ing puberulent petioles and rachises and alternately arranged leaflets.

The probable hybrids are listed below, along with label information. Three specimens (H02, H07, and H08) might represent backcrosses and, although similar to other probable hybrids, had leaves with longer rachises and pinnae, more typical of *A. schottii*. UNITED STATES: Texas: Brewster County: clay-slate hills, near Lajitas, 27 June 1978, A. M. Powell 3333 (SRSC, TEX); limestone soil 2 miles E of Packsaddle Mountain, elevation 1,070 m, 12 June 1949, B. L. Turner 1072 (SRSC); limestone hills at Boquillas, Big Bend National Park, elevation 985 m, 5 August 1966, B. H. Warnock 20896 (SRSC); sandy soil near Adobe Wall Spring, elevation 1,020 m, 19 June 1949, B. H. Warnock, B. L. Turner, and J. O. Parks 1134 (SRSC). Presidio County: gravel hills, ca. 5 miles N of Lajitas, 7 July 1984, A. M. Powell and M. L. Powell 4406 (SRSC).

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# TEMPORAL ASSESSMENT OF A WEST TEXAS STREAM FISH ASSEMBLAGE

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Abstract—We compared fish survey data across 3 collection periods (1952 to 1968, 1976 to 1994, and 2001 to 2002) from Independence Creek (Rio Grande drainage, Terrell County, Texas) to assess long-term changes in fish assemblage structure. The number of species collected declined from 28 in the 1952 to 1968 collection period, to 26 (plus 1 hybrid) in the 1974 to 1994 collection period, and to 23 (plus 1 hybrid) in the 2001 to 2002 collection period. Species loss included 5

native fishes that currently persist in the adjoining Pecos River and 4 species that were non-native to the lower Pecos River. Species additions included species native to the Pecos River that rarely inhabit smaller tributary streams and species that were introduced into the Pecos River. Twenty species were collected consistently from 1952 through 2002. Unweighted averages of abundant species across collection periods were *Dionda episcopa* (32%), *Gambusia* spp. (23%), *Cyprinella proserpina* (11%), *C. lutrensis* (10%), and *Notropis amabilis* (9%). Although apparent extirpations and additions of several rare species (<1% in relative abundance each) were noted, the Independence Creek fish assemblage remained similar during the last 50 years, in contrast to the general trend of native species reductions in much of the Rio Grande drainage.

RESUMEN—Comparamos los datos de estudios pesqueros en el arroyo Independencia (cuenca del río Grande, condado de Terrell, Texas), a lo largo de tres períodos de colecta (1952 a 1968, 1976 a 1994 y 2001 a 2002), para evaluar los cambios a largo plazo en la estructura del ensamblaje de peces. El número de especies colectadas declinó de 28 en el periodo 1952 a 1968, a 26 (más 1 híbrido) en el periodo 1974 a 1994 y a 23 (más 1 híbrido) en el periodo 2001 a 2002. La pérdida de especies incluyó a 5 especies de peces nativas que actualmente persisten en el adyacente río Pecos y 4 especies no nativas de la parte baja del mismo río. El aumento de especies incluyó especies nativas del río Pecos que rara vez habitan en los pequeños arroyos tributarios y especies que fueron introducidas al río Pecos. Veinte especies fueron colectadas consistentemente, de 1952 a 2002. Los promedios no ajustados de las especies abundantes a lo largo de los periodos de colecta fueron *Dionda episcopa* (32%), *Gambusia* spp. (23%), *Cyprinella proserpina* (11%), *C. lutrensis* (10%), y *Notropis amabilis* (9%). Aún cuando hubo erradicaciones y aumentos aparentes de varias especies raras (<1% de abundancia relativa de cada una), el ensamblaje de peces del arroyo Independencia se mantuvo similar durante los últimos 50 años, en contraste con la tendencia general en la reducción de especies nativas en la mayor parte de la cuenca del río Grande.

