

THE FRESHWATER DECAPOD CRUSTACEANS
(*Palaemonidae, Cambaridae*)
OF THE
SAVANNAH RIVER PLANT, SOUTH CAROLINA



by
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(U. S. - ERDA)

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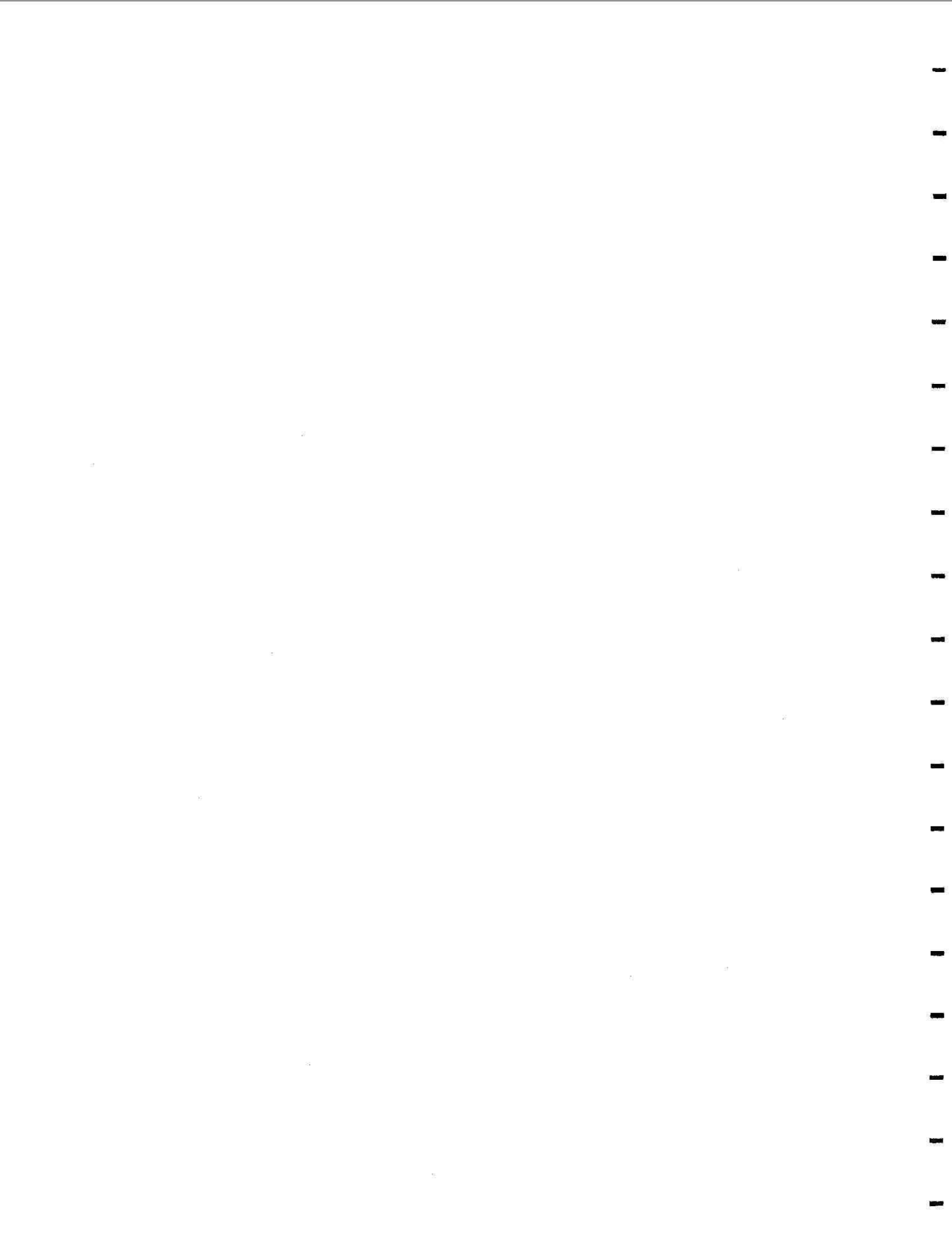


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INTRODUCTION

Decapod crustaceans (specifically crayfishes and freshwater shrimps) are quite numerous in the drainages of the southeastern United States and occupy an extremely important niche in aquatic systems. As predators they act as disturbance components on benthic freshwater communities and may serve an integral position in the early stages of detrital decomposition. They constitute an important prey item in the diets of a wide variety of terrestrial and aquatic vertebrate predators, including game fishes, such as Micropterus salmoides (La Cepède) and other centrarchids.

Researchers at the Savannah River Plant (SRP) employ these crustaceans in studies of the effects of thermal and heavy metal pollution on survival and behavior, as well as in investigations of the fates of heavy metals and radioactive pollution in freshwater environments. A common problem to these studies is the uncertainty of species determinations, and it is our intent to present an illustrated dichotomous key to the decapod crustaceans found in the aquatic habitats of the SRP. In addition, each species is treated separately with reference to specific taxonomic characters, ecology, life history, color patterns, etc. A brief discussion of collecting techniques, preservation and preparation and equipment needed for identification also is presented.

STUDY AREA

The Savannah River Plant (SRP) occupies approximately 200,000 acres in southwest South Carolina and is located near the cities of Augusta, Georgia and Aiken, South Carolina. Recently the SRP has been designated as the first National Environmental Research Park, a protected outdoor laboratory in which experimental and analytical research may be conducted. Bordering 22 miles of the Savannah River, this unique area includes a diversity of protected ecosystems where long range projects concerning man's impact on the environment can be

implemented. The SRP is located on the geological Fall Line and supports natural vegetational communities typical of the upper southeastern coastal plain. These habitats include extensive lowland hardwood forests and cypress-gum swamps, sandhills dominated by turkey oak and longleaf pine, upland oak-hickory forests, and a large old field area. The aquatic habitats include a large swamp bordering the Savannah River, a 2800-acre reservoir, various natural and thermally affected (from several nuclear production reactors located on-site) streams, and numerous Carolina bays, beaver-dam ponds, and abandoned farm ponds.

SPECIES LIST OF DECAPOD CRUSTACEANS ON THE SRP

Two families, five genera, and fifteen species of decapod crustaceans are included in the following list. Those species that have not been collected but the ranges of which abut or encompass the SRP and probably occur there are marked with an asterisk.

FAMILY PALAEMONIDAE Rafinesque, 1815

GENUS Palaemonetes Heller, 1869

Palaemonetes paludosus (Gibbes, 1850)

FAMILY CAMBARIDAE Hobbs, 1974a¹

GENUS Cambarus Erichson, 1846

Cambarus (Depressicambarus) sp. Hobbs (description in prep.)

Cambarus (Depressicambarus) latimanus (LeConte, 1856)

Cambarus (Lacunicambarus) diogenes diogenes Girard, 1852*

GENUS Fallicambarus Hobbs, 1969a

Fallicambarus sp.

GENUS Faxonella Creaser, 1933

¹For synonymies and additional references pertaining to the crayfishes see Hobbs, 1974b.

Faxonella clypeata (Hay, 1899)

GENUS Procambarus Ortmann, 1905

Procambarus (Hagenides) pygmaeus Hobbs, 1942*

Procambarus (Hagenides) truculentus Hobbs, 1954*

Procambarus (Leconticambarus) barbatus (Faxon, 1890*)

Procambarus (Ortmannicus) acutus acutus (Girard, 1852)

Procambarus (Ortmannicus) hirsutus Hobbs, 1958a

Procambarus (Ortmannicus) pubescens (Faxon, 1884)

Procambarus (Pennides) echinatus Hobbs, 1956*

Procambarus (Pennides) raneyi Hobbs, 1953

Procambarus (Scapulicambarus) trogloodytes (LeConte, 1856)

ECOLOGICAL CONSIDERATIONS

The following is a classification of the habitats that will be useful in locating decapod specimens in the SRP, and also listed are the most efficient and productive methods for capture of decapods.

LENTIC HABITATS

Ponds - trap, dipnet (littoral zone), headlight at night

Roadside ditches - dipnet, dig (burrowers), headlight at night

Carolina Bays - dipnet, seine (if vegetation allows), dig (burrowers)

Burrows - dig (burrowers), headlight at night (swamps and seepage areas)

LOTIC HABITATS

Streams - seine, dipnet, trap, headlight at night

Seepage areas - dig (burrowers), headlight at night

Burrows - dig, headlight at night

Swamp - dipnet, seine, headlight at night

COLLECTING TECHNIQUES

Palaemonidae. The grass shrimp found in the streams of the SRP are most easily secured with the aid of a fine-meshed dipnet or a $\frac{1}{4}$ -inch-mesh seine (specimens will easily pass through larger mesh sizes). The use of wire traps with inverted cones and baited with meat (chicken scraps, liver, fish scraps, etc.) will also produce samples of populations, however this method is not required unless the area to be sampled is heavily choked with vegetation or is typified by deep water. In some of the shallow, sand-bottomed streams, they may be caught at night with the aid of a headlight and dipnet; the light reflected by their eyes appears scarlet in color.

Cambaridae. In places where the water is shallow and not choked with vegetation, a $\frac{1}{4}$ -inch-mesh seine has proven to be the best sampling device for crayfishes. The seine may be anchored downstream no more than two meters from the area to be sampled, and debris and vegetation may be vigorously agitated. Crayfishes will "back-stroke" and be carried by the current into the seine. Pools and shallow ponds may be sampled effectively by dragging the seine across them, always taking care to keep the anchored portion of the seine in contact with the substrate. As mentioned for shrimp, in vegetation-choked or deep bodies of water, wire traps may be utilized, with best results occurring after a residence time of a night or two. A sturdy dipnet (i.e. D-ring) is extremely useful in sampling small mud-bottomed pools, roadside-ditch pools, and areas choked with vegetation. Since crayfishes are generally nocturnal, activity increases at night and those individuals which remain in burrows in the stream bank during the day move into open water at night. A headlight and small hand net are most useful for night collecting.

Under severe conditions of drought, almost without exception, crayfishes burrow into the moist substrate until appropriate water levels return. However,

numerous species invade the hypogean habitat regularly and some are restricted to burrows through all or most of their life (primary burrowers). In the SRP three species occur as primary burrowers: Cambarus (L.) d. Diogenes, C. (D) sp., and Procambarus (H.) truculentus. Two species, Fallicambarus sp. and Procambarus (L.) barbatus are generally found in burrows but wander into open water during rainy periods (secondary burrowers).* The remaining species are tertiary burrowers; they burrow only during periods of drought or occasionally, but not necessarily, during the breeding season.

The usual seine and dipnet techniques of collection are of little aid in capturing the burrowers and several additional methods have been found to be moderately successful. Since the size of the burrow, and more so, the size of the chimney pellets, gives some indication of the size of the crayfish that made the excavation, one may assume that the smaller burrows contain juveniles, and thus concentrate on larger burrows (if all openings are small, these may be the temporary homes of Faxonella clypeata and/or Fallicambarus sp., particularly if the sample area is a ditch). After selecting a promising burrow, the chimney, if present, should be carefully removed and the mouth of the burrow opened and enlarged to allow the hand to be inserted to the level of the water. The water should be agitated vigorously and left undisturbed for several minutes, after which individuals of most species come to the surface in a short time. The antennae may be seen waving at the surface of the water and an open hand should be thrust swiftly into the hole, pinning the crayfish to the side of the burrow. With careful manipulation, the individual can be seized with the fingers. If the crayfish escapes by retreating into the burrow, usually it again returns to the surface within a few minutes.

Many crayfishes that construct complex ramifying burrows are apparently more reluctant to investigate a disturbance at the mouth of their excavation.

*Cambarus (D.) latimanus is also a secondary burrower but specimens on the SRP appear to spend a great deal more time in the streams rather than in burrows.

Therefore, a dissection of the entire structure with the hand and a small shovel or trowel may be necessary. In such burrows, the inhabitant usually seeks the deepest tunnel but infrequently retreats to one of the side tunnels. A particularly bad problem exists in dissecting the burrows on the SRP since the substrate of many areas consists of sandy soil. When excavation of a burrow is initiated, very quickly one recognizes the problems of continual collapse of the sides of the galleries; the walls of the tunnels collapse and form a thick soup. In a sandy substrate, it is suggested that a hole be dug parallel to the burrow so that the sand particles do not fill the crayfish excavation. Then the burrow may be dissected, allowing the sand to fall away from the tunnels. It should be pointed out that the use of gloves is of no help. If used, the crayfish is often crushed before one realizes that it is in one's grasp.

Less effort is expended if collections are made at night. The burrowing crayfishes come to the mouths of their burrows and often wander over the surface of the ground. This is particularly true following a rain or when the humidity is high. With the aid of a headlight, occasionally they can be collected in large numbers.

PRESERVATION OF DECAPOD CRUSTACEANS

Individual crayfishes and shrimps should be killed in 5-6% neutral formalin and should remain in the solution for up to a week, depending upon the size. The specimens should be washed in running tap water for several hours and then be transferred to 70% ethanol (Ethyl alcohol). In this solution coloration cannot be preserved but if kept in darkness, the colors fade more slowly. White and Peters (1969) have devised a technique that adequately preserves colors but it is recommended that only a few selected specimens be so treated, as large

collections would require entirely too much time to be preserved in this manner. Whatever preservative is utilized, the solution should be changed periodically (every 3-5 years) to insure long-time safe keeping of specimens.

PREPARATION OF SPECIMENS FOR IDENTIFICATION

Palaemonidae:

Reliable identification of freshwater shrimps can be made only if appendages are dissected and mounted on a microscope slide. However, since only a single species of Palaemonidae is known from SRP, identification is straightforward. It is still advised that the second pleopod of adult males should be extirpated and mounted on a slide (water or glycerin) for examination. Such males are recognized by a well-developed appendix masculina on the second pleopod (Figs. 2b, c, 3). The distal portion of the appendix masculina should be viewed and the apical and subapical setae counted, taking note of the position of the setae on the appendix and their relative position on the endopod (Figs. 2b, c).

For further clarification of species, all appendages of shrimp should be cleared. The clearing process involves "cooking" the entire shrimp in a lactic acid-chlorazol Black E stain solution (3-5 drops of 1% alcoholic (95%) stain solution per 20 ml of lactic acid - can substitute a 1% solution of fast green) at 150°C for 15 minutes (longer for larger specimens). The soft parts should then be absent and a translucent purple (or green) organism can then be washed and transferred to glycerine. A semi-permanent slide can be made of separate appendages by mounting them in glycerine and "ringing" the cover slip with a suitable sealing compound.

Cambaridae:

For many of the crayfishes, a hand lens is adequate for identifying the larger specimens; however, many smaller specimens cannot be observed adequately without the aid of forceps, needles and a stereoscopic microscope.

Although the dichotomous key presented below is applicable to both adult male and most female crayfishes (and shrimp), often first form (breeding) males are required for positive identification of a species. First form males may be distinguished from juvenile and second form (non-breeding adults - apparently incapable of transferring sperm to the female) by the presence of one or more corneous yellow to brown terminal elements on the distal ends of the first pleopods (Fig. 4a). First pleopods of juvenile and second form males have much less well defined terminal elements, of which are all non-corneous. The two forms referred to are two distinctly different and usually alternating (at each molt) morphological forms definitely associated with the reproductive cycle. Secondary sexual characters of Form I males include strongly developed hooks on the ischiopodites of various pereopods and often enlarged outgrowths (bosses) from the bases of the coxopodites (proximal segments) of the fourth and/or fifth pereopods (Figs. 5a, b).

Most females demonstrate no dimorphism with reference to molting-reproductive cycles and the annulus ventralis (located between the 5th pair of pereopods) is, like the first pleopods of males, often required for positive species identification.

Of the several characters used in the identification of crayfishes at the Savannah River Plant, the first pleopod of the male and the annulus ventralis of the female are the most reliable of all taxonomic characters, for they demonstrate minimal variation within the species and are apparently little affected by adaptation to the environment (Hobbs, 1942:25).

