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# Modification of a Water Hyacinth sieve and description of Hubbard rakes for sampling small aquatic salamanders

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***Abstract.*—Jollyville Plateau Salamanders (*Eurycea tonkawae*) can be difficult to detect and capture in submerged leaf litter packs, woody debris, and vegetation. Here we describe the modification of a Water Hyacinth sieve and introduce three designs of Hubbard rakes to effectively sample these cover objects. Data are reported on the captures of *E. tonkawae* using the sieve and all three rakes, as well as captures of *E. pterophila*, *E. naufragia*, *E. chisholmensis*, and several co-occurring tadpoles, small fishes, and invertebrates. The application and success of these tools are described in detail for various cover types, water depths, and substrates.**

**Keywords.** Amphibia, Caudata, central Texas, cover objects, *Eurycea*, monitoring

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## Introduction

Jollyville Plateau Salamanders (*Eurycea tonkawae*) are small, fully-aquatic salamanders endemic to central Texas, USA (Chippindale et al. 2000), which are listed as Threatened by the U.S. Fish and Wildlife Service (USFWS 2013). Bowles et al. (2006) and USFWS (2013) considered submerged rocks and gravel to be the preferred habitat for this taxon, but it has also been documented from leaf litter, woody debris, and aquatic vegetation (Bowles et al. 2006; Chippindale 2005; Davis et al. 2001; O'Donnell et al. 2008). Submerged rocks are easily surveyed by overturning them and visually searching underneath for salamanders (Bowles et al. 2006; Pierce et al. 2010; Sweet 1977). In contrast, *E. tonkawae* are difficult to detect in leaf litter packs, woody debris, and vegetation because these cover objects can be dense and often occur on silty substrate (Bowles et al. 2006; Davis et al. 2001). Bowles et al. (2006) recognized that this difficulty may have caused underestimates of *E. tonkawae* relative abundance in large leaf packs.

Previous researchers have surveyed for salamanders in submerged, dense leaf litter, and vegetation with pipe and box samplers, dip nets, and seines (Shaffer et al. 1994; Skelly and Richardson 2010), but these techniques are difficult to apply in shallow water (less than 15 cm) and in areas with gravel or bedrock substrates that characterize *E. tonkawae* habitat (Z.C. Adcock, pers. obs.). Sweet (1977) collected central Texas *Eurycea* in gravel substrates by shoveling the material onto a wire-mesh screen suspended over a large tray. This method could be applied to leaf litter, woody debris, and vegetation, but it requires bulky gear that may be difficult for one surveyor to use or to transport in the field. O'Donnell et al. (2008) reported catching *E. tonkawae* by sweeping leaf litter into a large net, but this method does not allow for easy quantification of the surveyed area and has limited applicability to other cover objects.

Passive and active traps, such as funnel traps, drift nets, leaf litter bags, and mopheads, can capture *Eurycea* salamanders in various aquatic covers (Devitt and Nissen 2018; Pauley and Little 1998; USFWS 2014; Waldron et al. 2003; Willson and Dorcas 2003; Willson and Gibbons 2010). However, the animals which are captured can die if passive traps are not checked frequently (Willson and Gibbons 2010), and all trapping methods require several subsequent site visits which may not always be practical. Some traps can also result in a size-biased sample (Luhring et al. 2016).

Here, we provide the details for a modification of the Godley Water Hyacinth (*Eichhornia crassipes*) sieve (Godley 1982) and describe the use of this sieve and Hubbard rakes to sample *E. tonkawae* in a variety of cover types, water depths, and substrates. We designed these

