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ARTICLE

Comparison of Two Crayfish Trapping Methods in Coastal Plain Seasonal Wetlands

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Abstract
We compared crayfish collections from minnow versus microhabitat traps in the Dahomey National Wildlife Refuge, Bolivar County, Mississippi, extending the knowledge of microhabitat trap effectiveness to seasonal bottomland hardwood forest floodplains. Crayfishes were captured in three seasonally flooded habitat types: wooded, trail, and open habitats. The CPUE of vernal crayfish *Procambarus viaeviridis* and White River crayfish *P. acutus* was higher in minnow traps, whereas the CPUE of swamp dwarf crayfish *Cambarellus puer* was higher in microhabitat traps. The CPUE did not differ among habitat types for either trap type. In minnow traps, the CPUE of vernal and White River crayfishes increased steadily during the study, whereas the CPUE of swamp dwarf crayfish did not vary over time. In microhabitat traps, the CPUE did not vary over time for any species. Microhabitat traps were more effective at collecting adult, female vernal crayfish in the winter than in spring, whereas minnow traps were more effective at collecting adult, female vernal crayfish in the spring than in winter. Form I males of all three species were collected in both trap types throughout the study, whereas the only ovigerous females collected were swamp dwarf crayfish. Microhabitat traps caught more small crayfishes, pertinent to studies of population structure and recruitment, and were more effective at collecting adult swamp dwarf crayfish, a species five times smaller than other collected species. Conversely, minnow traps provided a better understanding of abundances and population structures of larger crayfishes. Using both trap types provided data on all size-classes and life stages and reduced sampling selectivity.

Effective sampling methods are key to obtaining accurate population estimates, understanding community structure, and monitoring populations efficiently (DiStefano 1993; Rabeni et al. 1997; Dorn et al. 2005). Sampling biases can lead to inaccurate population models and predictions, reducing the effectiveness of conservation and population management efforts (Begon et al. 2005; Grand et al. 2007). Baited minnow traps are commonly used to sample crayfishes in lentic environments (Collins et al. 1983; Stuecheli 1991; Price and Welch 2009; Litvan et al. 2010). However, minnow trap collections are often biased toward large males, which tend to be more active and aggressive (Brown and Brewis 1978; Abrahamsson 1983; Somers and Stetchy 1986; Stuecheli 1991; Larson and Olden 2016). Parkyn et al. (2011) used a microhabitat trap to more accurately assess the population structure of long-pincered crayfish *Faxonius longidigitus* in a large reservoir. The traps were biased toward females and juveniles but showed promise as a representative sampling method for studies of juvenile recruitment (Parkyn et al. 2011). However, the trap design has not been further tested. The aim of this study was to extend the knowledge of microhabitat trap effectiveness from large, deep reservoirs to small, shallow pools in seasonal wetlands by comparing its collections with those from a more conventional trapping method.

Seasonal wetlands are essential ecosystems (Wehrle et al. 1995; King et al. 1996) that provide habitat for a

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diverse invertebrate community (Wiggins et al. 1980; Brooks 2000), but these habitats are declining worldwide due to anthropogenic alterations (Danielson 1998; Tockner and Stanford 2002). In addition, 48% of native crayfishes from the United States and Canada are species of concern (Taylor et al. 2007). Crayfishes dominate the biomass of many freshwater invertebrate communities, serving as ecosystem engineers and playing a major role in food web dynamics in aquatic systems (Chambers et al. 1990; Hanson et al. 1990; Statzner et al. 2003; Usio and Townsend 2004). Accurate assessments of crayfish population structure give insight into species' status and habitats that are most important for each sex and life stage.

Understanding trap biases when characterizing crayfish populations is important because it allows investigators to understand the relationship of their data to reality, account for biases, and choose methods that will produce the most accurate data relative to their research questions. Because of the known sex and size biases of minnow traps, our goal was to test whether microhabitat traps are a more reliable method for obtaining population and community structure estimates in seasonal wetlands. Our objectives were to compare relative effectiveness of minnow traps versus microhabitat traps in terms of (1) species and habitat differences by comparing the relative CPUE (number of crayfish per trap) of species collected within different seasonal wetland habitat types, (2) seasonal differences by comparing changes in species CPUE over time, (3) sex and life stage differences by comparing sex ratios, along with total and seasonal CPUE of adult and juvenile males and females, and (4) size differences by comparing vernal crayfish lengths and numbers of age-classes estimated.

STUDY SITE

The study area was on the Dahomey National Wildlife refuge (hereafter "refuge") in the Lower Mississippi Alluvial Valley, Bolivar County, Mississippi (33.707710°N, −90.930108°W). The refuge was dominated by mature bottomland hardwood forests (Barnett et al. 2017). Normally, winter and spring flooding partially inundate low areas of the refuge (USFWS 1993), creating pools that persist for about 6 to 8 months.

We sampled five sites in three habitat types (wooded, open, and trail) common on the refuge (sites 2B, 3A, 3B, 3C, and 4A in Figure 1 of Barnett et al. 2017). We selected sample sites (see phase 2 in Barnett et al. 2017) that represented three habitat types where low to high CPUEs of vernal crayfish *Procambarus viaeviridis* occurred in earlier sampling (phase 1 in Barnett et al. 2017). Wooded sites (sites 2B, 3A, and 3B) had relatively undisturbed soils, sparse understory vegetation, and abundant large and small woody debris (Barnett et al. 2017). The trail site (site 4A) was on or along dirt roads that passed through forests and were closed to most vehicle traffic. Although the trail site had substantial tree canopy, soils were compacted and understory vegetation was absent (Barnett et al. 2017). The open site (site 3C) was in annually mowed strips between roads and forest and had ≤5% canopy cover (Barnett et al. 2017).

