Freshwater Mussel Assemblage Structure in a Small Edwards Plateau Impoundment with Comments on Conservation Implications for Texas Fatmucket, Lampsilis bracteata (Gould 1855)

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NOTE

FRESHWATER MUSSEL ASSEMBLAGE STRUCTURE IN A SMALL EDWARDS PLATEAU IMPOUNDMENT WITH COMMENTS ON CONSERVATION IMPLICATIONS FOR TEXAS FATMUCKET, *LAMPSILIS BRACTEATA* (GOULD 1855)

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ABSTRACT

While freshwater mussels are often negatively impacted by large reservoirs, the influence of smaller low-head dams on resident mussel fauna is variable. A 2017 planned dewatering of Robinson Lake, a small water-supply reservoir located in the Llano River, Texas, presented an opportunity to quantify the native unionid community. We also compared unionid communities between Robinson Lake and a riverine portion of the mainstem Llano River to assess how impoundments may influence assemblage structure, and we evaluated the conservation implications for two Endangered Species Act (ESA) candidate species. In total, we salvaged and relocated 1,012 live unionids representing five species from Robinson Lake, including ESA-candidate species *Lampsilis bracteata* and *Cyclonaias petrina*. Lentic specialists were observed exclusively in Robinson Lake, while lotic specialists and habitat generalists occurred in the Llano River. Though community composition differed, we did observe overlap among sites, suggesting that Robinson Lake contains a subset of the unionid community within nearby riverine reaches, and it supports more lentic-adapted species. Contrary to previous habitat assessments, observations of *L. bracteata* reproduction in Robinson Lake suggests that this species is able to adapt to lacustrine environments and establish populations within small impoundments, though catch rates suggest higher densities in lotic habitats. As increased utilization of water resources and changing climactic patterns continue to impact spring-fed river systems of the Edwards Plateau region, such impoundments may become important conservation units for *L. bracteata* during major drought conditions.

KEY WORDS: community structure, freshwater mussels, Llano River, Texas fatmucket, reservoir, Unionidae

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INTRODUCTION

Since the early 20th century, the decline of freshwater mussels has been largely ascribed to the modification and impoundment of rivers and streams (Haag and Williams 2014). Large reservoirs have drastically altered the hydrology and morphology of North American rivers, inundating and fragmenting habitat for many unionids and their host fishes (Bogan 1993; Neves et al. 1997; Watters 2000). Along with the inundation of upstream lotic habitats, large reservoirs may alter the natural hydrology, temperature, and sediment dynamics downstream, which can be harmful to mussels at multiple ontogenetic stages (Layzer and Madison 1995; Haag 2012). Effects of large reservoirs have resulted in the localized extirpation or extinction of multiple freshwater mussel species across the USA (Vaughn and Taylor 1999; Garner and McGregor 2001; Parmalee and Polhemus, 2004; Haag 2009).

While large impoundments pose a major threat to many native unionids through alteration of natural hydrology, temperature, and sediment transport regimes, the influence of smaller low-head dams and associated reservoirs on freshwater mussel populations are more variable (Hart et al. 2002). Low-head dams in several North American Midwest rivers have acted as barriers to freshwater mussels and host fish species, decreasing freshwater mussel occurrence in upstream areas (Watters 1996). Similarly, low-head dams on the Neosho River, Kansas, are thought to influence mussel assemblages within inundated areas, decreasing species richness (Dean et al. 2002). In contrast, several small dams in Alabama have been shown to improve downstream mussel habitat (Gangloff et al. 2011) and actually enhance downstream mussel growth (Singer and Gangloff 2011). Similarly, in Mississippi, diverse and healthy mussel assemblages have been documented downstream of a low-head dam, due to the presence of stable lotic habitats (Haag and Warren 2007). These studies suggest that the influence of small dams on freshwater mussel

