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Distribution, Habitat, and Status of the Gilt Darter (Percina evides) in Minnesota

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ABSTRACT — The distribution and habitat of gilt darter (*Percina evides*) populations in Minnesota were studied from 1977 through 1983. Gilt darters occurred only in the St. Croix River drainage in moderate to large rivers or near the mouths of large streams. In the late spring, gilt darters were found most often in cobble raceways of moderate to swift current, where they later spawned. Young-of-the-year occupied this same habitat until early fall, when they and the adults moved to deep, swift chutes of rubble riffles to overwinter. Gilt darters tended to associate with the deeper, swifter portions of raceways and riffles, and they were not associated with rooted aquatic vegetation. Gilt darters were one of the most abundant riffle species encountered during the study. Their closest ecological associates were the longnose dace (*Rhinichthys cataractae*), the slenderhead darter (*Percina phoxocephala*), and the logperch (*P. caprodes*). The species appears to be highly intolerant of siltation and probably does not occur in the Lower Mississippi or Minnesota River drainages for this reason. The gilt darter's existence in Minnesota could become threatened if sediment loading increases markedly in the St. Croix drainage.

Introduction

The gilt darter, *Percina evides* (Jordan and Copeland), is one of several species of darters (Percidae: Etheostomatini) whose distribution has been shrinking steadily throughout this century (1-5). Formerly, this species occurred from the Allegheny River drainage of southwestern New York and Pennsylvania west to the St. Croix River drainage of Minnesota and the White River of Northern Arkansas, and south to the Tennessee River drainage of northern Alabama and Mississippi and the Hiwassee River drainage of northern Georgia. However, gilt darters have not been collected in Ohio, Illinois, or Iowa for many years, and the species is considered extirpated in those states (6-8). In Indiana, Kentucky, Pennsylvania, and Wisconsin, gilt darters have been accorded rare or endangered status by various authors (4, 9-12).

Because the status of Minnesota populations was unclear and because very little was known about the species's habits (13), a study was initiated in 1977 to provide details about the distribution, habitat, life history, and status of gilt darter populations in Minnesota. This paper presents the current Minnesota distribution and the general habitat and ichthyofaunal associates of Minnesota gilt darters. Further details are provided about the seasonal habitats and migration of a Sunrise River, Chisago County, population. Finally, the current status of Minnesota populations is discussed and recommendations are made for their conservation.

Habitat terminology

The following terminology is used throughout this paper to describe the general habitat of gilt darters. The terms refer to a continuum of habitats distinguished primarily on the bases of flow characteristics, depths, and substrate types. **Riffles** are relatively shallow sections of stream exhibiting swift and turbulent current flowing over rocks of varying size. A prefix of **boulder** (greater than 6.5 cm in diameter) or **cobble** (2.5-6.5 cm in diameter) indicates the predominant type of substrate in the riffle (or any other habitat). **Rubble riffles** are further distinguished by a non-homogenous mixture of boulder and cobble substrates. **Raceways** are characterized by moderate depth and swift to moderate current that is not obviously turbulent. The reduction in turbulence is due primarily to raceways' somewhat smaller and more homogenous substrate. **Runs** are deep, usually straight sections of stream that may exhibit moderate to slow current depending upon their hydrologic origin. **Pools** are deep, very slow-moving sections of stream that may have any type of substrate depending upon their age and hydrologic origin, although their substrate most often is sand, silt, or mud.

Materials and Methods

Distribution was determined from an examination of past records and collections and from intensive and extensive collecting carried out from 1977 through 1983. All extant darter collections and records of the James Ford Bell Museum of Natural History, University of Minnesota, were examined, along with the personal collection records of James C. Underhill, Department of Ecology and Behavioral Biology, University of Minnesota. Distribution information also was obtained from the Minnesota Department of Natural Resources, the University of Minnesota/Department of Natural Resources

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cooperative stream survey data (1973-1983), and the work of Denoncourt (14) and Becker (15).