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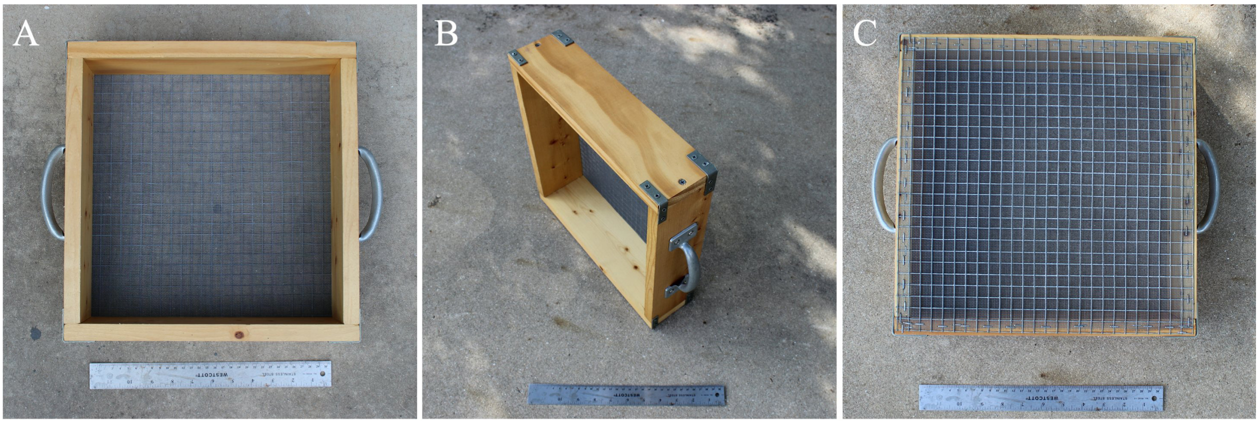


**Fig. 1. (A)** Top, **(B)** side, and **(C)** bottom of a salamander sieve. Scale: 30 cm. *Photos by Michelle Adcock*.

tools to be small so they would work efficiently within the often-narrow spring runs and cave streams occupied by these salamanders and to allow a single researcher to easily carry and operate the equipment. Like the Godley sieve, and its predecessor, the Goin dredge (Goin 1942) our modified sieve and rakes sample a known area, thus enabling estimates of salamander densities. Although we designed these sampling devices to capture *E. tonkawae*, we demonstrate they are also effective for other central Texas *Eurycea* salamanders, as well as several co-occurring vertebrates and invertebrates.

## Materials and Methods

**Sieve.** Our modified sieve design required 1.25 m of 1.9-cm × 8.9-cm (standard 1-inch × 4-inch) untreated pine lumber, eight 3.8-cm (1.5-inch) galvanized corner braces, two galvanized gate handles, a 91-cm × 2.1-m (3-foot × 7-foot) roll of fiberglass window screening, a 1.27-cm × 61-cm × 152-cm (0.5-inch × 2-foot × 5-foot) roll of 19-gauge galvanized steel hardware cloth, a box of 1.27-cm (0.5-inch) stainless steel staples, and a can of spar urethane (Table 1). We cut the lumber into two 30-cm and two 32-cm lengths to form a box frame with 30 cm × 30 cm interior dimensions (Fig. 1A), but we note that the interior dimension should be adjusted to accommodate the target taxa, sampling site, and project goals. We attached the corner braces on the outside of the frame to eliminate any sharp corners inside the sieve that could harm captured animals (Fig. 1B). We then sealed the frame with spar urethane and attached the gate handles after the frame dried. The bottom was constructed by attaching window screening which was supported by hardware cloth to the bottom of the frame with staples (Fig. 1C). Because of the small sieve size, staples adequately supported the bottom, and a bottom brace as described by Godley (1982) was not required.

The materials to construct one sieve cost about USD $56.00. However, much of this cost was associated with excess materials because the smallest amount available for purchase exceeded the amount needed for construction (see Table 1). The construction of additional sieves from the excess material (up to 10 total) would only require the purchase of more lumber, corner braces, and gate handles for about USD $20.50 per sieve.

When the water was deep enough and floating cover objects (e.g., woody debris, unrooted vegetation) were present, the sieve could be positioned underneath the material and lifted straight up, as described by Goin (1942, 1943) and Godley (1980, 1982). In shallow water and situations with rooted vegetation, we used a large dustpan to scoop gravel, leaf litter, woody debris, vegetation, and the inhabitants into the sieve (Fig. 2A). Dustpans with similar dimensions to our modified sieve

