

Conservation Status of Crayfishes of the United States and Canada

By Christopher A. Taylor, Melvin L. Warren, Jr., J. F. Fitzpatrick, Jr., Horton H. Hobbs III, Raymond F. Jezerinac, William L. Pflieger, and Henry W. Robison

ABSTRACT

The American Fisheries Society (AFS) Endangered Species Committee herein provides a list of all crayfishes (families Astacidae and Cambaridae) in the United States and Canada that includes state and provincial distributions; a comprehensive review of the conservation status of all taxa; and references on biology, conservation, and distribution of crayfishes. The list contains 338 native crayfishes, of which 2 (< 1%) taxa are listed as endangered, possibly extinct; 65 (19.2%) as endangered; 45 (13.3%) as threatened; 50 (14.8%) as special concern; and 176 (52.0%) as currently stable. Limited natural range is implicated as the primary factor responsible for the noted imperilment of crayfishes; other threats include habitat alteration and the introduction of nonindigenous crayfishes. Using the best available information, we estimate that almost 50% of crayfishes in United States and Canada are in need of conservation recognition. We hope that this report spurs increased research efforts from aquatic biologists and proactive actions by resource personnel, citizens, and lawmakers.



G. Allen

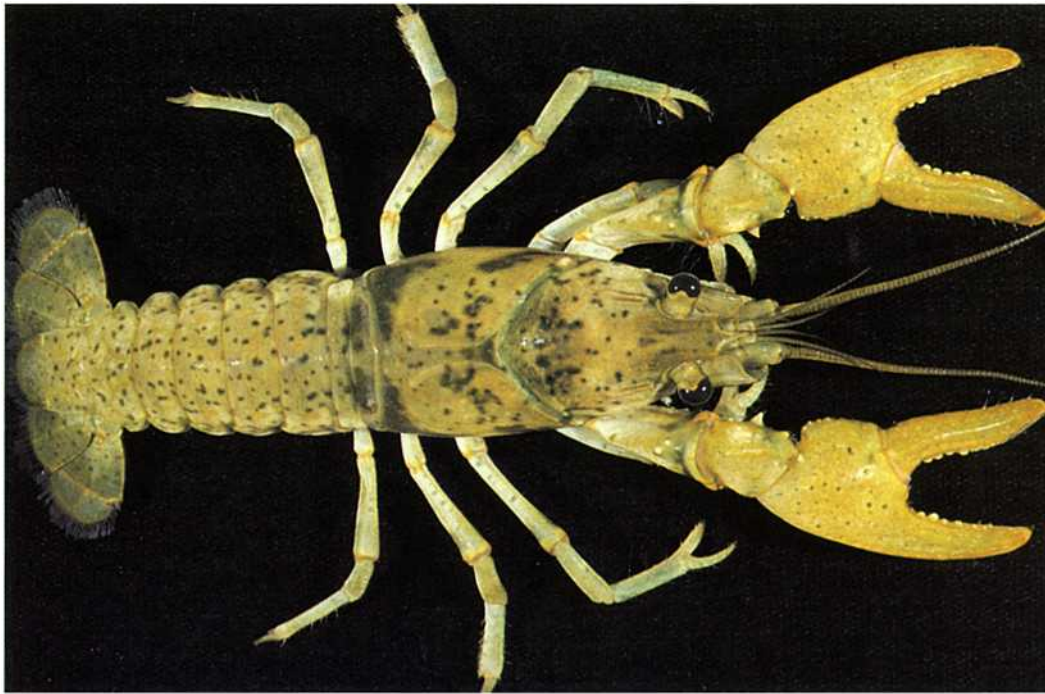
Procamburus clarkii, a crayfish found throughout the southern United States, is currently stable.

Decapod crustaceans in the families Astacidae, Cambaridae, and Parastacidae, commonly known as crayfishes or crawfishes, are native inhabitants of freshwater ecosystems on every continent except Africa and Antarctica. Although nearly worldwide in distribution, crayfishes exhibit the highest diversity in North America north of Mexico with 338 recognized taxa (308 species and 30 subspecies). Mirroring continental patterns of freshwater fishes (Warren and Burr 1994) and freshwater mussels (J. D. Williams et al. 1993), the southeastern United States harbors the highest number of crayfish species.

Crayfishes are a significant component of aquatic ecosystems. They facilitate important ecological processes, sustain

recreational and commercial bait fisheries, and serve as a profitable and popular food resource. Crayfishes often make up a large proportion of the biomass produced in aquatic systems (Rabeni 1992; Griffith et al. 1994). In streams, sport fishes such as sunfishes and basses (family Centrarchidae) may consume up to two-thirds of the annual production of crayfishes, and as such, crayfishes often comprise critical food resources for these fishes (Probst et al. 1984; Roell and Orth 1993). Crayfishes also contribute to the maintenance of food webs by processing vegetation and leaf litter (Hury and Wallace 1987; Griffith et al. 1994), which increases availability of nutrients and organic matter to other organisms. In some rivers, bait fisheries for crayfishes constitute an

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Forty-five crayfish species (13.3%), including *Orconectes peruncus*, found in the St. Francis river drainage of southeastern Missouri, are threatened.

integral part of the recreational fishery and provide a substantial boost to local economies (Nielsen and Orth 1988). Crayfishes are an economically important food source in the United States and abroad, where both wild and cultured populations are harvested. Total annual world commercial production of crayfishes is estimated as 70,000 to 100,000 metric tons (Huner 1989). Centered primarily in the states of Louisiana and Texas, annual commercial harvesting of wild crayfishes in the United States ranges between 5,000 and 25,000 metric tons. Another 60,000 metric tons are harvested through aquaculture (Huner 1989).

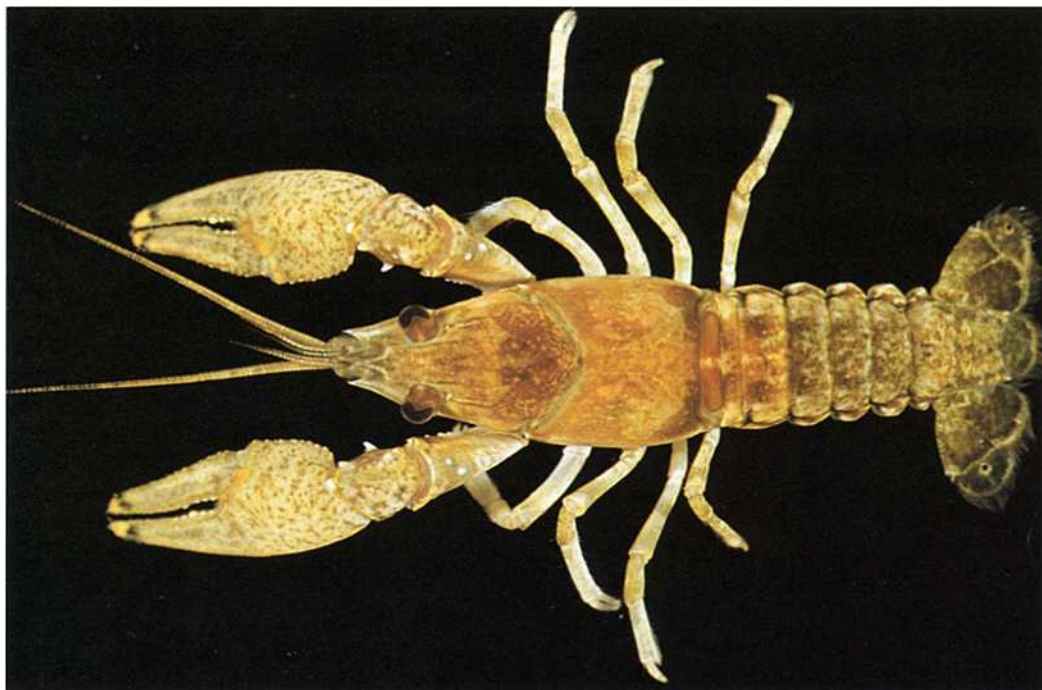
Recognition of the diversity of U.S. and Canadian crayfishes has increased significantly during the past half-century, primarily as a result of the work of a few dedicated taxonomists. Their efforts have highlighted the need for attention to this group of animals by aquatic ecologists, fisheries professionals, natural resource agencies, and conservation organizations. Nevertheless, knowledge of the basic biology of most crayfishes is fragmentary or lacking. A compilation of the limited information on the distribution and conservation status of crayfishes reveals a precarious state. More than 65 taxa are currently known from a single locality or a single river drainage in a 1- to 2-county area. The Nature Conservancy recognizes 36% of the crayfish fauna as extinct or imperiled and another 26% as vulnerable (Master 1990). At the state level, 47 species in 8 states receive conservation recognition or protection. Under the Endangered Species Act of 1973 (ESA), the U.S. Fish and Wildlife Service (USFWS) recognizes only four species (< 1% of the crayfish fauna) as endangered (*Pacifastacus fortis*, *Cambarus aculabrum*, *Cambarus zophonastes*, *Orconectes shoupi*) and none as threatened (USFWS 1994a). Thirty-four species are candidates for federal recognition but as such receive no protection under the ESA (USFWS 1994b). The broad disparity in the recognition of actual or potential imperilment of crayfishes should serve as a warning shot that dictates

the attention of government agencies, private organizations, and individuals beyond the field of astacology.

Given concerns regarding the declining quality of aquatic habitats and fauna (Williams and Neves 1992) and the reality that crayfishes are an important constituent of aquatic biodiversity, the AFS Endangered Species Committee formed a subcommittee to investigate the conservation status of crayfishes in the United States and Canada. Following J. E. Williams et al. (1989) on freshwater fishes and J. D. Williams et al. (1993) on freshwater mussels, the goal of this subcommittee is to provide information that will enable natural resource managers and lawmakers to recognize the plight of crayfishes and help form protective strategies. The purpose of this paper is to (1) provide state distributions, (2) assign conservation status to all native crayfishes in the United States and Canada using the best information available, and (3) compile a list of references on the biology, conservation, and distribution of crayfishes in the United States and Canada.

