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Pseudemys gorzugi Ward 1984 – Rio Grande Cooter, Western River Cooter, Tortuga de Oreja Amarilla, Jicotéa del Río Bravo

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Summary. – The Rio Grande Cooter, *Pseudemys gorzugi* (Family Emydidae), is a medium-sized to large (carapace length to at least 372 mm) riverine turtle that is endemic to the Rio Grande (= Río Bravo del Norte) drainage basin of the southwestern United States and northeastern Mexico. The species is monotypic and genetically distinct from congeners. Relatively little research has focused on the natural history and population status of this species anywhere in its range and it is among the least-studied turtles in North America. Degradation and fragmentation of this species' aquatic habitat and over-collection for the pet trade likely pose the greatest threats to its survival. Protective measures currently in place for this turtle in the United States and Mexico are very limited to non-existent.

Distribution. – Mexico, USA. Distributed along the Rio Grande (= Río Bravo del Norte) from the Big Bend region to the Gulf of Mexico; the Pecos River from southeastern New Mexico to its confluence with the Rio Grande, with an apparent gap from south of the New Mexico border to Independence Creek in Terrell County, Texas; and in tributary streams to these two rivers in northeastern Mexico (Coahuila, Nuevo Leon, Tamaulipas, and possibly Chihuahua) and the southwestern United States (New Mexico and Texas).

Synonymy. – *Pseudemys concinna gorzugi* Ward 1984, *Pseudemys gorzugi*.

Subspecies. – None.

Status. – IUCN 2016 Red List: Near Threatened (NT, assessed 2010); CITES: Not Listed; USA ESA: Not Listed; Mexico SEMARNAT: Threatened; New Mexico: State Threatened, Species of Greatest Conservation Need; Texas: Not Listed, Species of Greatest Conservation Need.

Taxonomy. — Prior to its recognition as a distinct taxon, populations of *P. gorzugi* were referred to other *Pseudemys,* including *P. texana* (e.g., Strecker 1915; Stejneger and Barbour 1933), *P. floridana texana* (e.g., Carr 1952), and *P. concinna texana* (e.g., Degenhardt and Christiansen 1974; Smith and Smith 1980). Specimens obtained from northeastern Mexico in the 1800s that were assigned to other taxa (e.g., "*Ptychemys mobiliensis*" from Nuevo Leon; Agassiz 1857) were presumably of this species (Smith and Smith 1980).

Ward (1984) described the *Pseudemys* of the Rio Grande basin as a new subspecies (*P. concinna gorzugi*) based on a holotype specimen from the Río San Diego, 5.6 km W of Jiménez, Coahuila, Mexico. Frost and Hillis (1990) suggested that *P. c. gorzugi* should be recognized as a distinct monotypic species, mainly because of its allopatric distribution in relation to other *Pseudemys*, an arrangement that was formally recognized first by Ernst (1990) and also by Collins (1991) but rejected by Iverson (1992) based on a lack of supporting analysis.

Several phylogenetic studies based on morphological and electrophoretic data (Seidel 1994) and molecular analyses (Starkey 1997; Stephens and Wiens 2003; Wiens et al. 2010; Jackson et al. 2012; Spinks et al. 2013) have supported the recognition of *P. gorzugi* as a species. It is related to, but within a lineage distinct from other cooters in the subgenus *Pseudemys* such as *P. concinna, P. floridana,* and *P. texana* (Seidel 1994). Despite controversy over the taxonomic treatment of other *Pseudemys* species (e.g., Jackson 1995; Seidel 1995), the recognition of *P. gorzugi* has been generally accepted (Fritz and Havaš 2007; TTWG 2007, 2014; Ernst and Lovich 2009; Iverson et al. 2012). No subspecies have been described.

Following earlier usage, Iverson et al. (2012) proposed the English standard name Rio Grande Cooter for *P. gorzugi*. The names Western River Cooter (Degenhardt et al. 1996; Collins and Taggart 2009) and, erroneously, Rio Grande River Cooter have also been used. The proposed Spanish standard name is *Tortuga de Oreja Amarilla* (Liner and Casas-Andreu 2008) although *Jicotéa del Río Bravo*

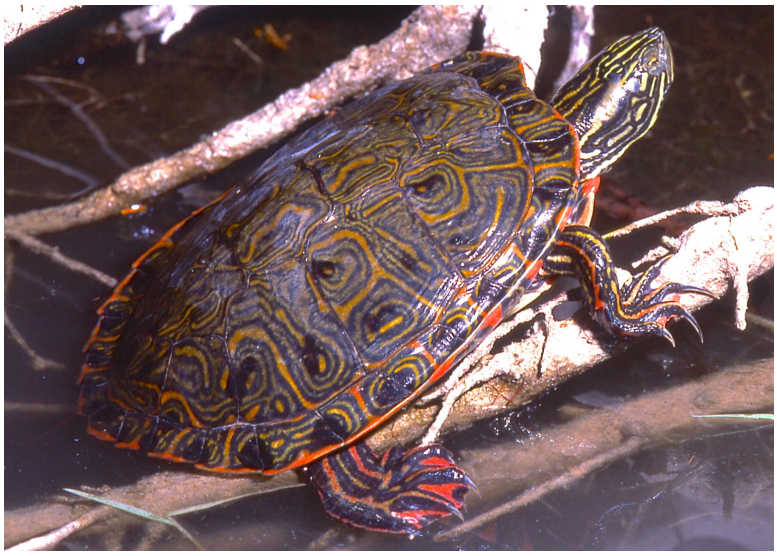

Figure 1. *Pseudemys gorzugi*, adult, from Black River, Eddy County, New Mexico, USA. Photo by C.W. Painter.

also has been used (SEMARNAT 2010; Legler and Vogt 2013). The specific epithet *gorzugi* honors George R. Zug, Curator Emeritus of Amphibians and Reptiles, National Museum of Natural History (Ward 1984; Ernst 1990).