METHODS

We sampled crayfishes with minnow traps and microhabitat traps baited with Purina Cajun World Crawfish Bait, Gray Summit, Missouri, just as described in phase 2 of Barnett et al. (2017). Minnow traps were cylindrical (419 mm long × 190 mm diameter) with 6.4-mm galvanized steel mesh and two conical entrances, each with a 25-mm-diameter opening. Microhabitat traps (Miller Net Company, Memphis, Tennessee) were circular (46 cm in diameter), collapsible nets (3-mm mesh) with shelter bundles secured to the middle of the trap (Barnett et al. 2017). Shelter bundles consisted of the branching tops of Asian bamboo *Phyllostachys* sp. (~46 cm in diameter) bound together with zip ties (Warren et al. 2009). Microhabitat traps lay collapsed on the substrate, with three ropes attached equidistantly along the net's metal frame, and only trapped organisms when lifted from the substrate (Parkyn et al. 2011; Barnett et al. 2017). We replaced shelter bundles as necessary throughout the study (Barnett et al. 2017). At each site, a maximum of 20 minnow traps and 12 microhabitat traps were deployed monthly (Barnett et al. 2017). The number of traps per site varied as pool sizes changed, with a minimum of three traps of each type per site. Traps were placed at least 3 m apart and near existing structure when possible (Barnett et al. 2017).

We sampled monthly from December 2013 to May 2014. Minnow traps were set for one night in December 2013, but because few crayfishes were collected traps were set for two consecutive nights (checked daily) in all subsequent sampling months. Microhabitat traps were set on November 18, 2013, deployed continuously throughout the study, and checked for crayfishes during each sample (once per month). Trapping continued until pool water was too shallow to cover minnow trap entrances (height = 14 cm: Barnett et al. 2017) or until pools were too small to hold at least three traps of each type. Crayfishes were preserved in 70% ethanol, and species, sex, and life stage (adult or juvenile) were identified. For adults, we recorded reproductive form: female (without eggs), ovigerous female (bearing eggs), form II male (nonreproductive), or form I male (reproductive). We used the postorbital carapace length (POCL) of the smallest form I male from each species to demarcate juveniles from adults. In addition, POCLs of all vernal crayfish, the target species in a related life history study (Barnett et al. 2017), were measured to allow a comparison of sizes caught by the two trapping methods.

Habitat and seasonal differences.— For each species (swamp dwarf crayfish *Cambarellus puer*, White River crayfish *P. acutus*, and vernal crayfish), we compared (1) the CPUE among trap and habitat types (CPUE model) and (2) changes in CPUE over time (temporal model). We conducted each comparison using repeated-measures ANOVA models (see below) in the "lmerTest" package (Kuznetsova et al. 2016) in R software version 3.3.1. Catch per unit effort was calculated for each sampling night, averaged across nights within months, and $\log_e$(CPUE + 1) transformed for each analysis. The CPUE model tested the effects of trap type, species, and habitat type on total crayfish CPUE, while controlling for covariates, site, and date. Tukey's post hoc tests were used for pairwise comparisons of species and habitat type CPUE. The temporal model tested whether temporal changes in a species' CPUE differed between trap types, while controlling for site (each species modeled separately). Histograms of model residuals did not depart from normality, and Levene's tests on model residuals indicated that homogeneity of variance assumptions were met.

Sex and life stage differences.— For each species, we compared CPUE by sex and life stage between minnow and microhabitat traps with paired (CPUEs from the same site and date) Wilcoxon signed-rank tests using the "coin" package (Hothorn et al. 2017) in R. We corrected *P*-values for these and subsequent multiple comparisons using the Benjamini–Hochberg method (false discover rate: Benjamini and Hochberg 1995).

Seasonal differences between male and female crayfish collections were compared between trapping methods. For each species and life stage, the CPUE of males and females were compared between trap type and season using a log-linear model computed using the "stats" package (R Core Team 2013) in R. Due to low numbers (<10 individuals) during some months, we combined catches into winter (December–February) and spring (March–May) samples. These groupings coincided with average monthly water temperatures below (winter) and above (spring) 10.5°C, a threshold indicative of changing crayfish activity levels (Somers and Stetchy 1986; Barnett et al. 2017). Because male and female seasonal differences by trap type were the focus of this model, only model interactions were interpreted.

For each trap type, we calculated male to female (M:F) sex ratios separately for adults and juveniles of each species and tested them for deviation from 1:1 using chi-square statistics computed using the "stats" package (R Core Team 2013) in R. Data were grouped across sites.

Size differences.— Vernal crayfish lengths and estimated numbers of age-classes were compared between trap types. Vernal crayfish POCLs, pooled across dates and sites, were compared between trap types using separate *t*-tests for juveniles and adults. We estimated the number of age-classes (all dates and sites combined) using mixed-distribution analysis (flexmix R package) of the length-frequency data (France et al. 1991; Leisch 2004). Models were run with 1,000 iterations and a four-group-maximum assumption (Page 1985; France et al. 1991; Barnett et al. 2017). The best model was selected using integrated completed likelihoods (ICLs) (Biernacki et al. 2000).

RESULTS

Three crayfish species were collected: vernal crayfish (n = 917), White River crayfish (n = 480), and swamp dwarf crayfish (n = 138). The vernal crayfish was the most widespread species and was collected at all sites (Appendix S3 in Barnett et al. 2017).

