Texas Hornshell (*Popenaias popeii*) in the Devils and Lower Pecos Rivers, Texas

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Executive Summary

The goal of this study was to determine the status, distribution, and mesohabitat associations for *Popenaias popeii* (Texas Hornshell), a candidate for protection under the Endangered Species Act, in the Lower Pecos and Devils Rivers of the Rio Grande drainage in Val Verde, Terrell, and Crockett Counties, Texas. We compiled records of occurrence from published reports and museum records to establish the historical range for this species in these tributaries to the Rio Grande in west Texas. We used recent and historical data to inform a sampling program within this section of the range of *P. popeii.* In total, we surveyed 43 sites from the Independence Creek confluence with the Pecos River to the influence of Amistad Reservoir, and found 3 live *P. popeii* at 2 of 43 (4.6%) sites surveyed, with three live individuals found immediately downstream of Pandale, TX in rock wall habitats. In the Devils River, we surveyed 34 sites from approximately 3 river kilometers above Baker's Crossing (HWY 163) to Satan Canyon where the influence of Amistad Reservoir begins and found 66 live *P. popeii.* The majority of individuals from the Devils River were found in riffle habitats in the central portion of the study area. Within the Devils River, size frequency distributions, using shell length as a proxy for age, suggest that some level of recruitment is occurring, and observations of reproductive activity (i.e. brooding females) are congruent with observations from the population of Texas Hornshell in the Black River, New Mexico.

Introduction

The objectives of this study were to assess the distribution, abundance, and habitat use for *P. popeii* in the Lower Pecos and Devils Rivers of west Texas as a continuation of surveys conducted within the Rio Grande from the Big Bend National Scenic Riverway to Roma, TX. Prior data suggested that a population existed in these tributaries, but significant knowledge gaps remained including presence or absence of live individuals within the Pecos River. We developed a survey program to inform the habitat use and distribution of populations within the Devils River, and to detect the presence of live individuals that may persist in the Pecos River, which had not been surveyed comprehensively to date.

In tributaries of the Rio Grande, Texas hornshell is known to have existed in the Devils River from the confluence with the Rio Grande upstream to Miller Canyon, Val Verde County at present (Strecker 1931, data herein). Historically, *P. popeii* was known in the Devils from Blaine's Lake, a widening in the river now inundated by Amistad Reservoir (Strecker 1931). Other historical records of *P. popeii* from the Devils River were collected by William Lloyd: USNM_118394 (in Stearns 1891) without locality info. Bereza and Fuller collected specimens in 1976 (ANSP_34891); listed as from Comstock, but this locality information is suspect. Other records without dates or locality information from the Devils river include the following: C.R. Orcutt: USNM_252546, J.D. Mitchell: USNM_464728, and a type specimen collected by Captain Pope: USNM_25735.

For reaches of the Pecos that flow through Texas, weathered shell material for *P. popeii* has been collected near Barstow, TX, Ward County (J.D. Mitchell, ~1890, USNM 464732), though Karatayev et al. (2012), Burlakova and Karatayev (2014) and Karatayev et al. (2015) incorrectly reported these individuals as live at time of collection. Downstream of this location, a single fragment of a *P. popeii* shell has been found from the Pecos River near Iraan, TX (Pecos/Crockett Counties) and long dead shells from an ~ 8 km stretch in the lower Pecos, just upstream from the confluence with the Rio Grande. Between these locations, live *P. popeii* have been collected near Pandale, Val Verde County, Texas downstream of the Independence Creek confluence in 1973 (A.L. Metcalf 1974, USNM 709228).

Until recently Texas hornshell was considered extremely rare. Singley (1893) recorded *P. popeii* from very few locations (in the Devils and Pecos Rivers) and commented that this species was rare. Neck (1982) suggested considering this species for listing by the USFWS. Williams et al. (1993) listed the species as threatened and more recently elevated it to endangered (Williams et al. in review). NatureServe ranks *P. popeii* as critically imperiled across its range and this species is currently listed as a candidate for protection under the U.S. Endangered Species Act (USFWS 2001). Surveys by Miller et al. (unpublished data), Karatayev et al. (2012), and Burlakova and Karatayev (2014) have reported live individuals or recently dead specimens for this species from the Devils River (Val Verde Co.), Rio Grande near John's Marina (Terrell Co.), Del Rio, TX (Val Verde Co.), and Laredo, TX (Webb Co.). These surveys were not initially designed to detect species with low abundance, assess evidence of recruitment, or provide population estimates. Thus, the conservation status of this species throughout its historic range is still uncertain.

Popenaias popeii have been reported to reside in rock crevices, travertine shelves, and under large boulders, where small-grained material, such as clay, silt, or sand gathers (references in Carman 2007; Howells 2010). Karatayev et al. (2012) and Burlakova and Karatayev (2013) performing surveys in portions of the upper and middle Rio Grande reported similar observations, however, their findings were also anecdotal as they primarily focused on habitats that were known or suspected to harbor *P. popeii* populations (i.e., rock slabs and boulders). Other habitats that may be suitable for mussels (e.g., banks or backwater areas) were not surveyed. Thus, habitat associations for this species remain untested and for juveniles, undescribed.

Methods

Study Area

The World Wildlife Fund currently ranks the Rio Grande as the most imperiled river in the United States due to water over-extraction and over-appropriation by human populations along the river (Wong et al. 2007). The Devils River is a pristine tributary to the Rio Grande originating in Sutton County, TX, and flows intermittently southward into Val Verde County, TX, where it becomes perennial. Flow is unregulated and provided from groundwater seepage and springs. The river lies within the Edwards Plateau region and drains an approximate area of 10,000 km^2, which is sparsely populated (Cantu and Winemiller 1997). The Pecos River is the largest tributary to the Rio Grande from the North and originates in New Mexico, draining approximately 115,000 km^2. This river is highly saline in Texas due to saline aquifer input as well as anthropogenic impacts such as groundwater extraction and irrigation; and has experienced a dramatic shift in fish fauna as well as harmful algal blooms from golden alga (*Prymnesium parvum*) since the 1980s (Southard 2010).

