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To the Graduate Council:

I am submitting herewith a dissertation written by Raymond William Bouchard entitled "A Contribution to the Knowledge of Tennessee Crayfish." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Zoology.

Major Professor

We have read this dissertation and recommend its acceptance:

Accepted for the Council:

Vice Chancellor for
Graduate Studies and Research

# A CONTRIBUTION TO THE KNOWLEDGE OF TENNESSEE CRAYFISH

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A Dissertation

Presented to

the Graduate Council of

The University of Tennessee

---

In Partial Fulfillment

of the Requirements for the degree

Doctor of Philosophy

---

by

Raymond William Bouchard

August 1972

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ABSTRACT

The state of Tennessee has 60 nominal species or subspecies of crayfish within its political boundary or in nearby tributaries that flow into the state. These crayfish represent five genera. The genera Procambarus and Cambarus are further subdivided into subgenera to show phylogenetic relationships within the genus. Each species is listed under its generic or infrageneric category with the following information: (1) type locality, (2) location of type specimens, (3) range, (4) crayfish associates, (5) life history notes, (6) ecological data, and as needed (7) notes on taxonomic status or information not covered in any of the above six sections.

The physiographic provinces in Tennessee are described. Methods for collecting and preservation are included.

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# I. INTRODUCTION

At present Tennessee's crayfish fauna exhibits the most extensive speciation of any state. There are at least two reasons for this. First, Tennessee with its wide east-west distribution crosses six physiographic regions offering many varied ecological habitats. Second, Middle Tennessee, inhabited by a number of primitive endemic species, is thought to be an area of early speciation. As stated by Hobbs (1967: 15), "centers of origin for Orconectes, [and] Cambarus...existed in the area of northern Alabama northward through the limestone belt of Tennessee onto the Cumberland Plateau." The majority of this area is situated in Middle Tennessee.

Although a number of new crayfish species have been described from Tennessee, there have been only five published faunal studies on any areas within the state. These areas are as follows: Nickajack Cave (Hay, 1902b), Southern Appalachians (Ortmann, 1931), Nashville Region (Fleming, 1938-39), Big South Fork of the Cumberland River (Hobbs and Shoup, 1942), and Reelfoot Lake area (Hobbs and Marchand, 1943). A faunal list from each of the above studies and the present status of each reported species is given in Appendix A.

## II. PHYSIOGRAPHIC PROVINCES OF TENNESSEE

The drainage area of Tennessee covers six physiographic provinces. These provinces are illustrated in Figure 1 (in pocket) and described below (modified from Tennessee Valley Authority, 1963).

### BLUE RIDGE PROVINCE

The easternmost province in Tennessee is the Blue Ridge which forms the boundary between Tennessee and North Carolina. The Blue Ridge in Tennessee is formed by the Unaka Mountain group. There are many mountain ranges within this group, such as, the Holston, Iron, Stone, Roan, Great Smoky, Unicoi, and Little Frog ranges. There are many prominent elevations within this province with at least 15 peaks above 5,000 feet. Most of the higher elevations are in the Great Smoky Mountains including the highest point in the state at Clingmans Dome (6,642 feet).

This province is underlain with Cambrian sedimentary rocks and Precambrian sedimentary, metamorphic, and igneous rocks. The sedimentary rocks are mainly clastics that have undergone varying degrees of metamorphism and are now conglomerates, quartzose sandstones, graywackes, and slates (King, 1955). The metamorphic rocks are mainly crystalline

(gneisses, schists, etc.) and the igneous rocks are granites, rhyolites, etc.

Within this province are a few inliers of Ridge and Valley topography represented by Ordovician limestones and shales in the small flat coves, such as, Cades, Tuckaleechee, and Wear.

On the upper slopes and crests surface drainage is rapid; shallow ground waters follow joints and bedding and fracture planes rather than solution channels. Consequently, the water contains little dissolved mineral constituents.

Below this zone, the topography is less rugged and surface drainage is less rapid. Springs are numerous and the water is heavily charged with mineral matter.

The lower slopes and outwash plains have water charged with dissolved constituents accumulated in its downward passage from the upper mountain slopes, and it often contains iron and other minerals in solution.

## RIDGE AND VALLEY PROVINCE

The Ridge and Valley province extends across the region in a northeast-southwest direction varying in width from 35 to 55 miles. It is limited on the east and southeast by the Blue Ridge and on the north and northwest by the eastern escarpment of the Cumberland Plateau. Within the main valley are numerous long, narrow, parallel ridges separated

by narrow valleys. These ridges have a general northeast trend. In the northwest corner are two prominant ranges (the Clinch and Powell Mountains) whose valleys faunistically share a number of species with the Cumberland Plateau (i.e., Cambarus distans, C. parvoculus, C. (Puncticambarus) ms. sp.).

The region is underlain by folded and faulted limestones, dolomite, chert, siltstone, shales, and sandstones principally of Ordovician and Cambrian periods. Of these, limestone is the dominant type in both thickness and areal extent. The readily soluble characteristic of limestone accounts for the fact that it principally occupies the valleys, whereas the more insoluble and resistant sandstones and shales usually form the intervening ridges.

Caves in this province trend along the valleys separated by the noncaverniferous rocks of the ridges. With cave systems limited to narrow strikebelts in single limestone valleys, species dispersal is restricted. There are no troglobitic crayfish known from this province.

The ground water in the Ridge and Valley province varies considerably in chemical and mineral composition. In the area of ridges, the surface streams are relatively fast and clear, and both springs and surface streams contain little calcium carbonate. In the valley areas, the streams are less rapid and are frequently turbid. Springs and streams in such areas contain a variety of mineral constituents,

including considerable quantities of calcium carbonate, which have been accumulated from the drainage area.

## CUMBERLAND PLATEAU

The Cumberland Plateau including Lookout Mountain crosses the Tennessee River Basin in a northeast-southwest direction varying in width from about 30 to 70 miles. Its elevation is 1,500 feet on the Alabama-Tennessee state line, 2,000 feet in the central part, and over 3,500 feet in the northeastern portion. Elevations on Lookout Mountain in Tennessee and northwestern Georgia range up to 2,100 feet. The plateau surface stands about 1,000 feet above the adjacent regions on either side. The eastern edge (Walden Ridge) is an abrupt scarp that extends in a relatively straight line for approximately 100 miles. The western edge is an equally abrupt scarp but is notched by the headwaters of streams that have eaten into the plateau from the west. The surface, while measurably flat, is diversified by shallow valleys and low ridges. A number of well known mountain ranges occupy the northeast edge (e.g., Crab Orchard, Pine Cumberland Mountains, etc.).

The rocks of the plateau are principally of the Pennsylvanian period and essentially flat-lying. Much of the surface is underlain by sandstone, shale, conglomerate, siltstone, and coal, which forms an open porous soil producing

numerous springs. During the summer and fall many of the springs and streams decrease in volume or go entirely dry. The water may contain varying amounts of iron from the sandstones or sulfur from the interbedded shales and coals.

The western edge of the plateau is underlain by vast expanses of highly soluble limestones of the Mississippian period. This highly caverniferous belt of limestone acts as a dispersal corridor where Orconectes australis is distributed from Alabama to Kentucky.

The most striking topographic feature of the Cumberland Plateau is the Sequatchie Valley. The Sequatchie Valley represents an inlier of the Ridge and Valley province in structure, topography, and faunistics, but is considered a part of the Cumberland Plateau because it is separated from the Ridge and Valley province by Walden Ridge and Lookout Mountain. The gap between Walden Ridge and Lookout Mountain through which the Tennessee River trends westward is Walden Gorge.

The Sequatchie Valley is approximately 68 miles long in Tennessee. The valley arises in the Crab Orchard Mountains involving a fold of sandstones and conglomerates (Rogers, 1950). A short distance south of the Crab Orchard Mountains this fold is breached by Mississippian limestones and exposed in a karst valley called Grassy Cove. This cove was created by subsurface solution. South of Grassy Cove begins

the Sequatchie Valley proper with exposed Ordivician limestones. Another small cove is forming northeast of Grassy Cove, and in time both will become part of the Sequatchie Valley (Thornbury, 1963).

## EASTERN AND WESTERN HIGHLAND RIMS

West of the Cumberland Plateau lies the Highland Rim, extending westward past the lower reaches of the Tennessee River. The width of the rim is about 160 miles at the Kentucky border and about 100 miles at the Alabama border. Its average elevation is approximately 1,000 feet, while the crest stands at an average height of about 450 feet above the central floor of the Nashville Basin (Thornbury, 1963). Viewed broadly, its surface is level; viewed in detail, it is gently undulating or cut by small streams into narrow but sometimes steep-sided valleys.

The siliceous beds of the Mississippian period form the principal surface of the Highland Rim. These beds consist of limestones, siliceous shales, chert, shale, siltstone, sandstone, and dolomite. They have been exposed to the leaching action of water so long that the calcareous material has been removed to a considerable depth, and the surface is a disintegrated mass of reddish clay and porous chert.

The waters of the Highland Rim are mostly free of calcium carbonate, although some contain iron. Where the

lime has not yet been entirely leached from the rocks, the waters may be hard. Springs are numerous but often weak or seasonal. Many of the smaller streams dry up in the summer and fall.

Along the eastern margin of the Highland Rim at the foot of the escarpment which rises to the Cumberland Plateau, numerous very large springs flow from the outcrop of the flat-lying Mississippian limestones underlying the sandstones of the plateau. In the western portion of the Highland Rim area adjacent to the Nashville Basin are many sulfur springs, while the steep slopes between the two are supplied with springs from the outcropping Devonian shale, containing iron and other minerals.

South of the Dripping Springs Escarpment in Kentucky lies a limestone plain portion (Pennyroyal Plateau) of the rim containing innumerable sinkholes. This karst plain extends into Robertson and Montgomery Counties. It is through solution channels in this region that Orconectes pellucidus invades the state of Tennessee.

## THE NASHVILLE BASIN

The Nashville Basin is an elliptical plain eroded out of the Highland Rim and extending in a northeast direction across the central portion of Tennessee. It is approximately 120 miles long, 40 to 70 miles wide, and at an average

elevation of 500 to 700 feet. The basin is entirely surrounded by the Highland Rim, which rises 450 or more feet higher than the basin with a fairly definite escarpment.

The central floor of the basin is a rolling plain of low relief, but outward toward the Highland Rim escarpment relief increases, and numerous outliers of the Highland Rim stand 200 to 400 feet above the basin floor. As the highly irregular Highland Rim escarpment is approached, the outliers increase in number and height and are ultimately replaced by spurs of the Highland Rim projecting into the basin.

The Ordovician limestones, shales, dolomite, siltstone, sandstone, and claystone that form the floor of the basin dip away from its center in all directions, but at such a low angle that they appear nearly flat. Average dips on the flanks of the dome are about 15 feet per mile and rarely exceed 25 feet. The Cumberland River cuts across the northern end of the structure, and it may be that its sharp bend to the northwest is a result of downdip migration of the stream course (Thornbury, 1963).

Numerous springs occur in these limestones, some of them large. They contain clear, cold, hard water as a rule, however, some contain sulfur. During the dry seasons many of the weaker springs and smaller streams go dry.

Caves in the basin are located in exposures of highly soluble limestones. The limestones are discontinuous and broken by numerous deposits of shale.

## MISSISSIPPI EMBAYMENT

The westernmost physiographic region of Tennessee is called the Mississippi Embayment. This province is a broad west-sloping plain extending to the Mississippi River. Although the region as a whole constitutes a sloping plain, the general surface is marked by numerous small ridges and drainage divides caused by stream erosion.

The underlying formations consist of a thick series of essentially unconsolidated sands, gravel, silt, clays and loess from Cretaceous to Quaternary periods.

The western edge of the Mississippi Embayment consists of a narrow aluvial plain called the Mississippi Flood Plain. Here river laid deposits of sand, silt, and clay of the Quaternary period are found. The width of the plain varies from about 34 miles in the Reelfoot Lake area to approximately 10 miles in the Memphis area.

## III. COLLECTING TECHNIQUES

Information for each species of crayfish was compiled from the collections of the author, the United States National Museum (USNM), and the collection of Joseph F. Fitzpatrick, Jr.

Various collecting techniques are employed to obtain crayfishes, depending on the habitat(s) of the species. The collecting methods can be categorized as they pertain to three very broad habitats--hypogean waters, burrows, epigean waters.

### HYPOGEAN CRAYFISH

Hypogean waters will here be defined as those occuring in caves, sinkholes, etc. The hypogean species are easily collected with a D-ring dip net. A carbide lamp mounted on a helmet is a convenient light source. Cave species are most commonly in the open water or under rocks. But due to the high humidity of caves, it is not unusual to see individuals out of water.

In hypogean waters too deep to wade, specimens may be obtained by scuba diving with a dip net or setting traps. Using a lift net or a baited line and dip net are other possibilities. To trap crayfish a cylindrical minnow trap with a funnel opening at each end and baited with meat scraps, fish, cheese, etc. can be used.

## BURROWING CRAYFISH

Burrowers are here divided into three categories based upon their propensity to dig. Since all crayfish burrow when the water table drops, only those forms that burrow during "normal" conditions will be categorized. Of special note are a number of species in the Mississippi Embayment province occupying small lentic habitats that typically dry up. These forms are well adapted to this mode of life and the drying of their habitat can be considered "normal."

Primary burrowers are those species that typically complete their life cycles within a burrow. Although occasional adults or a number of juveniles may be found outside the burrow, researching these species entails removal of specimens from burrows.

Secondary burrowers are defined as those species that can be collected both within surface waters and in burrows, although large adults may be more common in burrows. These species may burrow due to lack of sufficient substrate cover, during ovigeration, or due to the temporary nature of their small lentic habitats as indicated above. Most species within the Mississippi Embayment province are secondary burrowers.

Tertiary burrowers are those species that occupy surface waters at all times during the year. Ovigerous females can be collected without digging. These forms usually dig short

burrows into the bank, although complex burrows in the bank are not uncommon.

Unfortunately some burrowers will not strictly fit any one category and may be listed as secondary and tertiary burrowers, etc.

Five methods of obtaining burrowers have yielded some measure of success in Tennessee. Much time and effort is saved by only working fresh burrows since they are more likely to be inhabited. The methods are as follows: (1) trapping, (2) inducing the crayfish to come to the surface of the burrow, (3) collecting at night, (4) fishing, and (5) dissecting the burrow.

