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NOTES

AQUATIC INVERTEBRATES OF CUATRO CIÉNEGAS, COAHUILA, MÉXICO: NATIVES AND EXOTICS

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ABSTRACT—A recent survey of benthic macroinvertebrates of the Cuatro Cienegas basin found 118 species in the 21 sites collected. Four exotic macroinvertebrates that could threaten the native biota were found within or near the basin.

RESUMEN—Una inspección reciente de macroinvertebrados bénticos del bolsón de Cuatro Ciénegas encontró 118 especies en los 21 sitios que se muestrearon. Cuatro macroinvertebrados exóticos que podrían amenazar la biota nativa se encontraron dentro o cerca del bolsón.

The Cuatro Ciénegas basin is a small valley (about 1,500 km^2) in central Coahuila formed by the mountain ranges of the Sierra Madre Oriental. Although it is in one of the driest areas of the Chihuahuan Desert (<200 mm of rainfall per year), it is estimated to contain more than 200 springs and other associated aquatic habitats with many endemic organisms and modern stromatolites. Six types of aquatic habitats occur in the basin: pozas (small spring-fed pools), lagunas (larger spring-fed lakes), playa lakes (large lakes fed by surface runoff, but without outlets), ciénegas (shallow swamps), human-made canals (constructed between the late 1800s and 1960s), and rivers (Minckley, 1969). The aquatic and terrestrial vegetation has been well described (Pinkava, 1984), as have fish and aquatic snail faunas (Minckley, 1984; Hershler, 1985). Largely due to its great biodiversity and high degree of endemism, but also due to imminent threats of water extraction and exotic species, the Mexican government declared the basin a protected area of flora and fauna in 1994 (Secretaría de Desarrollo, 1994).

Initial studies of the Cuatro Ciénegas basin focused on endemic aquatic organisms and their habitats (e.g., Minckley, 1969). Despite the presence of large numbers of species of endemic snails and crustaceans (Taylor, 1966; Cole, 1984; Hershler, 1985), there have been no comprehensive surveys of aquatic insects and other non-gastropod and non-crustacean invertebrates (e.g., Annelida, Acarina), nor have regional surveys been published. The entire state of Coahuila lacks distributional records of even some common aquatic insect orders, such as mayflies (Ephemeroptera) (McCafferty and Lugo-Ortiz, 1996). The order and suborders that are well studied in Coahuila are dragonflies (Odonata: Anisoptera) and damselflies (Odonata: Zygoptera) (Needham and Westfall, 1954; Westfall and May, 1996). Within the basin, Crustacea, Gastropoda, and parasitic flukes have been studied (for respective reviews see Cole, 1984; Hershler, 1984; and Guajardo-Martinez, 1984). The only published work on aquatic insects of the basin described a new widespread species of *Rhagovelia* (Hemiptera: Veliidae), which occurs throughout the Sierra Madre Oriental (Polhemus, 1997). Anecdotal reports on aquatic insects in the valley usually describe them as depauperate.

We conducted seasonal surveys of 21 sites in the basin during June and July 1999, October 1999, January 2000, and August 2000 (Table 1,

TABLE 1—Aquatic habitats sampled during survey of Cuatro Ciénegas basin, Coahuila, México, 1999 through 2000. All UTM coordinates are for Zone 13. Site codes are cross-referenced to Table 2.

	UTM coordinates			
Locality	North	East	Habitat	Site
Poza Becerra	2976191	784293	Poza	1
Canal de la Becerra	2976730	186706	Canal	2
Charcos Prietos	2979912	198466	Laguna	3
Poza Churince	2981039	191524	Poza	4
Poza Escobedo	2977959	193371	Poza	5
Poza Juan Santos	2978786	187438	Laguna	6
Laguna Grande	2972981	783337	Playa lake	7
Las Playitas Intet	2980193	796276	Playa lake	8
Las Playitas SE Shore	2979863	796817	Playa lake	9
Los Gatitos	*	*	Ciénega	10
Ciénegas de los Gatos	2977405	798314	Ciénega	11
Los Hundidos	2977405	194917	Laguna	12
Poza Mojarral Este	2981484	189919	Laguna	13
Poza Mojaral Oeste	2980897	785725	Poza	14
Poza Azul	2969600	795644	Poza	15
Puente Chiquita	2981076	793510	River	16
Río Garabatal	2977958	782316	River	17
Río Mesquites las Palapas	2980218	789999	River	18
Canal de Saca Salada	2980345	793672	Canal	19
Poza Tio Cándido	2974517	790796	Laguna	20
Río Salado de Nadadores	*	*	River	21

* data not available.

Fig. 1). Twenty of the sites were within the protected area of the basin; one, the Río Salado de Nadadores was just outside the basin. Number of sites collected in each period depended on the time available; thus, we could not collect in all 21 sites every time. We collected aquatic insects and other invertebrates using aquatic dip nets (mesh size 250 μm), Ponar dredge samplers, as well as hand sorting of littoral vegetation. Quantitative samples of lentic and littoral habitats are difficult to collect and process, so we focused our efforts on qualitative presence-absence data and comprehensive sampling of all microhabitats. Because the endemic hydrobiid snails were well studied, our surveys did not include them. Invertebrates were preserved in 95% ethanol and we used keys to North American taxa (Needham and Westfall, 1954; Menke, 1979; Pennak, 1989; Thorp and Covich, 1991; Westfall and May, 1996; Merritt and Cummins, 1996; Wiggins, 1996) to key specimens to the lowest possible taxon, usually genus. Because most taxonomy is based on terrestrial adult stages, identification of larvae to species is difficult or impossible for many taxa. Lack of keys to Mexican taxa and limited distributional data also make species identification difficult.

We identified 2,459 individuals of 118 taxa (Table 2). The number of taxa by habitat ranged from 94 in rivers to 16 in ciénegas. Although we limited our collections to presence-absence, we observed that most taxa were present only in low densities. We were only able to collect single individuals of some taxa despite spending full days sampling. Additionally, because we could not sample every site in every season, seasonality represents overall occurrence in the basin and not occurrence in a specific site (Table 2). The only taxa commonly present in large numbers were *Hyalella* (Amphipoda: Taltridae) and *Palaemonetes suttkusi* (Decapoda: Palaemonidae). *Hyalella* in the basin are probably at least 2 different species, but Cole (1984) suggested that there might be 6 species.

We used Non-Metric Multidimensional Scaling (NMDS) combined with Multi-Response Permutation Procedure (MRPP) to discern differences in invertebrate assemblages between

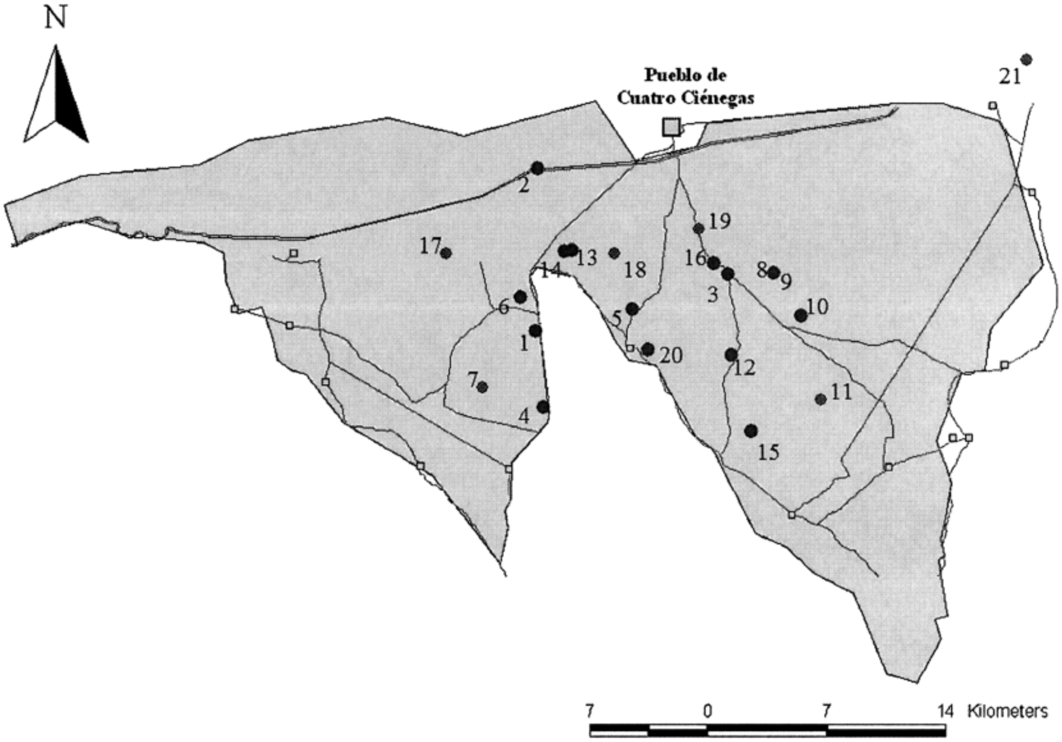

FIG. 1—Map of the Cuatro Ciénegas basin, Mexico, showing aquatic habitats sampled for aquatic invertebrates in 1999 and 2000. See Table 1 for names of numbered habitats. Shaded area defines the boundary of the Protected Area. Lines are major roadways located in and around the basin.

habitat types. NMDS allows visualization of patterns, and MRPP is a significance test using randomization that tests null hypotheses of no grouping (e.g., invertebrate assemblages are not different from one habitat to another). MRPP analysis showed that there were significant differences in the invertebrate assemblages among all habitat types ($P = 0.002$), but pairwise comparisons showed that invertebrate assemblages in pozas were not significantly different from laguna assemblages ($P = 0.43$), suggesting that these habitats share many qualities, such as water chemistry and substrate types. For a complete description of analyses and test results, see Dinger (2001).

Our knowledge of the distribution of aquatic insects throughout the basin is incomplete. For example, we made visual observations of adult alkali flies (Diptera: Ephydridae) in one location (Las Salinas), but upon our later return, we did not find them in any of our samples. Furthermore, previous records of anostracans in Laguna Grande (Cole, 1984) suggest that we should have collected them, but they were not present in any of our samples. Continued sampling over a longer time frame will fill in the gaps of our knowledge. All specimens are currently in the collection of ECD, but will be deposited in invertebrate collections of the University of Texas at Austin, Universidad Autónoma de Nuevo León, and Universidad Nacional Autónoma de México.

Identification of possible endemic species is confounded by the limitations of larval taxonomy, as well as a lack of distributional data for the region. With further studies, certain invertebrate taxa could prove to be endemic to the basin. These are likely to be insects with limited dispersal capabilities, such as riffle beetles (Coleoptera: Elmidae), or other groups with low vagility, such as leeches (Annelida: Hirudinea). It is hoped that our preliminary study will stimulate future regional studies.

Our collections also included several exotic species (Table 3), including the previously reported turban snail, *Melanoides tuberculata* (Gas-

TABLE 2—List of taxa, habitat preference, seasonality, and distributional data for aquatic invertebrates collected form Cuatro Ciénegas basin, Coahuila, México, 1999 and 2000. Habitat type: Ca = canal, Ci = ciénega, PL = playa lake, Po = poza, R = river, L = laguna. Seasonality: S = summer, F = fall, W = winter. Site code key is in Table 1.

Taxa	Habitat	Season	Site
Insecta			
Coleoptera			
Curclionidae			
Notiodes	Ca	W	12
Dryopidae			
Helichus suturalis	Po, R	S, W	15, 17
Dytiscidae			
Brachyvatus	PL	S	7
Cybister	L, R	S, W	17, 20
Hydrovatus	L, Po, R	S, W	5, 12, 17
Rhantus	L	W	12
Elmidae			
Heterelmis	Ca	S	19
Hexacylloepus scabrosus	R	S	16, 17, 19
Macrelmis	R	S	RSN
Microcylloepus	Po, R	S, W	15–17
Stenelmis	Po	S	15
Gyrinidae			
Gyretes	R	S	16
Haliplidae			
Haliplus	L, PL	S, W	7, 9, 12
Hydrochidae			
Hydrochus	L	S	7
Hydradenidae			
Octhebius	Ca	W	12
Hydrophilidae			
Berosus	L, PL, Ca, R	S, W	7, 12, 17
Enochrus	L, R	S, W	17
cf. *Helochares*	R	S	17
Laccobius	PL, Po	S, W	5, 9
Tropisternus	Ci, L, R	S, W	6, 10
T. lateralis	L, Ca	W	12
Lutrochidae			
Lutrochus	Po, Ca	S, F, W	2, 5, 9
Psephenidae			
Psephenus texanus	Po, R	S, W	4, 16, 18
Diptera			
Ceratopogonidae			
Bezzia/Palpomyia	Po, R	S, F, W	16–19
Probezzia	PL	S, F	2, 15
Culicoides	Ca, R	S, F	2, 17, 19
Chironomidae			
various taxa	All	S, F, W	All

TABLE 2—Continued.

Taxa	Habitat	Season	Site
Culicidae			
Aedes	Ca	W	12
Dixidae			
Dixella	L, Po	W	5, 6, 15
Simuliidae			
Simulium	R	S, W	3
Stratiomyidae			
Nemotelus	Ca	W	12
Stratiomys	Po, Ca, R	S, W	4, 5, 12, 17
Tabanidae			
Chrysops	L, Po, Ca, R	S, F, W	4, 12, 15, 16, 20
Tabanus	R	S	17
Tipulidae			
Hexatoma	Po, Ca	S, F	14, 19
Limonia	Po	W	15
Limnophila	R	F	16
Ephemeroptera			
Baetidae			
Americabaetis	Po, R	S, W	15, 16, 18
Baetodes	R	S	18
Baetis	L	S, F, W	6
Callibaetis	L, Po, R	S, F, W	4–6, 16–18
Camelobaetidius	Ca	S	19
Fallceon	Ca, L, R	S, W	2, 3, 17, 19
Caenidae			
Caenis	Ci, L, PL, Po, R	S, F, W	3, 7, 9–12, 14, 15, 17
Ephemeridae			
Hexagenia	PL, Po, R	S, F, W	7, 15, 18
Leptophebiidae			
Thraulodes	L, Po, Ca, R	S, F	5, 6, 12, 15, 16, 18
Traverella	Ca, R	S, W	18, 19
Tricorythodidae			
Tricorythodes	Ci, PL, Po, Ca, R	S, F, W	2, 5, 7, 11, 14–19
Leptohypes	R	S, W	18
Hemiptera			
Gerridae			
Metrobates	Po, R	S, F	15, 16
Trepobates	R	S	17
Aquarius	Ci	S	10
Belostomatidae			
Abedus	R	S	RSN
Belostoma	Ci, R	S	11, 17
Lethocerus	R	S	17
Corixidae			
Trichocorixia	Ci	S	9, 11

TABLE 2—Continued.

Taxa	Habitat	Season	Site
Hebridae			
Merragata hebroides	Ci, Po, R	S	4, 10, 17
Hydrometridae			
Hydrometra	R	S	17
Mesoveliidae			
Mesovelia	R	S	17
Naucoridae			
Ambrysus californicus	Ci, L, Po, Ca, R	S, F, W	2, 3, 5–7, 10, 12, 16–18
Nepidae			
Ranatra	Ca	S	19
Veliidae			
Rhagovelia novahispanae	R	S, F	16
Lepidoptera			
Pyralidae			
Petrophila	L, Po, R	S, F, W	6, 16
Megaloptera			
Corydalidae			
Corydalus luteus	Ca, R	S, W	14
Sialidae			
Sialis	PL, R	S, F, W	7, 18
Odonata (suborder Zygoptera)			
Calopterygidae			
Hetaerina americana	R	S, W	16
H. titia	R	S	RSN
Coenargrionidae			
Argia fumipennis	R	S	17
A. plana	R	S	RSN
A. pulla	L, Po, Ca, R	S, F, W	3–5, 12, 15, 17, 18
A. nahuana	Po	S	4
A. sedula	R	S	16, 18
A. tonto	PL	S	5
A. translata	L, Po, R	S, F, W	1, 5, 13, 14, 16
Enallagma basidens	L, Po, R	S, F, W	1, 5, 15–18
Enallagma 1	Po, Ca	W	5, 12, 15
Enallagma 2	L	W	12
Enallagma 3	Po	W	14
Hesperoagrion heterodoxum	R	S	17
Nehallenia minuta	Po	W	5
Protoneuridae			
Protoneura	R	S	RSN
Odonata (suborder Anisoptera)			
Aeshnidae			
Anax junius	L, R	S, W	12, 16
A. walsinghami	L, R	S	17

TABLE 2—Continued.

