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Reprinted from THE SOUTHWESTERN NATURALIST
Vol. 44, No. 2, July 1999
Made in United States of America

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Many native stream fishes of the American Southwest are morphologically and behaviorally adapted to survive severe, periodic flooding (Harrel, 1978; Meffe, 1984; Minckley and Deacon, 1991), or rapidly recolonize after floods (Collins et al., 1981; Meffe, 1984). Minckley and Meffe (1987) suggested that many nonnative fishes are not so adapted and are often displaced from narrow, canyon-bound streams of the region. Thus, flooding has been hypothesized as a mechanism allowing native fishes to persist over time in unregulated streams containing introduced species (Meffe, 1984; Minckley and Meffe, 1987).

Sabino Creek, Pima Co., Arizona (Gila River Basin) drains 91.9 km^2 (United States Geological Survey, 1992). It originates near Mt. Lemmon (elevation 2,790 m) and has an average gradient of 34 m/km (Miller, 1961). Daily mean discharge prior to 1993 was 0.4 m^3/s (1905–1911, 1933–1974, 1990–1992) with the highest daily mean discharge (60 m^3/s) and maximum instantaneous discharge (219 m^3/s) both occurring on 6 September 1970 (United States Geological Survey, 1992).

A record flood struck Sabino Creek during unusually high precipitation in winter 1992–1993. Occasional instantaneous discharges >28 m^3/s were recorded from 28 December to 19 February. On 8 January the daily mean discharge was 90 m^3/s and maximum instantaneous discharge was 365 m^3/s (United States Geological Survey, 1993), the highest values ever recorded.

Pre-flood distributions of native Gila chub (*Gila intermedia*) and nonnative green sunfish (*Lepomis cyanellus*) and western mosquitofish (*Gambusia affinis*) were delineated in October 1992 (Arizona Game and Fish Department, in litt.). Common and scientific names follow Robins et al. (1991). The area sampled was from Sabino Dam upstream to about 0.5 km above bridge 9 (Fig. 1). Nine stone bridges (1.5 m to 2.5 m high) cross in this reach, acting as barriers (waterfalls) to upstream movement by fish. A Smith-Root VII (DC) electrofishing unit was the primary collecting method.

During this pre-flood survey, green sunfish occurred downstream of bridge 8; green sunfish and Gila chub occurred from bridge 7 to bridge 8; and only Gila chub occurred above bridge 8. Western mosquitofish were throughout reaches downstream of bridge 3.

After flooding, we sampled from Sabino Dam upstream to 1.6 km above bridge 9 and recorded distribution and relative abundance of fishes from September to November 1993. Fish were located primarily through underwater observations by moving slowly upstream through centers of pools (n = 15; area sam-

