

The illustration of *L. gracilicornis* by Daday (1927) agrees closely with our observations on clasper morphology. However, rostral morphology as illustrated by Daday differs in that the male rostrum has obvious antero-lateral projections (as opposed to the minute projections seen in our Fig. 2B) and a shallow median cleft, and the female rostrum has rounded antero-lateral lobes. The rostral morphology of *L. gracilicornis* from Texas agrees closely with that of our Florida specimens. It is possible that Daday's illustration is from a more dorsal angle, accentuating the disto-lateral upturned rostral margin. Rostral morphology is known to vary among lynceid populations (Straskraba 1965; *L. brachyurus*) and with ontogeny, and fungal growth can erode or alter rostral margins (D. Belk, pers. commun.).

Among the known North American species of *Lynceus*, *L. gracilicornis* most closely resembles the widely distributed *L. brachyurus*. The two species differ in clasper and rostral morphology, with *L. brachyurus* having a rostrum produced in the female into a long acute process with antero-lateral projections and having male right and left claspers of similar size and shape. Both *L. gracilicornis* and *L. brachyurus* differ from *L. mucronatus* in the possession by the latter of a diagnostic large, recurved hook on the posterior trunk appendage and a terminal knob on the edge of the clasper (Mattox 1959). The fourth North American species, *L. brevifrons*, is immediately separated by the abruptly truncate male rostrum (in lateral view) and short clasper.

Lynceid zoogeography is poorly known. It appears that some species are widespread; *L. brachyurus* is found in Europe, Asia, Canada and many regions of the United States (Mattox 1959; Pennak 1978). Other species are known from a single locality or region. Such was the case for *L. gracilicornis*, which previous to this paper was known only from Texas, although an unpublished record exists for a population in North Carolina (D. Belk, pers. commun.). It seems certain that populations exist between the Texas and Florida locations, although none has been reported. Our report is the first mention of the family in the southeastern United States.

Acknowledgements

We gratefully acknowledge the kind assistance of Dr. Denton Belk, Our Lady of the Lake University, San Antonio, Texas, for sending us specimens of *Lynceus gracilicornis* from Texas, along with other members of the genus for comparative purposes. Dr. Belk is also acknowledged for constructive criticism of the manuscript. We thank also Dr. Geoffrey Fryer, Freshwater Biological Association, Far Sawrey, Ambleside, U.K., for critical review of the manuscript. We are extremely grateful to Tom Fellers and Bill Miller for their expertise with electron microscopy.

Abbreviations used in the figures

af	anterior flagellum of second antenna
am	adductor muscle
an1	first antenna
an2	second antenna
as	anal somite
c	carapace (shell)
cl	coxal lobe of thoracopod

cla	male clasper (modified first thoracopod)
cp	compound eye
dl	dorsal lamella of female trunk
e	egg
en(1-5)	endites 1-5 of endopod
ep	epipod
exd	dorsal lobe of exopod
exv	ventral lobe of exopod
g	midgut
h	hinge
hp	hepatopancreas
la	labrum
lag	labral gland
m	mouth
mb	mandible
mg	maxillary gland
ms	site of attachment of adductor muscle to carapace
ne	naupliar eye
oc	oral comb apparatus
ol	opercular lamellae of penultimate somite
on	occipital notch
op	olfactory papillae
pf	posterior flagellum of second antenna
r	rostrum
rc	rostral carina
sf	sensory field
tf	telsonal filament
th	thoracopod(s)

References

- Belk, D. 1982. Branchiopoda. In *Synopsis and classification of living organisms* (ed. S. P. Parker) 2: 174-180. McGraw-Hill, New York.
- Bowman, T. E. 1971. The case of the nonubiquitous telson and the fraudulent furca.—*Crustaceana* 21: 165-175.
- Daday, E. 1927. Monographie systematique des Phyllopes Conchostraces. Troisième partie (fin).—*Anns. Sci. nat. Zool.*, Sér. 10 10: 1-112.
- Förro, L. & Brtek, J. 1983. Anostraca and Conchostraca taxa described by E. Daday together with a catalogue of pertinent material in the Hungarian Natural History Museum.—*Miscnea zool. Hung.* 2: 75-104.
- Geiser, S. W. 1933. On the type localities of certain Texas Phyllopora.—*Fd Lab.* 1: 47-50.
- Kaestner, A. 1970. *Invertebrate zoology, Vol. 3, Crustacea*. John Wiley and Sons, New York.
- Linder, F. 1945. Affinities within the Branchiopoda, with notes on some dubious fossils.—*Ark. Zool.* 37: 1-28.
- Lynch, J. E. 1964. Packard's and Pearse's species of Branchinecta: analysis of nomenclatural involvement.—*Am. Midl. Nat.* 71: 466-488.
- Mattox, N. T. 1957. A new estheriid conchostracan with a review of the other North American forms.—*Am. Midl. Nat.* 58: 367-377.
- Mattox, N. T. 1959. Conchostraca. In *Fresh-water biology* (H. Ward and G. Whipple), 2nd Edn (ed. W. T. Edmondson): 577-586. John Wiley and Sons, New York.
- McLaughlin, P. A. 1980. *Comparative morphology of Recent Crustacea*. W. H. Freeman and Co., San Francisco.
- Packard, A. S. Jr 1871. Preliminary notice of new North American Phyllopora.—*A. J. Sci. Arts.* 102: 108-113.
- Packard, A. S. Jr 1883. A monograph of the phyllopod Crustacea of North America, with remarks on the order Phyllocarida.—*A. Rep. U.S. geol. geogr. Surv.* 1878 (Hayden Survey) Sect. 1: 295-592.
- Pannak, R. W. 1978. *Fresh-water invertebrates of the United States*, 2nd Edn. John Wiley and Sons, New York.
- Retallack, J. T. & Clifford, H. F. 1980. Periodicity of crustaceans in a saline prairie stream of Alberta, Canada.—*Am. Midl. Nat.* 103: 123-132.
- Sars, G. O. 1896. Phyllocarida og Phyllopora.—*Forch. Vidensk Selsk. Krist., Fauna norv.* 1: 1-140.
- Saunders, J. F. & Wu, S. 1984. Eubranchiopoda of Colorado, Part 3. Conchostraca.—*Nat. Hist. Inventory Colo.* 8: 1-19.
- Schminke, H. K. 1976. The ubiquitous telson and the deceptive furca.—*Crustaceana* 30: 292-300.
- Straskraba, M. 1965. Taxonomical studies on Czechoslovak Conchostraca II. Families Lynceidae and Cyzicidae.—*Acta Soc. zool. Bohemoslov.* 3: 205-214.
- Tasch, P. 1969. Branchiopoda. In *Treatise on invertebrate paleontology, Part R, Arthropoda 4* (ed. R. C. Moore) 1: R128-R191. University of Kansas Press, Lawrence.