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A Distributional Analysis and Identification Key for Crayfishes (Decapoda: Cambaridae) of the Clinch and Powell River Systems, Virginia

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INTRODUCTION

Most of the aquatic vertebrate taxa in southwestern Virginia have been extensively sampled and reported in the literature. The fishes were covered by Jenkins & Burkhead (1994) and Masnick (1974), the amphibians by Tobey (1985), and the reptiles by Mitchell (1994). However, among the invertebrate groups, only mollusks (mussels, snails) have received considerable attention (Neves et al., 1980; Ahlstedt, 1986; Ahlstedt, 1991). There has been no concerted effort to sample the crayfishes, which are an ecologically important group of invertebrates. Consequently, little is known of crayfish distribution, abundance, and natural history in this area. There is no regional key to the crayfishes, but experts such as the late H. H. Hobbs, Jr., R. W. Bouchard, and others have acknowledged the importance of the upper Tennessee River and the likely occurrence within its basin of rare or new species. The high diversity, relative to other regions, known for aquatic vertebrates and mollusks should apply to crayfishes as well. It is important, therefore, to catalog the crayfish species of this region, describe their distributions, and assess threats to their continued existence.

Crayfishes are considered to be keystone species in many of the ecosystems they inhabit, and function as important predators and prey in many faunal assemblages (DiStefano, 1993; Hobbs, 1993; Momot, 1995). In streams and rivers, they are prey to most gamefish species, converting autochthonous and allochthonous organic matter to usable nutrients and energy for vertebrate predators. In the Powell River, Virginia, for example, crayfishes are the dominant food items in diets of adult *Ambloplites rupestris* (rock bass) and *Micropterus dolomieu* (smallmouth bass), and crayfish abundance has been correlated with the abundance and condition of both of these species (Cummins, 1994). Maintaining crayfish populations may be essential to sustaining recreational fishing in this region.

The goals of this study were to 1) document geographic distributions of crayfishes in the Clinch and Powell river systems in Virginia, and 2) construct a key to the crayfishes of this region based on external structure for use by state natural resource managers and amateur naturalists.

MATERIALS AND METHODS

Study Area

The Clinch and Powell rivers, major tributaries to the upper Tennessee River, flow roughly parallel and join at Norris Lake about 20 km south of the Virginia/Tennessee line (Fig. 1). Their catchments span two physiographic provinces, the Valley and Ridge to the southeast and the Cumberland Plateau to the northwest

(Fig. 1). Both rivers are 6th-order when they cross the state line. They feature well-developed, pool-riffle fluvial morphology.

Qualitative Sampling

Crayfishes were sampled at 109 sites from summer 1992 to spring 1996 (Fig. 1). Exact location data for each site are available in Winston et al. (1996). Sample sites were located in a variety of lotic systems, from river mainstems to 1st-order tributaries and springs, including many of the largest springs in the region (Collins, 1930). Sampling methods, seasons, and personnel varied during the project. Collection effort was not standardized, nor do we know how much effort would be required to collect all species in an area. Sufficient effort to collect common species at a site was based on the experience of the principal collector (P. S. Lookabaugh or M. R. Winston). In summer 1992, P. S. Lookabaugh and assistants sampled 35 sites by electroshocking. During the summers of 1993 and 1994, P. S. Lookabaugh and an assistant sampled 48 sites using a handheld net while snorkeling, or by excavating bankside burrows. During fall 1995 and spring 1996, 26 sites were sampled, mostly by M. R. Winston and an assistant. Riverbank burrows were excavated, whereas streams were sampled by lifting rocks and chasing crayfishes into a seine. Most preserved crayfishes from these surveys were deposited with the Virginia Museum of Natural History in Martinsville; reference specimens were kept at the Department of Fisheries and Wildlife Sciences, VPI&SU, in Blacksburg.

Identification of Species

Voucher specimens were identified by Dr. R. W. Bouchard, Philadelphia Academy of Natural Sciences. These identifications, along with extant keys and descriptions (Hobbs, 1972, 1981, 1989; Hobbs & Bouchard, 1994; Jezerinac et al., 1995), were used to construct a key for identification of crayfish species in the Clinch and Powell river systems.

Subgeneric categories used in this study were based on Hobbs (1989) and Fitzpatrick (1987). The monophyly of the genus *Orconectes* and Fitzpatrick's subgeneric designations based on morphological characters have recently been questioned by molecular evidence (Crandall