Habitat and Seasonal Differences

Both trap types captured all three species in open and wooded habitats, but in trail habitats, microhabitat traps captured all three species whereas minnow traps captured only two (White River and vernal crayfishes). In the CPUE model, crayfish species and trap type interacted ($F_{2,\ 147}$ = 4.23, P = 0.02; Figure 1), indicating that neither trap type was the most efficient at capturing all three

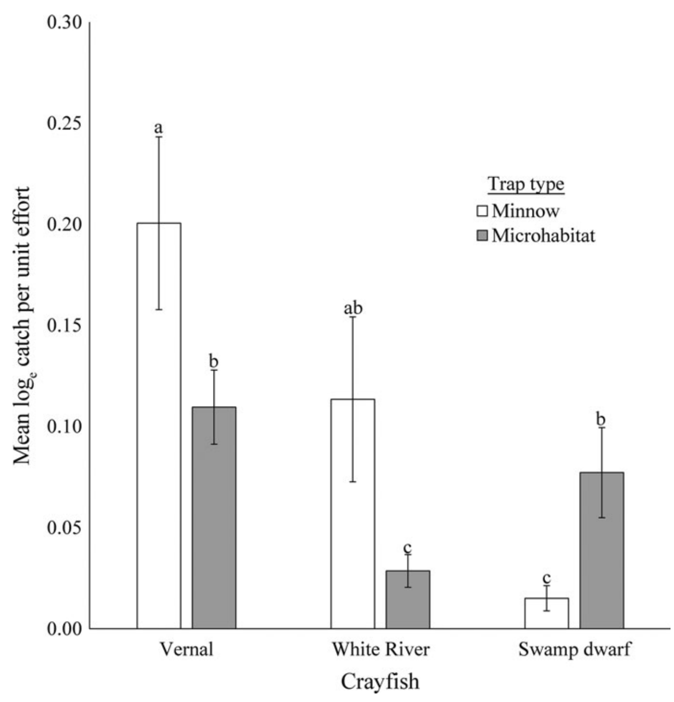

FIGURE 1. Mean $\log_e$ CPUE (number of crayfish per trap) ± SE for each species collected (all sizes combined) from minnow trap and microhabitat traps from December 11, 2013 to May 6, 2014. Different letters above bars indicate significant differences (P < 0.05) in CPUE.

species. Most swamp dwarf crayfish (86%) were caught in microhabitat traps, whereas most vernal and White River crayfishes (72% and 89%, respectively) were caught in minnow traps. Catch per unit effort did not differ among habitat types for either trap type ($F_{2,\ 147} = 1.34$, $P = 0.27$).

The temporal patterns in CPUE of vernal crayfish and White River crayfish differed between trap types (temporal model: $F_{1,\ 50} = 23.07$, $P < 0.001$; $F_{1,\ 49} = 12.32$, $P < 0.01$, respectively; Figure 2). From December to May, the CPUE of vernal and White River crayfishes steadily increased in minnow traps, but not microhabitat traps. Temporal patterns in swamp dwarf crayfish CPUE did not differ between trap types ($F_{1,\ 49} = 0.65$, $P = 0.42$; Figure 2), and no apparent trend in CPUE was shown for either trap type.

Sex and Life Stage Differences

Catch per unit effort by sex and life stage differed between trapping methods for all species. Catch per unit effort differed between trap types for both sexes of all species except vernal crayfish females (Figure 3). Adult vernal and White River crayfishes were more abundant in minnow traps than in microhabitat traps, whereas adult swamp dwarf crayfish were more abundant in microhabitat traps (Figure 3). Juvenile vernal crayfish and White River crayfish CPUE did not differ by trap type. Juvenile swamp dwarf crayfish were only collected during 1 month of the study so they were not analyzed.

Catch per unit effort of males and females differed by season and trap type for vernal and White River crayfishes. For collecting adult, female vernal crayfish, microhabitat traps were more effective in winter than in spring, whereas minnow traps were more effective in spring than in winter (Table 1; Figure 4). There was no difference between adult vernal crayfish male and female collections in the winter, but more males were collected in the spring (Table 1; Figure 4). Minnow traps were also more effective at collecting juvenile vernal and adult White River crayfishes in the spring than in winter, while microhabitat trap collections did not differ across seasons (Table 1; Figure 4). Numbers of males and females collected did not differ between trap type or season for any other species or life stage (Table 1; Figure 4). Log-linear analyses of juvenile swamp dwarf crayfish were precluded by low numbers (Table 1; Figure 4).

Sex ratios of vernal and White River crayfishes differed between seasons for both trap types (Table 2). Adult vernal crayfish sex ratios were female biased in microhabitat traps in the winter and male biased in minnow traps in the spring (Table 2). White River crayfish sex ratios in minnow trap collections were biased toward females for juveniles in winter and for both adults and juveniles in spring (Table 2). Swamp dwarf crayfish sex ratios were female biased in both trap types and seasons (Table 2).