**Table 1.** Cost of materials for the construction of one salamander sieve.

| Material | Quantity | Total approximate cost (US dollars) |
|---|---|---|
| 1.9-cm × 8.9-cm × 1.8-m (standard 1-inch × 4-inch × 6-foot) untreated pine lumber | 1 | $3.50 |
| 3.8-cm (1.5-inch) galvanized corner brace | 8 | $7.00 |
| Spar urethane* | 1 can | $10.00 |
| Galvanized gate handle | 2 | $10.00 |
| 91-cm × 2.1-m (3-foot × 7-foot) roll of fiberglass window screening* | 1 roll | $7.00 |
| 1.27-cm × 61-cm × 152-cm (0.5-inch × 2-foot × 5-foot) roll of 19-gauge galvanized steel hardware cloth* | 1 | $6.50 |
| 1.27-cm (0.5-inch) stainless steel staples* | Box of 1,000 | $12.00 |
| **Total Cost** | | **$56.00** |

*The quantity of these materials indicates the smallest amount available for purchase, not the quantity needed for construction of a single sieve.

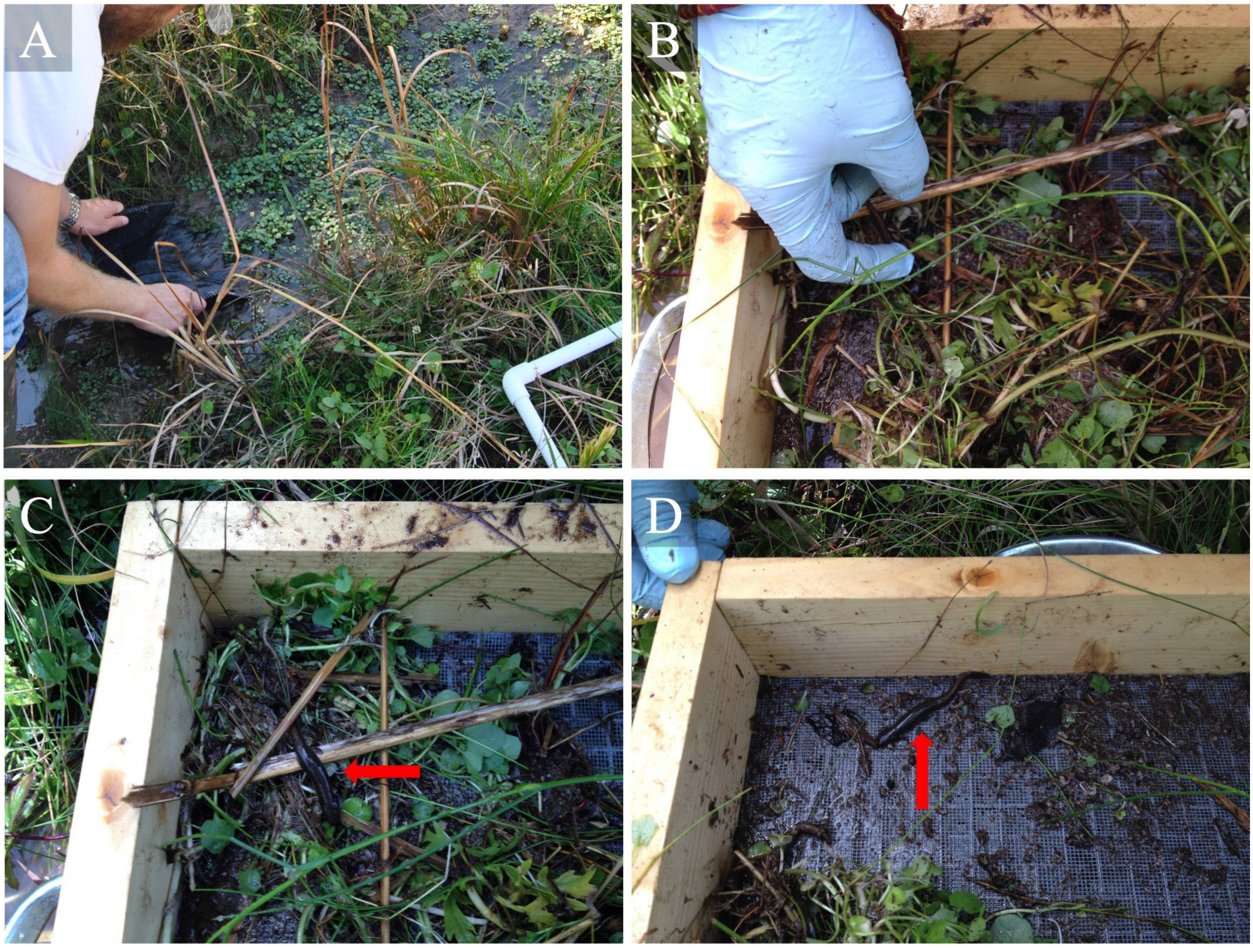


**Fig. 2.** Salamander sieve demonstration. **(A)** Cover objects are scooped into the sieve using a dustpan and **(B)** carefully searched for fauna to **(C–D)** reveal a salamander. Red arrows identify a Jollyville Plateau Salamander (*Eurycea tonkawae*) trapped in the sieve. *Photos by Madison Torres* (*A*) *and Zach Adcock* (*B–D*).

design are available at most hardware stores for about USD $7.00. Nets, strainers, or other scooping devices can also be used to fill the sieve, but we chose a dustpan in order to collect the sample in a single scoop, rather than multiple small scoops which may cause animals to flee before capture. We washed the collected cover material with water to rinse away silt, then carefully sorted through it to find salamanders and co-occurring fauna (Fig. 2 B–C). Once inside the sieve, salamanders are unlikely to escape (Fig. 2D), reducing the false absences often associated with these difficult-to-sample cover types (Bowles et al. 2006; Davis et al. 2001).

