Digging Deep for Crayfish Clues

SURVEYING FOR CRAYFISH MEANS CUT HANDS, COLD FINGERS — AND CRITICAL DATA

By Susan B. Adams and Scott G. Hereford

Most biologists kneeling in a wet prairie, arm extended to the armpit in a muddy hole, quickly arrive at the thought, "There's got to be a better way." So it's not surprising that, when it comes to sampling for burrowing crayfishes (also known as crawfish, crawdads or mudbugs — Superfamily Astacoidea), they have devised some creative solutions.

But how effective are they? Sampling methods for fishes and amphibians are well studied. Sampling efficiencies and biases for crayfishes have seldom been quantified, especially in the southeastern United States — the global center of crayfish biodiversity.

Crayfishes' propensity to burrow ranges widely. North American taxa are often assigned to one of three categories (Hobbs 1942). Primary burrowing crayfishes dig complex, branching burrows that can extend more than 2 meters down to the water table. At times, they venture across land, most notably on warm wet nights, but they seldom occur in surface waters. Secondary burrowers create less-complex burrows, spending time in surface waters but residing in burrows for much of their lives. Tertiary burrowers live primarily in surface waters, burrowing only when necessary.

Digging them up can be miserable. Hands get cut. Fingers get cold and sore. Thoughts turn to fears of what may lurk in those burrows. But it can also be a fun — and strangely addictive —pursuit. Feeling the tip of a claw or the wriggle of something against the burrow wall produces the satisfaction of unearthing buried treasure after a frustrating and sometimes painful hunt. An element of friendly competition sneaks in among diggers, too. Then, specimens in hand, we try to note species, sex and reproductive form and sometimes measure, weigh and take tissue samples.

Crayfishes are often overlooked, but quantitative sampling is important to understanding them. It is fundamental to our ability to assess population trends and conservation status (Richman et al. 2015), as well as the effects of land and stream management (e.g., Adams 2013) on populations. Efforts to maintain or restore ecosystems are more likely to succeed when reliable information is available. Crayfishes are typically among the key players in the Southeast's aquatic and wet terrestrial ecosystems, so having reliable data depends on efficient, quantitative sampling methods. That's why we have been quantifying crayfish sampling methods and biases in diverse habitats since 2013.

Crayfish among cranes

The Mississippi Sandhill Crane National Wildlife Refuge was one place where biologists needed some crayfish answers. Located in Mississippi near the Gulf of Mexico, the refuge was established in 1975 to conserve the last remaining population of the nonmigratory Mississippi sandhill crane (*Grus canadensis pulla*), an endangered species and one of North America's rarest birds (Hereford and Dedrickson 2018).

Since the refuge's creation, its land management has focused on restoring and maintaining

A *Creaserinus oryktes* just excavated from a burrow on the Mississippi Sandhill Crane National Wildlife Refuge in Jackson County, Mississippi.

Credit: S. B. Adams/ U.S. Forest Service

Credit: S.G. Hereford/U.S. Fish and Wildlife Service

▲ A Mississippi sandhill crane walks through a pine savanna on the refuge. Pale pitcher plants (*Sarracenia alata*) are scattered throughout the foreground.

▼ Active sampling methods tested for sampling burrowing crayfishes on the refuge included excavating and suctioning. Stewart Ray, a U.S. Fish and Wildlife Service volunteer, excavates a burrow (top), and Zanethia Barnett uses a slurp gun to suction a burrow (bottom), both in a frequently burned savanna in January 2017.

Credit: S.B. Adams/U.S. Forest Service

landscapes used by the crane. Managers have used fire and mulching to provide open prairie and savanna. As refuge biologists broadened their management goals to include more flora and fauna unique to the sandy, wet pine savanna and prairie, they began wondering how their practices affected at-risk burrowing crayfishes. The questions also applied to nearby lands managed by the U.S. Forest Service, The Nature Conservancy and others.

Of all the places to dig for burrowing crayfishes, the refuge offers one of the best experiences. The loose, sandy soils made digging by hand relatively easy. We non-botanists got to spend hours kneeling among beautiful, carnivorous plants. Near the end of the day when we couldn't dig another burrow, we were treated to the wild calls of cranes flying overhead. It was a welcome respite from trash-strewn roadside ditches with vehicles zooming by.

