

STATE WILDLIFE GRANT PROJECT - FINAL REPORT

Project T20 -8

STREAM CRAYFISH OF THE NORTHEAST ARKANSAS OZARKS

By

Brian K. Wagner¹, Christopher A. Taylor², and Mark D. Kottmyer³

¹Arkansas Game and Fish Commission
915 E. Sevier Street,
Benton, AR 72015

²Illinois Natural History Survey
Center for Biodiversity and Ecological Entomology
1816 S. Oak
Champaign, IL 61820

³The Nature Conservancy
675 North Lollar Lane
Fayetteville, AR 72701
479-973-9110

Presented to

The Arkansas Game and Fish Commission
August 29, 2008

APPROVALS:



Brian Wagner, Project Coordinator

August 31, 2008

Date

Steve Filipek, Programs Assistant Chief

Date

Mike Armstrong, Chief of Fisheries

Date

Executive Summary

Orconectes neglectus chaenodactylus, the gapped ringed crayfish, is an uncommon and poorly-known stream-dwelling crayfish that is endemic to the central White River basin of Arkansas and Missouri. This study surveyed a semi-random selection of stream sites in the Arkansas portion of this range in order to characterize the crayfish communities including coldwater crayfish, *Orconectes eupunctus*, another species of interest, and to evaluate the status of *O. n. chaenodactylus* in Arkansas. Collections of a total of 1,811 individual crayfish specimens were made at 82 sites, including 497 *O. n. chaenodactylus* from 21 sites. *O. punctimanus* was the crayfish species most commonly associated with *O. n. chaenodactylus*, occurring at 71% of sites occupied by *O. n. chaenodactylus*. *O. n. chaenodactylus* was found in streams not significantly different from the median characteristics of streams sampled in the study. On the other hand, *Orconectes eupunctus* was only encountered at one site during study collections, likely reflecting the paucity of larger, mainstem sample sites sampled within its range. It is our opinion that *O. n. chaenodactylus* is of moderate concern due to its limited distribution in Arkansas, and should be considered uncommon. More work is needed to ascertain the true status of *O. eupunctus* in Arkansas.

Introduction

The ringed crayfish, *Orconectes neglectus*, was originally described from Mill Creek in Wabaunsee County, Kansas (Faxon 1885). The gapped ringed crayfish, *Orconectes neglectus chaenodactylus*, was recognized as a distinct subspecies based on specimens from White Creek in Douglas County, Missouri (Williams 1952). In addition to its long-standing recognition based

on morphological characteristics, more recent genetic studies suggest the possibility that it is a distinct species (Crandall and Fitzpatrick 1996, Crandall 1998, Dillman et al. 2007).

O. n. chaenodactylus is a stream-dwelling crayfish with a limited and poorly understood distribution. Original work suggested its endemism to the North Fork White River basin in Missouri (Williams 1954). It was first collected in Arkansas by 1967 at the latest (Robison 2002: USNM 131642). Populations were originally thought to be restricted to the North Fork White River, and intergrades were hypothesized between it and *O. n. neglectus* throughout the remainder of the White River basin (Hobbs 1989, Pflieger 1996, Williams 1952). It has subsequently been reported from a few divergent locations in Arkansas, primarily in the North Fork White River and Sylamore Creek basins. It has recently been discovered, due to a suspected introduction, in the Spring River basin (Rabalais and Magoulick 2006). Taylor et al. (2007) considered it to be “vulnerable” and The Nature Conservancy ranks it as G5T3S2.

The coldwater crayfish, *Orconectes eupunctus*, also a stream-dwelling crayfish, has a limited distribution in the eastern White River basin of Missouri and Arkansas. It was originally described from the Eleven Point River in Oregon County, Missouri (Williams 1952). Williams (1954) also examined specimens from the Spring River in Lawrence County, Arkansas. Its habitat is described as “clear, cold, fast streams” (Hobbs 1989), and Pflieger (1996) notes that it does not inhabit tributaries of the Eleven Point River. It was first collected from the Strawberry River basin in 1972 (Robison 2002). Taylor et al. (2007) considered it to be “threatened” and The Nature Conservancy ranks it as G2S1.

The objective of this study was to document the diversity and distribution of the crayfish fauna of the North Fork White, Middle White, Eleven Point, and Strawberry river basins in Arkansas and establish baseline distributions and status of *Orconectes neglectus chaenodactylus* and *Orconectes eupunctus* in these basins.

Methods

Study Area and Site Selection

This study focused on portions of the North Fork White, Middle White, Eleven Point, and Strawberry basins in northern Arkansas. Based on the National Hydrology Dataset (NHD), these hydrologic units comprise 7,801 identified stream segments totaling 153,112 km. The Arkansas portion of these units includes parts of Baxter, Cleburne, Fulton, Independence, Izaard, Lawrence, Randolph, Searcy, Sharp, and Stone counties. Since these areas are largely in private ownership, road access to sampling sites was particularly important. U. S. Census Bureau data on roads in these counties and the NHD data were combined using ArcMap GIS software to identify stream segments that intersect roads. A semi-random subset of these segments was selected for sampling by generating a random number between 0 and 19 as a start point, and then every 20th segment listed in the pooled list of accessible stream segments was chosen. Since the NHD segments were generally adjacent to one another in order, this reduced selection of clustered sampling sites and provided a fairly uniform distribution of sites. This process was repeated for each of the four basins and resulted in selection of 133 stream segments as potential sample sites.

Because headwater streams are more numerous and more easily bridged than larger streams, it was acknowledged that site selection was biased toward headwater streams. Some of these

headwater streams were intermittent and did not hold water or crayfish when visited for sampling, or were inaccessible due to fencing, posting, and/or lack of landowner permission. When either was the case, the site was replaced with a nearby site on a larger stream that was not randomly selected for sampling. Some stream segments selected turned out to be erroneously assigned to the study basins, and were replaced in the same manner. Additional collections made during Ozark hellbender surveys prior to this study are included to supplement distribution data in the Eleven Point River mainstem.

Sampling Methods

The majority of collections were made September – November 2006. Comparable data for one collection in October 2005 was also included. All available habitats at selected sites were sampled using minnow seines or dip nets appropriately sized to the area being sampled. This was supplemented when possible by approximately 30 person-minutes of visual search and hand capture of crayfish by overturning rock slabs if present. At larger river sites, hand capture was completed using snorkeling. Supplemental data from the Eleven Point River was collected August – September 2005. Some of these supplemental collections were accomplished using a Surface Supplied Breathing Apparatus (so-called “hookah rig”).

At each sample site, latitude and longitude coordinates in decimal degrees (North American Datum 1927) were recorded for the sample location. Other information recorded included water temperature, typical depth and width of pool and riffle habitats, predominant substrate sizes, and notes regarding aquatic vegetation, riparian vegetation, turbidity, and flow class (none, slow, moderate, swift). For this study, habitats were classified as pools if they had slower flow,

undisturbed surface, and were the deeper habitats in the sample area; conversely, riffles were habitats with rapid flow, surface disturbance, and relatively shallow water.

Crayfish were sorted by perceived species, sexed, and measured to the nearest mm carapace length (CL). A series of voucher specimens including males and females of each species were also taken. All voucher specimens were preserved in 70% ethanol, identification to species verified by the second author, and deposited in the collection of the Illinois Natural History Survey or the AGFC Nongame Aquatics Program reference collection.

Results

One hundred thirty three stream segments were targeted for sampling within the Eleven Point River (21 sites), Strawberry River (40 sites), North Fork White River (31 sites), and Middle White River basins (41 sites). Due to lack of water or access, several sites were deleted or relocated, resulting in samples actually being conducted at 82 sites (Eleven Point - 13 sites, Strawberry - 24 sites, North Fork White 22 sites, and Middle White River - 23 sites). Sites sampled are mapped for each species collected in Figures 1*a-m*. Crayfish species and numbers collected by site are noted in Table 1. Additional collections made during 2005 Ozark hellbender surveys are included to supplement distribution data in the Eleven Point River mainstem (Table 2).

A total of 1,811 crayfish specimens of twelve different species (and 2 subspecies) was collected in the study (summarized in Table 3). The most abundant taxon was *Orconectes ozarkae* (n=612), followed by *O. neglectus chaenodactylus* (n=497), *O. punctimanus* (n=351), *O.*

neglectus neglectus (n=137), *Procambarus acutus* (n=83), *O. virilis* (n=47), *O. meeki meeki* (n=20), *O. eupunctus* (n=17), *Fallicambarus fodiens* (n=13), *Cambarus hubbsi* (n=9), *O. longidigitus* (n=3), *O. palmeri longimanus* (n=3), and *C. diogenes* (n=1). There were also 14 *O. neglectus* from one site that have not been assigned to subspecies yet and 4 female *Orconectes* from 2 sites that could not be identified to species. The most commonly encountered taxon in the study was *O. punctimanus*, found at 46 sites, followed by *O. ozarkae* (41 sites), *O. neglectus chaenodactylus* (21 sites), *P. acutus* (9 sites), *O. virilis* (9 sites), *O. neglectus neglectus* (8 sites), *F. fodiens* (2 sites), and *C. hubbsi* (2 sites); *O. meeki meeki*, *O. eupunctus*, *O. longidigitus*, *O. palmeri longimanus*, and *C. diogenes* were each found at a single site. Mean lengths and sex distributions by species are displayed in Table 4. Length frequencies of individuals collected (carapace length in mm) are provided in Figures 2 a-i. *C. hubbsi*, *O. longidigitus*, *O. palmeri longimanus*, and *C. diogenes* were found in small numbers, thus their length frequencies were not graphed.

Crayfish Species Associations

Species associations and dominance are reported in Table 5. *O. n. chaenodactylus*, a Species of Greatest Conservation Need (Anderson 2006), co-occurred with three species, *O. punctimanus* (71%), *O. ozarkae* (24%), and *O. neglectus neglectus* (14%). It also co-occurred at a single site with *C. hubbsi* and *O. longidigitus*. Species associations with *O. n. chaenodactylus* were also examined using the metrics of dominance, constancy, and fidelity (Table 6), as described by Pflieger (1978). *O. n. chaenodactylus* was the dominant species where found, comprising an average of 65% of the crayfish collected at those sites. Constancy results indicated that *O. punctimanus* was the associated species found most often at sites having *O. n. chaenodactylus*

(75%). Fidelity estimates, incorporating all sampled sites regardless of *O. n. chaenodactylus*' presence, were greatest for *O. n. neglectus* (50%), an artifact of the underrepresentation of the true range of *O. n. neglectus* among the sites included in analysis.

Since *Orconectes eupunctus* was only found at one site during the study, we did not perform comparable analyses for it, even though it is also a Species of Greatest Conservation Need (Anderson 2006). At this one site *O. eupunctus* was a slightly dominant species (40%), and co-occurred with *C. hubbsi* (5%), *O. ozarkae* (36%), and *O. virilis* (19%).

Habitat Characteristics

Table 7 provides a comparison of selected habitat variable observations from sites with *O. n. chaenodactylus*, across all Middle White River basin sites, across all Norfolk River basin sites, across all Middle White River and Norfolk River basin sites combined (basins encompassing the presumptive native range of the subspecies), and across all sites sampled in this study. *O. n. chaenodactylus* appears to occupy clear streams with slightly more aquatic vegetation than average, substrate typical of the area sampled, slightly more than average forested riparian areas, and moderate current. These habitat variables were not significantly different for sites with *O. neglectus chaenodactylus*, compared to sites with *O. neglectus neglectus*.

Discussion

Distribution

O. neglectus was described by Faxon (1885) from what turns out to be a small, disjunct population in Mill Creek, Wabaunsee County, Kansas. Williams (1952) recognized *O. n.*

chaenodactylus as a distinct subspecies in the North Fork White River basin in Missouri. The subspecies was later recognized from the Arkansas portion of this basin and nearby basins in the Middle White River area. Genetic data implies that this is a distinct species (Crandall and Fitzpatrick 1996, Crandall 1998, Dillman et al. 2007). Recent studies show that the situation is much more complex, with *O. neglectus* possibly containing several cryptic species (Dillman et al. 2007). This shines some doubt on the true distribution of all lineages within *O. neglectus*, but we are reasonably confident that *O. n. chaenodactylus* will be found to be a valid taxon at some level and that its range includes the North Fork White River basin and portions of the Middle White River basin. It is interesting to observe that some sites in this area are occupied by 2 or more likely taxa of *O. neglectus*. The distribution and population levels of *O. n. chaenodactylus* in Missouri are understood primarily by Pflieger's (1996) work, with limited work since (R. J. DiStefano, Missouri Department of Conservation, pers. comm.).

Recommendations

Orconectes neglectus chaenodactylus appears to have a localized distribution in north central Arkansas (and into Missouri), but it is abundant at sites where it does occur. It has been introduced into the South Fork Spring River, where it is proving to be invasive and displacing other species. While its limited range causes it to be of some conservation concern, its abundance where found reduces its priority for conservation efforts. *Orconectes eupunctus*, on the other hand, was only found in one collection during this study and at 2 supplemental sites. This is due to the limited selection of large stream locations for sampling. Additional work on this species is needed, and we recommend systematic sampling of the Strawberry, Mill Creek, Eleven Point, Spring, and South Fork Spring mainstems to fill this data gap.

Acknowledgements

Field assistance was provided by S. Barkley, S. Henry, K. Irwin, M. Oliver, and S. Todd of the Arkansas Game and Fish Commission. C. Dillman of Saint Louis University assisted some species identifications.

Literature Cited

- Anderson, J. E. (Ed.). 2006. Arkansas Wildlife Action Plan. Arkansas Game and Fish Commission, Little Rock, Arkansas. 2028 pp.
- Crandall, K. A. 1998. Conservation phylogenetics for Ozark crayfishes: assigning priorities for aquatic habitat protection. *Biol. Cons.* 84(2): 107-117.
- Crandall, K. A. and J. F. Fitzpatrick, Jr.. 1996. Crayfish molecular systematics: using a combination of procedures to estimate phylogeny. *Syst. Biol.* 45(1): 1-26.
- Dillman, C. B., B. K. Wagner, and R. M. Wood. 2007. Systematics of species of special concern in the genus *Orconectes* from the Ozark Highlands - case studies from species pairs: *Orconectes neglectus neglectus*, *Orconectes neglectus chaenodactylus* and *Orconectes macrus*, *Orconectes nana*. State Wildlife Grant Project T20-2 Final Report to Arkansas Game and Fish Commission, Little Rock, Arkansas. 68 pp.
- Faxon, W. 1885. Preliminary Catalogue of the Crayfishes of Kansas. Bulletin of the Washburn College Laboratory of Natural History, 1(4): 140-142.
- Hobbs, H.H. Jr. 1989. An illustrated checklist of the American crayfishes (Decapoda: Astacidae, Cambaridae & Parastacidae). *Smithsonian Contributions to Zoology*, 480: 1-236.
- Pflieger, W. L. 1978. Distribution, status, and life history of the Niangua darter, *Etheostoma nianguae*. Missouri Department of Conservation Aquatic Series Report No. 16. Jefferson City. 25 pp.
- Pflieger, W. L. 1996. The Crayfishes of Missouri. Missouri Dept. Cons., Jefferson City. 152 pp.

Rabalais, M. R. and D. D. Magoulick. 2006. Influence of an invasive crayfish species on diurnal habitat use and selection by a native crayfish species in an Ozark stream. *American Midland Naturalist*, 155: 295-306.