Taxa	Habitat	Season	Site
Gomphidae			
Erpetogomphus compositus	PL, R	S, W	7, 16–18
Phyllogomphoides	PL, Po, R	S, W	7, 15, 16
Progomphus borealis	PL, Po, Ca, R	W	5, 7, 12, 17
Libellulidae			
Libellula auripennis	Po, R	W	18
Pachydiplax longipennis	R	S	17
Macomiinae			
Macromia annulata	Ci, L, PL, Po, R	S, F, W	4, 9–11, 16, 18, 20
Orthoptera			
Acridadae			
Leptysma	R	S	17
Trichoptera			
Helicopsychidae			
Helicopschye	Ca	S	19
Hydrobiosidae			
Atopschye	R	S, W	18
Hydroptilidae			
Hydroptila	R	S, W	16
Leucotrichia	R	S	RSN
Mayatrichia	R	S	16
Metrichia	Ca, R	S	17, 19
Oxeytheira	L, R	W	6, 17
Hydropschydiae			
Leptonema	Ca, R	S, W	18, 19
Smicridea (Rhyacophylax)	Ca, R	S	19
Smicridea (Smicrideae)	Ca, R	S	16
Leptoceridae			
Nectopschye	R	W	16
Oecetis	PL, R	S, W	19
Polycentropidae			
Cernotina	Po, R	S, F, W	4, 15–17
Polyplectropus	Ca, R	S, W	3, 16, 19
Crustacea			
Amphipoda			
Taltridiae			
Hyalella 1	All	S, F, W	All
Hyalella 2	L, R	S, W	18
Decapoda			
Palaemonidae			
Palaemonetes suttkusi	All	S, F, W	4, 6, 7, 10–12, 15–18, 20
Cambaridae			
Procambarus clarkii	L, R	S	13, 17, 18

TABLE 2—Continued.

Taxa	Habitat	Season	Site
Ostracoda			
various taxa	Ci, L, PL, Po, R	S, F, W	4, 7, 10, 12, 16–18, 20
Arachnida (Chelicerata)			
Acarina			
various taxa	All	S, W	4–7, 10–12, 14–18
Annelida			
Hirudinodiea			
Glossiphniidae			
Helobdella 1	R	S	16, 17
Helobdella 2	R	W	18
Hirundinidae			
Unknown	R	S	16
Oligochaeta			
various taxa	All	S, F, W	All
Mollusca			
Gastropoda			
Physidae			
Physella	Ci, L	S, F, W	7, 11, 12, 16, 17
Ancylidae			
Hebetancylus	Po, R	S, W	14, 16
Thiaridae			
Melanoides tuberculata	Ca, Po, R	S, F, W	2, 4
Turbellaria			
Dugesia	L, Ca, R	S, F, W	1, 3, 4, 6, 12–19
Nematoda			
various taxa	Po	S	17

TABLE 3—Known locations of invertebrate exotic species collected from Cuatro Ciénegas basin, Coahuila, Mexico, 1999 and 2000. Río Salado de Nadadores is immediately outside the basin, but was connected through canals.

Species	Collection locality	New record
Cobicula fluminea, Asiatic clam	Río Salado de Nadadores	Yes
Melanoides tuberculata, turban snail	Poza Churince	No
	Río Mesquites	No
	Santa Tecla	No
	Canal de la Becerra	No
Thiara granifera, turban snail	Río Salado de Nadadores	Yes
Procambarus clarkii, southeastern crayfish	Río Garabatal	Yes
	Río Mesquites	Yes
	Mojarral Este	Yes

tropoda: Thiaridae) (Contreras-Arquieta, 1998). *Melanoides tuberculata* was collected in 1994 by Contreras-Arquieta (1998) at 2 sites, including Poza de La Becerra, where we failed to find living specimens despite approximately 40 total hours of searching in all possible microhabitats (only one shell with travertine deposits on it was found). This does not mean that *M. tuberculata* is not there, but if they are, then any potential ecological effect in this poza is probably minimal. In Poza Churince, *M. tuberculata* was abundant only in the decaying detritus of cattails (*Typha dominguensis*) that lined portions of the littoral zone. *Melanoides tuberculata* did not inhabit locations where native hydrobiid snails occur. *Melanoides tuberculata* was abundant in intermediate size classes only (1 to 2 cm) in Canal de la Becerra. The fourth site with *M. tuberculata* was Santa Tecla, where they were collected with limited sampling effort.

The southeastern crayfish, *Procambarus clarkii* (Decapoda: Cambaridae) is at the edge of its natural range just outside the basin (Campos and Rodríguez-Almaraz, 1992), but given the number of canals built in Cuatro Ciénegas and the failure of early researchers to record its presence, we suspect that it has been recently introduced. Although we collected it at 4 sites in the basin, this is a conservative estimate, because our standard collection techniques often did not collect crayfish. Because *P. clarkii* is omnivorous, is resistant to desiccation, and burrows (Hobbs, 1991), it has the potential to negatively affect multiple trophic levels.

We collected another exotic species, the Asiatic clam *Corbicula fluminea* (Pelecypoda: Corbiculidae), only in one artificial site—the Canal de Río Cañon. While not yet collected in a natural site, presence of *C. fluminea* in the Río Salado de Nadadores, east and downstream from the basin, and the turban snail, *Thiara granifera* (Gastropoda: Thiaridae), indicate that both *C. fluminea* and *T. granifera* pose potential threats to the basin. Contreras-Arquieta (1998) observed the upstream migration of *M. tuberculata* from the Río Salado de los Nadadores into Cuatro Ciénegas from 1986 until their collection in 1994. It is likely that these exotics will continue to emigrate upstream until they inhabit the waters of Cuatro Ciénegas.

Our results show that there is a diverse assemblage of aquatic insects in Cuatro Ciénegas despite their low abundances. In addition, 4 exotic invertebrates pose potential threats to the native fauna and should be carefully monitored.

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STATUS OF *DIONDA DIABOLI* AND REPORT OF ESTABLISHED POPULATIONS OF EXOTIC FISH SPECIES IN LOWER SAN FELIPE CREEK, VAL VERDE COUNTY, TEXAS

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ABSTRACT—Sampling from April 2001 to March 2003 revealed San Felipe Creek, Val Verde County, Texas, still supported a breeding population of the threatened Devils River minnow (*Dionda diaboli*). The species was restricted to creek habitats and was not found in the outflow channels of San Felipe Springs. We determined that breeding populations of introduced tropical fish species *Hypostomus* (a South American armored catfish) and *Oreochromis aureus* (an African cichlid) also were present in San Felipe Creek. We obtained evidence to suggest that presence of exotic species, particularly *Hypostomus,* might have a negative effect on the Devils River minnow. We recommend periodic monitoring of fish populations in San Felipe Creek to document future changes in the population of Devils River minnow and other endemic species, and to facilitate design and implementation of conservation plans in San Felipe Creek.

RESUMEN—Muestreos entre abril de 2001 y marzo de 2003 mostraron que el riachuelo San Felipe, condado de Val Verde, Texas, todavía alberga una población reproductiva de la amenazada sardinita *Dionda diaboli.* La especie estuvo restringida a los hábitats del arroyo, y no se encontró en los canales de corrientes del manantial de San Felipe. Determinamos que poblaciones reproductivas de las especies introducidas de peces tropicales *Hypostomus* (un bagre de Sudamérica) y *Oreochromis aureus* (un cíclido africano) también están presentes en el riachuelo de San Felipe. Obtuvimos evidencia para sugerir que la presencia de especies exóticas, particularmente *Hypostomus,* podría tener un efecto negativo sobre la sardinita *D. diaboli.* Recomendamos monitoreo periódico de las poblaciones de peces en el riachuelo de San Felipe para documentar cambios futuros en la población de la sardinita y otras especies endémicas, y para facilitar el diseño e implementación de planes de conservación en el riachuelo de San Felipe.

Introduction of non-indigenous species into fragile desert ecosystems can have irreversible effects on the native fauna (Edwards, 2001; Edwards et al., 2002; Echelle et al., 2003). In western Texas, the increasing demands that agriculture and urban development place on already limited water resources (e.g., Urbanczyk, 2003) create additional threats for native species. Construction of dams, groundwater pumping, and introduction of nonnative taxa, among other human-induced alterations, have caused the decline or disappearance of several fishes in the Chihuahuan region of Texas (Hubbs and Garrett, 1990; Edwards et al., 2002; Hubbs, 2003; Echelle et al., 2003).

Spring-fed San Felipe Creek, Val Verde County, Texas, is one of the remaining habitats for the Devils River minnow (*Dionda diaboli,* Cyprinidae), a species listed as threatened by the Texas Parks and Wildlife Division and the United States Fish and Wildlife Service (Garrett et al., 1992, 2004). The creek also harbors 2 other state-threatened fishes: Rio Grande darter (*Etheostoma grahami*) and proserpine shiner (*Cyprinella proserpina*). All 3 species are listed as vulnerable in the IUCN Red List (http://www.redlist.org/; species 6623, 6139, and 8115, respectively). Range of *D. diaboli* in Texas also includes the Devils River, Sycamore Creek, and a recently discovered population in Pinto Creek (Kinney County). The species was extirpated from Las Moras Creek, parts of the Devils River, and possibly Sycamore Creek (Garrett et al., 1992, 2004). San Felipe Creek was last sampled in 1989, and *D. diaboli* was not found in the headwaters, but densities in other localities had not changed significantly in the last 10 years (Garrett et al., 1992). To our knowledge, this was the last report of the status of *D. diaboli* in San Felipe Creek. Other recent work reported 2 South American exotic fish species in San Felipe Creek. A single specimen of the Raphael catfish (*Platydoras costatus,* Doradidae) was collected in 1999 (Howells, 2001), and 4 specimens of the armored catfish *Hypostomus* (Loricariidae) were captured on November 1997 in the San Felipe Country Club (G. Garrett, pers. comm.; Texas Natural History Collection catalog number 25205). A previous extensive survey in 1989 did not report any exotic catfishes (Garrett et al., 1992).

Presence of a loricariid catfish in San Felipe Creek is of potential concern for Devils River minnow and other endemic species. Loricariid catfishes are specialized and efficient algivores (Power et al., 1989; Armbruster, 2003) that might compete for food resources with other algae-eating species, including *D. diaboli* (Garrett et al., 2002). Loricariids have established relatively large, viable populations in some locations in Texas. *Hypostomus* has been established in the San Antonio River at least since 1964 (Barron, 1964; Edwards, 2001), and reproducing populations of *Pterygoplichthys* were recently reported from Bexar, Hays, and Harris counties (Edwards, 2001; Nico and Martin, 2001). In this note, we offer an update on the status of the Devils River minnow in the lower portion of San Felipe Creek and report potential effects of reproducing populations of the armored South American catfish *Hypostomus* and the African cichlid *Oreochromis aureus.*

San Felipe Creek, a tributary of the Rio Grande, is a spring fed, clear-water stream extending from a point 4 km (2.5 miles) north of United States Highway 90 to its confluence with the Rio Grande, just south of the city of Del Rio, Val Verde County, Texas (Brune, 1981; Texas Parks and Wildlife, http://www.tpwd.state.tx.us/). Five sites were monitored quarterly from April 2001 to May 2003 along the segment of San Felipe Creek that bisects the San Felipe Country Club and borders Roosevelt Park in the city of Del Rio. San Felipe Springs (2 springs located east and west of San Felipe Creek) are located within the country club, and their outflows join the creek within the golf course. Results presented are a subset from a broader, community-level study of this portion of San Felipe Creek (Winemiller et al., unpubl.). Sampling sites were chosen to facilitate comparison of aquatic communities from: 1) sites upstream of the spring outflows versus sites downstream from the outflows and 2) sites within spring outflows versus sites on San Felipe Creek. These comparisons should help determine: 1) if the golf course and related activities affect habitat or community assemblage along this segment of San Felipe Creek and 2) whether habitat or fish communities in spring outflows are different from those in the creek. Site 1 (29°22.29N, 100°53.04W) was located approximately 75 m downstream of the eastern spring outflow, several meters above its juncture with San Felipe Creek. Site 2 (29°22.30N, 100°53.04W) was located in San Felipe Creek in the middle of the golf course, approximately 100 m north of United States Highway 90. Site 3 (29°22.24N, 100°53.06W) was located in San Felipe Creek approximately 50 m upstream from the northern boundary of the golf course. Site 4 (29°22.37N, 100°53.15W) was located approximately 75 m downstream of the western spring outflow, upstream from its juncture with San Felipe Creek. Site 5 (29°21.79N, 100°53.29W) was located in San Felipe Creek approximately 200 m south of United States Highway 277, on the western boundary of Roosevelt Park.

Channel width (measured at 9 points and 3 transects along a 30-m channel segment during each sampling event) was 8.5 to 9.5 m on average at sites 1 through 4, and 13.3 to 14 m at site 5. Average channel depth (measured as above) was roughly 42 cm at site 1; 54 cm at site 2; 44 cm at site 3; 65 cm at site 4; and 1 m at site 5. Average water temperature at all sites ranged between 22 and 24°C, but the creek sites showed some seasonal variation, particularly at sites 2 and 3 (Fig. 1). Substrate composition was generally a mixture of sand and gravel, frequently covered by a fine layer of silt and detritus. The only exception was site 3, in which the substrate was entirely formed by bedrock covered with a layer of silt. Sites 1 and 4 (spring outflows), and to a lesser extent site 5 (creek), had dense and diverse cover of sub-

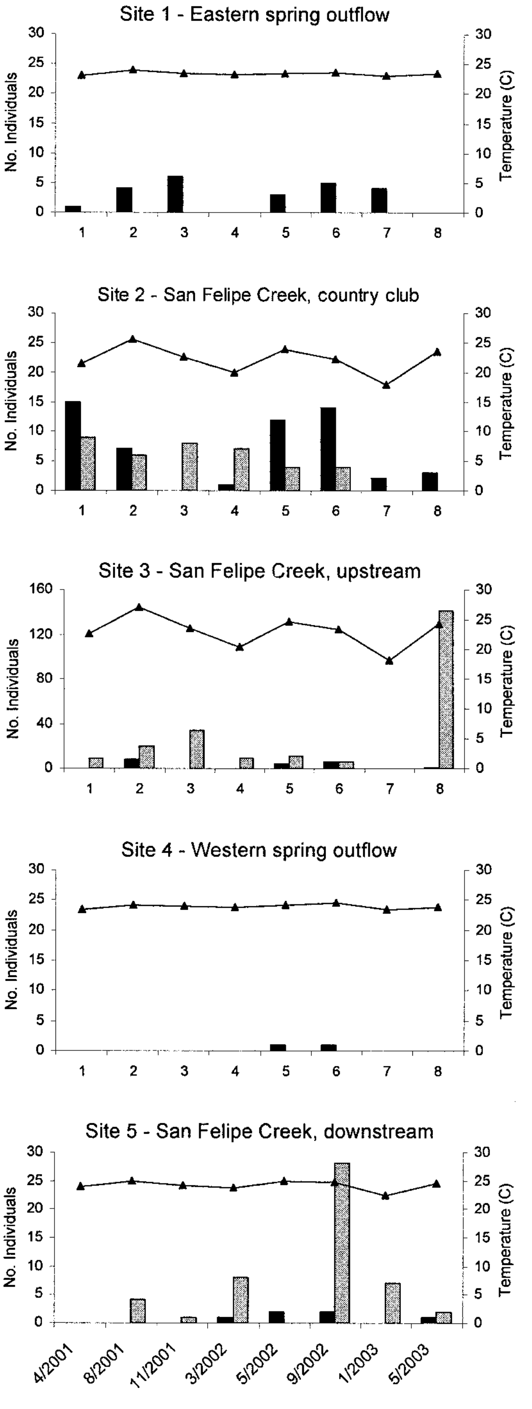

FIG. 1—Water temperature and number of individuals of *Hypostomus* and the Devils River minnow (*Dionda diaboli*) captured at 5 sites in San Felipe Creek and San Felipe spring outflows in Del Rio, Texas, from April 2001 to May 2003. Line = temperature, black columns = *Hypostomus,* gray columns = *D. diaboli.* Note that left-scale for site 3 graph is different from the others.