**Hubbard Rakes.** Aluminum rakes were constructed by Hubbard Rakes in Jonesport, Maine, USA (http://www.hubbardrakes.com), and they are custom designs that combine aspects of their lowbush blueberry, cranberry, and sea glass rakes. Each rake costs about USD $50.00 plus shipping and handling. The interior dimensions (30 cm × 30 cm × 11.5 cm) match our modified sieve dimensions for comparable density estimates. All rakes have a backend (30 cm × 14 cm × 11.5 cm) that is enclosed on all sides and serves as a receptacle for scooped material. We drilled large drain holes and small holes for window screen attachment into the receptacle, and lined the rakes with window screening to prevent fauna from escaping through the teeth and drain holes (Fig. 3).

We designed three rakes that differ in the sampling edge (i.e., flat edge, short teeth, and long teeth) to accommodate different cover objects (Fig. 4). The flat-edged rake is scooped through the cover objects, like the dustpan, but as it is drawn through the water column, all material and inhabitants are entrapped in the receptacle. The short-toothed rake has ~6.5 cm teeth, and the long-toothed rake has ~15 cm teeth. Both are designed to rake through dense, rooted vegetation and comb any resident fauna out of the vegetation and into the rake receptacle. As with the sieve, salamanders are unlikely to escape once inside the rakes (Fig. 5).

**Sampling.** To test the efficacy of these devices, *E. tonkawae* were sampled at springs in the vicinity of Round Rock and Cedar Park, Texas, USA, from 2014 through 2019. From July 2014 to August 2016, *E. tonkawae* captures and survey effort were quantified using the sieve and Hubbard rakes as well as standard visual encounter surveys by searching under rocks (see Bendik et al. 2014; Pierce et al. 2010). In subsequent years, the sieve and