Description. — *Pseudemys gorzugi* is a medium-sized to large aquatic turtle with pronounced sexual dimorphism in body size and other characteristics. The carapace in adults is elongated and oval in shape, more domed in females than males, and has its highest point near the middle and the widest point just behind the middle. The posterior marginals are serrated and the pleurals are shallowly rugose (Ernst and Lovich 2009). Males have significantly longer, thicker tails and more elongated foreclaws than females (Ward 1980, 1984; Ernst 1990; Ernst and Lovich 2009).

Stout et al. (2005) recorded a female from Texas measuring 372 mm carapace length (CL) and 5600 g mass, while B. Stearns (pers. comm.) recorded a female from Devil's River, Texas, of over 400 mm (CL). In a Texas sample, the mean CL and mass for 43 adult females were 243 mm and 1956 g, for 81 adult males 198 mm and 957 g, and for 3 juveniles 84 mm and 105 g, respectively (Bailey et al. 2014); combining all 127 individuals examined, CL ranged from 83–372 mm and mass ranged from 105–5600 g.

The species may attain smaller adult sizes in New Mexico populations. Degenhardt et al. (1996) reported that of 238 specimens of known sex examined from New Mexico, 97 females ranged from 80–285 mm CL with an average of 195.3 mm and ranged in mass from 85–3100 g with an average of 1139.1 g, whereas 141 males ranged from 89–232 mm CL with an average of 152.3 mm and ranged in mass from 112–1675 g with an average of 496.2 g. Stearns (pers. comm.) reported curved carapace lengths (CCL) for females caught in the lower Pecos River below Carlsbad, New Mexico, as ranging from 256 to 300 mm, while females from the Black River ranged from 222 to 264 mm CCL.

The carapace is ornately marked and exhibits a complicated pattern of whorls or ocelli, many of which are truncated and appear as backward facing C-shaped markings, but it normally lacks the distinct C-shaped marking

Figure 2. *Pseudemys gorzugi*, adult female, from Devil's River, Val Verde County, Texas, USA. Photo by B. Stearns.

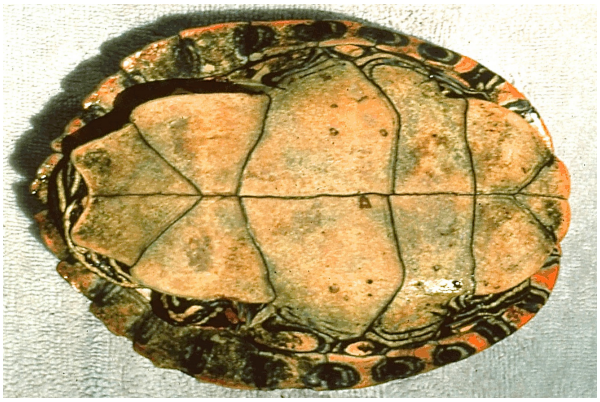

Figure 3. *Pseudemys gorzugi*, adult male, from Del Rio, Val Verde County, Texas, USA. Photo by J.P. Ward.