←

merged plants (e.g., *Chara, Bacopa, Ludwigia*), whereas site 2 had only small patches of *Chara,* and site 3 had virtually no submerged vegetation. Site 1 had the most diverse riparian vegetation, including a variety of grasses and tree species. Sites 2 and 4 had a mixture of golf-course turf and some tall grasses; at site 2, emergent grasses densely covered the left bank of the creek. Site 3 was lined by a belt of tall grasses several meters wide, frequently overhanging, and partially submerged in the aquatic habitat. At site 5, the left bank was channelized by a rock wall that delimits Roosevelt Park, whereas the right bank was covered by tall grasses and residential gardens.

During each survey, we attempted to document assemblage composition and species relative abundances at each site. Fishes were sampled using a 3 m × 1.8 m, 3.2-mm mesh seine along a 30-m reach of stream. All available habitat types in each site were sampled, and each site was seined until 5 consecutive hauls produced no additional species in the sample. Voucher specimens of fishes were deposited in the Texas Cooperative Wildlife Collection, Texas A&M University, College Station.

Devils River minnow was captured in relatively low abundance during most survey events at the 3 San Felipe Creek sites (Fig. 1, gray bars), but was never captured from the 2 spring outflows. Abundance of Devils River minnow was highest at site 3, and peaked during November 2001, when many juveniles were captured, and May 2003, when only juveniles where collected. At site 2, *D. diaboli* numbers declined over the study period and eventually disappeared, whereas *Hypostomus* increased, especially during the summer months. Devils River minnow was also collected at site 5, but usually in low numbers. Juvenile recruitment was evident during each of the 2 summer surveys. Devils River minnow in San Felipe Creek seems to prefer stream seeps, as has been also observed in the Devils River population (Hubbs and Garrett, 1990). *Dionda diaboli* apparently prefers habitats near submerged vegetation (Garrett et al., 2002, 2004), but our samples revealed the species was most abundant at sites 2 and 3, where submerged vegetation was scarce or completely absent. However, sites 2 and 3 had abundant riparian vegetation overhanging the banks, probably offering a structure similar to that of submerged macrophytes.

No specimens of the previously reported Raphael catfish (Howells, 2001) were captured, but 2 other introduced species were found in San Felipe Creek. Juveniles of the African cichlid *Oreochromis aureus* (blue tilapia) were sporadically collected at sites 2, 3, and 5, and adults of the species were seen but not captured at site 5. The blue tilapia has been present in the Rio Grande Basin for at least 40 years, and it is now widespread in the region (Fuller et al., 1999; Edwards et al., 2002). This cichlid is an omnivore-detritivore (Gu et al., 1997) that consumes algae and, thus, might compete with algivorous *D. diaboli.* Blue tilapia reproduce in San Felipe Creek, as demonstrated by the capture of juveniles, but the relatively small population did not seem to be a major threat to *D. diaboli.*

During the first 4 surveys, the loricariid catfish (*Hypostomus*; J. Armbruster, pers. comm.) was captured repeatedly at sites 1 and 2, and sporadically at sites 3 and 5. During the second year, individuals were collected at all 5 sites. Size of captured specimens ranged from 10 to 260 mm standard length. Juveniles (<50 mm standard length) dominated our samples, and the average size of *Hypostomus* tended to increase over time, especially in our summer and fall samples, suggesting that the population was expanding. *Hypostomus* was more abundant at sites 1 and 2, especially during the warmer months, and presence of large numbers of juvenile specimens indicated breeding during that period. Abundance of *Hypostomus* in samples from site 2 largely correlates with water temperature. *Hypostomus* was captured in higher numbers during warmer periods at sites 2 and 3, the locations with greatest temperature variation. Even at site 1, a spring-outflow channel, where temperature was stable year-round, *Hypostomus* was more abundant during summer months.

Hypostomus was probably introduced by aquarium release sometime between 1989 and 1997, and the population has expanded since then, with recruitment apparently during the spring and summer months. Low temperatures partly explain population reduction during the winter. Shafland and Pestrak (1982) found that *Hypostomus* (it is not known if this is the same undescribed species) could resist temperatures as low as 11.2°C, which were never observed during our surveys. More likely, mortality during colder months is influenced by other factors. Increased predation on juveniles by native predators (e.g., largemouth bass) during winter, or reduced primary production and food availability might contribute to the observed population decline, particularly reduction of small individuals. It also is possible that *Hypostomus* might be more difficult to capture during the colder months. *Hypostomus* and *D. diaboli* both graze attached algae and associated microorganisms. Combining species abundance at all sites, analysis of total number of individuals of both species showed a significant association between species and sampling date ($\chi^2 = 111.7$, $df = 7$, $P < 0.001$). Independence of abundance of both species across dates is expected if abundance of one species does not affect abundance of the other. On this basis, changes over time in abundance of *D. diaboli* are associated with changes in the population of *Hypostomus*. Given this trend at all sites, gradual reduction of Devils River minnow densities at site 2 might be a consequence of the expansion of the *Hypostomus* population. Further expansion of *Hypostomus* in San Felipe Creek might have additional detrimental effects on the population of Devils River minnow and other native fishes.

San Felipe Creek continues to support a breeding population of *D. diaboli*. Implementation of monitoring of fish populations in San Felipe Creek should reveal future changes in the population of Devils River minnow and other species of concern (e.g., proserpine shiner, Rio Grande darter), and will facilitate conservation planning in the creek. Public relations efforts should be undertaken to discourage people from introducing additional aquarium fishes into the San Felipe Creek system.

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HELMINTH PARASITES OF FOUR SPECIES OF ANURANS FROM NUEVO LEON, MEXICO

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Abstract—We examined 50 amphibians of 4 species (*Bufo marinus, B. nebulifer, Rana berlandieri,* and *Scaphiopus couchii*) from 4 localities in the state of Nuevo León, Mexico. We collected 7 species of digeneans (*Cephalogonimus americanus, Clinostomum* sp. (metacercariae), *Haematoloechus complexus, Halipegus occidualis, Langeronia* cf. *macrocirra, L.* cf. *jimenezi,* and *Megalodiscus americanus*) and 1 monogenean (*Pseudodiplorchis americana*), 3 cestodes (*Distoichometra bufonis, Ophiotaenia filaroides,* and larvae of 1 proteocephalidean), and 4 nematodes (*Cosmocercoides* sp., *Chabaudgolvania* sp., *Rhabdias fülleborni,* and *R. savagei*). Eleven host records are new, and the geographic ranges of *C. americanus, H. occidualis, P. americana, O. filaroides, Chabaudgolvania* sp., *Cosmocercoides* sp., *R. fülleborni,* and *R. savagei* are expanded by these records.

Resumen—Examinamos 50 anfibios de 4 especies (*Bufo marinus, B. nebulifer, Rana berlandieri,* y *Scaphiopus couchii*) de 4 localidades en el estado de Nuevo Léon, Mexico. Se recolectaron 7 especies de digéneos (*Cephalogonimus americanus, Clinostomum* sp. (metacercarias), *Haematoloechus complexus, Halipegus occidualis, Langeronia* cf. *macrocirra, L.* cf. *jimenezi* y *Megalodiscus americanus*), 1 monogéneo (*Pseudodiplorchis americana*), 3 céstodos (*Distoichometra bufonis, Ophiotaenia filaroides* y larvas de un Proteocephalidea) y 4 nemátodos (*Cosmocercoides* sp., *Chabaudgolvania* sp., *Rhabdias fülleborni* y *R. savagei*). Once de los registros de hospedero son nuevos y se amplía la distribución geográfica de *C. americanus, H. occidualis, P. americana, O. filaroides, Chabaudgolvania* sp., *Cosmocercoides* sp., *R. fülleborni* y *R. savagei.*

Because parasites can provide information about ecological interactions, patterns of distribution, and evolutionary history of their hosts and their ecosystems, they should be an

TABLE 1—Localities, amphibian species collected, and number of specimens examined (*n*) from Nuevo Léon, México. Specimens deposited in the Herpetological Collection at the Universidad Autónoma de Nuevo León, México (accession numbers UANL6141-6172).

Locality	Host species	*n*
La Laguna, Higueras (25°56′06″N; 99°59′46″W)	*Rana berlandieri*	29
	Bufo marinus	4
	Bufo nebulifer	2
Río Pesquerías, Zuazua (25°53′31″N; 100°04′47″W)	*Bufo marinus*	1
Río Salinas, El Carmen (25°55′68″N; 100°21′30″W)	*Bufo marinus*	1
	Bufo nebulifer	5
	Scaphiopus couchii	1
La Presita, El Carmen (25°55′63″N; 100°21′14″W)	*Bufo marinus*	7

important component of every biodiversity study. The amphibian species richness of México is among the greatest in the world, with an unusually high endemism (Flores-Villela, 1998). However, fewer than 20% of the amphibian species in México have been examined for parasites (Pérez-Ponce de León et al., 2002). In the state of Nuevo León, 22 species of anurans have been reported (Lazcano-Villarreal and Contreras-Arquieta, 1995); of these, only 4 species have been examined for helminths (Martínez, 1969; Iruegas-Buentello and Salinas-López, 1989). In this paper, we present a list of the helminth parasites in 4 additional species of amphibians from 4 localities in the state of Nuevo León, México (Table 1).

In July 2002, 50 individuals of 4 amphibian species were collected by hand or using nets. Hosts were killed with an overdose of anesthetic (sodium pentobarbital), and all the organs were examined under a stereomicroscope. Collected worms were initially placed in saline (0.65%) and afterwards killed by sudden immersion in hot 70% ethanol. Trematodes, cestodes, and monogeneans were stained with Meyer's paracarmine or Gomori's trichrome and whole-mounted in Canada balsam. Nematodes were cleared in Amman lactophenol or glycerine and examined on temporary slides. Voucher specimens of collected worms were deposited at the Colección Nacional de Helmintos (CNHE) (accession numbers in Table 2), Instituto de Biología, Universidad Nacional Autónoma de México, México City. Hosts were fixed following standard procedures (Simmons, 1985) and deposited at the Herpetological Collection of the Universidad Autónoma de Nuevo León (UANL) (accession numbers in Table 1).

We identified 15 helminth taxa: 7 digeneans, 1 monogenean, 3 cestodes, and 4 nematodes (Table 2). Seven of these species represent new records of parasite taxa in Nuevo León: *Cephalogonimus americanus, Halipegus occidualis, Ophiotaenia filaroides, Chabaudgolvania* sp., *Rhabdias fülleborni, Rhabdias savagei,* and *Pseudodiplorchis americana.* Seven of 11 helminth records are new for *Rana berlandieri* (Table 2). Martínez (1969) reported *Haematoloechus complexus, Langeronia macrocirra, Megalodiscus americanus,* and *Rhabdias sphaerocephala* in *R. berlandieri* from this region (original host record as *Rana pipiens,* but see Scott and Hillis, 1989). *Haematoloechus complexus* also has been recorded in this host species in Huauchinango, Puebla (León-Règagnon, 2003). All helminth records are new for *Bufo nebulifer.* This is the first record of *Langeronia jimenezi* and *Cosmocercoides* sp. in *Bufo marinus.*

Adults of *Clinostomum helvans* and *C. intermediale* were found parasitizing the egret *Ardea herodias* and the cormorant *Phalacrocorax penicillatum,* respectively, in Nuevo León (Bravo-Hollis, 1947). Nevertheless, we cannot assign our specimens to either of those species of *Clinostomum* because diagnostic features are not yet developed in the metacercariae. This is the fifth record of *Clinostomum* as a parasite of amphibians in México and the first in amphibians from Nuevo León.

Our specimens of Proteocephalidea could not be determined at a lower taxonomic level

TABLE 2—Helminth parsites of anurans of Nuevo León, México. Infection sites: I = intestine; E = eustachian tubes; L = lungs; M = mesenteries; m = muscle; S = skin; UB = urinary bladder. Infection modes: IAI = ingestion of aquatic invertebrates; IL = ingestion of larvae; SP = skin penetration. Localities: 1. La Laguna, Higueras; 2. Río Pesquerias, Zuazua; 3. Río Salinas, El Carmen; 4. La Presita, El Carmen. * = new host record; ** = larval stage.

Helminth taxa	Infection site (infection mode)	Host species (locality) helminth accession number			
		Rana berlandieri	*Bufo marinus*	*Bufo nebulifer*	*Scaphiophus couchii*
Platyhelminthes: Digenea					
Cephalogonimidae (Loss, 1899) Nicoll, 1914					
Cephalogonimus americanus Stafford, 1902	I (IAI, SP)	(1) 4629	(1) 4628		
Clinostomidae Lühe, 1901					
*Clinostomum***	M, m, S (SP)	(1*) 4633			
Hemiuridae Loss, 1907					
Halipegus occidualis Stafford, 1902	E (IAI)	(1*) 4630			
Lecithodendriidae Odhner, 1910					
Langeronia cf. *macrocirra* Caballero and Bravo-Hollis, 1949	I (IAI)	(1) 4631			
L. cf. *jimenezi* Iruegas and Salinas, 1989	I (IAI)		(1*) 4632		
Paramphistomidae Fischoeder, 1901					
Megalodiscus americanus Chandler, 1923	I (IAI, SP)	(1) 4627		(1*) 4626	
Plagiorchiidae (Lühe, 1910) Ward, 1917					
Haematoloechus complexus (Seely, 1906) Krull, 1933	L (IAI)	(1) 4634			
Platyhelminthes: Monogenea					
Polystomatidae Gamble, 1896					
Pseudodiplorchis americana (Rodgers and Kuntz, 1940) Yamaguti, 1963	(UB) (SP)				(3) 4635
Platyhelminthes: Cestoda					
Nematotaeniidae Lühe, 1910					
Distoichometra bufonis Dickey, 1921	I (IAI)		(1) 4638 (4) 4637		
Proteocephalidae La Rue, 1911					
Ophiotaenia filaroides La Rue, 1909	I (IAI)	(1*) 4636			
Proteocephalidea**	I	(1*) 4653			
Nematoda					
Cosmocercidae Travassos, 1925					
Cosmocercoides	I (SP)		(1*) 4647 (2) 4646 (3) 4644 (4) 4643	(3*) 4645	
Quimperiidae (Gendre, 1928) Baylis, 1930					
Chabaudgolvania	I (IL)	(1*) 4648			
Rhabdiasidae Railliet, 1916					
Rhabdias fülleborni Travassos, 1926	L (IL, SP)	(1*) 4642	(1*) 4641 (2*) 4640 (4*) 4639		
Rhabdias savagei Goldberg and Bursey (in press)	L (IL, SP)	(1*) 5034			

because they were in the plerocercoid stage. Although we found specimens of *Ophiotaenia filaroides* in the same host and locality, and it has also been recorded in *Rana dunni* from Pátzcuaro, Michoacán (Pulido, 1994), we cannot assign the plerocercoids to this species because diagnostic morphological features have not yet been developed.

We did not identify *Cosmocercoides* and *Chabaudgolvania* to species because we found only females, and the diagnostic characters for species in this genus are based on the arrangement of papillae in males. Previous *Cosmocercoides* records in México include *C. variabilis* in the anguid lizard *Barisia imbricata* from Hidalgo state, in the alligator lizard *Gerrhonotus ophius* from Veracruz state (Goldberg et al., 1999), and in the leopard frog *Rana magnaocularis* from Sonora state (Goldberg and Bursey, 2002); *C. dukae* in the ambystomatid salamander *Ambystoma lermaensis* from Mexico state (Mata-López et al., 2002); and *Cosmocercoides* sp. in *Hyla miotympanum* from the state of Nuevo Léon (Martínez, 1969). Our specimens resemble females of *C. variabilis* and differ from females of *C. dukae* in the body size, esophagus length, and tail length, but until males are available, we are unable to determine their specific identity. *Chabaudgolvania elongata* is the only species of that genus recorded in Mexico, where it has been found in ambystomatid salamanders from the central region of the country (Caballero and Bravo-Hollis, 1938; Baker, 1986; Mata-López et al., 2002). Our female specimens resemble *C. elongata* because of the small size of the esophagic bulb and the morphology of the cephalic region, where 3 onchia are present. Nevertheless, specific identity of specimens of this genus can only be determined by the number and distribution of caudal papillae in males.