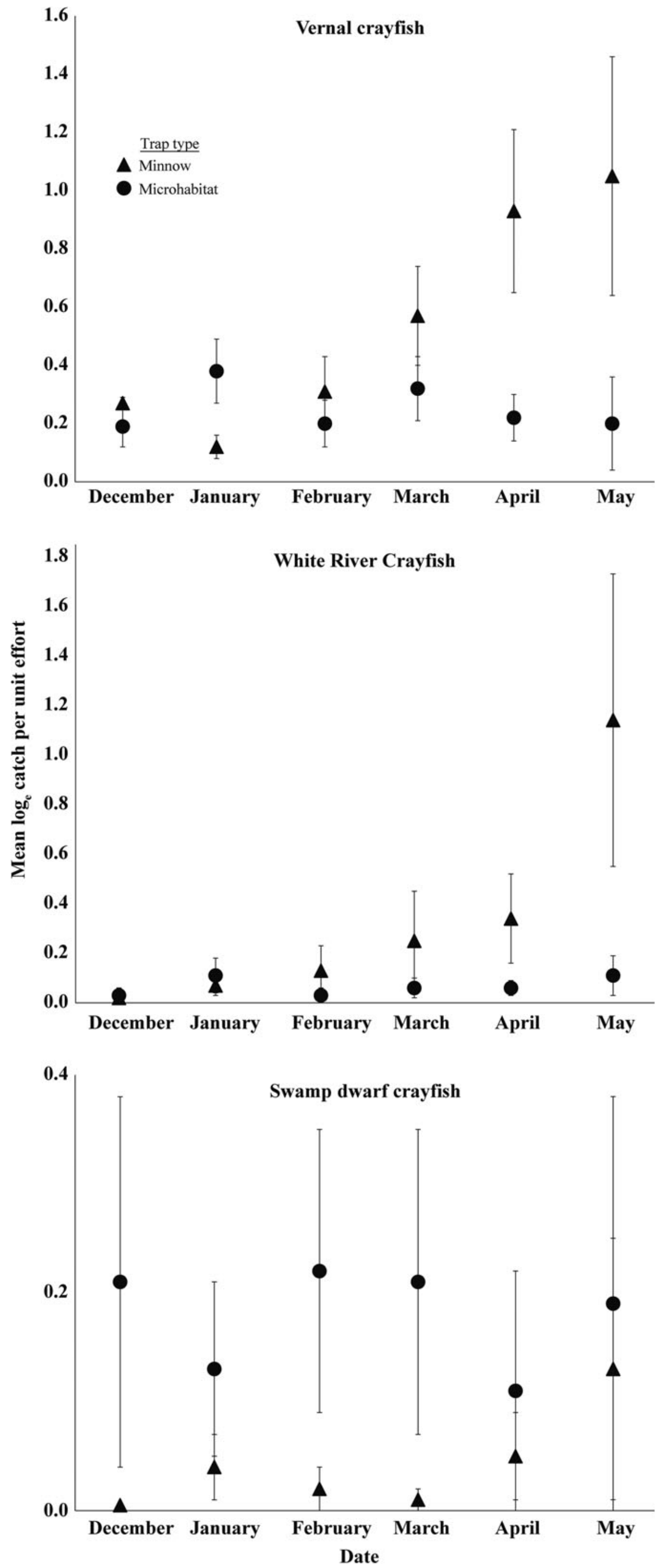

FIGURE 2. Mean monthly log$_e$ CPUE (number of crayfish per trap) ± SE for minnow trap and microhabitat traps over the 6-month sampling period (December 11, 2013–May 6, 2014). Note *y*-axis differences for each species.

