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Natural History of a Relict Population of Topeka Shiner (*Notropis topeka*) in Northwestern Kansas

WILLIAM J. STARK, JASON S. LUGINBILL, AND MARK E. EBERLE
Department of Biological Sciences, Fort Hays State University
Hays, Kansas 67601
e-mail: wstark@fhsu.edu

The Topeka shiner (*Notropis topeka*), an endemic minnow of the Great Plains, has been extirpated over much of its former range. The U.S. Fish and Wildlife Service listed it as an endangered species in January 1999. The only extant population of *N. topeka* remaining on the High Plains is located in northwestern Kansas. During 1999, we studied aspects of the natural history of this isolated population. *Notropis topeka* fed in aggregations comprised of central stonerollers (*Campostoma anomalum*), fathead minnows (*Pimephales promelas*), green sunfish (*Lepomis cyanellus*), orangespotted sunfish (*Lepomis humilis*), and orangethroat darters (*Etheostoma spectabile*). *Notropis topeka* also raided the nests of *P. promelas* to consume eggs. Nests of *N. topeka* were located on the periphery of *L. cyanellus* nests, and possibly on the periphery of *L. humilis* and *P. promelas* nests. We describe the spawning act of *N. topeka* on the periphery of *L. cyanellus* nests, as well as their interspecific behavior near the nests of *L. cyanellus, L. humilis,* and *P. promelas.*

INTRODUCTION

The Topeka shiner (*Notropis topeka*) is a small minnow (<75 mm total length) endemic to a large area of the midwestern United States (Gilbert, 1980) that has been extirpated over much of its former range (USFWS, 1998). The U.S. Fish and Wildlife Service listed *N. topeka* as an endangered species, effective 14 January 1999 (USFWS, 1998). The largest number of extant populations in Kansas occurs in the Flint Hills region (Minckley and Cross, 1959; Schrank and others, 2001), and only one population is known to occur yet on the High Plains in Wallace County, Kansas, near the Colorado border (Eberle and others, 1989).

The habitat of *N. topeka* typically is large, open pools in small "headwater" streams of the upland prairie, where fish diversity is relatively low (Minckley and Cross, 1959; Barber, 1986; Pflieger, 1997). Generally, these pools have relatively clear water, little rooted vegetation, and substrates of sand, gravel, or larger material, usually covered by a layer of silt (Minckley and Cross, 1959). Stream segments where *N. topeka* occurs rarely have a strong, continuous flow and might be intermittent during the summer; however, the level of water in the pools is maintained by groundwater seepage (Minckley and Cross, 1959).

Notropis topeka is a diurnal species, and its diet consists primarily of aquatic insects, but they also consume other invertebrates and fish eggs (Kerns and Bonneau, 2002). In a study conducted in the Flint Hills of Kansas and in aquaria, Topeka shiners primarily fed on the stream bottom (Kerns and Bonneau, 2002). Although they have been reported to swim in the lower portion of the water column with central stonerollers (*Campostoma anomalum*) (Kerns and Bonneau, 2002), schools of *N. topeka* may swim in midwater or near the surface of pools (Pflieger, 1997).

The life span of *N. topeka* is 2–3 years. They can become sexually mature as yearlings (Cross, 1967), but most males are not reproductively active until their second year (Kerns and Bonneau, 2002). They are reproductively active from late May to July (Kerns and Bonneau, 2002; Pflieger, 1997). Pflieger (1997) described what is known of the breeding behavior of *N. topeka* based on observations made in Missouri. They spawn over the nests of sunfish (*Lepomis* spp.), with *N. topeka* males occupying small territories around the periphery of the sunfish nest. Pflieger (1997) stated that *N. topeka* males swim below the females, rather than beside them, but the actual spawning act was not observed.

In a study conducted in the upper Cottonwood River basin in the Flint Hills of eastern Kansas, Barber (1986) reported that populations of *N. topeka* were comprised of two groups of individuals: a larger sedentary group and a smaller mobile group. Adults, particularly males, were most likely to move upstream or downstream between March and May, before the spawning period, when precipitation typically increased in spring and raised stream levels. In many instances, the fish later moved back to their original pool. In the fall, young-of-the-year (YOY) individuals tended to move downstream. Fish also were displaced downstream during periods of high flows.