Specimens of *Langeronia* show a large amount of morphological variation, thus the taxonomy of this genus has been controversial (Ubelaker, 1965; Christian, 1970; Dailey and Goldberg, 2000). Morphology of specimens collected in *Rana berlandieri* from La Laguna, Higueras, corresponds to the original description of *L. macrocirra* (Caballero and Bravo-Hollis, 1949), although measurements are slightly different, while morphological traits of specimens collected in *Bufo marinus* from the same locality correspond to *L. jimenezi* (Iruegas-Buentello and Salinas-López, 1989). A detailed study on the intraspecific variation of these species to determine the validity of *L. jimenezi* is currently in progress.

The host species that harbored the highest species richness of helminths is *Rana berlandieri* with 11 helminth taxa. Most of them are acquired in the aquatic environment with the ingestion of invertebrates (Freeze, 1969; Yamaguti, 1971; Anderson, 2000) (Table 2). The predominantly aquatic habits of this host species and its broad diet probably affect the richness of its helminthological fauna, which is composed predominantly of trematodes (6 species) that include in their life cycles aquatic invertebrates as intermediate hosts. In contrast, hosts, such as *Bufo nebulifer, Bufo marinus,* and *Scaphiopus couchii,* that have more terrestrial habits harbor no more than 5 helminth taxa, the majority of which are nematodes or monogeneans acquired in the terrestrial environment (Table 2). This correspondence between a higher number of platyhelminth species and water dependency of hosts has been well documented (Brandt, 1936; Goater et al., 1987; Aho, 1990; Guillén-Hernández et al., 2000; Pérez-Ponce de León et al., 2000), and our data support this observation.

All of the helminth taxa recorded in this study are typical of amphibians with the exception of the metacercariae of *Clinostomum.* Specimens of *Clinostomum* mature in ichthyophagous birds. They are frequently found as metacercariae in fish and less frequently in amphibians (Yamaguti, 1971). *Rana berlandieri* might serve as a paratenic host for this species.

Pseudodiplorchis americana is a typical highly specific parasite of *Scaphiopus* (Kuntz, 1941; Lamothe, 1985; Tinsley and Jackson, 1986, 1988) and was the only species we found in *S. couchii.* Goldberg and Bursey (1991) examined the gastrointestinal tract and lungs of 76 specimens of *S. couchii* from southern Arizona, and they recorded 2 nematode species (*Aplectana incerta* and *Oswaldocruzia pipiens*) and 1 cestode species (*Distochometra bufonis*). These 3 species are generalists of several groups of amphibians (Baker, 1987; Goldberg and Bursey, 1991), and 2 of them (*O. pipiens* and *D. bufonis*) were found in low prevalence and abundance. The differences between the helminth record of *S. couchii* in Arizona and this study might be due to the fact that we collected only one specimen of this host species, and the record might not be well represented. On the other hand, *P. americana* was not found in *S. couchii* of Arizona, because this species inhabits the urinary bladder and this organ was not examined in the study of Goldberg and Bursey (1991). This is the second record of this helminth species in México; the first was in Baja California Sur (Lamothe, 1985).

The genus *Rhabdias* has a worldwide distribution. It contains 48 species that are parasites in the lungs of amphibians and reptiles (Baker, 1978; Bursey et al., 2003; Bursey and Golberg, in press). In Mexico, 7 species have been reported, 3 Nearctic species: *R. americanus* (Goldberg and Bursey, 2002), *R. ranae* (Goldberg and Bursey, 2001, 2002) and *R. fuscovenosa* (Pérez-Ponce de León et al., 2001); 3 Neotropical species: *R. fülleborni* (Galicia-Guerrero et al., 2000; Goldberg et al., 2002), *R. tobagoensis* (Goldberg et al., 2002), and *R. elegans* (Goldberg et al., 2002); and 1 Palearctic species: *R. sphaerocephala* (Bravo-Hollis and Caballero, 1940; Caballero, 1949; Caballero-Deloya, 1974). Among the collected specimens, we found 1 of the species recorded previously. *Rhabdias fülleborni* presents an inflated corpus, pre-equatorial vulva, and large body size (Travassos, 1926). *Rhabdias savagei* was identified based on its small body size, the inflated corpus, the presence of 4 lips, the post-equatorial position of the vulva, and the shape and length of the tail (Bursey and Golberg, in press). This represents the first record in Mexico; it was described originally in *R. forreri* from Costa Rica (Bursey and Golberg, in press). These 2 species are typical of anurans. Martínez (1969) reported *Rhabdias sphaerocephala* in *Bufo marinus* and *Rana berlandieri* from Nuevo León, México, although Baker (1987) suggested that this species was not present in the Americas.

Martínez (1969) studied the helminths of *Rana berlandieri, Bufo marinus, B. nebulifer* (originally recorded as *B. valliceps,* but see Mulcahy and Mendelson, 2000), and *Hyla miotympanum* in Nuevo León, Mexico. He recorded 7 species in *R. berlandieri,* 3 in *B. marinus,* 1 in *B. nebulifer,* and 2 in *H. miotympanum.* Comparing his helminth record with our data, we found that they only share 5 species (*M. americanum, H. complexus, L.* cf. *macrocirra, D. bufonis,* and *Cosmocercoides*). We did not find 4 of the species recorded by that author (*Gorgoderina megalorchis, Oswaldocruzia pipiens, Rhabdias sphaerocephala,* and *Aplectana* sp.), but on the other hand, we found 8 taxa that were not recorded in that study (*Cephalogonimus americanus, Langeronia* cf. *jimenezi, Clinostomum* sp., *Halipegus occidualis, Ophiotaenia filaroides, Pseudodiplorchis americana, Rhabdias fülleborni, Rhabdias savagei,* and *Chabaudgolvania* sp.), most of them typical parasites of amphibians. These differences in the helminthological record are partially due to the host species that were examined [Martínez (1969) did not examine specimens of *Scaphiopus couchii,* and we did not examine *Hyla miotympanum*], and probably to the ecological conditions of each particular locality (we only sampled in 1 of the 3 localities studied by that author). It is also possible that the specimens of *Rhabdias sphaerocephala* recorded by Martínez (1969) actually belong to one or both species reported herein. Unfortunately, specimens are not available for reexamination.

Most of the helminth fauna reported in this study is typical of the Nearctic region (with the exception of *Langeronia* cf. *macrocirra, Rhabdias savagei,* and *Rhabdias fülleborni,* which are Neotropical species), contrasting with studies of helminths of amphibians in more southern localities on the Atlantic slope of Mexico, in which the helminth record was composed almost entirely by Neotropical species (Guillén-Hernández et al., 2000; Goldberg et al., 2002). The biogeographical history is determinant on the composition of the helminth record. It has been well documented that a vicariant event took place in the eastern coast of Mexico during the late Miocene, with the formation of the Transvolcanic Belt and the elevation of the sea level (Ewing and López, 1991). This event caused a division of the Gulf Coastal Plain into northern and southern sides in the central area of the state of Veracruz, and has been supported by biogeographical evidence (Rosen, 1978; Pérez-Higareda and Navarro, 1980; Mulcahy and Mendelson, 2000; Zaldivar-Riverón et al., 2004). The parasitological data presented herein give additional support to previous biogeographical evidence showing the potential of information that can be obtained by including parasites in biodiversity studies (Brooks, 2003; León-Régagnon, 2003).

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LIFE HISTORY CHARACTERISTICS SUPPORT SEPARATE ORIGINS OF D-DESIGNATION COLOR PATTERN CLASSES IN PARTHENOGENETIC *ASPIDOSCELIS TESSELATA* (SQUAMATA: TEIIDAE)

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ABSTRACT—We compared several life history characteristics between 2 syntopic color pattern classes (Conchas C-E and Conchas D) of parthenogenetic *Aspidoscelis tesselata* from Conchas Lake, New Mexico. These pattern classes lacked significant differences in mean clutch size, mean size of gravid females, SVL frequency distributions of gravid females, and SVL frequency distributions of complete samples. We then compared the Conchas Lake assemblage to the other 2 pattern class assemblages (Higbee, Colorado, and Sumner Lake, New Mexico) whose life history characteristics had been previously reported. Comparisons of life history attributes within and between the 3 assemblages augment morphological and genetic evidence that each population of pattern class D was derived by mutation from individuals of pattern classes C or C-E in different geographic areas.

RESUMEN—Comparamos varias características de historia de vida entre 2 clases sintópicas de patrones de coloración (Conchas C-E y Conchas D) de la lagartija partenogenética *Aspidoscelis tesselata* de lago Conchas, Nuevo México. Estos patrones de coloración no presentaron diferencias significativas en el tamaño promedio de la puesta, tamano promedio de las hembras grávidas, distribución de frecuencias de LHC de hembras grávidas, y distribución de frecuencias de LHC de las muestras completas. Entonces, comparamos la ensambladura del lago Conchas con las otras 2 ensambladuras de clase (Higbee, Colorado, y lago Sumner, Nuevo Mexico) cuyas características de historias de vida han sido reportadas previamente. Comparaciones de los atributos de historias de vida dentro y entre las 3 ensambladuras aumentan la evidencia morfológica y genética de que cada población con un patrón de coloración clase D se derivó por mutación de individuos con patrones de coloración clases C o C-E en diferentes localidades geográficas.

Evolution in parthenogenetic *Aspidoscelis tesselata* is evidenced by modified karyotypes (Wright and Lowe, 1967; Taylor et al., 2001), genotypic variation (Parker and Selander, 1976; Dessauer and Cole, 1989; Taylor et al., 2003), and different color-pattern classes (Zweifel, 1965; Walker et al., 1995; Walker et al., 1997) that are maintained by clonal inheritance (barring mutations) in laboratory and field settings (Dessauer and Cole, 1986; Taylor et al., 2001, 2003). Evolution in life history characteristics also has occurred. Our studies of life history characteristics in *A. tesselata* have focused on 3 assemblages of color pattern classes at Sumner Lake, De Baca County, New Mexico; Conchas Lake, San Miguel County, New Mexico; and Higbee, Otero County, Colorado. For each assemblage, representatives of different pattern classes are syntopic at some sites, thereby facilitating an interpretation of within-area and between-area differences. The Sumner Lake and Higbee assemblages have been compared for snout-vent length (SVL) distributions, SVL of the smallest reproductive individual, mean SVL of gravid females, and mean clutch size. All 4 characteristics are significantly different between pattern classes C and E at Sumner Lake, contrasting with an absence of such differences in pattern classes C and D at Higbee (Taylor et al., 1999, 2000). Unfortunately, the pattern class assemblage at Conchas Lake, New Mexico, could not be included in these comparisons because we lacked samples of gravid females.

The purpose of this study was to complete the comparisons based on recently acquired samples from the Conchas Lake assemblage of *A. tesselata*. The within-assemblage and between-assemblage comparisons provided an explanation for the similarities and differences among the 3 assemblages. In addition, new evidence was acquired to test the hypothesis that pattern class D originated independently in each geographic area by mutations in individuals of pattern classes C or C-E (Taylor et al., 1996, 2003), an idea first proposed by Zweifel (1965).

One of the 2 color pattern classes at Conchas Lake is a D, and pattern class C has been the traditional designation for the second pattern class (Zweifel, 1965; Walker et al., 1997; Cordes and Walker, 2003; JMW, in litt.). However, Taylor et al. (2003) considered the C-designation to be misleading because E-like as well as C-like color pattern elements were present in adult representatives of this Conchas Lake pattern class. This impression was further supported by discriminant and canonical variate analyses (CVA) of color pattern and scalation characters; therefore, designation C-E was used for the non-D pattern class at Conchas Lake (Taylor et al., 2003). To facilitate communication, we identify specific samples by combining general sampling locality and pattern class.

Samples of Conchas C-E and Conchas D were collected during June 2000, a month in which gravid individuals would be expected. Comparative samples of *A. tesselata* from the Higbee and Sumner Lake assemblages are listed in Taylor et al. (2000) and Appendix 1, and representatives of the assemblages are illustrated in Walker et al. (1997) and Taylor et al. (2003). Statistical analyses were conducted with SPSS 11.0 software (SPSS, Inc., Chicago, Illinois). We used linear regression to verify the relationship between clutch size and SVL, *t*-tests to compare sample means, the Mann-Whitney test to compare SVL frequency distributions, and $\alpha = 0.05$ to interpret results of statistical tests. We follow Reeder et al. (2002) in using *Aspidoscelis* rather than *Cnemidophorus* for the species in question to avoid paraphyly in the latter genus as previously constituted.

Three morphological subgroups of Conchas C-E (1, 6, and 8) were previously identified by CVA, using meristic characters and samples of 3 genotypic clones (I, VI, and VIII) as a priori groups (Taylor et al., 2003). We pooled these subgroups, which also presumably include the unaccounted for clone VIIC of Parker (1979), because none was distinctive in clutch size ($F_{2,21} = 0.458$, $P = 0.64$). The pooled sample of Conchas C-E included 3 year-classes estimated from SVL distributions and collecting dates: individuals in their second year (60 to 75 mm, $n = 26$), third-year individuals (82 to 90 mm, $n = 15$), and fourth-year individuals (93 to 96 mm, $n = 8$). Gravid individuals included 2 individuals in their second year (both 73 mm SVL, with 1 and 2 eggs, respectively), 15 individuals in the third year-class (1 to 5 eggs), and 8 individuals in the fourth year-class (4 to 7 eggs) (Fig. 1). Among these 25 gravid females, the most frequent clutch sizes were 3 (6 females) and 4 (6 females), and the largest clutch of 7 eggs was present in 2 large lizards of 95 and 96 mm SVL.

Based on SVL distributions, the sample of Conchas D also included 3 year-classes: second year (63 to 71 mm, $n = 11$), third year (82 to 90 mm, $n = 5$), and fourth year (92 to 98 mm, $n = 4$). In contrast to Conchas C-E, only individuals in the third year-class (2 to 4 eggs, $n = 5$) and fourth year-class (4 and 6 eggs, $n = 3$) were gravid (Fig. 1), and the modal number of eggs was 4 ($n = 3$ females). The largest clutch of 6 eggs was present in the largest lizard of 98 mm SVL.

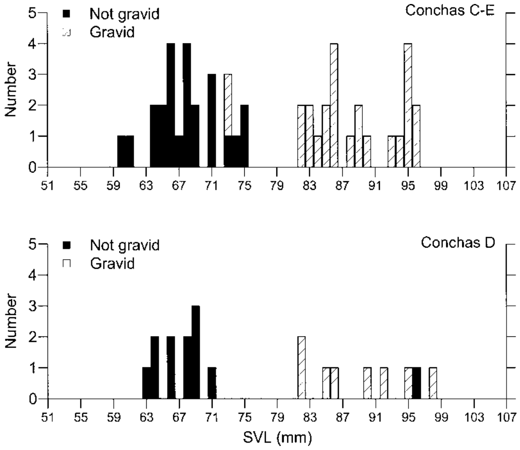

FIG. 1—Body size (snout-vent length, SVL) distributions and reproductive status of females in samples of color-pattern classes Conchas C-E and Conchas D of *Aspidoscelis tesselata* from Conchas Lake State Park, San Miguel County, New Mexico.

A difference in size at reproductive maturity was suggested (73 mm SVL in Conchas C-E and 82 mm SVL in Conchas D), but the small size of the Conchas D sample makes this conclusion provisional (Fig. 1). The ratio of 49 individuals of Conchas C-E to 20 individuals of Conchas D was consistent with previous observations that Conchas C-E is the more abundant pattern class (Taylor et al., 2003). However, neither clutch size (t_{31} = 0.188; P = 0.85) nor SVL of gravid individuals (t_{31} = 0.460; P = 0.65) was significantly different between the 2 pattern classes. Their similarities extended to SVL frequency distributions (Fig. 1), both for gravid females (Mann-Whitney U = 95.5; P = 0.85) and for all individuals in the samples (Mann-Whitney U = 461.0; P = 0.70). That largest clutches were found in largest females was consistent with clutch size being positively related to SVL in the pooled sample of Conchas C-E and Conchas D (R^2 = 0.60; $F_{1,31}$ = 47.229, $P < 0.001$).