(1) Traps are made from large cans with a screen funnel at one end and bait either attached to the capped end or placed at the side of the funnel. The burrow is then opened to accomodate the can. Most of the can must be below the water level.

(2) Inducing a crayfish to come to the surface of a burrow is most effective with Cambarus d. diogenes. The chimney is removed and the opening of the burrow is enlarged to permit one's hand to fit into the burrow. Water is poured into the burrow, filling it to the top, and then roiled. A grass stem placed in the top of the burrow indicates the presence of a crayfish when the stem begins to rise up. When the antennae appear a hand is quickly thrust into

the burrow and the crayfish is pinned against the wall and carefully extricated. If negative results are indicated after waiting several minutes, the procedure may be repeated a number of times before patience gives way to another method of capture.

(3) Collecting at night may be advantageous, especially after a rain or during an evening of high humidity. The crayfish may be wandering about or sitting at the mouths of their burrows or in a small pool that has inundated the burrow. A flashlight will reveal the presence of the burrower. A pole to "plug" the entrance may help detain specimens near the mouth of a flooded burrow since the crayfish will dart to the safety of its burrow.

(4) Fishing for crayfish is done in flooded burrows by inserting a line with a split shot and bait down to the greatest possible depth. The burrow is opened large enough to permit the hand to be placed inside. Several dozen lines may be set out at once. The lines are checked periodically. If a crayfish is felt taking the bait, the line is slowly retrieved. When the crayfish is near the top, a hand is quietly inserted into the burrow and the crayfish pinned against the wall and removed.

(5) Often the only method that produces any results is the careful dissection of the burrow. With a shovel and trowel, the burrow and chambers are methodically opened

until a crayfish is uncovered or the burrow terminates.

## EPIGEAN CRAYFISH

Epigean crayfish have been collected with dip nets, seines, traps, and chemicals depending on the habitat. The most successful methods are with a D-ring dip net and/or seine. Dip nets are usually used by the author because of their greater maneuverability by a single person and ease of carrying through brush, etc. The dip net is used (1) under rocks as they are lifted, (2) placed downstream from a rock in areas of sufficient current, (3) placed next to the bank for kicking, or (4) used to shovel pockets of leaf litter onto the bank for examination. The dip net can also be used at night with a flashlight to capture certain species that are in burrows during the day. Seines are especially useful since they cover much more area than a dip net. Seining is often the most successful method in lentic habitats that are not choked with vegetation.

The other two methods, traps and chemicals, have rarely been used by the author. Trapping is useful in deep pools or areas of dense vegetation. This method is covered in the section on hypogean crayfish.

While collecting fish with sodium cyanide it is noted that a few crayfish are uncharacteristically seen walking in open water. Small forms, such as Orconectes compressus and

Cambarus friaufi, which inhabit the interstices of the substrate were slightly immobilized on the bottom or on rocks at the air-water interphase and easily collected. If a specimen is dropped, it will swim a short distance and is then easily retrieved. Since large amounts of this chemical are needed to immobilize crayfish, consequent adverse effects on the fish's cytochrome system preclude the use of this compound as a collecting technique.

Collected specimens are placed in quart jars which are carried in two army canteen holders attached to an army field belt. Carrying two quart jars into the field allows one jar to be used for live specimens (kept for photographs or males to molt into form one). The other jar for specimens to be preserved contains only water and subsequently enough formaldehyde is added to make a 10 per cent formalin solution. Plastic quart jars should be used in collecting hypogean environments to assure against breakage. Before specimens are catalogued, they are rinsed thoroughly and transferred to 70 per cent ethyl alcohol or 40 per cent isopropyl alcohol. Isopropyl alcohol tends to make the appendages more brittle but better preserves the branchiobdellid (Annelida, Oligochaeta) commensals.

# IV. RESULTS

## NOMINAL SPECIES

Fifty-eight species or subspecies of crayfish have been collected within the state of Tennessee. Two other probable species are included since they occur in neighboring states within drainage systems that flow into Tennessee.

The crayfish fauna of Tennessee is presently divided into five genera (Cambarellus, Cambarus, Fallicambarus, Orconectes, and Procambarus). Two of the genera (Cambarus and Procambarus) have been further divided into subgenera.

Each species is listed under its generic or infrageneric category with the following data: type locality, location of types, crayfish associates, life history notes, ecology, and notes on other pertinent information (size, taxonomic status, etc.).

Type localities are not necessarily in the original notation of the author. Misspellings (C. girardianus) and errors in correct locality (O. erichsonianus) are listed properly. Localities that have been more exactly defined (C. carolinus, C. extraneus, O. lancifer, etc.) are given.

Locations of types have been abbreviated. Appendix C lists the full name of these abbreviations.

The list of crayfish associates contains actual and

probable associates. I have been conservative in adding these probable associates to make the list more complete since a good deal of sampling still remains. Introduced populations that do not appear established (C. shoupi) have no associates included from outside their native range. Introduced populations that are established (C. girardianus, O. virilis) have associates included.

Primary burrowers have not been included in epigean crayfish associate lists although is is not uncommon to collect occasional burrowers in surface streams. Conversely, no epigean species have been included in the list of primary burrowers.

Life history notes may be misleading since they are based on available collections rather than a complete ecological study. In general, the optimum period to collect in Tennessee is September to April. During these months form one males can be obtained in numbers. Most females will be found carrying eggs during the spring. In the sand and clay bottom streams of West Tennessee, collecting appears to be more successful in the spring when the water is turbid. Crayfish are more likely to be out in these open environments at this time unless one collects at night. Species that prefer dense vegetation are more common when these growths are luxurient. Hypogean waters are more easily collected during the summer and fall when water levels are lowest.

Ecological data on habitat preference refer to areas typically occupied by the species. Since crayfish have a wide adaptability, it is possible to find occasional specimens in a broad range of environments. Records of troglo-xenes are not reported since crayfish are photonegative and will not hesitate to enter caves.

Keys have been devised to allow classification without the use of form one males wherever possible, although form one males are applicable.

Form one males are distinguished from juveniles and form two males by the presence of one or more yellowish corneous elements on the distal end of the first pleopod, typically the central projection. These appendages extend from the base of the abdomen forward to lie against the thorax. The first pleopods of juveniles and second form males are of the same texture, lacking the corneous material, and are more blunt, lacking the finer contour of the form one male pleopod.

Terms used in the keys are defined in the glossary (Appendix D). Pleopod terminology is more easily understood through illustrations than through descriptions. The form one pleopods of the Tennessee genera are illustrated in Figure 2 (Appendix E).

A chela that is regenerated will not fit the keys. Re-generated chelae can be recognized by their disproportionately

short palm, long fingers, and general misshaping.

## Key to the Genera of Tennessee Crayfish

(Based on males)

1 First pleopod terminating in only two distinct elements.....2

1' First pleopod terminating in three or more distinct elements.....4

2(1) Central projection recurved at angle of 90° or more, if less than 90° (*Cambarus bouchardi*, *C. obeyensis*, *C. pristinus*), shorter than one fifth total length of pleopod (never recurved less than 45°).....3

2' Central projection recurved at angle less than 45°, if greater than 45°, longer than one fifth total length of pleopod.....*Orconectes* (p. 63)

3(2) Opposable margin of dactyl with prominent excision.....*Fallicambarus* (p. 61)

3' Opposable margin of dactyl without prominent excision, may be slight concavity in *C. d. diogenes*.....*Cambarus* (p. 23)

4(1') Hooks on ischiopodites of second and third pereiopods; first pleopod with three elements; rarely longer than 2 to 3 centimeters.....*Cambarellus* (p. 21)

4' Hooks on ischiopodites of third and fourth pereiopods; first pleopod with four elements.....Procambarus (p. 81)

Genus Cambarellus Ortmann, 1905a: 97

Type, designated by Ortmann, 1905a: 106, Cambarus montezumae Saussure.

Diagnosis: "First pleopod of first form male terminating in three distinct parts; the cephalic process is always absent; the three terminals may be spiniform, somewhat truncate, spatulate or even trough-like. In the male hooks are present on the ischiopodites of the second and third pereiopods. Third maxillipeds proportionally of normal size, with a row of teeth along the inner margin of the ischiopodite." (Hobbs, 1942: 350)

Key to Tennessee Cambarellus

1 Elements of first pleopod of male curved..puer (p. 21)

1' Elements of first pleopod of male straight.....shufeldtii (p. 22)

Cambarellus puer Hobbs, 1945: 469

Type locality: Roadside ditch 7 miles west of Dayton at U.S. 90, Liberty County, Texas.

Location of types: Primary types--USNM; paratypes--ANSP, MCZ, TU, USNM.

Range: Mississippi Flood Plain and western edge of Mississippi Embayment.

Crayfish associates: Cambarellus shufeldtii, Orconectes immunis, O. lancifer, O. p. palmeri, Procambarus a. acutus, P. clarkii, P. viaeviridis.

Life history notes: Form one males--April and June; ovigerous females--April and June.

Ecology: Sluggish streams and lentic habitats (i.e., swamps, ditches, sloughs, ponds, etc.). Secondary burrower.

Notes: Due to their small size (rarely longer than 2 to 3 centimeters), Cambarellus are often overlooked as juveniles of larger species.

Cambarellus shufeldtii (Faxon, 1884: 134)

Type locality: Near New Orleans, Louisiana.

Location of types: Syntypes--USNM.

Range: Mississippi Flood Plain and western edge of Mississippi Embayment.

Crayfish associates: Cambarellus puer, Orconectes immunis, O. lancifer, O. p. palmeri, P. a. acutus, P. clarkii, P. viaeviridis.

Life history notes: Form one males--April, June, July; ovigerous females--July.

Ecology: Sluggish streams and lentic habitats (i.e., swamps, ditches, sloughs, ponds, etc.). Secondary burrower.

Notes: See Cambarellus puer.

Genus Cambarus Erichson 1846: 88

Type, designated by Faxon, 1398: 644, Astacus bartonii Fabricius.

Diagnosis: "Mesial margin of palm of chela with row of fewer than 12 tubercles or spines except in albinistic species in which there are more; opposable margin of dactyl never with prominent excision, except occasionally in C. d. diogenes. Ischiopodite of third pereiopod of male with hook. Coxa of fourth pereiopod with prominent caudomesial boss. Unless albinistic, antennal scale more than twice as long as broad. First pleopod of first form male symmetrical and terminating in two or three distinct parts (mesial process, central projection and occasionally a caudal knob; cephalic process always absent), two prominent ones bent caudad or caudolaterad between 45 and 100 degrees or with central projection corneous and 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 slightly distal to base; caudal element seldom present, but occasionally represented by knob-like prominence at caudolateral base of central projection." (Hobbs, 1969: 94)

## Key to the Subgenera of Tennessee *Cambarus*

(Based on males)

1 Albinistic; eyes reduced.....*Aviticambarus* (p. 26)

1' Pigmented; eyes well developed.....2

2(1') Antennae conspicuously bearded; lateral margin of chela with spines.....*Barbicambarus* (p. 28)

2' Antennae not conspicuously bearded; lateral margin of chela without spines.....3

3(2') Chela with conspicuous long setae.....*Jugicambarus* (in part) (p. 45)

3' Chela without conspicuous long setae.....4

4(3') Width and length of palm of chela equal.....*Veticambarus* (p. 59)

4' Width of palm of chela distinctly greater than length.....5

5(4') Areola densely punctate.....6

5' Areola with scattered punctations.....7

6(5) Fingers of chela with poorly defined longitudinal ridges, usually strongly gaping basally, with conspicuous tuft of setae basally.....*Hiaticambarus* (p. 40)

6' Fingers of chela with well defined longitudinal ridges, gaping slightly basally, without tuft of setae basally.....*Puncticambarus* (p. 57)

7(5') Areola obliterated.....8

7' Areola not obliterated.....9

8(7) Mesial margin of palm with two complete rows of tubercles; carapace vaulted....Lacunacambarus (p. 55)

8' Mesial margin of palm with one complete row of tubercles; carapace not vaulted.....Jugicambarus (in part, see gentryi) (p. 45)

9(7') Suborbital angle rounded or obsolete.....10

9' Suborbital angle acute.....11

10(9) Lateral margin of dactyl with prominent tubercles; never with tubercles on lateral margins of rostrum; occurs in lower Blue Ridge province.....Depressicambarus (in part, see latimanus) (p. 33)

10' Lateral margin of dactyl without prominent tubercles; tubercles present on lateral margins of rostrum in Cambarus rusticiformis; occurs in Western Highland Rim east to western part of Cumberland Plateau.....Erebicambarus (p. 37)

11(9') Mesial margin of palm with two complete rows of tubercles.....12

11' Mesial margin of palm with one complete row of tubercles.....13

12(11) Chela broadly triangular, strongly depressed; does not occur in streams draining Lookout Mountain.....Depressicambarus (p. 33)

12' Chela subrectangular, not strongly depressed;

occurs in streams draining Lookout Mountain.....
.....Jugicambarus (in part, see unestami) (p. 45)

13(11') Areola width goes into length less than six times; tertiary burrowers and/or epigean species.....14

13' Areola width goes into length greater than six times; primary burrowers.....Jugicambarus (in part, see carolinus and dubius) (p. 45)

14(13) Mesial margin of palm with well developed row of serrate tubercles; chela subrectangular, fingers with high longitudinal ridges; occurs in Cumberland Plateau and western edge of Ridge and Valley province including the Clinch and Powell River systems.....Jugicambarus (in part, see distans and parvoculus) (p.45)

14' Mesial margin of palm with row of low rounded tubercles; chela triangular, fingers with low longitudinal ridges; occurs in Blue Ridge and Ridge and Valley provinces.....Cambarus (p. 30)

Subgenus Aviticambarus Hobbs, 1969: 99

Diagnosis: "Eyes reduced and without pigment. Antennae not heavily fringed on mesial border. Rostrum with marginal spines, margins not thickened. Postorbital and cervical spines (latter multiple in C. hamulatus and sometimes obsolete in C. jonesi) well developed. Suborbital angle lacking.