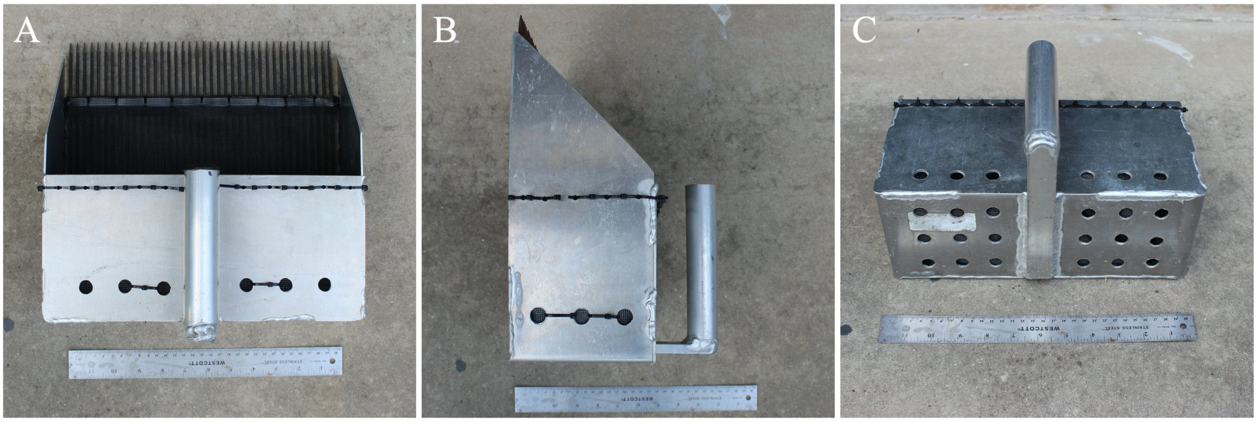


**Fig. 3. (A)** Top, **(B)** side, and **(C)** back of a Hubbard rake showing receptacle backend with drain holes and holes for window screen attachment using zip ties. Scale: 30 cm. *Photos by Michelle Adcock.*

Hubbard rakes were used to survey for other species of central Texas *Eurycea* salamanders (i.e., *E. pterophila*, *E. naufragia*, and *E. chisholmensis*) at various springs in Hays and Williamson counties, Texas, USA.

## Results

From July 2014 to August 2016, 325 *E. tonkawae* were captured using the sieve and Hubbard rakes, compared to 342 *E. tonkawae* in rock surveys, which corresponded to 0.53 salamanders per sieve/rake sample and 0.02 salamanders per searched rock. The sieve and Hubbard rakes were used to capture *E. tonkawae* in submerged gravel, leaf litter packs, small woody debris, silt, and several types of vegetation (e.g., floating, aquatic, and emergent). In addition, *E. pterophila*, *E. naufragia*, and *E. chisholmensis* were caught in these same cover types at their respective springs.

In addition to the targeted *Eurycea*, these tools captured a number of co-occurring tadpoles, fishes, and invertebrates. Bycatch included Blanchard's Cricket Frog (*Acris blanchardi*) tadpoles, Rio Grande Leopard Frog (*Lithobates* [*Rana*] *berlandieri*) tadpoles, small sunfish (*Lepomis* sp.), small bass (*Micropterus* sp.), Western Mosquitofish (*Gambusia affinis*), Slough Darters (*Etheostoma gracile*), crayfish (family Cambaridae), dragonfly and damselfly larvae (order Odonata), mayfly larvae (order Ephemeroptera), giant water bugs (family Belostomatidae), beetles (order Coleoptera), snails (order Gastropoda), hellgrammites (family Corydalidae), annelid worms (subclasses Hirudinea and Oligochaeta), and amphipods (order Amphipoda).

## Discussion

Approximately 49% of *E. tonkawae* were captured using the sieve and Hubbard rakes, and the remaining 51% were caught in traditional rock searching surveys. The frequency of salamander observations per rock (= 0.02) was comparable to those reported by Pierce et al. (2010) for *E. naufragia* but substantially lower than the salamander observations per sieve/rake sample (= 0.53). However, we acknowledge that these tools sample a larger area than the average rock size. Our goal was not to evaluate the best survey methodology or overall tool, but to demonstrate that most cover objects can be efficiently sampled with proper tool design and selection. Any potential differences in salamander or faunal captures among sampling tools would be more indicative of differences in cover object availability and use (Z.C. Adcock, unpub. data). Most importantly, our efforts demonstrate that the sieve and Hubbard rakes effectively capture central Texas *Eurycea* salamanders in cover objects that have been previously described as difficult