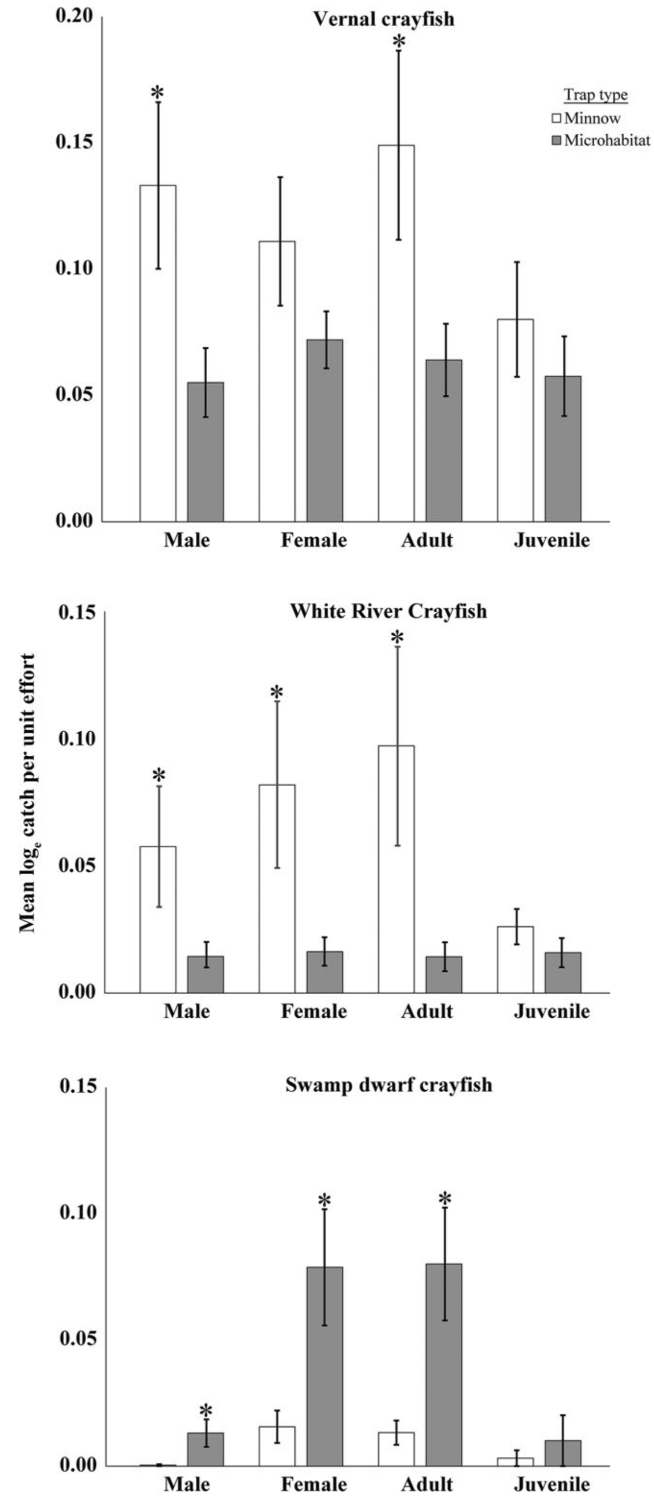

FIGURE 3. Mean $\log_e$ CPUE (number of crayfish per trap) ± SE for males, females, all adults, and all juveniles of each species collected in minnow traps and microhabitat traps. Asterisks (*) above bars represent collections with significantly different CPUE between trapping methods (Wilcoxon signed-rank test with Benjamini–Hochberg corrected $P \leq 0.05$). Juvenile swamp dwarf crayfish were not analyzed statistically because they were only collected during 1 month of the study.

Form I males were collected in both trap types throughout the study. Form I male vernal and White River crayfishes were most abundant in April and May (98% and 89%, respectively, of total form I male collections), whereas form I male swamp dwarf crayfish were most abundant in December and January (54% of total form I male collections). Most form I male vernal and White River crayfishes were collected in minnow traps, while most form I male swamp dwarf crayfish were collected in microhabitat traps (Figure 5). We collected ovigerous female swamp dwarf crayfish in microhabitat and minnow traps (CPUE: 0.24 and 0.05, respectively), as well as one female with young from a minnow trap. No vernal crayfish or White River crayfish ovigerous females or females with young were collected.

Size Differences

Smaller vernal crayfish were collected in microhabitat traps than in minnow traps, causing the number of age-classes estimated to differ between trap types. Juveniles in minnow traps (all dates and sites combined) averaged 30% longer than those in microhabitat traps (Student *t*-test: $t_{337} = -8.13$, $P < 0.001$). Mean lengths of adults did not differ between trap types ($t_{614} = -0.81$, $P = 0.42$). The mixed-distribution analysis indicated one age-class for vernal crayfish collected in minnow traps (median POCL = 18.4 mm) but two for those in microhabitat traps (median POCL: age-class 1 = 7.4 mm, age-class 2 = 19.4 mm) (Figure 6).

DISCUSSION

Unlike previously reported minnow trap biases favoring males (Somers and Stetchy 1986; Stuecheli 1991; Dorn et al. 2005; Parkyn et al. 2011), females dominated our minnow traps for White River and swamp dwarf crayfishes. Female swamp dwarf crayfish were also dominant in microhabitat traps, suggesting that rather than reflecting a trapping bias for this species the abundance of active females exceeded that of males in the pool habitats. Similarly, ovigerous females constituted 52–70% of total swamp dwarf crayfish collections from January to March in Louisiana (Black 1966). Due to low numbers of White River crayfish in microhabitat traps, sex biases could not be identified. However, White River crayfish sex ratios were 1:1 in ponds in South Carolina from November to June (Mazlum and Eversole 2004). Vernal crayfish sex ratios differed between seasons for both trap types. Previous reports of seasonal differences in sex ratio for vernal crayfish and signal crayfish *Pacifasticus lenisculus trowbridgii* were associated with breeding seasons (Mason 1975; Barnett et al. 2017). Barnett et al. (2017) reported an abrupt seasonal change in vernal crayfish female abundance that suggested females were highly active during

TABLE 1. Results of log-linear models comparing numbers of male and female crayfishes collected in microhabitat traps and minnow traps during winter (December–February) and spring (March–May) sampling, with only interaction terms shown ($P \leq 0.05$*, $P \leq 0.01$**); e^{β} = odds ratio, × symbol = interactions among parameters.

	Model parameters (e^{β})			
Species and stage	Trap × Season	Trap × Sex	Season × Sex	Trap × Sex × Season
Vernal crayfish adults	8.39*	0.13*	0.06**	4.19
Vernal crayfish juveniles	21.56**	0.37	0.47	2.92
White River crayfish adults	25.82**	3.44	5.20	0.28
White River crayfish juveniles	4.43	3.00	1.00	0.63
Swamp dwarf crayfish adults	1.08	3.02	2.98	0.70

winter months, then they copulated and subsequently burrowed in the spring. Differences in sample timing and seasonal changes in crayfish reproductive activity may help explain previously reported male-dominated collections from summer and fall sampling (Somers and Stetchy 1986; Stuecheli 1991; Dorn et al. 2005; Parkyn et al. 2011) and female-dominated collections (Black 1966) from winter and spring sampling. Although sex biases differed between trap types for vernal and White River crayfishes, without knowing the true population composition we cannot infer which trap type was biased.