Biology

In North America, crayfishes are found in a wide range of lotic, lentic, and subterranean habitats and are classified as burrowers or nonburrowers. Burrowers spend significant portions of their lives in subterranean burrows ranging from simple linear shafts to elaborate systems of multiple tunnels and chambers (Hobbs 1981). Burrowing allows crayfishes access to the water table in areas without permanent standing water such as wet pastures and roadside ditches. Burrows also are found near lake, river, spring, stream, and swamp margins. Nonburrowers live in permanent waters and spend daylight hours under rocks or among vegetation and debris. For refuge, some nonburrowers make shallow excavations or simple tubes under rocks or in the substrate. Crayfishes are most active between dusk and dawn when they abandon cover to forage for food. Crayfishes generally are opportunistic omnivores that feed on a wide variety of items,



Orconectes stannardi is a threatened species found in the Little Wabash River drainage of southeastern Illinois.

including aquatic and terrestrial vegetation, microbially enriched plant detritus, insects, snails, and small aquatic vertebrates (Hobbs III 1993). However, recent work has suggested that crayfishes are primarily carnivores (Momot 1995).

The life history of crayfishes is influenced by a continuous series of molts. This is especially significant in members of the family Cambaridae, in which males alternate between reproductively mature forms (form I, critical for identification of most species) and nonreproductive forms (form II). Mating usually occurs in the fall. In the spring, eggs are extruded and carried under the female's abdomen for several days to weeks before they hatch. Shortly thereafter, the juveniles leave the female to fend for themselves. In the southern United States, mating commonly occurs in the spring, and eggs are extruded in the fall. Most crayfishes live two to three years, but some subterranean species may live several decades.

Rationale and Threats

The loss of species and decline in population size of aquatic animals such as fishes and mussels is attributed primarily to destruction, degradation, or alteration of habitat; chemical pollution; overexploitation; and introduction of nonindigenous organisms (Allan and Flecker 1993; Williams et al. 1993; Warren and Burr 1994). These factors have affected crayfishes as well, but small natural range also is implicated as a factor underpinning potential or realized imperilment. Using the best available information, we document 11 crayfish species known from single localities and another 20 known from 5 or fewer localities; several of these species occur in fragile subterranean environments. By expanding imperiled status to include taxa known from seven counties or less, we add another 83 to the tally of crayfishes at risk. Many restricted distributions may be the result of anthropogenic activities rather than products of zoogeography. Taxa restricted in range to an area of 100 square miles or less are particularly vulnerable to habitat destruction or

degradation in the form of stream channelization, dredging, siltation, acid mine drainage, and impoundments. The overarching reality is that a species with a small range is more vulnerable to extirpation (Gilpin and Soulé 1986) and should be considered for conservation measures.

Habitat alteration in the form of dams and impoundments alter both the physical and chemical structure of streams (Williams et al. 1993), which can consequently affect stream-inhabiting crayfishes. The removal of gravel and boulder substrates, woody debris, and vegetation through dredging and channelization can affect crayfishes by reducing the amount and quality of habitat used for cover. Without such cover, crayfishes are more susceptible to predation (Stein 1977).

The introduction of nonindigenous crayfishes as bait or for aquaculture has contributed to population declines of native crayfishes and represents an ongoing threat (Holdich 1987; Hobbs III et al. 1989). As fishing bait, crayfishes are transported easily over land and are inadvertently introduced into aquatic habitats when they are discarded as unused bait. "Bait-bucket introductions" have led to dramatic range extensions of several species such as the rusty crayfish (*Orconectes rusticus*). This species is noted for its aggressive behavior and ability to displace native species (Capelli 1982; Butler and Stein 1985; Page 1985). Legislation has been enacted in at least two states, Illinois and Wisconsin, prohibiting possession of rusty crayfish. Likewise, the introduction of the nonindigenous *Orconectes juvenilis* (= *Orconectes spinosus*) into Mountain Lake, Virginia, in 1933 resulted in the elimination of native crayfishes within 24 years (Hobbs and Walton 1966). Imperiled crayfish also have been affected by nonindigenous species. The federally endangered Shasta crayfish (*Pacifastacus fortis*) has been displaced in large portions of its native range by the nonindigenous noble crayfish (*Pacifastacus leniusculus*) (Erman et al. 1993). The introduction of nonindigenous species for commercial culture has occurred in the western, southwestern, and southeastern United States (Hobbs III et al. 1989).

Methods and Definitions

Our review of the conservation status of crayfishes includes all species and subspecies from the United States and Canada as recognized by Hobbs (1989) with minor exceptions. *Fallicambarus hedgpethi*, *F. uhleri*, and subspecies of *Orconectes sanbornii* are not recognized, following Hobbs and Robison (1989) and Jezerinac et al. (1995), respectively. Twenty new taxa are included that were described subsequent to Hobbs (1989). Only scientific names are listed; less than one-quarter of crayfish taxa have common names (A. B. Williams et al. 1989). In determining conservation status and distribution, a variety of sources were used, including state and federal endangered species lists, agency reports, research publications, and books. In addition, we incorporated the observations and field experiences of the authors, reviewers, and other biologists actively working with crayfishes.

The AFS Endangered Species Committee has reviewed the best available distributional and status information and is responsible for the resulting conclusions. The assigned conservation category is based on the status of the taxon throughout its range without consideration of political boundaries. Restricted range was the primary criterion for

within the genus. Following the scientific name and author(s), the conservation status is given using a letter code: E = Endangered; E* = Endangered, Possibly Extinct; T = Threatened; SC = Special Concern; CS = Currently Stable. Parentheses around states indicate known or suspected introductions following Hobbs (1989); a dagger (†) denotes a species complex currently under taxonomic investigation. The distribution is listed alphabetically by states of the United States and provinces of Canada. Standard two-letter abbreviations for states and provinces follow J. E. Williams et al. (1989).

Family-Astacidae

Pacifastacus Bott

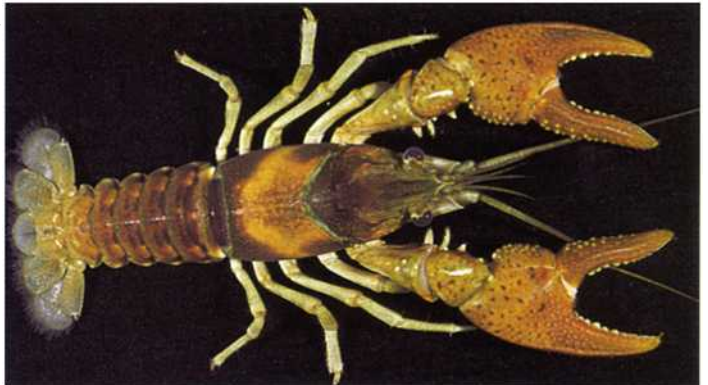
- Pacifastacus connectens* (Faxon). CS. ID, OR
Pacifastacus fortis (Faxon). E. CA
Pacifastacus gambelii (Girard). CS. (CA), ID, MT, NV, OR, UT, WA, WY
Pacifastacus leniusculus klamathensis (Stimpson). CS. CA, ID, OR, WA. Canada, BC
Pacifastacus leniusculus leniusculus (Dana). CS. (CA), ID, (NV), OR, (UT), WA. Canada, BC
Pacifastacus leniusculus trowbridgii (Stimpson). CS. (CA), ID, (NV), OR, WA. Canada, BC
Pacifastacus nigrescens (Stimpson). E*. CA

R. S. Simmons



Almost 15% of crayfishes in the United States and Canada are of special concern, including *Troglodromus maclanei* of Florida.

W. L. Pflieger



Orconectes marchandi of Oregon County, Missouri and Lawrence and Sharp counties, Arkansas is one of 65 species found to be endangered.

assignment of endangered or threatened status. Other threats such as introductions of nonindigenous crayfishes and proximity to metropolitan areas were taken into account in category assignments, but known range and consequent rarity were uppermost in applying category definitions. Conservation status categories follow J. D. Williams et al. (1993) and are defined as Endangered (E)—a species or subspecies in danger of extinction throughout all or a significant portion of its range—an asterisk (*) following the letter "E" indicates the taxon is possibly extinct; Threatened (T)—a species or subspecies likely to become endangered throughout all or a significant portion of its range; Special Concern (SC)—a species or subspecies that may become endangered or threatened by relatively minor disturbances to its habitat and deserves careful monitoring of its abundance and distribution; Currently Stable (CS)—a species or subspecies whose distribution is widespread and stable and is not in need of immediate conservation management actions.

List of Taxa

The list of crayfish species and subspecies is arranged alphabetically by genus and by species and subspecies

Family-Cambaridae

Barbicambarus Hobbs

- Barbicambarus cornutus* (Faxon). CS. KY, TN

Bouchardina Hobbs

- Bouchardina robisoni* Hobbs. SC. AR

Cambarellus Ortmann

- Cambarellus blacki* Hobbs. E. FL
Cambarellus diminutus Hobbs. T. AL, MS
Cambarellus lesliei Fitzpatrick and Laning. T. AL, MS
Cambarellus ninae Hobbs. SC. TX
Cambarellus puer Hobbs. CS. AR, IL, KY, LA, MS, MO, TN, TX
Cambarellus schmitti Hobbs. CS. FL
Cambarellus shufeldtii (Faxon). CS. AL, AR, IL, KY, LA, MS, MO, TN, TX
Cambarellus texanus Albaugh and Black. CS. TX

Cambarus Erichson

- Cambarus acanthura* Hobbs. CS. AL, GA, NC, TN
Cambarus aculabrum Hobbs and Brown. E. AR
Cambarus acuminatus Faxon. † CS. MD, NC, SC, VA
Cambarus angularis Hobbs and Bouchard. CS. TN, VA