Branchiostegal spine strong. Areola moderately broad (5.4-8.0 times longer than wide), constituting 40.0-45.0 per cent of entire length of carapace and with many moderately deep punctations. Chela slender and elongate; mesial surface of palm with scattered or several rows of tubercles and dorsal surface polished or with setiferous punctations; lateral margin of fixed finger weakly costate with row of setiferous punctations but never bearing row of spines; fingers not gaping and with well defined longitudinal ridges dorsally; proximal opposable margin of dactyl never deeply concave; conspicuous tuft of setae never present at mesial base of fixed finger, lateral base never deeply impressed. First form male with coxa of fourth pereiopod lacking large ventral setiferous pit on caudomesial boss; first pleopods comparatively widely separated basally and with distal portion of shaft almost straight or undulating but never inclined caudad; terminal elements consisting of (1) long, blade-like tapering central projection with shallow subterminal notch recurved at no less than 90 degrees to shaft, (2) long, comparatively slender mesial process directed caudad or curved throughout length with apex pointed proximad; caudal knob lacking." (Hobbs, 1969: 99)

Cambarus (A.) hamulatus Cope and Packard, 1881: 881

Type locality: Nickajack Cave, Marion County, Tennessee.

Location of types: Syntypes--MCZ.

Range: Caves draining the Cumberland Plateau into the Tennessee River system from Walden Gorge west to Franklin County.

Crayfish associates: Cambarus tenebrosus.

Life history notes: Form one males--August and September.

Ecology: Troglobite in subterranean waters. Hay (1902b) reported collecting C. hamulatus mainly under rocks in cave streams.

Subgenus Barbicambarus Hobbs, 1969: 98

Diagnosis: "Eyes moderately large with dorsal extension of stalk-exoskeleton into faceted area unusually deep. Antennae heavily fringed on mesial border. Rostrum with thickened margins and dorsally directed marginal spines. Postorbital and cervical spines strong. Suborbital angle lacking. Branchiostegal spine absent. Areola broad (4.4-5.3 times longer than wide), constituting 34.7-38.4 per cent of entire length of carapace and with scattered, shallow punctations. Chela comparatively long and of moderate width; mesial surface of palm with single row of spiniform tubercles and dorsal surface polished and punctate;

lateral margin of fixed finger strongly costate and bearing row of spines; fingers not gaping and with well defined longitudinal ridges dorsally; proximal opposable margin of dactyl never deeply concave; tuft of setae frequently present at mesial base of fixed finger, lateral base of finger somewhat depressed, distinctly so ventrally. First form male with coxa of fourth pereiopod bearing large ventral setiferous pit on caudomesial boss. First pleopods of first form male widely separated at base with distal portion of shaft inclined caudad; terminal elements consisting of (1) very short, distally rounded central projection curved caudad at much more than right angle to basal portion of shaft of appendage, (2) truncate, partially cornified mesial process bearing finger-like projection reaching caudad beyond tip of central projection." (Hobbs, 1969: 98)

Cambarus (B.) cornutus Faxon, 1884: 120

Type locality: Green River near Mammoth Cave, Edmonson County, Kentucky.

Location of types: Holotype (male I)--MCZ.

Range: Barren River system.

Crayfish associates: Cambarus friaufi, C. rusticiformis, C. striatus, C. tenebrosus, Orconectes barrenensis, O. compressus, O. putnami.

Life history notes: Form one males--November.

Ecology: Predominantly under medium sized to very large limestone slabs in the main current of large streams and rivers.

Notes: Cambarus cornutus is the largest species in the state. The largest known specimen has a total carapace length of 76.8 mm (62.4 mm postorbital carapace length).

Subgenus Cambarus Fowler, 1912: 341

Diagnosis: "Eyes of moderate size and pigmented. Antennea not heavily fringed on mesial border. Rostrum without marginal spines or tubercles, margins usually moderately thickened. Postorbital and cervical spines absent or vestigial. Suborbital angle present except in C. ortmanni. Branchiostegal spine present although sometimes reduced. Areola moderatley broad (4.2-6.5 times longer than wide) except in C. ortmanni (35.0-44.0), constituting 34.0-38.8 per cent and sparsely to moderately punctate. Chela not strongly depressed, with moderately broad, short palm; mesial surface of palm usually with single row of low tubercles, if second row present, those tubercles strongly adpressed, dorsal surface punctate; lateral margin of fixed finger of chela costate with row of punctations but never bearing row of spines; fingers sometimes gaping and with well defined longitudinal ridges dorsally, proximal opposable margin of dactyl never deeply concave; conspicuous tuft of setae never present at mesial base of fixed finger, lateral base never

deeply impressed. First form male with coxa of fourth pereiopod lacking large ventral setiferous pit on caudomesial boss; first pleopods contiguous at base and with distal portion of shaft almost straight, never inclined caudad; terminal elements consisting of (1) blade-like, only slightly tapering central projection recurved at no less than 90 degrees to shaft, and bearing subapical notch, (2) non-corneous bulbiform mesial process directed caudolaterad or caudad and usually somewhat proximad, reaching caudad about same level as central projection, contracted apical portion sometimes with two or more small prominences, (3) caudal knob usually obsolete, sometimes represented by slight eminence." (Hobbs, 1969: 109)

Cambarus (C.) bartonii (Fabricius, 1798: 407)

Type locality: North America. Restricted by Faxon (1914: 423) as "probably neighborhood of Philadelphia, Pennsylvania."

Location of types: Not extant.

Range: Blue Ridge and Ridge and Valley provinces. Occasionally penetrates the eastern edge of the Cumberland Plateau.

Crayfish associates: Cambarus asperimanus, C. conasaugaensis, C. distans, C. latimanus, C. longirostris, C. extraneus, C. parvoculus, C. robustus, Orconectes

erichsonianus, O. forceps, O. spinosus, O. virilis, Procambarus lophotus.

Life history notes: Form one males--January, March to December; ovigerous females---April and June; copulating pair--October.

Ecology: Predominantly a headwater species in pools under rocks, in vegetation, leaf litter, etc. Common in small to medium size mountain streams. In the Ridge and Valley province it prefers springs and small to medium size streams. Tertiary burrower into the stream bank but can often be found burrowing some distance from surface water. Also found in caves as a troglophile, ponds, and burrowing in marshy areas.

Notes: The subspecies C. b. cavatus and C. b. carinirostris are here synonymized with C. bartonii. Examination of topotypic cavatus has revealed no characters that will separate this form from the nominal subspecies. The other form, carinirostris, which is found in West Virginia consists of populations with an occasional specimen having a low carina on the rostrum. The majority of specimens are indistinguishable from C. bartonii. The carina, therefore, seems an insufficient character to designate these populations as subspecies.

Subgenus Depressicambarus Hobbs, 1969: 102

Diagnosis: "Eyes variable in size and pigmented. Antennea not heavily fringed on mesial border. Rostrum without marginal spines or tubercles except in C. halli, C. obstipus, and some populations of C. striatus (juveniles of others may have them) and margins seldom thickened. Postorbital and cervical spines rare except in C. halli and C. latimanus. Suborbital angle obsolete except in C. sphenoides and C. striatus. Branchiostegal spines, if present, reduced. Areola width highly variable (3.1-28.4 times longer than broad) and, except in C. halli (28.9-33.0 per cent) and occasional specimens of C. sphenoides (32.8-37.0 per cent), 37.0-42.0 per cent of entire length of carapace and usually bearing few shallow punctations, punctations numerous in C. halli. Chela broadly triangular, strongly depressed and with mesial margin of palm comparatively short; mesial surface of palm with at least two rows of tubercles, dorsal surface tuberculate or punctate; lateral margin of broad fixed finger strongly costate and punctate but never bearing row of spines; fingers never widely gaping but with well defined longitudinal ridges dorsally, proximal opposable margin of dactyl never deeply concave; conspicuous tuft of setae never present at mesial base of fixed finger, lateral base flattened. First form male with coxa of fourth pereiopod lacking large ventral setiferous pit on caudomesial boss;

first pleopods almost contiguous at base and with distal portion of shaft almost straight, never inclined caudad; terminal elements consisting of (1) blade-like, broad or tapering (sometimes subsetiform) central projection recurved 90 or more degrees to main shaft and occasionally forming arc of 100 degrees, subapical notch may or may not be present, (2) mesial process often bulbiform variously directed, and may or may not exceed tip of central projection caudally, contracted apical portion sometimes with two or more short projections, (3) caudal knob vestigial or absent" (Modified from Hobbs, 1969: 102)

Key to Tennessee Depressicambarus

1 Cephalic margin of epistomal zygoma gently curved.....striatus (p. 36)

1' Cephalic margin of epistomal zygoma distinctly arched.....2

2(1') Areola obliterated; color deep blue.....cymatilis (p. 35)

2' Areola moderately wide; color green, green-brown, brown.....3

3(2') Suborbital angle broadly rounded or obsolete; occurs in headwaters of Ocoee River system in Polk County.....latimanus (p. 35)

3' Suborbital angle acute; occurs in Cumberland Plateau.....sphenoides (p. 36)

Cambarus (D.) cymatilis Hobbs, 1970b: 251

Type locality: Near western city limits of Chatsworth off Chestnut Street, Murray County, Georgia.

Location of types: USNM.

Range: Ridge and Valley province of the Conasauga River system.

Crayfish associates: Cambarus d. diogenes.

Life history notes: Form one males--April (Georgia); ovigerous females--April (Georgia).

Ecology: Primary burrower.

Notes: Cambarus cymatilis has not been collected in Tennessee. Its proximity to the Tennessee border within the Conasauga River system is the reason for its inclusion here.

Cambarus (D.) latimanus (LeConte, 1856: 402)

Type localtiy: Athens, Clarke County, Georgia.

Location of types: Syntypes--ANSP, MCZ.

Range: Headwaters of Ocoee River system in the Ridge and Valley province.

Crayfish associates: Cambarus bartonii.

Life history notes: Form one males--October.

Ecology: Small to medium size streams, predominantly in pool areas under rocks, in leaf litter, etc. Secondary burrower.

Cambarus (D.) sphenoides Hobbs, 1968: 262

Type locality: Tributary to Clear Creek 11.2 miles north of Crossville at US 127, Cumberland County, Tennessee.

Location of types: USNM.

Range: Cumberland Plateau.

Crayfish associates: Cambarus distans, C. obeyensis, C. parvoculus, C. pristinus.

Life history notes: Form one males--April and July to November; ovigerous females--April and August; females with young--July.

Ecology: Small to large streams predominantly in pool areas under rocks, in leaf litter, etc. Tertiary burrower.

Cambarus (D.) striatus Hay, 1902b: 437

Type locality: Nashville, Davidson County, Tennessee.

Location of types: Syntypes--MCZ, USNM.

Range: Western Highland Rim, Nashville Basin, Eastern Highland Rim, and western edge of the Cumberland Plateau.

Crayfish associates: Cambarus brachydactylus, C. cornutus, C. distans, C. friaufi, C. girardianus, C. parvoculus, C. rusticiformis, C. tenebrosus, Orconectes alabamensis, O. barrenensis, O. compressus, O. erichsonianus, O. forceps, O. mirus, O. placidus, O. putnami, O. rhoadesi, O. shoupi, O. spinosus, Procambarus a. acutus.

Life history notes: Form one males--February, March,

May, July, October to December; ovigerous females--March and July.

Ecology: Small to large streams predominantly in pool areas under rocks, in leaf litter, etc. Tertiary burrower.

Notes: A large species with a specimen collected from the state measuring 68.6 mm total carapace length (59.7 mm postorbital carapace length).

Subgenus Erebicambarus Hobbs 1969: 99

Diagnosis: "Eyes small except in C. rusticiformis and pigmented except in C. hubrichti. Antennae not heavily fringed on mesial border. Rostrum with or without marginal tubercles, margins not markedly thickened except in C. rusticiformis. Postorbital and cervical spines or tubercles present or absent. Suborbital angle usually absent, obtuse if present. Branchiostegal spine rudimentary or absent except in C. hubrichti. Areola moderatley broad to narrow (4-16 times longer than wide), constituting 37.8-44.0 per cent (40.0-44.0 per cent except in C. rusticiformis) of entire length of carapace and bearing many shallow punctations. Entire chela stocky, not depressed, with comparatively long palm; mesial surface of palm usually with single row of tubercles, second row present or absent in C. laevis, otherwise punctate; lateral margin of fixed finger of chela somewhat costate with row of punctations but never bearing row of spines; fingers robust, never widely gaping but with well

defined longitudinal ridges dorsally, proximal opposable margin of dactyl never deeply concave; conspicuous tuft of setae never present at mesial base of fixed finger, lateral base never deeply impressed. First form male with coxa of fourth pereiopod lacking large ventral setiferous pit on caudomesial boss; first pleopods almost contiguous at base, except in C. rusticiformis, and with distal portion of shaft almost straight, never inclined caudad; terminal elements consisting of (1) blade-like central projection not markedly tapering apically, recurved at slightly more than 90 degrees to shaft and bearing subapical notch, (2) subconical mesial process recurved at angle greater than 90 degrees and sometimes extending farther caudad than central projection; caudal knob obsolete." (Hobbs, 1969: 99)

Key to Tennessee Erebicambarus

1 Tubercles present on lateral margin of rostrum; suborbital angle acute.....rusticiformis (p. 38)

1' Tubercles not present on lateral margin of rostrum; suborbital angle broadly rounded or obsolete.....tenebrosus (p. 39)

Cambarus (E.) rusticiformis Rhoades, 1944: 133

Type locality: Little River, 0.5 miles west of Cadiz, Trigg County, Kentucky.

Location of types: Primary--USNM; paratypes--MCZ, RR.

Range: Typically a species of the Cumberland and Barren River systems on the Eastern and Western Highland Rims. A well established population in the Paint Rock River system (Alabama and Tennessee) is separated from other known localities by a decided gap and probably should be interpreted as an introduction.

Crayfish associates: Cambarus friaufi, C. striatus, C. tenebrosus, Orconectes compressus, O. erichsonianus, O. mirus, O. placidus.

Life history notes: Form one males--March to May, July, August, October, November; ovigerous females--April.

Ecology: Rhoades (1944: 133) reports rusticiformis to be an inhabitant of fast water. This species, however, is found in pools as well as riffles of small streams to rivers.

Cambarus (E.) tenebrosus Hay, 1902a: 232

Type localtiy: Echo River, Mammoth Cave, Edmonson County, Kentucky.