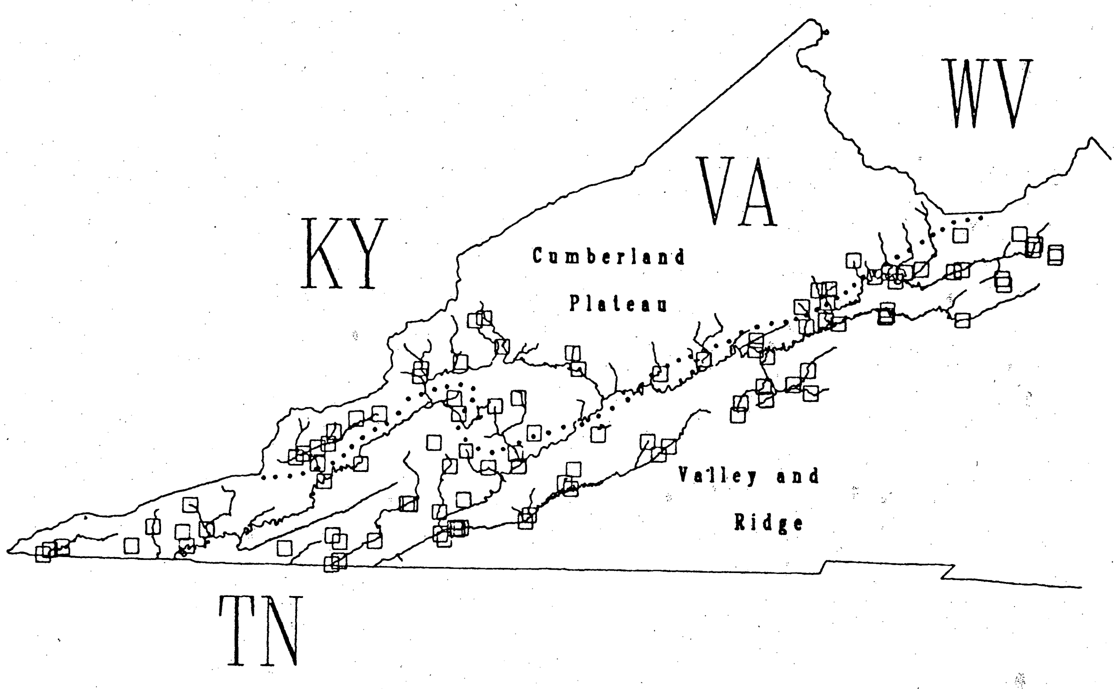

Fig. 1. The 109 sites sampled for crayfishes during this study. Only 4th-order or larger streams of the Clinch and Powell river systems in southwest Virginia are shown. The dotted line shows the approximate boundary between the Valley and Ridge and Cumberland Plateau physiographic provinces.

& Fitzpatrick, 1996; Fetzner, 1996). However, because no alternative classification has been offered, Fitzpatrick's system is used here.

RESULTS

Species Accounts

Nine species were collected at the 109 sites sampled in the Clinch and Powell systems in Virginia. An additional species was collected in the Clinch system just across the state line in Tennessee (see below). None of these species was considered rare by Taylor et al. (1996). A maximum of three species was collected together in streams and two species in burrows. Crayfish were present in all permanent waters. A key for identifying these species is provided in Table 1; a glossary of terms used in the text and the key is provided in Table 2.

Cambarus (Cambarus) angularis Hobbs & Bouchard

This species, endemic to the Clinch, Powell, and Holston systems, was described recently by Hobbs & Bouchard (1994). We collected it throughout the Clinch and Powell systems (Fig. 2), in small and large streams, at high and low elevations, and in both physiographic provinces. It was most readily collected in medium to small streams, and was the only species found in small headwater streams and springs. Its color ranged from reddish-brown in Valley and Ridge populations to yellowish-brown in Cumberland Plateau populations.

Most collections made from 1992 to 1994 contained only Form-II males, but the *Cambarus (Cambarus)* specimens were still identifiable as *C. angularis* because they had thickened rostral margins. There were some sites, however, where Form-II males did not show thickened rostral margins. Since these could have been *C. bartonii*, these sites were resampled in the fall and spring. All male *Cambarus (Cambarus)* collected were Form-I *C. angularis.*

Cambarus (Cambarus) bartonii cavatus Hay

This species was collected at only one site (Fig. 2). The Form-I male collected there was readily differentiated from *C. angularis* by a narrow areola and the lack of thickened rostral margins. The Form-II male collected was identified as *C. bartonii cavatus* rather than *C. angularis* because it, like the Form-I male, was collected from a burrow and had a narrow areola. *Cambarus angularis* always has a wide areola and has never been collected from burrows (personal observation; Hobbs & Bouchard, 1994).

Cambarus bartonii cavatus may be more widespread than indicated by our one collection. Finding and sampling crayfishes that live in burrows is time-intensive, which usually makes for small sample sizes. The presence of such species may go undetected unless concerted effort is made to collect them.

Cambarus (Jugicambarus) dubius Faxon

This species was collected from burrows throughout the Clinch and Powell systems, including the site where we found *C. bartonii cavatus* (Fig. 3). We collected two color types: one had a bright blue body and orange-tipped fingers on the chelae; the other had an orange body and chelae. This species was relatively easy to collect in marshy areas and at the edges of very small streams with low banks. We collected several from the edges of larger streams, but this was more difficult because of the greater depths of the burrows.

Cambarus (Jugicambarus) parvoculus Hobbs & Shoup

This species was collected only in the mainstem of the North Fork Powell River (Fig. 3), where it was uncommon. The population is at the extreme edge of the species range (Hobbs & Shoup, 1947; Hobbs, 1969). Most individuals collected were brown, but some had a light blue tinge. The best way to differentiate this species from *C. dubius* is to examine the gonopods of Form-I males. Although *C. parvoculus* is found in rocky streams and *C. dubius* generally in burrows, the latter is also sometimes found in rocky streams (Jezerinac et al., 1995).

Cambarus (Hiaticambarus) longirostris Faxon

This species was collected throughout the Valley and Ridge province, but only once from the Cumberland Plateau (Fig. 4). The specimen from the Cumberland Plateau was unusual in that it somewhat resembled the *C. angularis* with which it was found. We collected the greatest numbers of *C. longirostris* in riffles of the upper Clinch River, Copper Creek, and Little River. Individuals from Copper Creek were especially spectacular, with orange-red coloration, a black saddle pattern, pastel blue on the sides of the carapace, and large chelae (see James [1966] and Hobbs [1981] for further discussion of this species).

Cambarus (Puncticambarus) buntingi Bouchard

This species was temporarily named 'species D' by Hobbs (1969) and described by Bouchard (1973). Bouchard (1973), Hobbs (1989), and Taylor et al. (1996)