Sampling Methods

Site selection on the Devils and Pecos was accomplished *a priori* by one of two methods. In all cases habitat types were identified and categorized using aerial imagery. Then depending on access, sites were chosen randomly within 2km up and downstream from an access location, or the river was broken into 1km segments (reaches) and each habitat type was selected at random from those possible in each segment, then sampled during a downstream paddling trip. In both cases due to logistical constraints, we focused on locating live individuals. Riffles were targeted in the Devils River after determining that habitat type to be the most frequently occupied during early sampling trips. In the Pecos, we targeted habitats most similar to those occupied in the Rio Grande due to similarity, presence of shell material at those sites, and lack of riffle habitats as found in the Devils River.

Qualitative surveys using the timed search method were performed in each selected mesohabitat type. The timed search method was chosen because it provides a more effective means of

detecting rare species than quantitative sampling methodologies (Vaughn et al. 1997). At each site (i.e., mesohabitat type), we confined the search boundaries to the specific habitat type, ensuring that the search area did not exceed 150 m^2. Each site was surveyed tactilely and visually for a total of 4 person-hours (p-h). However, because we are interested in the amount of effort needed to detect *P. popeii* (which will be important for designing long-term monitoring programs), we divided the total search time into 4, 1 p-h intervals. At the end of each search interval, surveyors combined all live specimens into a mesh bag, which was kept submerged in water until completion of the survey. During each interval, surveyors were spread out in the search area and every effort was made to search all available microhabitats. Following completion of the survey, all live mussels from each time period were identified to species, counted, measured, checked for gravidity, and then returned back to the river into the appropriate habitat.

Data Analysis

Scatter plots were used to visually explore the longitudinal distribution and abundance of *P. popeii* in each river (Figures 1 and 2). Bar graphs were used to display habitat associations for live and *in situ* shells of *P. popeii* (Figures 3 and 4). Boxplots and length-frequency histograms were developed for *P. popeii* to assess demographic patterns and population structuring within each river, where sufficient data existed (Figures 5 - 7). Generally, multimodal size class distribution may indicate recruitment, whereas truncated distributions (absence of a particular age class, large, or small individuals) may indicate a lack of recent recruitment or a localized extinction event. In the present study, we defined groups by available mesohabitat type (i.e., riffle, midchannel, pool, backwater, bank).

Conservation maps

Conservation maps were developed using the Conservation Status Map package provided by the Georgia Department of Natural Resources (http://www.georgiawildlife.com/conservation_status_assessment_maps). Presence/absence data was obtained from the IRNR – Mussel Database, Texas Parks and Wildlife Department [TPWD], Texas Department of Transportation [TxDOT], Texas Commission on Environmental Quality [TCEQ], Texas Water Development Board [TWDB], and published literature. Locality information accompanying each record was georeferenced using ESRI ArcGIS ArcMAP 10.0.

Results & Discussion

Devils River

A total of 136 person hours were spent surveying 34 sites spanning 62 River Kilometers in the Devils River (Figure 8). A total of 66 *P. popeii* individuals were found from 11 of the 34 sites (Table 1). Relative abundance in the Devils River was 1.5 ± 2.4 mussels per person-hour (mean ± SD) at sites where *P. popeii* was present. No other native mussel species were encountered in the study area.

The size frequency distribution of *P. popeii* in the Devils River indicates that some level of recruitment is occurring as the shape of the histogram approximates an inverted teardrop, though the population does appear to have a relatively high number of mid-sized individuals suggesting either a large recruitment event recently, or a past event that removed larger individuals from our sample sites (Figure 5). In contrast to the Rio Grande, individuals in the Devils River appear to reach a smaller maximum size which may be due to reduced growth rate as determined by lower temperatures and nutrient levels in this tributary. Median shell length for this population was ~65 mm and minimum and maximum shell lengths were 31 mm and 84.5mm, respectively (Figure 6). We observed reproductive activity (gills containing maturing eggs or glochidia) in September of 2015 and May of 2016, which corroborate prior observations from the Black River, New Mexico of the reproductive season for this species (Smith et al 2003).

Results from our data suggest that habitat preferences for *P. popeii* are riffle habitats in the Devils River (Figure 3) contrary to previous findings in the Rio Grande where most individuals are found in bedrock crevices or under boulders. These habitats are present in the Devils River, but are frequently covered in silt which may limit their suitability.

Lower Pecos River

A total of 172 person-hours were spent surveying 43 sites in the Lower Pecos River of Texas, downstream from Independence Creek (Figure 9). A total of 3 live individuals of *P. popeii* were found from 2 of those 43 sites, all in reach "B" near the Pandale Crossing (Table 2, Figure 2, and Figure 9). No *P. popeii* shells were found in Reach "A" near Independence Creek, but were present in all other reaches downstream (Figure 2). Shells were found *in situ* and reflect habitat use in the past that is similar to trends present in the lower canyons of the Big Bend Wild and Scenic Riverway (See Rio Grande Texas Hornshell Report) where *P. popeii* predominantly inhabits crevices in rock walls and sloughed pieces of rock walls, or boulder fields. Only three live individuals were encountered in the Lower Pecos River, with shell lengths of 56, 64, and 95 mm (Figure 7). No inferences regarding population demographics can be inferred from this sample size. None of the live individuals were exhibiting reproductive behavior at the time of collection, and the lack of small individuals suggests recruitment is not occurring currently. No other native mussels were encountered during sampling on the Lower Pecos River.

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Table 1. Devils River study sites ordered from furthest upstream to the confluence of the Rio Grande. Sub-adults defined as individuals less than 30 mm in length.