In a lake experiment, microhabitat traps were biased toward smaller individuals and species and minnow traps toward larger ones (Parkyn et al. 2011). Similarly, in our study swamp dwarf crayfish were more susceptible to microhabitat traps and adult vernal and White River crayfishes to minnow traps. Adult swamp dwarf crayfish averaged 8–14 mm carapace length (Penn 1959; Penn and Black 1963), whereas vernal crayfish and White River crayfish adults are at least five times longer (Hobbs and Jass 1988; Walls 2009; Barnett et al. 2017). With hierarchical size-based dominance within crayfish communities (Stein 1976; Issa et al. 1999), larger crayfish may deter smaller individuals from entering minnow traps (Stuecheli 1991). Swamp dwarf crayfish may also have moved through the minnow trap mesh, reducing minnow trap efficiency for the species. Our results were consistent with Parkyn et al. (2011) in finding larger species dominating minnow traps and smaller species dominating microhabitat traps but contrasted in finding similar adult vernal crayfish sizes between trap types. Although adult vernal crayfish CPUE was higher in minnow traps, both trap types collected all sizes of adult vernal crayfish, indicating that neither trap size nor interstitial spaces within microhabitat bundles prevented trap occupancy by adults. On the other hand, smaller juvenile vernal crayfish were collected in microhabitat traps than in minnow traps. Warren et al. (2009) postulated that bamboo bundles, such as those used in our microhabitat traps, provide habitat and protection from predators, and this may increase survival by smaller crayfishes. Likewise, because predation is a main threat to ovigerous females (Archer 1988; Figler et al. 1995), the bamboo bundles may also increase their survival.

Trapping success depends on animal abundance and activity levels (Collins et al. 1983; Dorn et al. 2005), and temperature regulates crayfish activity levels (Capelli and Magnuson 1974; Somers and Stetchy 1986). Vernal crayfish and White River crayfish CPUE in minnow traps increased over time, along with increases in water temperatures and crayfish activity (Barnett et al. 2017). Conversely, microhabitat trap collections did not increase over time, suggesting that the shelter bundles were sought out for refuge from predators and winter weather conditions (Everett and Ruiz 1993; Warren et al. 2009).

Two to three age-classes have been estimated for vernal crayfish populations in Illinois (Page 1985) and Mississippi (Barnett et al. 2017). We separated the Mississippi age-class data by trap type for analyses in this study. Both trap types captured vernal crayfish in the size range of each age-class estimated in Illinois and Mississippi. Barnett et al. (2017) found three age-classes in 1 month when length data from both trap types were combined. When separated by trap type, low numbers of individuals from age-class 3 (POCL $\geq$ 24.00 mm) in microhabitat traps and of individuals from age-class 1 (POCL $\leq$ 15.00 mm) and age-class 3 in minnow trap collections prevented length-frequency analyses from recognizing three age-classes. Microhabitat trap age-class estimates were more accurate than estimates from minnow traps, but for the best estimations, trapping methods should be combined.

Both trap types captured 75–100% of the total known species richness at each sampling site (Barnett et al. 2017). Red swamp crayfish *P. clarkii*, a secondary burrower, was not captured in either trap type. During previous sampling, this species was collected in minnow traps throughout the refuge (n = 357), but at only one of our sampling sites in low numbers (n = 3) in early May (Barnett et al. 2017). The low numbers previously collected and the species' ability to travel as far as 17 km during their spring and fall breeding seasons (GISD 2011; Nagy et al. 2017)