Robison, H. W. 2002. Computerization of the Crayfishes of Arkansas. Final Report Submitted to Arkansas Game and Fish Commission, Little Rock. 24 pp and associated database.

Taylor, C. A., G. A. Schuster, J. E. Cooper, R. J. DiSefano, A. G. Eversole, P. Hamr, H. H. Hobbs III, H. W. Robison, C. E. Skelton, and R. F. Thoma. 2007. A reassessment of the conservation status of crayfishes of the United States and Canada after 10+ years of increased awareness. *Fisheries* 32(8): 372-389.

Williams, A. B. 1952. Six New Crayfishes of the Genus *Orconectes* (Decapoda: Astacidae) from Arkansas, Missouri and Oklahoma. *Transactions of the Kansas Academy of Science* 55(2): 330-351.

Williams, A. B. 1954. Speciation and distribution of the crayfishes of the Ozark Plateaus and Onachita Provinces. *Univ. Kansas Sci. Bull* 36:803-918.

Figure 1a: Map of north Arkansas depicting locations included in this report. Yellow circles indicate sites sampled as part of this study. Red circles indicate sites where *Cambarus diogenes* was encountered.

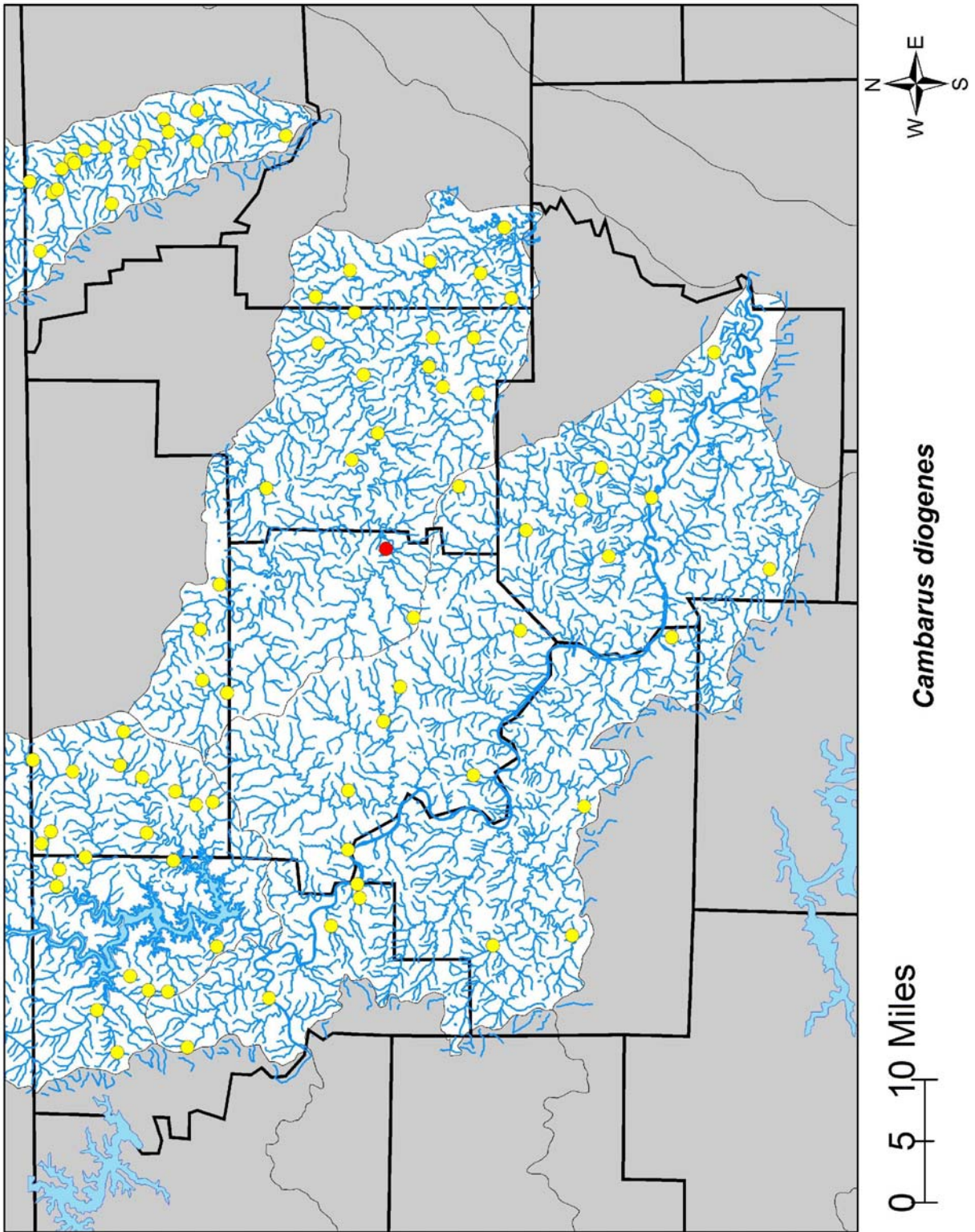


Figure 1b: Map of north Arkansas depicting locations included in this report. Yellow circles indicate sites sampled as part of this study. Red circles indicate sites where *Cambarus hubbsi* was encountered.

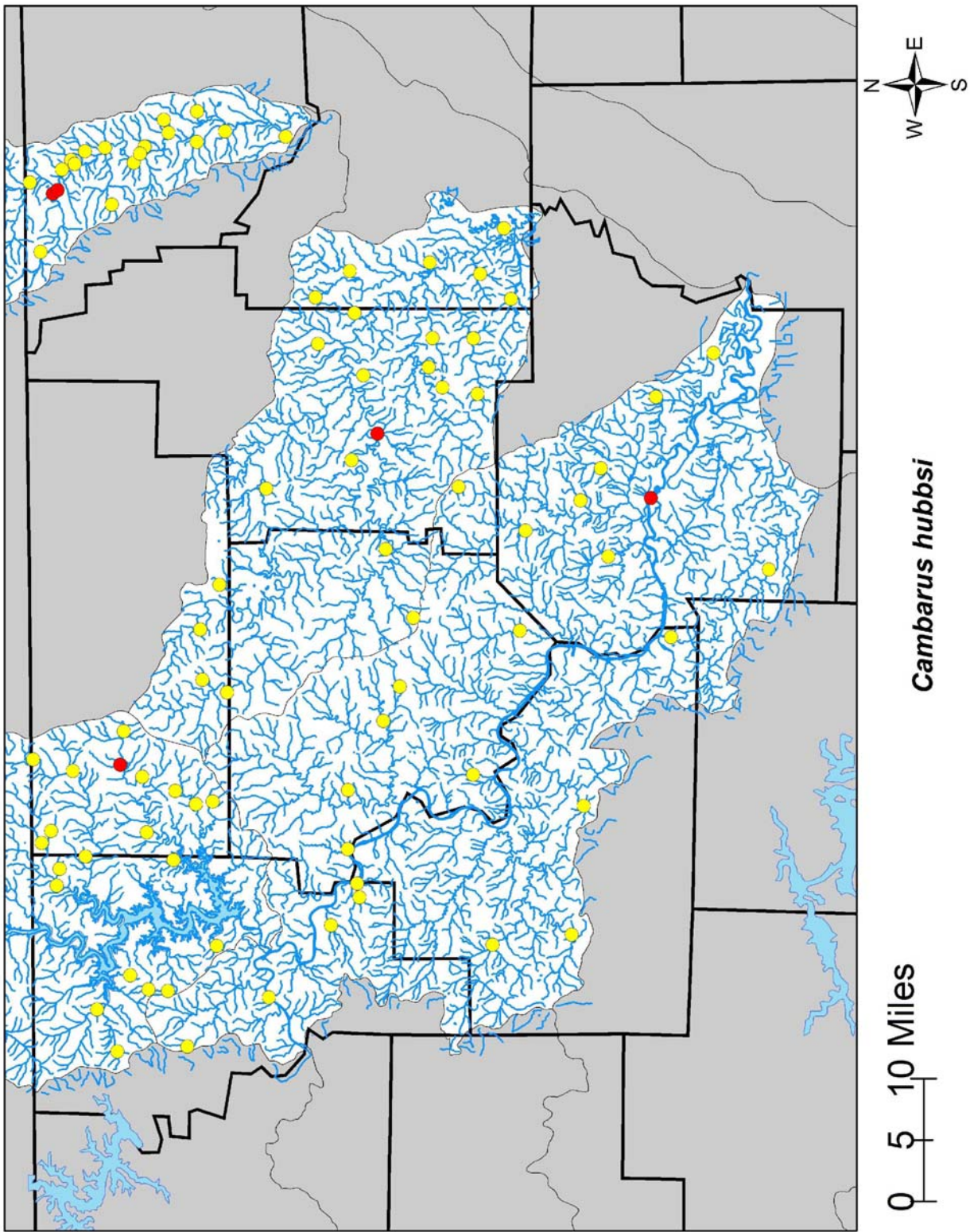


Figure 1c: Map of north Arkansas depicting locations included in this report. Yellow circles indicate sites sampled as part of this study. Red circles indicate sites where *Fallicambarus fodiens* was encountered.

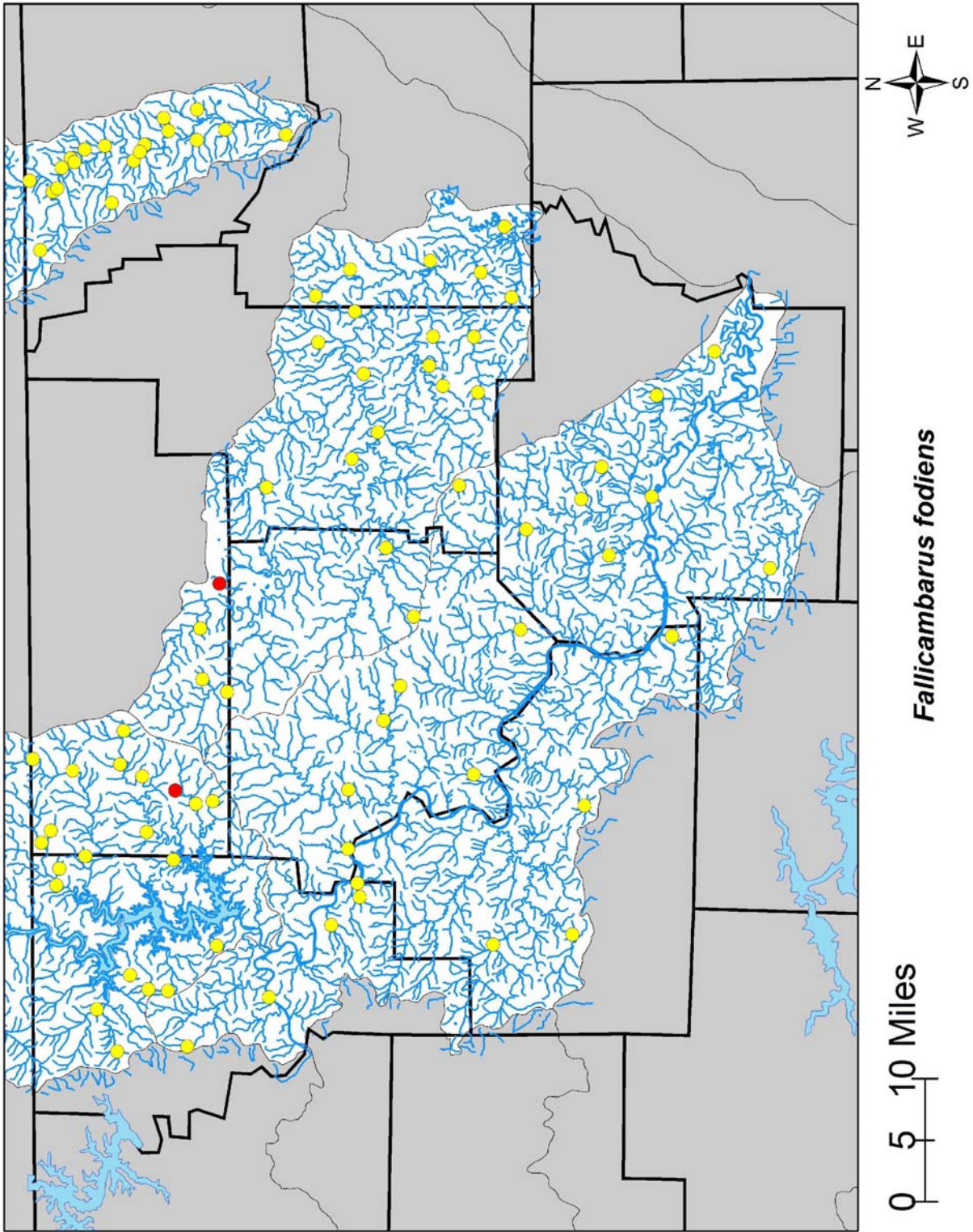


Figure 1d: Map of north Arkansas depicting locations included in this report. Yellow circles indicate sites sampled as part of this study. Red circles indicate sites where *Orconectes eupunctus* was encountered.

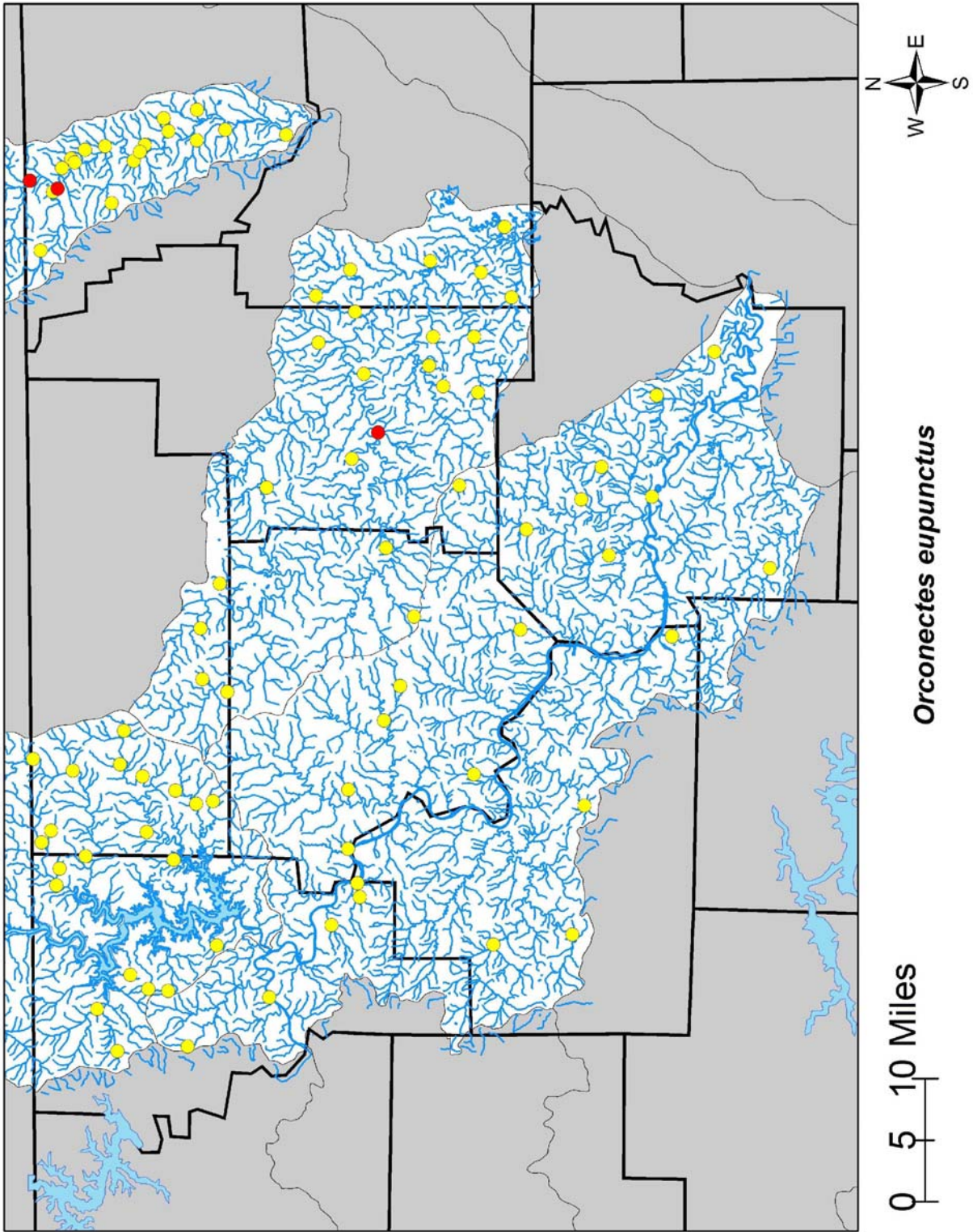


Figure 1e: Map of north Arkansas depicting locations included in this report. Yellow circles indicate sites sampled as part of this study. Red circles indicate sites where *Orconectes longidigitus* was encountered.