Some members of the genus Procambarus possess subterminal setae on the distal end of the first pleopod (i.e. P. (P.) raneyi) which partially or completely obscure the terminal elements. The setae must be removed carefully in order that these elements can be viewed clearly. The crayfishes' left

pleopod should be removed and placed in a dish of 70% ethanol under a stereoscopic microscope. The pleopod should be held at its base with forceps and setae removed with a fine needle. Care should be taken so as not to injure or break one of the terminal elements. The pleopod should then be positioned with the flattened mesial surface against the bottom of the dish and compared with the illustrations included in the text. Identification of crayfishes of other genera may be facilitated also by removal of the left pleopod and positioned as mentioned.

The major characters utilized in identification are illustrated and referred to throughout the text. Reference was made previously of the importance of the first pleopod and for descriptive purposes, this appendage is considered to hang pendant from the abdomen. Toward the attached ("hinged") end is considered proximal; toward the opposite ("free") end, distal; the side toward the anterior cephalic; toward the telson, caudal; the side facing the "middle" of the body and corresponding pleopod of the pair, mesial; and that facing the side of the body, lateral. For further clarification, when the appendage is held in normal or resting position against the sternum of the cephalothoracic region, the side in contact with the thorax is the cephalic surface and the side viewed in ventral aspect is the caudal surface.

ADAPTATIONS TO HABITAT

We have discussed previously some of the major features that are utilized for recognition of taxa. These characters are clearly phylogenetic; however, other characters may usefully be employed for species identification that are adaptive in nature. Strictly lotic crayfish species tend to be spinate with various spines located on the rostrum, postorbital ridges, and along the cervical groove (e.g. P. (P.) raneyi - see Figs. 6a, 18a). Spines of burrowing crayfishes

are reduced or absent (e.g. C. (D.) sp. - see Fig. 8a). The length - breadth ratio of the areola is indicative of habitat type; that is, most crayfishes that have a broad and short areola (see Fig. 16a) and thus a smaller gill chamber (presumably an adaptation to high oxygen levels) are restricted to lotic habitats. Those crayfishes which are commonly found in lentic situations and, in particular, the primary burrowers, possess the largest gill chamber, as is noted by the long, narrow or partially obliterated areola (e.g. C. (L.) d. diogenes). Primary burrowers demonstrate other conspicuous structural adaptations such as a reduced abdomen, and broad, short, depressed chelae (Fig. 9b).

KEY TO THE GENERA AND SPECIES OF DECAPOD CRUSTACEANS
OF THE SAVANNAH RIVER PLANT

- 1 Rostrum and abdomen laterally compressed; rostrum extending well beyond antennal scale and armed with dorsal and ventral teeth (Fig. 2a, e); first two pairs of pereopods chelate, second pair of chelae larger than first (Fig. 2a).....(Palaemonidae)
Palaemonetes paludosus (Gibbes)
- 1' Rostrum and abdomen dorsoventrally compressed; rostrum short and lacking dorsal and ventral teeth (Fig. 4b); first three pairs of pereopods chelate, first pair of chelae larger than others (Figs. 4a, b).....(Cambaridae).....2
- 2(1') Areola obliterated along part of its length (Fig. 9a).....3
- 2' Areola open along its entire length (Fig. 4b).....5
- 3(2) Male with hooks on ischia of third and fourth pereopods (Fig. 5b); first pleopod with shoulder on cephalic surface (Fig. 19c); terminal processes directly distally (Fig. 19c); annulus ventralis of female comparatively flat and freely movable (Fig. 19g);.....
.....Procambarus (Scapulicambarus) troglydytes (LeConte)

- 3' Male with hooks on ischia of third pereipods only; first pleopod never with shoulder on cephalic surface (Fig. 5a); terminal processes directed at right angles to shaft of appendage (Fig. 7c); annulus ventralis of female distinctly sculptured and slightly, if at all, movable (Fig. 7f).....4
- 4(3') Color deep reddish purple; adult with opposable margin of dactyl of chela not concave proximally (Fig. 8b).....
.....Cambarus (Depressicambarus) sp.
- 4' Color olive to tan with scarlet tipped claws; adults with opposable margin of dactyl of chela concave proximally (Fig. 9b)-----
.....Cambarus (Lacunicambarus) diogenes diogenes Girard
- 5(2') Two or more cervical spines present (Fig. 6a).....6
- 5' Single cervical spine present or absent (Fig. 6b).....7
- 6(5) Usually with more than two cervical spines (Fig. 6a); first pleopod of first form male with cephalic process (Fig. 17f).....
.....Procambarus (Pennides) echinatus (Hobbs)
- 6' Never with more than two cervical spines (Fig. 6b); first pleopod of first form male without cephalic process (Fig. 18f).....
.....Procambarus (Pennides) raneyi Hobbs
- 7(5') Rostrum with marginal spines or tubercles (Fig. 15a).....8
- 7' Rostrum without marginal spines or tubercles (Fig. 10a).....10
- 8(7) Areola with no more than three punctations across narrowest part (Fig. 14a); first pleopod of first form male with subterminal setae located on cephalolaterally situated knob (Fig. 14c); tongue of annulus ventralis of female disappearing beneath highly elevated prominence (Fig. 14g).....
.....Procambarus (Ortmannicus) acutus acutus (Girard)

- 8' Areola with four or more punctations across narrowest part (Fig. 15a); first pleopod of first form male with subterminal setae located at cephalolateral base of terminal elements (Fig. 15c); tongue of annulus ventralis of female not projecting under elevated prominence (Fig. 15g).....9
- 9(8') First pleopod of first form male lacking caudal process (Fig. 15f); caudal knob rounded, never in the form of a ridge.....
.....Procambararus (Ortmannicus) hirsutus Hobbs
- 9' First pleopod of first form male with vestigial caudal process at base of central projection (Fig. 16f); caudal knob, when viewed laterally in form of ridge (Fig. 16e).....
.....Procambarus (Ortmannicus) pubescens (Faxon)
- 10(7') Areola narrow, with no more than one punctation in narrowest part (Fig. 12a).....11
- 10' Areola moderately broad to broad, with more than one punctation across narrowest part (Fig. 13a).....12
- 11(10) First pleopod of male with terminal portion of appendage conspicuously flared and terminal elements directed caudally (Fig. 12c); annulus ventralis of female subovate with greatest diameter in longitudinal axis and bearing broad median depression (Fig. 12g)
.....Procambarus (Hagenides) truculentus Hobbs
- 11' First pleopod of male with terminal portion of appendage not flared and terminal elements extending distally (Fig. 11c); annulus ventralis subcircular with longitudinal median trough (Fig. 11g)
.....Procambarus (Hagenides) pygmaeus Hobbs

- 12(10') First pleopod of male with setae on cephalodistal margin of appendage and terminating in three acute elements (Fig. 13c); chela of male with mesial surface of palm bearded (Fig. 13b); annulus ventralis of female flared and multituberculate cephalically (Fig. 13g)....
.....Procambarus (Leonticambarus) barbatus (Faxon)
- 12' First pleopod of male never with setae on cephalodistal margin of appendage and terminating in two elements (Fig. 10c); chela of male never with mesial surface of palm bearded; annulus ventralis of female neither flared nor bearing tubercles cephalically.....13
- 13(12') Areola with no more than three punctation across narrowest part (Fig. 7a); male with terminal elements of first pleopod bent at right angles to shaft of appendage (Fig. 7c); annulus ventralis of female with cephalolateral portion plane or depressed (Fig. 7f)
.....Cambarus (Depressicambarus) latimanus (LeConte)
- 13' Areola with four or more punctations across narrowest part (Fig. 10a); male with terminal elements of first pleopod consisting of one long and one vestigial element (Fig. 10c); annulus ventralis of female with cephalolateral portions elevated (ventrally) in rounded lobes (Fig. 10f).....Faxonella cylpeata (Hay)

DESCRIPTION OF DECAPODS

The following is a summary of information that aids not only in species determinations but also presents information concerning type-localities, geographic distribution of the species, their ecology, life history, and color patterns.

FAMILY PALAEMONIDAE RAFINESQUE, 1815:98

GENUS PALAEEMONETES Heller, 1869

DIAGNOSIS: Rostrum well developed and provided with dorsal and ventral teeth; carapace smooth with antennal and branchiostegal spines well developed and branchiostegal groove present. Abdomen smooth, pleura of first four segments rounded at tip; telson bearing two pairs of dorsal and two pairs of posterior spines. Antenna with well developed scaphocerite, outer margin of which terminating in distinct tooth; spine located on outside of antennal peduncle near base of scaphocerite. First pereopods slender, and chelate; second pereopods chelate, slender but longer than first pair; last three pairs of pereopods slender, not chelate. First pleopods with endopod lacking appendix interna, present on all other pleopods; second pleopod of male with appendix masculina extending beyond distal extremity of appendix interna.

TYPE SPECIES: Palaemonon varians Leach, 1814 from the Eastern Atlantic.

Palamonetes paludosus (Gibbes)

(Figures 2a-e, 3, 20)

DIAGNOSIS: Translucent; rostrum slender, extending to or somewhat beyond end of scaphocerite; upper margin concave with 6 to 8 teeth and tip-directed upwards; lower margin bearing 3 or 4 teeth. Branchiostegal spine situated

just beneath branchiostegal groove with more than half its length extending beyond anterior margin of carapace. Sixth abdominal segment less than twice as long as fifth and slightly shorter than telson. Anterior pair of dorsal spines on telson located immediately posterior to midlength; posterior pair situated approximately midway between anterior pair and posterior margin of telson; posterior margin terminating in generally distinct median point and provided with two pairs of spines. Second pair of pereopods distinctly longer than first; entire chela extending beyond scaphocerite. Male with four or more apical setae on appendix masculina; ovigerous female with relatively few (15-60-Dobkin, 1963:43) large eggs. See Fleming (1969) and Villalobos and Hobbs (1974) for a detailed account of taxonomic characters used in separating this species from others of the genus; see also Strenth (in press) for further systematic information concerning this species.

TYPE-LOCALITY: St. Andrews, Charleston County, South Carolina.

DISTRIBUTION: Common in fresh waters of the lower Piedmont and Coastal Plain provinces east of the Allegheny Mountains, from New Jersey to Florida. This species has been introduced into several localities west of the Alleghenies: Louisiana (environs of New Orleans and Morgan City), Texas (San Marcos) and Oklahoma (Holthuis, 1952:211). Hobbs and Hart (1959:150) reported it from Mississippi and Strenth (1974:8) noted that it had been introduced into southern California and northern Mexico. The shrimp serves as fish food, and Worth (1908) mentioned shipments of living specimens of P. paludosus from Halifax, North Carolina to Washington, D. C. and to Neosho, Missouri.

ECOLOGY: Meehean (1936:436) discussed the habitat of his P. paludosus (= P. kadiakensis, Rathbun, 1902) from the environs of Natchitoches, Louisiana, and his summary is applicable to the habitat of P. paludosus: "These shrimp

are fairly abundant in the quiet waters in this section of Louisiana. They are found among the emergent vegetation, on the branches of trees which have fallen into the water, or clinging under the duckweed which entirely covers the surface of some ponds during warm weather. In high water, the shrimp are abundant in the inundated terrestrial vegetation along the shore, and especially among the high grass and bushes. They may also be taken among the floating vegetation in lakes." Dobkin (1963:42) collected individuals "from a fresh water canal 18 miles west of Miami, Florida, by means of a push net swept through the floating vegetation and shallow water grasses." On the SRP, this species is widely distributed (Fig. 20) in all the major streams and is most abundant in lotic areas where vegetation is relatively dense.

LIFE HISTORY: Meehean (1936:438) reported "the life history of... (P. kadiakensis) is confined to a single year. The young appear in the samples as a smaller age group in about midsummer. Their growth can be traced until they reach the maximum size at approximately the time the first eggs are laid in the spring. These larger individuals die off leaving those which mature later and at a smaller size, until the whole generation reproduces and dies off to be replaced by the new one." Observations of individuals on the SRP indicate that this species follows closely the development indicated by Meehean; however, detailed study will be required (both laboratory and field) before an adequate understanding of this species on the SRP is attained. Dobkin (1963) gives a very detailed account of the postembryonic development of P. paludosus.

COLOR: Living forms are nearly translucent, with a slight tan or pink tint.

METHOD OF CAPTURE: This species is most easily attained by using a seine or dipnet, however a trap can also be utilized with some success.

FAMILY CAMBARIDAE HOBBS, 1974a:10

GENUS CAMBARUS Erichson, 1846

DIAGNOSIS: "Antenna never with conspicuous fringe on mesial border. Third maxilliped with teeth on mesial margin of ischium. Mesial margin of palm of chela with row of fewer than 12 tubercles except in albinitic species in which more present; lateral margin of fixed finger never bearing spiniform tubercles; opposable margin of dactyl almost never with prominent excision. Areola broad to obliterated or linear at midlength. Ischium of third pereopod with hook. Coxa of fourth pereopod of male with caudomesial boss. First pleopods of first form male symmetrical, contiguous basally, with distal portion of shaft never included caudally, and terminating in 2 or 3 distinct parts (medial process, central projection, and occasionally caudal knob; cephalic process always absent), 2 prominent ones bent caudally or caudolaterally between 45 and 100 degrees or with central projection forming arc approaching 180 degrees; central projection blade-like or tapering from base, with or without subapical notch; mesial process subconical, bulbiform, or conspicuously inflated at base, seldom corneous, never appearing twisted or subspatulate distally, and lacking eminence on cephalic (morphological) border; caudal element seldom present, but occasionally represented by knoblike prominence at caudolateral base of central projection. Female with annulus ventralis immovable or with caudal half slightly movable; first pleopod present, rudimentary, or absent" (Hobbs, 1974a:11-12).

RANGE: North America: Coastal region of New Brunswick, Canada, southward to panhandle of Florida; westward to Texas and northward to Minnesota and southern Ontario.

TYPE-SPECIES: Astacus Bartonii Fabricius, 1798 by subsequent designation.

Cambarus (Depressicambarus) latimanus (LeConte)

(Figures 7a-f, 21)

DIAGNOSIS: Rostrum without marginal spines or tubercles, concave with elevated margins and contracted distally to form short, triangular acumen. Cervical spine present or represented by tubercle. Areola moderately broad with 3 or 4 punctations in narrowest part; length constituting 28 to 37% of entire carapace length; chela compressed with two rows of five or six tubercles along mesial margin of palm. Male with hook on ischiopodite of third pereopod only; first pleopod of first form male reaching coxopodite of third pereopod when abdomen flexed, and terminating in two elements; mesial process bulbous, tapering to sub-acute prominence or with several excrescences and non-corneous; central projection scythe-like and corneous and directed proximally; cephalic and caudal processes absent. Annulus ventralis subovate with greatest length in transverse axis and possessing submedian longitudinal depression; anterior part of annulus only slightly obscured in ventral aspect by sternum.

TYPE-LOCALITY: Athens, Clarke County, Georgia

DISTRIBUTION: Common in small streams and borrows of the Piedmont and Coastal Plain provinces from North Carolina to Alabama, chiefly in the Piedmont but extending into western Florida along the Apalachicola River. On the SRP this species is the most widely distributed and certainly the most ubiquitous. It is present in all the major streams on the Plant where it is found from the upper to the lower reaches (Fig. 21).

ECOLOGY: This species on the SRP appears to be most prevalent in the small sand-or clay-bottomed streams; however, it occurs also in well drained swamp areas and in the beds of intermittent streams. It is found commonly in debris piles littering the stream beds and in burrows excavated in the banks

of the streams. The mouths of burrows are not always marked by a pile of mud pellets and the complexity of the burrows is extremely variable, ranging from a straight vertical tunnel to a complex, highly branching burrow. In addition to openings above the level of the water, often openings were observed beneath the surface. Most of the burrows are excavated to a depth of one-half meter; rarely so deep as a meter.

LIFE HISTORY: Breeding males (Form I) are evidently present in the populations except during July and August. Ovigerous females and those carrying young have been observed only during March and April (Hobbs, in prep.).