Over 175 sites in the Rainy, St. Croix, and Lower Mississippi river (Minnesota waters below St. Anthony Falls) drainages were sampled during the study. Sites were sampled with bag seines, one of which has a 9.5 mm chain attached to its lead line; Erickson nets (16); and two types of backpack electrofishers. Detailed distribution within a stream was determined by sampling small areas with Erickson nets. At each site water temperature, stream depth, and stream width were measured and recorded. Substrate, macroinvertebrate fauna, and aquatic and terrestrial vegetation were qualitatively described.

In the Sunrise River (Chisago County: Township 35N, Range 20W, Section 32), seasonal habitat utilization and migration were documented. Monthly sampling was conducted from April 1977 through October 1979 in each of four major habitats, except when prevented by ice cover or water level (Figure 1). Each habitat was given approximately equal sampling effort relative to its size. Water depths and temperature were measured routinely, and the substrate was characterized visually and by measuring diameters of stones collected haphazardly. On two occasions, benthic macroinvertebrates were sampled randomly in each habitat with a Waters stream bottom sampler (17). Periodically, subsurface current velocities were measured by repeatedly timing the movement of a neutrally buoyant plastic ball (5 cm diameter) over 5 to 25 m distances.

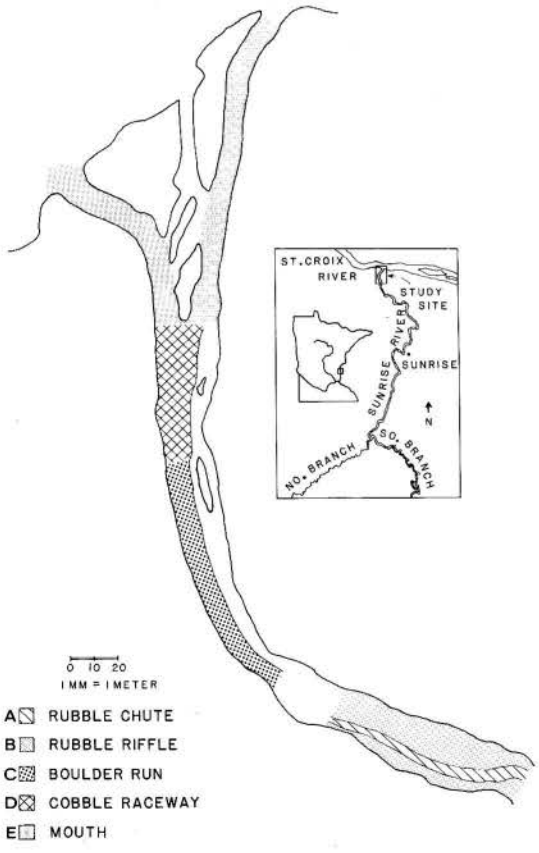

Figure 1. The Sunrise River study site in Chisago County, Minnesota, and a detail of the four major habitats studied. The "rubble chute" (A) is considered a part of the "rubble riffle" (B). Areas not marked by a pattern were not used in this study.

Quantitative information about distribution within habitats was obtained by making density estimates in the rubble chute area of the rubble riffle (Figure 1, A), in the cobble raceway (Figure 1, D), and in the mouth habitat (Figure 1, E). Each habitat was divided into several strata based on microhabitat characteristics, and as many darters as possible were collected within each stratum. They were counted by stratum and were marked by completely removing either the right (rubble riffle) or left (cobble raceway and mouth) pelvic fin. Darters were held for at least 1 hour after being fin-clipped to check for injury and then were returned to the strata in proportion to their capture. Recaptures were made in each stratum by taking 3-6 kick samples, each of which was obtained by kicking out 5-15 randomly selected 1 m^2 areas into an Erickson net. Sampling was carried out upstream to downstream within a stratum but downstream to upstream between strata. At the rubble riffle, recaptures were made 11 days after marking and a Peterson single-census population estimate was calculated using Chapman's adjusted formula (18). At the cobble raceway and mouth, recaptures were made one day and three days after initial marking. Additional darters were marked and returned on the first recapture date. In this case, Chapman's adjusted formula for the Schnabel multiple census method was used to calculate population size (18). Average density for an entire habitat was calculated by dividing the population estimate by the area of available habitat. This number was compared to the average density determined from the kick samples to estimate sampling efficiency. Efficiency levels were considered constant throughout each habitat, and kick sample density estimates from each stratum were then adjusted accordingly.