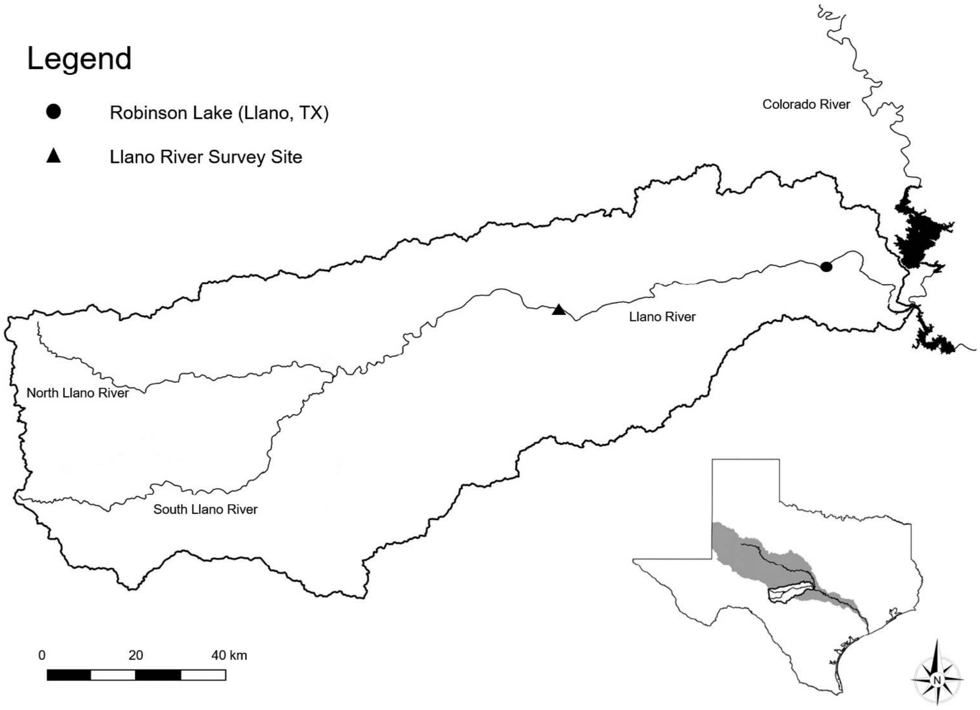

Figure 1. Map of the Llano River drainage area showing both the Robinson Lake salvage site and Llano River qualitative survey site.

populations may differ on a regional, site-specific, or reach scale.

Texas has more dams than any other U.S. state (Shuman 1995), with flood control and water storage impoundments of various sizes located in every major river basin (Zhang and Wurbs 2018). As in other areas, large reservoirs have been shown to negatively impact downstream unionid assemblages (Randklev et al. 2013, 2016; Tsakiris and Randklev 2016), but little information is available on the effects of small low-head dams and reservoirs, including the effects on the mussel communities that inhabit them. Given the number of such dams in the state, this insufficiency represents a critical data gap in the current understanding of Texas freshwater mussel populations.

For this study, a planned dewatering event at a small water supply reservoir in Llano, Texas, presented an opportunity to quantify the existing mussel community. Robinson Lake, also known as Llano Park Lake, is an impoundment created by a low-head dam on the Llano River (COLT 2018). Robinson Lake, along with another similarly sized reservoir downstream, is used by the City of Llano for municipal water supply, serving over 3,000 people (COLT 2018). During recent droughts, the Llano River at Llano stopped flowing, leaving the city's water supply dependent upon storage in the reservoirs until flows returned. As a result, Robinson Lake was purposefully drained in the fall of 2017 to dredge sand that had accumulated over the years, reducing storage capacity. A preliminary survey documented Texas fatmucket *Lampsilis bracteata* (Gould 1855) in Robinson Lake. Therefore, an aquatic resource relocation was conducted to minimize impacts to unionids during the dewatering process. Data collected during the drawdown summarize the unionid community present in this small reservoir, and supplement the available information on habitat utilization of *L. bracteata*, an Edwards Plateau endemic and Endangered Species Act (ESA) candidate species (USFWS 2011).