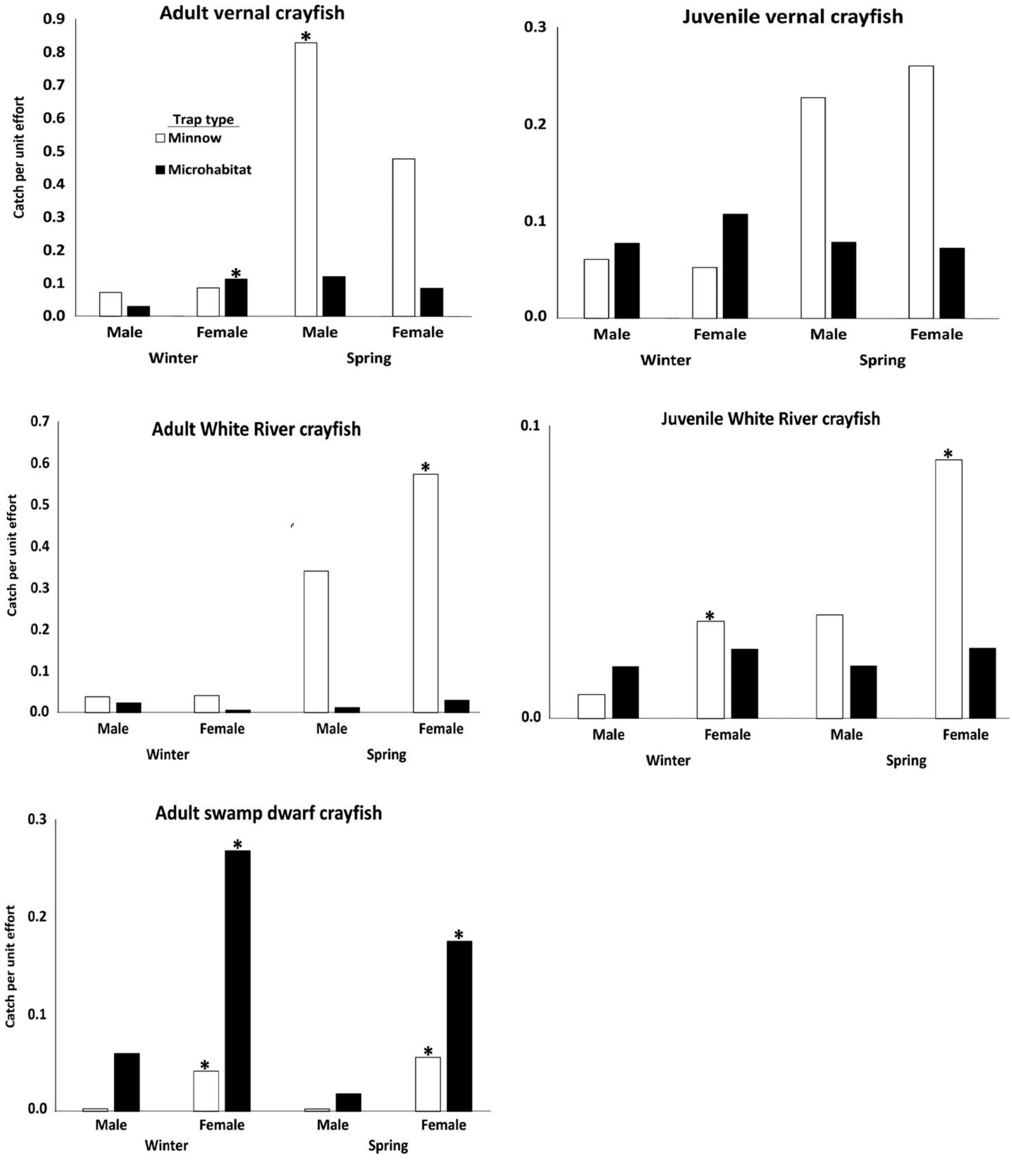

FIGURE 4. Mean CPUE (number of crayfish per trap) for adult and juvenile, male and female crayfish of each species collected in minnow traps and microhabitat traps during winter and spring. Asterisks (*) above bars represent collections with significantly different ($P \leq 0.05$) sex ratios between sampling methods.

TABLE 2. Results of chi-square tests for equal sex ratios for juvenile and adult crayfishes in minnow traps and microhabitat traps from winter (December–February) and spring (March–May) sampling (Benjamini–Hochberg corrected *P*-values: $P \leq 0.05$*, $P \leq 0.01$**); M:F = male : female ratio, *n* = total crayfish collected, NA = not applicable.

		Minnow traps			Microhabitat traps		
Species and stage	Season	M:F	df, *n*	χ^2	M:F	df, *n*	χ^2
Vernal crayfish adults	Winter	0.8	1, 57	0.44	0.3	1, 24	8.17**
	Spring	1.7	1, 517	37.37**	1.4	1, 34	1.06
Vernal crayfish juveniles	Winter	1.2	1, 41	0.22	0.7	1, 31	0.81
	Spring	0.9	1, 193	0.88	1.1	1, 25	0.04
White River crayfish adults	Winter	0.9	1, 29	0.03	4.0	1, 5	1.80
	Spring	0.6	1, 362	23.38**	0.4	1, 7	1.30
White River crayfish juveniles	Winter	0.2	1, 17	7.12*	0.8	1, 7	0.14
	Spring	0.3	1, 47	11.26**	0.8	1, 7	0.14
Swamp dwarf crayfish adults	Winter	0.0	1, 14	14.00**	0.2	1, 53	23.11**
	Spring	0.0	1, 21	21.00**	0.1	1, 30	22.53**
Swamp dwarf crayfish juveniles	Winter	NA	0, 0		NA	0, 0	
	Spring	0.1	1, 9	5.44*	0.0	1, 11	11.00**

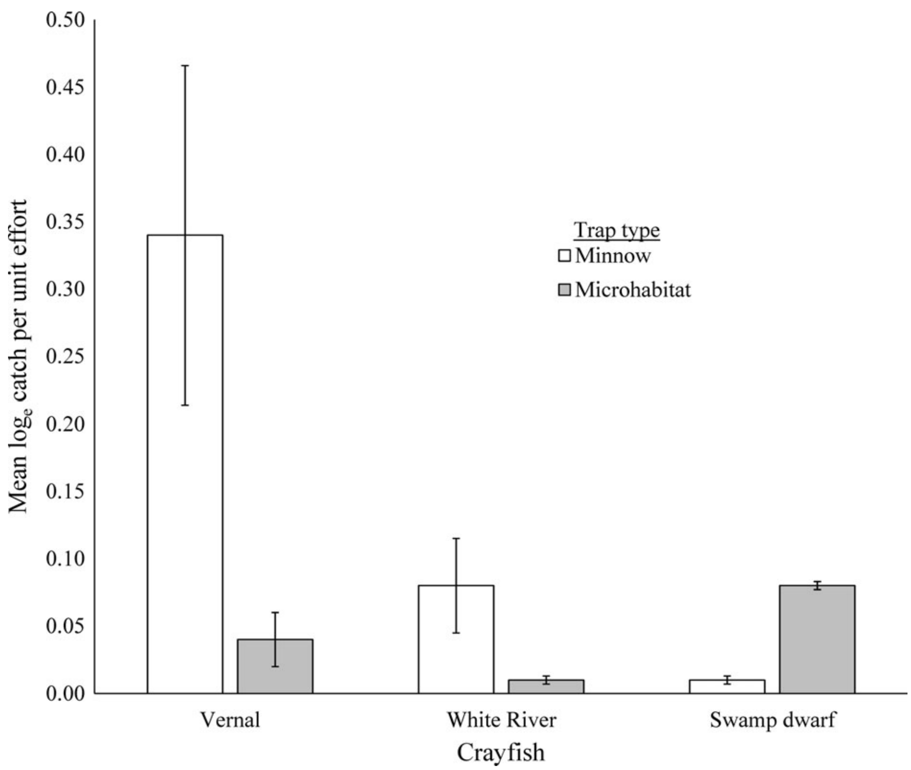

FIGURE 5. Mean CPUE (number of crayfish per trap) ± SE for form I males of each species collected in minnow traps and microhabitat traps.

suggest that the species probably did not permanently reside in our sample sites.