Results

Distribution and relative abundance

The extensive sampling efforts of this and other recent studies (19, 20) have confirmed that the gilt darter apparently is restricted to the St. Croix River drainage in Minnesota (Figure 2). The species is ubiquitous in riffles and raceways of the St. Croix River upstream of the St. Croix Dalles, and its relative abundance generally is higher than most other benthic riffle species (Table 1). If viable populations still exist downstream of the dalles, they are probably sporadic and uncommon. Although one juvenile was taken by Northern States Power Company biologists in 1977 in the vicinity of the Allan S. King power facility, no others were collected in this portion of the St. Croix or its Minnesota tributaries during this study. Only four other specimens are known from the lower St. Croix River. One was collected below the dam at Taylors Falls in 1928, and three were collected near O'Brien State Park in 1960.

The gilt darter also occurs in the Upper Tamarack, Kettle, Snake, and Sunrise rivers. In the Upper Tamarack River, a bog water river, the gilt darter occurs only in the lower 100 m where there is a cobble bottom and moderate current. In the Sunrise River, gilt darters occur in most riffles below the old power dam foundation at Sunrise, Minnesota, and they are especially abundant in the last 400 m of the stream (Tables 2 and 3). They do not occur above the confluence of the North and South branches of the river probably because of the low gradient and nature of the substrates, sand and detritus. Snake River gilt darters are abundant in riffles and raceways from the

Figure 2. Distribution of the gilt darter (*Percina evides*) in Minnesota. Solid circles show locations where gilt darters were collected during this study. Open circles indicate locations where gilt darters were known to occur prior to 1965.

mouth to 63 km upstream in the vicinity of Mora, Minnesota. Potential habitat exists for approximately 96 km upstream, but riffles in this area have not been sampled. There is only one record of the gilt darter from the Kettle River drainage. A large male in breeding colors was captured many years ago by Minnesota Department of Natural Resources biologists in the Kettle River near the city park in Sandstone, Minnesota. The Kettle River proper from Rutledge to the mouth (about 55 km) appears to offer excellent potential habitat, but extensive sampling of the river and its tributaries during the present study produced no specimens. The reason for the darter's absence or low numbers in this stream is not known.

Habitat and migration

Gilt darters collected in this study inhabited only clear, moderate to large-sized streams (20-100 m wide) that exhibited relatively strong flow all year. They were found most frequently in rubble riffles and cobble or boulder raceways where currents were moderate to swift (0.5-1.2 m/sec) and water depths were 0.2-1.1 m. They were rarely found in pools, shallow gravel riffles, or sandy shoals, and they were never collected from riffles overlaid with sediment. They were found only once in association with rooted aquatics (*Potamogeton* sp.) in a boulder run below a rubble riffle. All sites from which gilt darters were taken were heavily colonized by the immature forms of stoneflies (especially *Pteronarcys* and *Acroneuria*), mayflies (especially *Baetis* and *Ephemerella*), and caddisflies (especially species of the family Hydropsychidae).