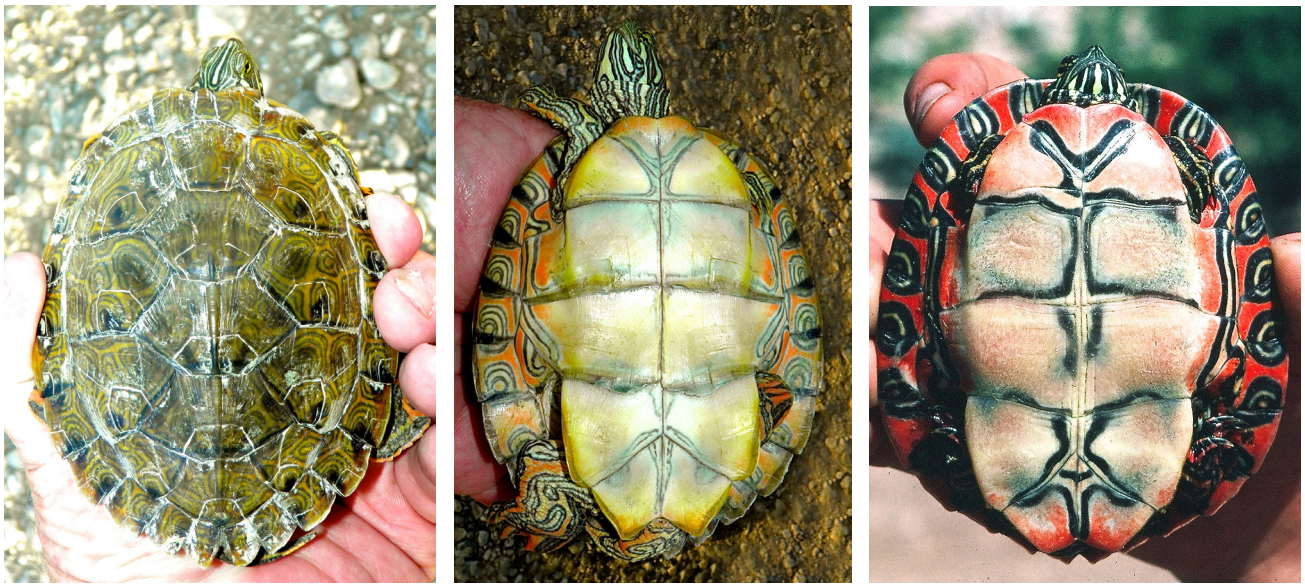

Figure 4. *Left and Middle*: Subadult *Pseudemys gorzugi* from Rio Sabinas, Coahuila, Mexico. Photos by T.R. Van Devender. *Right*: Subadult *P. gorzugi* from Black River, Eddy County, New Mexico, USA. Photo by B. Stearns.

on the posterior edge of the second and third pleural scutes as is found in *P. concinna* (Ward 1984; Ernst 1990; Seidel 1994; Ernst and Lovich 2009). This pattern of yellow lines and small whorls is most dense on the lateral and marginal scutes. The pattern on each carapacial scute has a brown to greenish background. Marginal scutes usually have a straight to slightly curved medial yellowish line. The carapacial pattern, most evident in juveniles, is often obscured or obliterated by melanistic blotches in older adults (Ward 1984; Legler and Vogt 2013; Bailey et al. 2014); Stearns (pers. comm.) observed this melanistic blotching only in male specimens.

The plastron is typically pale yellow, but can range to bright red in some individuals, usually with a dark lined pattern that follows the interscute seams. This lined pattern is most pronounced in juveniles and extends to all plastral seams, whereas in many adult specimens it is confined to the anterior plastral lobe. The ventral aspect of the bridge usually has a dark line or parallel dark lines running anteroposteriorly near the confluence with the plastron, particularly on the axillary and inguinal scutes.

In some specimens the carapace and plastron may be suffused with red pigmentation. This rubrivescence also occurs in all populations of *P. concinna* and some populations of *P. texana,* but is highly developed in *P. gorzugi*. In addition, reticulate melanism has been reported in male *P. gorzugi* greater than 250 mm CL (Seidel and Ernst 1996; Bailey et al. 2005a). The pattern, which has not been reported in *P. texana*, is similar to reticulate melanism in *P. nelsoni* and *Chrysemys picta bellii* and consists of dark vermiculate markings superimposed on the background color of the carapace and the ventral surface of the marginal scutes.

The head is striped with predominantly yellow lines, both broken and entire, although these lines may be variations of red as well, particularly in males. The postlabial stripe has two branches: an infralabial running along the mandible, and a supralabial running along the maxilla (Ward 1984). The lateral stripe is usually broken into a short narrow line posterior from the orbit terminating near the posterior end of the mouth, where it is interrupted by a space. Posterior to the space is a short yellow blotch, which may be broken further into spots. The lateral stripe then resumes onto the neck. There is a broken postorbital line, widest anteriorly, equating to the width of the supralabial; it is interrupted at the level of the posterior angle of the mouth, then runs continuously, although much narrower, onto the neck (Ward 1984). The temporal stripe is often the widest in *P. gorzugi*. Usually, there is a sagittal stripe. The dorsal stripes usually dominate the dorsum of the head, although these may fade with age, or be broken into spots in some specimens. The ventral stripes usually meet at or form a symphyseal line to the chin.

Foreleg stripes are well organized in branching or straight patterns. The prevalent pattern throughout the range of the species has the innermost stripe branching

Figure 5. *Pseudemys gorzugi*, melanistic adult, Black River, Eddy County, New Mexico, USA. Photo by B. Stearns.

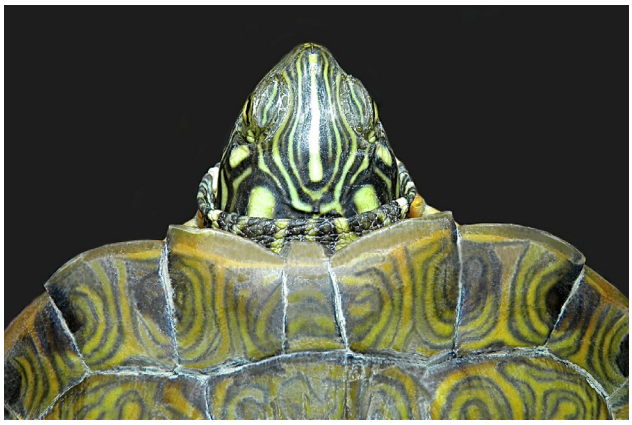

Figure 6. *Pseudemys gorzugi*, adult, from Rio Sabinas, Coahuila, Mexico. Photo by T.R. Van Devender.

Figure 7. *Pseudemys gorzugi*, adult, from Del Rio, Val Verde County, Texas, USA. Photo by J.P. Ward.

above the elbow joint, with a middle branch extending onto the forearm where it again branches. The hindleg stripes form continuous lines along the dorsum of the leg all the way to the toes.