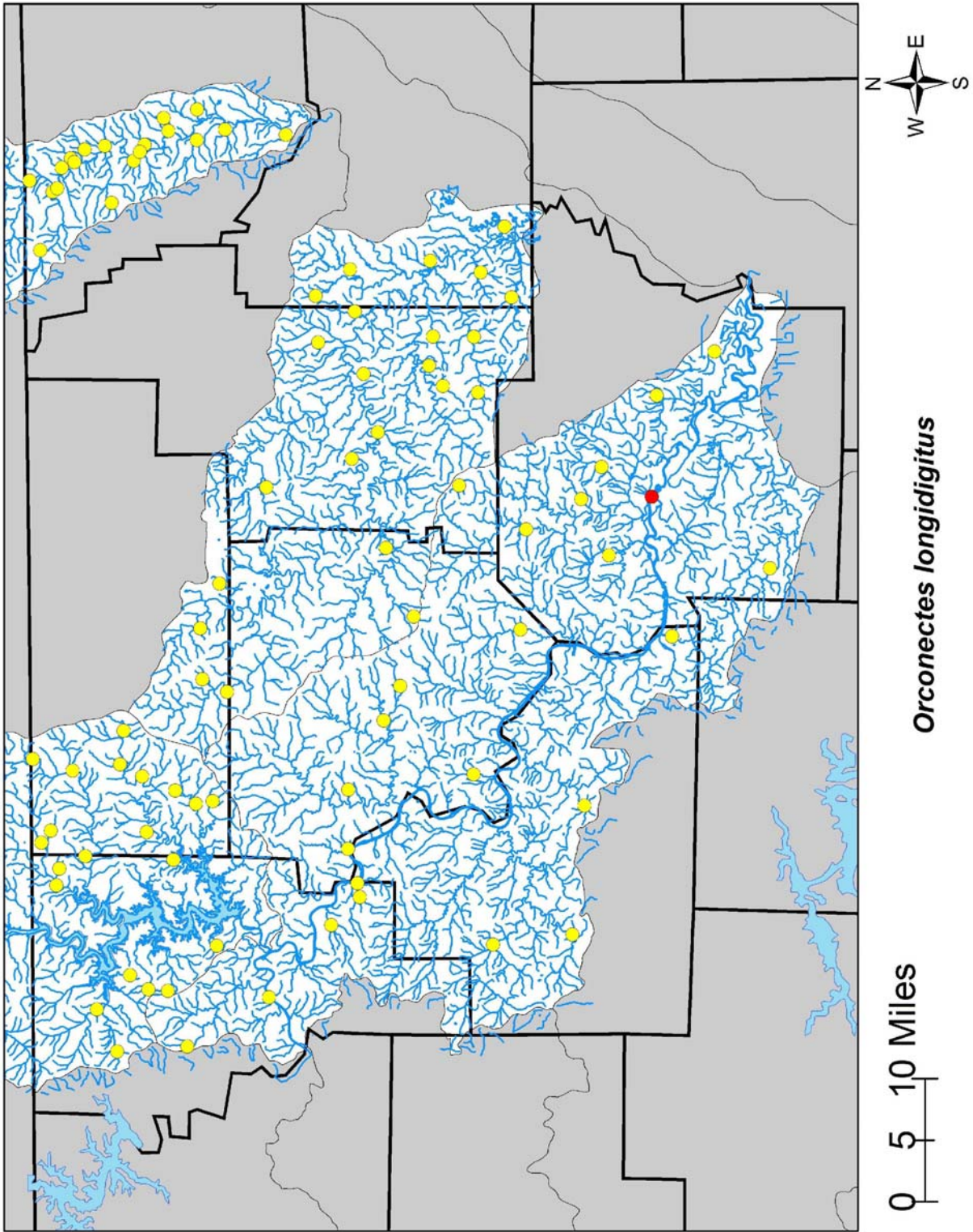


Figure 1f: Map of north Arkansas depicting locations included in this report. Yellow circles indicate sites sampled as part of this study. Red circles indicate sites where *Orconectes meeki* was encountered.

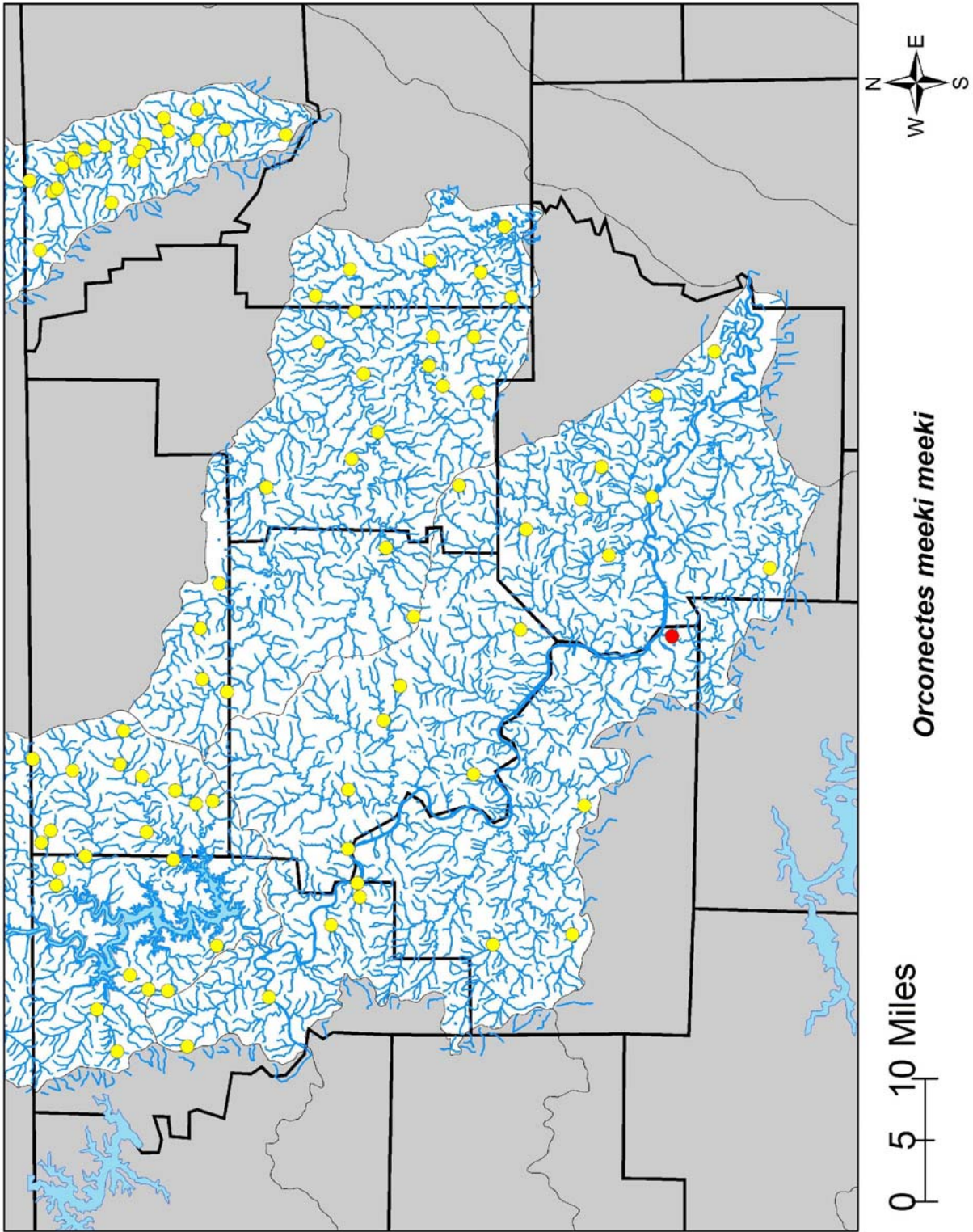


Figure 1g: Map of north Arkansas depicting locations included in this report. Yellow circles indicate sites sampled as part of this study. Red circles indicate sites where *Orconectes neglectus chaenodactylus* was encountered.

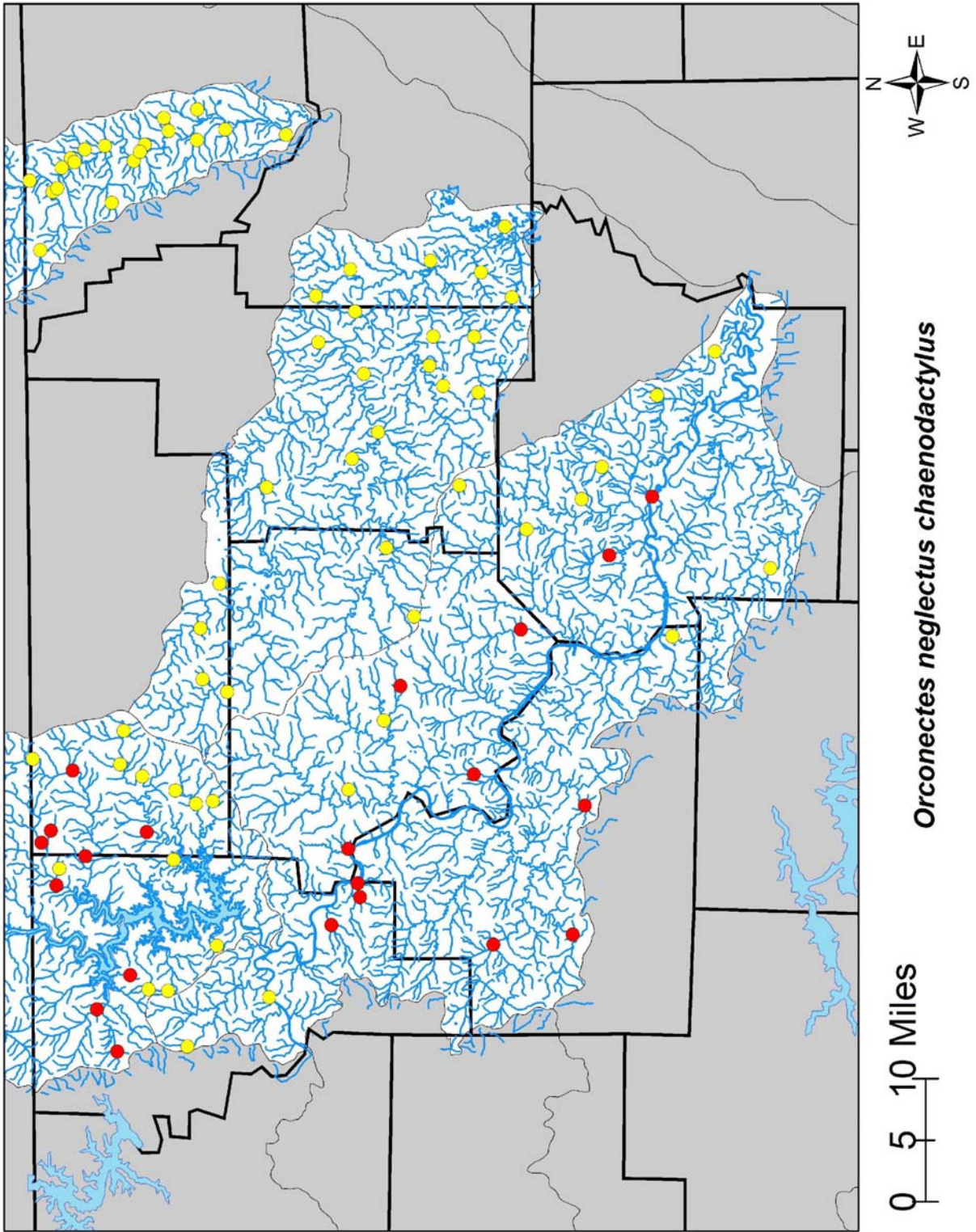


Figure 1h: Map of north Arkansas depicting locations included in this report. Yellow circles indicate sites sampled as part of this study. Red circles indicate sites where *Orconectes neglectus neglectus* was encountered.

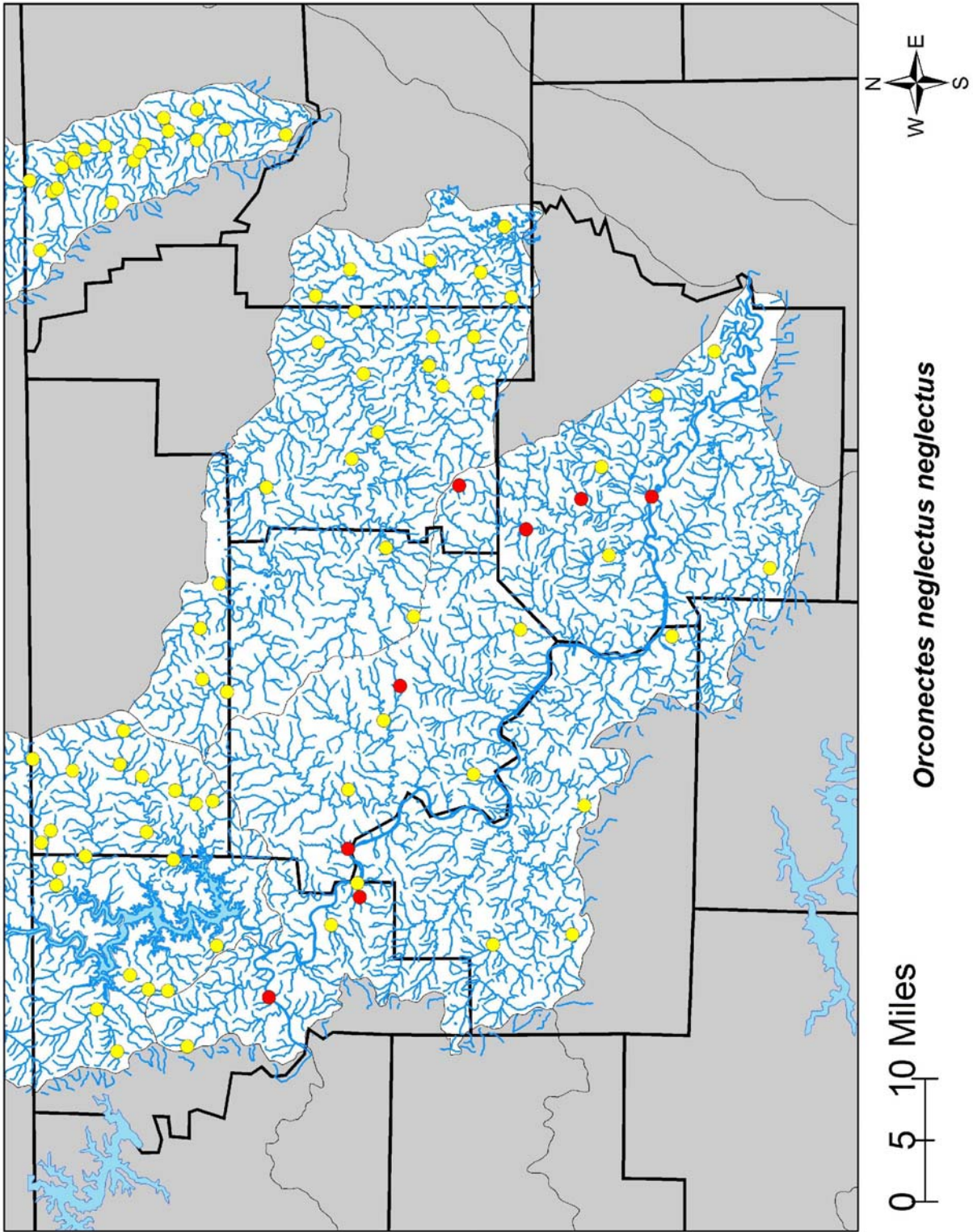


Figure 1*i*: Map of north Arkansas depicting locations included in this report. Yellow circles indicate sites sampled as part of this study. Red circles indicate sites where *Orconectes ozarkae* was encountered.