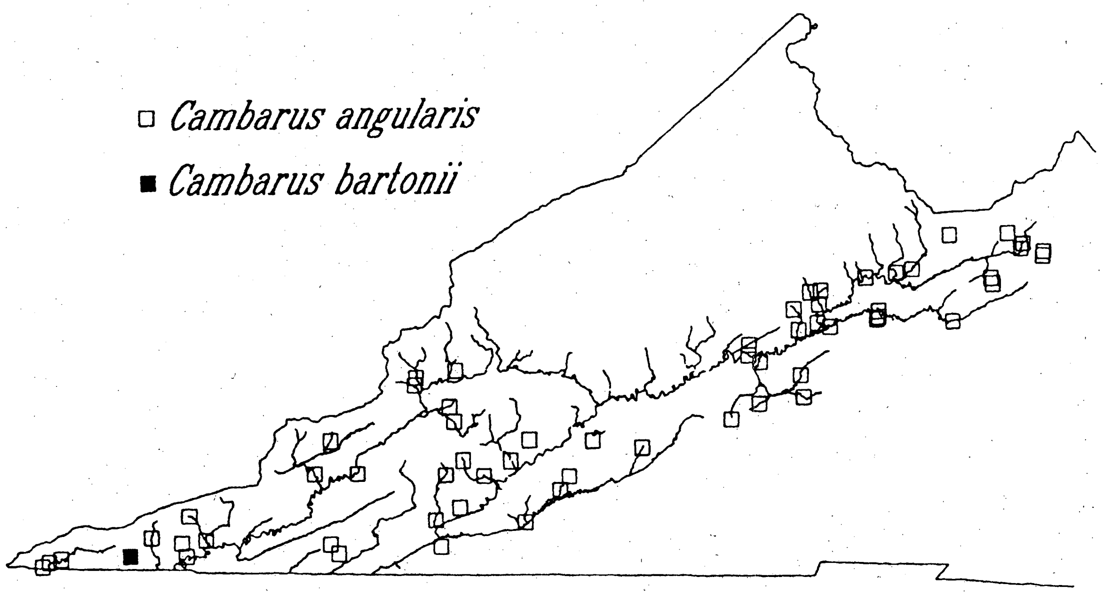

Fig. 2. C. (C.) *angularis* was found at 64 sites; C. (C.) *bartonii cavatus* was found at one site.

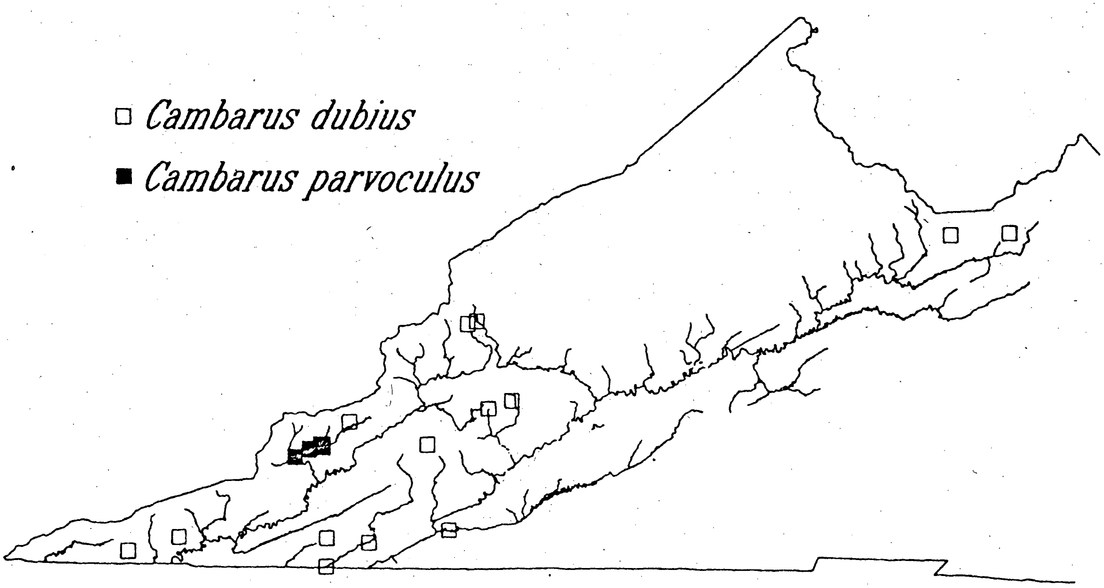

Fig. 3. C. (J.) *dubius* was found at 14 sites; C. (J.) *parvoculus* was found at three sites.

did not include it in the Virginia cambarid fauna, but Hobbs (1969) and Bouchard (1975b) indicated its presence in the state. We collected it only on the Cumberland Plateau, mainly from the North Fork Powell River and Guest River (Fig. 4), where it was common. Color was a distinctive green.

Orconectes (Crockerinus) erichsonianus (Faxon)

This species was collected only from Copper Creek, lower Clinch River, and North Fork Clinch River (Fig. 5), and was uncommon in these locations, which are at the northern edge of its range (Hobbs 1981; 1989). We collected it with *Orconectes (Procericambarus) forceps* (Faxon) but never with *Orconectes (Procericambarus) putnami* (Faxon). It is similar to *O. putnami* in general mien, and both species are bluish-green in color. The central projection of the gonopod (first pleopod) of Form-I males in our *O. erichsonianus* samples comprised about one-third of the total length of the appendage, which is at or near the upper extremes reported in the literature (Hobbs 1981; Fitzpatrick 1987).

Orconectes (Procericambarus) putnami (Faxon)

This species was common and widespread in the northern and higher elevation areas of the Clinch and Powell river systems, but was generally absent from the southern, low elevation sites (Fig. 5). This is the same species identified as *O. spinosus* in Jezerinac et al. (1995).

Orconectes (Procericambarus) forceps (Faxon)

This species was collected only in southern, low-elevation sites (Fig. 6), where abundance varied from rare to common. Large males were striking in appearance, with long chelae and widely gaping fingers. The mottled black pattern on a light brown background is reminiscent of the shadows made by sunlight shining through rippled water.

Orconectes (Procericambarus) rusticus (Girard)

This species was not found in Virginia, but was common in the Clinch River system in Tennessee, 20 km south of the Virginia line. Nineteen specimens were