COLOR: A dimorphic color pattern exists in this species on the SRP. The ground color in both patterns varies from light brown (tan) to a pale greenish gray. Like all crayfishes of the area, the colors and patterns are commonly masked by the dark "black" covering of tannins on the exoskeleton. One color pattern is characterized by a general tan to gray appearance and with orange-tipped chelae; the joints of the pereopods and tubercles on the palm of the chelae are cream colored; few other distinguishing patterns are readily visible, although a darker color accompanied by moderate spots is noted in the area of the "muscle scars" on the dorsal side of the carapace. The second color pattern is noted by a longitudinal stripe of light tan or cream color that is situated on the mid-dorsal line and extends from the basal third of the rostrum posteriorly to the ultimate or penultimate abdominal segment. The stripe, which is bounded laterally (from anterior to posterior) by the postorbital ridges and the muscle scars, expands laterally beyond the margins of the areola, and constricts to cover the mid-dorsal surface of the abdomen (where it is bounded laterally along its entire length by paired darker brown stripes). The tubercles of the palm of the chelae and numerous pereopod joints are cream colored and the tips of the chelae are often orange or red.

METHOD OF CAPTURE: This species may be captured using various methods, depending on the sample area: seine, dipnet, trap, digging from burrow.

Cambarus (Depressicambarus) sp. Hobbs, in prep.

(Figure 8a-f, 23)

DIAGNOSIS: Rostrum without marginal spines or tubercles; short and concave, with convergent, slightly thickened margins, contracted abruptly at base of short triangular acumen; eyes small. Cervical spine absent (two small tubercles representing cervical spines), but lateral surface of carapace with numerous punctations. Areola narrow with never more than one punctation in narrowest part; length constituting 40-44% of entire carapace length. Chela compressed with two well-defined rows of 7 or 8 tubercles along mesial surface of palm. Male with hooks on ischiopodite of third pereopod only; first pleopod of first form male reaching coxopodite of third pereopod and terminating in two elements: mesial process inflated but with slender apical portion; central projection strongly arched, its tip directed proximally and with adjacent subapical notch; caudal knob well defined; cephalic process absent. Annulus ventralis subovate with greatest length in transverse axis and with submedian depression; strongly asymmetrical; cephalic area with submedian trough, its caudal portion curved dextrally and obscured beneath high dextral wall; anterior part of annulus not obscured in ventral aspect of sternum.

TYPE-LOCALITY: Not yet designated.

DISTRIBUTION: Burrows (primary burrower) from Georgia: Burke and Effingham counties; South Carolina: Allendale and Barnwell counties.

ECOLOGY: On the SRP this species has been captured from a single locality (Fig. 23), a low-lying boggy area where the water table was only a few inches below the surface. The burrows are capped by poorly formed chimneys, consisting

simply of a pile of black muck and the tunnels are complex and interwoven among numerous roots. The mouths of the burrows may be covered beneath logs. The tunnels are relatively deep, one was dissected to a depth of approximately one meter. Hobbs (in prep.) describes localities similar to this but also has found this new species on higher ground (a seepage area on a bluff) along the Savannah River.

LIFE HISTORY: Hobbs (in prep.) reports Form I males during August and September, and a female with young was found in August.

COLOR: Ground color reddish brown to dark orange, no distinct markings on carapace; distal portion of finger pinkish orange; tubercles on entire chela pinkish cream to orange (see Hobbs, in prep. for more detailed account).

METHOD OF CAPTURE: This species is collected by excavating burrows or with the aid of a headlight at night.

Cambarus (Lacunicambarus) diogenes diogenes Girard

(Figures 9a-f)

DIAGNOSIS: Rostrum short, narrow and concave with elevated margins contracted to form short triangular acumen, and lacking marginal spines or tubercles. Cervical spine or tubercle absent (Fig. 6b). Areola very narrow, with room for no punctations in narrowest part or, more commonly, partially obliterated; length constituting 39-42% or entire length of carapace. Chelae large, broad and tuberculate; 2 or 3 rows of tubercles along mesial margin of palm, mesial most row consisting of 5 to 7. Male with hook on ischiopodite of third pereopod only first pleopod of first form male reaching coxopodite of third pereopod when abdomen flexed and terminating in two elements; mesial process slender and tapering to subacute prominence; central projection non-tapering and distally rounded, both projections directed caudally at angles

only slightly greater than 90 degrees; cephalic and caudal processes absent. Annulus ventralis somewhat diamond-shaped with greatest length in transverse axis and possessing an S-shaped median depression; nearly symmetrical.

TYPE-LOCALITY: Vicinity of Washington, D. C.

DISTRIBUTION: Burrows (primary burrower) and occasionally standing water of streams east of the Rocky Mountains and south of the Great Lakes (except Florida peninsular), the Allegheny Mountains and lower Mississippi River drainage in Louisiana (Hobbs, 1969b:K15). Although this species has not been collected from the SRP proper, it has been collected in the immediate environs and undoubtedly occurs there as well.

ECOLOGY: This species is commonly found burrowing along the banks of both large and small streams, and occasionally in seepage areas in the headwaters of small streams; individuals are found commonly burrowing roadside ditches. The mouths of the burrows are commonly covered by neatly constructed chimneys that often extend upwards as high as 30 cm. Usually the burrows have two or more openings, one below the water table and one or more above it, and seldom have more than two or three passageways. However, in seepage areas the burrows may branch in several directions and have two or more chimneys. Generally the burrows may extend into the soil to a depth of one meter; however, Hobbs and Hart (1959:189) state that the "Burrows along the banks of the Apalachicola River (Florida) with openings 10 to 15 feet above the water level are almost certainly excavated by this species" Harris (1903:85-96) and Ortmann (1906:416-424, 480-486) presented very comprehensive accounts of their observations on habits and habitats of this species, and although other more recent reports exist, little additional new information has been added to the studies mentioned.

LIFE HISTORY: Based on collections made in Florida, Georgia, North and South Carolina, breeding males are present in the populations during March to May, August, October to December; ovigerous females are found from late Spring to early Fall.

COLOR: The variable ground color ranges from a creamy yellow to a bluish green, with the majority of populations being tannish brown. Most individuals are marked with red or crimson along the margins of the rostrum, postorbital ridges, tubercles and tips of the chela.

METHOD OF CAPTURE: This species is collected primarily by digging, occasionally by using a seine.

GENUS FALLICAMBARUS Hobbs, 1969a

DIAGNOSIS: "Antenna never with conspicuous fringe on mesial border. Third maxilliped with teeth on mesial margin of ischium. Mesial margin of palm of depressed chela with row of fewer than 12 tubercles; lateral margin of fixed finger never with row of spines or tubercles; opposable margin of dactyl usually with prominent excision. Areola linear or obliterated at midlength. Ischium of third pereopod, and sometimes that of fourth, of male with hook. Coxa of fourth pereopod of male with prominent caudomesial boss. First pleopods of first form male symmetrical, contiguous basally, and terminating in 2 or 3 elements (mesial process, central projection, and, occasionally, cephalic process) bent caudally or caudomesially at angle greater than 95 degrees to main shaft or forming broad arc of almost 180 degrees; central projection bladelike or tapering, and usually lacking subapical notch; mesial process never bulbiform but appearing twisted and often with eminence on cephalic (morphological) border; cephalic process at least partially corneous, situated at mesial base of mesial process, and directed caudad or caudadistad. Female with annulus ventralis only slightly movable; first pleopod present" (Hobbs 1974a:12).

RANGE: North America: Texas to Ontario; southward to the panhandle of Florida.

TYPE-SPECIES: Cambarus strawni Reimer, 1966, by original designation.

Fallicambarus sp.

DIAGNOSIS: Two juvenile specimens collected from a small stream in a Cypress swamp in the southwest portion of the SRP (Fig. 21) have been tentatively assigned to the genus Fallicambarus. In as much as F. uhleri (Faxon, 1884:116) is the only member of the genus reported to occur in South Carolina (Hobbs, 1974b:24) they have tentatively been assigned to this species and definitive determination must await the capture of adult specimens.

GENUS FAXONELLA Creaser, 1933

DIAGNOSIS: "Antenna never with conspicuous fringe on mesial border. Third maxilliped with teeth on mesial margin of ischium. Mesial margin of palm of chela with or without much reduced tubercles; lateral margin of fixed finger never with row of spines or tubercles; opposable margin of dactyl never with prominent excision. Areola moderately broad at midlength. Ischium of third pereiopod of male with hook. Coxa of fourth pereiopod of male without caudomesial boss. First pleopods of first form male symmetrical, contiguous basally, and terminating in one long (central projection) and one short (mesial process) element, latter no more than half length of former; central projection of paired appendages always overlapping. Female with annulus ventralis freely movable; first pleopod rudimentary to virtually absent" (Hobbs, 1974a:13).

RANGE: North America: Oklahoma and Texas east to Gadsden County, Florida, and Richland County, South Carolina.

TYPE-SPECIES: Cambarus clypeatus Hay, 1899, by monotypy.

Faxonella clypeata (Hay)

(Figures 10a-f, 22)

DIAGNOSIS: Rostrum broad and spatulate and without marginal spines, widest immediately distal to base and lacking acumen. Cervical spines absent. Areola wide with about five punctations in narrowest part; length constituting about 20% of total length of carapace. Chela elongate (palm longer than movable finger) and not conspicuously depressed; palm bearing large number of small tubercles. Male with hooks on ischiopodite of third pereopod only; first pleopod of first form male reaching coxopodite of first pereopod when abdomen flexed and terminating in two rami: mesial process acute, non-corneous and very short; central projection slender, corneous, very long, and overlapping that of other first pleopod; cephalic and caudal processes absent. Annulus ventralis subovate with greatest length in transverse axis, freely movable, and cephalic region elevated in somewhat paired lobes overlying caudal portion of sternum.

TYPE-LOCALITY: Bay St. Louis, Hancock County, Mississippi.

DISTRIBUTION: LeFlore County, Oklahoma and Marion County, Texas to Gadsden County, Florida and Aiken, Barnwell, and Richland counties, South Carolina.

ECOLOGY: This species is reported from sluggish streams, lentic situations and burrows (tertiary burrower). All specimens collected in the SRP came from roadside ditches where they were caught with a dipnet or were dug from shallow burrows. They appear to be restricted to the low lying areas of the west and southwest portion of the SRP (Fig. 22). Hobbs (1942:155-156) reported them from at least four types of situations. He collected them from "... a roadside ditch in a small area of flatwoods, where they were common among the vegetation covering the bottom of the ditch and in burrows near the water. The burrows, marked by small, neatly constructed chimneys, were simple and ranged in depth

from six inches to a foot." He reported that "two females were taken from the submerged vegetation of a clear, sand bottomed, moderately flowing stream." Also he found specimens "in a small, sluggish, silty stream that flows through a section of pine and cypress lowland."..."In a small cypress pond"...this species was "seen scurrying about in the water as I waded into it. The bottom of the pond had a thick mat of leaves from which many specimens were taken with a dipnet."

LIFE HISTORY: "First form males have been collected...from February through April and from June through September. No females with eggs have been found" (Hobbs and Hart, 1959:185).

COLOR: Dimorphic color pattern existing in this species on the SRP. Ground color for both patterns varying from light to reddish brown. One color pattern characterized by mottled appearance with patches of dark red, tan and dark brown scattered over carapace; abdominal segments with lateral dark brown marks forming dark lateral streaks; first pereopod pale pink or cream-colored with red splotches randomly dispersed. Second color pattern characterized by median longitudinal stripe of light tan or cream situated on mid-dorsal line extending from apex of rostrum posteriorly to last abdominal segment. Stripe narrow anteriorly, expanding over areola, then constructs to form narrow streak on mid-dorsal surface of abdomen. On abdomen flanked on either side by gray-brown stripe, which in turn flanked ventrolaterally by cream-colored streak. Chelae tan and mottled with darker tan pigment.

METHOD OF CAPTURE: This species is captured by using a seine, dipnet, by digging, or with the aid of a headlight at night.

GENUS PROCAMBARUS Ortmann, 1905

DIAGNOSIS: "Antenna never with conspicuous fringe on mesial border.

Third maxilliped with teeth on mesial margin of ischium. Mesial margin of palm of chela with none to many tubercles; lateral margin of fixed finger never bearing spiniform tubercles; opposable margin of dactyl occasionally with prominent excision. Areola broad to obliterated at midlength. Ischia of third, fourth, or third and fourth pereopods of male with or without caudomesial boss. First pleopods of first form male symmetrical or asymmetrical (latter in all species on SRP), sometimes deeply withdrawn between bases of pereopods and at least partially concealed by setae extending from ventrolateral margin of sternum; subcontiguous, contiguous, or partially overlapping basally, and terminating in 2 or more, usually 3 or 4 elements; presence of subterminal setae in many members of genus unique; terminal elements highly variable in form and disposition; if only 2 elements present (mesial process and central projection), shoulder present on distal third of cephalic surface of appendage, or central projection forming distally projecting triangular plate, or central projection arising from caudal margin of enlarged terminal region; if more than 2 elements present, central projection seldom bladelike, if so, directed laterodistally or lacking subterminal notch, and elements never bend caudally at angle of so much as 90 degrees. Female with annulus ventralis freely movable, although sometimes partially covered ventrally by caudally projecting prominences from sternal plate immediately cephalic to it; first pleopod usually present" (Hobbs, 1974a:15-16).

RANGE: North America: Guatemala and Cuba to Minnesota and southern New England, except in mountains. Introduced into California, Hawaii, and Japan.

TYPE-SPECIES: Cambarus Digueti Bouvier, 1897, by subsequent designation.

Procambarus (Hagenides) pygmaeus Hobbs

(Figures 11a-g)

DIAGNOSIS: Rostrum without marginal spines; flattened dorsally with scattered punctations; acumen absent; margins converging to tip. Cervical spine prominent. Areola narrow with only one punctation in narrowest part; length constituting about 35% of total length of carapace. Chela distinctly depressed, of moderate length and breadth; inner margin of palm with cristiform row of 8 tubercles. Male with hooks on ischiopodite of third pereopods only. First pleopod of first form male reaching base of second pereopod when abdomen flexed and terminating in three distinct parts: mesial process slender and tapering, and extending caudodistally slightly beyond central projection; cephalic process absent; central projection subtriangular, large, plate-like, and directed distally; caudal element forming sharp corneous ridge along caudolateral base of central projection. Annulus ventralis subovate (nearly circular) with greatest length in longitudinal axis, and bearing conspicuous submedian longitudinal furrow.

TYPE-LOCALITY: A small swamp stream flowing through a cypress bay in the flatwoods region about 16 miles north of Fargo on Georgia State Highway 89, Clinch County, Georgia.

DISTRIBUTION: Coastal Plain of Georgia (from Tifton upland to coast), between Ogeechee and Suwannee basins, and from Florida (Gulf, Liberty, Leon, and Wakulla Counties).

ECOLOGY: Hobbs (1942:87) noted "that in every locality from which this species has been taken is in swampy terrain, and whether in quiet or flowing water Juncus repens is abundant. In most of these localities this brilliantly red and green colored plant forms thickly matted beds over large areas of the

pool or stream bottoms." Hobbs continues by indicating that this species had "been taken from burrows in nearly all of the localities cited. P. pygmaeus apparently is a secondary or tertiary burrower. These burrows are...complex ...having a number of side passages and sometimes several openings over which are moderately constructed chimneys. Most of the burrows I have seen were in soft muck very close to the edge of the water or in recently dried up ditches."

LIFE HISTORY: Breeding males have been taken in the Spring (March and April) and in the Fall (October) and a female with eggs was observed in May (Hobbs, 1942:86).

COLOR: The "bright green color set off by scarlet tubercles, ridges, and terminal margins of joints readily distinguishes this crayfish from any other known" (Hobbs and Hart, 1959:175). They continue (p. 176) by indicating "The ground color varies from olive to forest green, and practically all ridges, tubercles, and rims of joints are scarlet red. Red markings are also present on the epimera of the abdominal segments".