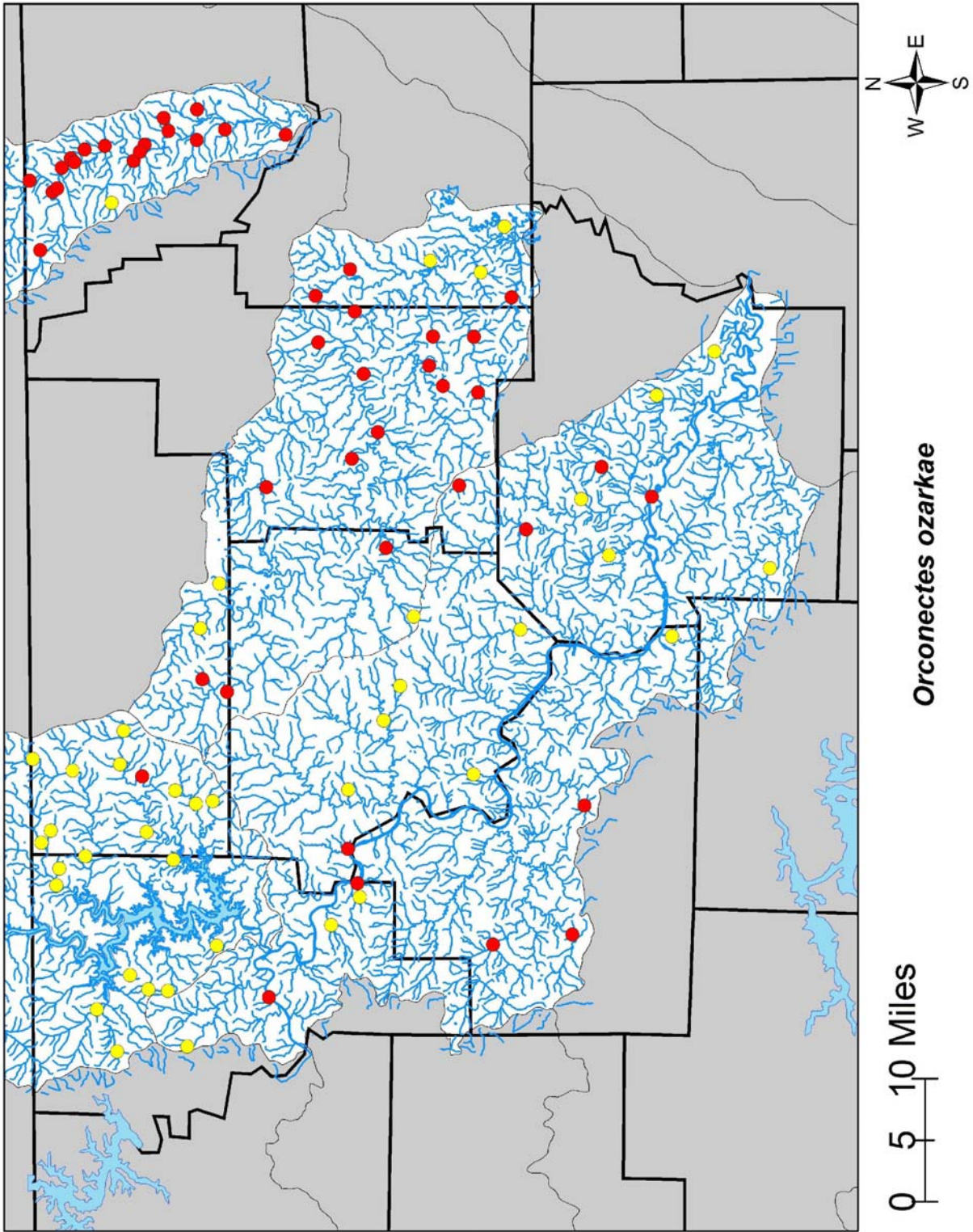


Figure 1j: Map of north Arkansas depicting locations included in this report. Yellow circles indicate sites sampled as part of this study. Red circles indicate sites where *Orconectes palmeri longimanus* was encountered.

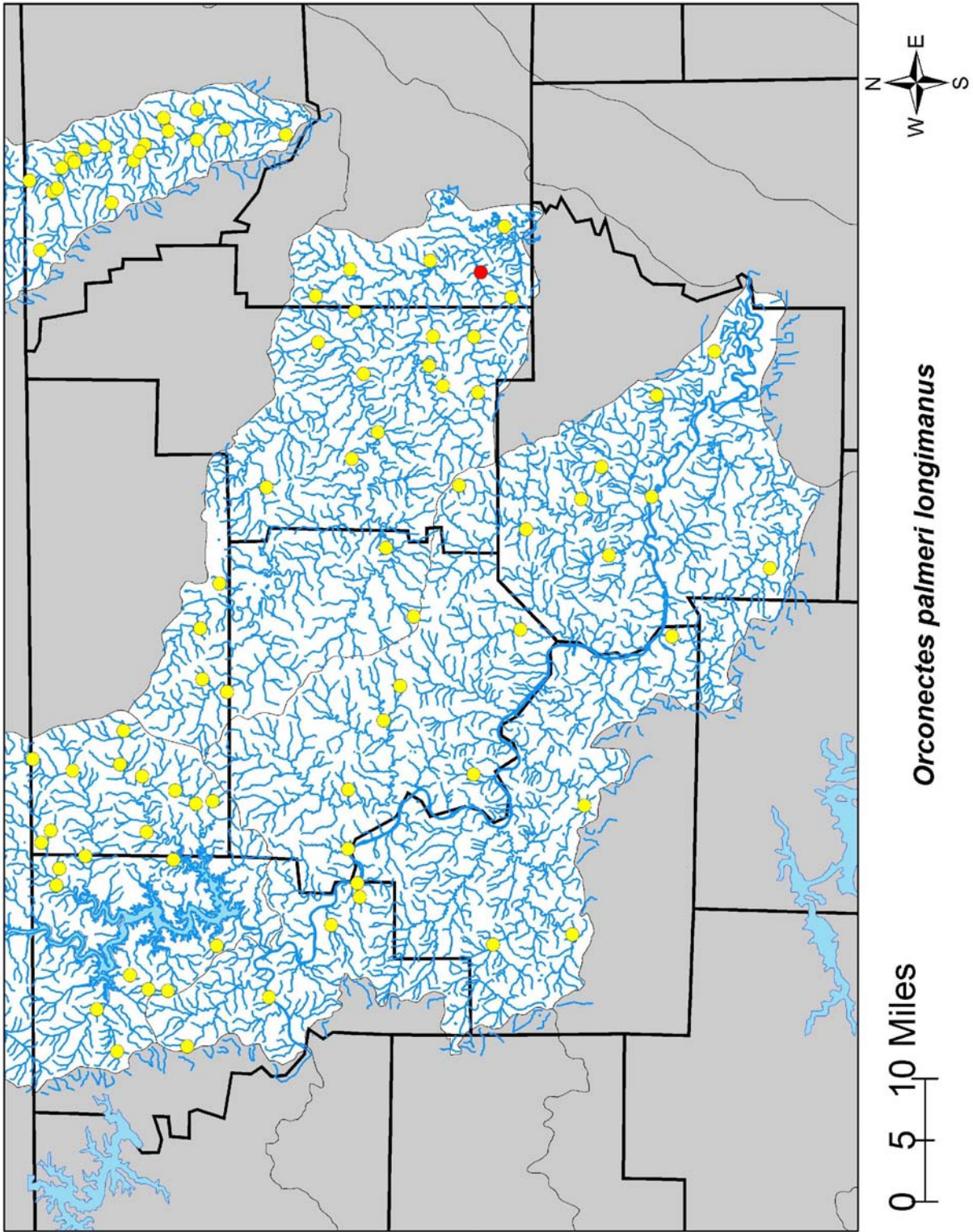


Figure 1k: Map of north Arkansas depicting locations included in this report. Yellow circles indicate sites sampled as part of this study. Red circles indicate sites where *Orconectes punctimanus* was encountered.

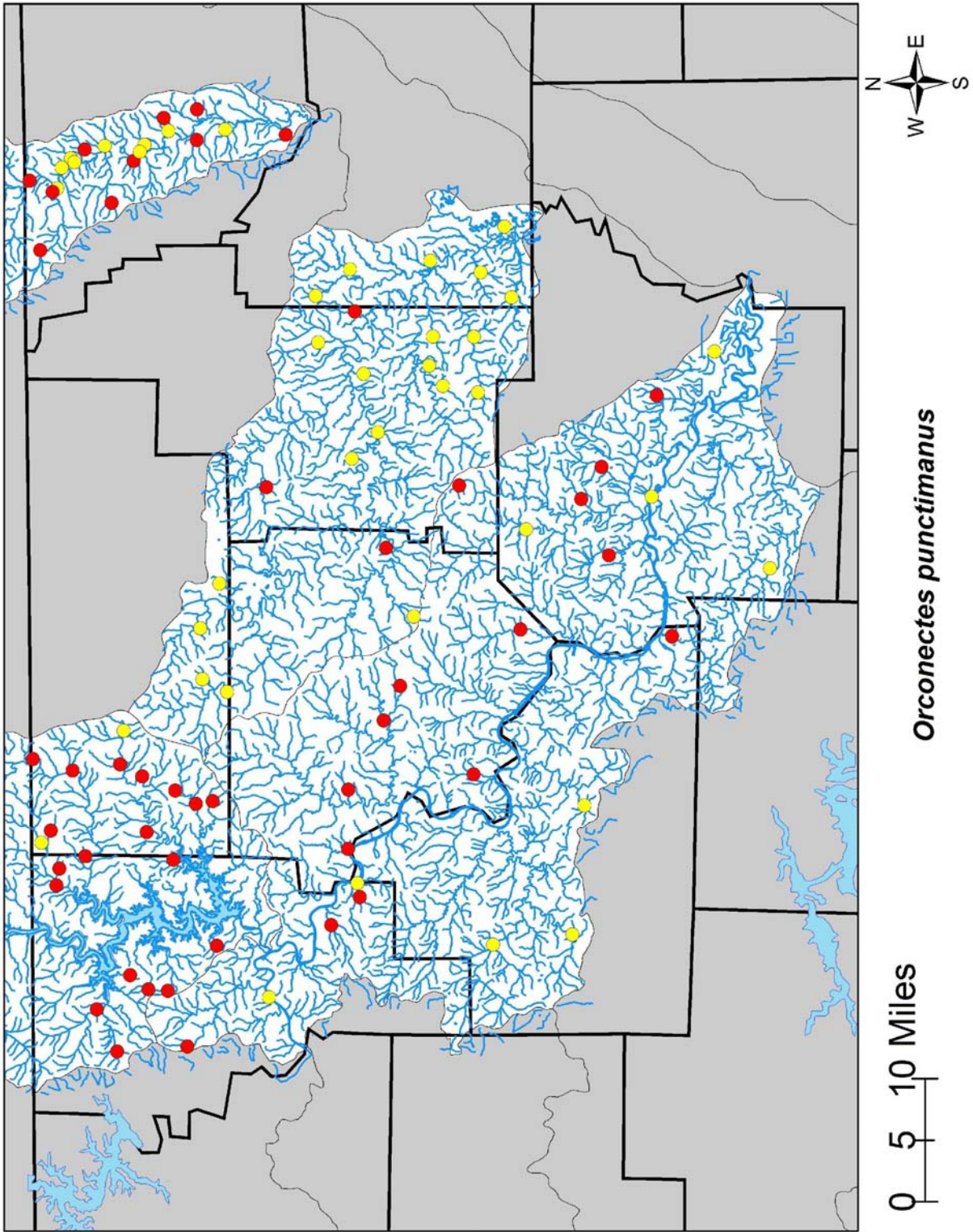


Figure 1/: Map of north Arkansas depicting locations included in this report. Yellow circles indicate sites sampled as part of this study. Red circles indicate sites where *Orconectes virilis* was encountered.