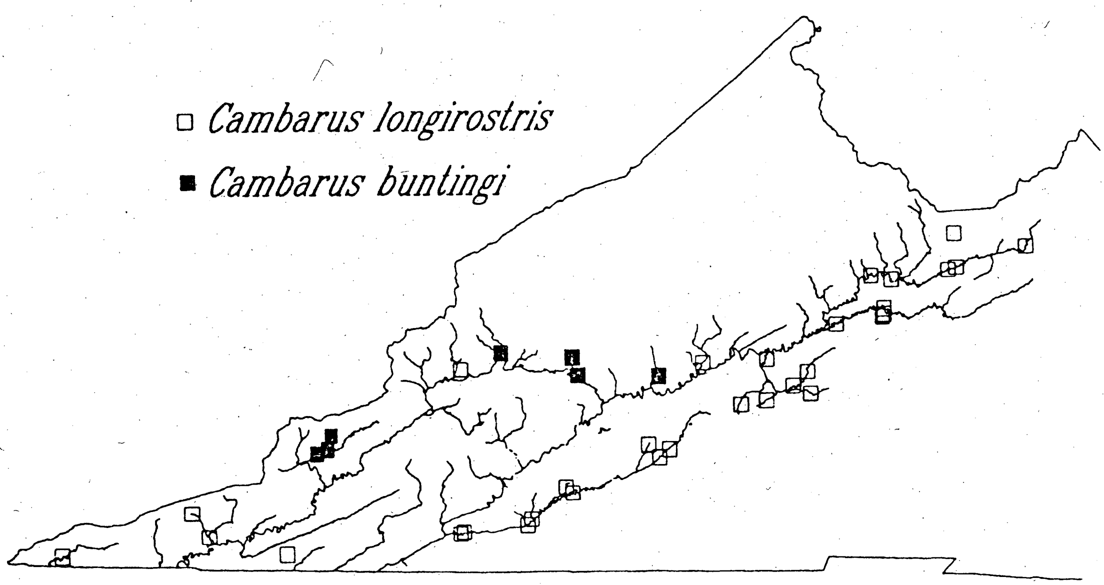

Fig. 4. C. *(H.) longirostris* was found at 34 sites; C. *(P.) buntingi* was found at seven sites.

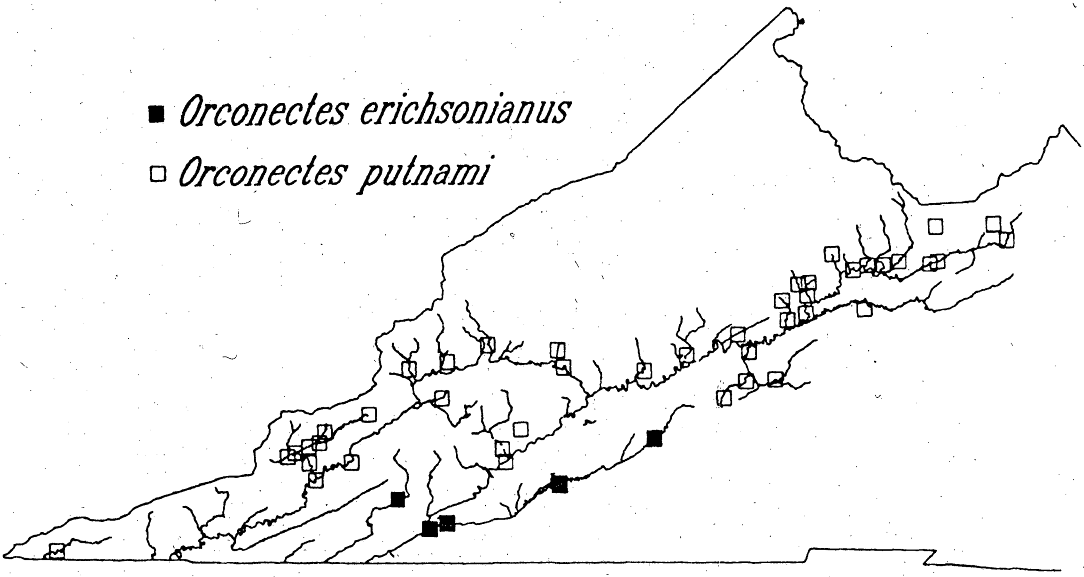

Fig. 5. O. (C.) *erichsonianus* was found at five sites; O. (P.) *putnami* was found at 47 sites.

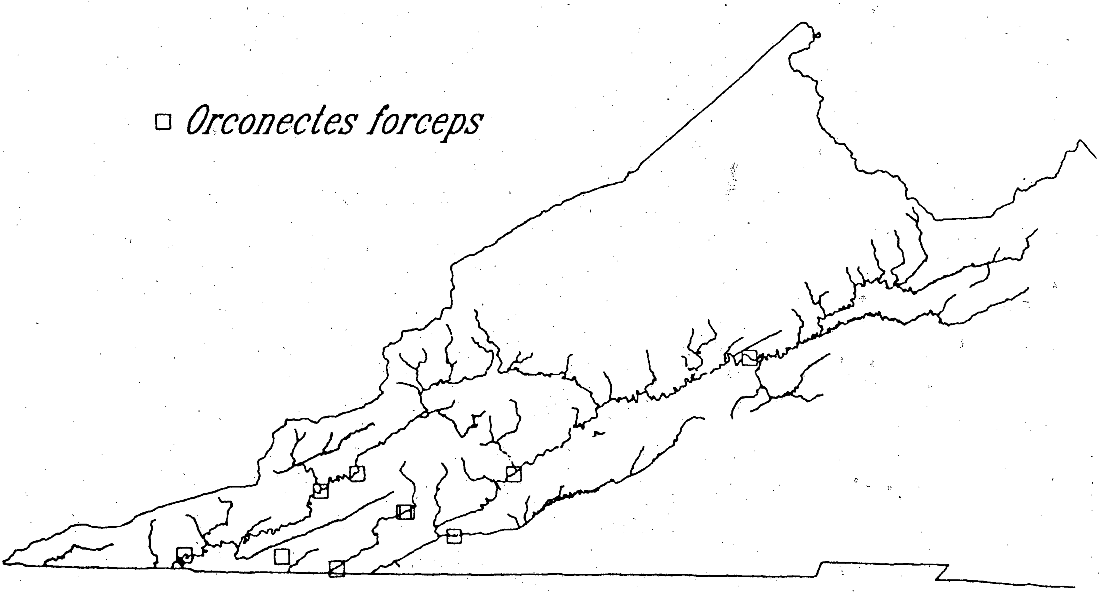

Fig. 6. O. (P.) *forceps* was found at ten sites.

collected, along with specimens of *O. forceps* and *C. longirostris*. They were collected while electrofishing on 25 August 1992, in Indian Creek, a tributary to Norris Reservoir, Grainger County, Tennessee. Three other streams in this area, Big War, Big Sycamore, and Swan creeks, also were sampled, but *O. rusticus* was not found. This species is not native to the upper Tennessee River (Bouchard, 1975a).