In the Sunrise River, gilt darters were most abundant in the lower 400 m of the stream where they occupied the rubble riffle and its chute (A and B), the cobble raceway (D), and the east and west channels of the mouth (E) (Figure 1). The rubble riffle was comprised predominantly of closely packed cobble (4.0-6.5 cm in diameter) and boulder (10-60 cm in diameter), the larger boulders being located in the chute of the riffle. Water depths varied considerably during the course of the study, but normal summer depths ranged from 65 cm in the deepest part of the chute to 15 cm in the shallower riffle area. The water was over 2 m deep during spring flooding. Current velocities often exceeded 1.2 m/sec even during low-flow conditions. *Cladophora* was present seasonally on much of the substrate, but rooted aquatics were absent. The cobble raceway was comprised predominantly of cobble (2.5-6.5 cm in diameter) embedded in gravel and sand and interspersed with small boulders (up to 9.5 cm in diameter). The cobble substrate became somewhat more homogenous in the lower one-fourth of the raceway. Water depths in summer ranged from 35 to 50 cm, decreasing in the downstream direction, and current velocities ranged from 0.5 to 0.8 m/sec. *Cladophora* was present seasonally, and *Vallisneria* grew along the east margin of the raceway, where the water was shallower (10-15 cm) and slower, and the substrate consisted of pebble, gravel, and sand. Substrates of the east and west channels of the mouth area were similar, the upper half of each channel consisting of loose pebbles and cobble and the lower half consisting of loose pebbles, cobble, and boulders. The east channel was deeper (50-90 cm) than the west channel (28-50 cm) and had a somewhat slower current (not measured). Current velocities in the west channel ranged from 0.5 to 0.8 m/sec in summer. Aquatic plants usually were not present in these channels. The cobble substrate of the last 30 m of the east channel and all of the middle channel normally was covered with several centimeters of sand and silt, and gilt darters were never found in these areas.

Table 1. Percentage composition of catches in areas where *Percina evides* occurred.*

Species	SUN-1	SUN-2	SC	UT	SNK
Rhinichthys cataractae	55.8	34.4	12.2	0.2	4.9
Percina evides	30.2	20.7	11.7	3.3	10.0
Percina caprodes	3.4	2.8	1.2	0.7	0.4
Etheostoma nigrum	3.3	5.8	6.2	1.8	0.4
Percina phoxocephala	1.5	0.1	0.7	0.1	2.7
Noturus flavus	1.1	0.5	1.9	0.0	1.0
Notropis cornutus	1.0	4.1	11.0	54.6	1.4
Percina maculata	0.7	0.9	5.7	1.3	0.0
Notropis stramineus	0.5	8.5	10.6	0.0	2.6
Notropis spilopterus	0.3	8.5	16.4	0.6	70.6
Hybognathus hankinsoni	0.1	2.5	0.4	4.9	0.2
Nocomis biguttatus	0.2	2.1	5.1	12.0	0.3
Pimephales promelas	0.0	1.8	0.0	0.0	0.0
Semotilus atromaculatus	0.0	1.4	0.2	7.4	0.1
Catostomus commersoni	0.3	1.2	0.4	6.2	0.2
Pimephales notatus	0.2	0.7	1.8	1.1	0.2
Moxostoma spp.	0.0	0.8	0.6	2.0	0.7
Others	1.4	3.2	13.9	3.8	4.3
Total number of fish	2825	5562	829	819	992
Total number of samples	24	14	12	1	5

*SUN = Sunrise River; SC = St. Croix River; UT = Upper Tamarack River; and SNK = Snake River. Data listed under SUN-1 were calculated from Erickson net catches in the lower 400 m of the river. These catches were biased toward benthic species. Remaining data columns were calculated from the combined catches of all collection gear and were more representative of the entire ichthyofauna that cohabited riffle and raceway areas with *P. evides*. For this analysis, a sample consisted of all fish collected from one site on one date.

Table 2. Means and standard errors (SE) of kick-sample density estimates of Sunrise River *Percina evides* in the chute area of the rubble riffle, March 18, 1979.*

Area	No. Fish	Density No./m^2 (SE)	Adjusted Density No./m^2
Upstream margins	8	0.53 (0.17)	1.07
Upstream chute	14	0.93 (0.30)	1.87
Main chute	32	1.07 (0.23)	2.13
Downstream chute	15	1.00 (0.31)	2.00
Downstream margins	3	0.20 (0.14)	0.40
Combined	72	0.80 (0.12)	1.60

*Adjusted density is based on 50% sampling efficiency, determined from comparisons with Peterson single-census population estimates.

Table 3. Means and standard errors (SE) of kick-sample density estimates of Sunrise River *Percina evides* in the cobble raceway and mouth area, November 9, 1980.*

Area	No. Fish	Density No./m^2 (SE)	Adjusted Density No./m^2
Upstream half raceway	46	1.15 (0.46)	3.38
Downstream raceway	21	0.70 (0.26)	1.54
Upstream half east channel	93	1.55 (0.30)	4.56
Downstream half east channel	59	0.98 (0.17)	2.89
Upstream half west channel	65	1.08 (0.26)	3.19
Combined	363	1.17 (0.12)	3.45

*Adjusted density is based on 34% sampling efficiency, determined from comparisons with Schnabel multiple-census estimates.