Site	Reach	Habitat	County	Number of live	CPUE	Sub Adult	Effort (hrs)	Area (m^2)
1	A	Riffle	Val Verde	0	0	-	4	150
2	A	Riffle	Val Verde	3	0.75	-	4	150
3	A	Backwater	Val Verde	0	0	-	4	150
4	A	Riffle	Val Verde	0	0	-	4	150
5	A	Pool	Val Verde	0	0	-	4	150
6	A	Riffle	Val Verde	1	0.25	-	4	150
7	A	Riffle	Val Verde	0	0	-	4	150
8	A	Riffle	Val Verde	0	0	-	4	150
9	A	Pool	Val Verde	0	0	-	4	150
10	B	Mid-Channel	Val Verde	0	0	-	4	150
11	B	Pool	Val Verde	0	0	-	4	150
12	B	Riffle	Val Verde	1	0.25	-	4	150
13	B	Bank	Val Verde	0	0	-	4	150
14	B	Bank	Val Verde	10	2.5	-	4	150
15	B	Mid-Channel	Val Verde	0	0	-	4	150
16	B	Mid-Channel	Val Verde	0	0	-	4	150
17	C	Rock slab	Val Verde	0	0	-	4	150
18	C	Mid-Channel	Val Verde	0	0	-	4	150
19	C	Backwater	Val Verde	0	0	-	4	150
20	C	Riffle	Val Verde	34	8.5	-	4	150
21	C	Riffle	Val Verde	0	0	-	4	150
22	C	Mid-Channel	Val Verde	8	2	-	4	150
23	C	Bank	Val Verde	0	0	-	4	150
24	C	Riffle	Val Verde	0	0	-	4	150
25	D	Rock slab	Val Verde	1	0.25	-	4	150
26	D	Bank	Val Verde	0	0	-	4	150
27	D	Riffle	Val Verde	0	0	-	4	150
28	D	Riffle	Val Verde	4	1	-	4	150
29	D	Backwater	Val Verde	0	0	-	4	150
30	E	Bank	Val Verde	0	0	-	4	150
31	E	Backwater	Val Verde	1	0.25	-	4	150
32	E	Riffle	Val Verde	2	0.5	-	4	150
33	E	Riffle	Val Verde	1	0.25	-	4	150
34	E	Riffle	Val Verde	0	0	-	4	150

Table 2. Lower Pecos River basin study sites ordered from furthest upstream to the confluence of the Rio Grande. Sub-adults defined as individuals less than 30mm in length.

Site	Reach	Habitat	County	Number of live	CPUE	Sub Adult	Effort (hrs)	Area (m^2)
1	A	Riffle	Terrell/Crockett	0	0	-	4	150
2	A	Rock slab	Terrell/Crockett	0	0	-	4	150
3	A	Bank	Terrell/Crockett	0	0	-	4	150
4	A	Riffle	Terrell/Crockett	0	0	-	4	150
5	A	Pool	Terrell/Crockett	0	0	-	4	150
6	B	Riffle	Val Verde	0	0	-	4	150
7	B	Rock slab	Val Verde	0	0	-	4	150
8	B	Boulder field	Val Verde	0	0	-	4	150
9	B	Bank	Val Verde	0	0	-	4	150
10	B	Riffle	Val Verde	0	0	-	4	150
11	B	Rock slab	Val Verde	1	0.25	-	4	150
12	B	Rock wall	Val Verde	0	0	-	4	150
13	B	Boulder field	Val Verde	0	0	-	4	150
14	B	Boulder field	Val Verde	0	0	-	4	150
15	B	Rock wall	Val Verde	0	0	-	4	150
16	B	Riffle	Val Verde	0	0	-	4	150
17	B	Backwater	Val Verde	0	0	-	4	150
18	B	Rock wall	Val Verde	0	0	-	4	150
19	C	Rock wall	Val Verde	2	0.5	-	4	150
20	C	Boulder field	Val Verde	0	0	-	4	150
21	C	Boulder field	Val Verde	0	0	-	4	150
22	C	Rock wall	Val Verde	0	0	-	4	150
23	C	Boulder field	Val Verde	0	0	-	4	150
24	C	Backwater	Val Verde	0	0	-	4	150
25	C	Boulder field	Val Verde	0	0	-	4	150
26	C	Riffle	Val Verde	0	0	-	4	150
27	C	Rock wall	Val Verde	0	0	-	4	150
28	D	Rock wall	Val Verde	0	0	-	4	150
29	D	Rock wall	Val Verde	0	0	-	4	150
30	D	Boulder field	Val Verde	0	0	-	4	150
31	D	Boulder field	Val Verde	0	0	-	4	150
32	D	Backwater	Val Verde	0	0	-	4	150
33	D	Riffle	Val Verde	0	0	-	4	150
34	E	Boulder field	Val Verde	0	0	-	4	150
35	E	Rock wall	Val Verde	0	0	-	4	150
36	E	Riffle	Val Verde	0	0	-	4	150
37	E	Boulder field	Val Verde	0	0	-	4	150
38	E	Backwater	Val Verde	0	0	-	4	150
39	E	Rock wall	Val Verde	0	0	-	4	150
40	F	Boulder field	Val Verde	0	0	-	4	150
41	F	Rock slab	Val Verde	0	0	-	4	150
42	F	Rock slab	Val Verde	0	0	-	4	150
43	F	Rock slab	Val Verde	0	0	-	4	150