In Kansas, *N. topeka* once occurred across the northern and south-central portions of the state, but it now is confined almost entirely to the grasslands of the Flint Hills (Minckley and Cross, 1959; Schrank and others, 2001). The reduced range of *N. topeka* has been attributed to declines in the groundwater levels that normally maintain pools in intermittent streams and to increased turbidity and siltation caused by runoff from plowed fields (Minckley and Cross, 1959). Construction of impoundments also poses a threat to this species. Several populations of *N. topeka* have been extirpated upstream and downstream from impoundments in Iowa, Kansas, and Missouri (USFWS, 1998). These extirpations were attributed to alteration of aspects of the stream hydrology that maintained *N. topeka* habitat and to predation by lacustrine piscivores (e.g., largemouth bass, *Micropterus salmoides*). In a logistic model developed for 26 sites in the Flint Hills of eastern Kansas, high densities of small impoundments, high densities of *M. salmoides* in pools, and long pools were the only significant variables associated with sites where *N. topeka* had been extirpated (Schrank and others, 2001). A logistic model for 111 sites in the Flint Hills had only the number of small impoundments per watershed area as a significant variable (Schrank and others, 2001). In Missouri, competition with introduced species of fishes (e.g., western mosquitofish, *Gambusia affinis,* and blackstripe topminnow, *Fundulus notatus*) also was cited as a possible reason for the decline of *N. topeka* (Pflieger, 1997).

From May through October 1999, we studied the last remaining population of *N. topeka* on the High Plains of Kansas in Willow Creek. This relict population is distinct genetically from other populations located 450 km to the east in the Flint Hills (Michels, 2000.). A specific goal of this study was to provide additional information about the breeding behavior of *N. topeka* and to document its spawning act in nature.

Study Area and Methods

Willow Creek is a small, southeasterly flowing tributary of the Smoky Hill River in western Wallace County, Kansas, and is one of the few sources of permanent surface water in the area. Permanent flow in Willow Creek originates from springs that surface 8 km north of Weskan, Kansas, approximately 250 m upstream from a north-south bridge that spans the stream (38° 56′ N, 101° 57′ W). From this origin, Willow Creek extends 12.5 stream-km to its confluence with the Smoky Hill River, which is an ephemeral stream in this region.

The section of Willow Creek near the spring origin was distinguished by a gallery forest of cottonwood (*Populus*) and willow (*Salix*) that extended to the bridge. Otherwise, trees were rare in the basin and associated with apparently permanent pools or with dwellings. Several springs surfaced along the upper portion of this reach, which was dominated by habitats of flowing water. The substrate was primarily coarse sand overlain by silt and detritus. *Nasturtium* and *Typha* were abundant within and along the watercourse.

Immediately downstream from the bridge, the riparian zone was characterized by growths of *Typha, Eleocharis, Scirpus,* and, to a lesser extent, woody shrubs (*Amorpha* and *Salix*) in a landscape otherwise dominated by shortgrass prairie. Surface water flowed through a complex of runs and pools but was interrupted by large areas of marsh-like habitats. Substrates of coarse sand were restricted to runs and the periphery of large pools. Within marshy areas, flow was almost imperceptible as the water moved through dense emergent, floating, and submerged vegetation (*Carex, Ceratophyllum, Chara, Eleocharis, Juncus, Lemna, Nasturtium, Potamogeton, Sagittaria,* *Scirpus*, and *Typha*). The dense vegetation and limited flow allowed organic debris to accumulate to depths of 1 m. Marshy areas were the dominant habitat within the first 2 stream-km downstream from the bridge. Cattle-grazing was excluded from approximately the uppermost 1500 m of permanent stream flow in Willow Creek (upstream and downstream from the bridge).

In the lowermost portion of Willow Creek, there were several large and presumably permanent pools (some about 100 m long and 2 m deep). All of the pools in the upstream portion of this reach were nearly filled with *Chara* to the extent that little substrate was observable. The stream flow became intermittent and then ephemeral in the lower portion of the creek to its confluence with the channel of the Smoky Hill River. Throughout this lowermost stream reach, the watercourse was more incised, and flow was restricted to the stream channel; marshy areas were absent.

We conducted fieldwork for periods of 2–3 days at biweekly intervals beginning in the third week in April and continuing through the second week in August 1999. An exception occurred during the last three weeks in May, when our fieldwork was nearly continuous in an attempt to document the initiation of spawning activities. We made a final fieldtrip in late October 1999 to assess the presence or absence of adult and YOY *N. topeka* throughout the length of flowing water in Willow Creek.