Location of types: Syntypes--USNM.

Range: Western Highland Rim, Nashville Basin, Eastern Highland Rim, and western part of Cumberland Plateau.

Crayfish associates: Cambarus brachydactylus, C. cornutus, C. girardianus, C. hamulatus, C. parvoculus,

C. rusticiformis, C. striatus, Orconectes alabamensis, O. a. australis, O. a. packardi, O. barrenensis, O. compressus, O. erichsonianus, O. forceps, O. incomptus, O. mirus, O. pellucidus, O. placidus, O. putnami, O. rhoadesi, O. shoupi, O. spinosus, O. validus.

Life history notes: Form one males--January, March, April, July, August, October to December; ovigerous females--March and July.

Ecology: Predominantly a headwater species in subterranean streams as a troglophile and in springs. Also found in spring streams and small streams to rivers, especially near spring and cave outflows. Found in all sections of the stream under rocks, in vegetation, leaf litter, etc. Tertiary burrower.

Notes: A large species with a specimen collected from the state measuring 59.2 mm total carapace length (52.0 mm postorbital carapace length).

Subgenus Hiaticambarus Hobbs, 1969: 105

Diagnosis: "Eyes of moderate size and pigmented. Antennae not heavily fringed on mesial border. Rostrum with thickened margins and with or without marginal spines or tubercles. Postorbital and cervical spines or tubercles present or absent. Suborbital angle present or absent, sometimes acute. Branchiostegal spine reduced to very weak spine or tubercle. Areola broad (2.3-6.0 times longer than

wide), constituting 32.0-38.0 per cent of entire length of carapace and bearing crowded, deep punctations. Chela moderately heavy and usually with slender fingers, both palm and fingers with deep punctations; mesial surface with single row of low tubercles; lateral margin of fixed finger weakly costate and bearing row of punctations; fingers strongly gaping and with poorly defined longitudinal ridges dorsally; conspicuous tuft of setae generally present at mesial base of fixed finger, lateral base somewhat depressed. First form male with coxa of fourth pereiopod lacking large ventral setiferous pit on caudomesial boss; first pleopods contiguous, or almost so, basally, and with distal portion of shaft almost straight, never inclined caudad; terminal elements consisting of (1) blade-like, distally notched or entire central projection curved more than at right angle to main shaft, (2) swollen, caudolaterally directed mesial process extending caudad no farther than tip of central projection, (3) caudal process vestigial or absent." (Hobbs, 1969: 105)

Key to Tennessee Hiaticambarus

1 Tubercles present on lateral margin of rostrum.....girardianus (p. 42)

1' Tubercles absent on lateral margin of rostrum.....longirostris (p.43 )

Cambarus (H.) girardianus Faxon, 1884: 117

Type locality: Cypress Creek, Lauderdale County, Alabama.

Location of types: Syntypes--MCZ, USNM.

Range: Tennessee River system from Hardin County east to Franklin County.

Crayfish associates: Cambarus striatus, C. tenebrosus, Orconectes alabamensis, O. compressus, O. erichsonianus, O. spinosus.

Life history notes: Form one males--March, April, June, October to December; ovigerous females--April.

Ecology: Small streams to rivers. Principally a riffle inhabitant although found in all parts of streams under rocks, etc.

Notes: The possession of rostral tubercles separates C. girardianus from C. (H.) longirostris. Some specimens of C. girardianus lack these tubercles and many populations of Hiaticambarus in southern East Tennessee have rostrums which lack tubercles or possess tubercles in various sizes. A large series of "longirostris" from DeKalb County, Alabama, typically lacks tubercles on the rostrum with the exception of several specimens possessing a single tubercle on one side. It is the opinion of the author that the two species will prove to be conspecific, but until the study of these forms is completed it is unwise to synonymize them.

Cambarus (H.) longirostris Faxon, 1885: 64

Type locality: Eastern Tennessee and West Virginia. Restricted by Ortmann (1931: 121) as Doe River, Elizabethton, Carter County, Tennessee.

Location of types: Holotype (male form II)--MCZ.

Range: Blue Ridge province, Ridge and Valley province, and eastern edge of Cumberland Plateau including the Sequatchie Valley.

Crayfish associates: Cambarus bartonii, C. distans, C. extraneus, C. parvoculus, C. robustus, Orconectes erichsonianus, O. forceps, O. spinosus, Procambarus lophotus.

Life history notes: Form one males--January to December; ovigerous females--March to June; females with young--June.

Ecology: Small streams to rivers. Principally a riffle inhabitant although found in all parts of streams under rocks, etc.

Subgenus Jugicambarus Hobbs, 1969: 106

Diagnosis: "Eyes small and pigmented except in troglobitic species. Antennae not heavily fringed on mesial border; antennal scale of troglobitic species less than twice as long as broad. Rostrum rarely with marginal spines or tubercles and with or without thickened margins. Postorbital and cervical spines present or absent, latter conspicuous only in troglobitic C. setosus. Suborbital angle

present or absent. Branchiostegal spine usually small or absent. Areola broad to linear (3.8 to 29.0 times longer than wide), constituting 33.0-46.2 per cent of entire length of carapace and sparsely to densely punctate. Chela subrectangular and rather short except in troglobitic species and somewhat depressed only in burrowing species; mesial surface of palm with single serrate or cristiform row of tubercles, occasionally with weak second row above and as many as three rows in troglobitic species, dorsal surface usually deeply pitted and both palm and fingers frequently bearing conspicuous setae; fingers never widely gaping and with well defined longitudinal ridges dorsally, proximal opposable margin of dactyl never deeply concave; conspicuous tuft of setae never present at mesial base of fixed finger, lateral base never deeply impressed. First form male with coxa of fourth pereiopod lacking large ventral setiferous pit on caudomesial boss; first pleopods contiguous, or almost so, basally and with distal portion of shaft almost straight or with cephalic convexity, never inclined caudad; terminal elements consisting of (1) blade-like, usually tapering central projection, sometimes with subapical notch and recurved as little as 55 degrees to shaft but most often much more and occasionally forming arc of 155 degrees, (2) subconical, usually long mesial process frequently extending farther caudad than central projection, (3) caudal knob

seldom conspicuous, usually reduced or lacking." (Bouchard, in press)

Key to Tennessee Jugicambarus

1 Elements of first pleopod reflected caudally at an angle less than 90 degrees.....2

1' Elements of first pleopod reflected caudally at an angle equal to or greater than 90 degrees.....3

2(1) Found in Roaring Paunch Creek system in Scott County.....bouchardi (p. 47)

2' Found in headwaters of East Fork of Obey River.....obeyensis (p. 53)

3(1') Two complete rows of tubercles on palm..... .....unestami (p. 54)

3' One complete row of tubercles on palm.....4

4(3') Chelae with conspicuous long setae.....5

4' Chelae without conspicuous long setae.....7

5(4) Suborbital angle rounded or obsolete; occurs in the Blue Ridge province.....asperimanus (p. 47)

5' Suborbital angle acute; occurs in the Highland Rims.....6

6(5') Palm of chela as long as or longer than dactyl.....brachydactylus (p. 47)

6' Palm of chela distinctly shorter than dactyl.....friaufi (p. 51)

7(4') Areola obliterated; occurs in Nashville Basin and Western Highland Rim.....gentryi (p. 52)

7' Areola not obliterated; does not occur in the Nashville Basin or Western Highland Rim.....8

8(7') Areola width goes into length less than six times (tertiary burrowers and/or epigean forms).....9

8' Areola width goes into length greater than six times (primary burrowers).....11

9(8) Suborbital angle rounded or obsolete.....conasaugaensis (p. 49)

9' Suborbital angle acute.....10

10(9') Annulus ventralis with wide cephalomedian trough, caudal wall distinctly much higher than cephalic portion.....parvoculus (p. 53)

10' Annulus ventralis with narrow cephalomedian trough flanked by longitudinal ridges, caudal wall little higher than cephalic portion.....distans (p. 50)

11(8') Color red or bright red-brown; occurs in Blue Ridge province from French Broad River system south.....carolinus (p. 48)

11' Color blue or brown to brown-red with blue legs; occurs in upper Cumberland Plateau and Ridge and Valley provinces and upper Blue Ridge Ridge province south to the Nolichucky River system.....dubius (p. 50)

Cambarus (J.) asperimanus Faxon, 1914: 391

Type locality: Flat Creek, Montreat, Buncombe County, North Carolina.

Location of types: Syntypes--USNM.

Range: Watauga to Little Tennessee River systems in the Blue Ridge province.

Crayfish associates: Cambarus bartonii, C. robustus.

Life history notes: Form one males--May to October; ovigerous females--April to June and December.

Ecology: Primarily in mountain seeps and small to medium size streams under rocks, etc. Tertiary burrower.

Cambarus (J.) bouchardi Hobbs, 1970b: 245

Type locality: Perkins Creek 6.9 miles north of Oneida at US 27, Scott County, Tennessee.

Location of types: USNM, UT.

Range: Roaring Paunch Creek.

Crayfish associates: No nominal species.

Life history notes: Form one males--April, July, September.

Ecology: Small to medium size streams under rocks, etc. Tertiary burrower.

Cambarus (J.) brachydactylus Hobbs, 1953: 20

Type locality: Louise Creek 13.9 miles south of

Clarksville at Tennessee 48, Montgomery County, Tennessee.

Location of types: Primary--USNM; paratypes--MCZ, USMN, TU.

Range: Tributaries of the Cumberland River on the Western Highland Rim.

Crayfish associates: Cambarus striatus, C. tenebrosus, Orconectes compressus, O. placidus.

Life history notes: Form one males--March, April, November; ovigerous females--March and April.

Ecology: Prefers gravel substrate in moving water where it makes short burrows. The collector walking in the stream bed can feel the loose gravel where the species occurs. Specimens have also been collected under rocks, in leaf litter, and in burrows under rocks at the shore.

Notes: Cambarus brachydactylus is separated from C. (J.) friaufi by the former's densly punctate areola, form one male pleopod lacking a caudal knob, and chela having a palm longer than or equal to the length of the dactyl. On the Western Highland Rim there are populations possessing characters of both species. It is likely C. friaufi will be reduced to a subspecies or synonym of C. brachydactylus. See C. (J.) friaufi for notes on size.

Cambarus (J.) carolinus (Erichson, 1846: 96)

Type locality: Along small creek at County Road 113,

1.3 miles east of County Road 92, Greenville County, South Carolina.

Location of types: Not extant.

Range: Blue Ridge province from French Broad River system south.

Crayfish associates: No primary burrowers.

Life history notes: Form one males--April and October; females with young--July and August.

Ecology: Primary burrower although occasional specimens are collected in streams. Occurs in montane to submontane spring seeps and the shore of small to medium size streams. Can often be collected in spring seeps under rocks or moss, etc.

Cambarus (J.) conasaugaensis Hobbs and Hobbs, 1962: 41

Type locality: Small tributary of Conasauga River 2.0 miles east of Chatsworth at US 72, Murray County, Georgia.

Location of types: USNM.

Range: Conasauga and Hiwassee River systems in the Blue Ridge province.

Crayfish associates: Cambarus bartonii.

Life history notes: Form one males--January, April, June, November; ovigerous females--June.

Ecology: Primarily mountain seeps and small streams under rocks, etc. Tertiary burrower.

Cambarus (J.) distans Rhoades, 1944: 136

Type locality: Cumberland River and small tributary above Cumberland River Falls (Falls Branch), McCreary County, Kentucky.

Location of types: Primary--USNM; paratypes--CM, USNM, RR.

Range: Upper Cumberland Plateau bordered by the Emory River system on the south and Obey and Wolf River systems on the west. Also occurs in the Clinch and Powell River systems of the Ridge and Valley province.

Crayfish associates: Cambarus bartonii, C. longirostris, C. parvoculus, C. sphenoides, Orconectes erichsonianus, O. forceps, O. placidus, O. spinosus.

Life history notes: Form one males--February, April, June to December.

Ecology: Small to large streams under rocks, in leaf litter, etc. Especially common in the smaller to medium size streams. Frequently burrows into the stream bank as a tertiary burrower.

Cambarus (J.) dubius Faxon, 1884: 114

Type locality: Cranberry Summit, Preston County, West Virginia.

Location of types: MCZ.

Range: Cumberland Plateau as far south as the Emory

River system, Ridge and Valley province south to mouth of Clinch River, and Blue Ridge province south to Nolichucky River system.

Crayfish associates: Cambarus d. diogenes.

Life history notes: Form one males--March, April, October, December; ovigerous females--May.

Ecology: Primary burrower although occasional specimens are collected in streams. May burrow in the stream bank or some distance from the stream. Found burrowing in spring habitats. Often collected without digging by turning large rocks and logs on the shore that extend into the water table.

Notes: This species was placed in synonymy with C. carolinus by Hay (1902c). Recent examinations of topotypic carolinus and dubius have shown the two to be distinct species. The presence of a subapical notch on the shorter pleopod of dubius is the outstanding character.

Cambarus (J.) friaufi Hobbs, 1953: 24

Type locality: Snow Creek at Elmwood, Smith County, Tennessee.

Location of types: Primary--USNM; paratypes--MCZ, USNM.

Range: Cumberland River system in the Eastern and Western Highland Rims.

Crayfish associates: Cambarus rusticiformis,

C. striatus, C. tenebrosus, Orconectes barrenensis, O. compressus, O. placidus, O. putnami.

Life history notes: Form one males--February to April, October, November; ovigerous females--March.

Ecology: See C. (J.) brachydactylus.

Notes: The brachydactylus - friaufi "complex" represents one of the smaller species groups known from the state. The largest known individual has a total carapace length of 25.8 mm (23.3 mm postorbital carapace length).

Cambarus (J.) gentryi Hobbs, 1970a: 163

Type locality: Boggy area below seepage along small tributary to Turnbull Creek 1.0 mile west of Kingston Springs, Cheatham County, Tennessee.

Location of types: USNM.

Range: Nashville Basin and Western Highland Rim.

Crayfish associates: Cambarus d. diogenes.

Life history notes: Form one males--March to May, October, November.

Ecology: Primary burrower although specimens are often collected under rocks at the edge of springs or small to medium size streams. Frequently found burrowing into the banks of springs.