Genetic evidence indicates that *A. tesselata* originated from a single hybrid (Maslin, 1967; Cordes and Walker, 2003) of *A. tigris marmorata* × *A. gularis septemvittata* (Neaves, 1969; Parker and Selander, 1976) produced in either northern Chihuahua or Trans-Pecos Texas (Parker and Selander, 1976). A single origin implies that mutations in the descendants of one female were responsible for the patterns of phenotypic divergence seen in *A. tesselata*. One pattern is the striking differences in life history characteristics between Sumner C and Sumner E. These differences exceed those between *A. exsanguis* and *A. flagellicauda* (Taylor and Caraveo, 2003)—parthenogenetic species arising from independent hybridizations between taxonomically different progenitors (Good and Wright, 1984; Densmore et al., 1989; Reeder et al., 2002). Our observations suggest that Sumner C and Sumner D operate with matching reproductive cycles and activity periods in shared habitats, all reducing the likelihood that environmental effects were responsible for their life history differences. Inferred genotypic differences and disparate morphological (Taylor et al., 2003) and life history differences suggest they were acquired prior to colonization of the Sumner Lake area.

The Higbee C and Higbee D assemblage and the Conchas C-E and Conchas D assemblage are each characterized by an absence of significant differences in SVL of gravid females and clutch size between the pattern classes at each site (for Higbee C and Higbee D: SVL: t_{37} = 1.336, P = 0.19; clutch: t_{37} = 1.151, P = 0.26; Taylor et al., 1999, 2000). This justified pooling pattern classes from each site for between-area comparisons. Although clutch size (Higbee: 4.7 ± 0.22 eggs; Conchas Lake: 4.0 ± 0.28 eggs) was similar (t_{70} = −1.964, P = 0.054), gravid females from Higbee were larger on average (92.9 ± 1.2 mm SVL, n = 39) than gravid females from Conchas Lake (87.8 ± 1.1 mm SVL, n = 33) (t_{70} = −3.157, P = 0.002).

Expression of similar life history patterns by Conchas D and Conchas C-E and by Higbee D and Higbee C reflect recent origins of these D-pattern classes from pattern classes C-E and C in these geographic areas. Sumner D is rare (Taylor et al., 1997), and only 5 individuals were seen (and collected) from 1995 through 1997; none was seen during visits to the park in 2002 and 2003. We hypothesize that Sumner D is the most recently derived of the D pattern classes and was (or is) in the process of establishment at this locality.

We express our appreciation to the State of New Mexico, Department of Game and Fish, for scientific collecting permits. Specimens at Regis University and University of Arkansas were collected under the authority of Scientific Collecting Permit 1905 issued to HLT and Scientific Collecting Permit 1850 issued to JEC. W. Rencehausen provided Special Use Permits for work at Conchas Lake State Park, and K. Sommerland, Park Ranger, Department of Army, Corps of Engineers (Conchas), granted permission to collect on adjacent federal government land. Regis University TSSC and SPARC Summer Research Grants supported field work of HLT in 2000, 2002, and 2003. We thank M. Paulissen for constructive suggestions for improving the manuscript and J. E. Lemos-Espinal for providing the resumen.

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APPENDIX 1

Primary Material—New Mexico, San Miguel County, vicinity of Conchas Lake. Numbers in parentheses (1, 6, and 8) are morphological subgroups identified by CVA of meristic characters, using samples of known genotype (I, VI, and VIII; Parker and Selander, 1976) as a priori groups for subgroup assignment (Taylor et al., 2003). *Aspidoscelis tesselata* (Conchas C-E): Along Army Corps of Engineer road east of and paralleling the entrance road to Conchas Lake State Park, approximately 1 km from the origin of this road east of the entrance to Central Recreation Area: Regis University, Department of Biology (RU) 0001 (8), 0002 (6), 0003 (6), 0008 (8), 0009 (6), 0010 (8), 0011 (1), 0012 (6), 0013 (1), 0014 (1), 0015 (6), 0016, 0017 (8), 0018 (1), 0019 (6), 0020 (1), 0021 (1), 0022 (1), 0027 (8), 0028 (1), 0029 (6), 0030 (1), 0031 (6), 0032 (6), 0033 (8), 0037, 0038 (6), 0039 (1), 0040, 0041 (1). North side Canadian River, 200 to 300 m below dam: GM (G. Manning, University of Arkansas, Department of Biological Sciences) 110 (1), 111 (1), 112 (1); south side Canadian River, near one-way road into park, below dam: GM 113, 114; south side Canadian River, plateau above river: GM 116 (8); south side Canadian River, parking lot below dam: GM 119, 120 (1); south side of Canadian River, South Recreation Area: GM 129; Central Recreation Area fronting lake: GM 136 (6), 137 (1), 138, 139; north side Canadian River, north of Park Office and North Recreation Area near Boy Scout camp: GM 142, 143 (1), 145 (1), 146 (1); north side of Canadian River, near (below) North Recreation Area: GM 147; north side of Canadian River, near (above) North Recreation Area: GM 152 (1). *Aspidoscelis tesselata* (Conchas D): New Mexico, San Miguel County. Along Army Corps of Engineer road east of and paralleling the entrance road to Conchas Lake State Park, 1 km from the origin of this road east of the entrance to Central Recreation Area: RU 0004–0007, 0023–0026, 0034–0036, 0042–0046. South side of Canadian River, 200 to 300 m below spillway, very close to river: GM 121, 122, 141. South of Canadian River Central Recreation Area of park, fronting lake: GM 134.

Comparative Material Collected in 2002—*Aspidoscelis tesselata*. New Mexico, De Baca County, Sumner Lake State Park. (1) adjacent to road leading to Eastside Campground, north of New Mexico Highway 203: Sumner C: RU 02025–02031, 02041, 02043, 02044, 02051. Sumner E: RU 02032–02034, 02042, 02054. (2) 3.2 km on road east of entrance to Eastside Campground leading to primitive area of park: Sumner C: RU 02037; Sumner E: RU 02035, 02036, 02038, 02039, 02045, 02046. (3) 4.5 km on road east of entrance to Eastside Campground leading to primitive area of park: Sumner C: GM 457, 460–463, 471; Sumner E: GM 458, 469, 474.

Sumner Lake specimens collected in 1995, 1996, and 1997 are identified in Taylor et al. (2000).

REPRODUCTIVE CHARACTERISTICS OF TWO SYNTOPIC, WIDELY FORAGING LIZARDS, *ASPIDOSCELIS DEPPII* AND *ASPIDOSCELIS GUTTATA* FROM OAXACA, MÉXICO

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ABSTRACT—We studied the reproductive characteristics, such as snout-vent length (SVL) at sexual maturity, clutch size, and egg volume, and morphological characteristics [head length (HL), head width (HW), femur length (FL), and tibia length (TL)] in *Aspidoscelis deppii* and *A. guttata* from Oaxaca, Mexico. In *A. deppii,* males were larger in SVL than females, whereas in *A. guttata,* females were larger than males. Males of *A. deppii* had larger morphological structures, such as HL, HW, FL, and TL, than females; in contrast, males and females of *A. guttata* were similar, except in TL, in which females were larger. Mean clutch size was 2.3 for *A. deppii* and 4.5 for *A.*

guttata. Females of *A. deppii* had smaller egg volume than females of *A. guttata*. Both *A. deppii* and *A. guttata* respond to the environmental factors from this region, but in different ways.

RESUMEN—Estudiamos las características reproductivas tales como longitud hocico-cloaca (LHC) a la madurez sexual, tamaño de la puesta y volumen del huevo, y las características morfológicas [largo de la cabeza (LC), ancho de la cabeza (AC), largo del fémur (LF), y largo de la tibia (LT)] in *Aspidoscelis deppii* y *A. guttata* de Oaxaca, México. En *A. deppii,* los machos fueron más grandes en LHC que las hembras, mientras que en *A. guttata,* las hembras fueron más grandes que los machos. Los machos de *A. deppii* presentaron estructuras morfológicas más grandes, como LC, AC, LF, y LT que las hembras; en contraste, machos y hembras de *A. guttata* fueron similares, excepto en LT, en que las hembras fueron más grandes. La media del tamaño de la puesta fue de 2.3 en *A. deppii* y de 4.5 en *A. guttata*. Las hembras de *A. deppii* presentaron un volumen más pequeño que las de *A. guttata*. Ambas especies *A. deppii* y *A. guttata* responden a los factores ambientales de la región, pero en diferente forma.

Many descriptive studies have been conducted on squamate reproduction in different environments (Guillette, 1981, 1982; Benabib, 1994; Ramírez-Bautista and Vitt, 1998; Ramírez-Bautista et al., 2002). These studies have provided information for the formulation and testing of hypotheses of life history evolution. The first studies on this topic were conducted by Tinkle (1969) and his colleagues (Tinkle et al., 1970), showing that lizard species that invest more energy in each reproductive event tend to mature early and are short-lived and highly fertile. In contrast, species that invest less energy in each reproductive event distribute the reproductive effort over a longer time period, and thus tend to be late-maturing and long-lived, and have fewer clutches. Recently, studies have shown that part of life history variation among species is historical (Vitt, 1992). That means that related species tend to be more similar in life history characteristics than unrelated ones. For example, snout-vent length (SVL) at sexual maturity, clutch and egg size, and clutch frequency in *Sceloporus* are more similar within species groups (*scalaris* and *spinosus*) than between them (Valdéz-González and Ramírez-Bautista, 2002).

In Mexico, species of the genus *Aspidoscelis* inhabit a wide range of environments, ranging from desert-temperate zones to wet and dry tropical (seasonal) environments. However, most of the studies on reproduction in *Aspidoscelis* have been focused on desert, temperate, and montane species in the United States, and few in tropical dry forest of Mexico (Ballinger and Schrank, 1972; Shall, 1978; Vitt and Breitenback, 1993; Vitt et al., 1997). *Aspidoscelis deppii* and *A. guttata* belong to the *A. deppii* species group (Reeder et al., 2002) and occur in sympatry in this area of tropical dry forest.

Few studies on reproduction have been carried out among lizards from the tropical dry forest of southeastern Mexico. Thus, conclusions regarding life history characteristics among lizards from such habitats will not be known until considerably more data become available.

We present data on selected reproductive characteristics and morphological characteristics for 2 tropical dry-forest syntopic whiptail lizards from Villa de Tututepéc de Melchor Ocampo (16°07′5″N, 97°36′25″W), Oaxaca, México, at an elevation of 250 m. The dominant vegetation in this area is thorn-scrub forest; the climate is warm and sub-humid, with precipitation concentrated during the summer and early fall (June–October). Mean annual temperature is 24°C (range 22.3 to 27.1°C; García, 1981) and mean annual precipitation is 1,600 mm (Campos et al., 1992).

We examined *A. deppii* (adult females and males, $n = 26$; juveniles, $n = 12$; one neonate) and *A. guttata* (adult females and males, $n = 12$; juveniles, $n = 4$). All individuals were collected on August 7 through 14 and December 14 through 29, 1999 by rubber bands in the same vegetation type. Lizards were sacrificed, measured (SVL to the nearest 1.0 mm), weighed (to the nearest 0.1 g), and fixed with 10% formalin, and the gonads were examined.

We counted the number of vitellogenic follicles, oviductal eggs, or both, measured the length and width of the left and right vitellogenic follicles or freshly ovulated eggs to the nearest 0.1 mm, and weighed the eggs to the nearest 0.01 g.

TABLE 1—Mean values (±1 *SE*) of morphological characteristics (SVL = snout–vent length, HL = head length, HW = head width, FL = femur length, and TL = tibia length) of sexually mature females and males of *Aspidoscelis deppii* ($n = 26$) and *A. guttata* ($n = 12$) from Villa de Tututepéc de Melchor Ocampo, Oaxaca, México. The statistical test is Mann-Whitney (* = $P < 0.05$, ** = $P < 0.001$, *** = $P < 0.0005$, n.s. = not significant).

	A. deppii			*A. guttata*		
Characteristics	*Males* ($n = 17$)	Females ($n = 9$)	Z	*Males* ($n = 3$)	Females ($n = 9$)	Z
Body mass (g)	15.1 ± 1.2	8.0 ± 0.64	−3.37***	14.5 ± 1.4	22.4 ± 3.5	−2.31*
SVL (mm)	76.3 ± 1.6	66.3 ± 1.6	−3.29**	76.0 ± 2.0	87.3 ± 5.1	−2.65*
HL (mm)	19.8 ± 0.64	16.5 ± 0.31	−3.5***	20.1 ± 0.15	21.9 ± 1.2	−1.3 (n.s.)
HW (mm)	12.5 ± 0.40	9.1 ± 0.16	−3.8***	11.7 ± 0.7	12.7 ± 1.0	−0.28 (n.s.)
FL (mm)	10.3 ± 0.23	8.2 ± 0.18	−3.8***	10.6 ± 1.1	11.4 ± 0.8	−0.46 (n.s.)
TL (mm)	16.6 ± 0.33	13.7 ± 0.32	−3.6***	17.8 ± 1.3	18.6 ± 1.1	−0.28 (n.s.)

Length and width of the gonads were used to obtain follicular and egg volume (V) using the formula for volume of an ellipsoid (Selby, 1965): $V = (^4/_3)\pi a^2 b$, where a is half the shortest diameter and b is half the longest diameter (see Ramírez-Bautista et al., 2002). The smallest female (as SVL) with either the largest vitellogenic follicles or oviductal eggs was used to estimate minimum size at maturity. Males were considered sexually mature if they showed enlarged testes and enlarged and highly convoluted epididymides (Goldberg and Lowe, 1966).

The morphological variables used to test sexual differences were SVL (mm), head length (HL, mm) and width (HW, mm), forearm length (FL, mm), and tibia length (TL, mm). Because these variables usually vary with SVL, we first calculated regressions of $\log_{10}$-transformed data for all variables with $\log_{10}$-transformed SVL. For significant regressions, we calculated residuals from the relationship of variables on SVL to produce SVL-adjusted variables. We used these residuals to examine sexual size differences between mature males and females and performed a Mann-Whitney *U*-test on HL, HW, FL, and TL. Means are presented ±1 *SE*. Statistical analyses were performed with the Macintosh version of Statview 4.5 (Abacus Concepts, 1992).

Body Size at Sexual Maturity—In *A. deppii,* sexually mature males ranged in size (SVL) from 61.0 to 87.0 mm, whereas females ranged from 59.0 to 73.0 mm. In *A. guttata,* sexually mature males ranged in size from 74.0 to 78.0 mm, and females ranged from 68.0 to 115.0 mm. There were differences between sexes in mean SVL of *A. deppii* and *A. guttata* (Table 1). Mean SVL of females was higher than males for *A. guttata,* but mean male SVL of *A. deppii* (Table 1) was similar in both species ($P = 0.748$). Males of *A. deppii* had larger SVL, HL, HW, FL, and TL than females (Table 1); in contrast, males and females of *A. guttata* had similar HL, HW, FL, TL, though SVL was larger in females (Table 1). Sexual dimorphism in body size is well known among lizard species. Males are often larger in SVL than females (Stamps, 1983) and have larger heads than females of the same size (Censky, 1995). Males *A. deppii* reached sexual maturity at larger size than females and attained larger maximum size and mass than females, a different pattern than occurs in many other species of *Aspidoscelis* from tropical environments (Fitch, 1973; Vitt et al., 1993; Ramírez-Bautista et al., 2000; Ramírez-Bautista and Pardo-De la Rosa, 2002). Also in this species, males were larger in HL, HW, FL, and TL than females, similar to sceloporine species (Ramírez-Bautista et al., 2002). In contrast, females and males of *A. guttata* in these morphological structures were similar, except in SVL, which was larger in females. Sexual size dimorphism in *A. deppii* might result from sexual selection in which larger males are at an advantage over smaller males in acquiring mates; however, larger females than males in *A. guttata* could be explained if larger females had larger clutch sizes, but no relationship was found between these variables. Another possible explanation is that, when no correlation exists between female SVL and clutch size,

TABLE 2—Mean value of reproductive characteristics of *Aspidoscelis deppii* and *A. guttata* from Villa de Tututepéc de Melchor Ocampo, Oaxaca, México. Mean ± *SE* (range, sample size). SVL = snout–vent length.