We used a common-sense minnow seine (6.1 m × 1.2 m with 6.5-mm ace mesh) and D-frame aquatic nets (1-mm square mesh) to sample fishes before onset and after cessation of breeding activity of *N. topeka*. Initially, we placed captured *N. topeka* individuals in a livewell and then transferred each individual into a water-filled 20-ml graduated cylinder and recorded total length (TL) to the nearest millimeter. Subsequently, we transferred fish to a water-filled watch glass on an electronic balance and weighed each individual to the nearest 0.05 g. We recorded breeding condition and gender, when they could be determined with certainty, and we released all individuals near the point of capture.

To avoid disruption of spawning habitat, we used minnow traps (6.5-mm square mesh wire) to capture *N. topeka* individuals after the onset of breeding activities (traps as in Hubert, 1996:172). We placed 10 minnow traps near aggregations of minnows for 8–10 h per sample period. We recorded the number of individuals, as well as their total lengths and weights.

Throughout the study, we investigated breeding behavior and interspecific interactions by direct observation, aided at times by an aquavision scope and standard snorkeling techniques. Our observations were made between 0900 and 1500 h to ensure that lighting conditions were as consistent as possible among observation periods.

RESULTS

We observed or captured *N. topeka* only within a 500-m stream reach directly downstream of the origin of permanent flow. We captured the majority of individuals in two large pools, one directly under the county road bridge (BP-1: 40 m × 7 m; max. depth 2 m) and the second approximately 200 m downstream from the bridge (BP-2: 45 m × 10 m; max. depth 3.5 m). The only capture of individuals upstream of BP-1 occurred after a high-water event on 1 July 1999. Subsequently, no individuals occurred in this reach. We captured no individuals downstream from BP-2, including a section of the creek that includes the only other historical collection locality. In addition, we observed spawning activity only within BP-1 and BP-2, although we cannot exclude the possibility that some limited spawning might have occurred unnoticed in intervening habitats between BP-1 and BP-2.

Fish species captured or observed within the same habitats as *N. topeka* included *C. anomalum, Pimephales promelas* (fathead minnow), *Cyprinella lutrensis* (red shiner), *Semotilus atromaculatus* (creek chub), *Ameiurus melas* (black bullhead), *Fundulus zebrinus* (plains killifish), *Gambusia affinis, L. cyanellus, L. humilis, L. macrochirus* (bluegill), *M. salmoides,* and *Etheostoma spectabile* (orangethroat darter). *Notropis topeka* interacted with *P. promelas, L. cyanellus,* and *L. humilis* near nests of these three species. In addition, we often observed *N. topeka* in feeding aggregations with *C. anomalum* and *P. promelas.* We occasionally observed *E. spectabile* and sunfishes (*Lepomis* spp.) less than 4 cm TL in these feeding aggregations.

The large size of BP-1 and BP-2 and the high density of wind-deposited tumbleweeds (*Kochia*) hindered underwater observations and efficient sampling with seines. We captured the largest number of *N. topeka* on 8 May 1999 ($n = 268$). Length-frequency analysis (Fig. 1) indicated two distinctive size classes and presumably two age classes (no scales were taken because of federal permit restrictions) within an overall size range of 15–70 mm TL. In this sample, we observed that a few males had begun to develop red breeding color in their dorsal fins; therefore, seining was suspended in the pools, and the use of passive minnow traps was initiated.

Length-to-weight relationships changed during May and June, presumably as a result of gonadal development before spawning (no individuals were sacrificed to verify this condition). The weight of *N. topeka* individuals 45–60 mm TL increased significantly during this period (ANCOVA: $F = 34.8$, $P < 0.001$). The sample size of individuals less than 45 mm TL was insufficient for statistical analysis, but no individuals this small were in breeding color or obviously gravid.

The breeding color that we observed initially in a few of the largest *N. topeka* males (TL >65 mm) on 8 May 1999 was pronounced by 25 May 1999 (see Cross, 1967 for a description of breeding coloration), and large