Distributional Patterns

The ten species of crayfishes collected in the Clinch and Powell river systems can be classified as ubiquitous, regionally restricted, or rare. *Cambarus angularis* and *C. dubius* were ubiquitous; i.e., they were collected throughout the systems. *Cambarus bartonii cavatus* and *O. rusticus* were rare; i.e., each was collected at only one site. The other six species were regionally restricted.

The most widespread of the regionally restricted species, *O. putnami*, was collected throughout the northern two-thirds of the region, but only once in the southern one-third of the region (Fig. 5). Complementary to this were the distributions of *O. erichsonianus* and *O. forceps* which, with the exception of one northern occurrence of *O. forceps* in the mainstem Clinch River, were collected only in the southern one-third of the region (Figs. 5, 6). Streams from the southern one-third of the region are generally lower in elevation and channel slope than streams in the northern part of the region.

The second most widespread of the regionally restricted species, *C. longirostris*, was collected in many locations in the Valley and Ridge province but only once in the Cumberland Plateau (Fig. 4). Complementary to this were the distributions of *C. parvoculus* and *C. buntingi*, which were collected exclusively in the Cumberland Plateau (Figs. 3, 4). The three main tributaries in this region are the North Fork Powell River, the upper Powell River, and Guest River (Clinch tributary). *Cambarus parvoculus* was collected only in the North Fork Powell River (Fig. 3), whereas *C. buntingi* was collected there and in the Guest River (Fig. 4). Why neither species was collected in the upper Powell River, an area between the North Fork Powell River and the Guest River, is unclear. Further collecting, especially in the mainstem of the upper Powell River, may reveal that these species occur there as well.

Some stream-size associations were evident. *Cambarus angularis* was collected in all sizes of streams, but it was the only species collected in headwater streams and springs. *Cambarus longirostris* was the most commonly collected crayfish in riffles of medium-sized streams, but was not collected in the larger rivers (Fig. 4). The *Orconectes* species, however, were often collected in the mainstem rivers (Figs. 5, 6).

These patterns were similar to those seen for fishes of the region (Angermeier et al., 1996), which exhibited distributional associations with stream size, physiography, elevation, and channel slope. However, they differed in that the crayfishes seemed to be more regionally restricted. For example, no fishes were restricted to the Cumberland Plateau, unlike the pattern seen for *C. parvoculus* and *C. buntingi*. Similarly, the demarcation between northern and southern species was not as clear for fishes as for the pattern seen for *O. putnami* versus *O. erichsonianus* and *O. forceps*.

DISCUSSION

Threats and Conservation

Displacement of native species by introduced species seems to be a common occurrence with crayfishes (Schwartz et al., 1963; Rorer & Capelli, 1978; Hill & Lodge, 1994; Light et al., 1995; Soderback, 1995). One of these species proven to be invasive, *O. rusticus*, was documented before 1975 from Norris Reservoir at the confluence of the Clinch and Powell rivers (Bouchard, 1975a). Our data showed that it had not spread upstream, but the situation bears watching.

As part of any plan to conserve the present crayfish diversity in the Clinch and Powell river systems of Virginia, the two stream species with the most restricted distributions, *C. parvoculus* and *O. erichsonianus*, should be monitored. In Virginia, *C. parvoculus* seems to be restricted to the mainstem of the North Fork Powell River above Pennington Gap, and *O. erichsonianus* is restricted to Copper Creek and the North Fork Clinch River downstream of Duffield. A single toxic spill could eliminate the population of *C. parvoculus*. If *O. rusticus* were to expand its range and threaten to displace other species, *O. erichsonianus* might be the most vulnerable because of its low population numbers and the population's proximity to Norris Lake. *Orconectes erichsonianus* may also require good habitat quality, since it inhabits only those locations shown by Angermeier & Smogor (1993) to have high biotic integrity.

Need for Additional Surveys

Neither *C. buntingi* nor *O. putnami* were listed among the 22 native and two introduced species in the latest checklist for Virginia (Taylor et al., 1996). With the addition of these species, the nine species collected in the Clinch and Powell river systems in Virginia represent 34 percent of the 26 native species known from Virginia. The three forks of the Holston River (the other Tennessee River headwaters in Virginia) may support many of the same species; however, a systematic survey of this region will be required before species composition can be verified. Of the nine species reported herein, only *C. bartonii cavatus* and *C. dubius* are native to Virginia outside of the Tennessee River system. We recently collected *O. putnami* in Tom's Creek (New River drainage) near Blacksburg. This may be the introduced species called *Orconectes juvenilis* by Hobbs & Walton (1966) and *O. spinosus* by Rorer & Capelli (1978). The most comprehensive information on the crayfishes of the New River drainage in Virginia is 30 years old (Hobbs et al., 1967).

Many crayfish species, especially those in the same subgenus, are difficult to distinguish. As emphasized by Hobbs (1972), identification of these species often requires Form-I males. In the present study, we returned to the rivers in the fall and spring to collect Form-I males, in order to help identify the summer-collected Form-II males and females. This was the case for *C. angularis/C. bartonii cavatus*, *C. dubius/C. parvoculus*, and *O. erichsonianus/O. putnami*. For the two *Cambarus* pairs, even with specimens of Form-I males in hand, the Form-II males could not be identified with complete confidence. Therefore, in order to maximize cost-effectiveness and accuracy, future surveys for crayfishes in Virginia should be undertaken in the fall and spring whenever possible.

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TABLE 1. KEY TO THE CRAYFISHES OF THE CLINCH AND POWELL RIVER SYSTEMS, VIRGINIA.

This key is not designed for use with specimens in other river systems in Virginia. Rare, undescribed, or introduced species not covered here may occur in these river systems. Terms are defined either in the Figures or in the Glossary (Table 2).