METHOD OF CAPTURE: This species is dug from burrows, or can be collected by the use of a seine or dipnet in lentic and lotic environments, especially in beds of Juncus repens.

Procambarus (Hagenides) truculentus Hobbs

(Figure 12a-g)

DIAGNOSIS: Rostrum excavate above with raised margins converging, and lacking spines; acumen indistinct. Areola very narrow with room for only two punctations in narrowest part; length constituting about 39% of entire length of cephalothorax; lateral surface of carapace lacking spines. Chela depressed and studded with tubercles; mesial margin of palm with single row of cristiform tubercles. Male with hook on ischiopodite of third pereopod only; first pleopod of first form male reaching coxopodite of second pereopod when abdomen flexed and terminating in three caudally directed parts; mesial process and

central projection acute; caudal element consisting of truncate caudal knob situated immediately proximal to central projection; cephalic process lacking. Annulus ventralis ovate with greatest length in longitudinal axis and bearing longitudinal midventral depression.

TYPE-LOCALITY: "Boggy, seepage area 11 miles north of Lyons in Emanuel County, Georgia, on U. S. Highway 1" (Hobbs, 1954:114).

DISTRIBUTION: This species is known from Jenkins, Emanuel, and Bulloch Counties, Georgia but is probably more widely distributed in the Coastal Plain province.

ECOLOGY: This crayfish is a primary burrower. The type-locality described by Hobbs (1954:115) was a seepage area lying "on a gently sloping hill at the foot of which is a small sluggish creek. The area in which the crayfishes were found in approximately 200 feet up the hill from the creek, and probably only in rainy seasons is there any appreciable surface run-off into the stream."

Hobbs (1954:117) further typifies this species' habitat and habits by stating that "Unlike some of the more astute burrowing species, P. truculentus may be attracted to the surface of the water in the burrow thus obviating the necessity for laborious digging. Most of my specimens were collected by opening the mouth of a burrow with a spade and vigorously roiling the water. After this was done other burrows were similarly opened. When a number of them had been so treated, upon quietly approaching the open burrows, the crayfish were often seen at the surface of the water, lying in a horizontal position with one of the branchiostegites exposed, and thus relatively easily caught with the hand.

"In order to determine the extent of some of the burrows they were carefully dissected, and it was found that while there were a number of passages that wound both vertically and horizontally, with several openings to the surface,

there was usually only one passage which dipped much below the normal water table. Such passages were seldom more than two or three feet deep, and they usually had no more than one side branch.

"The soil in the localities from which most of the specimens were taken is black, sandy muck, and supports a dense growth of wire grasses, pitcher plants, and other bog-inhabiting plants. The water table fluctuated from the surface to about two feet below it."

LIFE HISTORY: No first form males have been observed in their natural habitat, however Hobbs (1954:117) raised some in the laboratory and one individual molted to first form in November and another in October. He also reported that burrows were examined in the Spring (May) and a large number of those contained females with young approximately 10 mm in total length.

COLOR: "Ground color of carapace grayish-tan; cephalic portion lighter than thoracic region, the latter dark green with a buff suffusion changing to buff along ventral margins. Cervical groove, margins of rostrum, and postorbital ridges bluish-green. Abdomen grayish-buff with nondescript markings in cream and dark gray; pleura pale mauve on buff with a light greenish-gray line along base; telson and uropods with lateral portions and tips like pleura, otherwise colorless with grayish-green splotches. Ground color of chelae and pereopods buff with greenish-blue and gray markings (particularly at joints and on upper surfaces); tubercles on chelae bluish-green as are the bases of joints of dactyls; row of tubercles on inner margin of palm greenish-blue at base but cream at tips; outer margins of chelae and lower surfaces light orange-buff with pink suffusions; tubercles on opposable margins of fingers cream. Lower portion of body and appendages whitish cream. Hair on ventral surface light gray" (Hobbs, 1954:115).

METHOD OF CAPTURE: This crayfish is captured by digging or by using a headlight at night.

Procambarus (Leconticambarus) barbatus (Faxon)

(Figures 13a-g)

DIAGNOSIS: Rostrum spatulate, lacking acumen and marginal spines or tubercles. Cervical spines absent. Areola moderately broad with three to five punctations in narrowest part; length constituting about 31-35% of entire length of cephalothorax. Chelae somewhat depressed and palm slightly inflated and tuberculate; mesial margin of palm of first form male bearded with dense growth of plumose setae. Male with hooks on ischiopodite of third and fourth pereopods; first pleopod of first form male reaching coxopodite of third pereopod when abdomen flexed and terminating in three parts: mesial process (most conspicuous of elements subspiculiform, corneous, and directed distally and slightly recurved cephalically; cephalic process small, corneous, and arising from mesial surface of appendage; central projection small, corneous, triangular, and arising from central portion of tip; cephalic margin of main shaft near distal end of appendage bearing cluster of setae, forming single row; caudal process lacking. Annulus ventralis subrectangular with flared tuberculate cephalolateral prominences; greatest length in transverse axis and bearing submedian longitudinal furrow.

TYPE-LOCALITY: "Habitat in fossis Georgiae inferioris" (LeConte, 1856: 401); restricted by Hobbs (1974b:50) to "2.5 miles west of Riceboro, Liberty County Georgia, in pine flatwoods."

DISTRIBUTION: On the Coastal Plain, from the Altamaha River in Georgia to the Edisto River in South Carolina.

ECOLOGY: Although not collected in the SRP boundary, this species probably occurs there. It is a secondary burrower and is commonly found in roadside

ditches of flatwoods areas. Generally, the burrows are very simple, consisting of a single straight or forked tunnel which leads nearly straight downward for no more than one meter; although some burrows are curved and terminate in a slight enlargement. The mouth of the burrow is recognized by a low, crudely constructed chimney and occurs in sandy clay soil and black, rich organic "muck."

LIFE HISTORY: First form males have been collected from January through March, May, August, September, and December; ovigerous females carrying 31 to 265 eggs were taken from burrows in April and May (Hobbs, in prep.).

COLOR: Hobbs (in prep.) reports two color patterns for this species: "a striped phase characterized by a dorsomedian longitudinal light (cream tan to pale green) stripe extending from the rostrum to the telson and a speckled phase in which small irregular spots of dark brown or greenish black are scattered over the carapace and dorsum of the abdomen."

METHOD OF CAPTURE: This species is captured by digging or by the aid of a headlight at night.

Procambarus (Ortmannicus) acutus acutus (Girard)

(Figures 14a-g, 23)

DIAGNOSIS: Rostrum long, broad at base, tapered, terminating at base of acumen in acute cephalolaterally directed spines. Cervical spine prominent. Areola moderately narrow with about 3 punctations in narrowest part; length constituting about 20% of total carapace length. Chelae long and slender; row of 8 or 9 tubercles along mesial margin of palm. Male with hook on ischiopodite of third and fourth pereopods; first pleopod of first form male reaching coxopodite of third pereopod when abdomen flexed and terminating in four distinct parts: mesial process long and spiniform, directed laterodistally; caudal process and central projection acute, bladelike, cornerous, compressed

laterally and directed caudodistally; cephalic process also acute and directed caudodistally; terminal tuft of setae borne on laterally situated knob. Annulus ventralis subovate with greatest length in transverse axis and possessing longitudinal median furrow; slightly obscured cephalically in ventral aspect when abdomen flexed.

TYPE-LOCALITY: From a tributary to Mobile River in Kemper County, Mississippi.

DISTRIBUTION: Coastal Plain and Piedmont provinces from Maine to Georgia, from panhandle of Florida to Texas, and from Minnesota to Ohio; intergrades with P. (O.) a. cuevachicae (Hobbs, 1941) in southwestern Texas and northern Mexico.

ECOLOGY: This species is found in sluggish to moderately flowing streams and most lentic habitats. In the SRP this species appears to be confined to the lower reaches of the streams and swamps draining into the Savannah River (Fig. 23). It has been found in all of the tributaries on the SRP except Lower Three Runs and this is probably due to inadequate sampling.

LIFE HISTORY: Based on collections from Alabama, Florida, Georgia, North and South Carolina, breeding males have been collected from every month of the year. Ovigerous females are present in populations from May to August and a collection from Alabama contained a female with young in September.

COLOR: Ground color reddish brown to brown; carapace somewhat mottled with dark brown to black splotches widely spaced; rostrum and mid-dorsal area of carapace, immediately anterior to areola and posterodorsalmost area of carapace, dark brown to black. Abdomen with cephalic 5 somites bearing broad dark brown longitudinal band; cephalic portion of each somite pigmented heaviest. Pleura of 6 somites bounded dorsally by pale, brown, undulating streak, separated from broad dorsomedian band by pink streak and ventrally by tan to brown stripe;

sixth abdominal somite, telson, and uropods colored and mottled as in carapace. Merus and carpus of chelae light brown to pink and with dark brown tubercles; dorsal surface of palm brown to reddish brown and studded with dark tubercles; fingers of chelae brown to tan dorsally, and ventrally; remaining pereopods pink to olive.

METHOD OF CAPTURE: This species most easily collected with the aid of a seine or dipnet.

Procambarus (Ortmannicus) hirsutus Hobbs

(Figures 15a-g, 22)

DIAGNOSIS: Rostrum long, with acute marginal spines; upper surface pubescent and hirsute at base of acumen; slender acumen shorter than half remainder of rostrum. Entire dorsal surface of carapace with setiferous punctations. Postorbital ridges terminating cephalically in sharp spines. Cervical spine prominent. Areola broad and short, with 8 to 10 punctations in narrowest part, and constituting about 26 to 30% of total length of carapace. Chelae elongate, moderately slender and tuberculate (except for fingers); poorly defined rows of tubercles along mesial margin of palm. Male with hook on ischiopodite of third and fourth pereopods; first pleopod of first form male asymmetrically situated, reaching coxopodite of third pereopod when abdomen flexed, with rounded hump on cephalic surface, and terminating in four distinct parts: mesial process subspiculiform, curved caudodistally and somewhat laterally; cephalic process also directed caudodistally, but with distal part curved, and apex directed almost caudally; central projection corneous, beaklike, and directed more caudally than ventrally; caudal element consisting of prominent rounded knob on distal caudolateral portion of appendage--caudal process lacking. Annulus ventralis elliptical with

greatest length in transverse axis and possessing submedian depression; sternum cephalic to annulus without caudally projecting prominences.

TYPE-LOCALITY: Salkehatchie River, 1.9 miles south of Barnwell, Barnwell County, South Carolina, on State Highway 3.

DISTRIBUTION: This species appears to be confined to the drainage systems of the Edisto, Salkehatchie, and Savannah Rivers in South Carolina (Aiken, Allendale, Bamberg, Barnwell, Calhoun, Colleton, Lexington and Orangeburg Counties).

ECOLOGY: Hobbs (1958a:163) states that the Salkehatchie River at the type-locality "varies greatly in width, quite narrow in deep areas and more than 50 feet wide in the shallow reaches. The dark brown water flows over a sand and mud bottom and at the bridge are many rocks. Vallisneria, Saururus cernuus, and Pontederia are abundant. My specimens of P. hirsutus were collected at night on the open mud bottom and among the eelgrass." Apparently this species is restricted to sandy-mud bottomed lotic environments that support a growth of aquatic macrophytes.

LIFE HISTORY: First form males have been collected in January, April, June, July, August, and September and females with eggs have been found in April (Hobbs, 1958a:164).

COLOR: "Body dark brown with bright orange (or scarlet) mottlings over entire carapace and terga of abdomen. A poorly defined dark saddle-like marking present in the form of a transverse bar across the caudal margin of the carapace and a pair of forward-projecting lateral horns on the lateral surfaces of the branchiostegites. This pattern is frequently modified so that the lateral horns are represented by two lateral pairs of dark spots representing the anterior and posterior portions of the horns. Upper surface of chelae brownish orange with black tubercles, while the tubercles on lower surface are light.

Legs dark gray above and below; fingers of chelate appendages greenish blue as are distal podomeres of fourth and fifth pereopods" (Hobbs, 1958a:163).

METHOD OF CAPTURE: This species is most easily obtained by using a seine or dipnet in lotic environments.

It must be pointed out that this species and P. (O.) pubescens are very closely related and are somewhat difficult to distinguish. Using the characters outlined in the diagnoses of each species (particularly with reference to the terminal elements of the first pleopod of males) and the color differences, these two species should not be misidentified on the SRP. Although not consistent in all individual of all populations the following colors and patterns will generally aid in their identification. P. pubescens has a complete saddle with uninterrupted horns laterally; P. hirsutus possesses a saddle that in which the horns are represented by two spots on each side. P. hirsutus is generally more mottled in appearance (particularly on the abdomen) than is P. pubescens; P. pubescens possesses a definite light tan, orange, or cream mid-dorsal stripe on the carapace; generally this is lacking in individuals of P. hirsutus (see Hobbs (1958b) for a discussion of these and other crayfish species).

Procambarus (Ortmannicus) pubescens (Faxon)

(Figures 16a-g, 24)

DIAGNOSIS: Rostrum long with acute marginal spines, upper surface pubescent and hirsute at base of acumen; slender acumen shorter than half remainder of rostrum. Entire dorsal surface of carapace with setiferous punctations. Post-orbital ridges terminating cephalically in sharp spines. Cervical spine prominent. Areola broad and short, with 8 to 10 punctations in narrowest part, and constituting about 25 to 30% of total length of carapace. Chelae elongate, moderately

slender, and tuberculate (except for fingers); poorly defined rows of tubercles along mesial margin of palm. Male with hook on ischiopodite of third and fourth pereopods. First pleopod reaching coxopodite of third pereopod when abdomen flexed, with rounded hump on cephalic surface, and terminating in four distinct parts: mesial process subspiculiform, straight, and directed caudodistally; cephalic process, also slender and straight, directed caudodistally; central projection subtriangular and disposed subparallel to mesial process; caudal element consisting of caudal knob, somewhat depressed laterally and forming ridge along distal margin, and small but well defined subtriangular caudal process situated at caudomesial base of central projection. Annulus ventralis subovate with greatest length in transverse axis and possessing submedian depression; sternum cephalic to annulus without caudally projecting prominences.

TYPE-LOCALITY: McBean Creek, south of Augusta, Richmond County, Georgia.

DISTRIBUTION: Georgia and South Carolina in the Oconee Ogeechee, and Savannah River systems.

ECOLOGY: This crayfish frequents a wide variety of lotic habitats ranging from small clear, sandy brooks to sluggish mud-bottomed deep creeks. Although populations seem to be larger in rock-littered or vegetation choked areas, stretches of small streams with little litter or cover, except for undercut banks, support many individuals of this species.

LIFE HISTORY: Hobbs (1947:5) reported breeding males to have been found in April, May, August, September, and December. An ovigerous female was found by him in September, and females carrying young were obtained in August and September.

COLOR: Body dark brown to tan with orange mottlings over entire carapace and terga of abdomen; light tan or orange stripe extending from rostrum to

posterior margin of carapace on mid-dorsal line; dark saddle-like marking in form of transverse bar across caudal margin of carapace; pair of anterior-projecting lateral horns on lateral surfaces of branchiostegites, rarely modified on SRP such that lateral horns represented by two lateral pairs of dark spots (anterior and poster portions of horns). Upper surface of chelae brownish orange to tan with black tubercles; tubercles on lower surface light. Legs dark gray to brown above; see above discussion of P. hirsutus for further color notes.

METHOD OF CAPTURE: This species is collected with the aid of a seine or dipnet from lotic environments.

