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HABITAT UTILIZATION BY AN INTRODUCED FISH, *GAMBUSIA AFFINIS,* IN NEBRASKA (ACTINOPTERYGII: POECILIIDAE)

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Mosquito-fish (*Gambusia affinis*) were introduced into Nebraska in 1972, and by 1987 had become well-established in two major rivers (Platte and Republican). In Nebraska, these fishes occupy lentic habitats (mostly sandpits and marshes into which they were usually introduced), but they also are abundant in lotic habitats (mostly in major rivers), where they primarily occur in shallow waters having low currents, habitats they invaded following escape from "cultivation." In these lotic microhabitats, they have the potential to achieve high population densities and to severely exploit such resources as become available.

† † †

INTRODUCTION

Gambusia affinis (Baird & Girard) was introduced into Nebraska in the spring of 1972. The stock was obtained from Provo, Utah, having been derived from a cold-acclimated stock developed at Salt Lake City between 1931 and 1933 (Rees, 1934). The Salt Lake City stock had been obtained originally from Memphis, Tennessee (Rees, 1934).

Following its introduction in 1972, persons associated with various county departments of health and the Nebraska Game and Parks Commission effected secondary introductions at some 158 locations within Nebraska (Lynch, 1988). Forty-five of these secondary introductions were in Scotts Bluff County; 72 were in Lincoln County (mostly in the immediate vicinity of North Platte); and 13 were in Lancaster County (within Lincoln and along its southwestern and southern edges).

Given this level of activity, it was not surprising that *Gambusia affinis* managed to establish itself in native waterways of Nebraska, becoming established in much of the middle Platte River and Republican River (Lynch, 1988). Feral populations are known for some 375 km of the Platte River (including portions of the North and South Platte rivers), for 120 km of the Republican River, and for some 12 km of the Elkhorn River. In addition, *Gambusia affinis* persists in many ponds and sandpits into which it was introduced as much as a decade ago. In the course of gathering data on the geographic distribution of *Gambusia affinis* in Nebraska, a good deal of ecological information was assembled as well. Those ecological data are the substance of this report.

ECOLOGICAL DISTRIBUTION

In its native distribution in the southeastern United States, *Gambusia affinis* is a fish primarily of marshes and swamps (Forbes and Richardson, 1920; Fowler, 1945; Pflieger, 1975; Smith, 1979). In these quiet waters, this small fish is normally described as frequenting the shoreline or some other microhabitat that is "weed-choked" (Clay, 1975; Douglas, 1974: Laerm and Freeman, 1986). Some authors describe it as the most common fish (e.g., Douglas, 1974: 264). The distribution of fins on *Gambusia affinis* would lead one to believe that this fish would not occupy moving water habitats such as predominate in Nebraska. However, even in its native range, *Gambusia affinis* is found in moving water, albeit as secondary habitat (Fowler, 1945: 353). The authors of two reports (also for the Plains states) made explicit reference to the frequent occurrence of *Gambusia affinis* in small and moderate-sized streams (Cross, 1967: 239, Miller and Robison, 1973: 160). In the case of Cross' report, these occurrences were for introduced fishes, whereas those reported by Miller and Robison were apparently native populations.

Persistence in presence of predatory fishes

Most of the persons involved in the introductions of *Gambusia affinis* in Nebraska were under the impression that the species could not survive in streams and rivers (they presumed that predators would quickly eat *Gambusia*), and that its ability to survive in Nebraska was restricted to bodies of water that did

not freeze over during the winter (either heated or spring-fed bodies of water). The lack of cold tolerance remains widely cited (e.g., Woodling, 1985: 64), and while it is possibly true that in Colorado overwintering requires surfacing groundwater (such as occurs along major rivers), such appears unnecessary in Nebraska. Neither of these suppositions (inability to withstand predation and requiring warmer waters) has proven correct in Nebraska.