Key to Genera and Species

1. Both terminal elements of gonopod curved caudally at 90 degrees or more to shaft axis (Fig. 9a): Genus *Cambarus* 2

   Both terminal elements of gonopod never bent at an angle as great as 90 degrees to shaft axis (Fig. 9b): Genus *Orconectes* 7

2. Tubercles on mesial margin of palm forming cristiform row (Fig. 10c); fingers relatively short: length of palm about two-thirds length of dactyl (Fig. 8) 3

   Tubercles on mesial margin of palm not forming cristiform row (Figs. 10a, b); fingers relatively long: length of palm usually much less than length of dactyl (Fig. 8) 4

3. Central projection of gonopod of Form-I male long and strongly recurved, extending proximally to distal margin of mesial process (Fig. 11a); inhabits rocky streamsC. *(Jugicambarus) parvoculus*

   Central projection of gonopod of Form-I male shorter, not extending proximally to distal margin of mesial process (Fig. 11b); usually found in burrows, rarely under rocks in streams .... *C. (J.) dubius*

4. Mesial margin of palm with 2 major rows of tubercles (Fig. 10a); rostrum acuminate (Fig. 12a).......... *C. (Puncticambarus) buntingi*

   Mesial margin of palm with single row of 3 to 6 tubercles, often indistinct, sometimes with second row of three or four small ones (Figs. 10b, c); rostrum usually with margins abruptly contracted at base of acumen (Figs. 12b-d) 5

5. Fingers of chela with extremely wide gape, with indistinct to moderately distinct longitudinal ridges dorsally; tuft of setae at base of opposable margin of fixed finger in all but large Form-I males (Fig. 10b); rostrum narrow with width less than two-thirds total length (Fig. 12d) .... *C. (Hiaticambarus) longirostris*

   Fingers of chela widely gaping only in some large individuals, and with distinct longitudinal ridges dorsally; no tuft of setae at base of opposable margin of fixed finger; rostrum broad with width greater than two-thirds total length (Figs. 12b, c) 6

6. Rostral margins of Form-I males thickened (Fig. 12c), those of Form-II males and females may or may not be thickened .... *C. (Cambarus) angularis*

   Rostral margins of Form-I males and females not thickened (Fig. 12b) .... *C. (C.) bartonii*

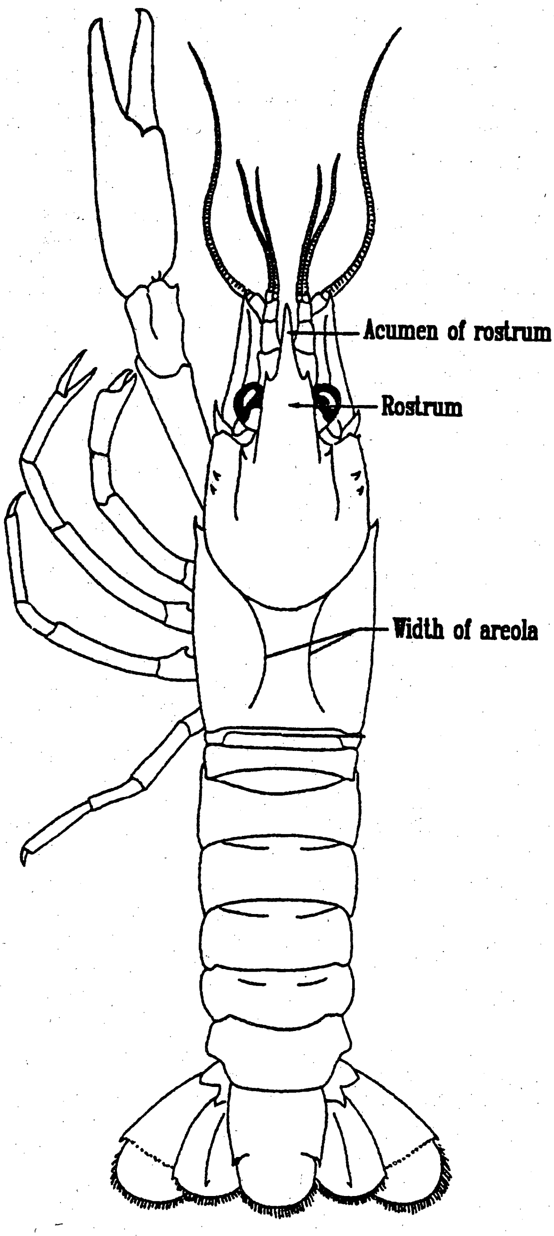

Fig. 7. Dorsal view of generalized male crayfish illustrating structures and measurements mentioned in the text and referenced in the key (modified from Hobbs, 1972).

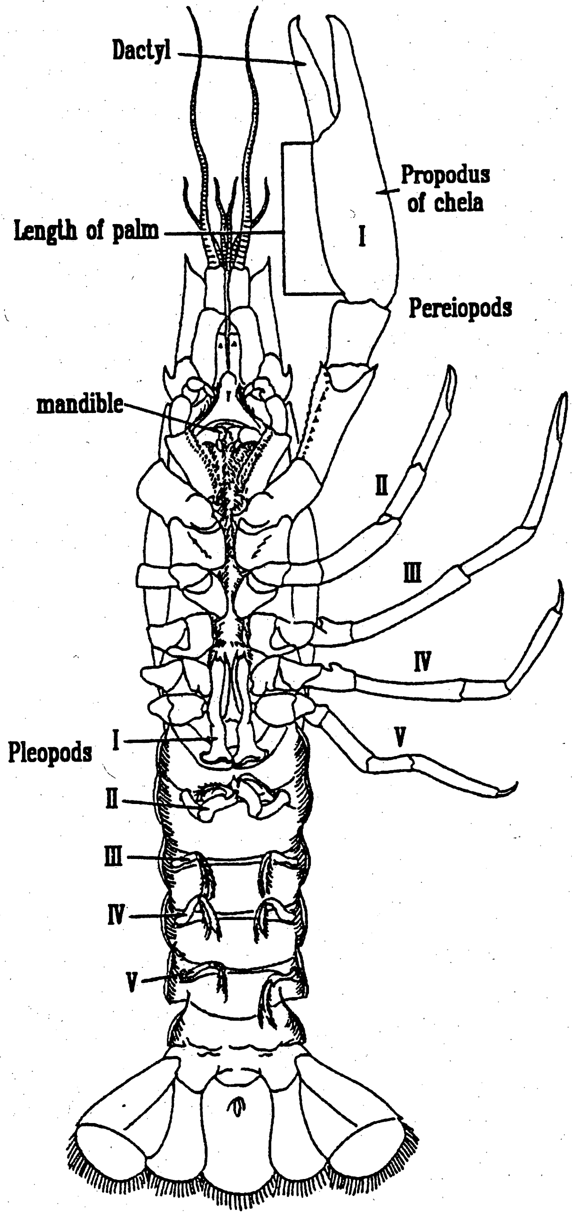

Fig. 8. Ventral view of generalized male crayfish illustrating structures and measurements mentioned in the text and referenced in the key (modified from Hobbs, 1972).