Procambarus (Pennides) echinatus Hobbs

(Figures 17a-g)

DIAGNOSIS: Rostrum long, excavate, with acumen longer than half remainder of rostrum; sides convex and bearing acute cephalolaterally directed spines as base of acumen. Two or more cervical spines present. Areola relatively broad and short with 8 or 9 fine punctations in narrowest part; length constituting 21 to 28% of total length of carapace. Chela somewhat depressed with palm slightly inflated with single row of 8 tubercles along mesial margin of palm; row of four tubercles immediately above this row and a single tubercle usually present below it near distal end. Male with hook on ischiopodite of third and fourth pereopods; first pleopod of first form male reaching coxopodite of third pereopod when abdomen flexed and terminating in four parts: mesial process subspiculiform with only tip corneous and directed at angle of about 80 degrees to main shaft of appendage; cephalic process corneous, slender and lying lateral to central projection; central projection (most conspicuous of terminal elements) corneous, subacute and directed at an angle of about 70 degrees to main shaft to

appendage; caudal element consisting of a poorly defined, truncate caudal knob from which arising subacute, scalelike, corneous caudal process. Annulus ventralis subovate with greatest length in transverse axis and possessing longitudinal median furrow; cephalic region partially obscured in ventral aspect by multituberculate prominences extending caudally from sternum.

TYPE-LOCALITY: Salkehatchie River, 1.9 miles south of Barnwell, Barnwell County, South Carolina, on State Highway 3.

DISTRIBUTION: The Salkehatchie River and in headwater streams of the Edisto River in Bamberg, Barnwell, and Aiken Counties, South Carolina.

ECOLOGY: Hobbs (1956:120) describes the type-locality: "Here the stream varies from 10 to 100 feet across with a sand and mud bottom. The water is dark brown, with little silt suspension, and in many places flows with a moderate current through dense growth of Vallisneria and Saururus cernuus. My specimens were taken after dark resting on eel grass in the swifter reaches of the stream and on submerged roots near the surface of the water."

LIFE HISTORY: Very few breeding males have been captured and no ovigerous females or those carrying young have been observed.

COLOR: "Carapace olive-green dorsad, fading ventrally into creamy white with ridges edged in black. In addition to the ground color of carapace the cephalic region is marked by a broad distinctly U-shaped black yolk following the contour of the cervical groove; however, base of U not continuous (sic) but broken between attachments of mandibular muscle. Thoracic portion of carapace with a similarly disposed and broken U-shaped black marking--the broken portion occurring at caudal end of areola. Abdominal segments greenish with caudal portion bright blue bearing reddish-purple and vivid red markings. Chela reddish black with white tubercles; distal portion of fingers red but fading at the extreme distal ends into the yellow corneous spines" (Hobbs, 1956:121).

METHOD OF CAPTURE: Seine or dipnet (handnet) from lotic environments.

Procambarus (Pennides) raneyi Hobbs

(Figures 18a-g, 23)

DIAGNOSIS: Rostrum moderately long, excavate; base of acumen long and set off by acute marginal spines. Two cervical spines prominent. Areola relatively broad and short (approximately 4 times as long as broad and constituting 28% of entire length of carapace). Chela depressed with palm inflated in middle and bearing row of 7-9 tubercles along mesial margin. Male with hook on ischiopodites of third and fourth pereopods; first pleopod of first form male reaching coxopodite of third pereopod when abdomen flexed and terminating in three distinct parts: cephalic process absent; mesial process long and slender and slightly recurved; central projection beaklike and most prominent of terminal elements; caudal process small, curved and situated at caudal base of central projection. Annulus ventralis subovate with greatest length in transverse axis and possessing a submedian depression near midlength; anterior region partially hidden in ventral aspect by tuberculate extensions from sternum.

TYPE-LOCALITY: South fork of the Broad River, one mile south of Carlton on the Oglethorpe-Madison County line, Georgia.

DISTRIBUTION: Ocmulgee and Savannah River basins in Georgia, and in latter in South Carolina.

ECOLOGY: This species is known only from lotic environments where it occurs among plants, stones, debris or under any object which will conceal it during the day. At night, by using a headlight, the crayfish may be observed near the surface clinging to blades of eel grass (Vallisneria) or moving around a meter or less from shore in open water.

LIFE HISTORY: Breeding males have been collected from March to June, September, and November; a single ovigerous female was collected in April; no female with young has been observed (Hobbs, in prep.).

COLOR: Ground color light olive tan with dark tan to brown markings.

"Dorsal surface of rostrum and dorsomesial postorbital areas greenish tan. Hepatic and both median and posterior gastric areas mottled with brown. Branchiostegites with paired, transverse, subrectangular, brown bars on caudodorsal margin and horns of saddle represented by sparsely arranged small brown spots not contiguous with bars. Marginal spines on rostrum, postorbital and cervical spines cream. Abdomen with cephalic 5 somites bearing paired dark brown rectangular spots dorsolaterally, those on sixth somite extending laterally onto pleura. Pleura of second through fifth somites with bluish brown line at base and vertical band along caudal margin; pleuron of second somite with cephalic vertical bar. Telson with cephalic region bearing brown transverse band and cephalomedian and cephalolateral brown spots; caudal region mottled dark brown. Uropods mottled, and basal article, proximal portion of mesial ramus, lateral margin of lateral ramus, and distal portions of both rami mostly dark brown...Distal portion of merus and carpus of cheliped olive tan, mottled with dark brown and bearing white-tipped tubercles; dorsal surface of palmar area of propodus yellowish tan and studded with dark brown tubercles, those tubercles along mesial margin of palm with white or cream tips; fingers of chela dark brown dorsally and ventrally with lighter tubercles, those on mesial margin of dactyl cream-tipped, and tips of both fingers red. Remaining pereopods mottled olive on cream distal to midlength of merus. Ventral surface of body and bases of appendages bluish cream or cream" (Hobbs, in prep.).

METHOD OF CAPTURE: This species is most easily collected with the aid of a seine or dipnet.

Procambarus (Scapulicambarus) trogloodytes (LeConte)

(Figures 19a-g, 24)

DIAGNOSIS: Rostrum of moderate length, subplanar, margins convergent with or without small spines or tubercles at base of short acumen. Post-orbital ridges terminating cephalically in weak spines or tubercles. Cervical spine small. Areola narrow, with only 1 or 2 punctations in narrowest part and constituting about 28 to 30% of total length of carapace. Chelae elongate, weakly depressed, and tuberculate (except for fingers); well defined row of tubercles (7 or 8) along mesial margin of palm. Male with hook on ischiopodite of third and fourth pereopods. Left first pleopod of first form male reaching coxopodite of third pereopod when abdomen flexed, with distinct shoulder on cephalic surface at base of distal one third, and terminating in four distinct parts: mesial process subspiculiform, straight and directed caudodistally; cephalic process consisting of large rounded hump; central projection comparatively small, subtriangular and disposed subparallel to mesial process; caudal element situated in caudal-most position of appendage and directed distally. Annulus ventralis subovate with greatest length in transverse axis and planar except for paired cephalic ridges; sternum cephalic to annulus lacking tuberculate caudal extensions.

TYPE-LOCALITY: Rice fields in Georgia.

DISTRIBUTION: This species ranges from the Altamaha to the Pee Dee basin, in Georgia and South Carolina.

ECOLOGY: This appears to be a ubiquitous species, inhabiting roadside ditches, cypress ponds, streams and burrows. Although not collected from burrows on the SRP, P. trogloodytes constructs simple burrows consisting of a single verticle tube or, at most, bifurcating once. The preferred habitat appears to be somewhat temperary lentic or sluggish lotic habitats.

LIFE HISTORY: Breeding males have been collected during every month except November; no ovigerous females or females carrying young have been collected, suggesting that females of this species probably burrow prior to ovulation.

COLOR: Ground color a dark brown with orange and tan mottlings over entire carapace and terga of abdomen; dorsum of abdomen dark, flanked laterally by tan to orange stripes which in turn abutted ventrally by undulating dark stripe; lateral margin of rostrum orange to light tan; upper surface of chelae brown with orange tubercles; legs dark brown to tan.

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EXPLANATION OF FIGURES

- Figure 1: Map of Savannah River Plant, showing major aquatic features. Solid black lines - streams; solid black areas - lakes and ponds; wavy lines - swampy areas.
- Figure 2: Palaemonetes paludosus (Gibbes): a, lateral view of male; b, dorsal view of anterior region of carapace of male; c, second pleopod of male; d, lateral view of abdomen of ovigerous female; e, distal portion of appendix masculina.
- Figure 3: Schematic diagram of shrimp in lateral view: b, basis; c, coxa; d, dactylus; i, ischium; m, merus; p, propodus; ai, appendix interna; am, appendix masculina; as, antennal spine; bh, branchiostegal grove; bs, branchiostegal spine; cp, carpus; end, endopod; ep, epipod; ex, exopod; hs, hepatic spine; ps, pterygostomian spine; sc, scaphocerite; ss, supraorbital spine (from Hobbs, Hobbs, and Daniel, in press).
- Figure 4: Schematic diagram of male crayfish: a, ventral view; b, dorsal view (from Hobbs, Hobbs, and Daniel, in press).
- Figure 5: Ventral view of basal podomeres of pereopods of male crayfishes showing variation in number of hooks on ischia (solid black) of third and fourth: a, hook on third pereopod; b, hooks on third and fourth pereopod (modified from Hobbs, 1972:15).
- Figure 6: Lateral view of carapace: a, showing cervical spines (cs); b, showing no cervical spines (modified from Hobbs, 1972:15).

After examining crayfish specimens on the SRP for variation of morphological features, Figures 7, 9-19 were redrawn from Hobbs, 1974b. The lettering utilized in Figure 7 also applies to Figures 8-10; that in Figure 11, to Figures 12-19.

Figures 7 - 10: a, dorsal view of carapace of male; b, dorsal view of chela of first form male; c, mesial view of first pleopod of first form male; d, lateral view of same; e, lateral view of first pleopod of second form male; f, annulus ventralis; ce, central projection, m, mesial process.

Figures 11 - 19: a, dorsal view of carapace of male; b, dorsal view of chela of first form male; c, lateral view of first pleopod of first form male; d, lateral view of same of second form male; e, mesial view of tip of first pleopod of first form male; f, lateral view of same; g, annulus ventralis, c, caudal process; ce, central projection, ck, caudal knob, cp, cephalic process; m, mesial process.

Figures 20 - 24: Distribution maps of decapod species on the SRP.

20, P. paludosus; 21, C. (D.) latimanus and Fallicambarus sp.;
22, P. (O.) hirsutus and F. clypeata; 23, P. (O.) a acutus,
P. (P.) raneyi, and C. (D.) sp.; 24, P. (S.) troglodytes and
P. (O.) pubescens.

The distribution of species in Figures 20-24 is not meant to be complete. Continual sampling should reveal wider distributions for most of the species listed.