While collecting *Gambusia* from lakes, ponds, and sandpits, I captured six other species in the same sweeps of the dip net or small seine. In two sandpits, *Gambusia* coexisted with *Pimephales promelas*. In six lakes and ponds, *Gambusia* was captured with five predacious species of fishes (*Ictalurus melas, Lepomis cyanellus, L. macrochirus, Micropterus salmoides,* and *Pomoxis nigromaculatus*). The collections from microhabitats within rivers produced more species. All of the above predators were found (excepting *P. nigromaculatus*) as well as the following: *Lepomis humilis, Micropterus dolomieui, Morone chrysops,* and *Pomoxis annularis.*

Collections within microhabitats in the river included many other minnows and minnow-like fishes, some predacious (e.g., *Semotilus*). Syntopic fishes included the gasterosteid *Culaea inconstans,* the clupeid *Dorosoma cepedianum,* the fundulids *Fundulus sciadicus* and *F. zebrinus,* the atherinid *Labidesthes sicculus* (another species carelessly introduced into Nebraska waters), the catostomids *Carpiodes cyprinus, Catostomus commersoni,* and *Moxostoma macrolepidotum*, and the following cyprinids: *Cyprinella lutrensis, Cyprinus carpio, Notropis blennius, N. dorsalis, N. stramineus, Pimephales promelas,* and *Semotilus atromaculatus.*

The most frequent river associates of *Gambusia affinis* were *Cyprinella lutrensis* and *Pimephales promelas*. Among the "typical" predator fishes, the most frequent associates were *Lepomis cyanellus* and *Micropterus salmoides.*

Coexistence in the river habitats is probably facilitated by the great variability in water depths and the constantly changing pattern of backwaters and side channels as water levels rise and fall. Predacious fishes are generally much larger than *Gambusia* and are thus less likely to remain for any length of time in the microhabitats preferentially occupied by *Gambusia* (see below). In contrast, coexistence in lakes and ponds would seem less likely because there is less fluctuation of habitat there, the edges of the ponds are more often steep, and, seemingly, less of the particular microhabitat for *Gambusia* is present. However, *Gambusia* seem to persist in such bodies of water for long periods in the presence of often substantial populations of predators. At Crystal Springs (Jefferson County), *Gambusia* has survived for six years in the presence of large populations of *Lepomis cyanellus* (which also are prominent along the shoreline) and lesser populations of *Ictalurus melas* and *Micropterus salmoides.* At Twin Lakes (approximately 3.6 km NE of North Platte), *Gambusia* has persisted in the presence of substantial numbers of *Lepomis cyanellus* apparently for nine years (since 1979). In an I-80 lake (190N) near Maxwell, *Gambusia* has persisted in large numbers with a large population of *Micropterus salmoides* for eight years. Persistences of substantial populations of *Gambusia* for shorter periods in ponds with as many as 6 or 7 species of predator fishes are known for farm ponds in Lancaster County. The population of *Gambusia* first detected in 1981 near Sutherland in an oxbow has persisted for 7 years in the presence of five species of centrarchids as well as (in some years) *Perca flavescens* and large numbers of *Ictalurus melas,*

Extinction of *Gambusia* from stocked ponds was found in only a few cases. *Gambusia* failed to survive the winter of 1986-87 in a heated pond in east Lincoln (at St. Elizabeth Hospital) although the population of *Carassius auratus* (goldfish) remained substantial. *Gambusia* had occupied a sandpit on the property of Dr. Bernie Taylor in south North Platte for more than a decade, but went extinct during the spring of 1987. *Gambusia* occupied a sandpit near interchange 179 of I-80 (North Platte) for several years, but went extinct around 1985. *Gambusia* failed to survive in one of four ponds at Crystal Springs, Fairbury. In the last three cases, there were other species of fishes (centrarchids and ictalurids) in the ponds.

At several of the permanent bodies of water where I found *Gambusia* in the presence of substantial populations of predators, the *Gambusia* were easily frightened and difficult to collect. However, at other sites having large predator populations, *Gambusia* were easily collected and did not appear to exhibit any finely-tuned escape behaviors. "Fright" reactions were most often observed in bodies of water where little vegetative cover was available, but these were also seen in bodies of water with dense growths of aquatic weeds (and *Lepomis cyanellus*).