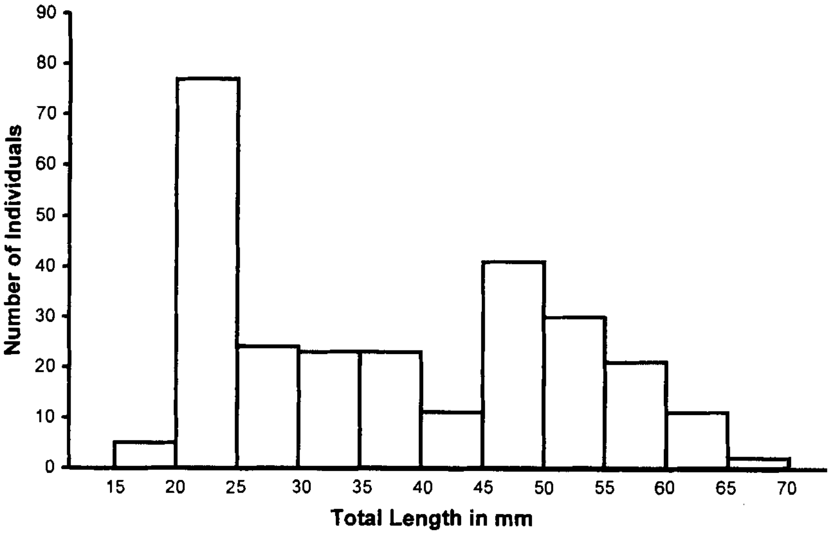

Figure 1. Length-frequency histogram sample of Topeka shiners collected from Willow Creek, Wallace County, Kansas, on 8 May 1999.

females were obviously gravid at this time. In late May, large *N. topeka* males established territories on the periphery of *P. promelas* nests, around which groups of *N. topeka* aggregated. We observed no spawning activity by *N. topeka* on the nests of *P. promelas,* although it might have occurred. Groups of *N. topeka* entered *P. promelas* nests and attempted to consume eggs; however, the *P. promelas* male could guard the nest effectively against a few individuals. In addition, the territorial *N. topeka* male on the periphery of the *P. promelas* nest would aid in guarding the nest if potential nest raiders happened to approach from the general direction of his territory. However, groups of *N. topeka* comprised of 15–20 individuals were able to overwhelm guarding males of both species and consume some of the eggs.

Notropis topeka males also established territories near the periphery of *L. humilis* nest depressions, and groups of *N. topeka* were attracted to these areas; however, no nest raiding was observed. The greatest activity of *N. topeka* around these nest sites occurred during June. Although we did not witness specific spawning events by *N. topeka* during June, we suspect some might have occurred, especially during and after the 15 June 1999 sample date. This suspicion is based on the fidelity of a few *N. topeka* males to the *L. humilis* nest sites.

By the 30 June–1 July 1999 sample period, *L. cyanellus* males were building and guarding nest depressions. The majority of *N. topeka* breeding groups moved to these larger depressions. The activity of *N. topeka* was much reduced near the nests of *L. humilis* and nearly absent at *P. promelas* nest sites at this time. As many as 10–12 *N. topeka* males had territories along the periphery of each *L. cyanellus* nest depression, and often 20–30 females (or at least individuals without male breeding colors) were observed in groups swimming around these territories. We observed groups of 20–25 apparently nonbreeding individuals of *N. topeka* (TL <50 mm) swimming near the banks of BP-1 and BP-2, but they avoided the spawning groups. *Lepomis cyanellus* males guarding the nests seemed to be oblivious to the large groups of *N. topeka* adjacent to their nests. We observed no *N. topeka* individuals or groups within or swimming through a nest depression while a *L. cyanellus* male was present; however, *N. topeka* would raid the *L. cyanellus* nest while the male sunfish chased other fish from his nest site.

We observed spawning (release of gametes) by *N. topeka* within the territories located on the periphery of *L. cyanellus* nests. A *N. topeka* male met a female at the edge, or near the edge, of its territory, and they swam as a pair to the center of his territory, the male slightly behind and below the female. Near the center of the territory, the female slowed briefly and shuddered slightly as she released eggs. Simultaneously, the male rose at an angle, such that his head was slightly higher and his caudal fin slightly lower than those of the female in a vertical plane, but their anal fins were approximately parallel. During this movement, the male apparently released gametes. Subsequently, the female left the territory and joined nearby groups of *N. topeka*. The actual events were observed in their entirety only twice, but fragments of the behavior were observed on a number of occasions. Observation was difficult because the entire process was rapid, perhaps no more than 2–3 seconds in duration. In addition, 2–3 nonterritorial males moved quickly into the territory while the resident male was engaged in spawning; this activity initially distracted us from our observations. Nonterritorial males apparently were attempting to fertilize deposited eggs; however, the resident male responded immediately and chased the intruders from his territory.

After 1 July 1999, the wheat harvest in the Willow Creek basin was complete, and turbidity increased after rains. Observation was nearly precluded on 15 July 1999, but we observed one spawning aggregation. No spawning aggregations were observed in August 1999, but visibility was poor.