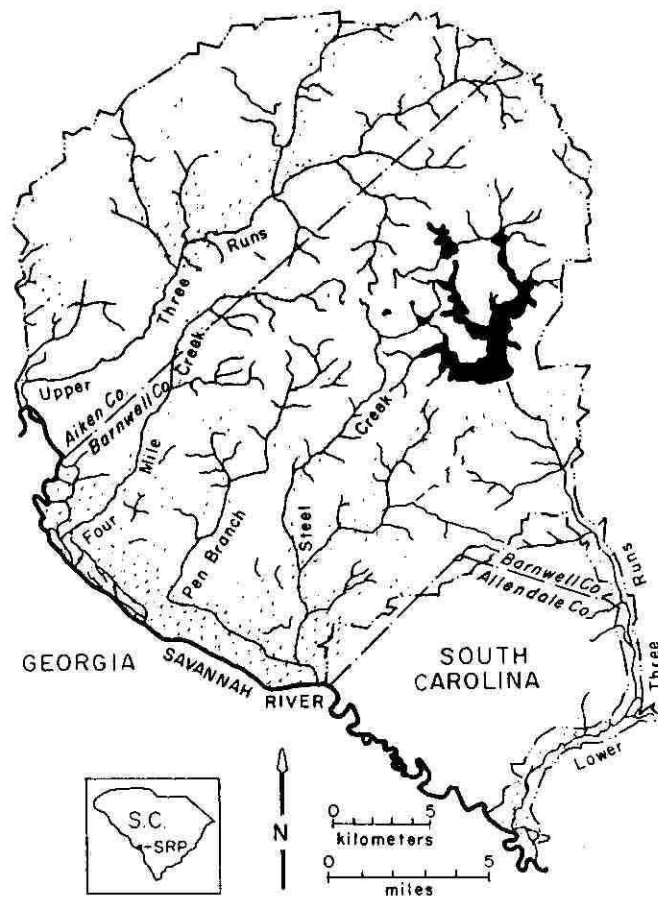


Figure 1. Map of the Savannah River Plant

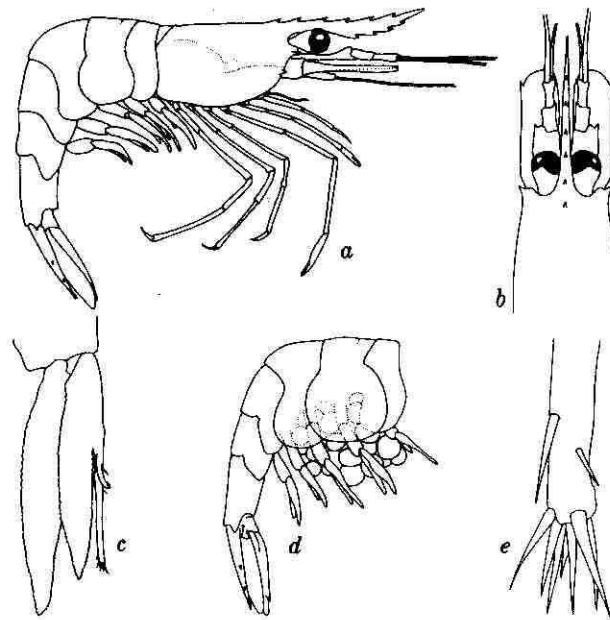


Figure 2. *Palaemonetes paludosus*

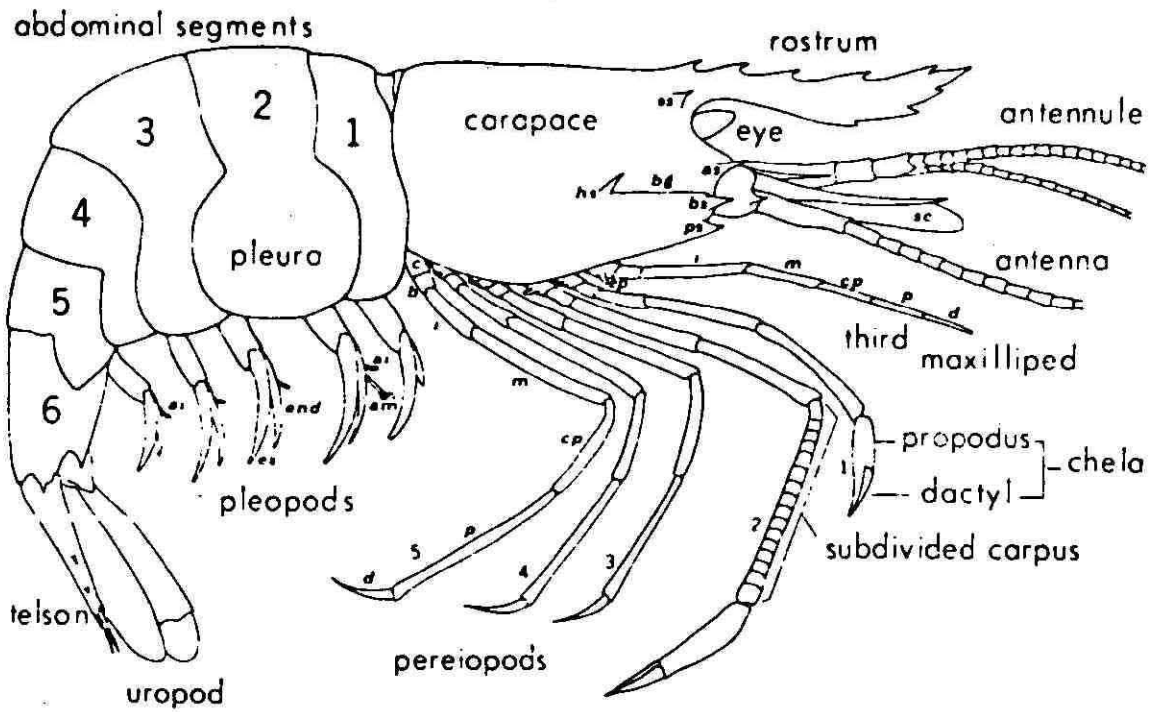


Figure 3. Schematic diagram of shrimp

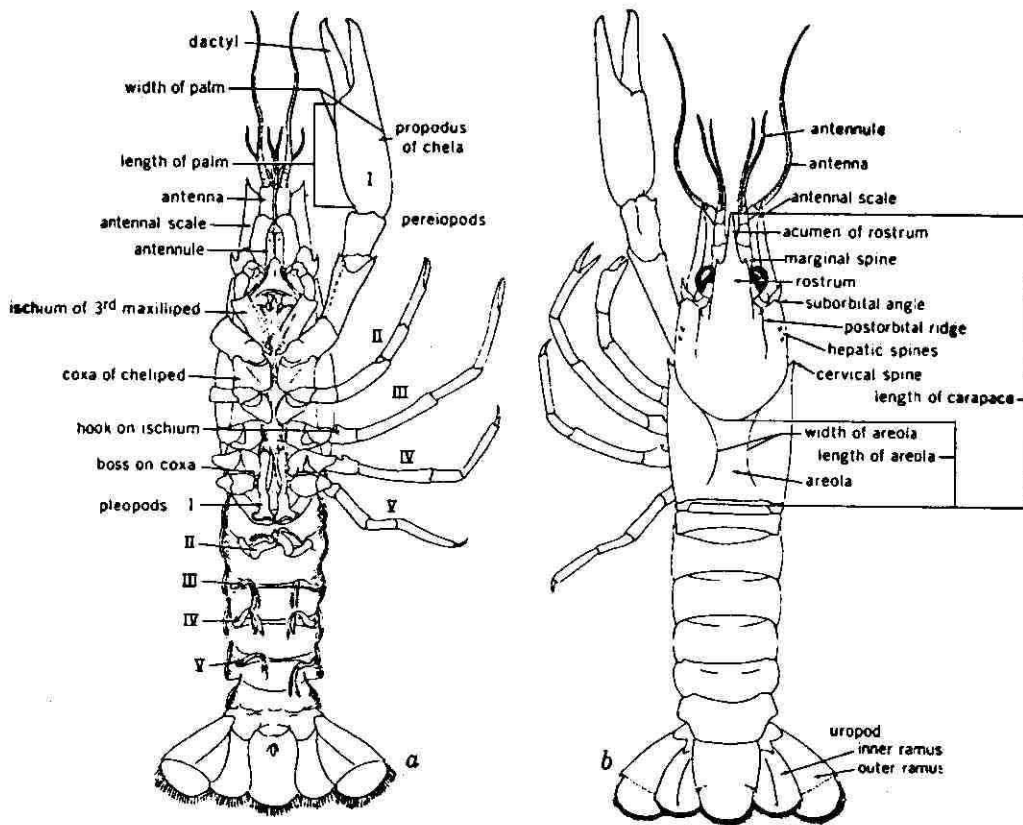


Figure 4. Schematic diagram of male crayfish

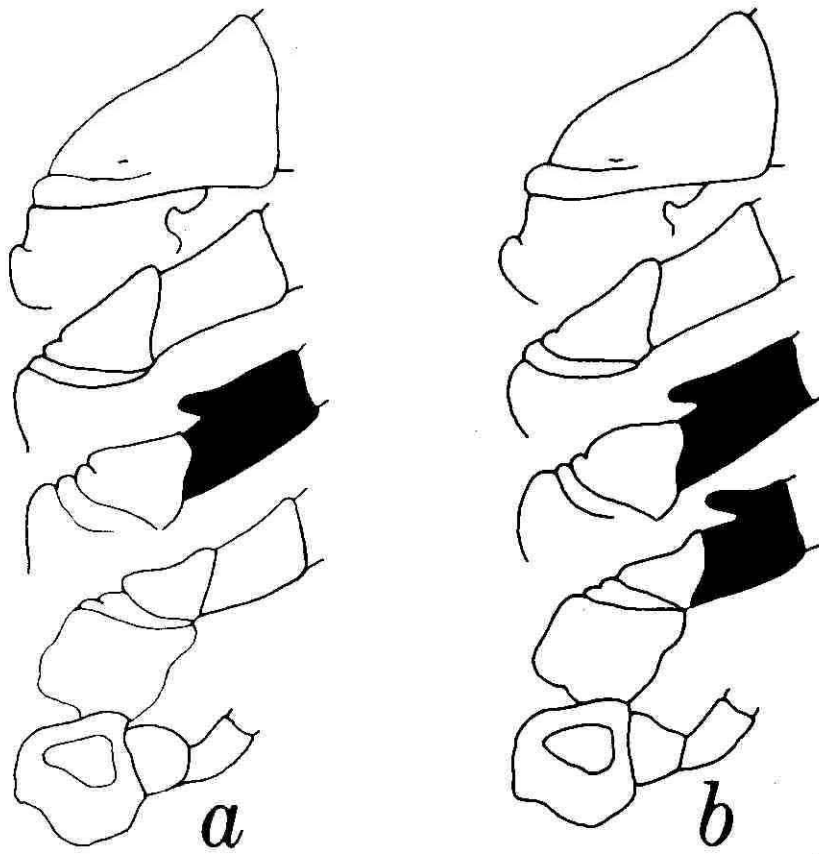


Figure 5. Basal podomeres of pereopods of male crayfishes

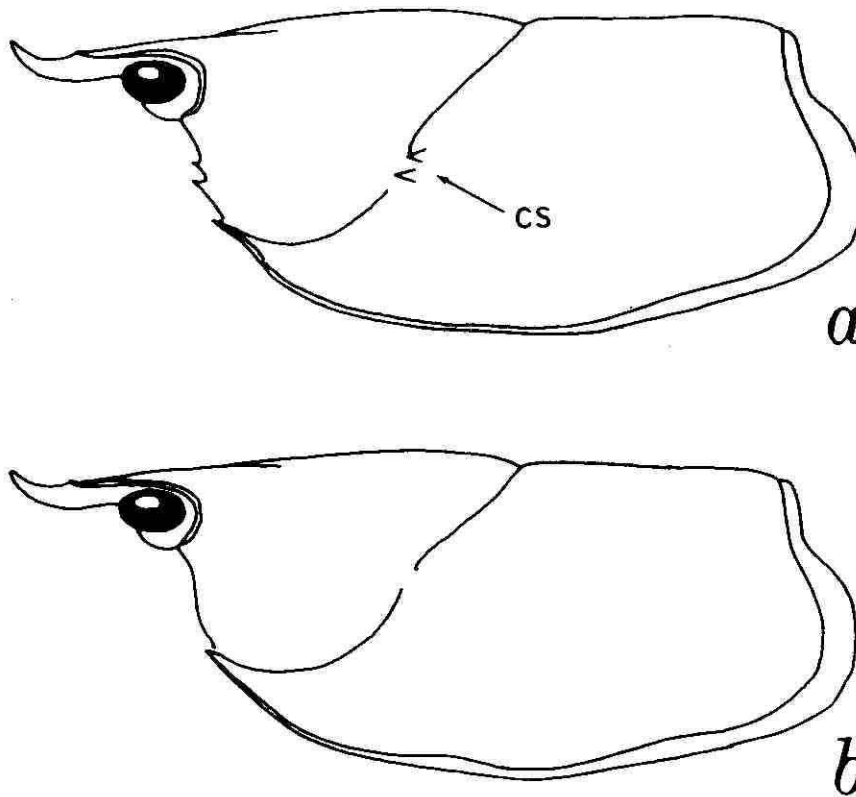


Figure 6. Lateral view of carapace

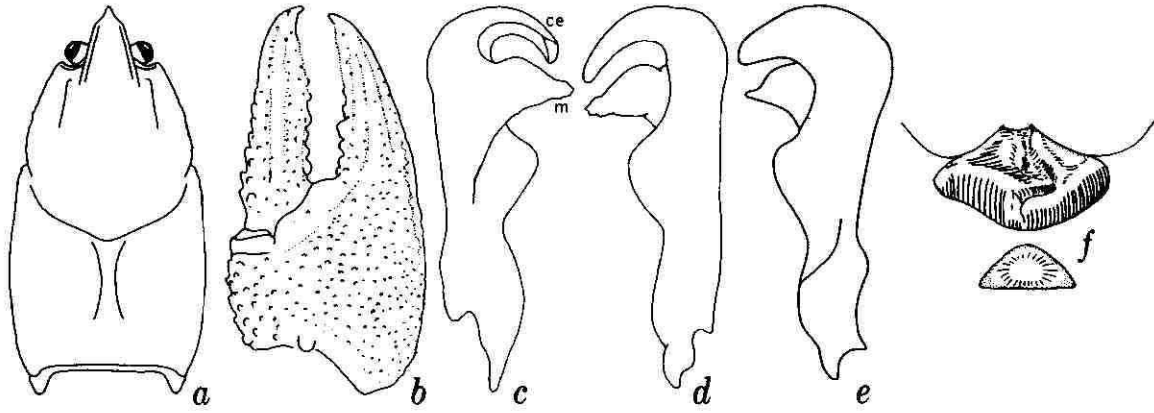


Figure 7. Cambarus (Depressicambarus) latimanus

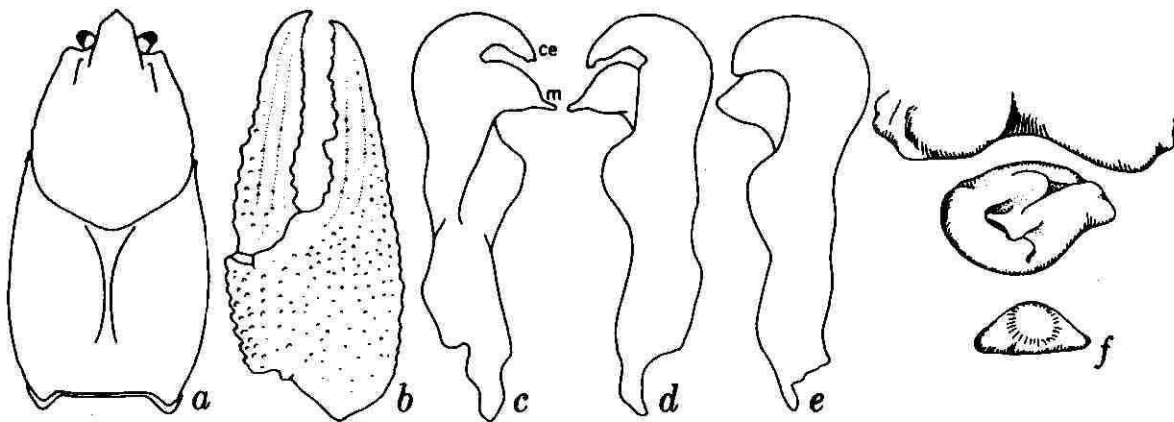


Figure 8. Cambarus (Depressicambarus) sp.