Habitat use in major rivers

My observations on *Gambusia* habitat preference are largely in agreement with observations elsewhere, except that most of the observations were made within the main banks of relatively large rivers. At these river sites, *Gambusia* is normally encountered in quiet waters (see below), but is sometimes found in areas of substantial current.

In late July, 1987, the water level of the North Platte River below Lake McConaughy was raised about 15–30 cm, flooding a series of low islands near the US Highway 30 bridge (NE corner of City of North Platte). Two weeks earlier, *Gambusia* were found swimming in small schools of a few females and several "attending" males along the edges of these islands as well as along the edges of the major channels in the river. Following the rise in water level, most of the islands were submerged. As we collected in the channels around the remaining islands, similar constellations (2 or 3 females and 8–10 males) of *Gambusia*

could be found on the lee sides of such islands. I walked across the areas that were recently submerged and looked for fishes in those areas where some submerged vegetation remained. *Gambusia affinis* were still relatively abundant, but were dispersed (never more than 2 individuals in a group, and mostly single individuals were seen). These fish were "treading" water in areas where presumably the current was slightly less swift. Of the perhaps two dozen fishes seen, all were relatively large females and each was gravid. Presumably, the smaller males had been unable to fight the current and had been swept downstream during the week or so since water levels had risen.

At several collecting sites on the Platte River I found *Gambusia* at the river's edge, where currents were considerable. Small groups of fish were behind clumps of grass hanging into the current south of Overton (Phelps County). Upon disturbance, the pod of fish would swim out into the current and quickly return to the lee side of a grass clump, but with sustained molestation both males and females were capable of swimming against the current for distances of 0.5–1.0 m.

Much more frequent was the observation of small groups of *Gambusia* in the quiet waters between chunks of concrete (rip-rap) placed at river's edge to reduce erosion. At these sites, these micro-backwaters were relatively deep (15–20 cm) and immediately adjacent to very swift water. Those containing only a few liters of water contained fewer than six fish, but larger ones might contain a dozen or more *Gambusia* (as well as other species, most often *Lepomis* and *Cyprinella lutrensis*). Almost without exception, these small aggregates of *Gambusia* were made up of three to five males per female. In a stretch of 100 meters of shoreline protected by rip-rap, there would be a continuous series of small aggregates of *Gambusia affinis* and every 10-20 m I encountered an aggregate of very small young, segregated from any adults.

The "normal" microhabitats for river populations of *Gambusia affinis* in Nebraska are those having little or no current, with some silt cover on the bottom (Fig. 1). Any substantial obstruction to the current (logs, islands, wingdikes, some bridge abutments, and heavy debris) creates a backwater satisfying the