Cambarus asperimanus Faxon. CS. GA, NC, SC, TN
Cambarus bartonii bartonii (Fabricius). CS. AL, CT, DE, GA, ME, MD, MA, NJ, NY, NC, PA, RI, SC, TN, VT, VA, WV. Canada, NB, ON, PQ
Cambarus bartonii carinirostris Hay. CS. OH, PA, WV
Cambarus bartonii cavatus Hay. CS. AL, GA, KY, OH, TN, VA, WV
Cambarus batchi Schuster. SC. KY
Cambarus bouchardi Hobbs. E. KY, TN
Cambarus brachydactylus Hobbs. CS. TN
Cambarus buntingi Bouchard. CS. KY, TN
Cambarus carolinus (Erichson). CS. NC, SC, TN
Cambarus catagius Hobbs and Perkins. T. NC
Cambarus causeyi Reimer. SC. AR
Cambarus chasmodactylus James. CS. NC, VA, WV
Cambarus chaugaensis Prins and Hobbs. E. GA, SC
Cambarus conasaugaensis Hobbs and Hobbs. SC. GA, TN
Cambarus coosae Hobbs. CS. AL, GA, TN
Cambarus coosawattae Hobbs. E. GA
Cambarus cracens Bouchard and Hobbs. E. AL
Cambarus crinipes Bouchard. CS. KY, TN
Cambarus cryptodytes Hobbs. T. FL, GA
Cambarus cumberlandensis Hobbs and Bouchard. CS. KY, TN
Cambarus cymatilis Hobbs. E. GA, TN

Cambarus laevis Faxon. CS. IL, IN, KY
Cambarus latimanus (Le Conte). CS. AL, FL, GA, NC, SC, TN
Cambarus longirostris Faxon. CS. GA, NC, SC, TN, VA
Cambarus longulus Girard. CS. NC, VA, WV
Cambarus ludovicianus Faxon. CS. AL, AR, KY, LA, MS, MO, TN, TX
Cambarus maculatus Hobbs and Pflieger. CS. MO
Cambarus manningi Hobbs. CS. AL, GA, TN
Cambarus miltus Fitzpatrick. T. AL, FL
Cambarus monongalensis Ortmann. CS. PA, VA, WV
Cambarus nerterius Hobbs. E. WV
Cambarus nodosus Bouchard and Hobbs. CS. GA, NC, SC, TN
Cambarus obeyensis Hobbs and Shoup. T. TN
Cambarus obstipus Hall. SC. AL
Cambarus ornatus Rhoades. CS. KY
Cambarus ortmanni Williamson. CS. IN, KY, OH
Cambarus parrishii Hobbs. E. GA, NC
Cambarus parvoculus Hobbs and Shoup. CS. GA, KY, TN, VA
Cambarus pristinus Hobbs. E. TN
Cambarus pyronotus Bouchard. E. FL
Cambarus reburrus Prins. SC. NC
Cambarus reduncus Hobbs. CS. NC, SC
Cambarus reflexus Hobbs. CS. GA, SC
Cambarus robustus Girard. CS. CT, IL, IN, KY, MI, NY, NC, OH,



C. A. Taylor and K. S. Cummings

Species with very limited natural ranges such as *Cambarus pristinus* of Tennessee are especially vulnerable to habitat threats.

Cambarus deweesae Bouchard and Etnier. E. TN
Cambarus diogenes Girard. † CS. AL, AR, CO, DE, FL, GA, IL, IN, IA, KS, KY, LA, MD, MI, MN, MS, MO, NE, NJ, NC, ND, OH, OK, PA, SC, SD, TN, TX, VA, WI, WY. Canada, ON
Cambarus distans Rhoades. CS. AL, GA, KY, TN
Cambarus dubius Faxon. CS. KY, MD, NC, PA, TN, VA, WV
Cambarus elkensis Jezerinac and Stocker. T. WV
Cambarus englishi Hobbs and Hall. SC. AL, GA
Cambarus extraneus Hagen. T. GA, TN
Cambarus fasciatus Hobbs. T. GA
Cambarus friauffi Hobbs. CS. TN
Cambarus gentryi Hobbs. CS. TN
Cambarus georgiae Hobbs. E. GA, NC
Cambarus girardianus Faxon. CS. AL, GA, TN
Cambarus graysoni Faxon. CS. AL, KY, TN
Cambarus halli Hobbs. SC. AL, GA
Cambarus hamulatus (Cope). CS. AL, TN
Cambarus harti Hobbs. E. GA
Cambarus hiwasseeensis Hobbs. SC. GA, NC, TN
Cambarus howardi Hobbs and Hall. SC. AL, GA
Cambarus hubbsi Creaser. CS. AR, MO
Cambarus hubrichti Hobbs. CS. MO
Cambarus jonesi Hobbs and Barr. CS. AL



C. A. Taylor and K. S. Cummings

Fifty-two percent of crayfishes, including *Orconectes placidus* of Alabama, Illinois, Kentucky, and Tennessee, are currently stable.

PA, TN, VA, WV. Canada, ON
Cambarus rusticiformis Rhoades. CS. IL, KY, TN
Cambarus sciotensis Rhoades. CS. KY, OH, VA, WV
Cambarus scotti Hobbs. T. AL, GA
Cambarus setosus Faxon. SC. MO, OK
Cambarus speciosus Hobbs. E. GA
Cambarus sphenoides Hobbs. CS. KY, TN
Cambarus spicatus Hobbs. T. NC, SC
Cambarus striatus Hay. CS. AL, FL, GA, KY, MS, SC, TN
Cambarus strigosus Hobbs. T. GA
Cambarus subterraneus Hobbs. E. OK
Cambarus tartarus Hobbs and Cooper. E. OK
Cambarus tenebrosus Hay. † CS. AL, IL, KY, TN
Cambarus thomai Jezerinac. CS. KY, OH, PA, TN, WV
Cambarus truncatus Hobbs. E. GA
Cambarus unestami Hobbs and Hall. T. AL, GA
Cambarus veteranus Faxon. T. KY, VA, WV
Cambarus williamsi Bouchard and Bouchard. E. TN
Cambarus zophonastes Hobbs and Bedinger. E. AR

Distocambarus Hobbs

Distocambarus carlsoni Hobbs. SC. SC
Distocambarus crockeri Hobbs and Carlson. SC. SC

Distocambarus devexus (Hobbs). E. GA
Distocambarus youngineri Hobbs and Carlson. E. SC

Fallicambarus Hobbs

Fallicambarus burrisi Fitzpatrick. T. AL, MS
Fallicambarus byersi (Hobbs). CS. AL, FL, MS
Fallicambarus caesius Hobbs. CS. AR
Fallicambarus danielae Hobbs. T. AL, MS
Fallicambarus devastator Hobbs and Whiteman. SC. TX
Fallicambarus dissitus (Penn). CS. AR, LA
Fallicambarus fodiens (Cottle). CS. AL, AR, FL, GA, IL, IN, KY, LA, MD, MI, MS, MO, NC, OH, OK, SC, TN, TX, VA, WV, Canada, ON
Fallicambarus gilpini Hobbs and Robison. E. AR
Fallicambarus gordonii Fitzpatrick. E. MS
Fallicambarus harpi Hobbs and Robison. E. AR
Fallicambarus hortonii Hobbs and Fitzpatrick. E. TN
Fallicambarus jeanae Hobbs. SC. AR
Fallicambarus macneesei (Black). SC. LA, TX
Fallicambarus oryctes (Penn and Marlow). SC. AL, LA, MS
Fallicambarus petilicarpus Hobbs and Robison. E. AR
Fallicambarus strawni (Reimer). T. AR

Faxonella Creaser

Faxonella beyeri (Penn). CS. LA, TX
Faxonella blairi Hayes and Reimer. CS. AR, OK
Faxonella clypeata (Hay). CS. AL, AR, FL, GA, LA, MS, MO, SC, TX
Faxonella creaseri Walls. SC. LA

Hobbseus Fitzpatrick and Payne

Hobbseus attenuatus Black. E. MS
Hobbseus cristatus (Hobbs). T. MS
Hobbseus orconectoides Fitzpatrick and Payne. T. MS
Hobbseus petilus Fitzpatrick. T. MS
Hobbseus prominens (Hobbs). CS. AL, MS
Hobbseus valleculeus (Fitzpatrick). T. MS
Hobbseus yalobushensis Fitzpatrick and Busack. E. MS

Orconectes Cope

Orconectes acares Fitzpatrick. CS. AR
Orconectes alabamensis (Faxon). SC. AL, MS, TN
Orconectes australis australis (Rhoades). CS. AL, TN

Orconectes australis packardii Rhoades. T. KY
Orconectes barrenensis Rhoades. CS. KY, TN
Orconectes bisectus Rhoades. E. KY
Orconectes blacki Walls. T. LA
Orconectes causeyi Jester. CS. CO, KS, (NM), OK, TX
Orconectes chickasawae Cooper and Hobbs. CS. AL, MS
Orconectes compressus (Faxon). CS. AL, KY, MS, TN
Orconectes cooperi Cooper and Hobbs. E. AL, TN
Orconectes deanae Reimer and Jester. E. NM
Orconectes difficilis (Faxon). CS. LA, OK, TX
Orconectes durelli Bouchard and Bouchard. CS. KY, TN
Orconectes erichsonianus (Faxon). CS. AL, GA, TN, VA
Orconectes etnieri Bouchard and Bouchard. CS. MS, TN
Orconectes eupunctus Williams. SC. AR, MO
Orconectes forceps (Faxon). CS. AL, GA, TN, VA
Orconectes harrisonii (Faxon). SC. MO
Orconectes hartfieldi Fitzpatrick and Suttkus. T. MS
Orconectes hathawayi Penn. SC. LA
Orconectes hobbsi Penn. CS. LA, MS
Orconectes holti Cooper and Hobbs. T. AL
Orconectes hylas (Faxon). CS. MO
Orconectes illinoiensis Brown. SC. IL
Orconectes immunis (Hagen). CS. AL, CO, (CT), IL, IN, IA, KS, KY, (ME), (MA), MI, MN, MO, MT, NE, (NH), NY, ND, OH, (RI), SD, TN, (VT), WI, WY. Canada, MB, ON, PQ
Orconectes incomptus Hobbs and Barr. E. TN
Orconectes indianensis (Hay). SC. IL, IN
Orconectes inermis inermis Cope. CS. IN, KY
Orconectes inermis testii (Hay). T. IN
Orconectes jeffersoni Rhoades. E. KY
Orconectes jonesi Fitzpatrick. T. AL, MS
Orconectes kentuckiensis Rhoades. T. IL, KY
Orconectes lancifer (Hagen). CS. AL, AR, IL, KY, LA, MS, MO, TN, TX
Orconectes leptogonopodus Hobbs. CS. AR, OK
Orconectes limosus (Rafinesque). CS. CT, DE, ME, MD, MA, NH, NJ, NY, PA, RI, VT, VA, WV. Canada, ON
Orconectes longidigitus (Faxon). CS. AR, MO
Orconectes luteus (Creaser). CS. KS, MO
Orconectes macrus Williams. CS. AR, MO
Orconectes maletae Walls. T. LA, TX
Orconectes marchandi Hobbs. E. AR, MO
Orconectes medius (Faxon). CS. MO

J. E. Cooper



Knowledge of the basic biology of most crayfishes is incomplete or nonexistent. Here, *Barbicambarus cornutus* of the Green River drainage of Kentucky and Tennessee is listed as currently stable.