More descriptions of markings and color patterns are found in Ward (1980, 1984), Ernst (1990), Ernst and Lovich (2009), and Legler and Vogt (2013). Clinal variation in color pattern and comparisons to other *Pseudemys* species are discussed by Ward (1980, 1984) and Seidel (1994).

Ward (1980, 1984) described the skeletal and muscular elements of the jaw mechanisms in adult *P. gorzugi* as similar to those of *P. concinna*, with adaptations associated with herbivory. Morphometric variation in adults and juveniles of both sexes is described by Legler and Vogt (2013).

The karyotype has not been described but is assumed to be the same as in *P. concinna*: 2n = 50; 26 macro- and 24 microchromosomes (Legler and Vogt 2013).

Distribution. — *Pseudemys gorzugi* is endemic to the drainage systems of the Rio Grande (= Río Bravo del Norte) and a major tributary, the Pecos River, of the southwestern United States (Texas and New Mexico) and northeastern Mexico (Coahuila, Nuevo León, Tamaulipas, and possibly Chihuahua). Of 49 nonmarine turtle species in the United States, *P. gorzugi* has the 13th smallest range (Reed and Gibbons 2002). Detailed maps of the species' distribution in the U.S. and Mexico are in Iverson (1992; for *P. concinna*) and Legler and Vogt (2013).

In the Rio Grande drainage along the USA–Mexico border, the species occurs from near the mouth of the river upstream to the Big Bend region where it has been reported from Big Bend National Park (Bailey et al. 2005b) and Calamity Creek, Brewster Co., Texas (Strecker 1909, 1915; Brown 1950), although the status of these western populations is questionable (see below). Many records within the Rio Grande basin are not from the mainstem river itself but from smaller tributaries; Bailey et al. (2008) noted an absence of the turtle in the main channel of the Rio Grande below Roma, Starr Co., Texas (see also Brush et al., in press), and Legler and Vogt (2013) noted few if any records from the river proper.

Rio Grande tributaries that support populations of *P. gorzugi* include the Río Salado–Río Sabinas drainage system (Coahuila, Nuevo León, Tamaulipas); the Ríos San Diego and San Rodrigo (Coahuila) (Lemos Espinal and Smith 2007); the Río San Juan (Nuevo León, Tamaulipas); small streams in Val Verde and Maverick counties, Texas (Bailey and Forstner 2004); and the Devil's River basin (including Evans Creek) in Texas (Powell et al. 1984; Dixon 2000, 2013; Bailey et al. 2008; Legler and Vogt 2013).

The species is reportedly fairly common in the Rio Grande and in a pond on park property at Big Bend National Park (Bailey et al. 2005b; M. Forstner, pers. comm.). It probably also occurs in the northeast corner of Chihuahua, opposite Big Bend National Park. Some records from northeastern Mexico are based on specimens originally identified by Schmidt and Owens (1944) as *Pseudemys gaigeae* (= *Trachemys gaigeae*) (Legler 1960; Legler and Vogt 2013). In the lowermost reach of the Rio Grande, the species seems to be entirely or mainly confined to tributaries on the Mexico side of the border (Smith and Smith 1980; Ward 1984).

In the Pecos River drainage, *P. gorzugi* has been reported as far upstream as the Bitter Lake National Wildlife Refuge, Chaves Co., New Mexico (Bundy 1951), and a carcass of a specimen was found there in August 2008 (Giermakowski and Pierce, 2016). However, surveys on the refuge since 1950 have otherwise failed to find the species (Degenhardt and Christiansen 1974; Degenhardt et al. 1996; Buhlmann and Gibbons 2006) and the presence of an undetected population at the refuge was considered doubtful by Degenhardt et al. (1996). Populations occur farther downstream on the Pecos below Avalon Dam and at Carlsbad Municipal Lake in New Mexico (Christman and Kamees 2007). The most robust populations in New Mexico are found in the main stem of the Pecos River below Sixmile Dam, south of Carlsbad, and in the Black and Dela-