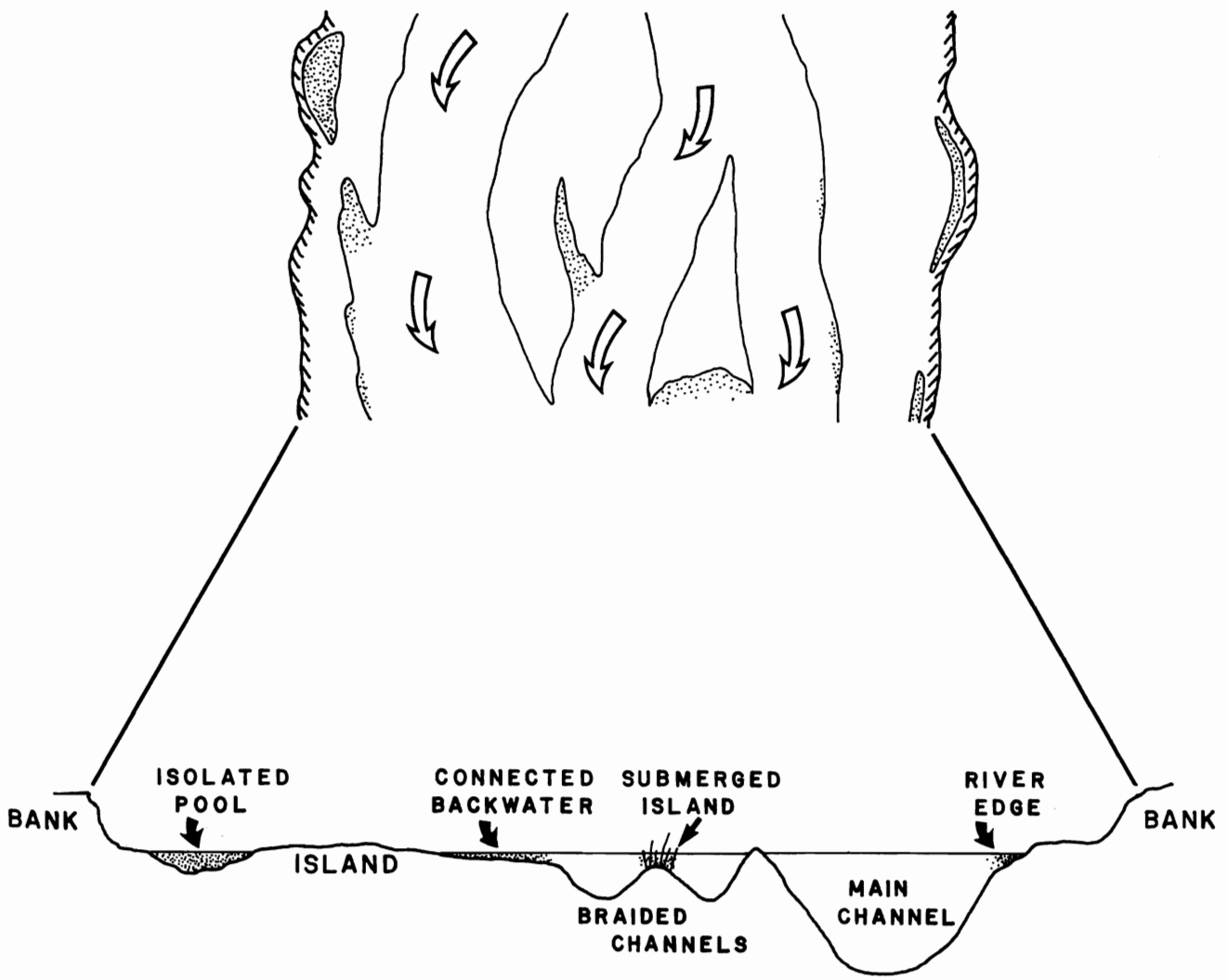

FIGURE 1. Idealized drawing of a Plains river in mid-summer as seen from above (top) or in cross-section (bottom). In the top panel, stipple indicates where *Gambusia* are found. In the lower panel, microhabitats are named and stipple again indicates the presence of *Gambusia*.

calm water preferences of *Gambusia affinis*. In addition, natural backwaters formed by the closure of a channel provide a microhabitat within which *Gambusia* thrive. The pools normally isolated near the main banks by falling summer water levels differ only in that they are deeper (commonly 0.5–1.3 m deep, but up to 2.0 m) and contain larger river fish.

Very large populations of *Gambusia* develop in isolated pools and in larger backwaters. In many of these there is substantial growth of aquatic vegetation (*Myriophyllum* or filamentous alga), and *Gambusia* of every size can be found in very dense populations. When *Gambusia* becomes very dense, few other fish species are found in the pool; it remains to be demonstrated for Nebraska waters whether this is cause or effect.

In all the collecting sites on the Platte River for 1987, I found *Gambusia* in six different microhabitats (Fig. 1). A single observation was made of *Gambusia* on submerged islands, they were found behind large obstructions twice (not illustrated), in braided side channels four times, along the river edge (amidst rip-rap, etc.) 13 times, in isolated pools 16 times, and from backwaters connected to a channel 25 times. For the Republican River, they were in one isolated pool, in one side channel, along the river's edge four times, and in backwaters five times.