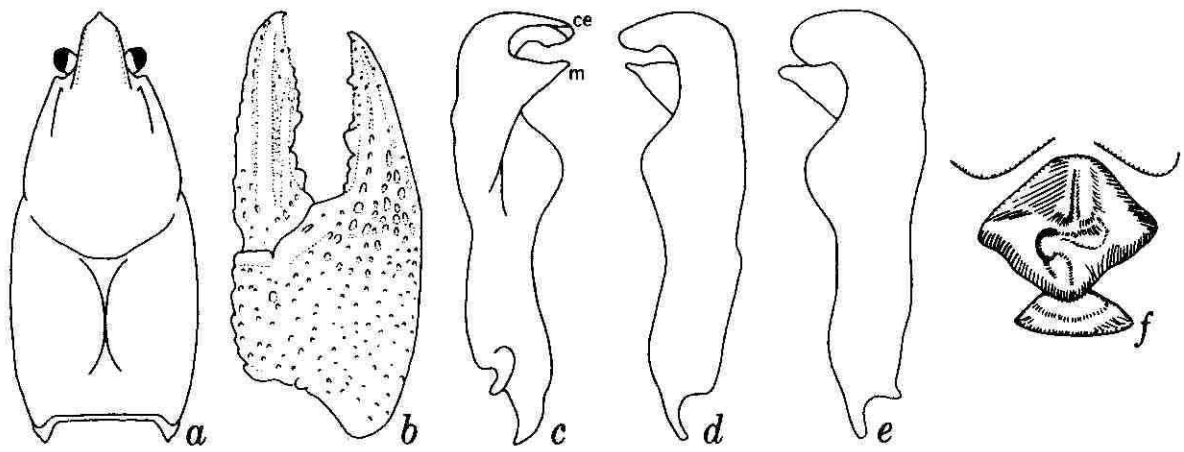


Figure 9. Cambarus (Lacunicambarus) diogenes diogenes

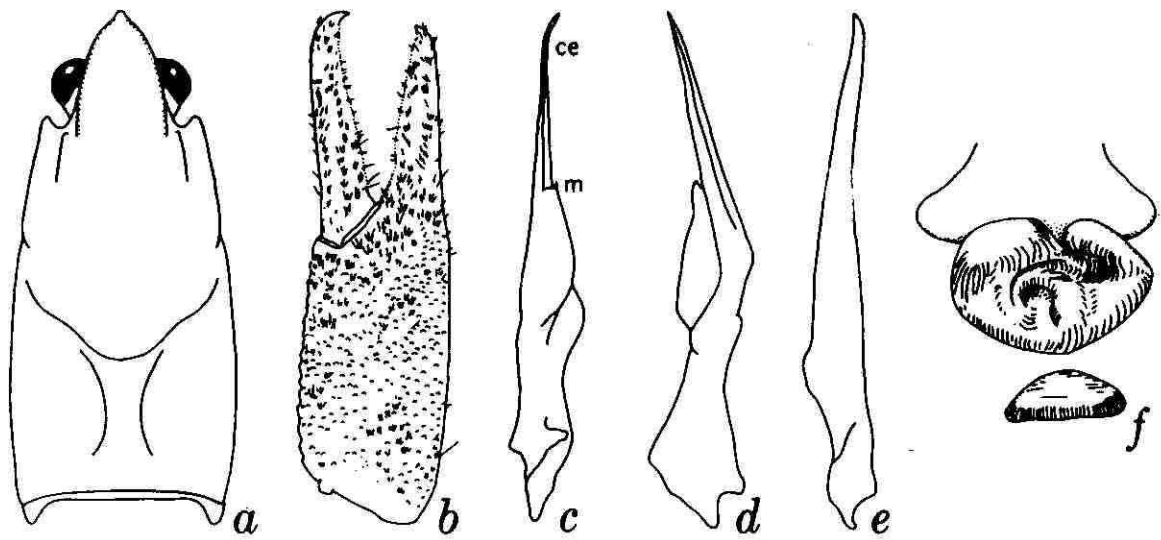


Figure 10. Faxonella clypeata

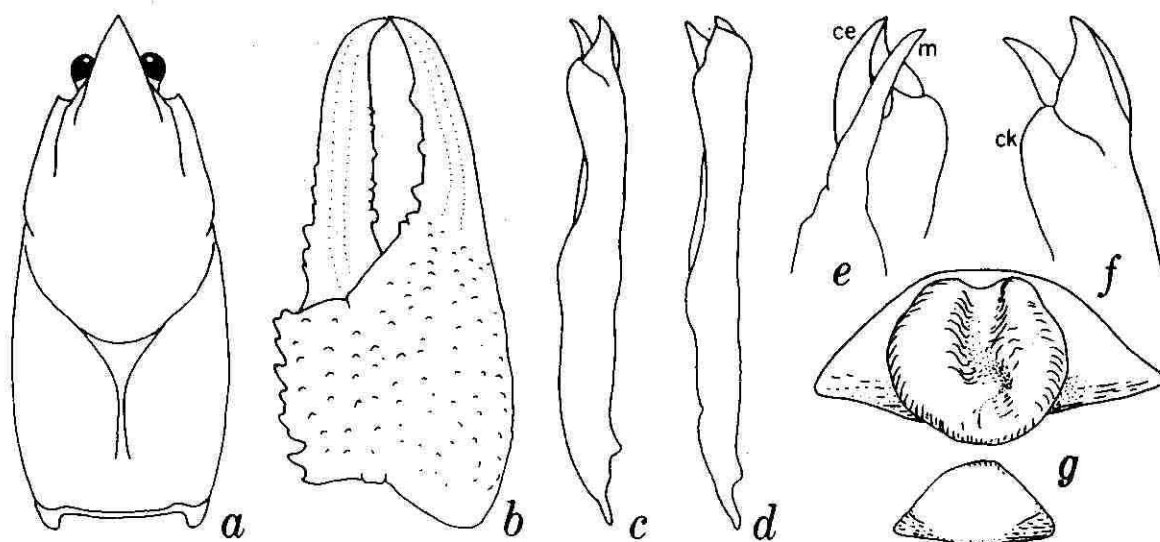


Figure 11. Procambarus (Hagenides) pygmaeus

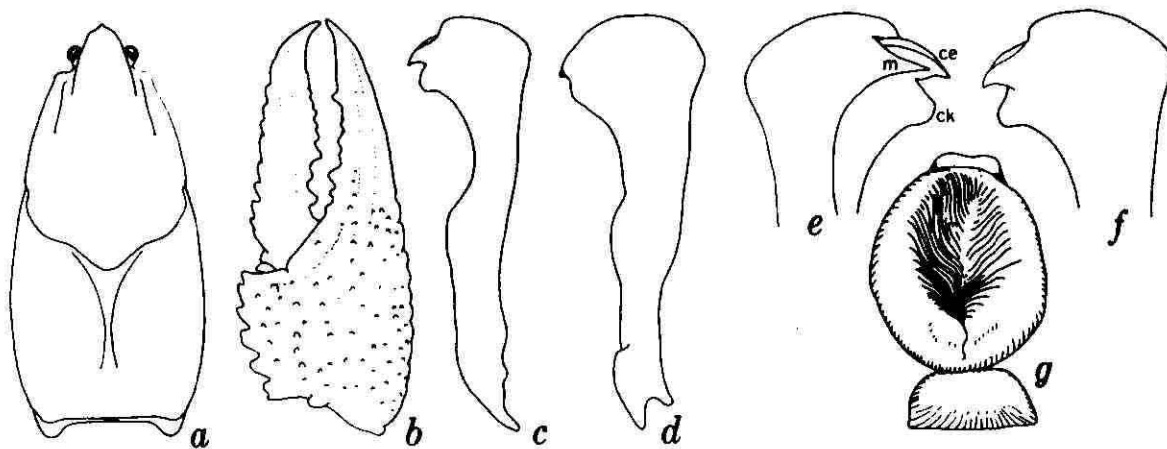


Figure 12. Procambarus (Hagenides) truculentus

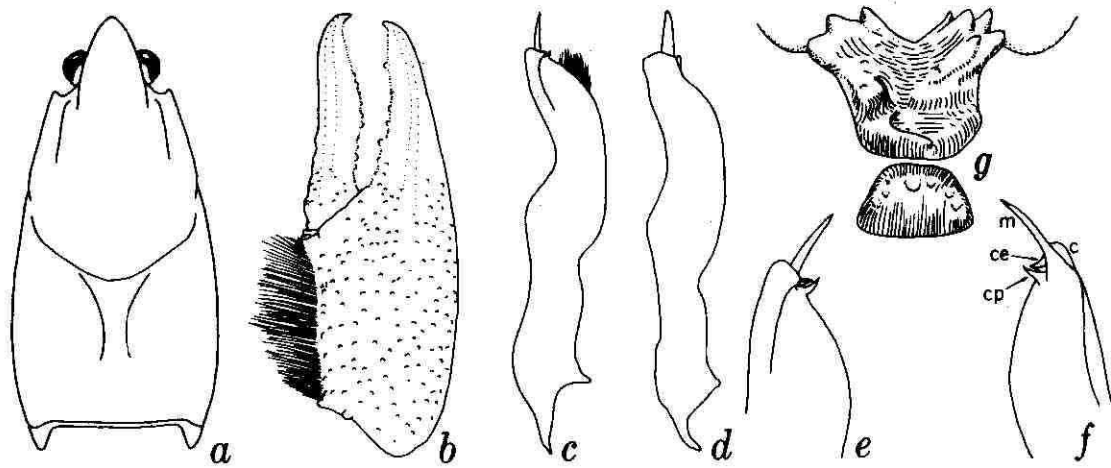


Figure 13. Procambarus (Leonticambarus) barbatus

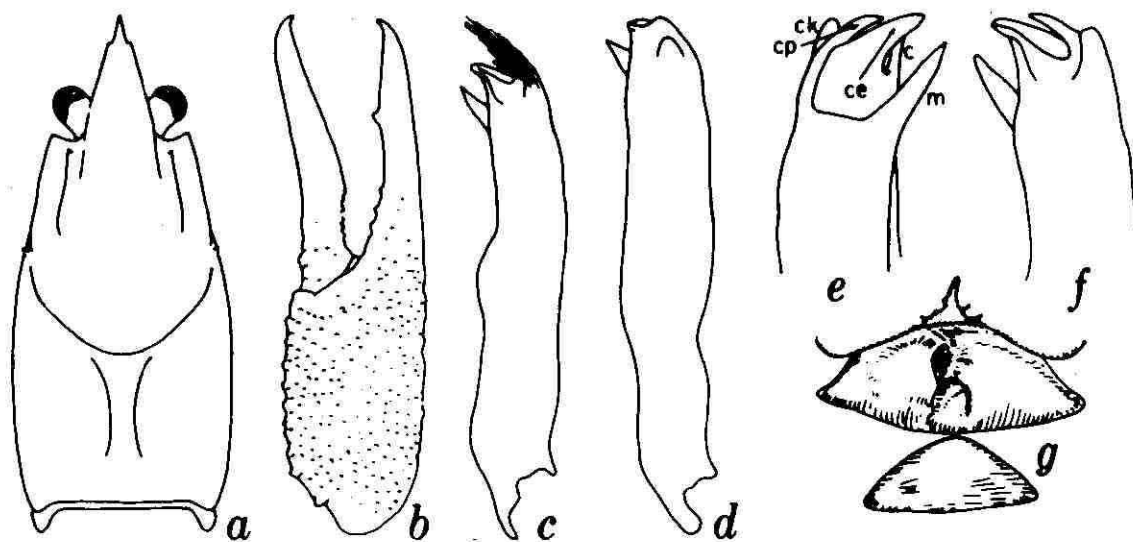


Figure 14. Procambarus (Ortmanicus) acutus acutus

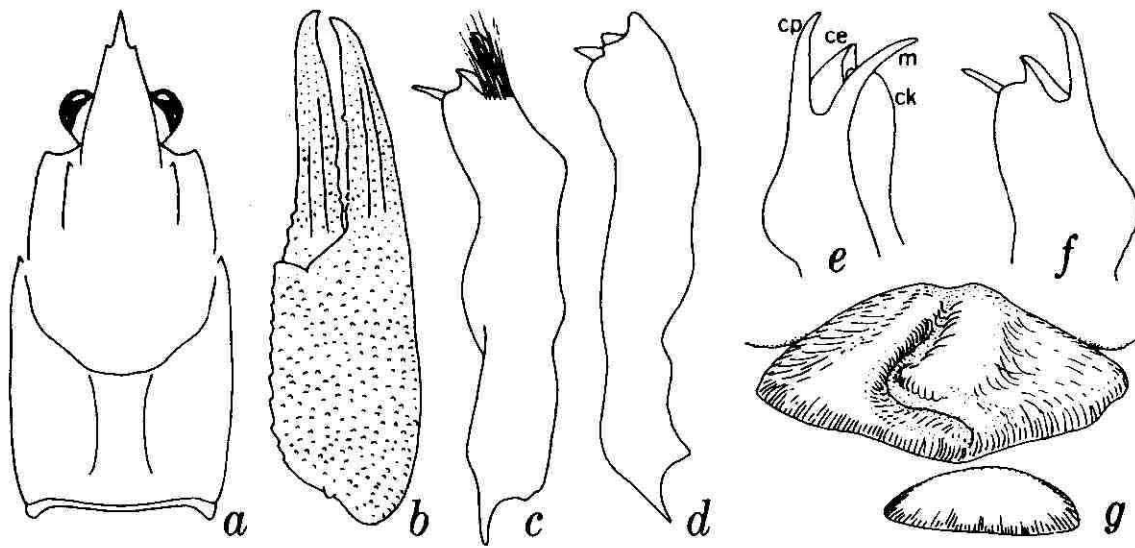


Figure 15. Procambarus (Ortmanicus) hirsutus

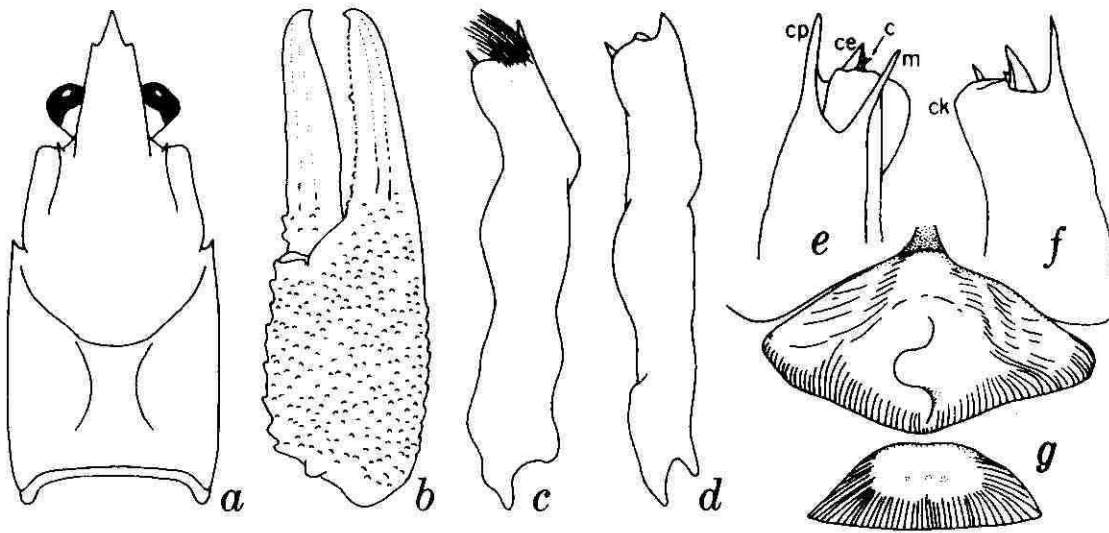


Figure 16. Procambarus (Ortmanicus) pubescens

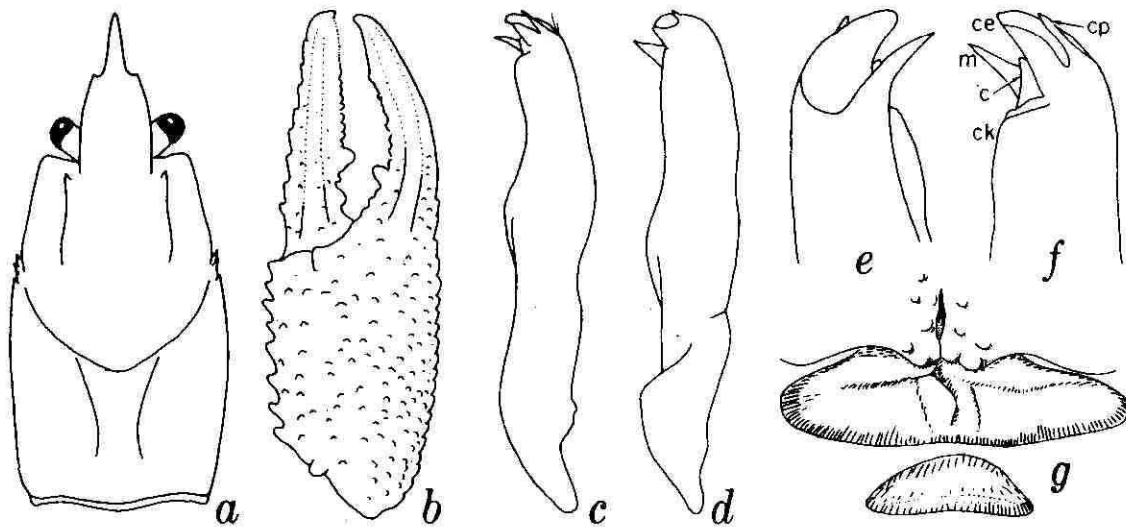


Figure 17. Procambarus (Pennides) echinatus