We captured YOY *N. topeka* (TL <25 mm) in both BP-1 and BP-2 during the October 1999 sample period. Large mixed schools of YOY *N. topeka* and *P. promelas* occurred at the inflow of BP-1 near extensive beds of *Nasturtium*. In four aquatic net samples, we identified and released 133 YOY *N. topeka* and a similar number of *P. promelas*. We observed schools of a similar size in BP-2, but we made no further attempts to quantify YOY because of concerns for the health of the fish (given the time and handling required to identify individuals with certainty). In a thorough survey of

Willow Creek downstream of BP-2, using both seines and aquatic nets, we did not observe or capture *N. topeka.*

Discussion

We observed spawning by *N. topeka* only near *L. cyanellus* nests in Willow Creek, but the possibility that spawning occurred near nests of *L. humilis* or *P. promelas* cannot be excluded. However, the concentration of territorial males and groups of *N. topeka* around the periphery of *L. cyanellus* nests in July relative to other nesting species suggests that the habitat provided by *L. cyanellus* is important for the reproductive success of *N. topeka.*

Species interactions did not deviate markedly from those observed in populations from the Flint Hills of Kansas. Before the breeding season, *N. topeka* aggregated with *C. anomalum,* usually feeding with them in the lower portion of the water column, as reported by Kerns and Bonneau (2002). Although *N. topeka* groups in Willow Creek actively foraged in detrital substrates with *C. anomalum* and other species, *N. topeka* individuals would maintain positions above the other species feeding on the bottom and wait until potential food items were disturbed before moving in to feed in an opportunistic fashion, which was similar to behavior reported from observations of *N. topeka* kept in aquaria (Kerns and Bonneau, 2002).

In Willow Creek, *P. promelas* might be a more important part of the fish community relative to *N. topeka* than reported elsewhere. *Pimephales promelas* males excavated nest depressions and began spawning 4–6 weeks earlier than *L. cyanellus* males in Willow Creek. *Notropis topeka* individuals entering the spawning cycle in early May were associated closely with *P. promelas* nests and raided the nests for eggs in the later half of May and through most of June. The timely availability of this short-term but energy-rich resource might be a significant component in the reproductive success of the Willow Creek population of *N. topeka.*

USFWS (1998) and Schrank and others (2001) hypothesized that the presence of relatively high densities of *M. salmoides* contributed to the extirpation of *N. topeka* in other areas. In BP-1, we observed three adult *M. salmoides,* which had been placed there by a local landowner in 1998. In June 2001, we saw several *M. salmoides* in BP-2, where they had not been seen in 1999. We have observed no nesting activity or YOY individuals of this species, which suggests that additional stocking has occurred. The apparently increased number of *M. salmoides* might pose a threat to the population of *N. topeka* in Willow Creek.

The amount of suitable habitat available for *N. topeka* apparently has declined substantially in Willow Creek. Schryer and Ebert (1972) reported that the origin of permanent flow in Willow Creek formerly was about 3.5 km upstream of the current location. In addition, permanent flow extended for a total of 17.7 km within the basin compared to the 3–4 km observed during this study. This approximately 80% reduction in permanent surface water represents a serious threat to the long-term viability of the last remaining *N. topeka* population on the High Plains.

Notropis topeka was captured in only a 500-m stream reach of the 3–4 km of permanent surface water, and breeding almost certainly was limited to this area. However, Kansas Department of Wildlife and Parks personnel collected *N. topeka* from a site approximately 8.5 km downstream from BP-1. In 1994, 263 *N. topeka* individuals were captured and released, and in 1995, four and three individuals were collected on separate occasions (R. Waters, pers. comm.). A fourth sample collected from this site by Kansas Department of Wildlife and Parks personnel in June 2000 included a single *N. topeka* adult (K. Mitchell, pers. comm.). All four samples were obtained through equal sampling effort as part of standardized stream surveys. Our investigation of this site and other sites throughout this segment of Willow Creek suggests that *N. topeka* infrequently occurs in the lower portion of the basin. We suspect that the individuals collected in 1994, 1995, and 2000 either swam out or were "washed out" of upstream areas during periods of high flows, such as occurred in 1993 and 1999. Barber (1986) noted similar displacements in his study area in the Flint Hills. Presumably, *N. topeka* cannot maintain a population in this intermittent to ephemeral portion of Willow Creek.

It is unlikely that any reasonable management option can completely safeguard this genetically distinct population that is essentially restricted to two pools. Therefore, we suggest that individuals from Willow Creek should be used to establish additional populations of *N. topeka* within its historic native range on the High Plains. Adequate assessment of potential sites would require a rigorous evaluation of environmental parameters and the structure of the *N. topeka* population in Willow Creek that builds on this initial investigation. Research to support this proposal was initiated in 2001.

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