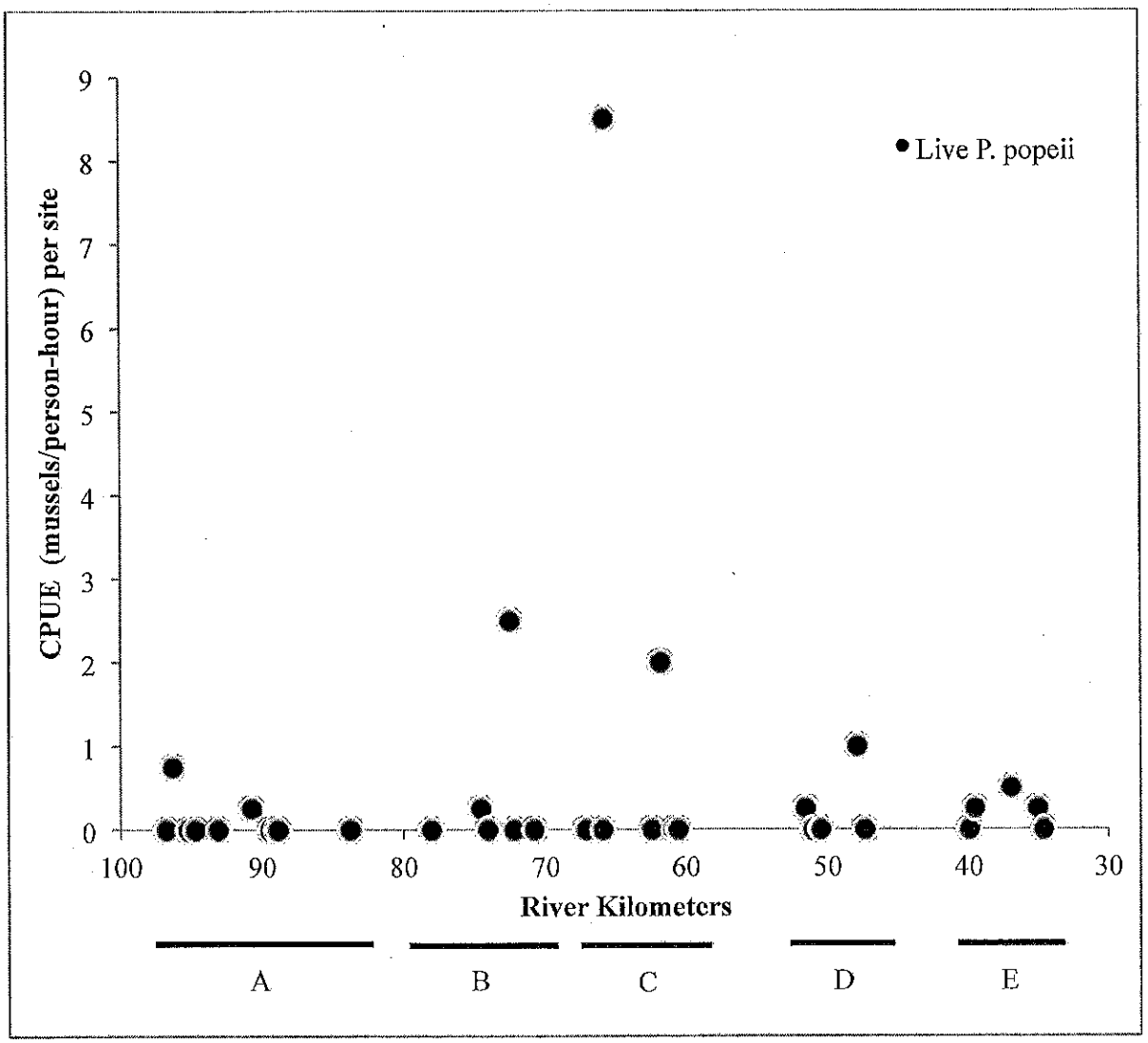

Figure 1. Longitudinal placement of study sites and live mussel occurrences on the Devils River. Reaches are labeled under the X- axis.

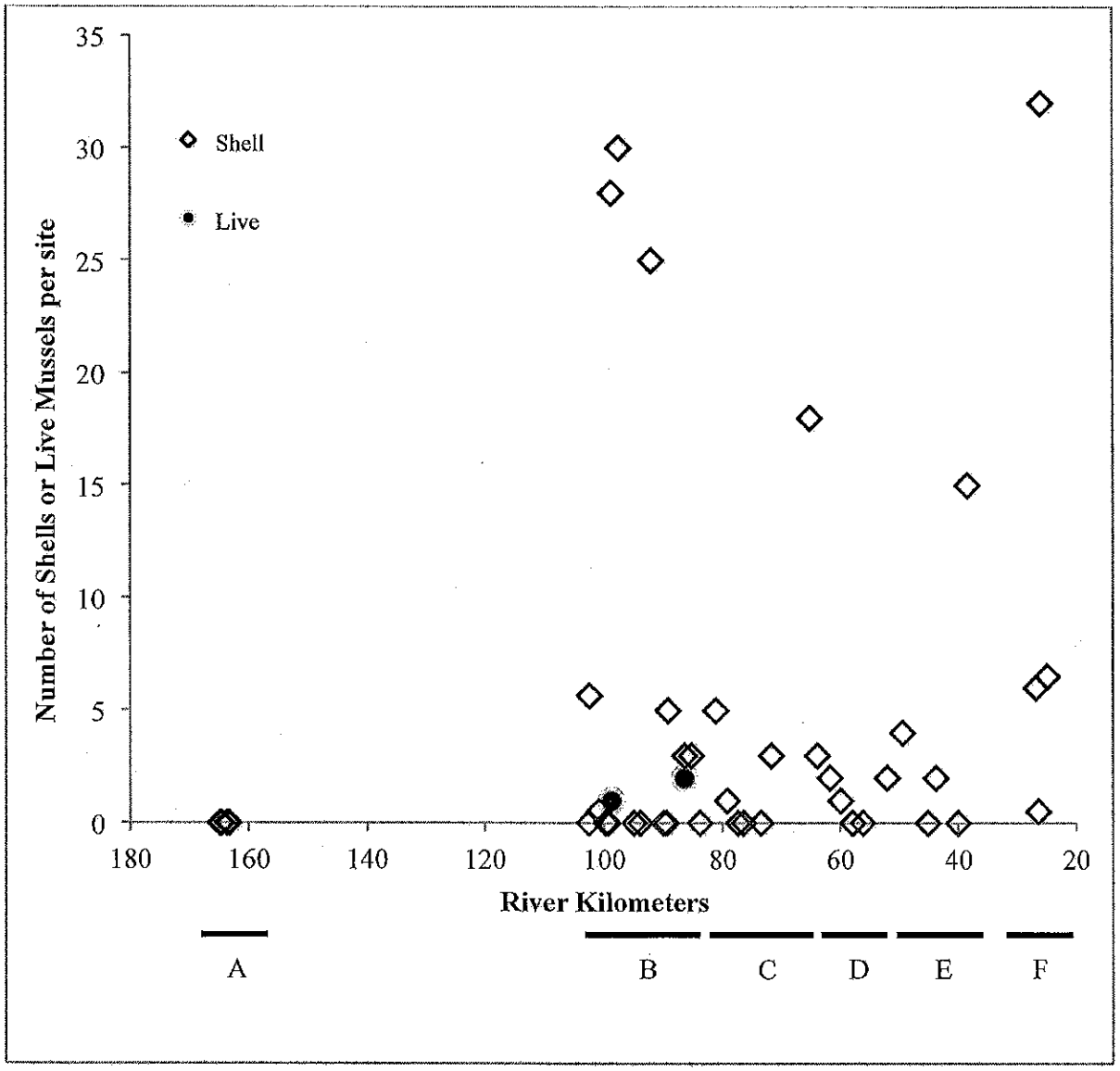

Figure 2. Longitudinal placement of shell and live mussel collections on the Pecos River. River Kilometers are measured upstream from the confluence with the Rio Grande. Symbols indicating zero shells found at a site also represent zero live mussels at that location. Reaches are labeled under the X-axis