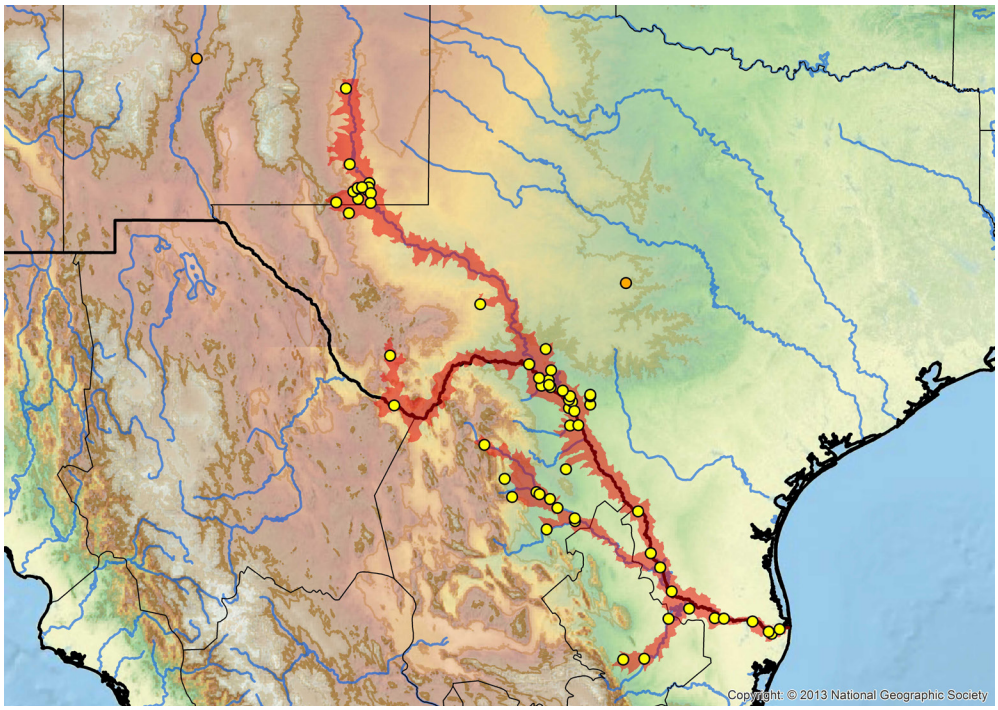

Figure 8. Historic distribution of *Pseudemys gorzugi* in southwestern USA (New Mexico and Texas) and northeastern Mexico (Coahuila, Nuevo Leon, Tamaulipas, and possibly Chihuahua). Yellow dots = museum and literature occurrence records of native populations based on Iverson (1992), plus more recent and authors' data; orange dots = introduced or misidentified specimens; red shading = projected historic distribution. Distribution based on GIS-defined level 12 HUCs (hydrologic unit compartments) constructed around verified localities and then adding HUCs that connect known point localities in the same watershed or physiographic region, and similar habitats and elevations as verified HUCs (Buhlmann et al. 2009; TTWG 2014), and adjusted based on authors' subsequent data.

ware rivers, tributaries to the Pecos in Eddy County. The species is also known from the headwaters of the Black River at Carlsbad Caverns National Park, as well as Blue Spring and Willow Lake (Legler 1958; Painter 1993; Degenhardt et al. 1996; Christman and Kamees 2007; Prival and Goode 2011).

In Texas, *P. gorzugi* is currently apparently absent in the Pecos River and adjoining tributaries from the New Mexico state line downriver to the confluence of Independence Creek, Terrell Co. (Bailey et al. 2008), although the species has been taken in Independence Creek itself, both historically and recently (Milstead et al. 1950; I. Mali and M. Forstner, pers. comm.). Ward (1984) similarly described a nearly 160-km hiatus in the range of *P. gorzugi* on the Pecos River of Texas that currently effectively separates the New Mexico populations from the nearest records in Texas.

Several distribution records represent introductions or are problematic. The species has been reported from the San Saba River drainage (Colorado River basin) in Menard Co., Texas (Franklin and Reams 2001), but the specimen on which this record is based is apparently a *P. texana* (M. Forstner, pers. comm.). Conant (1977) suggested that cooters identified as "*P. concinna*" were possibly introduced at Brownsville, Texas, near the mouth of the Rio Grande, although *P. gorzugi* is known to naturally occur in the general area. An extralimital specimen from the Rio Grande Valley in Socorro Co., New Mexico, was presumably an introduction (Stuart 1995). Older records from Calamity Creek in Trans-Pecos Texas (Strecker 1909, 1915) require verification.

Habitat and Ecology. — Few studies have been published on the habitat and ecology of *P. gorzugi* and some such information is likely obscured in the literature due to the relatively recent recognition of this taxon as distinct (Ernst 1990, 1995; Legler and Vogt 2013). The species is found in a variety of freshwater habitats, both lentic and lotic. Although considered by Moll and Moll (2004) as a riverine turtle, Legler and Vogt (2013) noted its preference for small tributaries and described the habitat as "shallow, clear streams with chiefly rocky or sandy bottoms and long, slow reaches between riffles." Degenhardt et al. (1996) noted its preference for larger, deeper pools on the streams it occupies, usually but not always where aquatic plants are present. Substrates in its aquatic habitat vary from muddy or sandy to rocky, including algae-covered limestone bedrock, and water quality ranges from clear to turbid (Degenhardt et al. 1996; B. Christman, pers. comm.). A specimen from Maverick Co., Texas, ca. 4 km southeast of Jiménez, Coahuila, Mexico, was taken from an irrigation ditch (Bailey and Forstner 2004). The species occurs at elevations from near sea level in the lower Rio Grande to about 1100 m in southeastern New Mexico (Degenhardt et al. 1996).

Figure 9. Habitat of *Pseudemys gorzugi*. *Top Left*: Devils River, Texas, USA. Photo by M.R.J. Forstner. *Top Right*: Black River, Eddy County, New Mexico, USA. Photo by B. Lang. *Bottom Left*: Rio Bravo (= Rio Grande), Coahuila, Mexico. Photo by S. Sanoja-Sarabia. *Bottom Right*: Rio Grande, Texas, USA. Note the three *P. gorzugi* heads in the lower left corner. Photo by M.R.J. Forstner.

It is unknown to what extent *P. gorzugi* uses large impoundments on the Rio Grande. The species has been observed in Amistad Reservoir but only in the tailwater below the dam at Falcón Reservoir (M. Forstner, pers. comm.). Some locations in Mexico are from dams (see Smith and Smith 1980). Prival and Goode (2011) caught the species in low numbers in the Amistad National Recreational Area. Although the species has been caught in Carlsbad Municipal Lake, it has not been captured during trapping efforts in either Brantley or Red Bluff reservoirs in New Mexico (Painter, unpubl. data; B. Christman, pers. comm.).