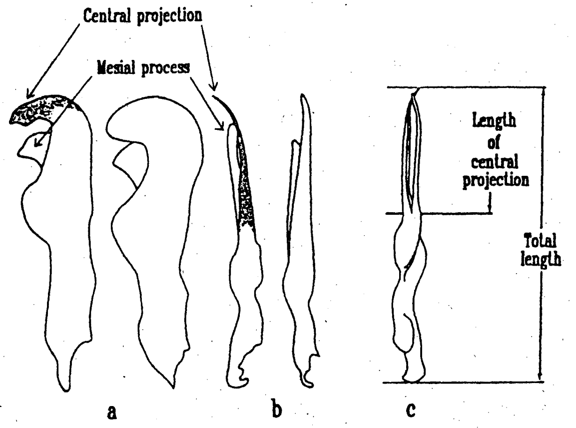

Fig.9. Left gonopods of *Cambarus* and *Orconectes* (from Hobbs, 1972). *a-b*, Lateral views of Form-I and Form-II males, corneous central projection shaded – *a*, *Cambarus*; *b*, *Orconectes*; *c*, Method of measuring gonopods (mesial view) in *Orconectes*.

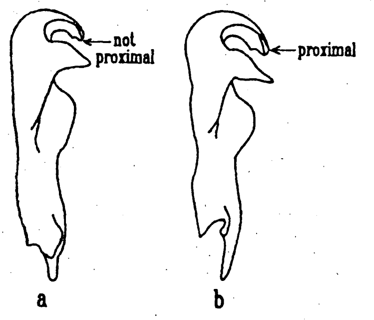

Fig. 11. Mesial view of Form-I gonopod (modified from Hobbs, 1989). a, C. (J.) dubius, with central projection not extending proximally to distal margin of thesesial process; b, C. (J.) parvoculus, illustrating central projection extending proximally to distal margin of the mesial process.

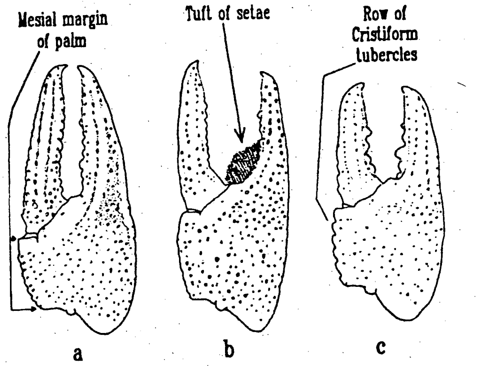

Fig. 10. Dorsal view of male right chela (modifeid from Hobbs, 1989). *a*, C. (*P.*) *buntingi*, showing 6 to 9 rows of tubercles on mesial margin of palm; *b*, C. (*H.*) longirostris, showing tuft of setae at base of fixed finger; *c*, C. (*J.*) *parvoculus*, illustrating cristiform tubercles on mesial margin of palm.

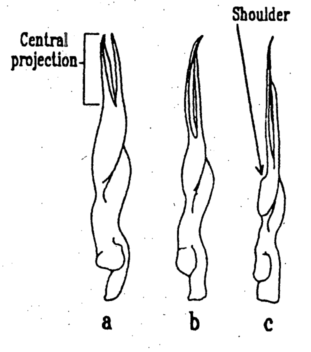

Fig. 13. Mesial view of Form-I gonopod (modified from Hobbs, 1989). *a*, O. (C.) *erichsonianus*, central projection no more than one-third of mesial length of gonopod; *b*, O. (*P.*) *forceps*, cephalic surface lacking shoulder at base of central projection; *c*, O. (*P.*) *spinosus*, cephalic surface with shoulder at base of central projection.

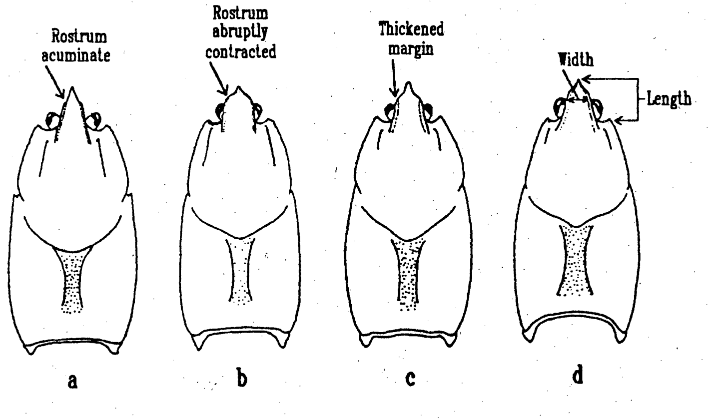

Fig. 12. Dorsal view of carapace (modified from Hobbs, 1989). *a*, C. (*P.*) *buntingi*, showing acuminate rostrum; *b*, C. (C.) *buntingii*, showing broad rostrum, margins not thickened; *c*, C. (C.) *angularis*, showing broad rostrum, margins abruptly contracted at base of acumen, and thickened rostral margins; *d*, C. (*H.*) *longirostris*, showing narrow rostrum with margins abruptly contracted at base of acumen.