Cambarus (J.) obeyensis Hobbs and Shoup, 1947: 138

Type locality: Big Hurricane Creek on Montgomery-Clark Range Road.

Location of types: Primary--USNM; paratypes--MCZ, TU, USNM.

Range: East Fork of the Obey River.

Crayfish associates: Cambarus parvoculus, C. sphenoides, Orconectes placidus.

Life history notes: Form one males--April and July; ovigerous females--April.

Ecology: Small to medium size streams under rocks, in leaf litter, etc. Tertiary burrower.

Cambarus (J.) parvoculus Hobbs and Shoup, 1947: 142

Type locality: Small tributary to Big Hurricane Creek, Fentress County, Tennessee.

Location of types: Primary--USNM; paratypes--MCZ, TU, USNM.

Range: Cumberland Plateau, western edge of Ridge and Valley province including the Clinch River system.

Crayfish associates: Cambarus bartonii, C. distans, C. longirostris, C. obeyensis, C. pristinus, C. sphencides, C. tenebrosus, Orconectes erichsonianus, O. forceps, O. spinosus, Procambarus lophotus.

Life history notes: Form one males--March, April, July to November; ovigerous females--February and April.

Ecology: See C. distans.

Cambarus (J.) unestami Hobbs and Hall, 1969: 287

Type locality: Daniel Creek 2.5 miles west of Walker County line on Georgia 143, Dade County, Georgia.

Location of types: USNM.

Range: Known only from tributaries of Lookout and Chattanooga Creeks on the Cumberland Plateau (Lookout Mountain).

Crayfish associates: None

Life history notes: Form one males--April, May, October, November; ovigerous females--May.

Ecology: Predominantly in small to medium size streams under rocks, in leaf litter, etc. and in short burrows in the stream banks as a tertiary burrower.

Notes: There are no permanent tributaries of Lookout or Chattanooga Creeks in Tennessee. Both creeks, however, flow into Tennessee with the Georgia tributaries nearby. It seems highly probable that occasional specimens of this species may be collected in Tennessee.

Cambarus unestami was originally placed in the subgenus Puncticambarus but has been moved to Jugicambarus based on relationships with an as yet undescribed member of the latter subgenus (Bouchard, in press).

Subgenus Lacunicambarus Hobbs, 1969: 110

Diagnosis: "Eyes reduced and pigmented. Antennae not heavily fringed on mesial border. Rostrum without marginal spines or tubercles and with margins moderately thickened. Postorbital and cervical spines absent. Suborbital angle present, usually subacute. Branchiostegal spine reduced to small tubercle or absent. Areola obliterated or linear along much of its length and constituting 36.9-45.0 per cent (usually at least 40.0) of entire length of carapace. Chela moderately robust, not strongly depressed with palm comparatively short; mesial surface of palm with two or more rows of tubercles, dorsal surface tuberculate mesially and punctate laterally; lateral margin of fixed finger of chela subcostate with punctations but never bearing row of spines; fingers gaping and with moderately well defined longitudinal ridges dorsally, proximal opposable margin of dactyl deeply concave; conspicuous tuft of setae never present at mesial base of fixed finger, lateral base never deeply impressed. First form male with coxa of fourth pereiopod lacking large ventral setiferous pit on caudomesial boss; first pleopods contiguous at base and with distal portion of shaft almost straight; terminal elements consisting of (1) short, broad, blade-like, distally truncate or rounded central projection recurved at about 90 degrees to shaft, (2) swollen mesial process variously shaped and directed and frequently bearing

one to four small tuberculiform prominences apically, (3) often rudimentary caudal knob at caudolateral base of central projection." (Hobbs, 1969: 110)

Cambarus (L.) diogenes diogenes Girard, 1852:88

Type locality: Vicinity of Washington, D.C.

Location of types: Not known to be extant except a questionable paratype.

Range: Known from across Tennessee with the exception of the higher elevations of the Blue Ridge province.

Crayfish associates: Only possible primary burrower associates are listed as follows: Cambarus cymatilis, C. dubius, C. gentryi, Fallicambarus fodiens, F. hedgpethi, F. hortoni.

Life history notes: Form one males--March to July, November, December; ovigerous females--March, April, June; females with young--May.

Ecology: Primary burrower although individuals are often collected in streams, springs, or ponds.

Notes: Marlow (1960) studied the range and variations of Cambarus diogenes. Several systematists have questioned Marlow's conclusions concerning the ranges and number of taxa warranting recognition. Since C. diogenes has a large range and requires further study, I will here follow Marlow to avoid adding any further confusion to the issue.

Subgenus Puncticambarus Hobbs, 1969: 101

Diagnosis: "Eyes large, except in the troblobitic C. nerterius, and pigmented. Antennea not heavily fringed on mesial border. Rostrum with or without marginal spines or tubercles and margins not conspicuously thickened. Post-orbital and cervical spines usually present (cervical spines lacking in C. species C). Suborbital angle usually present and often acute. Branchiostegal spines strong. Areola broad (2.1-6.2) times longer than wide and less than 5.1 in all but C. nerterius and C. robustus), constituting 30.3-40.0 per cent of entire length of carapace and bearing many, usually shallow, punctations. Chela elongate, somewhat depressed and with mesial margin of palm moderately long; mesial surface of palm with two rows of tubercles, dorsal surface tuberculate or punctate; lateral margin of fixed finger costate and punctate but never bearing row of spines; fingers never widely gaping but with well defined longitudinal ridges dorsally, proximal opposable margin of dactyl never deeply concave; conspicuous tuft of setae never present at mesial base of fixed finger, lateral base conspicuously impressed dorsally and ventrally. First form male with coxa of fourth pereiopod lacking large ventral setiferous pit on caudomesial boss. First pleopods nearly contiguous basally and with distal portion of shaft almost straight, never inclined caudad; terminal elements consisting

of (1) blade-like central projection not markedly tapering apically, with subapical notch and recurved caudad at approximately 90 degrees to shaft, (2) bulbiform mesial process variously directed and reaching caudad about same level as central projection, (3) caudal knob obsolete or, if present, vestigial." (Hobbs, 1969: 101)

Key to Tennessee Puncticambarus

1 Tubercles present on lateral margin of rostrum.....extraneus (p. 58)

1' Tubercles absent on lateral margin of rostrum.....robustus (p. 59)

Cambarus (P.) extraneus Hagen, 1870: 101

Type locality: "Tennessee River, Georgia." The Tennessee River proper does not enter Georgia. This species is known only from South Chickamauga Creek in Georgia and Tennessee. There are then two possible interpretations of the type locality. (1) Tennessee River near the mouth of South Chickamauga Creek, Hamilton County, Tennessee. (2) Tributary of Tennessee River (South Chickamauga Creek system) in Georgia.

Location of types: Syntypes--MCZ, USNM.

Range: South Chickamauga Creek.

Crayfish associates: Cambarus bartonii, C. longirostris, Orconectes erichsonianus, O. forceps, Procambarus lophotus.

Life history notes: Form one males--April and May (Georgia).

Ecology: Springs and small to medium size streams under rocks, in vegetation, etc.

Cambarus (P.) robustus Girard, 1852: 90

Type localtty: Humber River, near Toronto, Canada.

Location of types: Not extant.

Range: Blue Ridge province as far south as the French Broad River system.

Crayfish associates: Cambarus asperimanus, C. bartonii, C. longirostris, Orconectes erichsonianus, O. forceps, O. spinosus.

Life history notes: Form one males--January, March to June, August to November; ovigerous females--June and July; females with young--August.

Ecology: Small to large streams. Typically found in the larger streams under rocks, etc.

Subgenus Veticambarus Hobbs, 1969: 96

Diagnosis: "Eyes very large and pigmented. Antennae not heavily fringed on mesial border. Rostrum without marginal spines or tubercles, margins not thickened. Post-orbital and cervical spines weak. Suborbital angle acute. Branchiostegal spine small. Areola very broad (1.8-2.3 times longer than wide), constituting 30.0-33.3 per cent of

entire length of carapace and with many shallow punctations. Chela Procambarus-like, elongated and subovate in cross section with elongated palm; mesial surface of palm with at least two rows of tubercles, dorsal surface with punctations and studded with squamous tubercles; lateral margin of fixed finger somewhat costate with row of setiferous punctations but never bearing row of spines; fingers not gaping and with well defined longitudinal ridges dorsally; proximal opposable margin of dactyl never deeply concave; conspicuous tuft of setae never present at mesial base of fixed finger, lateral base never deeply impressed. First form male with coxa of fourth pereiopod lacking large ventral setiferous pit on caudomesial boss; first pleopods almost contiguous basally and with distal portion of shaft slightly recurved but not inclined caudad; terminal elements consisting of (1) short, blade-like central projection, with subterminal notch recurved at 80-85 degrees to shaft, (2) thumb-like process directed caudodistad and somewhat laterad and extending caudad beyond tip of central projection, (3) caudolaterally situated tuberculiform caudal knob." (Hobbs, 1969: 96)

Cambarus (V.) pristinus Hobbs, 1965: 268

Type locality: White Oak Creek 3.9 miles east of White-Cumberland County line at US 70S and 0.1 miles south on gravel road, Cumberland County, Tennessee.

Location of types: Primary--USNM, paratypes--MCZ, USNM.

Range: Tributaries of Caney Fork River on the Cumberland Plateau.

Crayfish associates: Cambarus parvoculus, C. sphenoides, C. tenebrosus.

Life history notes: First form males--April, August, October; ovigerous females--April; copulating pair--October.

Ecology: Small to large streams under rocks, in vegetation, etc.

Genus Fallicambarus Hobbs, 1969: 111

Type species, Cambarus strawni Reimer, 1966: 111

Diagnosis: "Mesial margin of palm of chela with row of fewer than 12 tubercles; opposable margin of dactyl usually with prominent excision. Areola linear or obliterated. Antennal scale more than twice as long as broad. First pleopods of first form male symmetrical and terminating in two or three distinct parts (mesial process, central projection and, occasionally, cephalic process; caudal element always absent) bent caudad or caudomesiad at angle greater than 95 degrees to main shaft or forming broad arc; central projection corneous, blade-like or tapering (but flattened laterally) and lacking, except in F. byersi, subapical notch; non-corneous mesial process never bulbiform but appearing twisted and usually with eminence on cephalic (morphological) border slightly distal to base; cepahlic process small, at

least partially corneous, situated mesially at base of mesial process and directed caudad or caudodistad." (Hobbs, 1969: 111)

Key to Tennessee Fallicambarus

1 Areola obliterated.....2

1' Areola with room for at least one punctation..... .....fodiens (p. 62)

2(1) Annulus ventralis with wide cephalomedian trough.....hedgpethi (p. 63)

2' Annulus ventralis with wide cephalolaterad trough.....hortoni (p. 63)

Fallicambarus fodiens (Cottle, 1863: 217)

Type locality: "Indigenous to this Province..." Huntsman (1915) restricted the type locality to Ontario.

Location of types: Not extant.

Range: Mississippi Embayment province and penetrating the Western Highland Rim, and southern parts of the Nashville Basin and Eastern Highland Rim as far east as Lincoln County.

Crayfish associates: Cambarus d. diogenes.

Life history notes: Form one males--March; ovigerous females--March.

Ecology: Primary burrower although it is not uncommon to find individuals in surface waters.

Fallicambarus hedgpethi (Hobbs, 1948c: 224)

Type locality: Lower middle part of the Aransas National Wildlife Refuge, Aransas County, Texas.

Location of types: USNM.

Range: Mississippi Embayment province.

Crayfish associates: Cambarus d. diogenes.

Life history notes: Form one males--March and April.

Ecology: See F. fodiens.

Fallicambarus hortoni Hobbs and Fitzpatrick, 1970: 829

Type locality: Low area along roadside ditch leading to tributary of Cypress Creek 7.5 miles east of the Hardeman County line at Tennessee 57, McNairy County, Tennessee

Location of types: Primary--USNM; paratypes--USNM, JFF.

Range: Known only from McNairy County in the Hatchie River system.

Crayfish associates: Cambarus d. diogenes.

Life history notes: Form one males--April.

Ecology: See F. fodiens.

Genus Orconectes Cope, 1872: 419

Type, by monotypy, Orconectes inermis Cope

Diagnosis: "First pleopod of first form male terminating in two distinct parts, both parts ending in straight or gently curved, short or long spines (occasionally

the central projection, 'outer part,' terminates in a blade-like process). Never is a strongly developed shoulder present on the cephalic margin near the tip of the appendage. the central projection is corneous while the mesial process is usually much softer. In the male, hooks are generally present on the ischiopodite of the third pereiopod only, but occasionally they are present on that of the third and fourth pereiopods. Third maxillipeds of normal size with a row of teeth along the inner margin of the ischiopodite." (Hobbs, 1942: 350)

## Key to Groups of Tennessee Orconectes

(Based on males)

1 Albinistic.....Group A (p. 65)

1' Pigmented.....2

2(1') Both elements of first pleopods distinctly shorter than one half total length of pleopod.....Group B (in part, see shoupi and wrighti (p. 67)

2' Both elements of first pleopod subequal or longer than one half total length of pleopod.....3

3(2') Both elements curved, at least at distal end.....Group D (p. 75)

3' At least one element straight.....4

4(3') Margins of rostrum concave....Group C (in part)(p. 69)

4' Margins of rostrum convex or subparallel.....5

5(4') First pleopods reach base of first pair of pereiopods.....Group C (in part) (p. 69)

5' First pleopods reach base of second pair of pereiopods.....Group B (in part, see erichsonianus) (p. 67)

Key to Tennessee Orconectes Group A

1 First pleopod without shoulder at cephalic base of central projection; occurs in Pennyroyal Plateau of Western Highland Rim.....pellucidus (p. 67)

1' First pleopod with shoulder at cephalic base of central projection; occurs in western edge of Cumberland Plateau and Nashville Basin in Jackson County.....2

2(1') Rostrum without marginal spines or tubercles..... .....incomptus (p. 67)

2' Rostrum with marginal spines or tubercles.....3

3(2') Hooks usually absent on ischiopodites of fourth pereiopods.....a. australis (p. 65)

3' Hooks usually present on ischiopodites of fourth pereiopods.....a. packardi (p. 66)

Orconectes Group A

Orconectes australis australis (Rhoades, 1941: 142)

Type locality; Shelta Cavern north of Huntsville, Madison County, Alabama.