Major ecoregions in which *P. gorzugi* occurs include the Chihuahuan Desert, Edwards Plateau, Southern Texas Plains, and Western Gulf Coastal Plain (Wiken et al. 2011). Conant (1974) noted that the distribution of *P. gorzugi* closely matches that of Blanchard's Cricket Frog (*Acris blanchardii*) in the Rio Grande and Pecos River drainages, suggesting some similarity in habitat use, although the turtle also occurs in the Río Salado, where the frog is apparently absent.

Activity and Movements. — The Rio Grande Cooter is a basking species that is most active in daylight hours, and rests under water at night (Degenhardt et al. 1996). Preliminary studies indicate the species actively basks all day and always has a body temperature higher than that of ambient (Bailey et al. 2014). The species is mostly sedentary and does not typically make lengthy forays (Ward, pers. obs.); maximum recorded movements in the Black River were about 300 m (Degenhardt et al. 1996; Painter, unpubl. data). Degenhardt et al. (1996) found *P. gorzugi* active in the Black River during December when the water temperature was 12ºC. Seasonal activity has not been studied, although the species is likely active almost year-round in much of its range.

Diet. — The food habits of *P. gorzugi* have not been well-studied, but the species is apparently omnivorous and an opportunistic feeder (Painter, unpubl. data). As with other *Pseudemys*, adults are probably more herbivorous than juveniles. Legler (1958) noted an adult specimen from Blue Spring, New Mexico, had finely chopped vegetable matter in its stomach and gut. Other specimens caught in New Mexico have been observed feeding on algae growing on submerged boulders in the Black River, and often defecated vegetable matter, especially green algae (Degenhardt et al. 1996; B. Stearns, pers. comm.). One specimen had consumed a crayfish (Degenhardt et al. 1996). Painter (1993) reported observing *P. gorzugi* feeding on leaves of a cottonwood tree (*Populus* sp.) along the Black River. The

species has been caught in hoop traps baited with fresh fish, canned sardines, watermelon, or lettuce (Degenhardt et al. 1996). A variety of foods are taken in captivity (see Captive Husbandry).

Reproduction. — Male courtship behavior has not been studied although it likely follows the pattern reported for other species of *Pseudemys*. In other cooters, the male approaches the female when both are underwater and positions himself above her and facing the same direction; he then places his head above hers and uses his elongated foreclaws to stroke her head and neck (Seidel and Fritz 1997). Forstner (pers. comm., *in* Legler and Vogt 2013) reported observations of female *P. gorzugi* being courted by male *Trachemys scripta*, without copulation, where the two species were sympatric.

In New Mexico, nesting is known to occur in late May based on the capture of gravid females and discovery of depredated nests (Degenhardt et al. 1996), but presumably extends later into the summer. Nests found in friable soils during telemetry studies were often found some distance from a water source and under the shade of large plants, such as seepwillow (*Baccharis* sp.; Painter 1993). A gravid female from the Black River that was X-rayed contained 9 oviductal eggs; she was induced to oviposit and the eggs averaged 42 mm x 31 mm in size (Degenhardt et al. 1996). Incubation of eggs in the laboratory lasted 70 days and the four surviving hatchlings averaged 33.9 mm CL with an average mass of 10.1 g. Another female from the Black River was found to have 10 eggs, with a range of egg widths as measured from the x-ray of 27.2–30. 5 mm with an average of 29.3 mm (Lovich et al. 2016).

Four wild-caught hatchlings that apparently had just emerged from the nest were collected on 17 August and had an average CL of 37.8 mm and mass of 11.3 g (Degenhardt et al. 1996). A sample of 14 captive-bred hatchlings from Texas averaged 36.9 mm CL and 13.4 g in mass (Bailey et al. 2014). Neonates may leave the nest soon after hatching in late summer or fall, or overwinter until spring, as evidenced by seven hatchlings found emerging from a nest site near the Pecos River on 14 April (J. Sherman, pers. comm., *in* Degenhardt et al. 1996).

Females likely produce multiple clutches each season, but this has not been confirmed (Painter, unpubl. data; Legler and Vogt 2013). As in other *Pseudemys*, the species presumably has temperature-dependent sex determination (Legler and Vogt 2013).

Males likely achieve sexual maturity at around 100 mm CL in the fourth or fifth full season of growth, whereas females mature at around 160 mm CL in the fifth or sixth full season of growth (Legler and Vogt 2013). No information is available on longevity.

Deformities and Disease. — Kyphoscoliois and aberrant carapace scutellation was observed in an otherwise healthy adult in the Black River, New Mexico (Zymonas 2009). The bacterium *Salmonella* was not detected in a small number of captive *P. gorzugi* in Texas (Gaertner et al. 2008). The parasite fauna of *P. gorzugi* has not been studied.

Associated Turtle Species. — Native aquatic turtles that co-occur with *P. gorzugi* in at least part of its range include: *Chelydra serpentina*, *Kinosternon flavescens*, possibly *K. hirtipes*, *Chrysemys picta*, *Trachemys gaigeae*, *T. scripta*, and *Apalone spinifera* (Iverson 1992; Degenhardt et al. 1996; Christman and Kamees 2007; Dixon 2013; Legler and Vogt 2013; Lovich et al. 2016).