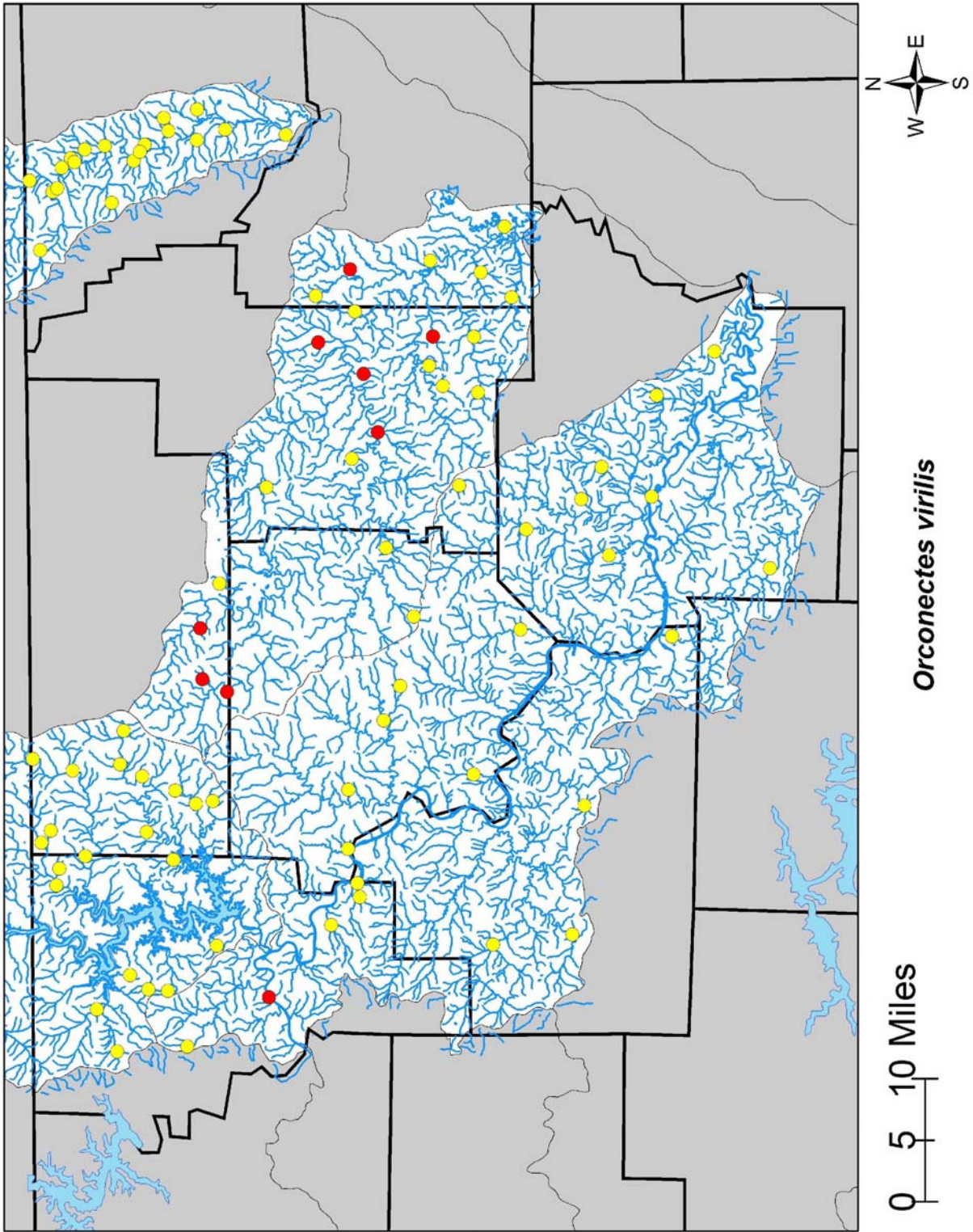


Figure 1*m*: Map of north Arkansas depicting locations included in this report. Yellow circles indicate sites sampled as part of this study. Red circles indicate sites where *Procambarus acutus* was encountered.

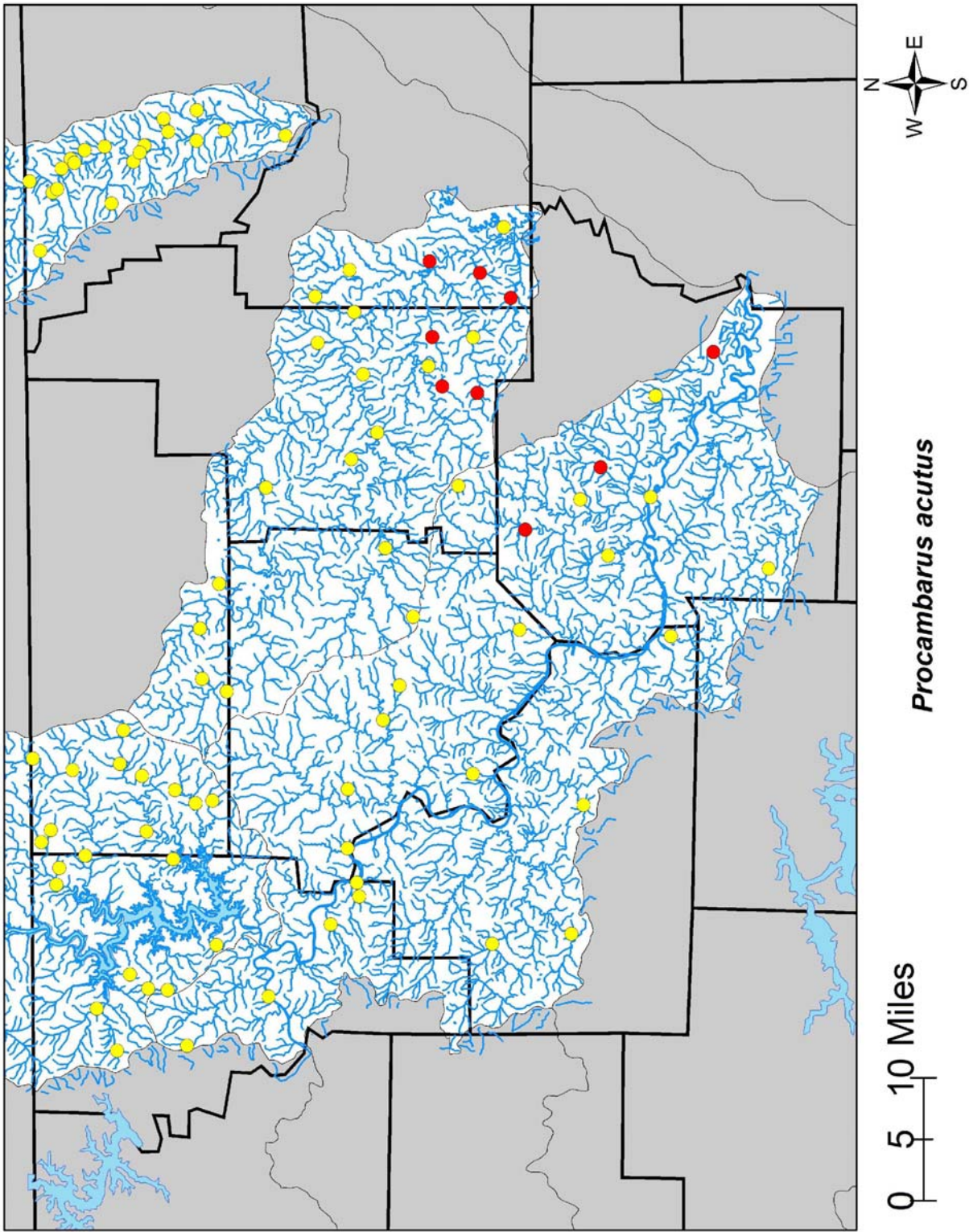


Figure 2a: *Fallicambarus fodiens* length frequency.

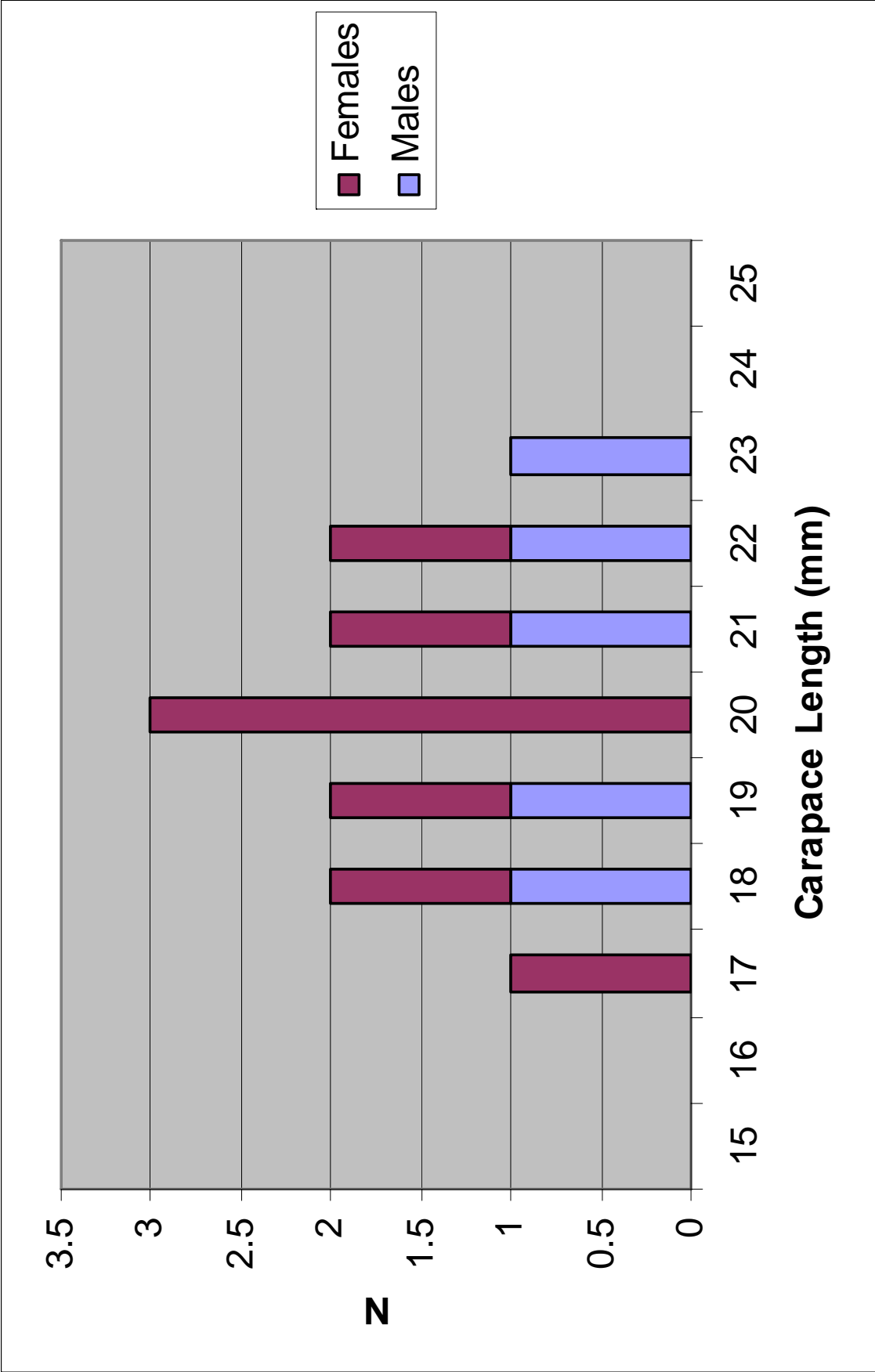


Figure 2b: *Orconectes eupunctus* length frequency.

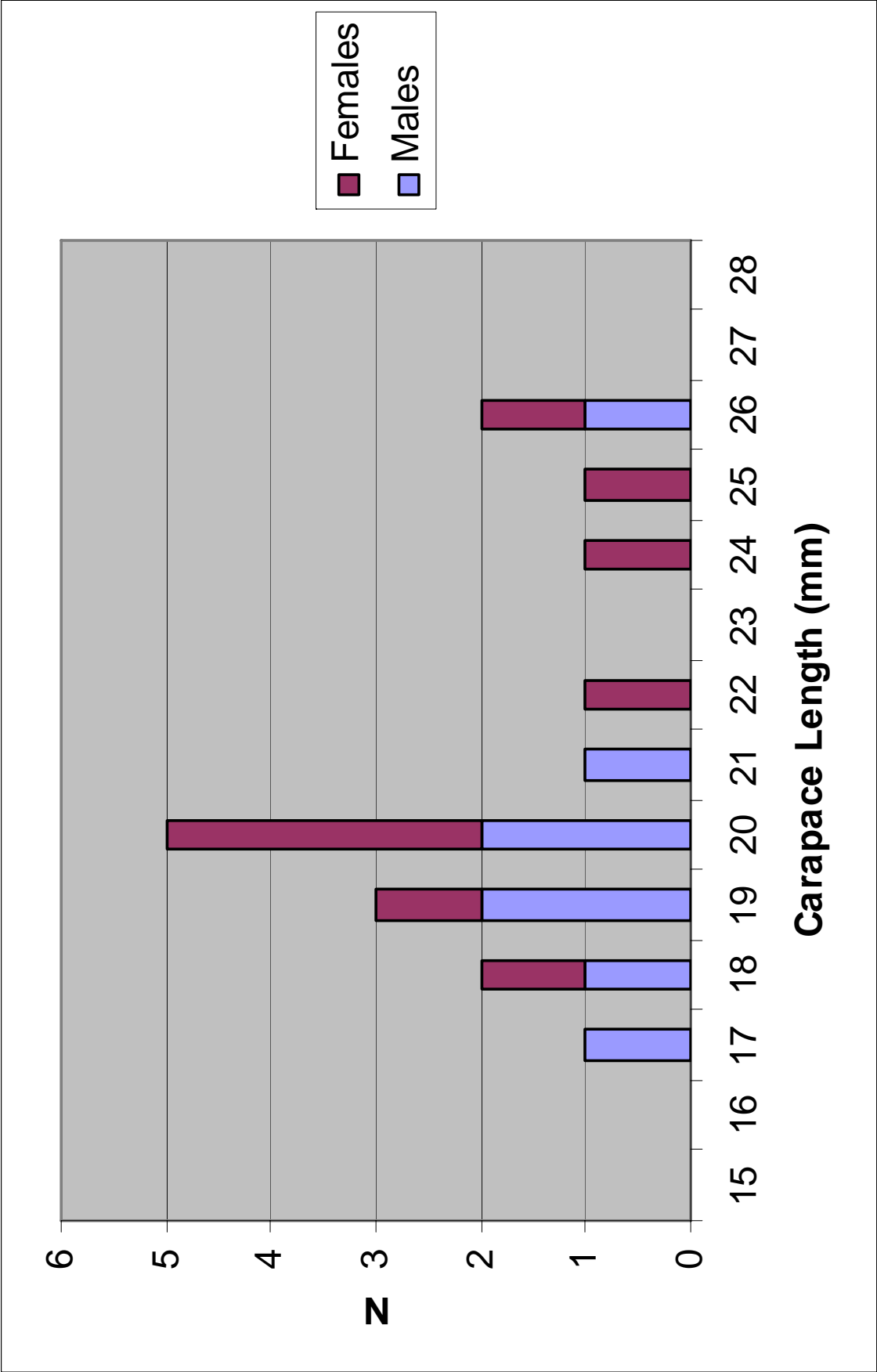


Figure 2c: *Orconectes meeki meeki* length frequency.