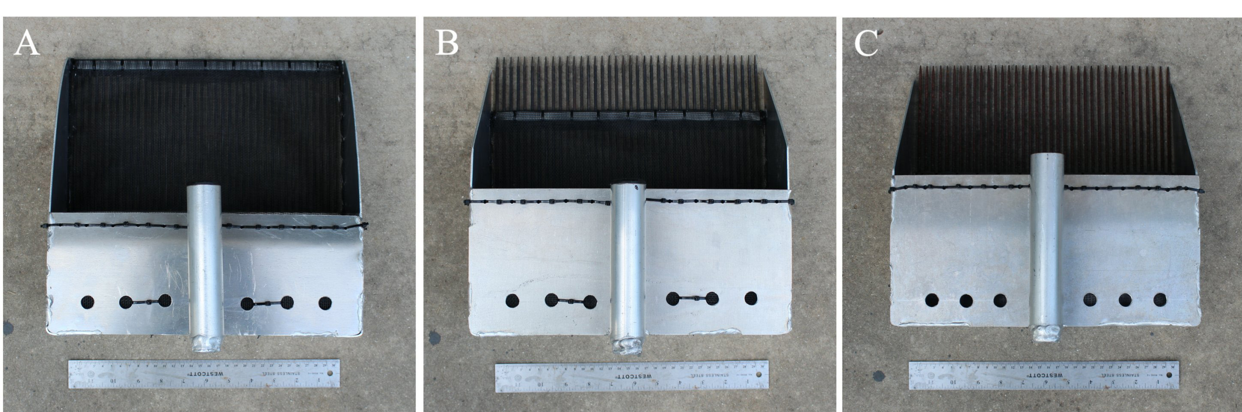


**Fig. 4. (A)** Flat-edged, **(B)** short-toothed, and **(C)** long-toothed Hubbard rake designs. Scale: 30 cm. *Photos by Michelle Adcock.*

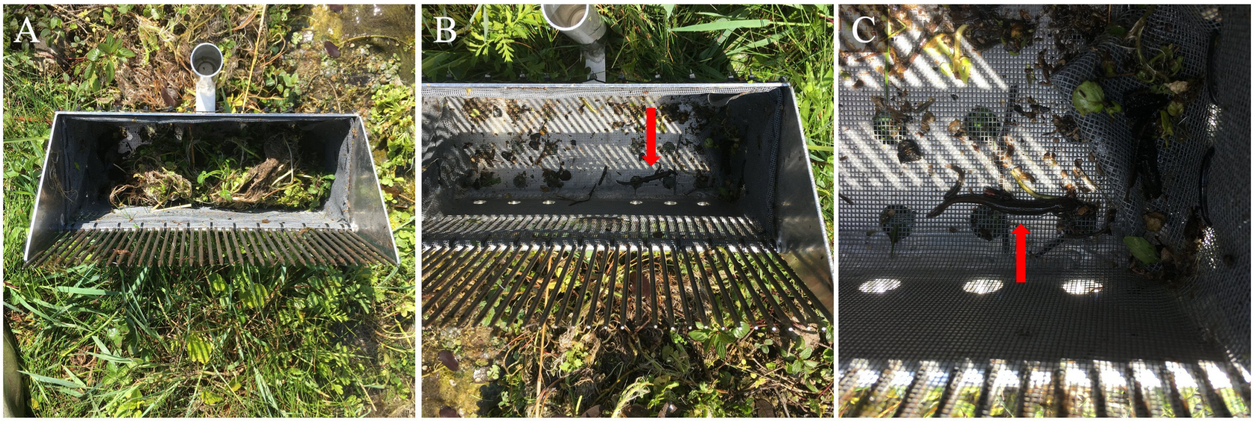


**Fig. 5.** Hubbard rake demonstration. **(A)** Cover objects are scooped into the rake receptacle and **(B–C)** carefully searched for fauna to reveal a salamander. Red arrow identifies a Jollyville Plateau Salamander (*Eurycea tonkawae*) trapped in the rake. *Photos by Zach Adcock.*

to sample (Bowles et al. 2006; Davis et al. 2001) and in cover objects the USFWS considers to be suboptimal habitat (USFWS 2013).