- Orconectes meeki brevis* Williams. T. AR, OK
Orconectes meeki meeki (Faxon). CS. AR, MO
Orconectes menae (Creaser). T. AR, OK
Orconectes mirus (Ortmann). CS. AL, TN
Orconectes mississippiensis (Faxon). T. MS
Orconectes nais (Faxon). CS. KS, MO, OK, TX
Orconectes nana Williams. SC. AR, OK
Orconectes neglectus chaenodactylus Williams. SC. AR, MO
Orconectes neglectus neglectus (Faxon). CS. AR, CO, KS, MO, NE, OK, (OR), WY
Orconectes obscurus (Hagen). CS. ME, MD, NY, OH, PA, VA, WV. Canada, ON
Orconectes ozarkae Williams. CS. AR, MO
Orconectes palmeri creolanus (Creaser). CS. LA, MS
Orconectes palmeri longimanus (Faxon). CS. AR, KS, LA, OK, TX
Orconectes palmeri palmeri (Faxon). CS. AR, KY, LA, MS, MO, TN
Orconectes pellucidus (Tellkampf). CS. KY, TN
Orconectes perfectus Walls. CS. AL, MS
Orconectes peruncus (Creaser). T. MO
Orconectes placidus (Hagen). CS. AL, IL, KY, TN
Orconectes propinquus (Girard). CS. IL, IN, IA, MA, MI, MN, NY, OH, PA, VT, WI. Canada, ON, PQ
Orconectes punctimanus (Creaser). CS. AR, MO
Orconectes putnami (Faxon). CS. IN, KY, TN
Orconectes quadruncus (Creaser). T. MO
Orconectes rafinesquei Rhoades. SC. KY
Orconectes rhoadesi Hobbs. CS. TN
Orconectes rusticus (Girard). CS. (CT), (IL), IN, (IA), KY, (ME), (MA), MI, (MN), (NH), (NJ), (NM), (NY), OH, (PA), (TN), (VT), (WV), (WI). Canada, ON
Orconectes sanbornii (Faxon). CS. KY, OH, WV
Orconectes saxatilis Bouchard and Bouchard. E. OK
Orconectes shoupi Hobbs. E. TN
Orconectes sloanii (Bundy). T. IN, OH
Orconectes spinosus (Bundy). CS. AL, GA, KY, OH, NC, TN, VA, WV
Orconectes stannardi Page. T. IL
Orconectes tricuspis Rhoades. CS. KY
Orconectes validus (Faxon). CS. AL, TN
Orconectes virginianensis Hobbs. CS. NC, VA
Orconectes virilis Hagen. CS. (AL), (AZ), AR, (CA), CO, (CT), IL, IN, IA, KS, KY, (ME), (MD), (MA), MI, MN, MO, MT, NE, (NH), (NJ), (NM), NY, ND, OH, OK, (PA), (RI), SD, (TN), TX, UT, (VT), (VA), (WV), WI, WY. Canada, AB, MB, ON, PQ, SK
Orconectes williamsi Fitzpatrick. SC. AR, MO
Orconectes wrighti Hobbs. E. TN

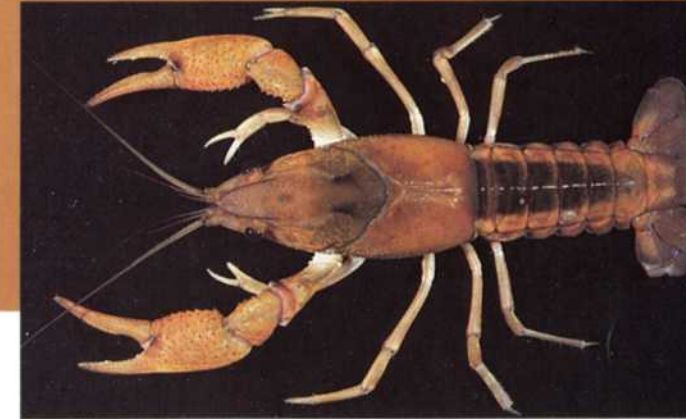
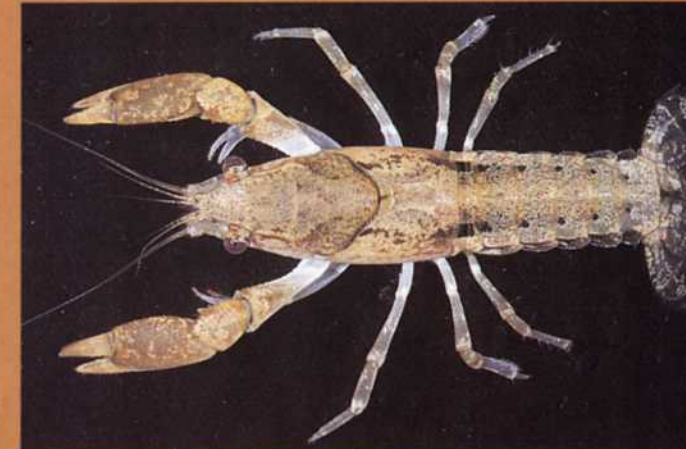
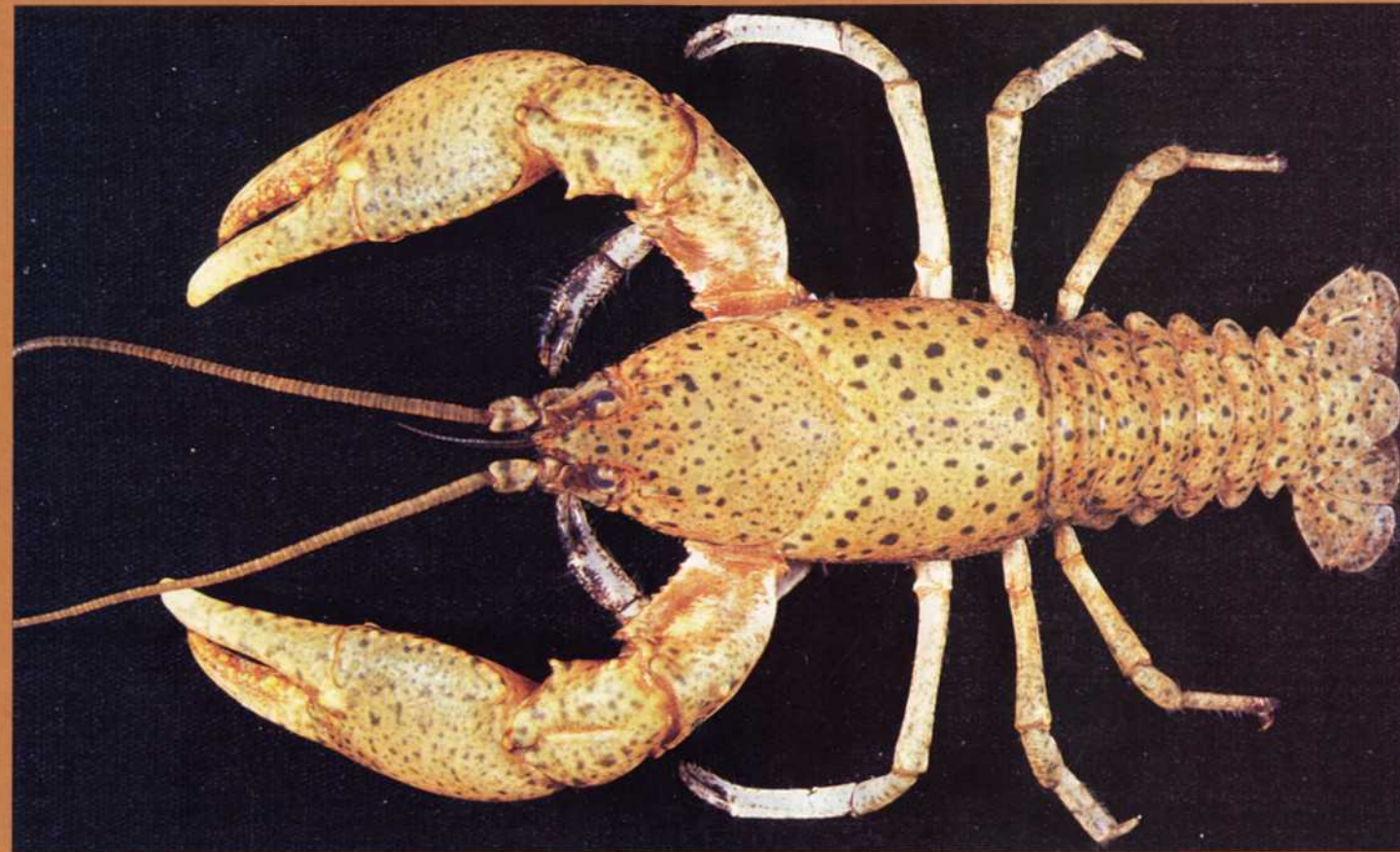
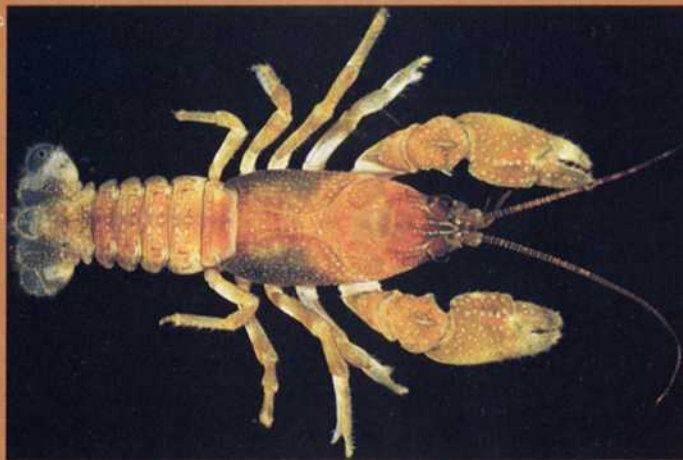
Procambarus Ortmann