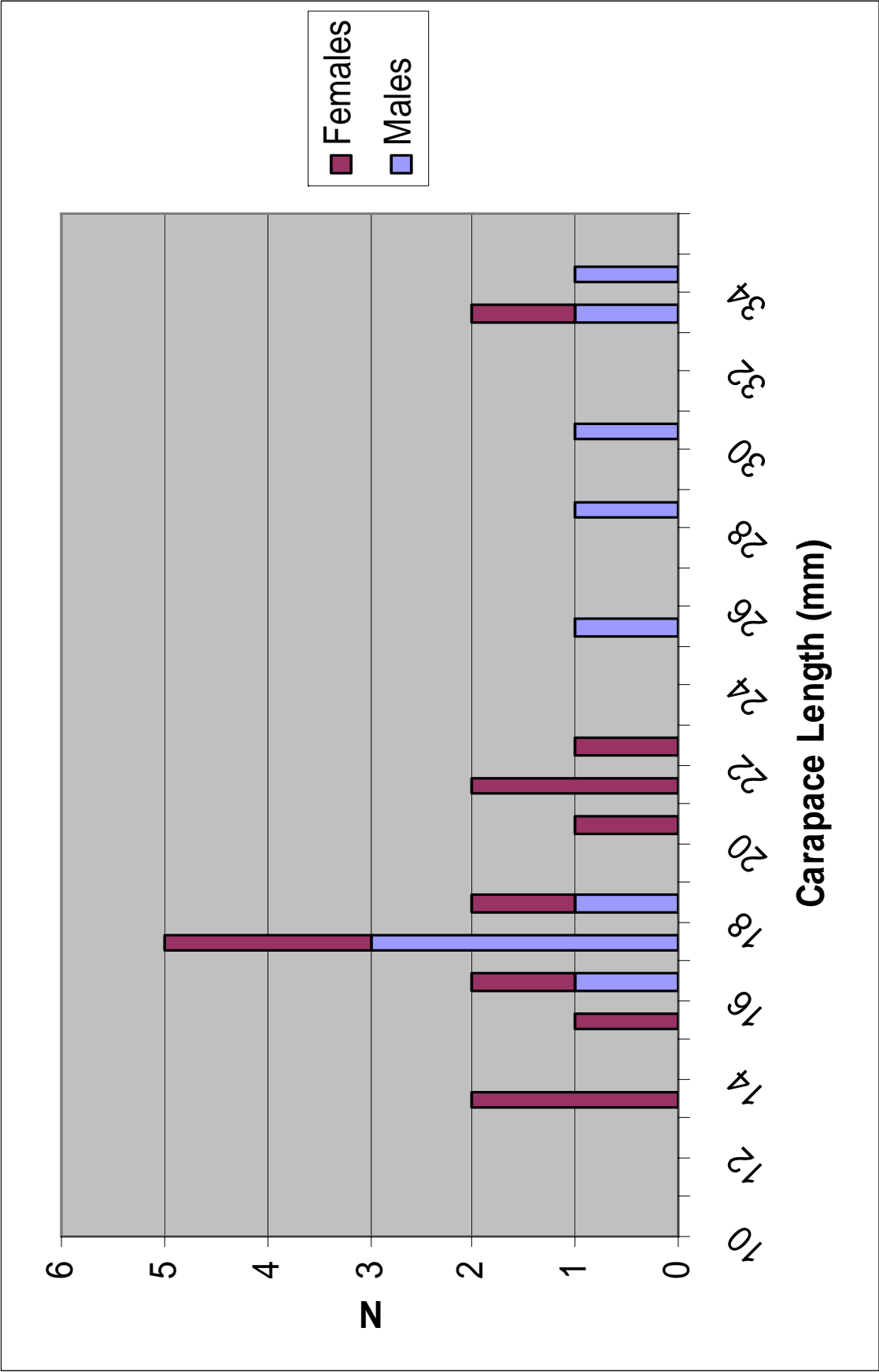


Figure 2d: *Orconectes neglectus chaenodactylus* length frequency.

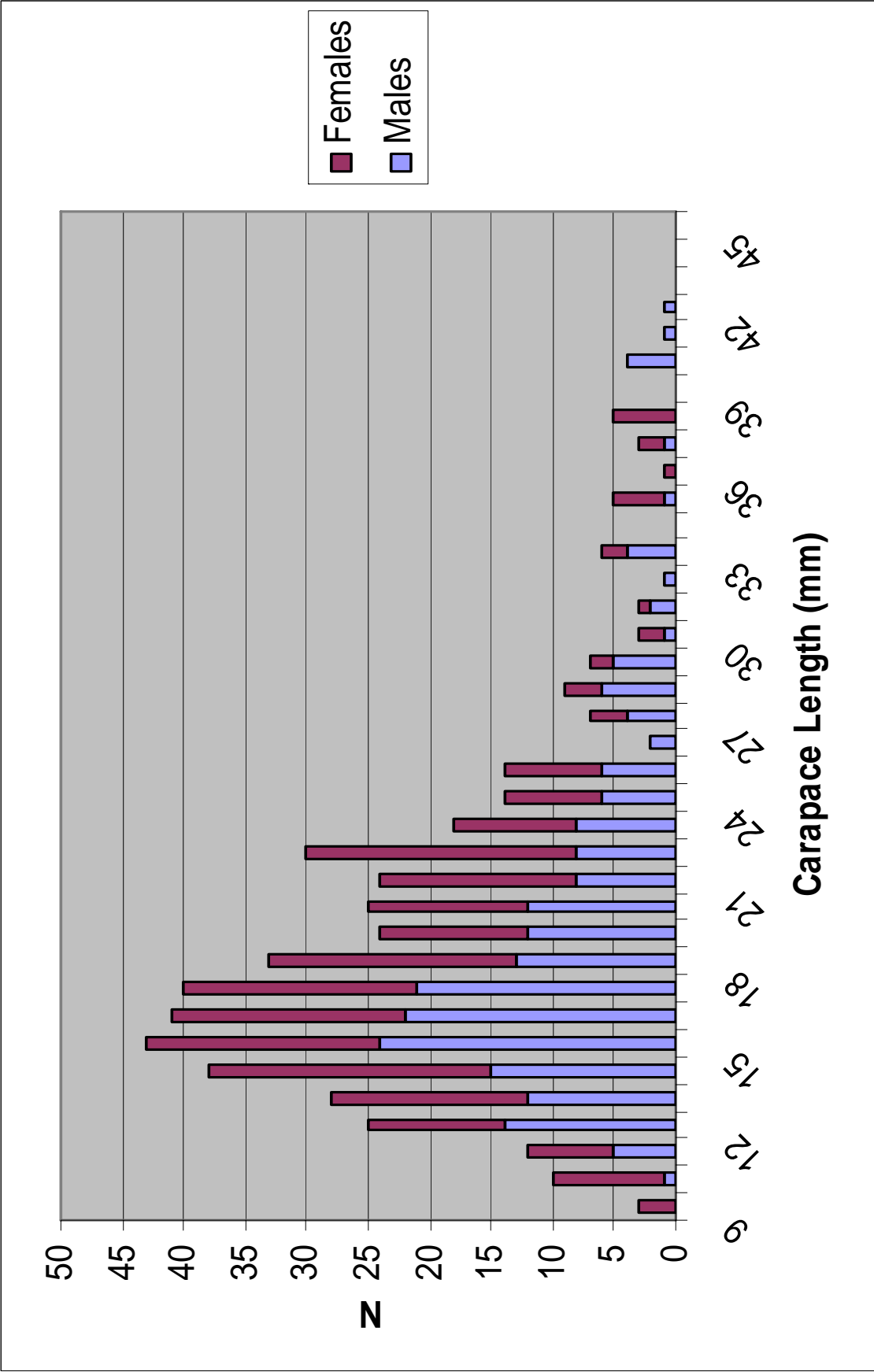


Figure 2e: *Orconectes neglectus neglectus* length frequency.

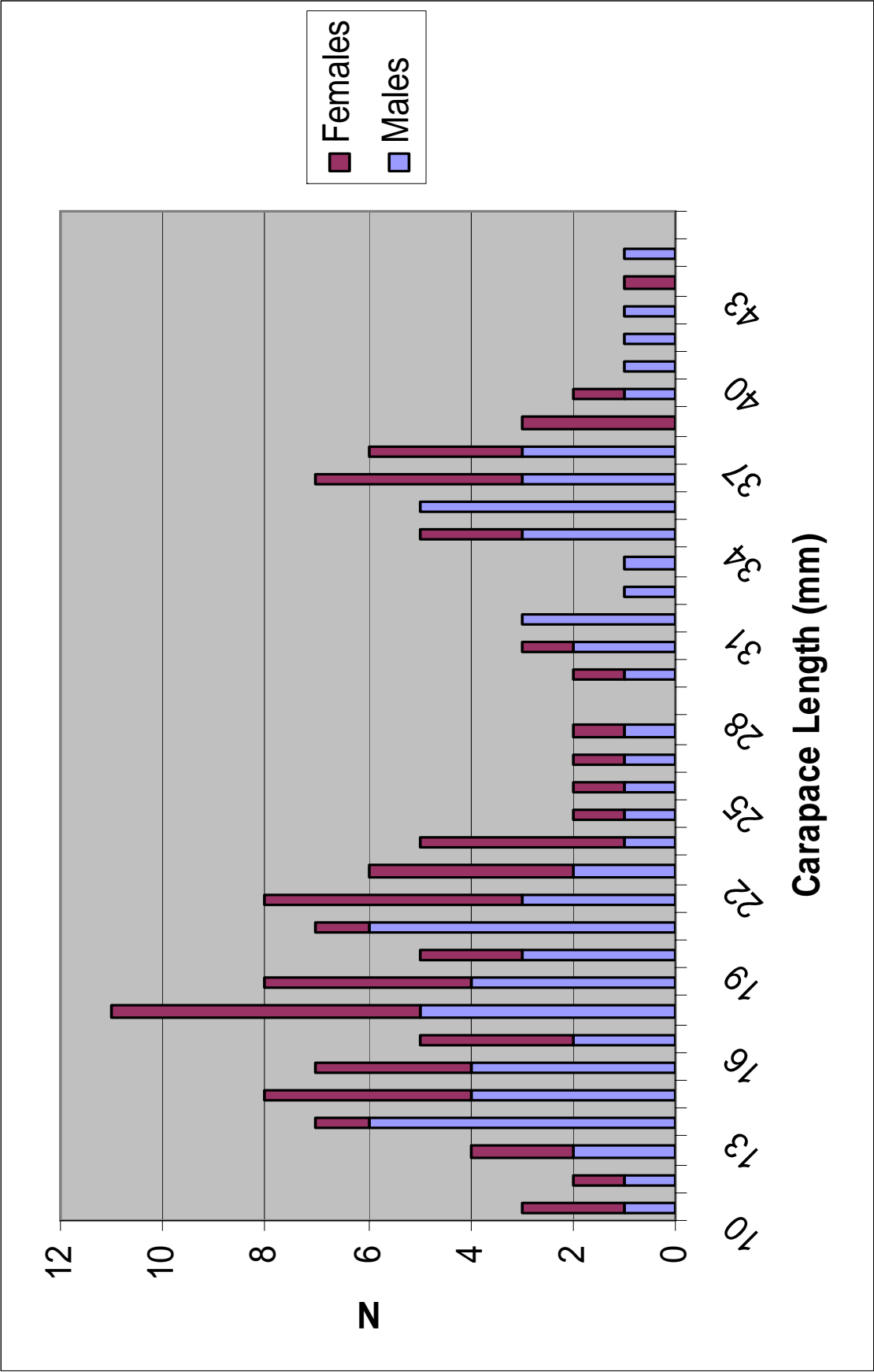


Figure 2f: *Orconectes ozarkae* length frequency.

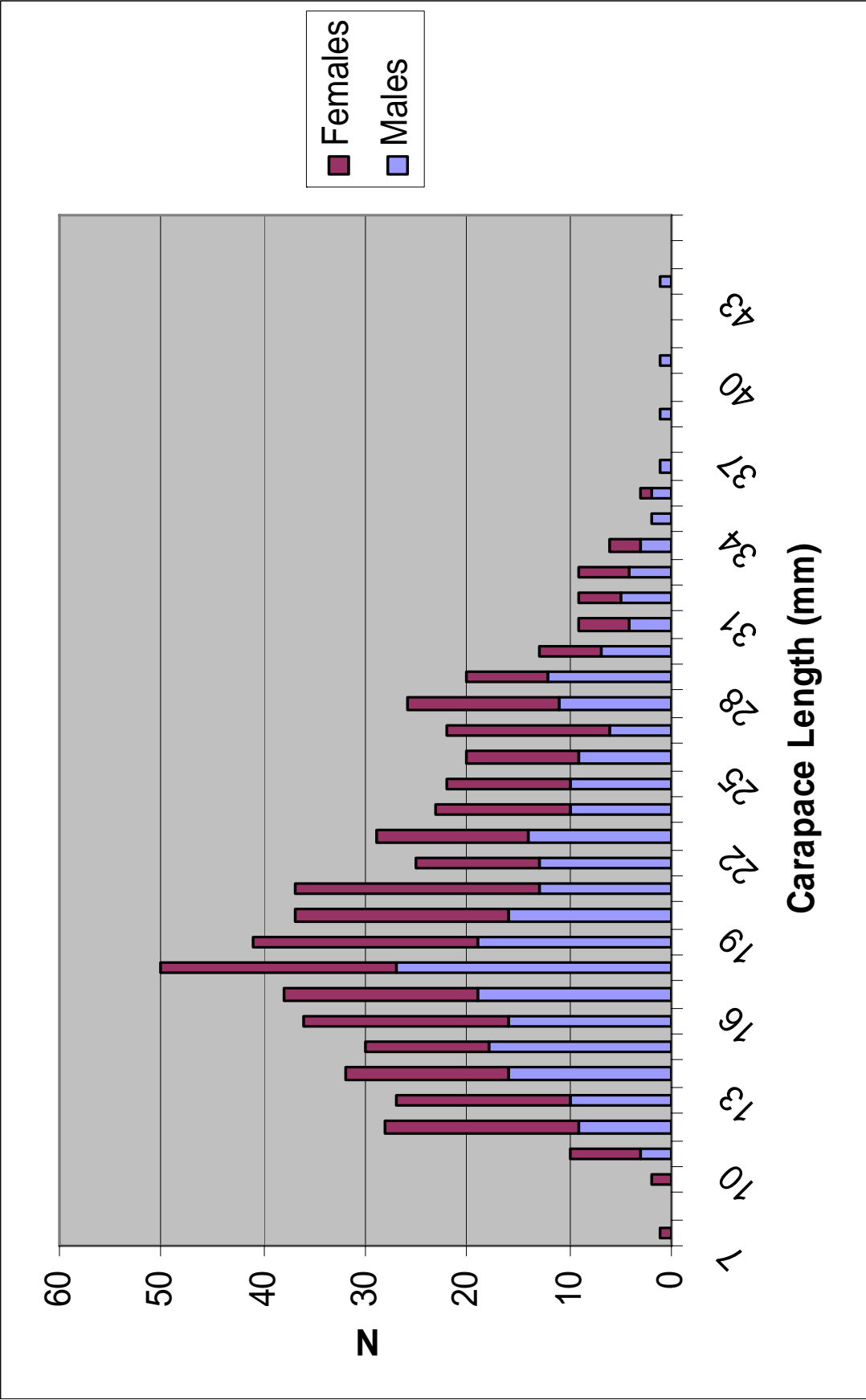


Figure 2g: *Orconectes punctimanus* length frequency.