In the lower Pecos River (Carlsbad, New Mexico, to the Rio Grande), the number of native fishes has been reduced by half because of anthropogenic modifications, including introduced species, reduced water quality, and diminished spring and stream flows (Hoagstrom, 2003). However, the largest tributary of the lower Pecos River, Independence Creek, has been minimally impacted by human activities and continues to support many of the fishes native to the lower Pecos River and Rio Grande drainages (Karges, 2003). The Independence Creek fish assemblage includes 2 state-listed (Texas) threatened species (*Cyprinella proserpina* and *Etheostoma grahami*), 1 species (*Notropis jemezanus*) considered threatened in Texas by Hubbs et al. (1991), 1 species (*Ictalurus lupus*) considered of special concern in Texas by Hubbs et al. (1991), and 2 species (*Dionda episcopa* and *Notropis amabilis*) endemic to the Edwards Plateau of Texas and Rio Grande drainages. In 1998, The Nature Conservancy purchased 8,000 ha that included 13 km of Independence Creek and Caroline Spring, a primary contributor of freshwater to the creek. The purpose of our study was to compare historical fish survey data with that from recent surveys to assess long-term changes in the fish assemblage of Independence Creek.

Independence Creek drains 1,935 km$^2$ of limestone-based Ector Rock Outcrop soils composed of stony loams, stony clay loams, and rock outcrops (Turner and Fox, 1974). The perennial portion of Independence Creek is about 16 km long and is sustained largely by Vanderbeek Spring and Caroline Spring, with several peripheral springs contributing lesser flow (Brune, 1981). Throughout its course, Independence Creek is dominated by runs and pools, with few riffles and backwater areas. Stream width ranges from 6 to 17 m, current velocity ranges from 5 to 45 cm/s, and depth ranges from 18 to 48 cm. Dominant substrates are cobble and gravel, with a few reaches of bedrock and cemented gravel. Dominant streamside plant associations are classified as Walnut-Desert Willow, Saltcedar, and Sawgrass-Willow (Webster, 1950).

Information on the fish fauna of Independence Creek was obtained from Tulane Museum of Natural History (1952 to 1976); L. Campbell (1959, Basic survey and inventory of species present in the Pecos River of Texas, Texas Game and Fish Commission, Austin); N. Valdez (1994, Composition and structure of

fish assemblages of Chandler Independence Creek Preserve, Texas A&M University, unpublished report); G. W. Linam and L. J. Kleinsasser (1996, Relationship between fishes and water quality in the Pecos River, Texas, Texas Parks and Wildlife Department, Austin); G. P. Garrett (1997, Chihuahuan Desert fishes status survey, Texas Parks and Wildlife Department, Ingram); and G. W. Linam, L. J. Kleinsasser, and K. B. Mayes (2002, Regionalization of the index of biotic integrity for Texas streams, Texas Parks and Wildlife Department, Austin). Collectively, these records were from 1952 through 1994. Specimens were collected with seines or electrofishing gear, but effort and habitat types sampled were not always recorded. We assumed that species composition and abundances obtained during these collections accurately represented the Independence Creek fish assemblage at the time and location of sampling.

Our collections were made from December 2001 through July 2002 at 7 sites on Independence Creek from its headwaters at Vanderbeek Spring to its confluence with the Pecos River. Fishes were collected with seines and a backpack electrofisher (Smith-Root Model 12-B), identified, enumerated, and released, except for voucher specimens. Voucher specimens were anesthetized in tricaine methane sulphonate and preserved in 10% formalin. Field identification of 3 previously reported *Gambusia* (*G. affinis, G. geiseri,* and *G. speciosa*) was complicated by hybridization and nomenclatorial confusion between *G. affinis* and *G. speciosa* (G. P. Garrett, pers. comm.). Therefore, all *Gambusia* were treated as 1 taxon.

Assemblage composition and relative abundances were compared among 3 collection periods: 1952 to 1968, 1974 to 1994, and 2001 to 2002. Shannon-Weiner index (*H*; natural base) for species diversity, evenness (Buzas and Gibson's *E*; Hayek and Buzas, 1997), and Renkonen similarity index (Krebs, 1989) were used to quantify and compare assemblages across time.