Location of types: Primary--USNM; paratypes--AMNH, ANSP, LH, RR.

Range: Western edge of the Cumberland Plateau. Intergrades with O. a. packardi near the Tennessee-Kentucky border.

Crayfish associates: Cambarus tenebrosus.

Life history notes: Form one males--January to December; ovigerous females--June to September, November.

Ecology: Subterranean waters.

Orconectes australis packardi Rhoades, 1944: 121

Type locality: Cumberland Crystal Cave (Sloans Valley Cave), Sloans Valley, Pulaski County Kentucky.

Location of types: Primary--USNM; paratypes--MCZ, USNM, RR.

Range: Western edge of the Cumberland Plateau near the Kentucky border. Intergrades with O. a. australis south of this area.

Crayfish associates: Cambarus tenebrosus.

Life history notes: Form one males--January to March, June, August to October (Kentucky); ovigerous females--June (Tennessee); female with young--January (Kentucky).

Ecology: Subterranean waters.

Orconectes incomptus Hobbs and Barr, 1972: 32

Type locality: Cherry Cave latitude 36° 28' 09" N, longitude 85° 36' 28" W, Jackson County, Tennessee.

Location of types: Primary--USNM; paratypes--USNM, HHH III.

Range: Nashville Basin in Jackson County, Tennessee.

Crayfish associates: Cambarus tenebrosus.

Life history notes: Form one males--August.

Ecology: Subterranean waters.

Orconectes pellucidus (Tellkampf, 1884: 383)

Type locality: Mammoth Cave, Edmonson County, Kentucky.

Location of types: Holotype (male form I)--ZBM.

Range: Pennyroyal Plateau of the Western Highland Rim in Montgomery and Robertson Counties.

Crayfish associates: Cambarus tenebrosus.

Life history notes: Form one males--February to August, October to November (Kentucky and Tennessee); ovigerous females--September (Kentucky).

Ecology: Subterranean waters.

Key to Tennessee Orconectes Group B

1 Margins of rostrum distinctly concave...shoupi (p. 68)

1' Margins of rostrum straight or convex.....2

2(1') Two rows of tubercles on palm; no conspicuous setal tufts on chela.....*erichsonianus* (p. 68)

2' One row of tubercles on palm; very conspicuous setal tufts on chela.....*wrighti* (p. 69)

*Orconectes* Group B

*Orconectes erichsonianus* (Faxon, 1898: 659)

*Type locality*: Roaring Fork 5.0 miles northwest of Greeneville, Greene County, Tennessee.

*Location of types*: Syntypes--MCZ, USNM.

*Range*: Ridge and Valley province west through Walden Gorge to Elk River system.

*Crayfish associates*: *Cambarus bartonii*, *C. extraneus*, *C. girardianus*, *C. longirostris*, *C. parvoculus*, *C. robustus*, *C. rusticiformis*, *C. striatus*, *C. tenebrosus*, *Orconectes forceps*, *O. mirus*, *O. rhoadesi*, *Procambarus lophotus*.

*Life history notes*: Form one males--January, April, August, September, November; ovigerous females--April.

*Ecology*: Small to medium size streams in pool areas, under rocks, in leaf litter, etc.

*Orconectes shoupi* Hobbs, 1948a: 14

*Type locality*: Mill Creek east of Oglesby near Antioch Pike, 10.0 miles south of Nashville, Davidson County, Tennessee.

Location of types: Primary--USNM; paratypes--MCZ, USNM.

Range: Known only from the type locality and Big Creek in Giles County (Elk River system). The latter locality, represented by one specimen, is extralimital and assuredly represents an introduction.

Crayfish associates: Only associates from the Mill Creek system are listed. Cambarus rhoadesi, C. striatus, C. tenebrosus.

Life history notes: Form one males--March, April, July October (Giles County, Tennessee), November.

Orconectes wrighti Hobbs, 1948b: 85

Type locality: Robinson Creek at Tennessee 57, Hardin County, Tennessee.

Location of types: USNM.

Range: Western tributaries of the Tennessee River in the Mississippi Embayment province.

Crayfish associates: Procambarus ablusus, P. a. acutus.

Life history notes: Form one males--March, September, October.

Ecology: Small to medium size streams in riffle and pool areas, under rocks, in leaf litter, etc.

Key to Orconectes Group C

1 First pleopods reach base of first pair of pereiopods.....2

1' First pleopods reach base of second pair of pereiopods.....3

2(1) Occurs in Barren River system.....putnami (p. 74)

2' Occurs in Tennessee River system from ascending arm of Tennessee River (Wayne County) upstream to Ridge and Valley province.....spinosus (p. 74)

3(1') Two weakly developed rows of tubercles on palm; base of fingers not widely gaping.....4

3' Two well developed rows of tubercles on palm; base of fingers widely gaping.....5

4(3) Occurs in Barren River system.....barrenensis (p. 70)

4' Occurs in Tennessee River system from Shoal Creek (Wayne County) east to Paint Rock River system.....mirus (p. 72)

5(3') Occurs in Cumberland, Duck, and tributaries of ascending arm of Tennessee River.....placidus (p. 73)

5' Occurs in Tennessee River system from Cypress Creek (Wayne County) east to Ridge and Valley province.....forceps (p. 71)

Orconectes Group C

Orconectes barrenensis Rhoades, 1944: 125

Type locality: Barren River, Beech Bend, 2.0 miles north of Bowling Green, Warren County, Kentucky.

Location of types: USNM.

Range: Barren River system.

Crayfish associates: Cambarus cornutus, C. friaufi, C. rusticiformis, C. striatus, C. tenebrosus, Orconectes compressus, O. putnami.

Life history notes: Form one males--February to April, November; ovigerous females--March.

Ecology: Small streams to rivers in pool and especially riffle areas, under rocks, etc.

Notes: Orconectes barrenensis has been listed as a subspecies of O. rusticus. Orconectes barrenensis, O. mirus, and an undescribed form in the Cumberland River system are distinct from O. rusticus and are more closely related to one another than to O. rusticus. There is no evidence of hybridization between O. rusticus and any of the three species listed above.

Orconectes forceps (Faxon, 1884: 133)

Type locality: Cypress Creek, Lauderdale County, Alabama.

Location of types: Syntypes--MCZ, USNM.

Range: Ridge and Valley and Blue Ridge provinces west through Walden Gorge to Cypress Creek, Wayne County, Tennessee.

Crayfish associates: Cambarus bartonii, C. extraneus, C. girardianus, C. longirosrtis, C. parvoculus, C. robustus,

C. striatus, C. tenebrosus, Orconectes alabamensis, O. compressus, O. erichsonianus, O. mirus, O. spinosus, O. validus, O. virilis.

Life history notes: Form one males--March to May, August, October, November; ovigerous females--April.

Ecology: Small streams to rivers. More common in the larger streams, especially in riffle areas, under rocks, etc.

Notes: Separation of O. forceps and O. placidus requires a more thorough study. Both species are here tentatively recognized and their ranges defined according to contiguous river systems that include the type locality.

Orconectes mirus (Ortmann, 1931: 81)

Type locality: Hurricane Creek, Cumberland Springs, Moore County, Tennessee.

Location of types: Syntypes--CM.

Range: Tributaries of the Tennessee River from Shoal Creek to the Paint Rock River system.

Crayfish associates: Cambarus girardianus, C. rhoadesi, C. rusticiformis, C. striatus, C. tenebrosus, Orconectes alabamensis, O. erichsonianus, O. forceps, O. spinosus, O. validus.

Life history notes: Form one males--March, May to November; ovigerous females--March.

Ecology: Small streams to rivers. Common in riffle

areas under rocks, etc., but also found in pools.

Notes: See O. barrenensis.

Orconectes placidus (Hagen, 1870: 65)

Type locality: Lebanon, Wilson County, Tennessee.

Location of types: Syntypes--MCZ, USNM.

Range: Western Highland Rim, Nashville Basin, Eastern Highland Rim, and western edge of the Cumberland Plateau except those tributaries of the Tennessee River from Cypress Creek eastward.

Crayfish associates: Cambarus brachydactylus, C. friaufi, C. parvoculus, C. rhoadesi, C. rusticiformis, C. striatus, C. tenebrosus, Orconectes compressus.

Life history notes: Form one males--March, May to November; ovigerous females--March.

Ecology: Small streams to rivers. Common in riffles as well as pool areas of streams under rocks, in leaf litter, etc.

Notes: Separation of O. forceps and O. placidus requires a more thorough study. Both species are here tentatively recognized and their ranges defined according to contiguous river systems that include the type localtiy.

Orconectes putnami (Faxon, 1884: 131)

Type locality: Bear Creek, Grayson Springs, Grayson County, Kentucky.

Location of types: Syntypes--MCZ, USNM.

Range: Barren River system.

Crayfish associates: Cambarus cornutus, C. friaufi, C. rusticiformis, C. striatus, C. tenebrosus, Orconectes barrenensis, O. compressus.

Life history notes: Form one males--March, June, August, November, December; female with eggs--March.

Ecology: Small streams to rivers. Especially in pool areas under rocks, etc.

Notes: The status of O. putnami and O. spinosus was doubted by Ortmann and both were later synonymized with O. juvenilis by Rhoades (1944) and Fitzpatrick (1969) respectively. All three share the common character of gonopods reaching the first pair of pereiopods. Since this juvenilis "complex" has such a wide range and requires more thorough examination, I list putnami and spinosus as possible species rather than bury them under synonymy of juvenilis.

Orconectes spinosus (Bundy, 1877: 173)

Type locality: Etowah, Oostanaula, and Coosa rivers in the vicinity of Rome, Georgia.

Location of types: Syntypes--MCZ, USNM.

Range: Tributaries of the ascending arm of the Tennessee River in Wayne County upstream to the Ridge and Valley province.

Crayfish associates: Cambarus bartonii, C. girardianus, C. longirostris, C. robustus, C. striatus, C. tenebrosus, Orconectes alabamensis, O. compressus, O. forceps, O. mirus, O. validus, Procambarus a. acutus.

Life history notes: Form one males--February to May, August, October to December; ovigerous females--March to May; copulating pair--October.

Notes: See O. putnami.

Key to Tennessee Orconectes Group D

1 Areola obliterated.....2

1' Areola narrow to wide.....3

2(1) Acumen length more than one half length of rostrum.....lancifer (p. 77)

2' Acumen length less than one half length of rostrum.....palmeri (p. 78)

3(1') Areola width goes into length less than five times.....4

3' Areola width goes into length more than five times.....5

4(3) Body compressed laterally; rostrum narrow with carina.....compressus (p. 76)

4' Body not compressed laterally; rostrum wide and flat with low carina.....alabamensis (p. 76)

5(3') Deep excision at base of opposable margin of dactyl; occurs in western edge of Mississippi Embayment.....immunis (p. 78)

5' Base of opposable margin of dactyl lacking deep excision; does not occur in western edge of Mississippi Embayment.....6

6(5') Well developed tubercles on lateral margin of dactyl; occurs in Douglas Lake and tributaries..... .....virilis (p. 80)

6' Tubercles on lateral margin of dactyl not well developed.....7

7(6') Occurs in Nashville Basin.....rhoadesi (p. 79)

7' Occurs in tributaries of Tennessee River on Western Highland Rim.....validus (p. 80)

Orconectes Group D

Orconectes alabamensis (Faxon, 1884: 125)

Type locality: Second Creek, Waterloo, Lauderdale County, Alabama.

Location of types: Syntypes--MCZ, USNM.

Range: Tennessee River on the Western Highland Rim from Shoal Creek downstream to the Buffalo River.

Crayfish associates: Cambarus girardianus, C. striatus,

C. tenebrosus, Orconectes compressus, O. forceps, O. spinosus.

Life history notes: Form one males--March, October, November; ovigerous females--March.

Ecology: Small to medium size streams especially in pools under rocks, etc. More common in springs under rocks, in vegetation, etc.

Orconectes compressus (Faxon, 1884: 127)

Type locality: Second Creek, Waterloo, Lauderdale County, Alabama.

Location of types: Syntypes--MCZ, USNM.

Range: Western Highland Rim. This species has penetrated the Duck River upstream to the Eastern Highland Rim although it is not very common in the Nashville Basin because of substrate preference (gravel).

Crayfish associates: Cambarus brachydactylus, C. cornutus, C. friaufi, C. girardianus, C. rusticiformis, C. striatus, C. tenebrosus, Orconectes alabamensis, O. barrenensis, O. forceps, O. placidus, O. putnami, O. spinosus, O. validus, Procambarus a. acutus.

Life history notes: Form one males--March, April, September to December; ovigerous females--March and April.

Ecology: Small to large gravel bottom streams where the species digs short tunnels in the substrate. Also occurs under rocks, in leaf litter, etc., in pools as well as riffles.

Notes: Orconectes compressus is one of the smaller species in the state. The largest known specimen has a total carapace length of 26.3 mm (21.3 mm postorbital carapace length).

Orconectes immunis (Hagen, 1870: 71)

Type locality: Lawn Ridge, Marshall County, Illinois.

Location of types: Syntypes--MCZ.

Range: Western edge of Mississippi Embayment province.

Crayfish associates: Orconectes lancifer, O. p. palmeri, Procambarus a. acutus, P. clarkii, P. viaeviridis.

Life history notes: Form one males--March, June, July.

Ecology: Sluggish to moderatley flowing streams and lentic habitats (i.e., lakes, ponds, roadside ditches, etc.) Especially common in small ponds. Secondary and tertiary burrower.

Orconectes lancifer (Hagen, 1870: 59)

Type locality: Rocky Ford near Etta, Union County, Mississippi (See Penn, 1939: 215).

Location of types: Holotype--MCZ.

Range: Western edge of the Mississippi Embayment province.

Crayfish associates: Orconectes immunis, O. p. palmeri, Procambarus a. acutus, P. clarkii, P. viaeviridis.

Life history notes: Form one males--June, August; ovigerous females--occupy burrows while carrying eggs.

Ecology: Sluggish streams and lentic habitats (i.e., roadside ditches, canals, ponds, bayous, etc.). Secondary burrower.

Orconectes palmeri palmeri (Faxon, 1884: 124)

Type locality: Creek at eastern side of Reelfoot Lake, Obion County, Tennessee.