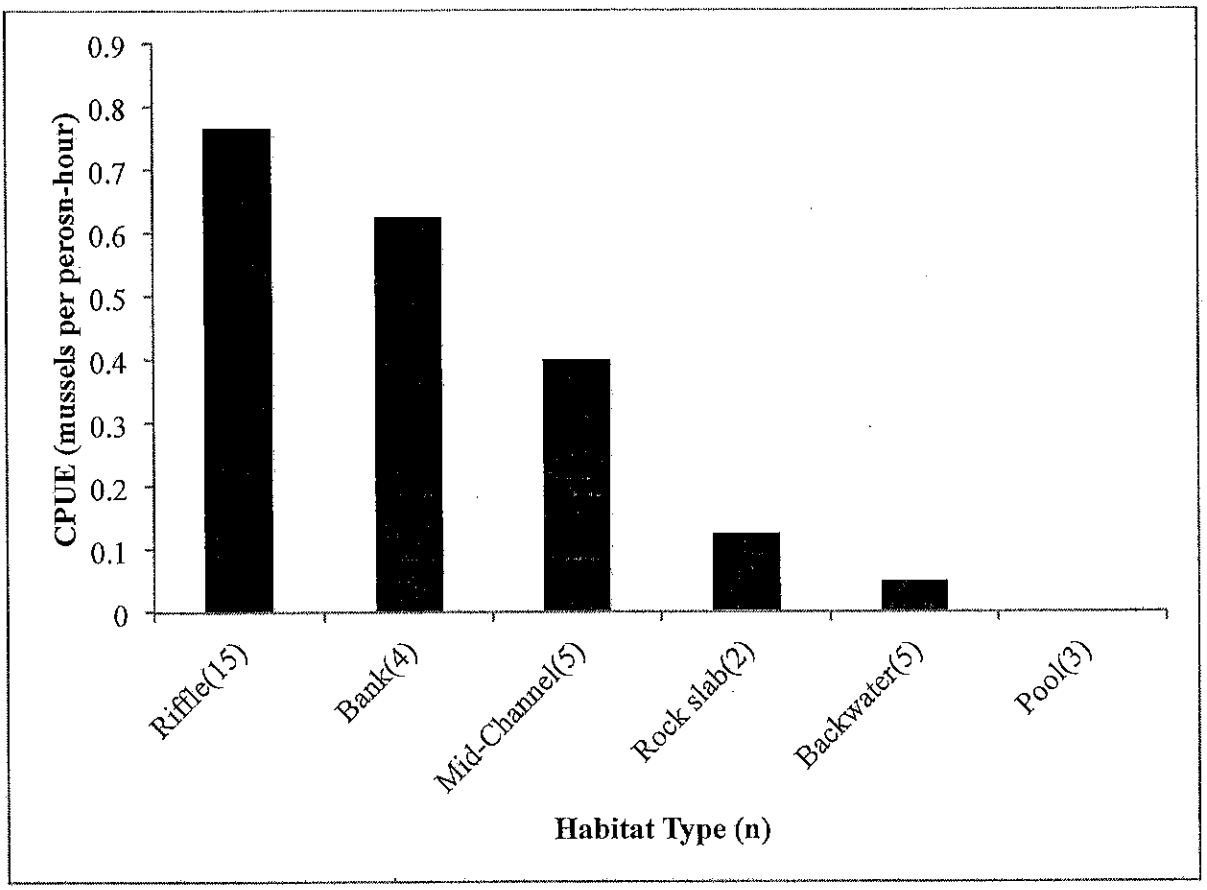

Figure 3. Proportional abundance (mussels per person-hour of effort) of *P. popeii* in each habitat type surveyed in the Devils River. The number of each habitat type sampled follows the label.