Gilt darters were present in different habitats at different times of the year. Usually, they were not present or were present in low numbers at the rubble riffle from May to middle or late August, but numbers there increased substantially in October and November of each year. Darters of all sizes were found there throughout the winter. Although the raceway and mouth could not be sampled during the winter due to ice cover, very low catches in late fall and early spring indicated that darters were not abundant in these habitats during the winter. Catches at the rubble riffle chute in April typically averaged 3-6 gilt darters per Erickson haul, but by mid-May catches were well below 1 per haul. Catches at the raceway were also quite low during this time but were higher than anywhere else.

As young-of-the-year darters reached seinable size (approximately 25 mm standard length), catches in the raceway increased to 2-3 darters per Erickson haul, while catches remained near zero at the rubble riffle. By middle to late August, large numbers (as high as 20 darters per Erickson haul on August 15, 1977) of gilt darters (mostly young-of-the-year) were present in the raceway and the east and west channels of the mouth. At about the same time, numbers at the rubble riffle also began to increase. By November darter catches were rather low at the raceway but were back up to 3 or more at the rubble riffle. This basic seasonal distribution pattern was observed in 1977, 1978, and 1979 and to a lesser extent in 1980. The pattern suggests that winter migration typically takes place between the raceway and the deep chute of the rubble riffle.

Collections and observations at several cobble raceways clearly indicated that this type of habitat is used extensively for spawning by gilt darters. As indicated above, adults move to these areas in mid- to late May just prior to the breeding season (it was unclear whether the movement was upstream or downstream) and are most abundant in the central portions, where flow is stronger, boulders are present, and the cobble is solidly embedded in the gravel and sand. Throughout the summer, juveniles use these same habitats as nursery areas.

Distribution within habitats

Tables 2 and 3 show the adjusted kick-sample densities of gilt darters in different strata of the rubble riffle, cobble raceway, and mouth. Gilt darters were most abundant in the deeper, swifter portions of each habitat. Additional semiquantitative sampling at the rubble riffle in winter yielded similar results. Also in the winter habitat, large males and females (more than 50 mm standard length) were taken only in the deeper parts of the chute, suggesting some habitat partitioning by size. Just prior to the breeding season, males in breeding colors were taken almost exclusively in the vicinity of large boulders, either in the rubble riffle or the upstream portion of the raceway.

Ichthyofaunal associates

The closest ecologial associates of Sunrise River gilt darters were benthic species that occurred in the rubble riffle and the central portion of the cobble raceway (Table 1). The longnose dace (*Rhinichthys cataractae*) was the most widely distributed benthic fish in the study area, and it exhibited the greatest degree of microhabitat overlap. The slenderhead darter (*P. phoxocephala*) was collected in the same Erickson haul with the gilt darter more often than any other darter at the rubble riffle, and the logperch (*P. caprodes*) held the same distinction at the raceway. The Johnny darter (*Etheostoma nigrum*) was quite common in the area but occupied a microhabitat different from that of the gilt darter. The stonecat (*Noturus flavus*) probably was a closer associate than Table 1 indicates because diurnal sampling underestimates the relative abundance of this nocturnal species. Based on limited night sampling, the stonecat's microhabitat in the riffle appeared to be similar to that of the gilt darter.

Other common associates that share the same general habitat are listed in Table 1. The data in the last four columns primarily reflect the species composition of cobble raceway-type habitats, which were sampled as thoroughly as possible with all types of collection gear. Each sample used in this analysis consisted of all fish collected at one site on one date.