Location of types: Syntypes--MCZ, USNM.

Range: Mississippi River tributaries in the Mississippi Embayment province.

Crayfish associates: Orconectes immunis, O. lancifer, Procambarus ablusus, P. a. acutus, P. clarkii, P. hayi, P. viaeviridis, P. vioscai.

Life history notes: Form one males--March, June, July, September; ovigerous females--occupy burrows while carrying eggs.

Ecology: Sluggish to moderately flowing streams and lentic habitats (i.e., roadside ditches, canals, ponds, bayous, etc.). Secondary burrower.

Orconectes rhoadesi Hobbs, 1949: 19

Type locality: Otter Creek between Granny White Pike and Hillsboro Pike, approximately 7.0 miles south of Nashville, Davidson County, Tennessee.

Location of types: USNM.

Range: Nashville Basin.

Crayfish associates: Cambarus girardianus, C. striatus, C. tenebrosus, Orconectes erichsonianus, O. forceps, O. mirus, O. placidus, O. shoupi.

Life history notes: Form one males--March to May, September to November; ovigerous females--March and April.

Ecology: Small to medium size streams. Usually more common in leaf litter or under bankings than under rocks.

Orconectes validus (Faxon, 1914: 382)

Type locality: Huntsville, Madison County, Alabama.

Location of types: Holotype--MCZ.

Range: Eastern Highland Rim of the Tennessee River system at Huntsville, Alabama, downstream to the Kentucky border and up the Cumberland River to Montgomery County.

Crayfish associates: Cambarus tenebrosus, Orconectes compressus, O. mirus, O. placidus, O. spinosus.

Life history notes: Form one males--March to May, September to November; ovigerous females--March and April.

Ecology: Small to medium size streams with a gravel substrate, under rocks, etc.

Orconectes virilis (Hagen, 1870: 63)

Type locality: Lake Superior.

Location of types: Holotype--MCZ; paratypes--AMS, MCZ, MHNP, WM.

Range: Douglas Lake.

Crayfish associates: Cambarus bartonii, Orconectes forceps.

Life history notes: Form one males--January to March; ovigerous females--March.

Ecology: Tributaries of Douglas Lake, but more common in the lake.

Notes: This species has been introduced into the lake, probably by a fisherman. The normal range of this species is north of the Ohio River. A population introduced into Maryland (see Schwartz et. al., 1963) is reported replacing some native species because of its aggressiveness. Tributaries of Douglas Lake in which O. virilis has been taken lack C. longirostris and O. erichsonianus, two common species. A survey of the Douglas Lake area in 1969 shows the species limited to tributaries of the western shore of the lake between Goose Creek and Koontz Creek near Dandridge. Cambarus bartonii is the only species found in creeks with O. virilis. Cambarus bartonii occurs with O. virilis in the native range of the latter species.

Genus Procambarus Ortmann 1905b: 437

Type, designated by Hobbs, 1942: 341, Cambarus digueti Bouvier.

Diagnosis: "First pleopod of first form male terminating in from two to five distinct parts which may be truncate, plate-like or spiniform. Shoulders present or absent on cephalic surface of distal third. If the pleopod terminates in only two parts this shoulder is always present. Hooks present on the ischiopodites of the third or of the third and fourth pereiopods in the male. Third maxillipeds of normal size bearing row of teeth along the inner margin of the ischiopodite." (Hobbs, 1942: 342)

Key to Subgenera of Tennessee Procambarus

1 Two cervical spines on each side of carapace.....
.....Pennides (p. 87)

1' One cervical spine on each side of carapace.....2

2(1') Areola obliterated; shoulder on cephalic surface of first pleopods.....Scapulicambarus (p. 89)

2' Areola not obliterated; no shoulder on cephalic surface of first pleopods.....Ortmannicus (p. 82)

Subgenus Ortmannicus Fowler, 1912: 341

Diagnosis: "Body pigmented or albinistic, eyes with or without pigment, reduced or well developed. Rostrum with or without marginal spines, tubercles, and median carina. Carapace with or without one cervical spine. Areola obliterated or as wide as 2.9 times longer than broad and

constituting 25 to 43 per cent of entire length of carapace. First three pairs of pereiopods without conspicuous brush of setae extending from basis to merus. Simple hooks on ischia of third and fourth pereiopods, those on fourth sometimes bituberculate. Coxa of fourth pereiopods with bulbous or subangular caudomesial boss. First pleopod reaching coxa of third pereiopod, almost always asymmetrical, lacking or with weak proximomedian lobe and seldom bearing proximomesial spur; shoulder on cephalic surface usually absent, if present, shoulder on right pleopod never folded caudally against mesial surface of mesial lamella of pleopod; subapical setae usually present (absent in Procambarus bivittatus, P. hybus, P. jaculus, and P. lewisi). Terminal elements of first pleopod including subspiculiform to sublanceolate mesial process directed caudally, caudodistally or distally and usually somewhat laterally; setiform, hooklike, or bladelike cephalic process (absent in P. mancus and in some populations of P. viaeviridis) situated cephalic, mesial, or lateral to central projection, and directed caudally, caudodistally, or distally; caudal process and/or caudal knob usually present (both absent in P. toltecae), sometimes vestigial (caudal process bladelike to knoblike, always situated caudally, caudomesially, or caudolaterally; caudal knob highly variable in size and form, varying in position from caudal surface laterally to cephalic surface); and central projection massive to minute, beaklike or

bladelike to dentiform, and directed caudally, caudodistally, or distally. Mesial ramus of uropod with median spine often reduced and never extending beyond margin of ramus." (Hobbs, 1972: 9)

Key to Subgenus Ortmannicus

1 Margin of rostrum without lateral spines.....viaeviridis (p. 86)

1' Margin of rostrum with lateral spines (may be small).....2

2(1') Highest elevation of annulus ventralis located laterally.....acutus (p. 84)

2' Annulus ventralis comparatively flat with high caudomedian elevation.....3

3(2') Occurs in lower East Tennessee.....lophotus (p. 86)

3' Occurs in lower West Tennessee.....hayi (p. 85)

Procambarus (O.) acutus acutus (Girard, 1852: 91)

Type locality: From an affluent of the Mobile River in Kemper County, Mississippi.

Location of types: Lost in the Chicago fire.

Range: Mississippi Embayment province and less common in tributaries of the Tennessee River on the Western Highland Rim upstream to Lincoln County.

Crayfish associates: Cambarellus puer, Cm. shufeldtii,

Orconectes immunis, O. lancifer, O. p. palmeri, O. spinosus, O. validus, O. wrighti, Procambarus ablusus, P. clarkii, P. hayi, P. viaeviridis, P. vioscai.

Life history notes: First form males--April to August, December; ovigerous females--occupy burrows while carrying eggs.

Ecology: Sluggish streams and rivers to large moderately flowing and lentic situations (i.e., swamps, ditches, sloughs, and ponds, etc.). Especially in vegetation, leaf litter, etc. Secondary burrower.

Procambarus (O.) hayi (Faxon, 1884: 108)

Type locality: Macon, Noxbee County, Mississippi.

Location of types: Syntypes--MCZ, USNM.

Range: Hatchie River.

Crayfish associates: Orconectes p. palmeri, Procambarus ablusus, P. a. acutus, P. clarkii.

Life history notes: Form one males--April to August (Mississippi); ovigerous females--occupy burrows while carrying eggs.

Ecology: Sluggish streams and lentic habitats (i.e., swamps, ditches, sloughs, and ponds, etc.). Especially common in small ponds in vegetation, leaf litter, etc. Secondary burrower.

Procambarus (O.) lophotus Hobbs and Walton, 1960: 123

Type locality: Roadside ditch 3.4 miles northeast of Haynesville on Alabama 111, Lowndes County, Alabama.

Location of types: Primary--USNM; paratypes--TU, USNM.

Range: Ridge and Valley province from the Hiwassee River system to Walden Gorge.

Crayfish associates: Cambarus bartonii, C. extraneus, C. longirostris, C. parvoculus, Orconectes erichsonianus, O. spinosus.

Life history notes: Form one males--April and November; ovigerous females--occupy burrows while carrying eggs.

Ecology: Predominantly in small to medium size streams; more common in vegetation, leaf litter, etc. Secondary burrower.

Procambarus (O.) viaeviridis (Faxon, 1914: 370)

Type locality: St. Francis River, Greenway, Clay County, Arkansas.

Location of types: Syntypes--MCZ.

Range: Mississippi Embayment province.

Crayfish associates: Cambarellus puer, Cm. shufeldtii, Orconectes immunis, O. lancifer, O. p. palmeri, Procambarus ablusus, P. a. acutus, P. clarkii.

Life history notes: Form one males--April and June; ovigerous females--occupy burrows while carrying eggs.

Ecology: Sluggish streams and lentic situations (i.e., swamps, ditches, sloughs, and ponds, etc.). Especially in vegetation, leaf litter, etc. Secondary burrower.

Subgenus Pennides Hobbs, 1972: 10

Diagnosis: "Body and eyes pigmented, latter well developed. Rostrum with marginal spines, seldom with median carina. Carapace with two or more cervical spines. Areola 3 to 5 times longer than broad and constituting 25 to 29 per cent of entire length of carapace. First three pairs of pereiopods without conspicuous brush of setae extending from basis to merus. Simple hooks on ischia of third and fourth pereiopods. Coxa of fourth pereiopod with bulbous or subangular caudomesial boss. First pleopod reaching coxa of third pereiopod, asymmetrical, with or without proximomesial spur; seldom with shoulder on cephalic surface; subapical setae present. Terminal elements of first pleopod with caudally to distally directed, slender, usually acute mesial precess; mesially to cephalolaterally situated cephalic process (absent in Procambarus gibbus, P. raneyi, P. spiculifer, and occasionally in P. ouachitae); caudal element variable, typically with caudal knob and process, but sometimes reduced, and occasionally lacking process; and central projection subdentiform to almost bladelike. Mesial ramus of uropod with median spine never

extending markedly beyond margin of ramus, usually not reaching margin." (Hobbs, 1972: 10)

Key to Subgenus Pennides

1 Highest portion of annulus ventralis a caudo-median elevation; occurs in Wolf River system of West Tennessee.....vioscai (p. 89)

1' Highest portion of annulus ventralis two lateral elevations bordering anterior portion of sinus; occurs in Hatchie River system and Robinson Creek, Hardin County, Tennessee.....ablusus (p. 88)

Procambarus (P.) ablusus Penn, 1936: 121

Type locality: Hatchie River 12.1 miles east of Ripley on Mississippi 4, Tippah County, Mississippi.

Location of types: Primary--USNM; paratypes--TU.

Range: Hatchie River system and Robinson Creek, Hardin County, Tennessee.

Crayfish associates: Orconectes p. palmeri, O. wrighti, Procambarus a. acutus, P. clarkii, P. hayi, P. viaeviridis.

Life history notes: Form one males--May; ovigerous females--occupy burrows while carrying eggs.

Ecology: Sluggish streams and rivers to moderately flowing rivers. Secondary burrower.

Notes: The Robinson Creek locality may possibly be

interpreted as being the result of stream capture due to its proximity to the Hatchie River system.

Procambarus (P.) vioscai Penn, 1946: 27

Type locality: Big Creek at Fishville approximately 3 miles east of Pollack, Grant Parish, Louisiana.

Location of types: USNM.

Range: Wolf River system in West Tennessee.

Crayfish associates: Orconectes p. palmeri, Procambarus a. acutus, P. clarkii, P. viaeviridis.

Life history notes: Form one males--April and June; ovigerous females--occupy burrows while carrying eggs. Secondary burrower.

Ecology: Sluggish streams to rivers.

Notes: Populations in the Wolf River system have been tentatively assigned to a new subspecies by Dr. J. F. Fitzpatrick, Jr.

Subgenus Scapulicambarus Hobbs, 1972: 11

Diagnosis: "Body and eyes pigmented, latter well developed. Rostrum with or without marginal spines or tubercles, lacking median carina. Carapace with or without one cervical spine or tubercle. Areola obliterated or as wide as 7.5 times as long as broad, and constituting 22 to 38 per cent of entire length of carapace. First three pairs of pereiopods without conspicuous brush of setae

extending from basis to merus. Simple hooks on ischia of third and fourth pereiopods. Coxa of fourth pereiopods with bulbous caudomesial boss. First pleopod reaching coxa of third pereiopod, symmetrical or asymmetrical, with broad, short proximomedian lobe, without proximomesial spur; prominent shoulder on cephalic surface of left pleopod, that on right always folded caudomesially to lie against mesial face of mesial lamella, thus making shoulders asymmetrical; subapical setae present but often sparse. First pleopod with terminal elements consisting of caudodistally directed acute mesial process; cephalically situated acute or lamelliform cephalic process; caudolateral subspatulate caudal process (distinct caudal knob always absent); and small to prominent central projection. Mesial ramus of uropod with median spine never extending beyond margin of ramus." (Hobbs, 1972: 11)

Procambarus (S.) clarkii (Girard, 1852: 91)

Type locality: Between San Antonio and El Paso del Norte, Texas.

Location of types: Destroyed in Chicago fire.

Range: Tributaries of the Mississippi River in the Mississippi Embayment province.

Crayfish associates: Cambarellus puer, Cm. shufeldtii, Orconectes immunis, O. lancifer, O. p. palmeri, Procambarus ablusus, P. a. acutus, P. viaeviridis, P. vioscai.

Life history notes: Form one males--April, June to August, October, November; females with young--occupy burrows while carrying eggs.

Ecology: Sluggish streams and lentic habitats (i.e., swamps, ditches, sloughs, ponds, etc.). Especially in vegetation, leaf litter, etc. Secondary burrower.

## MANUSCRIPT FORMS OF TENNESSEE CRAYFISH

There are at least 22 possible, though not probable, manuscript forms known from Tennessee. Since most of these forms will key to a nominal species (given in parentheses), they are listed below to make the reader aware of their presence. This list in no way can be interpreted to represent all the possible new species in the state.

### Genus Cambarus

Erebicambarus--One form that typically occupies the Western Highland Rim (C. rusticiformis).

Puncticambarus--Two forms that typically occupy the upper Cumberland Plateau and Ridge and Valley province (C. extraneus; C. robustus).