Efforts to compare and quantify crayfish sampling techniques in Gulf coastal plain surface waters were recently completed for some streams (Budnick, et al. 2018) and floodplain pools (Barnett and Adams 2018). We tested different sampling approaches — dipnetting versus backpack electrofishing in streams, for instance, and minnow versus habitat trapping in floodplain pools — and compared the resulting crayfish size, sex, species richness and catch-per-unit effort between methods.

Results from those contrasting habitats were consistent in one respect. Researchers were better able to capture the gamut of species and sizes by using multiple techniques. For example, minnow traps captured larger crayfishes in floodplain pools, whereas habitat traps — which attract crayfish by providing desirable microhabitat characteristics — caught more small crayfishes, including the swamp dwarf crayfish (*Cambarellus puer*) that rarely exceeds 30 mm in length.

Different lifestyles, different methods

The burrowing lifestyle, however, creates unique sampling challenges. The methods used in surface waters do not translate directly to capturing burrowing crayfishes. We needed quantitative sampling approaches that would work for them. To document life history information and clarify some taxonomic questions, we needed crayfish in hand. Indirect sampling methods such as burrow counts or eDNA wouldn't be enough.

We selected and categorized sites based on whether they had been frequently burned, mechanically treated or infrequently managed. We coarsely quantified vegetation, counted crayfish burrow entrances in quadrats along transects in each site and after trying out six methods, we tested four of them for sampling burrowing crayfishes.

We tested two passive sampling methods — mist net traps (Welch and Eversole 2006) and modified Norrocky traps (Norrocky 1984) of three diameters (3.2, 3.8, and 5.1 centimeters) — and assessed influences of weather on trap captures. Modified Norrocky traps consisted of a PVC pipe with a one-way flap near the bottom and a cap on top. The trap was carefully placed in a burrow opening so soil did not force the flap open. In concept, the crayfish exits the burrow and enters the trap as the one-way flap snaps closed behind it. A mist net trap consisted of a square of bird mist net material folded numerous times and tied in the middle with a string. The folded net was inserted into a burrow. The other end of the string was tied to a stake flag. When a crayfish tried to remove the net from the burrow, it would become tangled in the netting and await extraction by the biologist. At least that's how it was supposed to work. For creatures with very small brains, crayfish managed to foil these traps in remarkably diverse ways.

The four active sampling methods were excavating, suctioning, baited line sampling and visual surveys — the latter two conducted at night. We also assessed biases associated with the people excavating burrows. In the refuge's sandy soils, shovels were not needed, so we used our hands and, if necessary, a Japanese soil knife. Suctioning employed either commercially available slurp guns used by divers to capture fishes or homemade devices. The mouth of the outer tube was placed in water inside the burrow. The inner tube was pulled to create suction. This sometimes directly extracted crayfish, but more often, pumping it back and forth disturbed the burrow water until the crayfish came to the surface. The method worked well only when the water table was close to the surface, though, and in practice, it was often used along with excavating. Night sampling methods depended on first seeing crayfish, but we abandoned them. On the two nights we searched for crayfishes, we did not see any at all. Visual surveys are most effective on warm, wet nights, but we were only able to search on dry nights.

We mostly captured flatwoods diggers (*Creaserinus oryktes*) from burrows; but we also caught spinytail crayfish (*Procambarus fitzpatricki*), a federal priority at-risk species that occurs only in several southern Mississippi counties.

Roll up your sleeves

Bad news for the biologists with their arms in muddy holes: excavating produced far more crayfishes than any other method. The hope for passive sampling methods is that they will require less effort than active methods. Indeed, setting and checking traps was relatively easy, but it usually produced few or no crayfishes. A combination of methods produced more — a result similar to what we found in stream and floodplain pool habitats. However, in many sites, if we had focused our efforts exclusively on excavating burrows instead of trapping, we may have captured even more.