- Procambarus ablusus* Penn. CS. MS, TN
Procambarus acherontis (Lonnberg). E. FL
Procambarus acutissimus (Girard). CS. AL, GA, MS
Procambarus acutus (Girard). + CS. AL, AR, (CA), (CT), DE, FL, GA, IL, IN, IA, KS, KY, LA, (ME), MD, (MA), MI, MN, MS, MO, NJ, NY, NC, OH, OK, PA, (RI), SC, TN, TX, VA, WI
Procambarus advena (Le Conte). CS. GA
Procambarus alleni (Faxon). CS. FL
Procambarus ancylus Hobbs. CS. NC, SC
Procambarus angustatus (Le Conte). E*. GA
Procambarus apalachicola Hobbs. T. FL
Procambarus attiguus Hobbs and Franz. E. FL
Procambarus barbatus (Faxon). CS. GA, SC
Procambarus barbiger Fitzpatrick. T. MS
Procambarus bivittatus Hobbs. CS. AL, FL, LA, MS
Procambarus blandingii (Harlan). CS. NC, SC



Crayfishes such as *Cambarus ludovicianus* are burrowers that spend most of their time underground.

- Procambarus brazoriensis* Albaugh. E. TX
Procambarus capillatus Hobbs. CS. AL, FL
Procambarus caritus Hobbs. CS. GA
Procambarus chacei Hobbs. CS. GA, SC
Procambarus clarkii (Girard). CS. AL, (AZ), AR, (CA), FL, (GA), (HI), (ID), IL, IN, KY, LA, (MD), MS, MO, (NV), (NM), (NC), (OH), OK, (OR), (SC), TN, TX, (UT), (VA)
Procambarus clemmeri Hobbs. CS. AL, MS
Procambarus cometes Fitzpatrick. E. MS
Procambarus connus Fitzpatrick. E. MS
Procambarus curdi Reimer. CS. AR, OK, TX
Procambarus delicatus Hobbs and Franz. E. FL
Procambarus dupratzi Penn. CS. AR, LA, TX
Procambarus echinatus Hobbs. SC. SC
Procambarus econfinae Hobbs. E. FL
Procambarus elegans Hobbs. CS. AR, LA, MS
Procambarus enoplosternum Hobbs. CS. GA, SC
Procambarus epicyrtus Hobbs. SC. GA
Procambarus erythroptus Relyea and Sutton. E. FL
Procambarus escambiensis Hobbs. E. AL, FL
Procambarus evermanni (Faxon). CS. AL, FL, MS
Procambarus fallax (Hagen). CS. FL, GA
Procambarus ferrugineus Hobbs and Robison. E. AR



(Top left) The Southeast United States supports the largest number of crayfish species such as the endangered *Cambarus williamsi* of Tennessee. (Left) Crayfishes such as *Orconectes australis australis*,

(above) *Cambarus maculatus*, (right top) *Faxonella clypeata*, and (right bottom) *Procambarus viaeviridis* help the aquatic food web by processing vegetation and leaves and making them available to other organisms.

Procambarus fitzpatricki Hobbs. T. MS
Procambarus franzi Hobbs and Lee. E. FL
Procambarus geminus Hobbs. CS. AR, LA
Procambarus geodytes Hobbs. CS. FL
Procambarus gibbus Hobbs. SC. GA
Procambarus gracilis (Bundy). CS. IL, IN, IA, KS, MO, OK, TX, WI
Procambarus hagenianus hagenianus (Faxon). CS. AL, MS
Procambarus hagenianus vesticeps Fitzpatrick. SC. MS
Procambarus hayi (Faxon). CS. AL, MS, TN
Procambarus hinei (Ortmann). CS. LA, TX
Procambarus hirsutus Hobbs. CS. SC
Procambarus horsti Hobbs and Means. E. FL
Procambarus howellae Hobbs. CS. GA
Procambarus hubbelli (Hobbs). CS. AL, FL
Procambarus hybus Hobbs and Walton. CS. AL, MS
Procambarus incilis Penn. CS. TX
Procambarus jaculus Hobbs and Walton. CS. LA, MS
Procambarus kensleyi Hobbs. SC. TX
Procambarus kilbyi (Hobbs). CS. FL
Procambarus lagniappe Black. T. AL, MS
Procambarus latipleurum Hobbs. SC. FL
Procambarus lecontei (Hagen). SC. AL, MS
Procambarus leitheuseri Franz and Hobbs. E. FL
Procambarus leonensis Hobbs. CS. FL
Procambarus lepidodactylus Hobbs. † CS. NC, SC
Procambarus lewisi Hobbs and Walton. SC. AL
Procambarus liberorum Fitzpatrick. CS. AR
Procambarus litosternum Hobbs. CS. GA

Procambarus lophotus Hobbs and Walton. CS. AL, GA, TN
Procambarus lucifugus alachua (Hobbs). T. FL
Procambarus lucifugus lucifugus (Hobbs). E. FL
Procambarus lunzi (Hobbs). CS. GA, SC
Procambarus lylei Fitzpatrick and Hobbs. SC. MS
Procambarus mancus Hobbs and Walton. CS. MS
Procambarus marthae Hobbs. SC. AL
Procambarus medialis Hobbs. SC. NC
Procambarus milleri Hobbs. E. FL
Procambarus morrisoni Hobbs and Franz. E. FL
Procambarus natchitochae Penn. CS. AR, LA, TX
Procambarus nechesae Hobbs. E. TX
Procambarus nigrocinctus Hobbs. E. TX
Procambarus nueces Hobbs and Hobbs. E. TX
Procambarus okaloosae Hobbs. CS. AL, FL
Procambarus orcinus Hobbs and Means. T. FL
Procambarus ouachitae Penn. CS. AR, MS
Procambarus paeninsulanus (Faxon). CS. AL, FL, GA
Procambarus pallidus (Hobbs). SC. FL
Procambarus parasimulans Hobbs and Robison. CS. AR
Procambarus pearsei (Creaser). CS. NC, SC
Procambarus pecki Hobbs. E. AL
Procambarus penni Hobbs. SC. LA, MS
Procambarus petersi Hobbs. SC. GA
Procambarus pictus (Hobbs). T. FL
Procambarus planirostris Penn. CS. LA, MS
Procambarus plumimanus Hobbs and Walton. SC. NC
Procambarus pogum Fitzpatrick. E. MS

Procambarus pubescens (Faxon). CS. GA, SC
Procambarus pubischelae deficiens Hobbs. CS. GA
Procambarus pubischelae pubischelae Hobbs. CS. FL, GA
Procambarus pycnogonopus Hobbs. CS. FL
Procambarus pygmaeus Hobbs. CS. FL, GA
Procambarus raneyi Hobbs. CS. GA, SC
Procambarus rathbunae (Hobbs). T. FL
Procambarus regalis Hobbs and Robison. SC. AR
Procambarus reimeri Hobbs. E. AR
Procambarus rogersi campestris Hobbs. SC. FL
Procambarus rogersi expletus Hobbs and Hart. E. FL
Procambarus rogersi ochlocknensis Hobbs. SC. FL
Procambarus rogersi rogersi (Hobbs). E. FL
Procambarus seminolae Hobbs. CS. FL, GA
Procambarus shermani Hobbs. CS. AL, FL, LA, MS
Procambarus simulans (Faxon). CS. AR, CO, KS, LA, NM, OK, TX
Procambarus spiculifer (Le Conte). † CS. AL, FL, GA, SC
Procambarus steigmani Hobbs. E. TX
Procambarus suttkusi Hobbs. SC. AL, FL
Procambarus talpoides Hobbs. CS. FL, GA
Procambarus tenuis Hobbs. SC. AR, OK
Procambarus texanus Hobbs. E. TX
Procambarus troglodytes (Le Conte). CS. GA, SC
Procambarus truculentus Hobbs. CS. GA
Procambarus tulaneii Penn. CS. AR, LA
Procambarus verrucosus Hobbs. CS. AL
Procambarus versutus (Hagen). CS. AL, FL, GA

Procambarus viaeviridis (Faxon). CS. AL, AR, IL, KY, LA, MS, MO, TN
Procambarus vioscai paynei Fitzpatrick. CS. AL, MS, TN
Procambarus vioscai vioscai Penn. CS. AR, LA
Procambarus youngi Hobbs. T. FL
Procambarus zonangulus Hobbs. CS. AL, LA, MS, TX

Troglocambarus Hobbs

Troglocambarus maclanei Hobbs. SC. FL

Additional Reading

We provide this section to aid the reader in accessing additional information on crayfishes in the United States and Canada. The papers, organized alphabetically by state, are primarily taxonomic or distributional in nature but also cover topics associated with a variety of aspects of the biology of crayfishes. Some of the listed articles are not obtained easily without access to a major university or museum library. The Regional and General References section contains relevant papers for states lacking specific citations. For the interested reader, the literature-cited sections of these papers provide citations for other literature on crayfishes.