METHODS

The Llano River is a major tributary of the Colorado River in the Edwards Plateau region of central Texas (Heltmuller and Hudson 2009; Perkin et al. 2010). It begins near Junction, Texas (Kimble County), at the confluence of the North Llano River and South Llano River, flowing approximately 161 km east until draining into Lake Lyndon B. Johnson, a mainstem impoundment of the Colorado River (Perkin et al. 2010). Robinson Lake is an approximately 0.40-km^2 reservoir located in the lower portion of the basin (Fig. 1). The climate in the watershed from west to east exhibits a semiarid to subhumid gradient (Heltmuller and Hudson 2009). Karstic spring discharges in the North Llano and South Llano rivers provide perennial flows to the mainstem Llano River (Heltmuller and Hudson 2009; Perkin et al. 2010). Despite the perennial spring sources, the Llano River at Llano, Texas, which is distant from spring sources, has experienced zero-flow conditions during recent droughts (BBEST 2011).

From November 29 through December 1, 2017, as water levels in Robinson Lake were drawn down, a four- to eight-person crew systematically surveyed for emerged unionids for 95 person-h along the water's edge in recently desiccated portions of the reservoir, totaling 0.35 km^2 of search area. Salvaged unionids were placed into transport containers with water that was changed periodically. All unionids were compiled intermittently, identified to species, enumerated, and measured to the nearest millimeter. Following mussel collections, the majority of the unionids were translocated to the previously identified relocation site downstream. The site was located approximately 2.5 km downstream of Robinson Lake, after the Llano River transitions back to riverine conditions. This reach of the Llano River is expected to exhibit more perennial flows than areas immediately upstream of the reservoir and contains habitat that was consistent with previously documented occupied reaches (Randklev et al. 2017). A small portion of *L. bracteata* collected were shipped alive to Auburn University and U.S. Fish and Wildlife hatcheries as part of an ongoing research project (Bonner et al. 2018).

Additionally, we compared the Robinson Lake unionid community with a nearby riverine mussel community to explore differences in assemblages among lacustrine and riverine habitats. These data were based on a March 2017 qualitative survey we conducted in the mainstem Llano River, upstream of Robinson Lake (Fig. 1). This site was located in a perennial reach sustained by spring discharges (Randklev et al. 2017), with shallow run and pool sequences dominated by limestone bedrock. The main goal of this survey was to identify potential broodstock populations for the propagation of ESA candidate species Texas pimpleback *Cyclonaias petrina* (Gould 1855) and *L. bracteata*, and secondarily to identify what other taxa might be present. We used visual and tactile search methods, focusing our efforts in high-quality unionid habitat within all available mesohabitat types. Unionid sampling was completed based on when surveyors were confident that all mesohabitats were thoroughly searched, resulting in a 3–person-h search effort within an approximately 1,500-m^2 area. To summarize the Robinson Lake and Llano River mussel assemblages, we present raw abundance, relative abundance ([species total/total catch] • 100), catch per unit effort (mussels collected/person-h), and length frequency distributions.

RESULTS

We collected and salvaged a total of 1,012 live unionids representing five species from Robinson Lake. *Lampsilis bracteata* and paper pondshell *Utterbackia imbecillis* (Say 1829) were the most abundant species observed, accounting for 62.7% ($n = 635$) and 36.2% ($n = 366$) of the community, respectively. We also observed *C. petrina,* pimpleback *Cyclonaias pustulosa* (Conrad 1835), and lilliput *Toxolasma parvum* (Barnes 1823), which in aggregate accounted for 1.1% ($n = 11$) of the Robinson Lake community (Table 1). Moreover, we observed 15 gravid female *L. bracteata*, which were translocated to U.S. Fish and Wildlife hatcheries for propagation efforts. The overall size distribution of *L. bracteata* exhibited a left-skewed distribution, with about 50% ($n = 310$) ranging from 55 mm to 60 mm. We observed approximately 6% ($n = 35$) of *L. bracteata* collected at lengths 30 mm or less, including several individuals ranging from 12 mm to 15 mm. *Utterbackia imbecillis* exhibited a right-skewed distribution, with about 50% ($n = 59$) ranging from 45 mm to 55 mm. We also frequently observed individuals ranging from 60 mm to 90 mm, but we did not observe many individuals 30 mm or less. *Cyclonaias pustulosa* ranged from 36 mm to 57 mm, while the single *C. petrina* and *T. parvum* lengths were 51 mm and 21 mm, respectively (Fig. 2).