Population Status. — *Pseudemys gorzugi* appears to be persisting in the majority of the locations where it has been documented previously, although current information suggests that at least some populations are in decline (Degenhardt et al. 1996; Christman and Kamees 2007; Bailey et al. 2008, 2014). In Tamaulipas, Mexico, the species is considered threatened by the Mexican government (Farr 2015). Bailey et al. (2008) found the ratio of males:females:juveniles to be 94:55:6 and reported an estimated density of 1.3 turtles/km in the Pecos River and 1.9 turtles/km in the Devil's River. In another study of the species in Texas, Bailey et al. (2014) found adult:juvenile ratios for the Pecos River to be 123:3 and for the Devils River to be 68:3. This contrasts with the number of small or juvenile individuals reportedly observed in the mid- to late 1970s by Ward (pers. obs.) and by J. Dobie (pers. comm.).

The species is largely absent from the Rio Grande proper, although this might be due to its preference for smaller tributary streams of this river (Ward 1984; Bailey et al. 2008; Legler and Vogt 2013). A large population near Del Rio, Val Verde Co., Texas, reportedly disappeared between 1996 and 1998, potentially due to take for the foreign pet trade (Dixon 2000). However, in 2010, 15 individuals were observed at this site (Dixon 2013). Christman and Kamees (2007) discussed the limited habitat for this species in New Mexico and its vulnerability to illegal shooting and collection, and recommended that it continue to be recognized as State Threatened based upon their survey results. Snorkeling surveys in the Black River in 2011 and 2014 revealed fewer turtles than snorkeling surveys in the same areas in the 1990s (B. Stearns, pers. comm.). The number of *P. gorzugi* at Rattlesnake Springs in the headwaters of the Black River is likely low, with 13 being the most observed at one time (Prival and Goode 2011). The status of populations in Mexico, which have not been well-surveyed, is unknown.

Threats to Survival. — *Pseudemys gorzugi* is classified as Near Threatened by the International Union for Conservation of Nature (IUCN) due to its limited distribution (perhaps less than 2000 km^2), declines in the quality and quantity of its aquatic habitat, and collection of indi-

Figure 10. *Pseudemys gorzugi* and *Trachemys scripta* shells showing evidence of gunshots, Delaware River, Eddy County, New Mexico, USA. Photo by B. Stearns.

viduals from wild populations for the pet trade (van Dijk 2010). These multiple threats and others, combined with low genetic diversity and low recruitment in the species, imperil the persistence of the species in many locations (Bailey et al. 2008). In this regard, *P. gorzugi* is similar to other freshwater turtles in the Southwestern United States, that face similar threats (Rosen 2008).

Both the Rio Grande and Pecos River have been subjected to extensive human modification, including: 1) the damming and diversion of water for agriculture or municipal use; 2) flood control; 3) reductions in water quality (including salinization) from oil and gas extraction, municipal effluent, and agriculture; and 4) river maintenance activities such as dredging and channelization (Ford and Finch 1999; Bailey et al. 2008, 2014). Invasive saltcedar (*Tamarix* spp.), which has replaced much of the native riparian vegetation along these rivers, has also contributed to habitat degradation. Although some of the smaller tributaries occupied by *P. gorzugi* have experienced less environmental impact, these streams are also under pressure from increasing human activity in the region, especially water diversion and groundwater pumping, which have reduced surface flows (Painter, pers. obs.). Ward (1984) attributed the current hiatus in the species' distribution in the Pecos River of Texas to pollution from oil fields. Pesticide pollution in the Pecos River of New Mexico has been documented, including in fish samples taken at Brantley Reservoir (New Mexico Department of Game and Fish, unpubl. data), but it is unknown if this poses a risk to aquatic turtles. Localized loss of habitat and dam construction have also fragmented and isolated populations, making them more vulnerable to extirpation (Bailey et al. 2008, 2014; Painter, pers. obs.). Documentation of aquatic habitat degradation within the range of *P. gorzugi* in Mexico is less available, but likely comparable to that seen in the United States.

Pseudemys, including *P. gorzugi*, is popular in the commercial pet trade (Fitzgerald et al. 2004; Schlaepfer et al. 2005; Bailey et al. 2014). *Pseudemys gorzugi* may be especially vulnerable to over-collection due to its apparent preference for small, shallow streams where it can be more easily captured. An analysis of nonmarine turtles of the United States determined that of 40 species studied, *P. gorzugi* was the 16th most vulnerable to commercial harvest (Reed and Gibbons 2002).

These turtles are vulnerable to several other human-generated threats. Recreational shooting of *P. gorzugi* and other aquatic turtles was first noted in New Mexico in the 1990s (Painter, pers. obs.), and remains a problem in both that state and Texas (Christman and Kamees 2007; Bailey et al. 2008). Individuals are also apparently killed by some anglers, possibly due to a misperception that *P. gorzugi* preys on gamefish (Bailey et al. 2008). Aquatic turtles are vulnerable to drowning in underwater traps used to catch catfish, as has been observed in both Texas (Stuart, unpubl. data) and Mexico (W. Farr, pers. comm.), although such mortality has not been observed for *P. gorzugi*. Road mortality has not been documented often in *P. gorzugi*, although Walls (1996) reported an observation of many large females killed by vehicles in southern Texas as they left roadside ditches following heavy rains.