7. Central projection of gonopod of Form-I male constituting about one-third of total length of appendage (Figs. 9c; 13a); annulus ventralis lacking deep transverse fossa, with weakly to moderately developed cephalolateral prominences (Fig. 14a); rostral margins subparallel, rostrum without median carina (Fig. 15c) .... O. (*Crockerinus*) *erichsonianus*

Central projection of gonopod of Form-I male constituting nearly one-half of total length of appendage (Figs. 9c; 13b, c); annulus ventralis with deep transverse fossa and large, lobiform cephalolateral prominences (Fig. 14b); rostral margins concave without rostral carina (Fig. 15a) or subparallel with rostral carina (Fig. 15b) 8

8. Cephalic surface of gonopod of Form-I male lacking shoulder at base of central projection (Fig. 13b); fingers of chela strongly gaping (Fig. 16a); ventral surface of carpus of cheliped lacking distomedian spine or tubercle (Fig. 17b); rostral margins concave (Fig. 15a) .... O. (*Procericambarus*) *forceps*

Cephalic surface of gonopod of Form-I male with distinct shoulder at base of central projection (Fig. 13c); fingers of chela never strongly gaping (Fig. 16b); ventral surface of carpus of cheliped with distomedian spine or spiniform tubercle (Fig. 17a); rostral margins concave or subparallel 9

9. Cutting edge of mandible (Fig. 8) smooth; rostral margins concave without median carina ... O. (*P.*) *rusticus*

Cutting edge of mandible (Fig. 8) serrated; rostral margins subparallel, rostrum with median carina (Fig. 15b) .... O. (*P.*) *putnami*

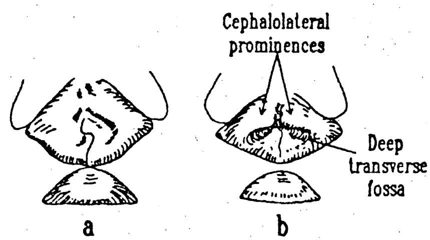

Fig. 14. Annulus ventralis and postannular sclerite of female (from Hobbs, 1989). *a*, O. (C.) *erichsonianus*, lacking deep transverse fossa; *b*, O. (P.) *spinosus*, with deep transverse fossa and prominent overhanging cephalolateral prominences.

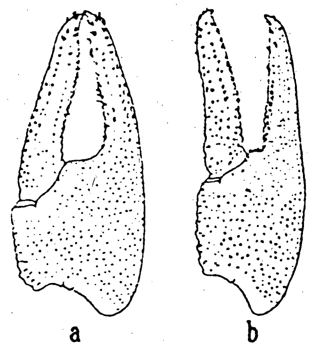

Fig. 16. Dorsal view of Form-I male right chela (from Hobbs, 1989). *a*, O. (P.) *forceps*, with strongly gaping fingers; *b*, O. (P.) *spinosus*, fingers not strongly gaping.

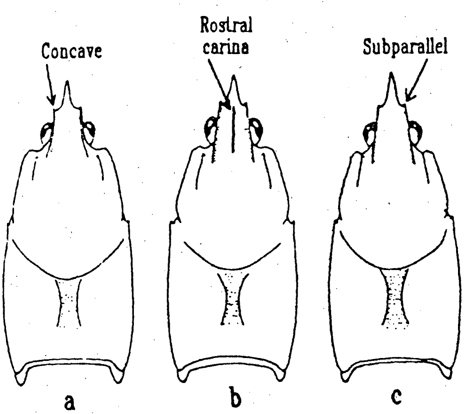

Fig. 15. Dorsal view of carapace (from Hobbs, 1989). *a*, O. (P.) *forceps*, showing concave rostral margins; *b*, O. (P.) *spinosus*, with subparallel rostral margins and rostral carina present; *c*, O. (C.) *erichsonianus*, rostral margins subparallel and rostral carina absent.

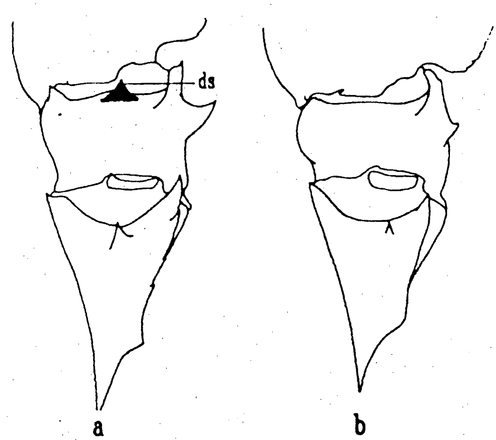

Fig. 17. Ventral surface of carpus of cheliped (from Hobbs, 1981). *a*, O. (P.) *spinosus*, distomedian spine (ds) or tubercle present; *b*, O. (P.) *forceps*, distomedian spine absent.

TABLE 2. GLOSSARY OF TERMS USED IN THE TEXT AND KEY.

acuminate - tapering to a point.

annulus ventralis- female sexual structure that receives sperm from the male gonopods; located between fourth pair of pereiopods on ventral surface (Fig. 8).

cephalic - toward the head.

cheliped- pereiopod I (Fig. 8).

cristiform - like a crest or cock's comb.

distal - away from the long axis of the body.

dorsal - "up" when the crayfish is held with the long axis of the body parallel to the ground.

fingers - the distal parts of the chela; the movable finger is the dactyl (Fig. 8).

Form-I and Form-II male - male crayfishes of the family Cambaridae alternate between a sexually mature and a sexually immature stage (Fig. 9a, b). The sexually mature males are referred to as Form-I, the sexually immature as Form-II (Payne 1978).

gonopod - pleopod I (Fig. 8) or first pleopod of male. The gonopods transfer sperm to the female.

lateral view of gonopod - with the long axis of the crayfish body held parallel to the ground, and the gonopods extended perpendicular to this axis, a lateral view of a gonopod is from the outside looking towards the middle of the body.

longitudinal- along the long axis.

mesial - towards the middle; inner.

mesial view of gonopod - with the long axis of the crayfish body held parallel to the ground and the gonopods extended perpendicular to this axis, a mesial view of a gonopod is from the middle of the body looking outward.

proximal - towards the long axis of the body.

punctations- tiny pores in the exoskeleton.

rostral carina - a flattened (in smaller specimens) to raised (in larger specimens) area in cephalomedian area of rostrum (Fig. 15b).

setae - hairs

subparallel- almost parallel.

subquadrate - nearly square.

transverse - perpendicular to the long axis of the body.

ventral - "down" when the crayfish is held with the long axis of the body parallel to the ground.