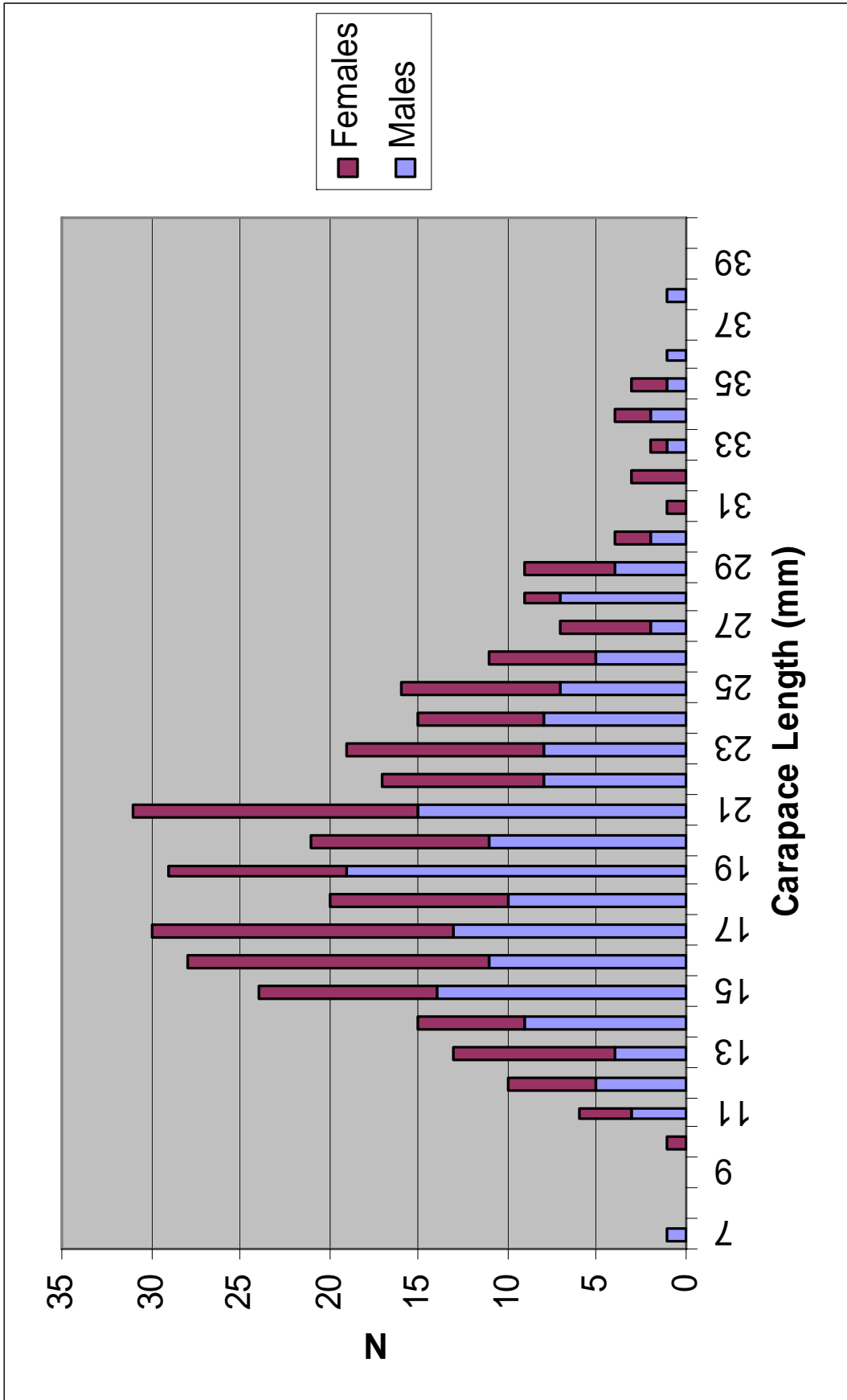


Figure 2h: *Orconectes virilis* length frequency.

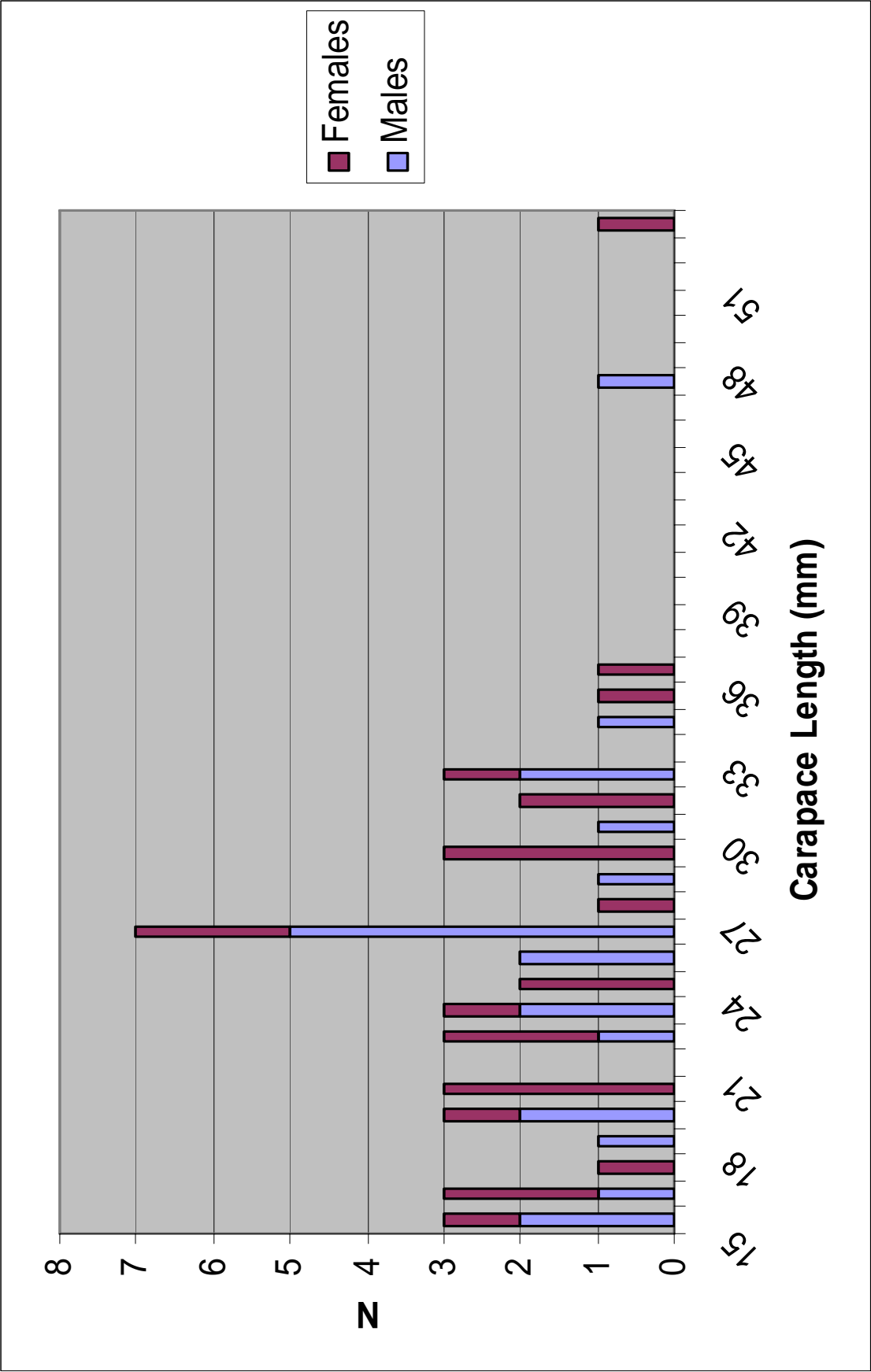


Figure 2i: *Procambarus acutus* length frequency.

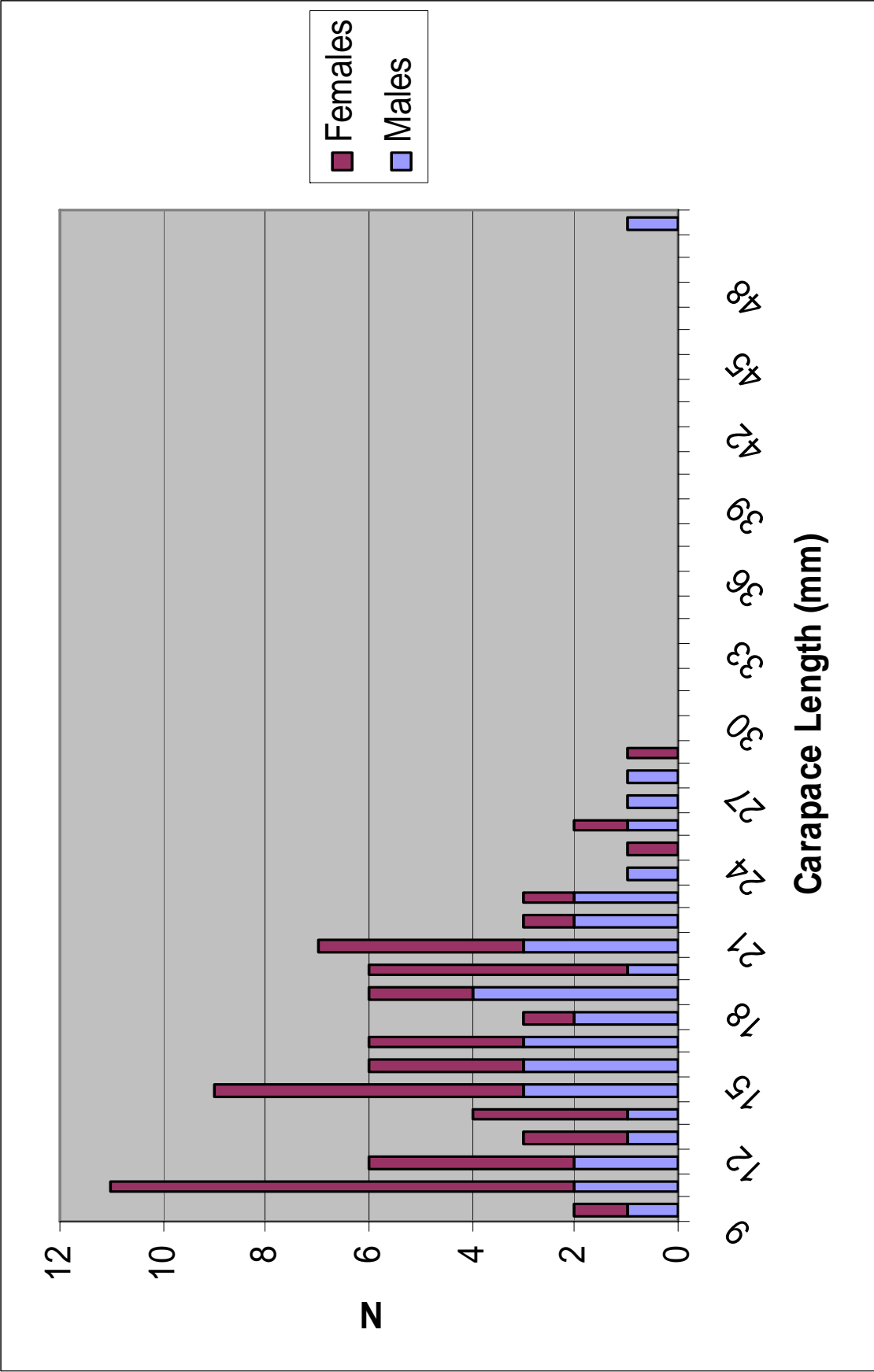


Table 1: Site locations and crayfish species and numbers collected by site. Collections are grouped by basin: Eleven Point = EP, Middle White = MW, North Fork White = NF, and Strawberry = ST. Latitude and longitude coordinates are in decimal degrees, North American Datum 1927.

Basin	Collection #	Stream	Collection Date	Longitude	Latitude	<i>C. diogenes</i>	<i>C. hubbsi</i>	<i>F. fodiens</i>	<i>O. eupunctus</i>	<i>O. longidigitus</i>	<i>O. m. meeki</i>	<i>O. n. chaenodactylus</i>	<i>O. n. neglectus</i>	<i>O. n. unknown</i>	<i>O. ozarkae</i>	<i>O. p. longimanus</i>	<i>O. punctimanus</i>	<i>O. virilis</i>	<i>P. acutus</i>	<i>O. sp. unidentified</i>
EP	bkw2006-076	Eleven Point River	09/12/06	-91.1141	36.3467										9					
EP	bkw2006-078	Powell Creek	09/18/06	-91.0943	36.25159										9					
EP	bkw2006-079	Cedar Creek	09/18/06	-91.1034	36.18025										10		8			
EP	bkw2006-080	Trib to Thompson Creek	09/18/06	-91.0643	36.2843										11		7			
EP	bkw2006-081	Trib to River Creek	09/19/06	-91.0757	36.32371										7		12			
EP	bkw2006-082	River Creek	09/19/06	-91.0948	36.31845										2					
EP	bkw2006-083	Upshaw Creek	09/19/06	-91.1195	36.41734										21		1			
EP	bkw2006-084	Cameron Creek	09/19/06	-91.1319	36.43372										44					
EP	bkw2006-085	Baker Den	09/19/06	-91.1454	36.44478										16					
EP	bkw2006-087	Diles Creek	09/19/06	-91.265	36.47195										7		2			
EP	bkw2006-088	Trib to Dry Creek	09/19/06	-91.1978	36.38709												36			
EP	bkw2006-089	Rickman Creek	09/19/06	-91.1373	36.3601										13		7			
EP	bkw2006-090	Bradley Creek	09/20/06	-91.1089	36.28536										4		17			

Basin	Collection #	Stream	Collection Date	Longitude	Latitude	<i>C. diogenes</i>	<i>C. hubbsi</i>	<i>F. fodiens</i>	<i>O. eupunctus</i>	<i>O. longidigitus</i>	<i>O. m. meeki</i>	<i>O. n. chaenodactylus</i>	<i>O. n. neglectus</i>	<i>O. n. unknown</i>	<i>O. ozarkae</i>	<i>O. p. longimanus</i>	<i>O. punctimanus</i>	<i>O. virilis</i>	<i>P. acutus</i>	<i>O. sp. unidentified</i>	
MW	bkw2005-055	White River	10/03/05	-91.6369	35.7566		6			3		17			1						
MW	bkw2006-074	White River	09/11/06	-92.1919	36.10831							41			25						
MW	bkw2006-075	White River	05/11/06	-92.3568	36.21327								36		72			2			
MW	bkw2006-139	Calico Creek	11/02/06	-92.1419	36.11916							13	10	14	6		11				
MW	bkw2006-140	Cataract Creek	11/02/06	-92.2122	36.10568							36	40				5				
MW	bkw2006-141	Sneeds Creek	11/02/06	-92.2525	36.13958							19					4				
MW	bkw2006-142	East Twin Creek	11/13/06	-92.0355	35.97025							4					10				
MW	bkw2006-143	Little Hurricane	11/13/06	-91.9558	36.07538												2				
MW	bkw2006-144	Bailey Creek	11/13/06	-92.0557	36.11806												7				
MW	bkw2006-145	Mill Creek	11/13/06	-91.9059	36.05569							33	5				6				
MW	bkw2006-146	Mill Prong	11/14/06	-92.0822	35.84017							24			11						
MW	bkw2006-147	Sylamore Creek	11/14/06	-92.2688	35.85564							9			1						
MW	bkw2006-148	Roasting Ear Creek	11/14/06	-92.2825	35.94907							32			2						
MW	bkw2006-150	trib to salado	11/27/06	-91.7429	35.6187																
MW	bkw2006-151	Wolf Bayou	11/27/06	-91.8387	35.73491						20						2				

Basin	Collection #	Stream	Collection Date	Longitude	Latitude	<i>C. diogenes</i>	<i>C. hubbsi</i>	<i>F. fodiens</i>	<i>O. eupunctus</i>	<i>O. longidigitus</i>	<i>O. m. meeki</i>	<i>O. n. chaenodactylus</i>	<i>O. n. neglectus</i>	<i>O. n. unknown</i>	<i>O. ozarkae</i>	<i>O. p. longimanus</i>	<i>O. punctimanus</i>	<i>O. virilis</i>	<i>P. acutus</i>	<i>O. sp. unidentified</i>
MW	bkw2006-152	Pfeiffer	11/27/06	-91.593	35.81525										16		3		1	
MW	bkw2006-153	Spring Creek	11/28/06	-91.7211	35.80795							36					4			
MW	bkw2006-154	West Lafferty Cree	11/28/06	-91.8269	35.91333							9					2			
MW	bkw2006-155	Sullivan Creek	11/28/06	-91.6169	35.98318								7		2		3			
MW	bkw2006-156	Poke Bayou	11/28/06	-91.6819	35.90501								12		11				5	
MW	bkw2006-157	Chinn Springs run	11/28/06	-91.6393	35.8397								26				3			
MW	bkw2006-158	Mud Creek	11/29/06	-91.4288	35.68015														13	
MW	bkw2006-159	Trib to Big Creek	11/29/06	-91.4905	35.74918												1			