Characteristics	*A. deppii*	*A. guttata*
Vitellogenic follicles number	6.7 ± 1.9 (3 to 9, n = 3)	5.3 ± 2.6 (2 to 13, n = 4)
Oviductal eggs number	2.3 ± 0.25 (2 to 3, n = 4)	4.5 ± 0.5 (4 to 5, n = 3)
Oviductal eggs volume (mm^3)	305.9 ± 49.2 (195.7 to 396.7)	890.9 ± 120.8 (722.4 to 1125.1)
SVL adult males (mm)	76.3 ± 1.6 (61.0 to 87.0, n = 17)	76.0 ± 2.0 (74.0 to 78, n = 3)
SVL adult females (mm)	66.2 ± 1.6 (59.0 to 73.0, n = 9)	87.3 ± 5.1 (68.0 to 115, n = 9)
Clutch frequency	2	2

larger females have larger neonates; this could occur in this species (Vitt, 1986; Vitt and Breitenbach, 1993; Ramírez-Bautista and Vitt, 1998).

Clutch Size—Clutch size of the 2 species varied from 2 to 5 (Table 2). Estimates based on vitellogenic follicles of *A. deppii* were higher (6.67 ± 1.8, $n = 3$) than oviductal eggs (2.3 ± 0.25, $n = 4$; Mann-Whitney *U*-test, $Z = -1.95$, $P < 0.05$) in females collected during August and December. In female *A. guttata,* the clutch size of vitellogenic follicles was similar to that of oviductal eggs (Mann-Whitney *U*-test, $Z = -0.387$, $P = 0.696$; Table 2). Clutch size was higher in *A. guttata* than *A. deppii* (Mann-Whitney *U*-test, $Z = -1.90$, $P < 0.05$). Clutch size of *A. deppii* was similar to other populations of the same species from tropical environments (Fitch, 1973; Vitt et al., 1993). Clutch size was not related to female SVL in *A. deppii* ($r^2 = 0.42$, $P > 0.05$) or in *A. guttata* ($r^2 = 0.11$, $P > 0.05$). Most species of the genus *Aspidoscelis* exhibit a positive relationship between clutch size and body size (Ballinger and Schrank, 1972; Schall, 1978; Ramírez-Bautista et al., 2000; Ramírez-Bautista and Pardo-De la Rosa, 2002); however, this pattern was different in these species and similar to other populations of *A. deppii* (Fitch, 1973; Vitt et al., 1993). Belonging to the *deppii* group, these 2 species of *Aspidoscelis* probably produce several clutches per season, as occurs in many whiptail lizards (Fitch, 1970, 1973; Ballinger and Schrank, 1972; Schall, 1978; Vitt and Breitenbach, 1993; Vitt et al., 1993). However, they exhibit a distinct pattern from that of other species of *Aspidoscelis* (Ramírez-Bautista et al., 2000; Ramírez-Bautista and Pardo-De la Rosa, 2002). Two females (25%) of *A. deppii* and 4 (50%) of *A. guttata* had vitellogenic follicles and oviductal eggs simultaneously, suggesting the laying of 2 or more clutches during the reproductive season. It is possible that the peak of reproduction in both species occurs during August, September, and October. In August, most females of *A. deppii* and *A. guttata* had vitellogenic follicles and oviductal eggs, and one hatchling (SVL = 30.0 mm) of *A. deppii* was caught in the field on December 27. During December, mean SVL of juveniles of *A. deppii* was 48.2 ± 1.61 mm (40.0 to 59.0, $n = 12$) and was 54.3 ± 4.6 (47.0 to 66.0, $n = 4$) for *A. guttata.*

Clutch Volume—Variation in vitellogenic follicles and egg volume existed in *A. deppii* (Mann-Whitney *U*-test, $Z = -2.31$, $P < 0.05$) and *A. guttata* (Mann-Whitney *U*-test, $Z = -2.24$, $P < 0.05$). Vitellogenic follicles volume in *A. deppii* and *A. guttata* was similar (Mann-Whitney *U*-test, $Z = -1.23$, $P = 0.219$). Considerable variation in clutch volume was found (Table 2). Females of *A. deppii* had smaller egg volume than females of *A. guttata* (Mann-Whitney *U*-test, $Z = -2.12$, $P < 0.05$). Low clutch size and clutch volume likely reflect the influence of the foraging mode on the evolution of morphology within Teiidae and likely have their origins in an ancient ancestor (Dunham and Miles, 1985; Vitt, 1992; Pianka and Vitt, 2003).

Although reproductive characteristics of both *A. deppii* and *A. guttata* are similar to that of other species of *Aspidoscelis* in clutch frequency and clutch size in relation to female SVL (Fitch, 1970), these characteristics are different in other species of the genus (Ballinger and Schrank, 1972; Vitt et al., 1997; Ramírez-Bautista et al., 2000; Ramírez-Bautista and Pardo-De la Rosa, 2002). In general, like all *Aspidoscelis* species, *A. deppii* and *A. guttata* are oviparous, with small clutch size and probably a small relative clutch mass. These reproductive characteristics shared in species of the *Aspidos-*

celis genus indicate the influence of foraging mode on the evolution of morphology within the entire clade Teeidae and likely had their origins in a distant ancestor (Dunham and Miles, 1985; Dunham et al., 1988; Vitt, 1992; Vitt and Breitenbach, 1993). However, additional data are needed to make conclusions about variation in clutch size and other reproductive characteristics in these species inhabiting an environment with seasonal variation.

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HERPETOFAUNAL INVENTORY OF FORT WOLTERS IN NORTH-CENTRAL TEXAS

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Abstract—Herpetofaunal diversity of the Fort Wolters Military Installation, Texas, was surveyed from September 2002 through August 2003. During the 1-y sampling period, all amphibian and reptile sampling methods combined resulted in 1,421 captures of 10 species of amphibians (all anurans) and 25 species of reptiles. These actions represent an effort of the Texas Army National Guard to inventory the flora and fauna of federal property and create a baseline for future monitoring and management.

Resumen—La herpetofauna de la Fort Wolters Military Installation, Texas, fue monitoreada de septiembre de 2002 a agosto de 2003. Durante el año del periodo de muestreo, todos los métodos de muestreo de anfibios y reptiles combinados resultaron en 1,421 de 10 especies de anfibios (todos anuros) y 25 especies de reptiles. Estas acciones representan un esfuerzo del Texas Army National Guard de llevar a cabo un inventario de la flora y fauna de la propiedad federal y de crear una base para futuros monitoreos y manejo.

The ecological, economic, and esthetic dimensions of biodiversity represent components of biological diversity that hold value based on our direct utilization of natural resources (Wilson, 1992; Lovejoy, 1997; Meffe and Carrol, 1997). Managing for biodiversity is therefore a priority for state and federal natural resource and wildlife agencies. One threat to regional biodiversity relates to trends in land-use practices that can result in fragmented or destroyed habitat, thus increasing the probability that some components of biodiversity will experience local extinction in these habitat patches (Newmark, 1995). In some instances, local biodiversity loss has lead to cascading ecosystem-wide changes in other natural resources (Cardinale and Palmer, 2002; Srivastava, 2002). Guided by this reasoning, the Texas Army National Guard (ARNG) implemented an Integrated Natural Resources Management Plan (INRMP) in 2001 to ensure that natural resource conservation measures and all activities conducted by the Texas ARNG are consistent with federal stewardship requirements. The INRMP is an adaptive management plan ensuring that the military mission remains compatible with the sustainability and restoration of forests and grasslands. As a result of this new mission described in the INRMP, it is imperative that all Texas ARNG properties be inventoried for their components of biodiversity. Such baseline information is essential for long-term monitoring of changes in biodiversity in response to trends in land use and development. The purpose of this study was to gather baseline information on amphibians and reptiles at Fort Wolters and establish a foundation for future management decisions allowing for long-term monitoring of biodiversity.

Established in 1925, Fort Wolters is a Texas ARNG training site (ca. 1,613 ha) located on the east side of Mineral Wells, Texas in Parker and Palo Pinto counties. This property is situated in an ecotone transition between the Oak Woods and Blackland Prairie ecological regions. Several streams on the property feed into nearby Lake Mineral Wells (Fisher et al., 1996). Mean annual precipitation is 74.4 cm, and the climate is characterized by hot, humid summers and dry winters. January is the coolest month (average monthly low 0.05°C) and July is the warmest month (average monthly high 36.3°C) (Bomar, 1983). Soils at Fort Wolters consist of Truce-Bonti and Chaney-Truce-Bonti loamy clays (Greenwade et al., 1977), and sloping plains interbedded with sandstone and limestone canyon morphologies characterize the landscape (Fisher et al., 1996).

Most of the native climax vegetation has been described as grassland dominated by little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), Indiangrass (*Sorgastrum nutans*), sideoats grama (*Bouteloua curtipendula*), and silver bluestem (*Bothriochloa saccharoides*). Climax woody vegetation consists of blackjack oak (*Quercus marilandica*), post oak (*Q. stellata*), live oak (*Q. virginiana*), red oak (*Q. texana*), elbowbush (*Forestiera pubescens*), hackberry (*Celtis reticulata*), greenbriar (*Smilax bonanox*), and skunkbush (*Rhus aromatica*) (Farquhar et al., 1996).

We conducted 13 surveys for amphibians and reptiles (herps) from September 2002 to August 2003 by using time-constrained searches, timed nocturnal road searches, and Y-shaped drift-fence arrays (Heyer et al., 1994). In April 2003, we seined ponds on the property using a 3.5-m seine with 10-mm mesh, and in May 2003, we used baited hoop nets and Gee Minnow Traps (Cuba Specialty Manufacturing Company, Fillmore, New York) to trap aquatic amphibians and reptiles in creek channels, ponds, and reservoirs. We deposited voucher specimens, supporting genetic materials, and field notes in the Texas Cooperative Wildlife Collection at the Department of Wildlife and Fisheries Sciences at Texas A&M University. Common names used here follow standards set by the Committee on Standard English and Scientific Names established by the American Society of Ichthyologists and Herpetologists, Herpetologists' League, and Society for the Study of Amphibians and Reptiles (Crother et al., 2003).

All combined herp-sampling methods resulted in 1,421 captures of 10 species of amphibians (all Anurans) and 25 species of reptiles (Table 1; Crother et al., 2003). Time-constrained searches and night driving together accounted for 1,392 (98.0%) of the total captures. These 2 methods also yielded the most species-rich samples, with 30 and 18 species sampled, respectively (Table 2). Nocturnal road searches provided the highest capture rate (1 capture/3.2 min) among amphibian and reptile active sampling methods, while hoop nets provided the highest capture rate (1 capture/1.8 trap nights) among passive sampling methods (Table 2). Eight animals representing 6 species were observed incidentally (Table 2); all of these species were also found with standardized sampling methods.

Although 35 species of amphibians and reptiles were captured, 42.9% of individuals captured were Blanchard's cricket frogs (*Acris crepitans blanchardi*) (Table 1). The cricket frog, gray treefrog (*Hyla versicolor*), spotted chorus

Table 1—Amphibian and reptile species captured by month at Fort Wolters, Texas.

	2002	2003								
Species	Sep	Jan	Feb	Mar	Apr	May	June	Aug	Total	%
Amphibia										
Anura										
Acris crepitans blanchardi	218			33	30	257	49	23	610	42.9
Bufo debilis debilis							11		11	0.8
B. nebulifer	1						6		7	0.5
B. woodhousii woodhousii	1			1	2		3		7	0.5
Gastrophryne olivacea				1	1	1	109		112	7.9
Hyla versicolor				1	1	8	23		33	2.3
Pseudacris clarki				37			135		172	12.1
P. streckeri streckeri			29	85					114	8.0
Rana blairi	28		2	5	1	40		2	78	5.3
R. catesbeiana	90			1		2	1		94	6.6
Reptilia										
Squamata (Lizards)										
Aspidoscelis gularis gularis	4			7	2	12		2	27	1.9
Crotaphytus collaris	1			7		2		1	11	0.8
Eumeces septentrionalis obtusirostris						2			2	0.1
E. tetragrammus brevilineatus				1					1	0.1
Sceloporus olivaceus					3	1			4	0.3
S. undulatus consobrinus	1			3		3			7	0.5
Scincella lateralis	1			4		2			7	0.5
Squamata (Snakes)										
Agkistrodon contortrix laticinctus	2				4	7			13	0.9
A. piscivorus leucostoma	5			3	3	2			13	0.9
Coluber constrictor flaviventris					2				2	0.1
Crotalus atrox				4		2	1		7	0.5
Elaphe slowinskii				2		2	1		5	0.4
E. obsolete lindheimeri						3			3	0.2
Lampropeltis getula splendida						1			1	0.1
Leptotyphlops dulcis dulcis					1				1	0.1
Masticophis flagellum testaceus				2		2	3		7	0.5
Nerodia erythrogaster transversa	3				2	8			13	0.9
N. rhombifer rhombifer						1			1	0.1
Sonora semiannulata				8	1	9		1	19	1.3
Tantilla gracilis				1					1	0.1
Thamnophis proximus rubrilineatus						4			4	0.3
Virginia striatula				1	1	3			5	0.4
Testudines (Turtles)										
Chelydra serpentina	1				1	1			3	0.2
Pseudemys texana				1					1	0.1
Trachemys scripta elegans	15			2		8			25	1.8
Total	371	0	31	210	55	383	342	29	1,421	
%	26.1	0.0	2.2	14.8	3.9	27.0	24.1	2.0		

frog (*Pseudacris clarkii*), and Strecker's chorus frog (*P. streckeri streckeri*) relative abundances combined to make Hylidae the most common family observed (65.4%), followed by Ranidae (11.9%), Microhylidae (7.9%), and Bufonidae (1.8%). Amphibians comprised 87.1% of all herps captured during the entire study. The Texas spotted whiptail (*Aspidoscelis gularis gularis*), red-eared slider (*Trachmeys scripta elegans*), and groundsnake (*Sonora semiannulata*)

TABLE 2—Summary of amphibian and reptile sampling success at Fort Wolters, Texas from September 2002 through August 2003.

Sampling method	Duration	Individuals captured	Individual capture rate	Species richness
Time-constrained searches (*n* = 67)	254.6 h	418	1/36.5 min	30
Nocturnal road searches (*n* = 20)	52.7 h	974	1/3.2 min	18
Seine samples (*n* = 7)	7 ponds	3	1/2.3 ponds sampled	2
Hoop nets (*n* = 8)	16 trap-nights	9	1/1.8 trap-nights	2
Minnow traps (*n* = 25)	100 trap-nights	3	1/33.3 trap-nights	2
Arrays (*n* = 4)	76 trap-nights	6	1/12.7 trap-nights	6
Incidental capture	—	8	—	6

exhibited the highest relative abundances among reptiles with 1.9%, 1.8%, and 1.3% of total captures, respectively (Table 1). Individual relative abundances for other reptiles were less than 1%. The short-lined skink (*Eumeces tetragrammus brevilineatus*), Texas threadsnake (*Leptotyphlops dulcis dulcis*), desert kingsnake (*Lampropeltis getula splendida*), northern diamond-backed watersnake (*Nerodia rhombifer rhombifer*), flat-headed snake (*Tantilla gracilis*), and Texas river cooter (*Pseudemys texana*) were each observed only once during the survey.

Detection of different species varies enormously because of differences in their life histories, activity periods, population numbers, and microhabitat use. These sorts of detection biases are inherent in all general survey methods, and we realized a priori that numbers of individual species would not be easily comparable. For example, anuran breeding vocalizations allowed easy sampling of amphibians, which resulted in biased representation of amphibians in our night-driving data set. Nevertheless, we believe the protocols used were adequate for documenting presence of species and coarse changes in the abundance and distribution of individual species through time.