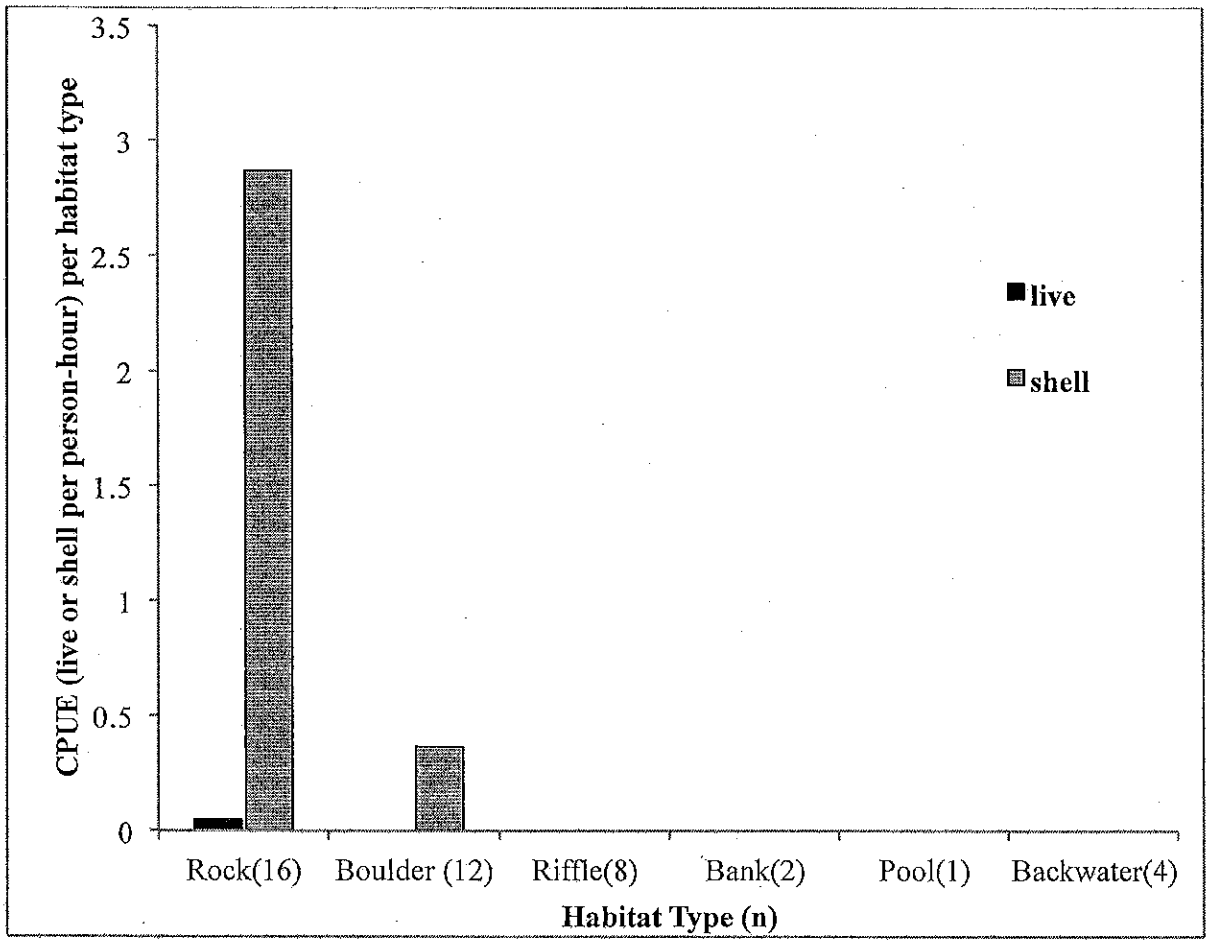

Figure 4. Proportional abundance (mussels or shells per person-hour of effort) of *P. popeii* in each habitat type surveyed in the Pecos River. The number of each habitat type sampled follows the label. "Rock" habitat includes rock walls and rock slabs from Table 2.

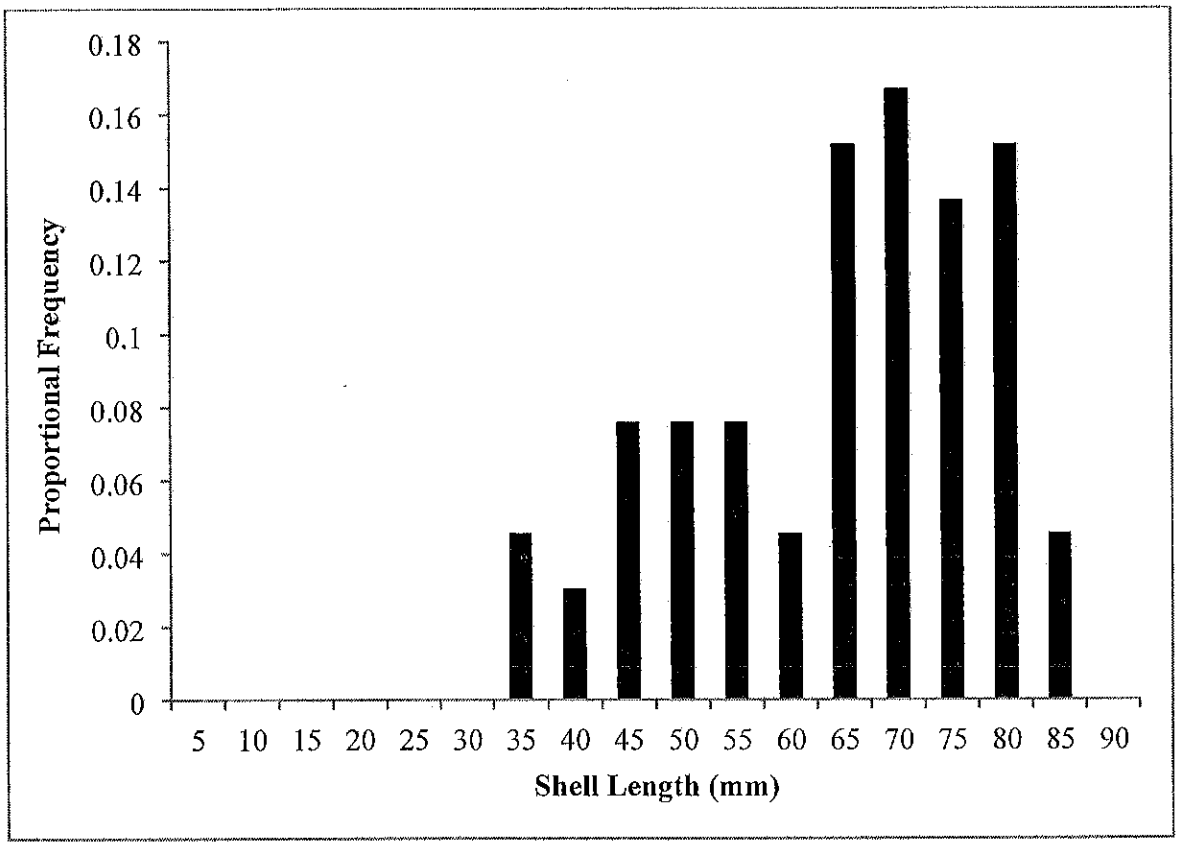

Figure 5. Histogram of *P. popeii* shell length data from the Devils River.