Thirty-three species and 1 hybrid were taken from Independence Creek from 1952 through 2002 (Table 1). The number of species collected declined from 28 in the 1952 to 1968 collection period, to 26 (plus 1 hybrid) in the 1974 to 1994 collection period, and to 23 (plus 1 hybrid) in the 2001 to 2002 collection period. Species diversity was 1.97 from the 1952 to 1968 and 1974 to 1994 collection periods, and slightly lower (1.79) for the 2001 to 2002 collection period. Evenness values (range 0.25 to 0.26) were not substantially different among

TABLE 1—Relative abundance (%) of species from 3 collection periods in Independence Creek, Texas. The letter "I" denotes nonnative species in Independence Creek. The letter "P" denotes fishes that were present but not counted.

| Species | Relative abundance 1952–1968 | 1974–1994 | 2001–2002 |
|---|---|---|---|
| *Lepisosteus osseus* | 0.02 | | |
| *Dorosoma cepedianum* | | 0.07 | P |
| *Campostoma anomalum* (I) | 0.04 | | |
| *Cyprinella lutrensis* | 21.3 | 7.0 | 0.5 |
| *Cyprinella proserpina* | 7.1 | 12.7 | 11.7 |
| *Cyprinella venusta* (I) | 0.01 | 0.05 | 0.2 |
| *Cyprinus carpio* (I) | 0.1 | | P |
| *Dionda episcopa* | 36.1 | 30.8 | 29.7 |
| *Macrhybopsis aestivalis* | 0.02 | 0.4 | |
| *Notropis amabilis* | 4.0 | 5.2 | 19.1 |
| *Notropis braytoni* | 0.5 | 8.7 | |
| *Notropis jemezanus* | | 0.9 | |
| *Notropis stramineus* | 0.02 | | |
| *Pimephales vigilax* | 0.2 | 0.7 | |
| *Carpiodes carpio* | 0.1 | | 0.02 |
| *Moxostoma congestum* | 0.05 | 0.1 | 0.4 |
| *Astyanax mexicanus* | 3.6 | 1.6 | 1.7 |
| *Ictalurus* sp. | 0.01 | | |
| *Ictalurus lupus* | 2.9 | 0.5 | 0.8 |
| *Ictalurus punctatus* | | 0.5 | P |
| *Pylodictis olivaris* | | 0.04 | 0.05 |
| *Cyprinodon variegatus* × *C. pecosensis* (I) | | 0.05 | 0.5 |
| *Fundulus zebrinus* | 5.1 | 0.02 | 0.5 |
| *Lucania parva* | 0.2 | 0.4 | 0.5 |
| *Gambusia* spp. | 13.2 | 26.8 | 28.7 |
| *Menidia beryllina* (I) | | 0.02 | |
| *Lepomis auritus* (I) | 0.1 | 0.4 | 2.5 |
| *Lepomis cyanellus* | 0.9 | 0.09 | 0.1 |
| *Lepomis macrochirus* | 0.04 | 0.02 | 0.07 |
| *Lepomis megalotis* | 1.2 | 1.1 | 0.5 |
| *Micropterus salmoides* | 0.2 | 0.2 | 0.3 |
| *Pomoxis annularis* (I) | 0.02 | | |
| *Etheostoma grahami* | 0.5 | 0.4 | 1.2 |
| *Cichlasoma cyanoguttatum* | 2.3 | 1.3 | 1.0 |
| Number of individuals | 8,388 | 5,514 | 4,062 |
| Species richness | 28 | 27 | 24 |
| Species diversity (*H*) | 1.97 | 1.97 | 1.79 |
| Evenness (*E*) | 0.25 | 0.26 | 0.25 |

collection periods. Assemblage similarity was 68% between 1952 to 1968 and 1974 to 1994 collection periods, and 79% between 1974 to 1994 and 2001 to 2002 collection periods. Although assemblages were similar among collection periods, some notable changes in assemblage composition and species abundance were apparent.