Night driving was the most efficient sampling method, but these surveys clearly favored detection of nocturnal and crepuscular species. Time-constrained searches yielded fewer captures than night driving, even with more time invested, but produced greater numbers of species and included diurnal, crepuscular, and nocturnal species. Seining, hoop nets, minnow traps, and drift-fence arrays failed to expand the species list generated from night driving and time-constrained searches. The latter 2 methods also were superior for documenting presence of species and coarse changes in their abundance and distribution through time, especially in Anurans. Seining, hoop nets, and minnow traps might be more appropriate for questions targeted specifically at aquatic species. In addition, precise population numbers for any species would require tailored methods and significant effort devoted to the species in question.

Survey trips were planned around periods of favorable weather to optimize survey conditions. This strategy gave us the advantage of finding species that were simply undetectable during unfavorable weather, but also resulted in unequal sampling across months, making temporal comparisons problematic. Still, temporal fluctuations in species abundances of anurans were apparent and revealed a seasonal phenology of the anuran community (Table 1). Chorus frogs were most abundant in the colder, wetter months of late winter (February–March). In the warmer, drier months of late spring (April–May), ranids became more abundant, followed by the more ephemeral breeding treefrogs and toads during the hot summer months (June–August), when weather was least predictable. Reptile species abundances peaked in March, April, and May, with no apparent differences among species.

Thirty-six species known to occur in Palo Pinto and Parker counties (Dixon, 2000) were not observed at Fort Wolters during this study and have never been found there to our knowledge. Of these, the Texas horned lizard (*Phrynosoma cornutum,* state protected) and Brazos River watersnake (*Nerodia harteri,* formerly federally threatened) are of special concern for conservation. The Texas horned lizard is disappearing from the eastern half of Texas, and the suggested causes of its disappearance are variable and complex. One of the most popular theories suggests that widespread use of the pesticide Mirex to eradicate imported fire-ant populations in the 1970s also decimated populations of the common harvester ant, a principal prey item of the Texas horned lizard (Dixon, 2000). Interestingly, Texas ARNG installations, including Fort Wolters, currently use chemical and biological methods to control fire ants, but we noted numerous harvester ant colonies on the property. Anecdotal reports from personnel at Fort Wolters suggest that Texas horned lizards might still be present in the area; however, this survey failed to confirm their presence.

The Brazos River watersnake was listed as threatened under the U.S.A. Endangered Species Act in 1987 when a large reach of its riverine habitat was scheduled to be inundated by reservoirs (Scott et al., 1989). Since then, research has shown that the species was not as adversely affected by the river impoundments as predicted, and in 1998, the United States Fish and Wildlife Service delisted the Brazos River watersnake. Records of Brazos River watersnakes have been reported on the Brazos River within 1 mile of Rock Creek (Dixon, 2000), but this survey failed to confirm their presence at Fort Wolters.

The primary goal of this project was to gather baseline information on amphibians and reptiles at Fort Wolters to help monitor population fluctuations in response to changes in land use and development. Land-use practices have drastically altered the landscape in this region of Texas, and military installations established by Texas ARNG provide islands of protected habitat surrounded by land modified for commercial, agricultural, and residential use. Integration of this baseline information on amphibian and reptile species abundances and distributions with the INRMP will allow assessment of population fluctuations in response to management and land-use practices both on and off Texas ARNG properties.

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TREE SWALLOW ENTANGLED ON TEDDY BEAR CHOLLA SPINES

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Abstract—Avian collisions with human-made objects are relatively common; however, documented avian collisions with naturally occurring objects are rare in scientific literature. On 22 April 2002, we observed a tree swallow (*Tachycineta bicolor*) entangled in the spines of a teddy bear cholla (*Opuntia bigelovii*) in the Tule Mountains, Cabeza Prieta National Wildlife Refuge, Arizona. Two possible causes of this incident include the swallow flying into the teddy bear cholla, possibly being blown by a gust of wind, or being placed there by a loggerhead shrike (*Lanius ludovicanus*). Because of the flying abilities of swallows and documented diets of loggerhead shrikes, either would be unusual.

Resumen—Los choques de aves con objetos hechos por humanos son relativamente comunes, sin embargo los choques de aves con objetos naturales son raramente documentados en la literatura científica. El 22 de abril del 2002, observamos una golondrina bicolor (*Tachycineta bicolor*) enredada en las espinas de una choya güera (*Opuntia bigelovii*) en las montañas de Tule, Cabeza Prieta National Wildlife Refuge, Arizona. Dos causas posibles del incidente incluyen que la golondrina bilocor chocó con la choya, posiblemente empujada por una ráfaga del viento, o puede haber sido colocada allí por un acaudón verdugo (*Lanius ludovicanus*). Debido a capacidades del vuelo de las golondrinas bicolor y las dietas documentadas de los acaudones, cualquiera de estas posibilidades sería inusual.

Avian mortalities due to collisions with various human-made objects have been documented for many species. Collisions with power lines, towers, fences, buildings, wind turbines, and aircraft have been observed for many avian species and are a regular occurrence in some areas (Baines and Summers, 1997; Janss and Ferrer, 1998). Risk of bird-object collisions varies depending on species, behavior, flight capabilities, season, weather conditions, and local situations (e.g., migration route) (Dolbeer et al., 2000; Barrios and Rodríguez, 2004). There are numerous studies documenting avian collisions with human-made objects; however, documented avian collisions with naturally occurring objects are rare in scientific literature (Rea, 1983).

On 22 April 2002, the weather was warm (ca. 26°C) with winds gusting to approximately 24 km/h on ridges in the Tule Mountains on the Cabeza Prieta National Wildlife Refuge, Arizona (32°14′23.9″N, 113°50′24.0″W). At approximately 0800 h, we observed a tree swallow (*Tachycineta bicolor*) entangled in the spines of a teddy bear cholla (*Opuntia bigelovii*) along the crest of a ridgeline. The spines of the cholla were embedded in the left side of the swallow, primarily in the wing and side of the head. The tree swallow was struggling, which suggested the incident had occurred recently. We extracted the apparently uninjured swallow from the cholla by grasping both the body and head and gently pulling. After we removed the swallow from the cholla, we released it and it flew away. Because the location was in an arid area without the open water sources typically associated with swallow breeding habitat, it was highly likely that this individual was a northbound migrant (Phillips et al., 1964; Robertson et al., 1992).

There are 2 plausible explanations of how the tree swallow became entangled in the teddy bear cholla, both of which would be unusual. The tree swallow might have flown into the teddy bear cholla, possibly being blown by a gust of wind, or it might have been placed there by a loggerhead shrike (*Lanius ludovicanus*). Given that tree swallows are adept, highly maneuverable fliers, a swallow flying into the cholla would be an unusual occurrence. However, wind is a factor in other bird-object collisions, and the gusty conditions might have contributed to this incident (Barrios and Rodríguez, 2004).

A loggerhead shrike might have attempted to impale the tree swallow on the teddy bear cholla (Yosef, 1996). Loggerhead shrikes are regularly observed on the Cabeza Prieta National Wildlife Refuge; however, we usually observed them on the valley bottoms rather than on the ridge tops, and none were observed in the area at the time this incident occurred. Whereas birds have been regularly documented prey of loggerhead shrikes, we were unable to find a citation that documented tree swallows or other swallows being preyed upon by loggerhead shrikes (Reid and Fulbright, 1981; Yosef, 1996). The use of vegetation with spines or thorns by loggerhead shrikes to impale prey in desert areas is a relatively common occurrence, but this is the first report of a tree swallow being entangled in a teddy bear cholla (Reid and Fulbright, 1981; Yosef, 1996).

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WESTWARD EXPANSION OF THE TAWNY-BELLIED COTTON RAT (*SIGMODON FULVIVENTER*) IN WEST-CENTRAL NEW MEXICO

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ABSTRACT—In New Mexico, the tawny-bellied cotton rat (*Sigmodon fulviventer*) previously was known only from central and southwestern parts of the state. In central New Mexico, most records were from areas of tall grass and marshes associated with the middle Rio Grande valley. In 2003, we discovered *S. fulviventer* in grassy and marshy habitats >100 km west of the Rio Grande in west-central New Mexico. Because past surveys in this region did not report captures of *Sigmodon,* we suspect our distributional records represent recent westward expansion of *S. fulviventer* in the state.

RESUMEN—En Nuevo México, la rata algodonera vientre leonado (*Sigmodon fulviventer*) ha sido restringida a la región central y suroeste del estado. En el centro de Nuevo México, la mayoría de los registros provenían de áreas de pasto alto y vegas asociados a la parte intermedia del valle río Grande. En 2003, descubrimos *S. fulviventer* en pastizales y hábitats pantanosos a >100 km al oeste del río Grande en el centro-oeste de Nuevo México. Debido a que monitoreos previos en esa zona no revelaron capturas de *Sigmodon,* sospechamos que nuestros registros de distribución representan una expansión reciente de *S. fulviventer* al oeste del estado.

The tawny-bellied cotton rat (*Sigmodon fulviventer*) occurs from central Mexico north to southeastern Arizona and central and southwestern New Mexico (Hall, 1981). *Sigmodon fulviventer* generally inhabits grasslands throughout its range (Baker and Shump, 1978; Shump, 1999). In New Mexico, the distribution of *S. fulviventer* is disjunct; it inhabits well-developed grasslands in the southwest and tall grass and marshy situations along the Rio Grande valley in central parts of the state (Findley et al., 1975; Cook, 1986).

While conducting mammalian surveys in west-central New Mexico, we discovered a population of *S. fulviventer* distant from previously published records. Thus, we intensified trapping efforts to determine the current distribution of *S. fulviventer* in the area and to examine possible routes of dispersal into the region. Herein we report new localities of *S. fulviventer* in west-central New Mexico, including evidence that suggests recent westward expansion in its distribution.

In July and August 2003, we set Sherman live traps to capture *S. fulviventer* in Cibola and Valencia counties. Our voucher specimens were deposited in the United States Geological Survey, Biological Survey Collection at the Museum of Southwestern Biology (MSB), University of New Mexico, Albuquerque. We also checked MSB for additional specimens of *S. fulviventer* in west-central New Mexico that might have been deposited since Findley et al. (1975).

In west-central New Mexico, we captured 27 *S. fulviventer* (including juveniles and reproductively active adults) and kept 12 as voucher specimens (Table 1). Our captures represent 9 new localities in Cibola County and 2 new localities in Valencia County (Fig. 1, Appendix 1). Tawny-bellied cotton rats were captured in marshy habitats, in grassy areas along roadsides containing moderately dense grass (i.e., some ground visible), in grassy areas along roadsides with dense grass (no ground visible), and in low-lying depressions with dense grass. Heights of grasses ranged from <0.25 to 2 m, and some grassy areas also contained shrubs. Marshy areas contained rushes 0.25 m in height. At locations inhabited by *S. fulviventer,* runways in grass were obvious and generally measured 55 mm in width. Most sections of runways were tunnel-like with a grass canopy. Although fresh feces were not always observed in runways, we

TABLE 1—Body mass (g) and reproductive condition of new specimens of *Sigmodon fulviventer* from west-central New Mexico. For males, measurements (mm) represent the greatest length and width of one testis. For females, measurements refer to crown-to-rump length of the largest fetus or to the diameter of the largest uterine swelling containing an embryo. NR = not recorded.

Date captured	Body mass	Reproductive status	Size of testes or number of embryos or fetuses
Males			
21 July	118	scrotal	16 × 10
24 July	115	scrotal	18 × 11
31 July	125	scrotal	15 × 8
31 July	123	scrotal	17 × 9
19 August	37.5	juvenile	7 × 4
Females			
21 July	118	pregnant	5 fetuses (28 mm)
21 July	84	adult	no embryos
24 July	NR	pregnant	6 fetuses (32 mm)
31 July	117	pregnant	4 fetuses (42 mm)
31 July	19.5	juvenile	no embryos
31 July	99	pregnant	6 embryos (6 mm)
19 August	98	lactating	no embryos

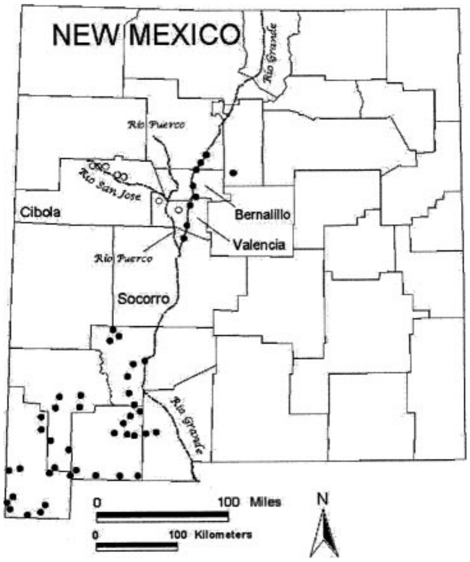

FIG. 1—Distribution of the tawny-bellied cotton rat (*Sigmodon fulviventer*) in New Mexico. Open circles represent new locality records reported in this study, and closed circles represent records published in Findley et al. (1975). Some open circles represent more than 1 locality. The westernmost open circle in Cibola County also represents the town of Grants.

mostly captured individuals when floors of runways were clear of debris. Not all runways in the region were used or constructed by *Sigmodon*; at some sites, we captured western white-throated woodrats (*Neotoma albigula*). Runways used by *N. albigula* seemed slightly wider because they usually were not lined with grasses and they did not contain a cover of plant material for most of their length.

Records from Cibola County—Nine capture sites were in the Rio San Jose valley between Grants and San Fidel (represented by the 5 open circles in Cibola County, Fig. 1). Capture sites included marshy areas, roadsides with dense grasses, and low-lying depressions with dense grasses. The most common grasses were alkali sacaton (*Sporobolus airoides*) and saltgrass (*Distichlis spicata*). We also trapped and searched for runways in appropriate habitats along the Rio San Jose at >10 sites between Grants and Bluewater (town located 19 km northwest of Grants). Here we were unable to locate wide runways, but we set traps in marshy habitats with narrow runways (25 mm in width). At these sites, we only captured deer mice (*Peromyscus maniculatus*) and Mogollon voles (*Microtus mogollonensis*). We also searched grassy roadside right-of-ways on New Mexico Highway 53 south of Grants. Because only narrow runways were observed, we did not set traps.

Records from Valencia County—Two capture sites were in Valencia County. Our easternmost capture site was about 13.5 km west of the Rio Grande on a plateau that separates the Rio Grande and Rio Puerco valleys (Fig. 1, Appendix 1). The Rio Puerco is a southward flowing drainage that empties into the Rio Grande in Socorro County (Fig. 1). *Sigmodon fulviventer* was captured in a flat roadside right-of-way containing moderately dense Wright's threeawn (*Aristida purpurea* var. *wrightii*) and four-winged saltbush (*Atriplex canescens*). Adjacent rangeland on either side of the road was heavily grazed by livestock and contained few shrubs and sparse grasses. Although grassy and shrubby drainages were not observed near the site, railroad tracks, which run into the middle Rio Grande and Rio Puerco valleys, were <1 km away from the capture site. We also captured a *N. albigula* at this site.

Our other capture site in Valencia County was near the junction of the Rio San Jose and Rio Puerco. The Rio San Jose valley continues eastward from Grants and then southeastward until it reaches the Rio Puerco. Here we captured individuals in dense grasses and scattered shrubs along a roadside right-of-way on New Mexico Highway 6.

Records of *S. fulviventer* in west-central New Mexico probably represent recent westward expansion in distribution, because past mammalian surveys conducted in the region failed to document any *Sigmodon*. We are aware of 4 published surveys that were conducted in areas and habitats that now contain *S. fulviventer* (Hooper, 1941; Mohlhenrich, 1961; Gennaro, 1968; Hubbard et al., 1983).

In 1939, Hooper (1941) set traps for 2 nights in the Rio San Jose valley. This site is near many of our westernmost localities with captures of *S. fulviventer.* Along the Rio San Jose, Hooper reported marshes with dense cattails and short-grass meadows, but he did not report captures of *Sigmodon* from the area. From 1957 to 1959, Mohlhenrich (1961) searched for cotton rats across New Mexico. He trapped at 6 locations (presumably grassy habitats) west of the Rio Grande valley in Bernalillo, Valencia, and (what is now) eastern Cibola counties. These sites likely were the same or at least near our sites in Valencia County. Mohlhenrich did not capture any *Sigmodon* at these localities. In 1961 and 1962, Gennaro (1968) trapped at 100 localities in central New Mexico, including >10 locations west of the middle Rio Grande valley. Many of these sites were located near the Rio Puerco, and one was near the east end of the Rio San Jose, close to one of our eastern sites. Gennaro captured no *Sigmodon* at these localities in the early 1960s. In 1977 and 1979, Hubbard et al. (1983) reported that traps were placed in marshes east of Grants along Interstate Highway 40 to capture *Microtus pennsylvanicus*. These authors did not report any *Sigmodon,* but unexpectedly captured *Microtus mexicanus* (=*M. mogollonensis*).