ALABAMA

Bouchard, R. W. 1976. Crayfishes and shrimps. Pages 13–20 in H. Boschung, ed. Endangered and threatened plants and



Cambarus cryptodytes is a threatened species found in caves in Jackson County, Florida and Decatur County, Georgia.

animals of Alabama. Bull. Ala. Mus. Nat. Hist. 2.

Fitzpatrick Jr., J. F. 1990. Decapoda. Pages 77–80 in S. C. Harris, ed. Preliminary considerations on rare and endangered invertebrates in Alabama. J. Ala. Acad. Sci. 61:64–92.

ARKANSAS

Bouchard, R. W., and H. W. Robison. 1980. An inventory of the decapod crustaceans (crayfishes and shrimps) of Arkansas with a discussion of their habitats. Ark. Acad. Sci. Proc. 34:22–30.

Hobbs Jr., H. H., and H. W. Robison. 1988. The crayfish subgenus *Girardiella* (Decapoda: Cambaridae) in Arkansas, with the descriptions of two new species and a key to the members of the *gracilis* group in the genus *Procambarus*. Proc. Biol. Soc. Wash. 101:391–413.

———. 1989. On the crayfish genus *Fallicambarus* (Decapoda: Cambaridae) in Arkansas, with notes on the *fodiens* complex and descriptions of two new species. Proc. Biol. Soc. Wash. 102:651–697.

CALIFORNIA

Eng, L. L., and R. W. Daniels. 1982. Life history, distribution, and status of *Pacifastacus fortis* (Decapoda: Astacidae). Calif. Fish Game 68:197–212.

Riegel, J. A. 1959. The systematics and distribution of crayfishes in California. Calif. Fish Game 45:29–50.

COLORADO

Unger, P. A. 1978. The crayfishes (Crustacea: Cambaridae) of Colorado. Nat. Hist. Inventory Colorado 3:1–19.

FLORIDA

Deyrup, M., and R. Franz, eds. 1994. Rare and endangered biota of Florida, Vol. IV. Invertebrates. University Press of Florida, Gainesville.

Franz, R., and S. E. Franz. 1990. A review of the Florida crayfish fauna, with comments on nomenclature, distribution, and conservation. Fla. Sci. 53:286–296.

Hobbs Jr., H. H. 1942. The crayfishes of Florida. University of Florida Publications, Biol. Sci. Ser. 3.

Hobbs Jr., H. H., and H. H. Hobbs III. 1991. An illustrative key to the crayfishes of Florida (based on first-form males). Fla. Sci. 54:13–24.

GEORGIA

Hobbs Jr., H. H. 1981. The crayfishes of Georgia. Smithsonian. Contrib. Zool. 318.

ILLINOIS

Brown, P. L. 1955. The biology of the crayfishes of central and southeastern Illinois. Ph.D. dissertation. University of Illinois, Urbana-Champaign.

Herkert, J. R., ed. 1992. Endangered and threatened species of Illinois: status and distribution. Vol. 2—animals. Ill. Endangered Species Protection Board, Springfield.

Page, L. M. 1985. The crayfishes and shrimps (Decapoda) of Illinois. Ill. Nat. Hist. Surv. Bull. 33:335–448.

INDIANA

Eberly, W. R. 1955. Summary of the distribution of Indiana crayfishes, including new state and county records. Ind. Acad. Sci. Proc. 64:281–283.

Page, L. M., and G. B. Mottes. 1995. The distribution and status of the Indiana crayfish, *Orconectes indianensis*, with comments on the crayfishes of Indiana. Proc. Ind. Acad. Sci. 104:103–111.

IOWA

Phillips, G. S. 1980. The decapod crustaceans of Iowa. Proc. Iowa Acad. Sci. 87:81–95.

KANSAS

Williams, A. B., and A. B. Leonard. 1952. The crayfishes of Kansas. Univ. Kans. Sci. Bull. 34:961–1012.

KENTUCKY

Burr, B. M., and H. H. Hobbs, Jr. 1984. Additions to the crayfish fauna of Kentucky, with new locality records for *Cambarellus shufeldtii*. Trans. Ky. Acad. Sci. 45:14–18.

Rhoades, R. 1944. The crayfishes of Kentucky, with notes on variation, distribution, and descriptions of new species and subspecies. Am. Midl. Nat. 31:111–149.

LOUISIANA

Penn, G. H. 1959. An illustrated key to the crawfishes of Louisiana with a summary of their distribution within the state. Tulane Stud. Zool. 7:3–20.

———. 1956. The genus *Procambarus* in Louisiana (Decapoda, Astacidae). Am. Midl. Nat. 56:406–422.

———. 1952. The genus *Orconectes* in Louisiana (Decapoda, Astacidae). Am. Midl. Nat. 47:743–748.

———. 1950. The genus *Cambarellus* in Louisiana (Decapoda, Astacidae). Am. Midl. Nat. 44:421–426.

Penn, G. H., and G. Marlow. 1959. The genus *Cambarus* in Louisiana. Am. Midl. Nat. 61:191–203.

Walls, J. G., and J. B. Black. 1991. Distributional records for some Louisiana crawfishes (Decapoda: Cambaridae). Proc. La. Acad. Sci. 54: 23–29.

MARYLAND

Meredith, W. G., and F. J. Schwartz. 1959. The crayfishes of Maryland. Maryland Tidewater News 15:1–2.

Meredith, W. G., and F. J. Schwartz. 1960. Maryland crayfishes. Maryland Depart. Research Education, Educational Ser. 46.

MICHIGAN

Creaser, E. P. 1931. The Michigan decapod crustaceans. Pap. Mich. Acad. Sci. Arts Lett. 13:257–276.

MISSISSIPPI

Fitzpatrick Jr., J. F. In press. Rare and endangered crawfishes of Mississippi. Bull. Miss. Mus. Nat. Sci.

MISSOURI

Missouri Department of Conservation. 1992. The checklist of rare and endangered species of Missouri. Missouri Department of Conservation, Jefferson City.

Pflieger, W. L. 1987. An introduction to the crayfishes of Missouri. *Mo. Conserv.* 48:17–31.

NEBRASKA

Engle, E. T. 1926. Crayfishes of the genus *Cambarus* in Nebraska and eastern Colorado. *Bull. Bur. Fish.* 42:87–104.

NEW JERSEY

Bouchard, R. W. 1982. The freshwater malacostracan crustaceans of New Jersey. Pages 83–100 in W. J. Cromartie, ed. *New Jersey's endangered and threatened plants and animals*. Stockton State College Center for Environmental Research, Pomona, NJ.

Francois, D. D. 1959. The crayfishes of New Jersey. *Ohio J. Sci.* 59:108–127.

NEW YORK

Crocker, D. W. 1957. The crayfishes of New York State (Decapoda, Astacidae). *New York State Mus. Sci. Service Bull.* 355.

NORTH CAROLINA

Cooper, J. E., and A. L. Braswell. Observations on North Carolina crayfishes (Decapoda: Cambaridae). *Brimleyana* 22:87–132.

LeGrand Jr., H. E., and S. P. Hall. 1995. Natural Heritage Program list of the rare animals of North Carolina. North Carolina Natural Heritage Program, Department of Environment, Health, and Natural Resources, Raleigh.

OHIO

Jezerinac, R. F. 1982. Life-history notes and distributions of crayfishes (Decapoda: Cambaridae) from the Chagrin River basin, northeastern Ohio. *Ohio J. Sci.* 82:181–192.

———. 1986. Endangered and threatened crayfishes (Decapoda: Cambaridae) of Ohio. *Ohio J. Sci.* 86:177–180.

———. 1991. The distribution of crayfishes (Decapoda: Cambaridae) of the Licking River watershed, east central Ohio: 1972–1977. *Ohio J. Sci.* 91:108–111.

Jezerinac, R. F., and R. F. Thoma. 1984. An illustrated key to the Ohio *Cambarus* and *Fallicambarus* (Decapoda: Cambaridae) with comments and a new subspecies record. *Ohio J. Sci.* 84:120–125.

Rhoades, R. 1944. Further studies on distribution and taxonomy of Ohio crayfishes and the description of a new subspecies. *Ohio J. Sci.* 44:95–99.

Turner, C. L. 1926. The crayfishes of Ohio. *Ohio State Univ. Bull.* 30:144–195.

OKLAHOMA

Creaser, E. P., and A. I. Ortenburger. 1933. The decapod crustaceans of Oklahoma. *Publ. Univ. Okla. Biol. Surv.* 5:14–47.

Dunlap Jr., P. M. 1951. Taxonomic characteristics of the decapod crustaceans of the subfamily Cambarinae in Oklahoma with descriptions of two new species and two keys to species. Master's thesis. Oklahoma Agricultural and Mechanical College, Stillwater.