Habitat use in eastern Nebraska

In eastern Nebraska, *Gambusia* appears to be less able to invade rivers and streams (Lynch, 1988), but some invasion has occurred. On 31 August, I found *Gambusia* at six sites on the Elkhorn River in Madison and Stanton counties. Five of the six sites were semi-isolated or isolated backwaters, and the sixth was a slow-moving stream as it entered the Elkhorn River (Corporation Ditch, the site of the Norfolk breeding population, drains into the Elkhorn at this site). *Gambusia affinis* has been collected once in the Salt Creek drainage, Lancaster County. On November 1, I collected two individuals in a small connected backwater in Oak Creek where it is crossed by First Street.

Dr. Edward Peters and his assistants collected two *Gambusia* from an isolated backwater of the Platte River (Dodge County) just east of North Bend, Nebraska, in late October, 1987. It was assumed that these fish were waifs from an established upstream population and, thus, on 14 November, efforts were made to locate *Gambusia* at and below the town of Schuyler where mosquito-fish were introduced in 1982. *Gambusia affinis* was collected in Lost Creek at the south edge of Schuyler, and from another site (also in Lost Creek). At the first locality (Schuyler), *Gambusia* was relatively common in protected areas near the shore (away from the modest current). At the second locality, fish were taken from an isolated weed-choked pool but were also seen in protected areas against the shore.

DISCUSSION

Mosquito-fish are famous for their role in consuming large numbers of mosquito larvae (Meisch, 1985), and on that basis have been widely introduced by persons associated with public health. Although mosquitos and their larvae are abundant in the lowlands along major rivers, mosquito larvae are not especially common in most of the microhabitats in which I found *Gambusia*. The broad range of acceptable foods of *Gambusia affinis* has been long known (Barnickol, 1941; Hess and Tarzwell, 1942; Harrington and Harrington, 1961) as has the awareness that prey choice is a matter of availability rather than preference (Hess and Tarzwell, 1942).

Mosquito-fish are equally famous for their reproductive capacities. Not only do they give live birth (obviating risks to zygotes and early larval stages), but also they reproduce throughout the growing season and attain sexual maturity rapidly (Krumholz, 1948). Such life-history qualities mean that they are able to quickly approach saturation of the habitat (and its resources) [this is cited as further evidence by promoters of its effectiveness as a biological control agent against mosquito larvae].

A third relevant component was long known to persons who keep tropical fishes. Early in this century, mosquito-fish enjoyed a brief popularity with aquarium fanciers, in spite of their relative drabness, because they were live-bearers. They were quickly brought into disfavor because they nipped the fins of tank mates (Innes, 1964: 339) and did not "fit in" in a community tank. The aggressive behavior of *Gambusia affinis* towards other fishes has been documented against *Poeciliopsis occidentalis*, and is thought to have contributed to local elimination of *P. occidentalis* by *Gambusia* in Arizona, although predation on young was the major factor (Meffe, 1985). In densely-planted aquaria, *Gambusia affinis* effects considerable fin damage on *Fundulus sciadicus* (*personal observations*). Presumably, such tissue damage would either reduce reproductive investment by a fish living more than one season or make the injured fish more prone to infection, thereby also reducing reproductive potential.

The microhabitat (relatively shallow, slowly moving water) which *Gambusia affinis* has invaded in large rivers in Nebraska is one that might appear to be under-utilized by native species. After all, aside from a few native species (e.g., *Culaea inconstans* and *Fundulus sciadicus*), the native Nebraska fishes occupy moving water, primarily streams and rivers. However, although the majority of adults and juveniles of native fishes might be described as stream-adapted, these fishes employ the shallow backwaters as breeding or nursery grounds (Cross, 1967; Pflieger, 1975; Smith, 1979) where zygotes are deposited and where the non-swimming larval stages occur. There are surely ecological costs to depositing eggs and early larval stages into the preferred microhabitat of an opportunistic and aggressive feeder such as mosquito-fish, especially when that species can quickly reach large population size.

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