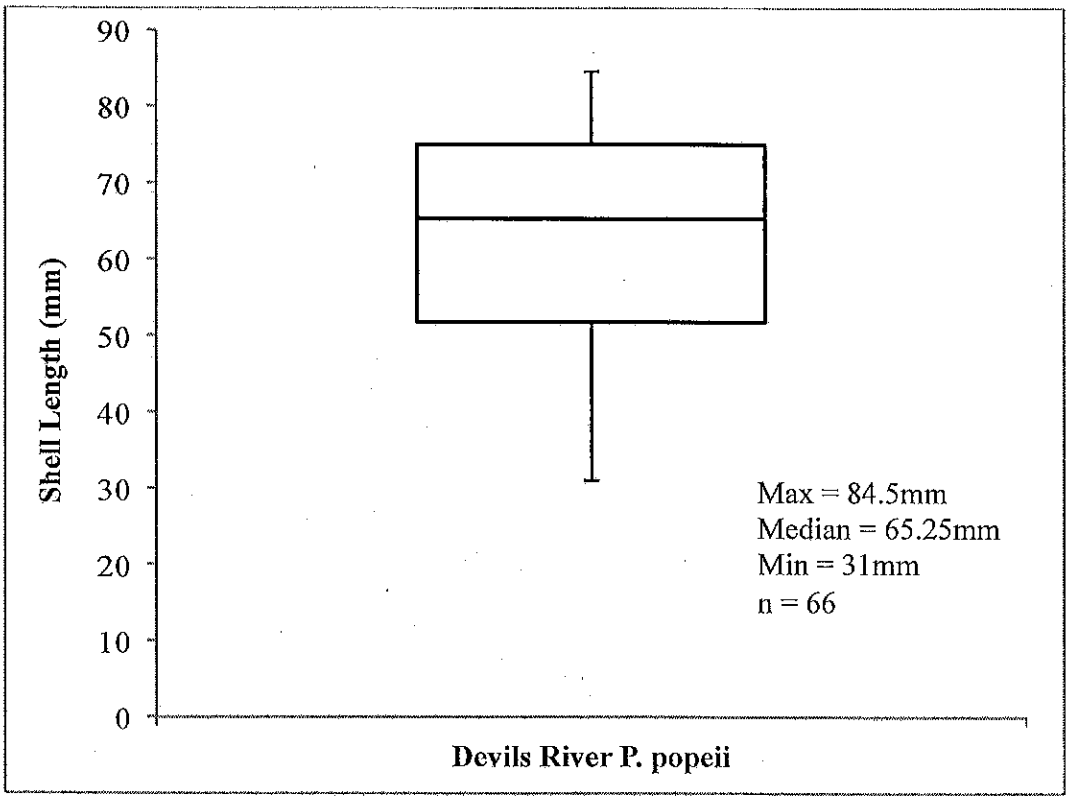

Figure 6. Box and Whisker plot of *P. popeii* shell length data from the Devils River. Insufficient sample size from the Pecos River prevent use of those data in this figure.

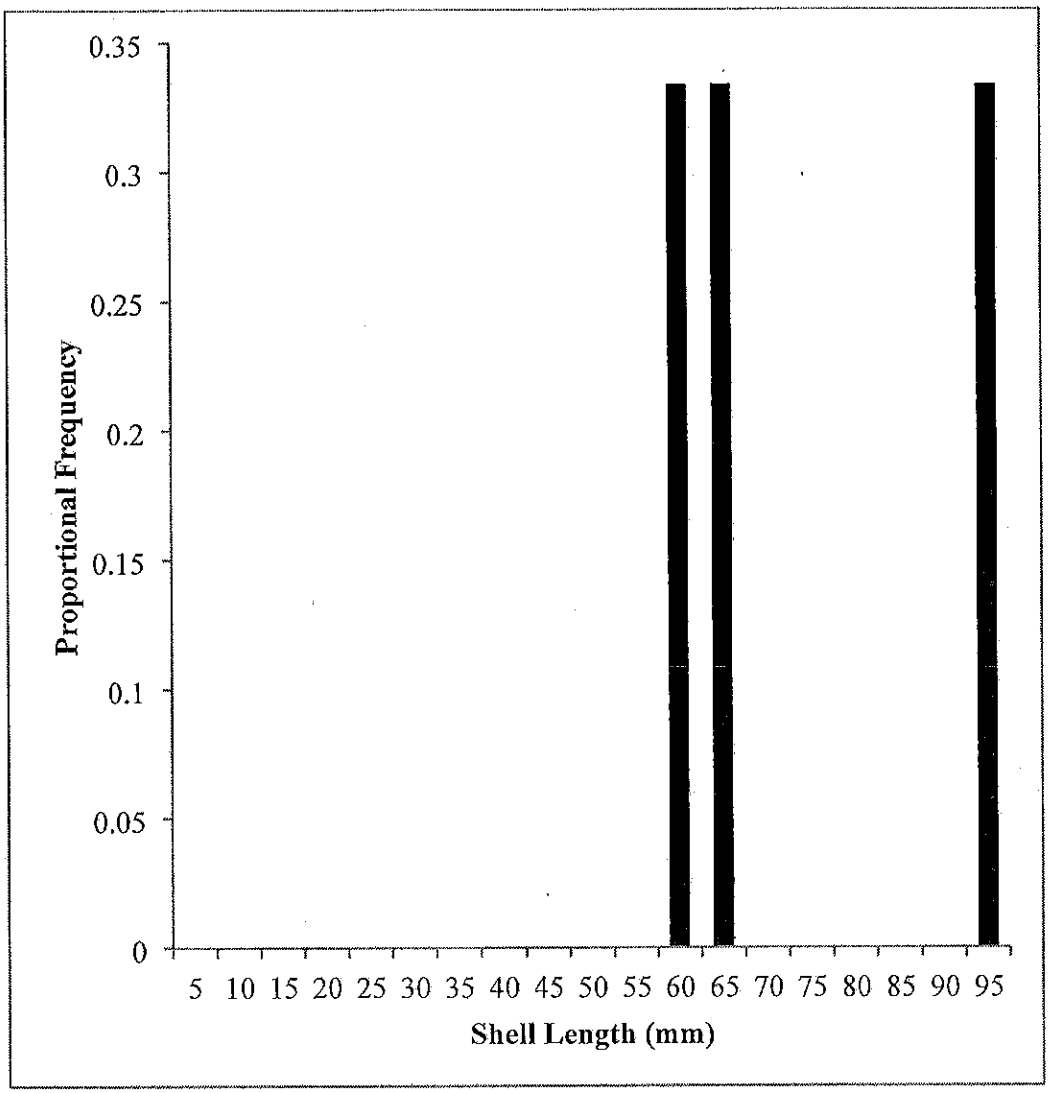

Figure 7. Histogram of live *P. popeii* shell length data from the lower Pecos River.