Depredation by animals apparently affects all life stages of *P. gorzugi*, from eggs to adults, although direct evidence is mostly lacking. Painter (unpubl. data) considered egg depredation to be a major factor in nest failure along the Black River, with the likely predator being raccoon (*Procyon lotor*). Depredated adult turtles have also been found on the Black River, perhaps taken by raccoons or other carnivores during forays away from the stream (Painter, pers. obs.). The invasive fire ant (*Solenopsis* spp.) is considered a threat to *P. gorzugi* nests in Texas (Bailey et al. 2014). The conspicuous lack of juveniles reported for some populations studied in Texas (Bailey et al. 2014) is potentially due to nest failures, high depredation rates, or over-collecting for the pet trade.

Painter (unpubl. data) observed some mortality of *P. gorzugi* in the Delaware River of New Mexico following a wildfire that burned through riparian habitat along this stream.

Conservation Measures Taken. — In New Mexico, *P. gorzugi* is classified as a Threatened species under the state's Wildlife Conservation Act. This designation makes it illegal to collect or kill the species without a permit, but affords no protection to habitat. Texas has implemented regulations that prohibit the commercial harvest of this species, although it may be collected for personal use. *Pseudemys gorzugi* is also considered a Species of Greatest Conservation Need under the State Wildlife Action Plans for both New Mexico and Texas (New Mexico Department of Game and Fish 2006; Texas Parks and Wildlife Department 2012). This designation makes it a priority species for research and management in those states, but confers

no legal protection. In Mexico, the species is classified as *Amenazada* (Threatened), and a special permit is required to collect, kill, or conduct research on it (SEMARNAT 2010).

Some populations occur on federal or state managed lands in the USA (e.g., Big Bend National Park, Texas, and Carlsbad Caverns National Park, New Mexico) and in Mexico (Parque Nacional Balneario de Los Novillos, Coahuila). Habitat conservation and restrictions against collecting of wildlife on most of these public lands provide some protection.

Conservation Measures Proposed. — Until more information on population structure and abundance is available, further conservation measures needed are unclear. Studies on the impact of river impoundments and invasive species on *P. gorzugi* were recommended under the Texas Comprehensive Conservation Strategy (Texas Parks and Wildlife Department 2012). Habitat improvement projects directed at improving water quality, riparian habitat, and stream function in occupied drainages should aid the survival of this species. Monitoring of the status of various populations is warranted. Although a population of *P. gorzugi* remains unconfirmed for Bitter Lake National Wildlife Refuge in New Mexico, Buhlmann and Gibbons (2006) made several recommendations toward the management of the species on the refuge, including habitat improvement and providing for the establishment of an assurance population there.

This remains one of the least studied species of turtles in the United States and Canada (Lovich and Ennen 2013), and studies on the ecology and behavior of the species are greatly needed (Ernst and Lovich 2009). Christman and Kamees (2007) provided a list of localities in New Mexico that warrant further investigation, including Brantley Reservoir, Carlsbad Municipal Lake, Willow Lake, and the Pecos River at Six Mile Dam. Bailey et al. (2014) proposed that further research is needed on the life history and ecology of the species, in particular how abiotic factors impact *P. gorzugi*. Such information is sorely needed to ascertain the status of the species and the effects of water pollution and manipulations of habitats on populations of *P. gorzugi*.

In 2012, the U.S. Fish and Wildlife Service (USFWS) was petitioned to list *P. gorzugi* as a threatened or endangered species under the U.S. Endangered Species Act (Adkins Giese et al. 2012). The USFWS (2015) found that the petition presented substantial scientific or commercial information, and that listing might be warranted based on impacts to habitat, overuse of the species for commercial or scientific purposes, and the inadequacy of existing regulatory protections. At present, the deadline for the listing finding is not scheduled until 2023 (https://www.fws.gov/endangered/improving_esa/listing_workplan.html).

Captive Husbandry. — Captive-rearing requirements of *P. gorzugi* have not been described in detail, but are presumably similar to those of *P. concinna* and other species of *Pseudemys* (Walls 1996; Ward and Jackson 2008). Although smaller individuals can be maintained in aquaria or indoor tanks if provided with an ultraviolet light source, adults likely do best when maintained in large outdoor ponds or livestock watering tanks equipped with a system for water circulation and filtration and basking platforms. Captives will eat lettuce and other leafy green vegetables in addition to commercial turtle foods and raw fish, chicken, and beef. Hatchlings require abundant sunshine or constant exposure to a regular incandescent light bulb to maintain body temperature and induce vitamin D formation necessary for proper calcium metabolism. Captive hatchlings will feed on mosquitofish (*Gambusia* sp.), crayfish, lettuce, spinach, and aquatic plants collected from the wild (Degenhardt et al. 1996), and juveniles thrive on commercially available foods such as dried or canned dogfood, trout and catfish chow, or cat food (Ward, pers. obs.).

Eggs that are laid in water by captive females may be incubated with excellent results, provided they are recovered soon after laying. Depending on temperature, incubation in captivity may take 70–110 days. Greater than 90% hatching success can be achieved by incubating eggs in damp newspaper, vermiculite, or clean sand (Ward, pers. obs.).

Current Research. — Ecological studies are currently underway or being designed in both New Mexico and Texas, driven in no small part by the ongoing review of the species by the USFWS. Radiotelemetry studies of populations in Texas are ongoing or recently concluded (Bailey et al. 2008). Population genetics have been studied in Texas, as well as initial work on basking behavior (Bailey et al. 2014).

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