Basin	Collection #	Stream	Collection Date	Longitude	Latitude	<i>C. diogenes</i>	<i>C. hubbsi</i>	<i>F. fodiens</i>	<i>O. eupunctus</i>	<i>O. longidigitus</i>	<i>O. m. meeki</i>	<i>O. n. chaenodactylus</i>	<i>O. n. neglectus</i>	<i>O. n. unknown</i>	<i>O. ozarkae</i>	<i>O. p. longimanus</i>	<i>O. punctimanus</i>	<i>O. virilis</i>	<i>P. acutus</i>	<i>O. sp. unidentified</i>
NF	bkw2006-117	Pigeon Creek	10/30/06	-92.3725	36.4163							63					4			
NF	bkw2006-118	Trib to Little Pigeon Creek	10/30/06	-92.434	36.39256							19					6			
NF	bkw2006-119	Bennetts Bayou	10/31/06	-92.1914	36.46287							35					1			
NF	bkw2006-120	Trib to Bennetts Bayou	10/31/06	-92.1669	36.4592												5			
NF	bkw2006-121	Bennetts River	10/31/06	-92.1492	36.42849							20					11			
NF	bkw2006-122	Little Creek	10/31/06	-92.1286	36.48005							19								
NF	bkw2006-123	Poor Hollow Branch	10/31/06	-92.1113	36.46866							2					7			
NF	bkw2006-124	Little Creek	10/31/06	-92.0239	36.44228							24					20			
NF	bkw2006-125	Trib to Bennetts River	10/31/06	-92.0066	36.48894												8			
NF	bkw2006-126	Trib to Big Creek	10/31/06	-91.9669	36.38181															
NF	bkw2006-127	Trib to Big Creek	10/31/06	-92.0337	36.36044										1		14			
NF	bkw2006-128	Shipman Creek	10/31/06	-92.0156	36.38655		1										6			
NF	bkw2006-129	Panther Creek	11/01/06	-92.3438	36.3555												8			
NF	bkw2006-130	Trib to Fall Creek	11/01/06	-92.3463	36.3325												19			
NF	bkw2006-131	Camp Spring Hollow Creek	11/01/06	-92.323	36.37671							13					15			

Basin	Collection #	Stream	Collection Date	Longitude	Latitude	<i>C. diogenes</i>	<i>C. hubbsi</i>	<i>F. fodiens</i>	<i>O. eupunctus</i>	<i>O. longidigitus</i>	<i>O. m. meeki</i>	<i>O. n. chaenodactylus</i>	<i>O. n. neglectus</i>	<i>O. n. unknown</i>	<i>O. ozarkae</i>	<i>O. p. longimanus</i>	<i>O. punctimanus</i>	<i>O. virilis</i>	<i>P. acutus</i>	<i>O. sp. unidentified</i>
NF	bkw2006-132	Big Creek	11/01/06	-92.1146	36.35611							31					26			
NF	bkw2006-133	Norfolk Lake	11/01/06	-92.1554	36.32473												7			
NF	bkw2006-134	Trib to South Brushy Creek	11/01/06	-92.0545	36.32172			5									1			
NF	bkw2006-135	Brushy Creek	11/01/06	-92.0741	36.29765												10			
NF	bkw2006-136	Trib to South Brushy Creek	11/01/06	-92.0708	36.27787												4			
NF	bkw2006-137	Big Creek	11/02/06	-92.4276	36.31												12			
NF	bkw2006-138	Trib to Norfolk Lake	11/02/06	-92.281	36.27458												7			

Basin	Collection #	Stream	Collection Date	Longitude	Latitude	<i>C. diogenes</i>	<i>C. hubbsi</i>	<i>F. fodiens</i>	<i>O. eupunctus</i>	<i>O. longidigitus</i>	<i>O. m. meeki</i>	<i>O. n. chaenodactylus</i>	<i>O. n. neglectus</i>	<i>O. n. unknown</i>	<i>O. ozarkae</i>	<i>O. p. longimanus</i>	<i>O. punctimanus</i>	<i>O. virilis</i>	<i>P. acutus</i>	<i>O. sp. unidentified</i>
ST	bkw2006-091	East Cooper Creek	09/20/06	-91.301	36.10747										29			3		
ST	bkw2006-092	Mars Branch	09/20/06	-91.3622	36.10275										35		6			
ST	bkw2006-093	Mill Creek	09/20/06	-91.4063	36.14638										55			3		
ST	bkw2006-094	Cooper Creek	09/20/06	-91.3385	36.14875										19					
ST	bkw2006-095	Trib to Strawberry River	09/21/06	-91.2906	36.01318														12	
ST	bkw2006-096	Steep Bank Creek	09/21/06	-91.3082	35.95377											3			11	
ST	bkw2006-097	Reed Creek	09/21/06	-91.4015	35.96305										30					
ST	bkw2006-098	Strawberry River	09/21/06	-91.5381	36.07808		2		17						15			8		
ST	bkw2006-099	Freeman Branch	09/21/06	-91.4528	36.09362										5			8		
ST	bkw2006-102	Spring Creek	10/18/06	-91.4724	36.00046										11				10	3
ST	bkw2006-103	Reeds Creek	10/18/06	-91.4824	35.95949										13				7	
ST	bkw2006-104	Trib to Strawberry River	10/18/06	-91.5759	36.10915										9					
ST	bkw2006-105	Trib to Piney Fork	10/18/06	-91.706	36.07041	1									16		3			
ST	bkw2006-106	trib to Caney Creek	10/18/06	-91.8061	36.03855															

Basin	Collection #	Stream	Collection Date	Longitude	Latitude	<i>C. diogenes</i>	<i>C. hubbsi</i>	<i>F. fodiens</i>	<i>O. eupunctus</i>	<i>O. longidigitus</i>	<i>O. m. meeki</i>	<i>O. n. chaenodactylus</i>	<i>O. n. neglectus</i>	<i>O. n. unknown</i>	<i>O. ozarkae</i>	<i>O. p. longimanus</i>	<i>O. punctimanus</i>	<i>O. virilis</i>	<i>P. acutus</i>	<i>O. sp. unidentified</i>
ST	bkw2006-107	Greasey Creek	10/19/06	-91.9118	36.25949										6			6		
ST	bkw2006-108	Trib to Strawberry River	10/19/06	-91.893	36.28859										6			11		
ST	bkw2006-109	Trib to Little Strawberry River	10/19/06	-91.8194	36.29024															
ST	bkw2006-110	Trib to Little Strawberry River	10/19/06	-91.8194	36.29024													15		1
ST	bkw2006-111	Trib to Hubble Branch	10/19/06	-91.7549	36.26682			8												
ST	bkw2006-112	Trib to Hackney Creek	10/19/06	-91.6158	36.21021										2		3			
ST	bkw2006-113	Caney Creek	10/20/06	-91.3452	35.918										5				1	
ST	bkw2006-114	Hill Slough	10/20/06	-91.2429	35.92485															
ST	bkw2006-115	Mill Creek	10/20/06	-91.4004	36.01133										25			2	23	
ST	bkw2006-116	South Big Creek	10/20/06	-91.4425	36.01663										25					

Table 2: Supplemental collection data from Eleven Point River - site locations and crayfish species and numbers collected by site. Latitude and longitude coordinates are in decimal degrees, North American Datum 1927.

Basin	Collection #	Stream	Collection Date	Longitude	Latitude	<i>C. diogenes</i>	<i>C. hubbsi</i>	<i>F. fodiens</i>	<i>O. eupunctus</i>	<i>O. longidigitus</i>	<i>O. m. meeki</i>	<i>O. n. chaenodactylus</i>	<i>O. n. neglectus</i>	<i>O. n. unknown</i>	<i>O. ozarkae</i>	<i>O. p. longimanus</i>	<i>O. punctimanus</i>	<i>O. virilis</i>	<i>P. acutus</i>	<i>O. sp. unidentified</i>
EP	bkw2005-0040	Eleven Point River	8/17/05	-91.1802	36.4560		2								2		3			
EP	bkw2005-0041	Eleven Point River	8/17/05	-91.1631	36.4830				2						3		1			
EP	bkw2005-0042	Eleven Point River	8/30/05	-91.1147	36.3935										4					
EP	bkw2005-0043	Eleven Point River	8/31/05	-91.1241	36.3526										1					
EP	bkw2005-0044	Eleven Point River	8/31/05	-91.1376	36.4299										1					
EP	bkw2005-0045	Eleven Point River	9/1/05	-91.1753	36.4503		28		24						1					

Table 3: Numbers of crayfish collected in study by species, % of total, number of sites occupied, and % of sites occupied.

	<i>Cambarus diogenes</i>	<i>Cambarus hubbsi</i>	<i>Fallicambarus fodiens</i>	<i>Orconectes eupunctus</i>	<i>Orconectes longidigitus</i>	<i>Orconectes meeki meeki</i>	<i>Orconectes neglectus chaenodactylus</i>	<i>Orconectes neglectus neglectus</i>	<i>Orconectes neglectus ssp.</i>	<i>Orconectes ozarkae</i>	<i>Orconectes palmeri longimanus</i>	<i>Orconectes punctimanus</i>	<i>Orconectes virilis</i>	<i>Orconectes sp.</i>	<i>Procambarus acutus</i>
Total # of individuals	1	9	13	17	3	20	497	137	14	612	3	351	47	4	83
% of individuals	<1	<1	<1	<1	<1	1.1	27.4	7.6	<1	33.8	<1	19.4	2.6	<1	4.6
# of sites	1	2	2	1	1	1	21	7	1	41	1	46	9	2	9
% of sites	1.2	2.4	2.4	1.2	1.2	1.2	25.6	8.6	1.2	50.0	1.2	56.1	11.0	2.4	11.0

Table 4: Crayfish mean length, standard deviation, and gender breakdown by species.

<u>Species (N assigned to a gender)</u>	<u>Mean Carapace Length (CL)</u>	<u>Standard Deviation CL</u>	<u>Males</u>	<u>Females</u>
<i>Cambarus diogenes</i> (1)	31 mm	-	0 (0%)	1 (100%)
<i>Cambarus hubbsi</i> (9)	24.7 mm	10.2	3 (33%)	6 (67%)
<i>Fallicambarus fodiens</i> (13)	20 mm	1.8	5 (38%)	8 (62%)
<i>Orconectes eupunctus</i> (17)	20.8 mm	2.8	8 (47%)	9 (53%)
<i>Orconectes longidigitus</i> (3)	- mm	-	2 (52%)	1 (48%)
<i>Orconectes meeki meeki</i> (20)	19.8 mm	5.6	9 (45%)	11 (55%)
<i>Orconectes neglectus chaenodactylus</i> (497)	19.0 mm	6.3	231 (46%)	266 (54%)
<i>Orconectes neglectus neglectus</i> (137)	23.4mm	9.2	75 (55%)	62 (45%)
<i>Orconectes neglectus</i> not assigned to subspecies (14)	20.5 mm	2.8	8 (57%)	6 (43%)
<i>Orconectes ozarkae</i> (611)	19.8mm	6.1	282 (46%)	329 (54%)
<i>Orconectes palmeri longimanus</i> (3)	25.7 mm	5.0	2 (67%)	1 (33%)
<i>Orconectes punctimanus</i> (351)	20.1mm	5.4	172 (49%)	179 (51%)
<i>Orconectes virilis</i> (47)	mm		22 (47%)	25 (53%)
Unidentified <i>Orconectes</i> (4)	20.3 mm	4.5	0 (0%)	4 (100%)
<i>Procambarus acutus</i> (83)	16.4 mm	6.0	35 (42%)	48 (58%)

Table 5: Species associations for most commonly encountered species.

	<i>Orconectes neglectus chaenodactylus</i>	<i>Orconectes neglectus neglectus</i>	<i>Orconectes ozarkae</i>	<i>Orconectes punctimanus</i>	<i>Orconectes virilis</i>	<i>Procambarus acutus</i>
# of sites	21	7	41	46	9	9
% of sites co-occurring with:						
<i>Orconectes neglectus chaenodactylus</i>	100	43	12	33	0	0
<i>Orconectes neglectus neglectus</i>	14	100	10	11	0	0
<i>Orconectes ozarkae</i>	24	57	100	30	89	67
<i>Orconectes punctimanus</i>	71	71	34	100	0	11
<i>Orconectes virilis</i>	0	0	20	0	100	11
<i>Procambarus acutus</i>	0	0	15	2	11	100
Dominance at sites where found	66%	43%	60%	53%	34%	49%

Table 6: Further analysis of *Orconectes neglectus chaenodactylus* species associations, including dominance, constancy, and fidelity, after Pflieger (1978). Dominance = the proportion of all crayfish collected at sites with *O. n. chaenodactylus* that are the given species. Constancy = the proportion of *O. n. chaenodactylus* sites also having the given species. Fidelity = the proportion of sites having the given species that also have *O. n. chaenodactylus*.

	<i>Orconectes neglectus chaenodactylus</i>	<i>Orconectes neglectus neglectus</i>	<i>Orconectes ozarkae</i>	<i>Orconectes punctimanus</i>
Dominance (%) at <i>O. n. chaenodactylus</i> sites	65	10	3	19
Constancy (%) at <i>O. n. chaenodactylus</i> sites	-	20	25	75
Fidelity (%) at <i>O. n. chaenodactylus</i> sites	-	50	5	33

Table 7: Comparison of selected habitat characteristics at sites with *Orconectes neglectus* *chaenodactylus*, Middle White basin sites, Norfolk basin sites, Middle White and Norfolk basin sites combined, and all sites sampled.

<u>Habitat Characteristic</u>	<u>MW O.n. neglectus sites</u>	<u>MW</u>	<u>NF</u>	<u>MW ± NF</u>	<u>All Sites Sampled</u>	<u>Sites with O. n. chaenodactylus</u>
Average Water Temperature (°C)	13.3	13.3	12.9	13.1	14.3	13.2
Described as “clear” (very low turbidity)	86%	71%	52%	62%	64%	79%
No aquatic vegetation present	50%	56%	76%	67%	70%	42%
Watercress present	17%	28%	5%	15%	12%	26%
Other Rooted Vegetation present	33%	16%	19%	18%	18%	32%
Boulder & Bedrock as dominant substrate	17%	19%	5%	12%	17%	15%
Cobble/boulder as dominant substrate	0%	10%	14%	12%	6%	10%
Gravel-Rubble as dominant substrate	83%	61%	76%	69%	65%	70%
Silt/Clay as dominant substrate	0%	10%	5%	7%	8%	5%
Shore 0-24% Wooded	33%	29%	30%	29%	26%	25%
Shore 25-49% Wooded	0%	9%	20%	15%	16%	10%
Shore 50-74% Wooded	33%	24%	25%	24%	22%	25%
Shore 75%+ Wooded	33%	38%	25%	32%	36%	40%
Stream width < 10 m	100%	85%	70%	78%	81%	63%
Stream width 10-25 m	0%	15%	25%	20%	18%	32%
Stream width 26-50 m	0%	0%	5%	2%	1%	5%
Current Slow or None	14%	18%	19%	19%	36%	5%
Current Moderate	86%	82%	81%	81%	62%	95%
Wadeable Streams or Smaller	100%	100%	95%	98%	99%	100%