Depressicambarus--Two forms, one that occupies West, Middle, and lower East Tennessee (C. sphenoides) and a second that burrows in the upper Ridge and Valley province (C. cymatilis or C. striatus).

Hiaticambarus--One form that occupies tributaries of the Tennessee River system west of Walden Gorge (C. longirostris).

Jugicambarus--There are three forms on the upper Cumberland Plateau that are similar to the highly variable C. distans and may represent new species. Two other forms, one on the lower Cumberland Plateau (C. unestami) and the other on the Eastern Highland Rim (C. friaufi). Another form is in press by the author (C. distans).

Cambarus--One form in the upper Ridge and Valley province extends into Virginia.

## Genus Orconectes

Orconectes Group B--One form found in the Red River system in Kentucky probably extends into Tennessee (O. wrighti).

Orconectes Group C--Four forms in Middle Tennessee (2 forms, O. putnami - O. spinosus complex; 1, O. placidus - O.forceps complex; 1, O. barrenensis - O. mirus complex). One form in West Tennessee (O. placidus - O. forceps complex).

Orconectes Group D--One form in West Tennessee and one form in Middle Tennessee (O. rhoadesi - O. validus complex).

# V. SUMMARY

The state of Tennessee has 60 nominal species or subspecies within its political boundary or in nearby tributaries that flow into the state. These crayfish represent five genera. The Genera Procambarus and Cambarus are further subdivided into subgenera to show phylogenetic relationships within the genus. The genus Orconectes is divided into groups of species with morphological similarities. Each species is listed under its generic or infrageneric category with the following information: (1) type locality, (2) location of type specimens, (3) range, (4) crayfish associates, (5) life history notes, (6) ecological data, and as needed (7) notes on taxonomic status or information not covered in any of the above six sections. A list of probable manuscript species is given.

The physiographic provinces in Tennessee are described. Methods for collecting and preserving crayfish are included.

The appendices list the crayfish fauna of Tennessee and previous faunal studies with up to date determinations.

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# APPENDICES

# APPENDIX A

## PREVIOUS FAUNAL STUDIES

| Species Reported | Present Status |
|---|---|
| Hay, 1902b | |
| *Cambarus latimanus* | An undescribed species |
| *C. hamulatus* | *C.* (*Aviticambarus*) *hamulatus* |
| Ortmann, 1931 | |
| *Procambarus* (*Ortmannicus*) *blandingi acutus* | *P.* (*O.*) *a. acutus* |
| *P.* (*O.*) *clarki* | *P.* (*Scapulicambarus*) *clarkii* |
| *Cambarus* (*Faxonius*) *erichsonianus* | *Orconectes erichsonianus* |
| *C.* (*F.*) *rusticus forceps* | *O. forceps* |
| *C.* (*F.*) *rusticus placidus* | *O. placidus* |
| *C.* (*F.*) *rusticus mirus* | *O. mirus* |
| *C.* (*F.*) *rusticus rusticus* | An undescribed species |
| *C.* (*F.*) *juvenilis* | See *Notes* on *O. putnami* |

| Species Reported | Present Status |
|---|---|
| C. (F.) immunis | C. immunis |
| C. (F.) validus | O. rhoadesi |
| C. (F.) palmeri | O. p. palmeri |
| C. (C.) hamulatus | C. (Aviticambarus) hamulatus |
| C. (C.) extraneus | C. (Eribicambarus) rusticiformis, C. (Hiaticambarus) longirostris, C. (E.) ms. sp., C. (Puncticambarus) ms. sp. |
| C. (C.) montanus acuminatus | C. (P.) ms. sp. |
| C. (C.) montanus veteranus | C. (H.) longirostris |
| C. (C.) longulus longirostris | C. (H.) longirostris |
| C. (C.) bartoni cavatus | C. (C.) bartonii, C. (Depressicambarus) striatus |
| C. (C.) b. bartoni | C. (Jugicambarus) distans |
| C. (C.) bartoni striatus | C. (D.) striatus, C. (D.) ms.sp. |
| C. (C.) carolinus | C. (J.) dubius |
| C. (C.) diogenes | C. (Lacunacambarus) d. diogenes |

| Species Reported | Present Status |
|---|---|
| Fleming, 1938-1939 | |
| *C. propinquus sanborni* | *O. shoupi* |
| *C. rusticus forceps* | An undescribed species |
| *C. rusticus placidus* | *O. placidus* |
| *C. diogenes* | *C. d. diogenes* |
| *C. bartonii striatus* | *C. striatus* |
| *C. bartonii laevis* | *C. tenebrosus* |
| *C. latimanus* | *C. striatus* |
| *C. c. carolinus* | *C. gentryi* |
| Hobbs and Shoup, 1942 | |
| *O. juvenilis* | See *Notes* on *O. putnami* |
| *C. extraneus* | An undescribed species |
| *C. b. bartonii* | *C. distans* |
| Regionally Restricted Variant 5 | *C. sphenoides* |
| Regionally Restricted Variant 6 | *C. distans*, *C.* (*J.*) sp. (in press) |

| Species Reported | Present Status |
|---|---|
| *C. m. montanus* | *C. robustus* |
| *C. b. bartonii*, atypical | *C. distans*, *C.* (*J.*) sp. (in press) |

Hobbs and Marchand, 1943

| | |
|---|---|
| *Cambarellus shufeldtii* | Status unchanged |
| *P. clarkii* | Status unchanged |
| *P. blandingi acutus* | *P. acutus acutus* |
| *C. d. diogenes* | Status unchanged |
| *O. i. immunis* | *O. immunis* |
| *O. lancifer* | Status unchanged |
| *O. p. palmeri* | Status unchanged |

## APPENDIX B

## A LIST OF TENNESSEE CRAYFISH SPECIES

Family Astacidae

Subfamily Cambarellinae

*Cambarellus puer*

*Cm. shufeldtii*

Subfamily Cambarinae

*Cambarus asperimanus*

*C. bartonii*

*C. bouchardi*

*C. brachydactylus*

*C. carolinus*

*C. conasaugaensis*

*C. cornutus*

*C. cymatilis* (probable)

*C. diogenes diogenes*

*C. distans*

*C. dubius*

*C. extraneus*

*C. friaufi*

*C. gentryi*

*C. girardianus*

*C. hamulatus*

Cambarus latimanus

C. longirostris

C. obeyensis

C. parvoculus

C. pristinus

C. robustus

C. rusticiformis

C. sphenoides

C. striatus

C. tenebrosus

C. unestami (probable)

Fallicambarus fodiens

F. hedgpethi

F. hortoni

Orconectes alabamensis

O. australis australis

O. australis packardi

O. barrenensis

O. compressus

O. erichsonianus

O. forceps

O. immunis

O. incomptus

O. lancifer

O. mirus

Orconectes palmeri palmeri

O. pellucidus

O. placidus

O. putnami

O. rhoadesi

O. shoupi

O. spinosus

O. validus

O. virilis (introduced)

O. wrighti

Procambarus ablusus

P. acutus acutus

P. clarkii

P. hayi

P. lophotus

P. viaeviridis

P. vioscai

## APPENDIX C

## LIST OF ABBREVIATIONS

AMNH--American Museum of Natural History (New York)

AMS--Australian Museum (Sydney)

ANSP--Academy of Natural Sciences (Philadelphia)

CM--Carnegie Museum (Pittsburgh)

HHH III--Private collection of Horton H. Hobbs III

JFF--Private collection of Joseph F. Fitzpatrick, Jr.

LH--Private collection of Leslie Hubricht

MCZ--Museum of Comparative Zoology, Harvard (Boston)

MHNP--Museum National d'Histoire Naturelle (Paris)

RR--Private collection of Rendell Rhoades

TU--Tulane University (New Orleans)

UT--The University of Tennessee (Knoxville)

UZM--Universitets Zoologiske Museum (København)

WM--Würzburg Museum (Würzburg, Germany)

ZBM--Zoologisches Museum der Humbolt-Universität (Berlin)

## APPENDIX D

## GLOSSARY

Acumun--median cephalic tip of rostrum.

Annulus ventralis--median sclerite located between the bases of the fourth and fifth pairs of pereiopods in females. Structure that receives sperm during copulation. Lacking in native crayfish species west of the Rocky Mountains.

Areola--That portion of the thorax defined by the cervical groove cephalically and the caudal edge of the thorax. The lateral margins are delimited by the branchiodardiac grooves.

Basis--second segment of an appendage.

Boss--Protuberant portion of the basis on the fifth pair of pereiopods.

Branchiocardiac grooves--usually somewhat concave impressions that mark the upper limits of the branchial chambers on the mid-dorsal surface of the thorax. Typically narrow or obliteratdd in burrowing forms.

Branchiostegal region--pleural region of thorax.

Branchiostegal spines--spines located on the extreme cephalic margin of the branchiostegal region, one near each end of the cervical groove.

Carina--median keel or ridge-like process on the rostrum.

Cervical groove--deep impression that delineates the head from the thorax.

Cervical spine(s)--located near mid-pleural region of thorax at caudal edge of cervical groove.

Chela--distal most segemnt of the first 3 pairs of pereiopods (claw).

Dactyl--movable finger of chela.

Epistome--large sclerite anterior to the mouth.

Epistomal zygoma--conspicuously thickened posterior portion of the epistome (see Bouchard, in press).

Fingers--two finger-like structures of the chela (pincers).

Ischiopodites--third segment of an appendage.

Longitudinal ridge--ridge located on dorsal and ventral surfaces of fingers.

Obliterated--refers to an areola in which the branchiocardiac grooves fuse.

Palm--portion of chela posterior to the fingers.

Pereiopod--serially homologous appendages of the thorax.

Pleopod--serially homologous appendages of the abdomen.

Postorbital spines--spines located at cephalic ends of postorbital ridges.

Postorbital ridges--grooved ridges located on dorsal surface of head posteriolaterad to margins of the rostrum.

Suborbital angle--angle formed by the cranial exoskeleton extending ventrocephalad to a point below the eye in species with an acute angle, while not extending below the eye if the angle is obsolete.

Troglobite--obligate cavernicole.

Troglophile--species that exhibit a preference for hypogean waters but are not especially modified for this form of life. Typically also collected in surface streams.

Trogloxenes--cave visitors.

Trough--shallow depression found, if present, in the anterior portion of the annulus ventralis.

Vaulted--refers to the highly arched cephalothorax of *Cambarus d. diogenes*.

APPENDIX E

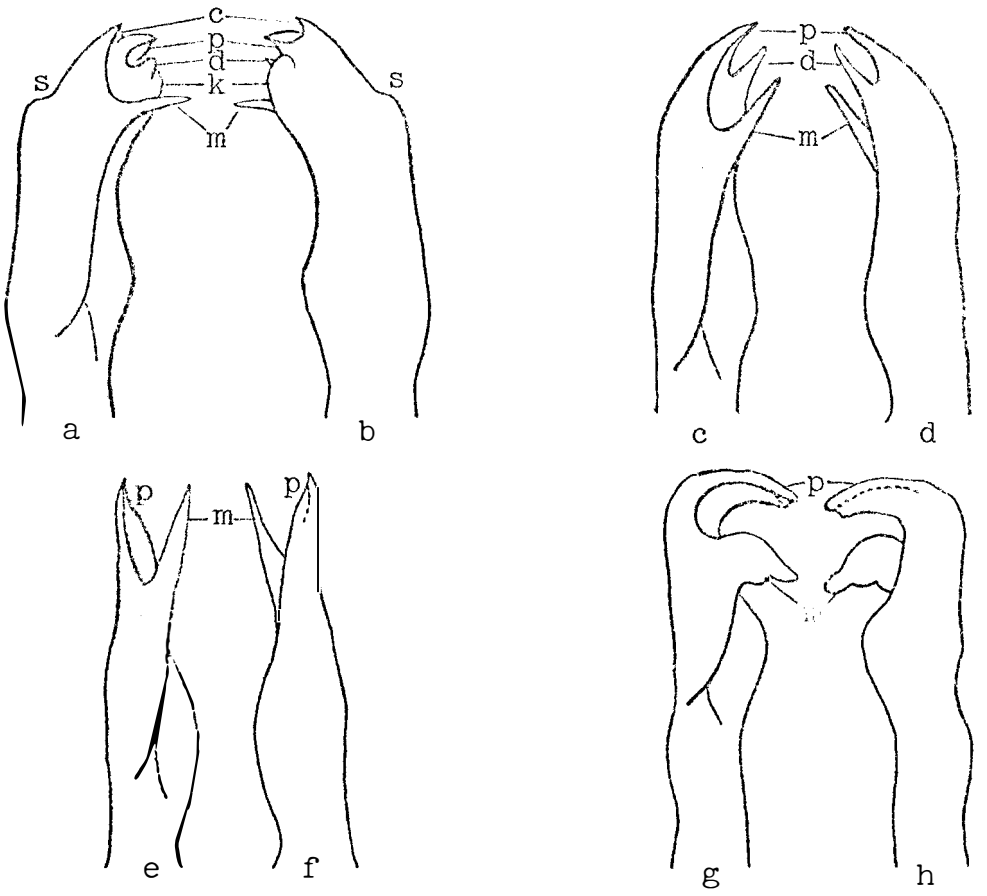


Figure 2. Form one pleopods of Tennessee Genera.

First left pleopods of crayfishes. a. Mesial view of generalized Procambarus; b. Lateral view of generalized Procambarus; c. Mesial view of generalized Cambarellus; d. Lateral view of generalized Cambarellus; e. Mesial view of generalized Orconectes; f. Lateral view of generalized Orconectes; g. Mesial view of generalized Cambarus and Fallicambarus; h. Lateral view of generalized Cambarus and Fallicambarus. (c, cephalic process; d, caudal process; k, caudal knob; m, mesial process; p, central projection; s, shoulder).

# VITA

Raymond William Bouchard was born in Fort Bragg, California, on May 28, 1944. He attended public schools in Leominster, Massachusetts, and graduated from high school in 1962. After working one year he entered Massachusetts State College at Fitchburg and graduated in August 1967, receiving a Bachelor of Science in Education with a major in Biology.

He entered the Graduate School at The University of Tennessee in September 1967, and received a Doctor of Philosophy degree with a major in Zoology in August 1972. He is a member of Phi Sigma and the Association of Southeastern Biologists.