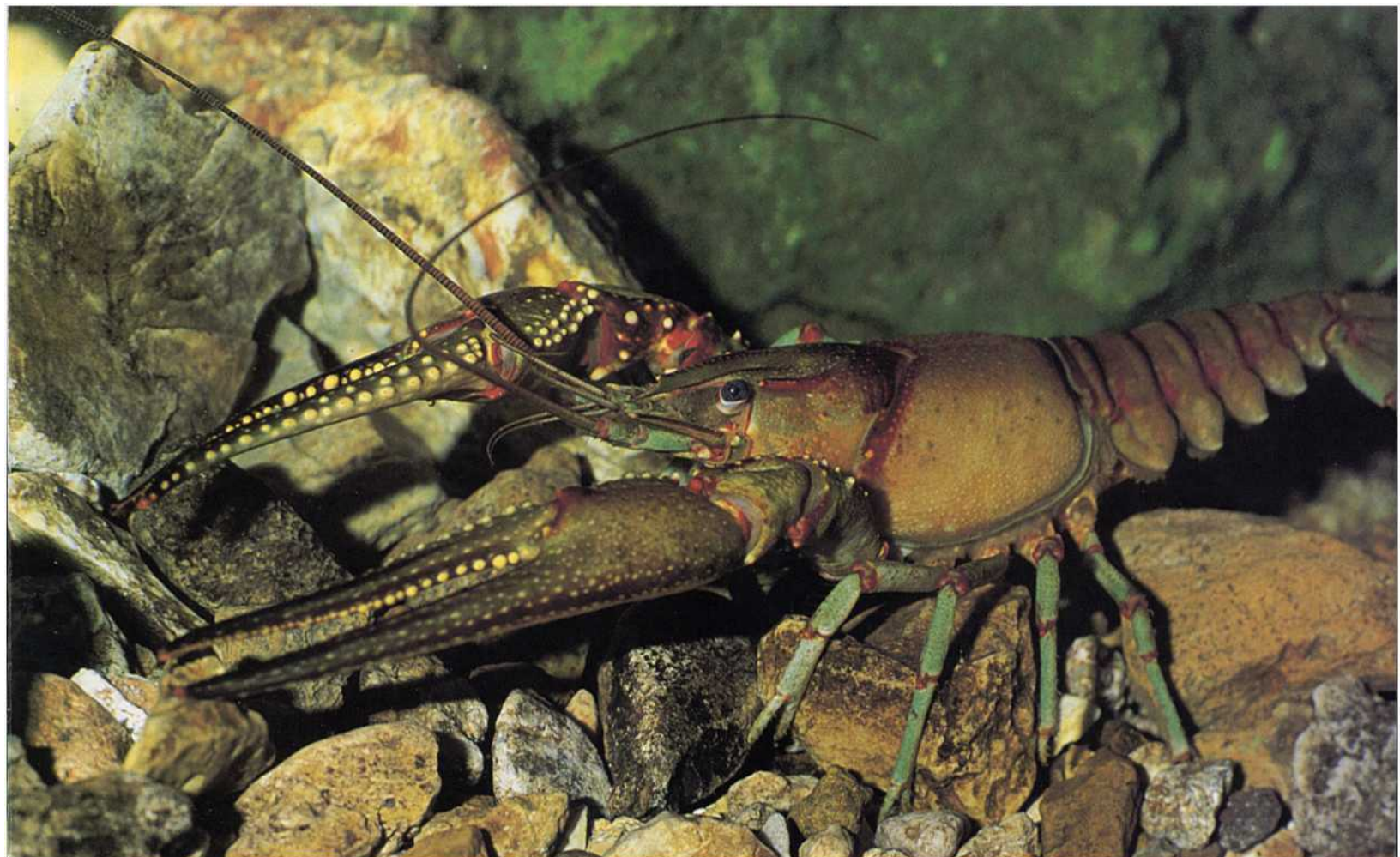
Reimer, R. D. 1969. A report on the crawfishes (Decapoda, Astacidae) of Oklahoma. *Proc. Okla. Acad. Sci.* 48:49–65.

OREGON

See Washington.

Orconectes longidigitus of northwest Arkansas and southwest Missouri is currently stable.

G. D. Chambers





Procambarus nigrocinctus known from Angelina and Jasper counties, Texas, is considered endangered.

PENNSYLVANIA

Ortmann, A. E. 1906. The crawfishes of the state of Pennsylvania. Carnegie Mus. Mem. 2:343–523.

Schwartz, F. J., and W. G. Meredith. 1960. Crayfishes of the Cheat River watershed West Virginia and Pennsylvania. Part I. Species and localities. Ohio J. Sci. 60:40–54.

SOUTH CAROLINA

Eversole, A. G. 1995. Distribution of three rare crayfish species in South Carolina. Freshwater Crayfish 8:113–120.

Hobbs III, H. H., J. H. Thorp, and G. E. Anderson. 1976. The freshwater decapod crustaceans (Palaemonidae, Cambaridae) of the Savannah River Plant, South Carolina. Savannah River Plant, National Environmental Research Park Program.

TENNESSEE

Bouchard, R. W. 1972. A contribution to the knowledge of Tennessee crayfish. Ph.D. dissertation. University of Tennessee, Knoxville.

TEXAS

Albaugh, D. W., and J. B. Black. 1973. A new crawfish of the genus *Cambarellus* from Texas, with new Texas distributional records for the genus (Decapoda, Astacidae). Southwest. Nat. 18:177–185.

Hobbs Jr., H. H. 1990. On the crayfishes (Decapoda: Cambaridae) of the Neches River basin of eastern Texas with the descriptions of three new species. Proc. Biol. Soc. Wash. 103:573–597.

Penn, G. H., and H. H. Hobbs, Jr. 1958. A contribution toward a knowledge of the crayfishes of Texas (Decapoda, Astacidae). Tex. J. Sci. 10:452–483.

UTAH

Johnson, J. E. 1986. Inventory of Utah crayfishes with notes on current distribution. Great Basin Nat. 46:625–631.

WASHINGTON

Miller, G. C. 1960. The taxonomy and certain biological aspects of the crayfish of Oregon and Washington. Master's thesis. Oregon State College, Corvallis.

WEST VIRGINIA

Jezerinac, R. F., G. W. Stocker, and D. C. Tarter. 1995. The crayfishes (Decapoda: Cambaridae) of West Virginia. Ohio Biol. Surv. Bull. NS 10(1).

Lawton, S. M. 1979. A taxonomic and distributional study of the crayfishes (Decapoda: Cambaridae) of West Virginia with diagnostic keys to species of the genera *Cambarus* and *Orconectes*. Master's thesis. Marshall University, Huntington, WV.

Newcombe, C. L. 1929. The crayfishes of West Virginia. Ohio J. Sci. 29:267–288.

Schwartz, F. J., and W. G. Meredith. 1960. Crayfishes of the Cheat River watershed West Virginia and Pennsylvania. Part I. Species and localities. Ohio J. Sci. 60:40–54.

WISCONSIN

Creaser, E. P. 1932. The decapod crustaceans of Wisconsin. Trans. Wis. Acad. Sci. Arts Lett. 27:321–338.

Hobbs III, H. H., and J. P. Jass. 1988. The crayfishes and shrimp of Wisconsin. Milwaukee Public Museum, Milwaukee, WI.

WYOMING

Hubert, W. A. 1988. Survey of Wyoming crayfishes. Great Basin Nat. 48:370–372.

CANADA

Crocker, D. W., and D. W. Barr. 1968. Handbook of the crayfishes of Ontario. University of Toronto Press, Toronto, ON.

REGIONAL and GENERAL REFERENCES

Bouchard, R. W. 1976. Geography and ecology of crayfishes of the Cumberland Plateau and Cumberland Mountains, Kentucky, Virginia, Tennessee, Georgia, and Alabama, Part I:

The genera *Procambarus* and *Orconectes*. Pages 563–584 in J. W. Avault, Jr., ed. Freshwater crayfish. Louisiana State University Division of Continuing Education, Baton Rouge.

———. 1976. Geography and ecology of crayfishes of the Cumberland Plateau and Cumberland Mountains, Kentucky, Virginia, Tennessee, Georgia, and Alabama, Part II: The genera *Fallicambarus* and *Cambarus*. Pages 585–605 in J. W. Avault, Jr., ed. Freshwater crayfish. Louisiana State University Division of Continuing Education, Baton Rouge.

———. 1978. Distribution, systematic status, and ecological notes on five poorly known species of crayfishes in western North America (Decapoda: Astacidae and Cambaridae). Pages 409–423 in O. V. Lindqvist, ed. Freshwater Crayfish 3. University of Kuopio, Kuopio, Finland.

———. 1978. Taxonomy, ecology, and phylogeny of the subgenus *Depressicambarus*, with the description of a new species from Florida and redescriptions of *Cambarus graysoni*, *Cambarus latimanus*, and *Cambarus striatus* (Decapoda: Cambaridae). Bull. Ala. Mus. Nat. Hist. 3:27–60.

Crocker, D. W. 1979. The crayfishes of New England. Proc. Biol. Soc. Wash. 92:225–253.

Fitzpatrick Jr., J. F. 1983. How to know the freshwater Crustacea. William C. Brown, Dubuque, IA.

———. 1983. A revision of the dwarf crawfishes (Cambaridae, Cambarellinae). J. Crust. Biol. 3:266–277.

———. 1987. The subgenera of the crawfish genus *Orconectes* (Decapoda: Cambaridae). Proc. Biol. Soc. Wash. 100:44–74.

Hobbs Jr., H. H. 1942. A generic revision of the crayfishes of the subfamily Cambarinae (Decapoda, Astacidae). Am. Midl. Nat. 28:334–357.

———. 1969. On the distribution and phylogeny of the crayfish genus *Cambarus*. Pages 93–178 in P. C. Holt, R. L. Hoffman, and C. W. Hart, Jr. eds. The distributional history of the biota of the southern Appalachians, Part I: Invertebrates. Virginia Polytechnic Institute, Research Division Monograph 1.

- . 1972. The subgenera of the crayfish genus *Procambarus* (Decapoda: Astacidae). *Smithson. Contrib. Zool.* 117.
- . 1972. Crayfishes (Astacidae) of North and Middle America. *Biota of Freshwater Ecosystems, Identification Manual* 9. U.S. Environmental Protection Agency, Cincinnati, OH.
- . 1984. On the distribution of the crayfish genus *Procambarus* (Decapoda: Cambaridae). *J. Crust. Biol.* 4:12–24.
- . 1989. An illustrated checklist of the American crayfishes (Decapoda: Astacidae, Cambaridae, and Parastacidae). *Smithson. Contrib. Zool.* 480.
- Hobbs Jr., H. H., and C. W. Hart, Jr. 1959. The freshwater decapod crustaceans of the Apalachicola drainage system in Florida, southern Alabama and Georgia. *Bull. Fla. State Mus.* 4:145–191.
- Hobbs Jr., H. H., H. H. Hobbs III, and M. A. Daniel. 1977. A review of the troglobitic decapod crustaceans of the Americas. *Smithson. Contrib. Zool.* 244.
- Holdich, D. M., and R. S. Lowery, eds. 1988. *Freshwater crayfish: biology, management, and exploitation.* Croom Helm, London.
- Ortmann, A. E. 1931. Crawfishes of the southern Appalachians and the Cumberland Plateau. *Ann. Carnegie Mus.* 20:61–160.
- Williams, A. B. 1954. Speciation and distribution of the crayfishes of the Ozark Plateaus and Ouachita Provinces. *Univ. Kans. Sci. Bull.* 36:803–918.