Of 8 species not taken during 2001 to 2002, 3 (*Lepomis microlophus, Pomoxis annularis,* and possibly *Campostoma anomalum*) are not native to the lower Pecos River (Hubbs et al, 1991; Hoagstrom, 2003), and 5 native fishes (*Lepisosteus osseus, Macrhybopsis aestivalis, Notropis stramineus, N. braytoni,* and *Pimephales vigilax*) persist in the lower Pecos River near Independence Creek (Hoagstrom, 2003). These native fishes normally inhabit larger rivers with silt and sand substrate, such as the lower Pecos River, and marginally or temporarily inhabit smaller tributaries with cobble and gravel substrate, such as Independence Creek (Pflieger, 1975; Robison and Buchanan, 1988; Edwards and Contreras-Balderas, 1991; Page and Burr, 1991; Rhodes and Hubbs, 1992). Thus, reduced species richness in the Independence Creek fish assemblage through time was not attributed to native species extirpations.

Six species (*Dorosoma cepedianum, N. jemezanus, I. punctatus, Pylodictis olivaris, Cyprinodon variegatus* × *C. pecosensis,* and *Menidia beryllina*) not taken during 1952 to 1968 were found during 1974 to 2002. Four species (*D. cepedianum, N. jemezanus, I. punctatus,* and *P. olivaris*) are native to the lower Pecos River, although *I. punctatus* might have derived from individuals stocked for sportfishing purposes in Caroline Spring (Karges, 2003). *Cyprinodon variegatus* (and its subsequent hybridization with *C. pecosensis*) and *M. beryllina* occurrences are attributed to incidental stockings in the late 1950s or early 1960s in the lower Pecos River (Minckley, 1965; Stevenson and Buchanan, 1973).

Eighteen species were present during each collection period. Two species (*Cyprinus carpio* and *Carpiodes carpio*) were not collected during 1964 through 1974. Among these 20 species, 4 (*Cyprinella venusta, Cyprinus carpio, L. auritus,* and 1 of the *Gambusia*) are not native to the lower Pecos River (Hubbs et al., 1991; Hoagstrom, 2003). Average percent abundances across all 3 periods were *D. episcopa* (32%), *Gambusia* (23%), *Cyprinella proserpina* (11%), *C. lutrensis* (10%), and *N. amabilis* (9%) for the most common fishes. Abundant species with the greatest change in relative abundance through time were *C. lutrensis* (decreased from 21 to 0.5%), *N. amabilis* (increased from 4% to 19%), and *Gambusia* (increased from 13 to 29%), although theses changes might be partially attributed to previous collections taken mainly from lower reaches, whereas 2001 to 2002 collections were evenly distributed throughout Independence Creek. In 2001 to 2002 collections, *C. lutrensis* was abundant only in the lower reach of Independence Creek.

Among species of conservation concern, *C. proserpina, E. grahami,* and *I. lupus* were taken during each collection period. *Cyprinella proserpina* was the most abundant state-listed threatened species in Independence Creek and was taken from all sampling locations in 2001 to 2002 collections. *Etheostoma grahami* and *I. lupus* were relatively uncommon (<3%) but persistent in Independence Creek. Among habitats, *E. grahami* was abundant in riffles and *I. lupus* was abundant in deep runs in the upper reaches of Independence Creek. *Notropis jemezanus* has not been collected in Independence Creek since 1991 or in the lower Pecos River since 1987 (Hoagstrom, 2003). *Dionda episcopa* and *N. amabilis,* species endemic to the Edwards Plateau and Rio Grande drainage, composed 49% of the current fish assemblage in Independence Creek.

Although apparent extirpations and additions of several uncommon species (<1% in relative abundance each) were noted, the Independence Creek fish assemblage remained similar during the last 50 years. This is in contrast to other lotic environments in the Rio Grande and Gulf slope drainages of Texas, where 80% of 129 fish assemblages were substantially changed during a 30-year period (Anderson et al., 1995). Reservoir construction, dredging, pollution, salination, and exotic introductions were responsible for changes in 60% of the assemblages characterized as altered by Anderson et al. (1995). Although habitats of Independence Creek have been modified by water diversions for irrigation, impoundment of Caroline Spring, and nonnative fish introductions, fish composition and abundance have not substantially changed. The persistence of a largely intact native fish assemblage in Independence Creek is a contrast to

the general trend of native species reductions in much of the Rio Grande drainage (Edwards and Contreas-Bladeras, 1991; Platania, 1991; Edwards et al., 2003; Hoagstrom, 2003).

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