Table 1. Relative abundance (raw abundance in parentheses) and catch per unit effort (CPUE; mussels/person-h) of live unionids collected during a 2017 salvage effort conducted in Robinson Lake.

Scientific Name	Common Name	Relative Abundance	CPUE
Cyclonaias petrina	Texas pimpleback	0.1 (1)	0.01
Cyclonaias pustulosa	Pimpleback	0.9 (9)	0.10
Lampsilis bracteata	Texas fatmucket	62.7 (635)	6.68
Toxolasma parvum	Lilliput	0.1 (1)	0.01
Utterbackia imbecillis	Paper pondshell	36.2 (366)	3.85
	Totals	1,012	10.65

We found a total of 102 mussels representing four species at the Llano River site. *Cyclonaias petrina* and *L. bracteata* were the dominant species, comprising 61.8% ($n = 63$) and 21.6% ($n = 22$) of the mussels observed, respectively. Creeper *Strophitus undulatus* (Rafineque 1820) represented 15.7% ($n = 16$) of unionids collected, while pistolgrip *Tritogonia verrucosa* (Rafineque 1820) was the least abundant at 1.0% ($n = 1$) (Table 2). In general, the size distribution of the species observed displayed a left-skewed distribution. Approximately 75% of *C. petrina* ($n = 46$) and *L. bracteata* ($n = 16$) ranged from 40 mm to 50 mm; similarly, 75% of *S. undulatas* had shell lengths between 50 mm and 60 mm (Fig. 3). Lastly, the shell length of the single *T. verrucosa* was 52 mm.

We observed greater overall catch rates at the Llano River (33.99 mussels/person-h) than at Robinson Lake (10.65 mussels/person-h). Only *C. petrina* and *L. bracteata* were observed at both sites. Catch rates of *C. petrina* were much higher at the Llano River compared to Robinson Lake, totaling 21.00 mussels/person-h and 0.01 mussels/person-h, respectively. In contrast, *Lampsilis bracteata* catch rates were

Table 2. Relative abundance (raw abundance in parentheses) and catch per unit effort (CPUE; mussels/person-h) of live unionids collected during a 2017 freshwater mussel survey in the Llano River.

Scientific Name	Common Name	Relative Abundance	CPUE
Cyclonaias petrina	Texas pimpleback	61.8 (63)	21.00
Lampsilis bracteata	Texas fatmucket	21.6 (22)	7.33
Strophitus undulatus	Creeper	15.7 (16)	5.33
Tritogonia verrucosa	Pistolgrip	1.0 (1)	0.33
	Totals	102	33.99