Routes of dispersal of *S. fulviventer* into west-central New Mexico probably were influenced by presence of hispid cotton rats (*Sigmodon hispidus*) and availability of suitable habitat. *Sigmodon fulviventer* originally was known from Bernardo (Gardner, 1948), just north of where the Rio Puerco meets the Rio Grande. However, Mohlhenrich (1961) reported that only *S. hispidus* occurred at Bernardo. Because *S. fulviventer* has not been found to coexist with *S. hispidus* in Socorro County and because *S. hispidus* seems to have excluded *S. fulviventer* from Socorro County and southern Valencia County (Mohlhenrich, 1961; Findley et al., 1975), populations of *S. fulviventer* probably did not exist along the lower Rio Puerco valley for individuals to expand northward into west-central New Mexico. Instead, we hypothesize that *S. fulviventer* dispersed westward from the middle Rio Grande valley by following grassy habitats along railroad waysides, roadside ditches, roadside right-of-ways, and low-lying depressions. Once *S. fulviventer* dispersed out of the middle Rio Grande valley, it probably encountered grassy habitats associated with the Rio Puerco valley. From these grassy habitats, *S. fulviventer* likely colonized the many lush and grassy habitats in the Rio San Jose valley.

At one of our trapping sites near the Rio Puerco on New Mexico Highway 6 in Valencia County (34°48.485′N, 107°01.421′W), we trapped a low-lying railroad wayside containing dense shrubs and grasses, including alkali sacaton. At this site, we observed grass clippings but no obvious runways as previously observed at all other sites with *S. fulviventer.* The following morning, we captured 2 *S. hispidus* (MSB 124262, MSB 124263), which represent the northernmost record of *S. hispidus* in central New Mexico (Findley et al., 1975). The nearest published record of *S. hispidus* is 24 km to the south at Pato Arroyo, which runs into the Rio Puerco (Mohlhenrich, 1961). Our record of *S. hispidus* suggests that it too is expanding northward, as it has along the Rio Grande in the past (see Mohlhenrich, 1961).

Distributions of mammals fluctuate over time, with many shifts being associated with changes in habitat, climate, or both (e.g., Humphrey, 1974; Frey, 1992; Hafner and Shuster, 1996; Benedict et al., 2000; Geluso, 2004). The occurrence of *S. fulviventer* in west-central New Mexico probably is another example of a distributional shift related to a change in habitat, climate, or both, and is not an example of populations that have gone undetected due to lack of surveys. Mohlhenrich (1961) reported that temperature and growing season are important factors limiting the distribution of cotton rats in New Mexico. Indices of climate change, especially in recent decades, suggest warmer temperatures and greater amounts of precipitation in parts of the southwestern United States (Karl et al., 1996). Detailed examination of climatic patterns (e.g., Brown et al., 1997) in west-central parts of New Mexico might further elucidate westward expansion of *S. fulviventer.* Our records of this species represent a 108-km westward expansion into west-central New Mexico, and our study demonstrates the importance of past mammalian surveys to help delineate shifting distributional patterns.

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Appendix 1—New records of the tawny-bellied cotton rat (*Sigmodon fulviventer*) in west-central New Mexico. Number of individuals captured and their reproductive status and age are given in parentheses. All museum specimens are deposited in the United States Geological Survey, Biological Survey Collection housed at the Museum of Southwestern Biology (MSB), University of New Mexico, Albuquerque.

CIBOLA COUNTY: Grants, 0.1 mi. WSW intersection Santa Fe Avenue and Roberta Road, E0242212, N3891204 (1 adult male, MSB 124256; 1 adult female; 1 pregnant female, MSB 124255; 2 juvenile females); El Malpais National Monument, 0.5 mi. NW of Rancho del Padre Spring, E0242665, N3889782 (1 pregnant female, MSB 124211; 1 juvenile male); El Malpais National Monument, 0.5 mi. NW of Rancho del Padre Spring, E0242399, N3889989 (1 adult male, MSB 124213; 1 adult female, MSB 124214); El Malpais National Monument, 0.5 mi. NW of Rancho del Padre Spring, E0242689, N3889776 (2 adult males; 3 adult females; 1 juvenile female); El Malpais National Monument, 0.5 mi. NW of Rancho del Padre Spring, E0242811, N3889753 (1 adult female); El Malpais National Monument, 0.5 mi. NW of Rancho del Padre Spring, E0242673, N3889765 (1 adult male); El Malpais National Monument, near Rancho del Padre Spring, E0242959, N3889075 (1 adult male); Exit 96 Interstate Highway 40, SW ramp, 35°04.370′N, 107°39.458′W (1 pregnant female, MSB 124260); 1.2 km W Exit 96 Interstate Highway 40, New Mexico Highway 124, 35°04.261′N, 107°40.232′W (1 adult male, MSB 124261).

VALENCIA COUNTY: 14 km SE Exit 126 Interstate Highway 40, New Mexico Highway 6, 34°53.229′N, 107°04.168′W (1 adult male, MSB 124257; 1 pregnant female, MSB 124258; 1 juvenile female, MSB 124259); 5.8 mi. W Interstate Highway 25, New Mexico Highway 6, 34°48.894′N, 106°51.735′W (1 adult male; 1 lactating female, MSB 124265; 2 juvenile males, MSB 124264).

BLACK BEARS FORAGE ON ARMY CUTWORM MOTH AGGREGATIONS IN THE JEMEZ MOUNTAINS, NEW MEXICO

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ABSTRACT—We observed black bears (*Ursus americanus*) foraging on aggregations of army cutworm moths (*Euxoa auxiliaris*) (Lepidoptera: Noctuidae) in subalpine felsenmeers (block fields) in the Jemez Mountains of New Mexico. Moth aggregations serve as food for grizzly bears (*Ursus arctos horribilis*) in the northern Rocky Mountains of Wyoming and Montana. However, black bears have not been reported to use these aggregations, nor have such aggregations been documented to occur this far south in the Rocky Mountains.

RESUMEN—Observamos osos negros (*Ursus americanus*) alimentándose de agregaciones de la mariposa (*Euxoa auxiliaris*) (Lepidoptera: Noctuidae) en felsenmeers (campos de rocas) subalpinos de las montañas Jemez de Nuevo México. Estas agregaciones sirven de alimento para el oso pardo (*Ursus arctos horribilis*) en el norte de las Montañas Rocosas de Wyoming y Montana. Sin embargo, no se había registrado el uso de estas agregaciones por los osos negros, ni se habían documentado estas agregaciones tan al sur en las Montañas Rocosas.

Aggregations of army cutworm moths (*Euxoa auxiliaris*) (Lepidoptera: Noctuidae) are excavated from high-elevation talus slopes and consumed by grizzly bears (*Ursus arctos horribilis*) in the northern Rocky Mountains of the USA (Chapman et al., 1955; Sumner and Craighead, 1973; Servheen, 1983; Klaver et al., 1986; Mattson et al., 1991; O'Brien and Lindzey, 1994; White et al., 1998*a*). Army cutworm moths migrate in the spring from the Great Plains to the alpine tundra of the mountains and then return to the prairies in the fall (Pruess, 1967; Burton et al., 1980; Kendall et al., 1983). Moths spend the early summer foraging on nectar-rich alpine forbs at night (Kendall et al., 1983) and roosting in dense aggregations in the interstitia of talus slopes during the day (O'Brien and Lindzey, 1994; White et al., 1998*b*). Later in the summer, the moths enter a period of dormancy whereby nocturnal foraging ceases (Kendall et al., 1983; O'Brien and Lindzey, 1994; White et al., 1998*b*) before their return to the plains. Throughout the summer months, moths are eaten by grizzly bears, common ravens (*Covus corax*), Clark's nutcrackers (*Nucifraga columbiana*), and rosy finches (*Leucosticte tephrocostis*) (O'Brien and Lindzey, 1994; White et al., 1998*a*). However, to our knowledge, black bears (*Ursus americanus*) have not been documented to forage on these moth aggregations, nor has it been well known how far south in the Rocky Mountains such moth aggregations extend. Here we describe 3 observations of black bears foraging on aggregations of army cutworm moths in the Jemez Mountains of New Mexico.

On the afternoon of 19 August 2003, while 3 of us were working on the western slopes of Redondo Mountain in the Valles Caldera National Preserve, we saw a single adult black bear within a large (ca. 10 ha) felsenmeer, at an elevation of 3,250 m. Felsenmeers (German for ''sea of rocks,'' also known as block fields) are periglacial landforms composed of angular blocks of frost-shattered bedrock. Because the bear was upwind and involved in a noisy activity, it remained unaware of our presence and we were able to observe it from within ca. 60 m. The bear was digging slowly among the large rocks, flipping them over and aside in what seemed to be a deliberate manner. As it excavated, the bear prodded its snout in and among the rocks, as though searching for or consuming some food buried within the rock

FIG. 1—A black bear (*Ursus americanus*) foraging on aggregations of army cutworm moths in a subalpine (3,250 m) felsenmeer on Redondo Mountain, New Mexico.

field. The bear continued with this activity for ca. 15 minutes after it was first noticed (Fig. 1). Large groups of ravens were active in the area, but were not foraging on the rocks at this time.

Over the next week, we observed 2 more episodes of activity on the felsenmeers of Redondo Mountain from a vantage point on a ridge ca. 1 km distant that allowed us to survey a much greater area. We spotted 2 bears on the afternoon of 20 August. These bears were using the same felsenmeer as the single bear had been using the day before, but were ca. 200 m farther upslope. On the afternoon of 22 August, we spotted 3 bears in this felsenmeer, while a lone bear appeared to be foraging in a separate felsenmeer ca. 1.5 km north. Though the distance from which these observations were made precluded a more precise determination of the activity of the bears, their behavior was consistent with the foraging we observed previously. Bears stayed within the felsenmeers for the entirety of each >10-minute period of observation and were either stationary or moving slowly across the rock fields. Large flocks of ravens were present in the vicinity of the bears, but we were not able to determine the nature of their activity on either of these days.

On the morning of 23 August, one of us visited these felsenmeers. At both sites where we had seen bears, army cutworm moths were evident in great numbers just beneath the surface of the rocky debris. Frequently, scores of moths could be found simply by displacing just a few large rocks. The presence of dead moths in various stages of degradation suggested that moths had been using these sites for a long time. Large, recent excavations of rocks were numerous in both areas, and abundant bear scats seemed to be comprised mostly or entirely of the chitinous exoskeletons of the moths. No bears were seen during this visit, but numerous ravens, Clark's nutcrackers, Audubon's warblers (*Dendroica coronata*), and a house wren

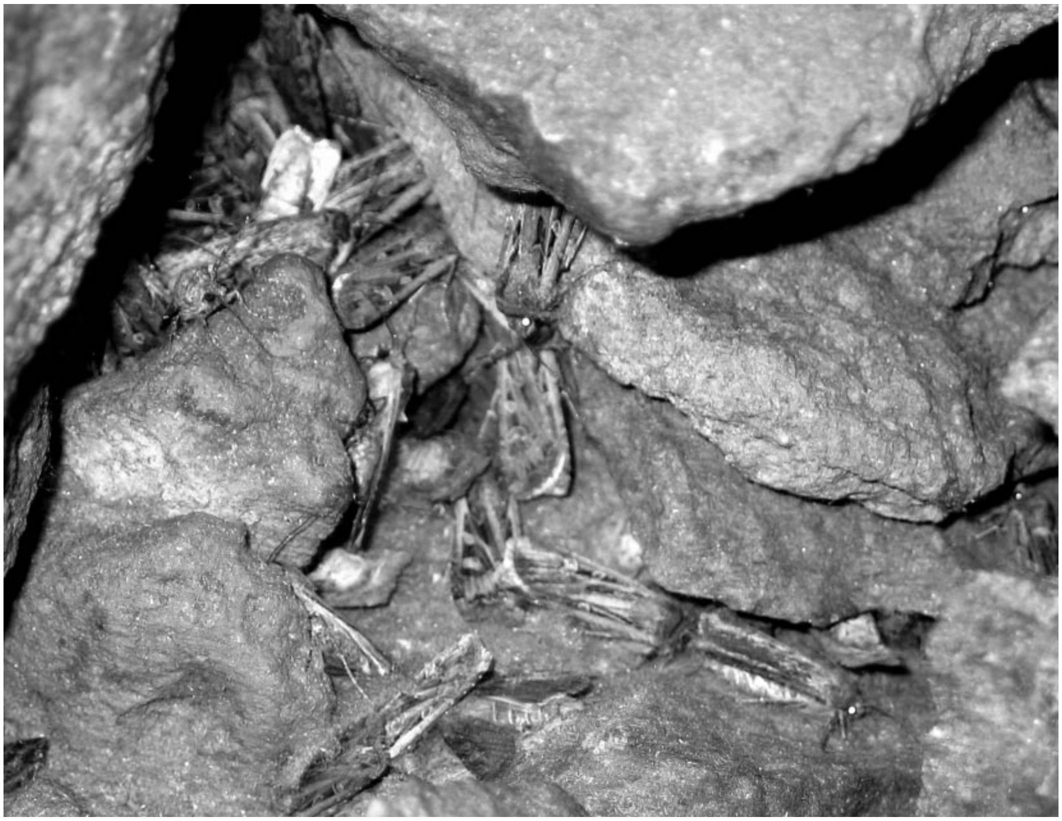

FIG. 2—Dense aggregations of army cutworm moths (*Euxoa auxiliaris*) just beneath the surface of the felsenmeer, Redondo Mountain, New Mexico.

(*Troglodytes aedon*), were foraging among the rocks.

Contrasting these observations with published studies of grizzly bear use of moth aggregations in the Northern Rockies revealed both similarities and differences. On Redondo Mountain, moths were aggregating in felsenmeers composed of blocky slabs of rock, ranging in size from ca. 0.25 to 1.5 m in diameter, derived from a densely welded volcanic tuff—the Tsirige member of the Bandelier Tuff (Smith et al., 1970). These felsenmeers occurred on steep (45 to 70%) slopes, with western to northwestern aspects ranging from 270° to 320°. Hence, in terms of rock size and slope inclination, these sites were similar to moth aggregation sites in talus slopes described by O'Brien and Lindzey (1994) in Wyoming and by White et al. (1998*a*) in Montana. Aspects were somewhat more northerly than those reported by these authors, though this distinction is relatively minor. Differences in the vegetation were much more pronounced. Moth aggregations described by O'Brien and Lindzey (1994) and White et al. (1998*a*) occurred in close proximity to alpine plant communities, where nectar-rich, animal-pollinated forbs were generally quite abundant. Army cutworm moths are thought to forage in alpine vegetation during the summer (Kendall et al., 1983; White et al., 1998*b*) and consequently to increase in body mass and lipid content (White et al., 1998*b*) before fall migration to the Great Plains. In contrast, there are no alpine plant assemblages in the Jemez Mountains. Subalpine vegetation at the elevations at which the moths were aggregating (between 3,150 and 3,250 m) on Redondo Mountain was comprised of coniferous forests and grasslands, with seemingly lower abundances of nectar sources. Moths aggregating on Redondo Mountain might be foraging widely in these plant communities to meet their energetic requirements, or they might increase their use of other nectar resources during migration.

Lastly, our observations raise questions regarding the extent of aggregations of army cutworm moths and their use by *U. americanus* south of the range of *U. arctos*. Both might be widespread but underreported, or might, in fact, be uncommon occurrences. During the spring of 2003, migrating populations army cutworm moths were noted to be exceptionally high throughout the southern Rocky Mountain region (W. Cranshaw, pers. comm.). Perhaps black bears only take advantage of this resource during infrequent years of high moth abundance.

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