Sampling crayfishes with microhabitat traps minimizes harm to nontargeted organisms, decreases sampling time, and increases possible sampling areas. Air-breathing organisms may drown in fully submerged minnow traps. Because organisms are free to move in and out of microhabitat traps, traps can be deployed for extended periods without harming nontarget organisms, an important consideration in the refuge where 13 amphibian and 12 reptilian species occur (one vulnerable species, IUCN red list category: van Dijk 2011; U.S. Fish and Wildlife Service,

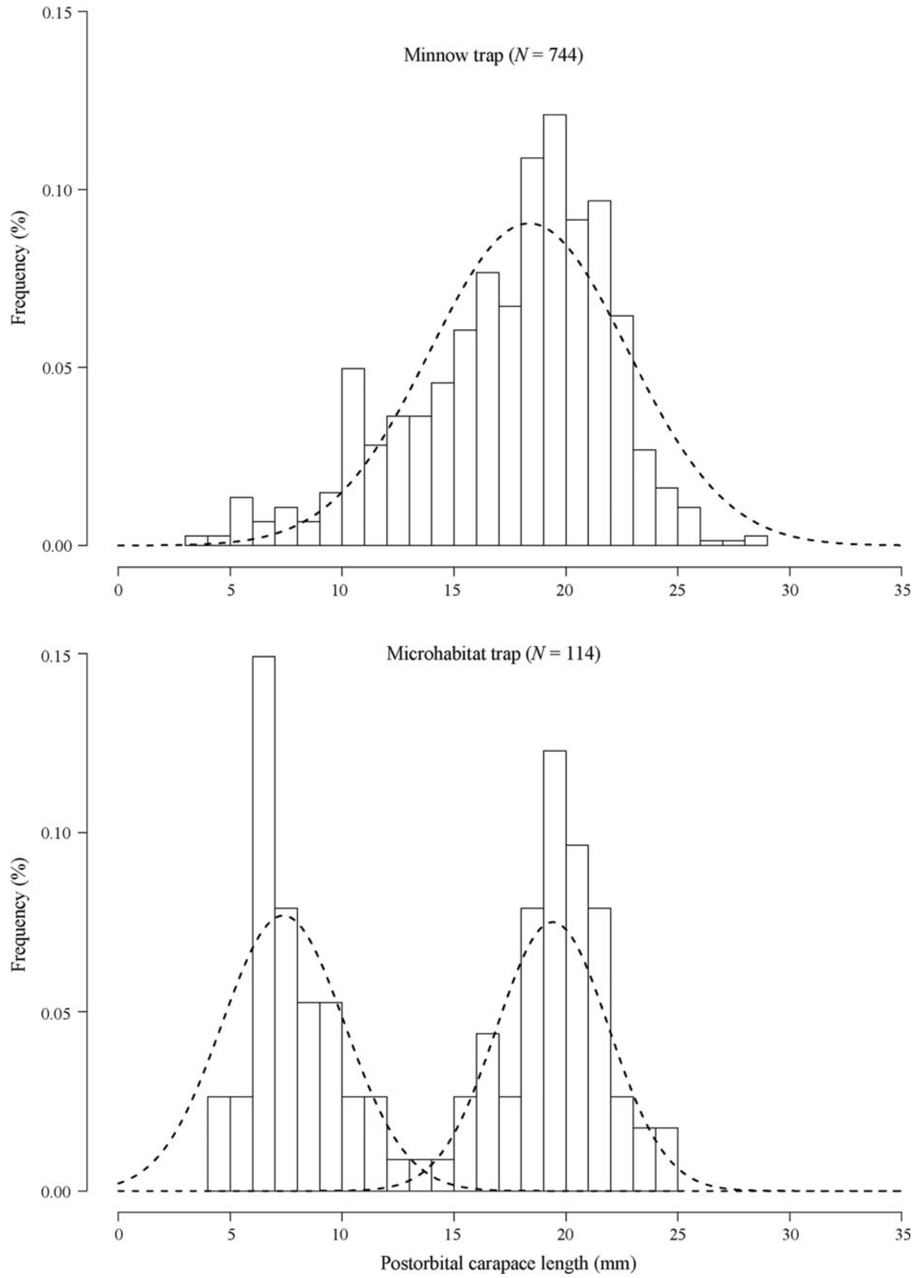

FIGURE 6. Frequency histograms of vernal crayfish postorbital carapace length distributions for minnow trap (upper panel) and microhabitat trap (lower panel) collections from the entire study duration. Dashed lines represent age-classes estimated using mixed distribution analyses, with peaks at age-class median postorbital carapace lengths.

unpublished data). Because of the potential harm minnow traps can cause, traps should be checked within 24 h of being set (Adams et al. 1997; Mulualem 2016). Consequently, minnow traps require 1 d per round of sampling for deployment. Conversely, microhabitat traps can be deployed during the first round of sampling and remain at sites for the duration of the study. The only additional time required for microhabitat traps is for the assembly of the shelter bundles. Microhabitat traps can also sample shallower waters (depths ≥ 3 cm) than minnow traps (depths ≥ 14 cm), thereby increasing the potential sampling area.

Using both minnow traps and microhabitat traps simultaneously will contribute to a better understanding of lentic crayfish population structures. Microhabitat traps increased our catch of smaller crayfishes, pertinent to studies of population structure and recruitment. Conversely, minnow traps provided a better understanding of abundances and population structures of larger crayfishes. Minnow traps may also be more suitable during warm seasons when crayfish activity is higher, whereas collections were stable across seasons for microhabitat traps. Although both trap types had biases, these biases differed and were offset by the use of the other trap type.

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