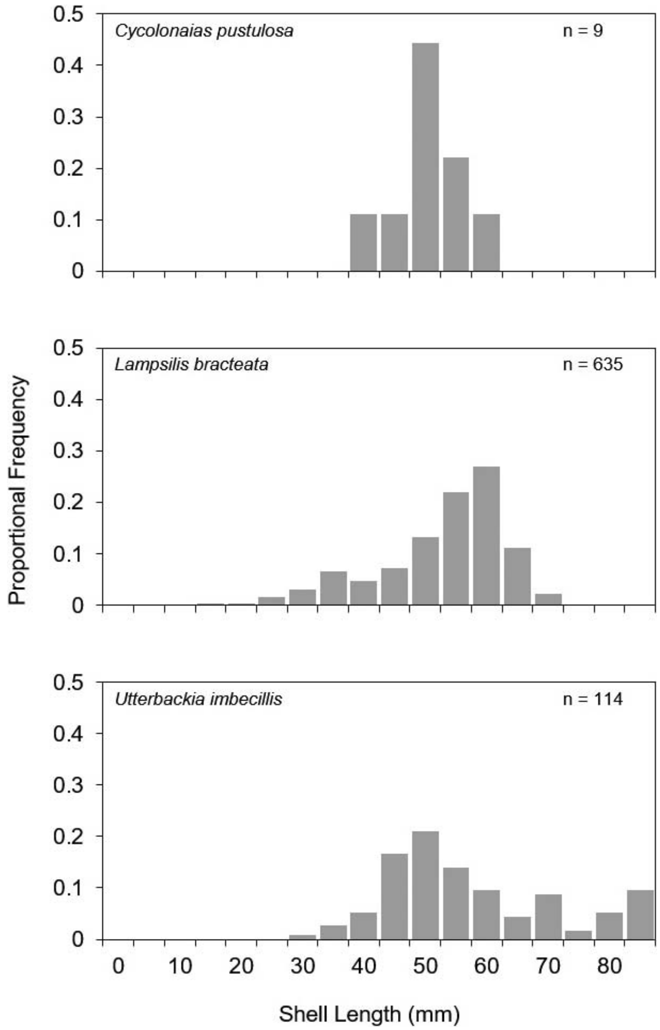

Figure 2. Histograms comparing proportional frequency of shell length for *Cyclonaias pustulosa*, *Lampsilis bracteata*, and *Utterbackia imbecillis* in Robinson Lake. Shell lengths are grouped into 5-mm bins.

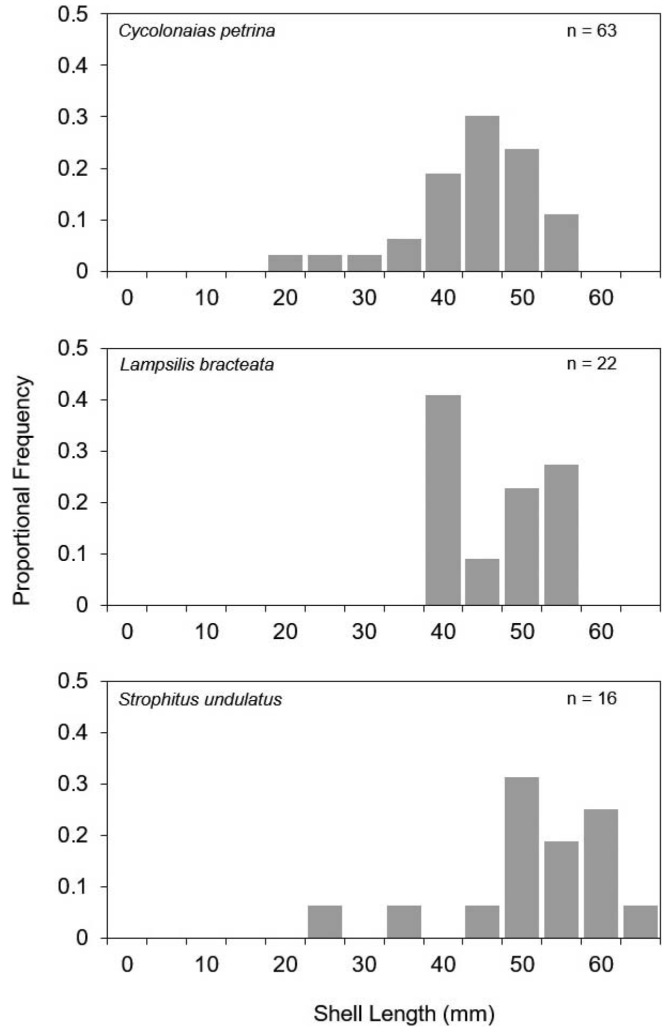

Figure 3. Histograms comparing proportional frequency of shell length for *Cyclonaias petrina*, *Lampsilis bracteata*, and *Strophitus undulatus* in the Llano River. Shell lengths are grouped into 5-mm bins.

generally similar among sites, with 6.68 mussels/person-h at Robinson Lake and 7.33 mussels/person-h at the Llano River (Tables 1 and 2).

DISCUSSION

We observed five species of unionids and multiple size classes in Robinson Lake. Species richness was similar to Llano River observations, though community composition differed. *Cyclonais petrina* and *L. bracteata* were the only species that occurred at both study sites. *Cyclonaias petrina* was the dominant species at the Llano River but was represented by only a single individual at Robinson Lake. In contrast, *L. bracteata* represented a larger percentage of the Robinson Lake community. The core difference in community composition was the variation in occurrence among the nonoverlapping species. Lentic specialist *U. imbecillis* was observed exclusively in Robinson Lake and characterized over a third of the community. We also observed the lentic-adapted *T. parvum* in Robinson Lake, though we found only a single individual. *Strophitus undulatus* and *T. verrucosa* were observed only in the Llano River. *Strophitus undulatas* is adapted to both lentic and lotic conditions (Howells 2014), and only a single *T. verruscosa* was observed. These differences support previous studies showing that small riverine impoundments contain a subset of the unionid community within surrounding riverine reaches, with the addition of more lentic-adapted species (Ahlstedt and McDonough 1993; Haag 2012; Pilger and Gido 2012). At Wheeler Reservoir, Tennessee, Ahlstedt and McDonough (1993) observed an incursion of lentic-adapted species, congruent with our observations in Robinson Lake.