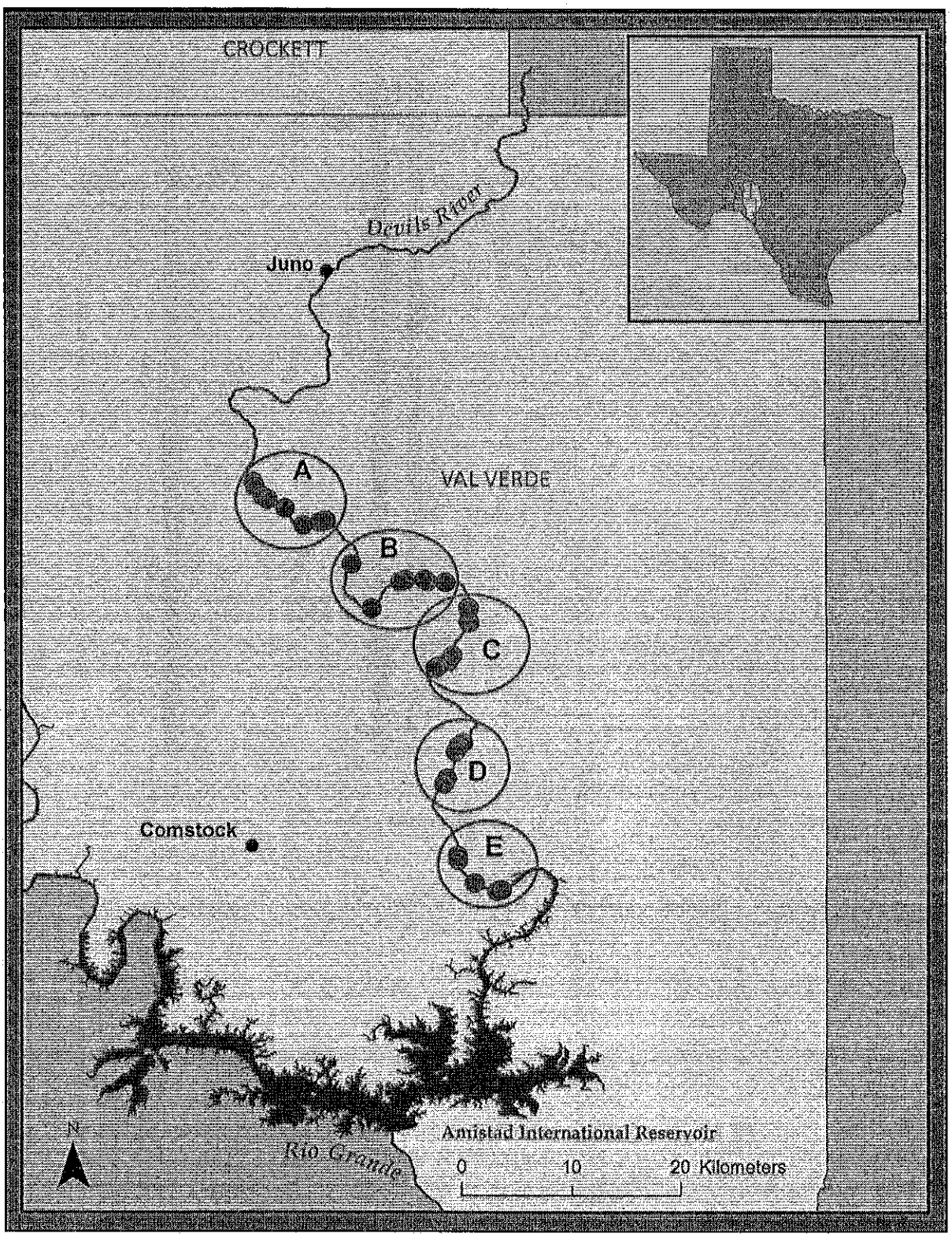

Fig 8. Devils River study area. Reaches correspond to table 1.

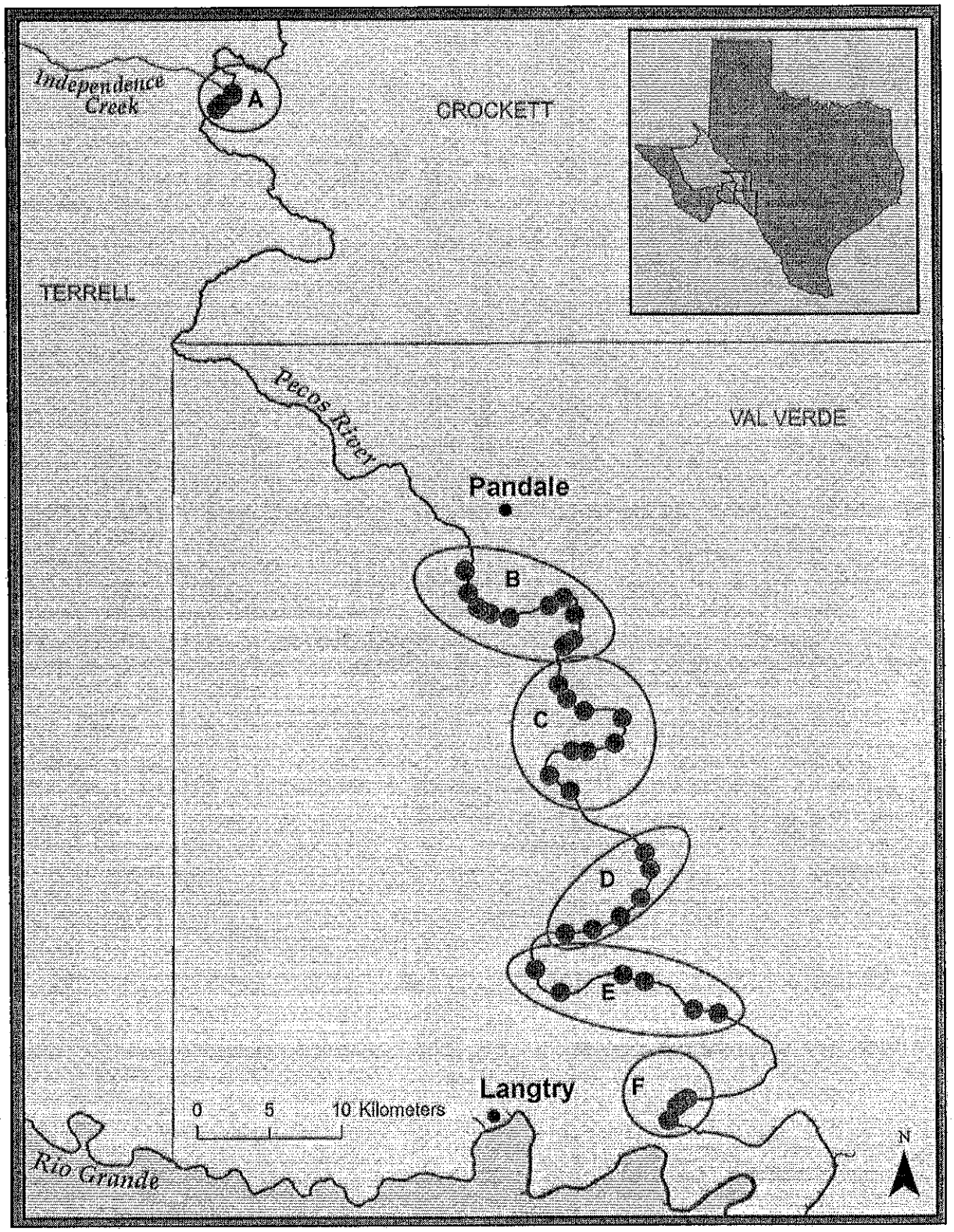

Figure 9. Pecos River study area. Reaches correspond to table 2.