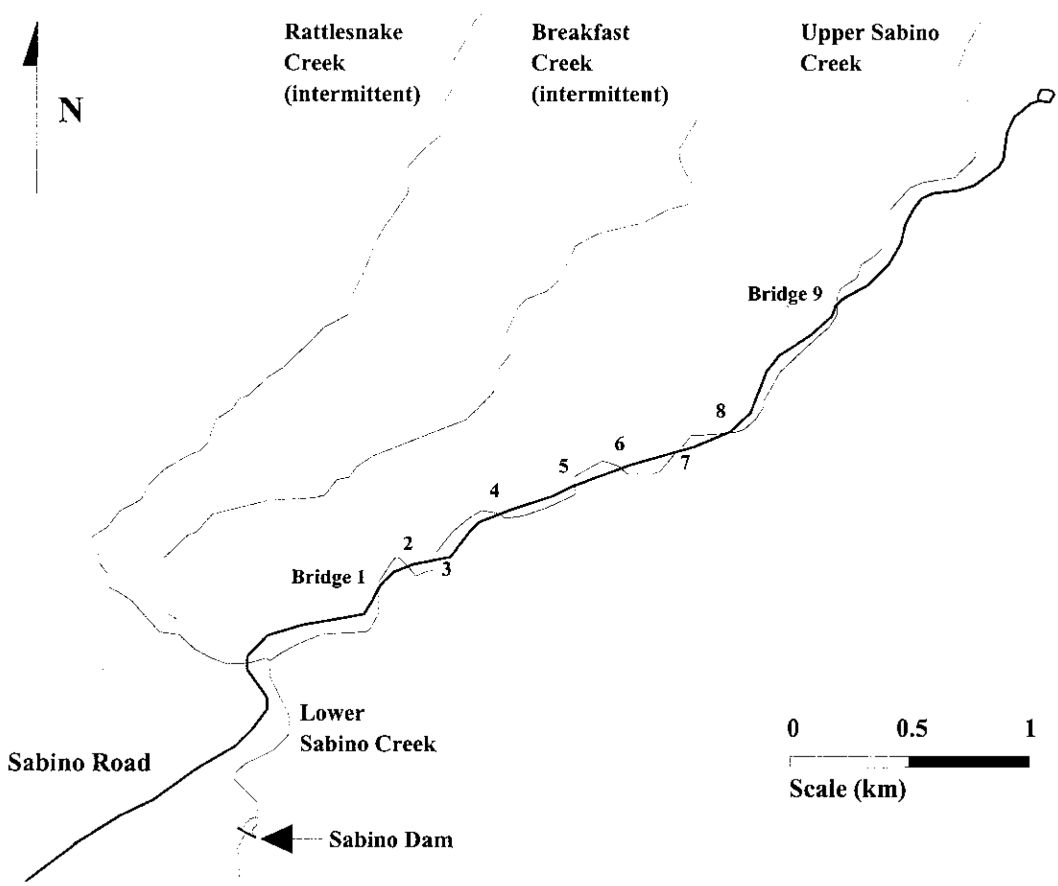

FIG. 1—Study area in Sabino Creek, Arizona.

pled = 3,878 m^2). All fish seen were counted; fish showed little reaction to the observer. The electrofishing unit was used to stun fish in riffles ($n = 7$; area sampled = 537 m^2).

During the post-flood survey, only green sunfish occurred downstream of 0.5 km below bridge 1; both Gila chub and green sunfish were upstream from this point to bridge 9; and only Gila chub occurred to about 1.6 km upstream of bridge 9 just below a natural waterfall. Western mosquitofish were not found in 1993 or in sampling throughout 1994.

The upper-most distribution of green sunfish in 1992 (below bridge 8), thus increased to below bridge 9 following the flood. Green sunfish might have moved upstream during flooding when surface flow connected areas above and below bridges. Alternatively, green sunfish could have been translocated by humans or were already present above bridge 8, but missed in pre-flood surveys. We found no difference, however, in mean densities (ANOVA; $P > 0.4$) or size-class structure of this species above bridge 8, between bridges 4 and 8, or below bridge 4 following flooding. These data are not indicative of major downstream displacement of green sunfish or of recent reinvasion.

Meffe (1984) found western mosquitofish to be severely reduced in number or eliminated by floods in southwestern streams. Further, this species was unable to maintain position in strong pulsing currents in experimental systems (Meffe, 1984). Western mosquitofish had occupied Sabino Creek at least since 1982 (D. Bieber, pers. comm.) with an upstream distribution in 1992 just below bridge 3. Apparently, western mosquitofish were completely displaced by the record flood.

Gila chub occurred about 2.0 km farther downstream after the flood than reported in October 1992 (Arizona Game and Fish Department, in litt.), which cannot be attributed unequivocally to flooding. Low densities of this species were present downstream, and the few found by sampling many downstream sites over several months in 1993 could have been missed in 1-day, pre-flood surveys of limited sites. Gila chub was abundant above bridge 9 before and after flooding.

To quantify relative force of flooding, Minckley and Meffe (1987) proposed an index of magnitude: the maximum instantaneous discharge (during a flood) divided by mean discharge. Floods with an index <10 had little effect on fishes, those between 10–100 reduced but rarely eliminated introduced species, and those >100 reduced numbers and often eliminated nonnative populations. The index for the winter flood of 1992–1993 in Sabino Creek was 902. Post-flood distribution and density of green sunfish did not reflect this value, but western mosquitofish did.

Pre-flood densities of Gila chub were lower in areas of co-occurrence with green sunfish than where green sunfish was absent (D. Bieber, pers. comm.). Similarly, post-flood densities of Gila chub were about an order of magnitude lower in areas with green sunfish than without (Dudley, 1995). Evidently, the status of Gila chub in lower Sabino Creek, where they occur with green sunfish, was not improved by the record flood.

Minckley and Meffe (1987) suggested that green sunfish might be more flood resistant than other nonnative fishes because they evolved in streams that periodically flooded. However, Harrel (1978) reported complete displacement of that species and other *Lepomis* by flooding in Devil's River, Texas. Elsewhere in the southwest, high-volume summer floods have been demonstrated to dramatically reduce centrarchid densities (Moyle and Nichols, 1974; Schlosser, 1985). A reason may be that floods in canyons are of greater intensity and shorter duration than floods in broader, lower gradient drainages of more mesic areas (Meffe, 1984; Minckley and Meffe, 1987).

Nearly all reports on differential effects of flooding on native and nonnative fishes are during summer (Minckley and Meffe, 1987). Many fishes of low-elevation southwestern streams are more active and use areas farther from cover in summer than in winter, perhaps making them more susceptible to displacement. Fausch and Bramblett (1991) suggested that fish occupying extensive cover and, thus, low water velocities are relatively immune to flood displacement. In winter, both Gila chub and green sunfish in Sabino Creek were reclusive and relatively inactive, probably because of low water temperature (winter mean = 5°C; summer mean = 29°C). Most green sunfish we located in winter (January and February 1994) occupied interstitial spaces between rocks and boulders which, even in riffles and runs, had no measurable water velocity (Dudley, 1995). Thus, green sunfish inactivity and use of protected habitat in winter may account for lack of displacement during winter flooding. Seasonal timing as well as magnitude of flooding may, therefore, differentially affect nonnative fishes.