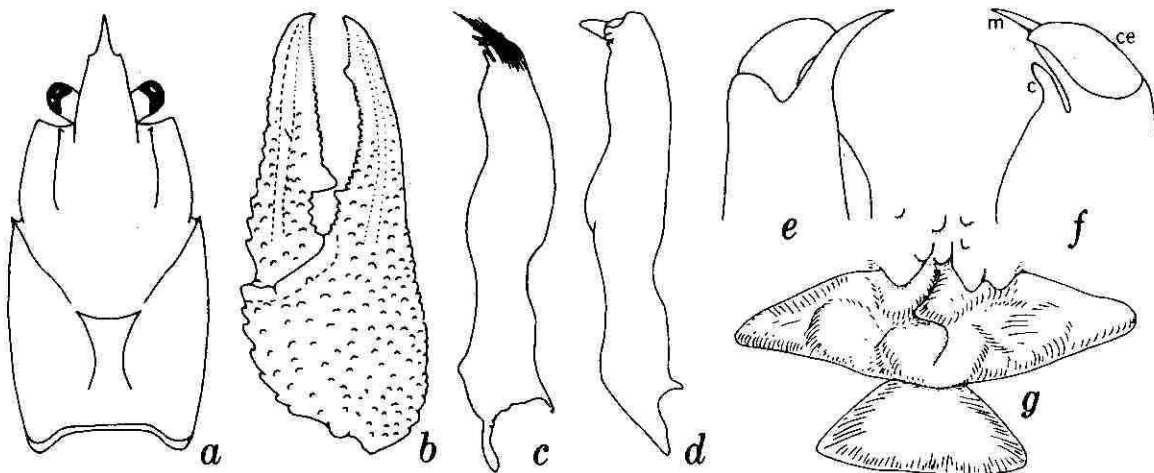


Figure 18. Procambarus (Pennides) raneyi

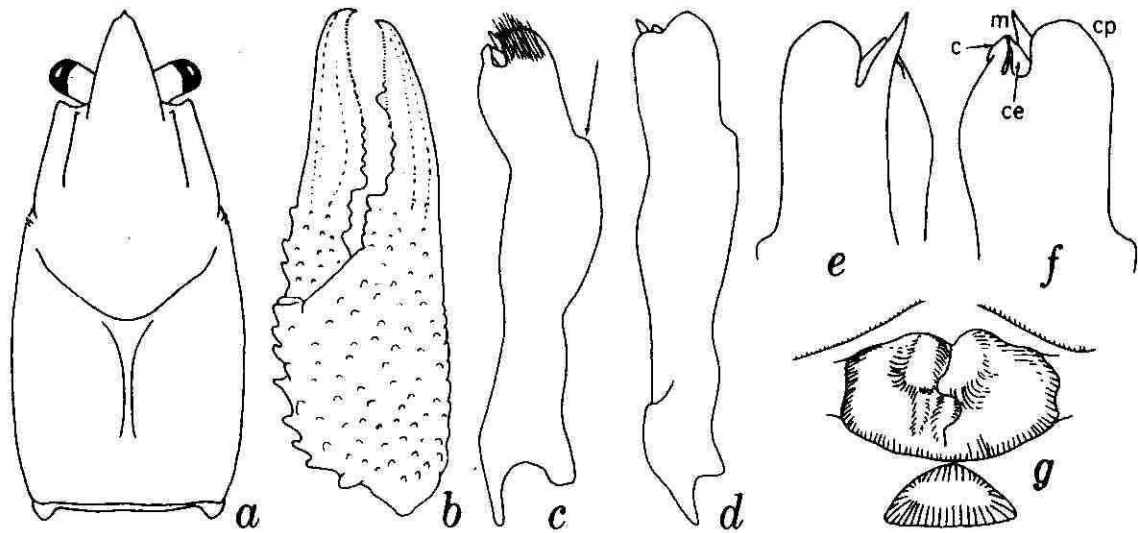


Figure 19. Procambarus (Scapulicambarus) troglodytes

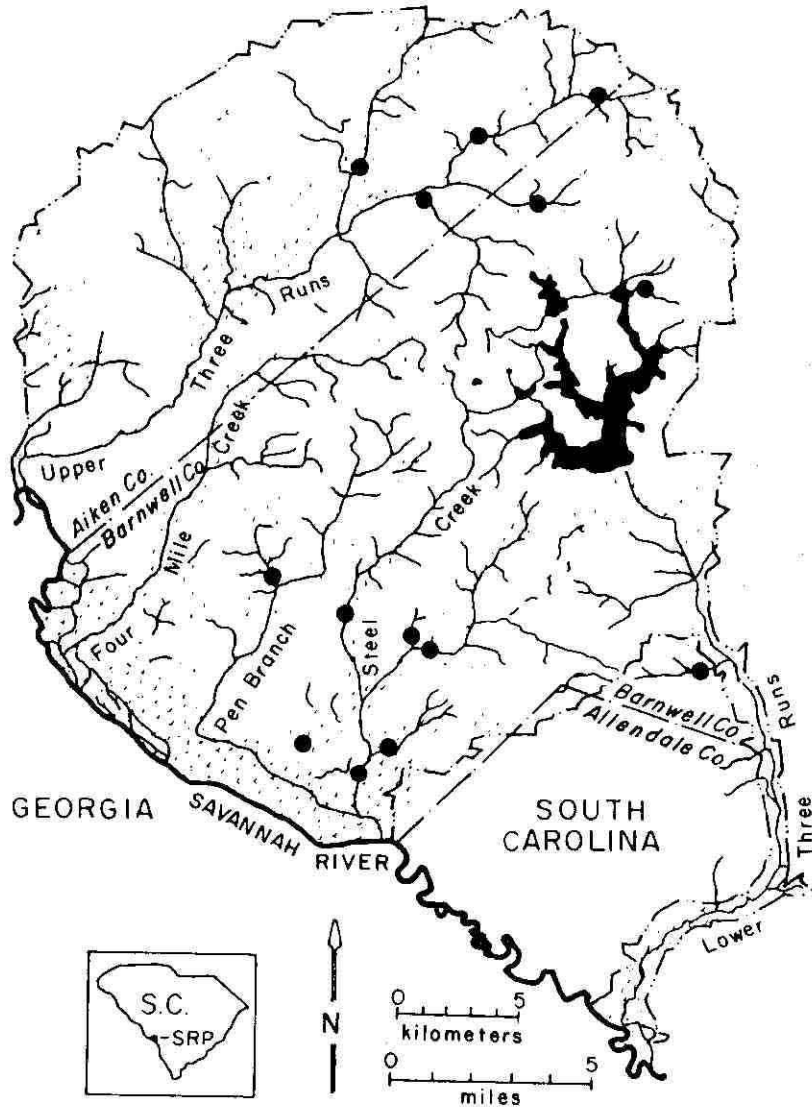


Figure 20. Circles are Palaemonetes paludosus

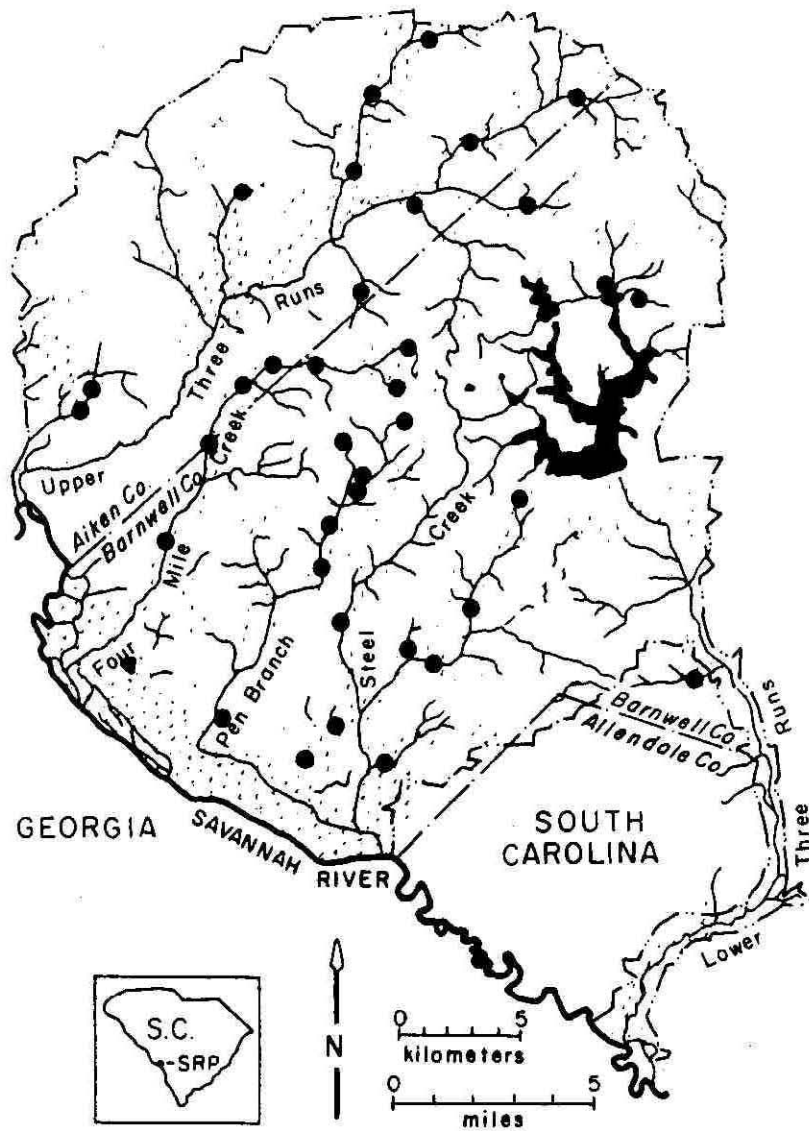


Figure 21. Circles are Cambarus latimanus, triangles are Fallicambarus sp.

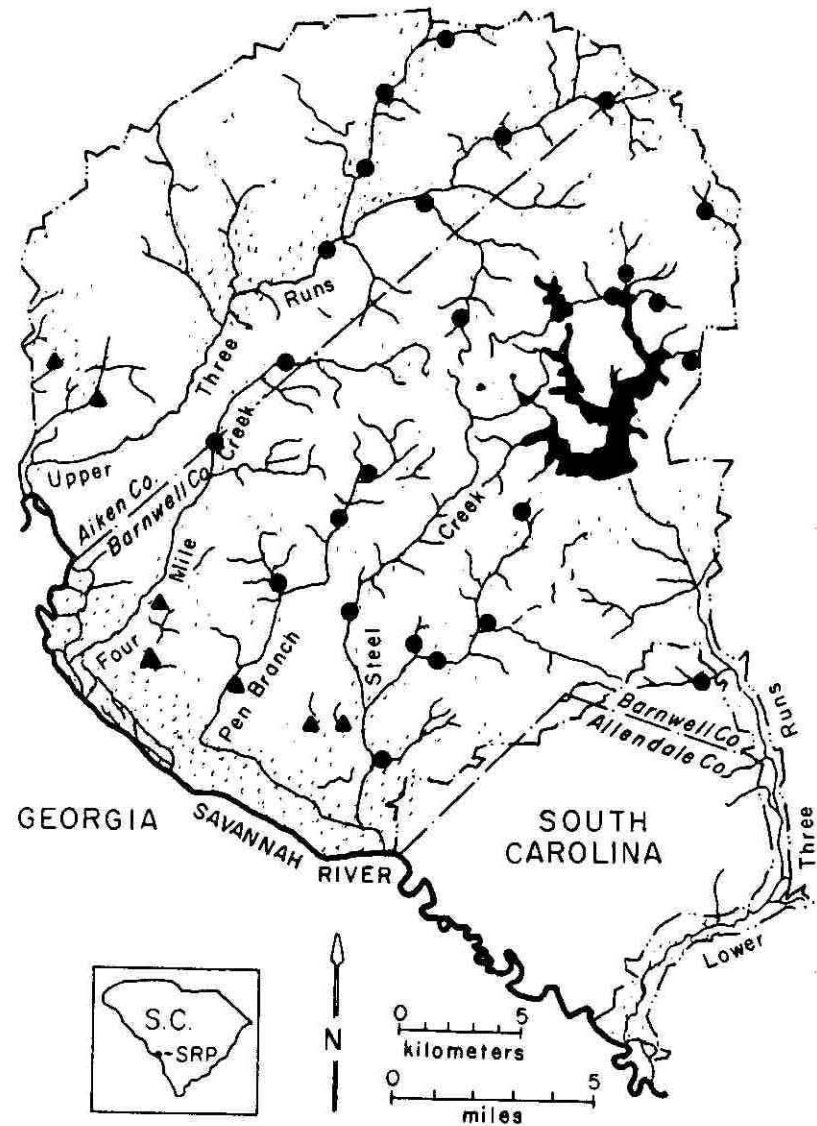


Figure 22. Circles are Procambarus hirsutus, triangles are Faxonella clypeata

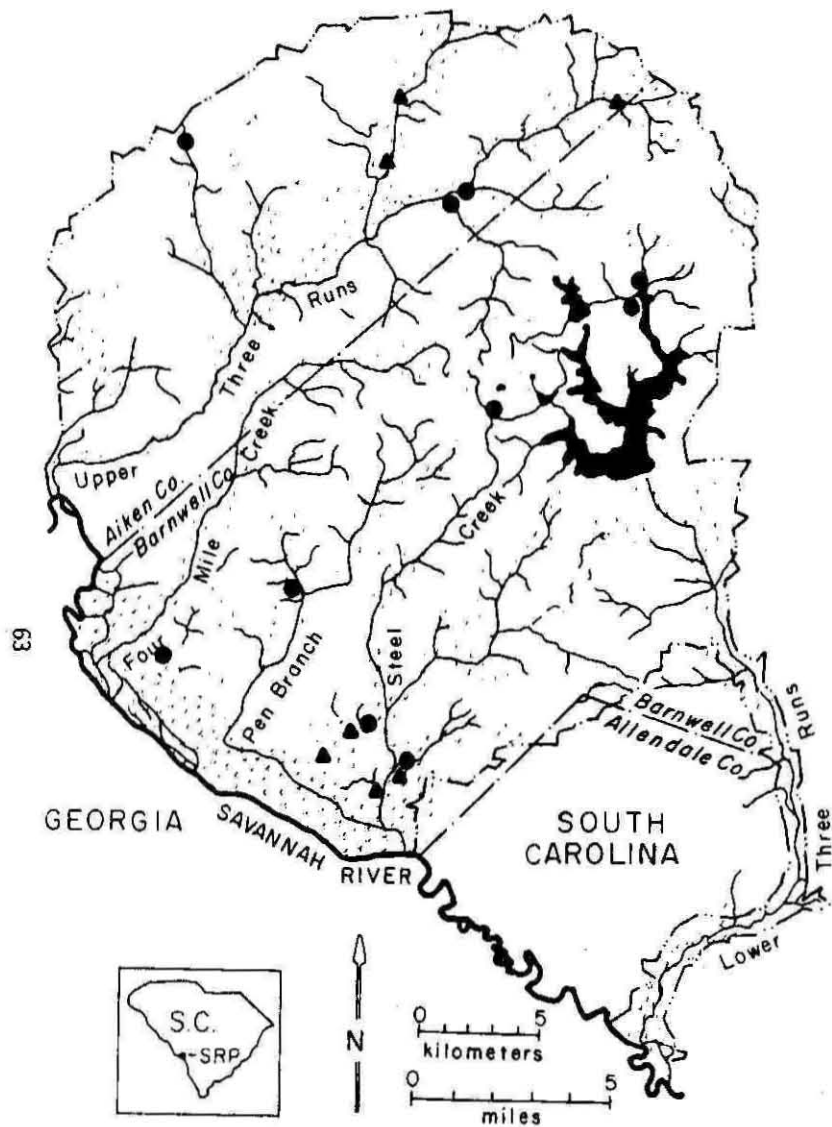


Figure 24. Circles are *Procambarus troglodytes*, triangles are *Procambarus pubescens*

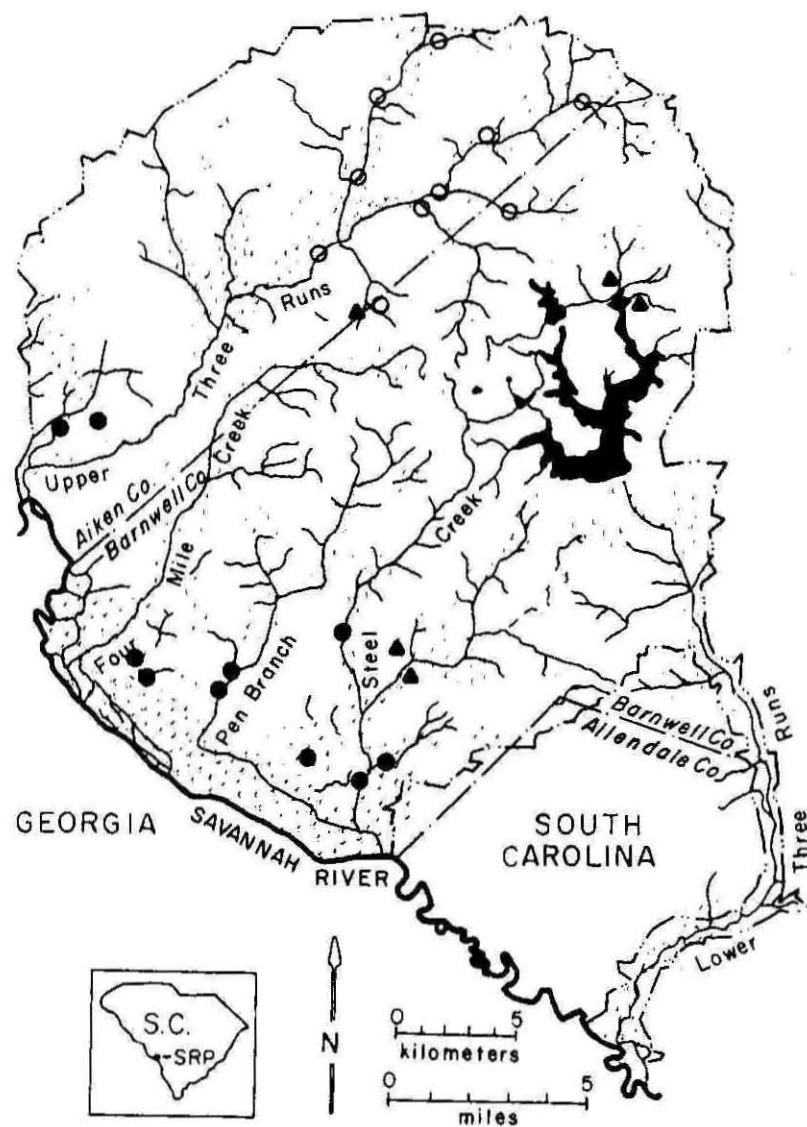


Figure 23. Closed circles are *Procambarus acutus acutus*, open circles are *Procambarus raneyi*, triangles are *Cambarus (D.) sp.*