Summary and Conclusions

The list of crayfishes of the United States and Canada includes 338 taxa. Possibly extinct, endangered, threatened, or special concern statuses are recognized for 162 taxa (48.0%). Of these, 2 (< 1%) are possibly extinct, 65 (19.2%) are endangered, 45 (13.3%) are threatened, and 50 (14.8%) are of special concern. Taxa classified as currently stable total 176 (52.0%). Imperilment of crayfishes (48%) parallels high levels of imperilment of fishes and freshwater mussels, almost 33% and 72%, respectively (J. E. Williams et al. 1989; J. D. Williams et al. 1993; Warren and Burr 1994). These assessments support the contention that aquatic diversity in North America is in far worse condition than its terrestrial counterpart (Master 1990).

For some crayfishes, limited natural range (e.g., one locality or one drainage system) precipitates recognition as endangered or threatened. But for many others, status assignments were hampered by a paucity of recent distributional information despite ostensibly small ranges. The dated, depauperate nature of crayfish biogeographical literature is apparent from a cursory examination of the Additional Readings section. Lack of recent species-specific information,

whether distributional or biological, does not warrant neglect by resource agencies. To the contrary, recognition of the potential for rapid decimation of crayfish species, especially those with limited ranges, should provide impetus for proactive efforts toward conservation as espoused by the American Fisheries Society (Angermeier and Williams 1994). Humankind can ill-afford to adopt an attitude that acknowledges only those taxa legally recognized as endangered or threatened at the state or federal level.

Crayfishes are an important and diverse component of aquatic ecosystems in the United States and Canada. Using the best available information, we estimate that almost 50% of the crayfish fauna deserves conservation recognition. We hope that future work will show our conservation status assignments are unwarranted for some of these taxa. The U.S. Fish and Wildlife Service and various state agencies recently have funded status surveys for several species (e.g., Fitzpatrick 1991; McGrath 1994; Eversole 1995), and we encourage continual support for surveys of taxa for which there is limited distributional and ecological information.

The AFS Endangered Species Committee, in publishing this list, summarizes for fisheries professionals, natural resource agencies, university researchers, conservation organizations, lawmakers, and citizens, the conservation status of crayfishes in the United States and Canada. The Committee encourages these and others to do the following:

- (1) critically examine the findings and bring to our attention additional information;
- (2) use the list as a planning and prioritization tool for conducting recovery efforts, status surveys, and biological research on imperiled crayfishes;
- (3) support graduate research and training in the distribution, taxonomy, and ecology of crayfishes;
- (4) propagate education of citizens; and
- (5) recognize the plight of aquatic resources and begin to think and act proactively. 🐞

Dedication

We dedicate this paper to the memory of Horton H. Hobbs, Jr. (1914–1994), whose life work provided a foundation for our knowledge of crayfishes and made this work possible.

Orconectes harrisoni of east central Missouri is listed as of special concern.



W. L. Pflieger

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References

- Allan, J. D., and A. S. Flecker. 1993. Biodiversity conservation in running waters. *Bioscience* 43:32–43.
- Angermeier, P. L., and J. E. Williams. 1994. Conservation of imperiled species and reauthorization of the Endangered Species Act of 1973. *Fisheries* 19(1):26–29.
- Butler, M. J., and R. A. Stein. 1985. An analysis of mechanisms governing species displacement in crayfish. *Oecologia* 66:168–177.
- Capelli, G. M. 1982. Displacement of northern Wisconsin crayfish by *Orconectes rusticus* (Girard). *Limnol. Oceanogr.* 27:741–745.
- Erman, D. C., T. Light, and C. Myrick. 1993. Survey of the status of the shasta crayfish (*Pacifastacus fortis*) in northeastern California (1991 study year). Final report to the California Department of Fish and Game, Sacramento.
- Eversole, A. G. 1995. *Distocambarus* (*Fitzcambarus*) *youngineri* status in South Carolina. Report to the U.S. Fish and Wildlife Service, Asheville, NC.
- Fitzpatrick Jr., J. F. 1991. Determination of the current status of the rare crayfish *Cambarus* (*Lacunibambarus*) *miltus* Fitzpatrick. Report to the U.S. Fish and Wildlife Service, Jackson, MS.
- Gilpin, M. E., and M. E. Soulé. 1986. Minimum viable populations: processes of species extinction. Pages 19–34 in M. E. Soulé, ed. *Conservation biology: the science of scarcity and diversity*. Sinauer Associates, Inc., Sunderland, MA.
- Griffith, M. B., S. A. Perry, and W. B. Perry. 1994. Secondary production of macroinvertebrate shredders in headwater streams with different baseflow alkalinity. *J. North Am. Benthol. Soc.* 13:345–356.
- Hobbs Jr., H. H. 1981. The crayfishes of Georgia. *Smithson. Contrib. Zool.* 318.
- . 1989. An illustrated checklist of the American crayfishes (Decapoda: Astacidae, Cambaridae, and Parastacidae). *Smithson. Contrib. Zool.* 480.
- Hobbs Jr., H. H., and H. W. Robison. 1989. On the crayfish genus *Fallicambarus* (Decapoda: Cambaridae) in Arkansas, with notes on the *fodiens* complex and descriptions of two new species. *Proc. Biol. Soc. Wash.* 102:651–697.
- Hobbs Jr., H. H., and M. Walton. 1966. *Orconectes juvenilis* [sic] (Hagen) in Mountain Lake, Virginia: an unplanned experiment in interspecific competition (Decapoda, Astacidae). *Va. J. Sci.* 17:136–140.
- Hobbs III, H. H. 1993. Trophic relationships of North American freshwater crayfishes and shrimps. *Milwaukee Publ. Mus. Contrib. Biol. Geol.* 85:1–110.
- Hobbs III, H. H., J. P. Jass, and J. V. Huner. 1989. A review of global crayfish introductions with particular emphasis on two North American species (Decapoda, Cambaridae). *Crustaceana* 56:299–316.
- Holdich, D. M. 1987. The dangers of introducing alien animals with particular reference to crayfish. Pages 15–30 in P. G. de Tiefenau, ed. *Freshwater Crayfish 7*. Muse Zoologique Cantonal, Lausanne, Switzerland.
- Huner, J. V. 1989. Overview of international and domestic freshwater crawfish production. *J. Shellfish Res.* 8:259–265.
- Huryn, A. D., and J. B. Wallace. 1987. Production and litter processing by crayfish in an Appalachian mountain stream. *Freshwater Biol.* 18:277–286.
- Jezerinac, R. F., G. W. Stocker, and D. C. Tarter. 1995. The crayfishes (Decapoda: Cambaridae) of West Virginia. *Ohio Biol. Surv. Bull* NS 10(1).
- Master, L. 1990. The imperiled status of North American aquatic animals. *Biodiversity Network News* 3:1–2, 7–8.
- McGrath, C. 1994. Status survey for the Greensboro burrowing crayfish *Cambarus* (*Depressicambarus*) *catagius* Hobbs and Perkins 1967. Final Report to the U.S. Fish and Wildlife Service, Asheville, NC.
- Momot, W. T. 1995. Redefining the role of crayfish in aquatic ecosystems. *Rev. Fish. Sci.* 3:33–63.
- Nielsen, L. A., and D. J. Orth. 1988. The hellgrammite-crayfish bait fishery of the New River and its tributaries, West Virginia. *N. Am. J. Fish. Manage.* 8:317–324.
- Page, L. M. 1985. The crayfishes and shrimps (Decapoda) of Illinois. *Ill. Nat. Hist. Surv. Bull.* 33:335–448.
- Probst, W. E., C. F. Rabeni, W. G. Covington, and R. E. Marteney. 1984. Resource use by stream-dwelling rock bass and smallmouth bass. *Trans. Am. Fish. Soc.* 113:283–294.
- Rabeni, C. F. 1992. Trophic linkage between stream centrarchids and their crayfish prey. *Can. J. Fish. Aquatic Sci.* 49:1714–1721.
- Roell, M. J., and D. J. Orth. 1993. Trophic basis of production of stream-dwelling smallmouth bass, rock bass, and flathead catfish in relation to invertebrate bait harvest. *Trans. Am. Fish. Soc.* 122:46–62.
- Stein, R. A. 1977. Selective predation, optimal foraging, and the predator-prey interactions between fish and crayfish. *Ecology* 58:1237–1253.
- USFWS (U.S. Fish and Wildlife Service). 1994a. Endangered and threatened wildlife and plants, 50 CFR 17.11 & 17.12. Division of Endangered Species, U.S. Fish and Wildlife Service, Washington, DC.
- . 1994b. Endangered and threatened wildlife and plants; animal candidate review for listing as endangered or threatened species; proposed rule, 50 CFR 17. *Fed. Reg.* 59(219):58982–59028.
- Warren Jr., M. L., and B. M. Burr. 1994. Status of freshwater fishes of the United States: overview of an imperiled fauna. *Fisheries* 19(1):6–18.
- Williams, A. B., L. G. Abele, D. L. Felder, H. H. Hobbs Jr., R. B. Manning, P. A. McLaughlin, and I. P. Farante. 1989. Common and scientific names of aquatic invertebrates from the United States and Canada: decapod crustaceans. *American Fisheries Society Special Publication* 17.
- Williams, J. D., M. L. Warren Jr., K. S. Cummings, J. L. Harris, and R. J. Neves. 1993. Conservation status of freshwater mussels of the United States and Canada. *Fisheries* 18(9):6–22.
- Williams, J. E., and R. J. Neves. 1992. Introducing the elements of biological diversity in the aquatic environment. *Trans. N. Am. Wildl. Nat. Resour. Conf.* 57:345–354.
- Williams, J. E., J. E. Johnson, D. A. Hendrickson, W. Contreras-Balderas, J. D. Williams, M. Navarro-Mendoza, D. E. McAllister, and J. E. Deacon. 1989. Fishes of North America endangered, threatened, or of special concern: 1989. *Fisheries* 14(6):2–20.