Although *L. bracteata* exhibited a higher raw abundance and relative abundance at Robinson Lake, catch rates of the species were proportionate between Robinson Lake and the Llano River. However, the area surveyed was substantially greater in Robinson Lake compared to the Llano River. Unionid surveys in the Pedernales, Llano, and San Saba rivers exhibited *L. bracteata* catch rates similar to those observed here, but in an even smaller search area of 150 m^2 (Randklev et al. 2017), which supports the finding that *L. bracteata* occur in higher densities in lotic systems. Despite this, the presence of gravid females and juveniles 30 mm or less suggests a reproducing population of *L. bracteata* in Robinson Lake. A previous study on population demographics of the wavyrayed lampmussel *Lampsilis fasciola* (Rafinesque 1820), a congener of *L. bracteata* (Inoue et al. 2019), aged individuals with shell lengths 20 mm to 30 mm as year-1 and year-2 juveniles, and individuals 20 mm or less as year-0 juveniles (Jones and Neves 2011). This supports recent recruitment of *L. bracteata* in Robinson Lake, though additional research on shell length–age relationships specific to *L. bracteata* are warranted.

Observations of successful spawning and recruitment suggests that *L. bracteata* can persist in lacustrine environments and establish populations within small impoundments. Similar observations of *Lampsilis* species have been observed within Midwest and Southeast U.S. drainages (Coker et al. 1921; Bogan 2002). Based on our results, impoundments may serve as potentially important conservation units for this species, and may be especially important given recent droughts in the Llano River basin.

Recent research of the effects of desiccation on *L. bracteata* documented that once completely emerged, 50% of *L. bracteata* died within approximately 2 d at an exposure temperature of 25°C, confirming that desiccation during extended periods of low flow may be detrimental to this species (Bonner et al. 2018). Increased utilization of water resources may exacerbate future drought conditions in the Llano River basin, increasing the intensity and duration of extreme low-flow events and potentially increasing the number of *L. bracteata* impacted by desiccation. Drought contingency plans typically outline hierarchal steps to decide if intervention and relocation of unionids is warranted for populations at risk of extirpation. Unionid relocation in situ is preferable, with ex situ (e.g., hatchery) relocation suggested as a last resort due to observed declines in unionid body condition and survival in hatchery environments (Newton et al. 2001). Robinson Lake could serve as a replacement for ex situ translocation for *L. bracteata* in the event that the main channel of the river is mostly desiccated and the reservoir maintains water. It should be emphasized that Robinson Lake would not be appropriate refugia for other rare species. For example, we observed only a single *C. petrina* at Robinson Lake, strongly supporting the idea that impoundments are detrimental to this species. Further investigation on why some species exhibit habitat pliability, while others do not, is warranted, and may be important for future habitat conservation of rare species.

In conclusion, results of this salvage effort offer valuable insight into the unionid assemblage within a small Edwards Plateau impoundment and how species composition compares to nearby riverine assemblages. These data refine the current knowledge on habitat utilization of two ESA candidates, *C. petrina* and *L. bracteata*. *Cyclonaias petrina* was far more common in riverine collections, while *L. bracteata* was well represented in both Robinson Lake and the Llano River. Contrary to previous habitat assessments (Howells et al. 1996; Howells 2014), this finding suggests that small reservoirs could serve as habitat for *L. bracteata*. As climate change and increased groundwater and surface water withdrawal (Bowles and Arsuffi 1993) continue to affect spring-fed river systems of the Edwards Plateau region, such small reservoirs could become crucial conservation units in the effort to preserve rare and endemic species.

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