Our modified sieve and dustpan combination worked particularly well in shallow water, as cover objects could be scooped without losing water and material over the edges of the dustpan. The dustpan was effective at scooping gravel, leaf litter, small woody debris, silt, and unrooted or weakly rooted vegetation into the sieve (Fig. 6). The sieve was also effective when floating cover objects were present in deep water, as previously described (Goin 1942, 1943; Godley 1980, 1982). We


**Fig. 6.** Examples of Jollyville Plateau Salamander (*Eurycea tonkawae*) cover objects that are effectively sampled using the salamander sieve and Hubbard rakes. **(A)** Submerged leaf litter and exposed roots, **(B)** submerged woody debris, **(C)** middle of springrun, noting aquatic vegetation with weak roots, as well as the springrun edges which are shallow with emergent vegetation, and **(D)** deep, aquatic vegetation with durable roots and stems. *Photos by Zach Adcock.*

found the sieve and dustpan combination to be ineffective for submerged cover objects in deep water (over 30 cm deep) and in vegetation with durable stems and roots. When scooping material in deeper water, cover objects (and likely fauna) spilled over the sides of the dustpan as it was brought up through the water column. Likewise, the dustpan was inadequate at pushing through durable roots or emergent vegetation, undoubtedly causing salamanders to retreat undetected. These deficiencies prompted our idea for combining the sieve and dustpan into a single tool, the Hubbard rakes.

The Hubbard rakes were capable in all water depths due to the enclosed backend receptacle. The flat-edged rake was effective in scooping all cover types except for vegetation with durable stems and roots, and we simply used the toothed rakes in these situations. The short-toothed rake performed well in aquatic vegetation and in emergent vegetation along creek edges. In emergent vegetation zones (Fig. 6C), the long-toothed rake often hit hard substrate (e.g., soil along the bank) before the vegetation encountered the receptacle edge, which allowed fauna to escape through the teeth. However, the long-toothed rake worked particularly well in large patches of aquatic vegetation in water over 15 cm deep (Fig. 6D). The toothed rakes did not perform well in gravel, leaf litter, or woody debris because these smaller items fell through the teeth during scooping. We note that we never impaled salamanders with the rake teeth, and researchers are unlikely to do so if the rakes are used in a combing motion.

These tools also allowed us to sample exposed vegetation roots in addition to stems and leaves. We frequently captured *Eurycea* salamanders by placing submerged, exposed root clumps in the sieve or rakes and washing with water, by combing through roots with the toothed rakes, and by scraping the bottom of dense root mats and undercut stream banks with the flat-edged rake or the wood edge of the sieve.

Central Texas *Eurycea* salamanders typically escape predators (and researchers) by diving into the interstitial spaces of the substrate. Sweet (1977) exploited this behavior with his wire-screen method, allowing salamanders to "escape" through the screen and into the collection tray. Our modified sieve and Hubbard rakes also exploit this behavior. Washing the sampled material created enough disturbance to cause most entrapped salamanders to retreat out of the cover objects and to the bottom of the sieve or rakes. We note that adult central Texas *Eurycea* were often easily noticed in the sieve and rake as they actively sought shelter. Small juvenile salamanders (less than 15 mm total length) were typically less active and frequently remained motionless. Therefore, we caution researchers to carefully search the sampled material and the sampling devices for juveniles.

During the surveys, sampled gravel, leaf litter, woody debris, silt, and similar cover objects were placed back into the streams to minimize habitat impacts. The toothed rakes caused minor damage to aquatic and emergent vegetation when combing through roots, stems, and leaves. Using the sieve and rakes results in destructive sampling for weakly rooted vegetation, but we rarely noticed the sampling impacts in subsequent survey events. The fast-growing Watercress (*Nasturtium officinale*) constituted much of our sampled vegetation, and a monthly survey timeframe allowed ample time for regrowth. We suggest that researchers be cognizant of potential oversampling by considering vegetation growth rates and their planned survey timing.

We modified the Water Hyacinth sieve and designed the Hubbard rakes to capture *E. tonkawae*, but they proved to be effective for other central Texas *Eurycea* salamanders and several co-occurring vertebrates and invertebrates. The density of salamanders and co-occurring fauna can be easily calculated by dividing the number of captures by the number of samples multiplied by the size of the sampling device. These tools are undoubtedly applicable to a wide variety of small, aquatic salamanders, tadpoles, fishes, and invertebrates if the appropriate device is matched to the cover objects to be sampled.

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