Resumen—Este estudio documenta los efectos de una inundación récord en distribuciones del charalito del Gila nativo (*Gila intermedia*) y el robalo verde no nativo (*Lepomis cyanellus*) y el guayacón mosquito del oeste (*Gambusia affinis*) en el Sabino Creek en Arizona. Mientras que el promedio diario de la descarga de agua en el Sabino Creek durante todos los años anteriores a la inundación fue de 0.4 m^3/s, la inundación récord del invierno de 1992–1993 tuvo un promedio de descarga máxima diaria de 90 m^3/s y una descarga instántanea máxima de 365 m^3/s. La inundación ha sido hipotetizada como un mecanismo que permite a los peces nativos persistir durante tiempo en corrientes no controladas que llevan especies introducidas. Aunque la inundación en el Sabino Creek desplazó completamente al guayacón mosquito del oeste, el robalo verde no pareció ser afectado negativamente por la inundación. La inactividad y el uso de hábitat protegido en el invierno puede explicar la falta de desplazamiento del robalo verde durante la inundación invernal. El estado del charalito del Gila en la parte más baja

de Sabino Creek, donde se encuentra junto con el robalo verde, no mejoró por la inundación récord.

We thank O. E. Maughan and C. C. McIvor, University of Arizona, for suggestions on research and the manuscript. We also thank S. P. Platania, Museum of Southwestern Biology, and D. L. Propst, New Mexico Department of Game and Fish, for editorial comments. Special thanks to Z. Hogan and also S. Anderson, B. Dorr, K. Hilwig, D. Kitcheyan, R. Maes, G. Merovich, G. Paz, and P. Roller for help in the field. Finally, we thank numerous employees of the United States Forest Service and especially D. Bieber for project support and generous access to Sabino Canyon. The project was funded through the Heritage Program of Arizona Game and Fish Department in cooperation with United States Forest Service and University of Arizona Cooperative Fish and Wildlife Research Unit.

Literature Cited

Collins, J. P., C. Young, J. Howell, and W. L. Minckley. 1981. Impact of flooding in a Sonoran desert stream, including elimination of an endangered fish population (*Poeciliopsis o. occidentalis*, Poeciliidae). Southwestern Naturalist 26:415–423.

Dudley, R. K. 1995. The effects of green sunfish on the distribution, abundance, and habitat use of Gila chub in Sabino Creek, Tucson, Arizona. Unpublished M.S. thesis, University of Arizona, Tucson.

Fausch, K. D., and R. G. Bramblett. 1991. Disturbance and fish communities in intermittent tributaries of a western Great Plains river. Copeia 1991:659–674.

Harrel, H. L. 1978. Response of the Devil's River (Texas) fish community to flooding. Copeia 1978:60–68.

Meffe, G. K. 1984. Effects of abiotic disturbance on coexistence of predator-prey fish species. Ecology 65:1525–1534.

Miller, J. B. 1961. Sedimentation studies in the Sabino Canyon area of Tucson, Arizona. Unpublished M.S. thesis, University of Arizona, Tucson.

Minckley, W. L., and J. E. Deacon. 1991. Battle against extinction: native fish management in the American west. University of Arizona Press, Tucson.

Minckley, W. L., and G. K. Meffe. 1987. Differential selection by flooding in stream-fish communities of the arid American southwest. In: Matthews, W. J., and D. C. Heins, editors. Community and evolutionary ecology of North American stream fishes. University of Oklahoma Press, Norman. Pp. 93–104.

Moyle, P. B., and R. Nichols. 1974. Decline of the native fish fauna of the Sierra Nevada foothills in central California. American Midland Naturalist 92:72–83.

Robins, C. R., R. M. Bailey, C. E. Bond, J. R. Brooker, E. A. Lachner, R. N. Lea, and W. B. Scott. 1991. Common and scientific names of fishes from the United States and Canada. Special Publication, American Fisheries Society 20:1–183.

Schlosser, I. J. 1985. Flow regime, juvenile abundance, and the assemblage structure of stream fishes. Ecology 66:1484–1490.

United States Geological Survey. 1992. Water resources data, Arizona. Water-data Report AZ-92-1. United States Government Printing Office, Washington, D.C.

United States Geological Survey. 1993. Water resources data, Arizona. Water-data Report AZ-93-1. United States Government Printing Office, Washington, D.C.

Submitted 3 October 1996. Accepted 17 October 1997. Associate Editor was Bruce Demarais.