Credit: S.B. Adams/U.S. Forest Service

▲ **Passive sampling methods tested included two types of trapping. Modified Norrocky traps of three diameters were tested. View of the bottom of a medium-sized (3.8 cm diameter) modified Norrocky trap showing the one-way flap (top left) and installed in a burrow in a mowed prairie in February 2017 (top right). Crayfish sometimes built new chimneys in burrows containing a mist net trap without getting captured (bottom left). A *Creaserinus oryktes* entangled in a mist net trap is shown after the trap was removed from the burrow (bottom right).**

Credits: top photos, G.A. Schuster; bottom left, S.B. Adams; bottom right, C. Lukhaup

▲ **We collected two crayfish species from burrows on the refuge: *Creaserinus oryktes* and *Procambarus fitzpatricki*. We found several color morphs of *C. oryktes*, including blue (top left), white (top right) and various shades of brown (bottom left). The small eyes of *C. oryktes* are indicative of primary burrowers. The secondary burrower *P. fitzpatricki* (bottom right) has slightly larger eyes.**

Courtesy U.S. Fish and Wildlife Service

▲ **A Mississippi sandhill crane feeds on a crayfish. The image was caught by a remote camera on the refuge on May 30, 2018 and provided the first evidence of the subspecies feeding on crayfish. The camera was installed to monitor marked cranes.**

None of the tested methods avoided the problem of substantial sampling biases. The success rates of all methods depended strongly on people or weather. Unsurprisingly to anyone who has worked with a crew digging crayfish, excavation success depended strongly on the digger. Some people regularly captured multiple crayfishes. Others never caught one.

We often think of passive sampling methods as being less biased by human factors than active methods, but ours appeared to be biased by weather conditions. Recent rainfall was associated with a jump in captures. Although we saw no relation between catch rates in traps and air temperatures, the catch rates increased each time we had

Courtesy U.S. Fish and Wildlife Service

▶ **Aerial burning of a prairie on the refuge created open habitat for Mississippi sandhill cranes — and burrowing crayfishes.**

rain in the previous 24 hours. Crawfish farmers have noted that farmed crawfish are stimulated to reproduce by barometric pressure changes typically associated with rain events rather than by the rain itself. Simulating rainfall by pouring water into burrows when setting our traps didn't seem to increase catch rates, suggesting that dropping barometric pressure might have also triggered crayfish to leave their burrows.

Better understanding the effectiveness of various sampling methods enables biologists to design more reliable research and efficient monitoring approaches. In this case, we learned that all burrow sampling methods tested had substantial biases. We hope to further test and explore the relationships between weather and trapping so future monitoring efforts can exploit those relationships. For example, if traps are set only when barometric pressure drops, the average catch-per-unit effort may be increased while sampling biases among sites are reduced. Additional physical factors that seem likely to influence sampling efficiency include water table depth and soil type.

Good for crayfishes, good for cranes

As for land management effects, we found some interesting correlations. In a result welcomed by refuge managers, we discovered that the treatments used to create habitat for cranes also seemed to benefit burrowing crayfishes. Crayfish burrow entrance densities were higher in frequently burned and mechanically treated sites than in infrequently managed sites that had more dense, taller woody vegetation.

This finding opens a world of new questions. A better understanding of how habitat conditions and crayfish species influence the number of entrances per burrow will help biologists use entrance counts to better answer ecological questions about burrowing crayfishes across diverse habitats and communities and help reveal more refined management implications.

This study adds another piece to the puzzle of managing the refuge as a complex ecosystem. Understanding how land management influences burrowing crayfishes will help refuge biologists and managers, and information about sampling efficiencies and biases provides a basis for future approaches.

Shortly after our study, the U.S. Fish and Wildlife Service obtained evidence of what we already suspected — that Mississippi sandhill cranes feed on crayfish, although how much is unknown. Crayfish certainly contribute to many trophic interactions on the refuge as both predators and prey. We know little about relationships between plant communities and crayfish burrowing and foraging. However, given that the refuge's unique plant communities co-evolved with burrowing crayfishes, the relationships are likely important. Information that muddy biologists kneeling in prairies and roadsides provide about quantitative sampling methods for burrowers improves the ability to address ecological and management questions relating to these small — but functionally important — community members.

▼ Still smiling at the end of the study, the final day's field crew shows some of the tools used for both terrestrial and aquatic crayfish sampling on the refuge.

Credit: S. G. Hereford/ U.S. Fish and Wildlife Service

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