Discussion

Distribution

The absence of gilt darters from drainages other than the St. Croix is explained by a consideration of postglacial dispersal

and ecological requirements. Although suitable habitat exists in streams of the Lake Superior, Rainy River, and Upper Mississippi River (above St. Anthony Falls) basins, the postglacial dispersal of the gilt darter into Minnesota waters apparently occurred after the connectives between the St. Croix and these basins closed (21). Since no geographical barriers exist between the St. Croix, Lower Mississippi (below St. Anthony Falls), and Minnesota drainages, presumably an ecological barrier exists.

One possible barrier is siltation. Throughout its range, the gilt darter occurs in relatively clear streams and appears to be intolerant of heavy siltation (15, 22, 23). Gerking (1), Smith (3), and Trautman (8) suggest that loss of habitat due to excessive siltation was the primary cause for extirpation of the gilt darter from the Maumee, Wabash, and Rock river drainages. Streams in these drainages began to show signs of heavy siltation between 1890 and 1900 (a result of deforestation and increased agricultural use of prairie lands), and by the early 1900s gilt darters were no longer present (14).

An examination of suspended sediment measurements in Minnesota waters shows that levels in streams of the Minnesota and Lower Mississippi drainages are one to two orders of magnitude higher than those of the St. Croix River and its tributaries (Table 4). Since stream sediment loading is usually highest during April, May, and June due to spring snowmelt and early summer rains, it may be that silting in of spawning habitat during the gilt darter's spawning season (June to mid-July in Minnesota; 24) prevents populations from becoming established in streams of central and southern Minnesota. Even in the St. Croix drainage, siltation produces noticeable temporary effects. In the Sunrise River in 1978, gilt darter spawning was delayed until July due to prolonged flooding that covered the cobble raceway with 10-20 cm of fine sediment. Relative spawning success in that year was not determined, but juvenile growth was much more variable than in 1977 or 1979. Spring and early summer peak sediment loading also coincides with peak feeding intensity of gilt darters (24). Since gilt darters sight-feed on small, often cryptically colored aquatic immature insects, high levels of suspended sediments must have an adverse effect on feeding efficiency.

Availability of appropriate substrate types during the nonbreeding season, flow characteristics of the stream, and quality and quantity of food resources also are important factors to consider. However, personal observations and data from Erickson (20) suggest that at least some Lower Mississippi tributaries with strong, sustained flow, like the Zumbro and Cannon rivers, have substrates and food resources similar to those characteristic of the St. Croix. Thus, while a combination of factors may prevent gilt darters from colonizing any particular riffle, siltation, resulting from heavy sediment loading, probably is the major ecological barrier preventing them from establishing populations in the Minnesota and Lower Mississippi river drainages.

Habitat and status

In general, Minnesota gilt darters occupy habitats similar to those occupied by populations in other regions. However, Minnesota populations typically occur in swifter current than those of the Ozark Plateau and the Ohio River drainage (14, 22). Minnesota darters also are less apt to be associated with aquatic vegetation and pool habitats than some other midwest populations (7, 23).

My observations and those of James Underhill (personal communication) indicate that deep chute portions of rubble riffles are an important over-wintering habitat for the gilt darter in Minnesota. Winter migration to deeper waters has been reported for the slenderhead darter, *P. phoxocephala* (25), and the river darter, *P. sciera* (26), and it has been suggested for Virginia populations of the gilt darter (14). It may be that the occurrence of rubble riffles with deep chutes, which abound in the St. Croix River and its major tributaries, in close proximity to silt-free cobble raceways (spawning habitat) is an important factor contributing to the success of Minnesota populations.

At present, gilt darter populations are common and well established in the St. Croix River above the St. Croix Dalles, in the Snake River, and in the lower portion of the Sunrise River. Nevertheless, gilt darter populations should continue to be monitored because of their vulnerability to siltation. Increased sediment loading from housing and agricultural developments that do not employ adequate soil conservation practices could jeopardize the well-being of these populations.

Table 4. Comparison of suspended sediment measurements in the Minnesota, lower Mississippi, and St. Croix drainages of Minnesota from water years 1980 (October 1979 through September 1980). Source: Water Resources for Minnesota, Water Year 1980, Volume 2, Upper Mississippi and Missouri River Basins; and U.S. Geological Survey, Water Resources Division, St. Paul, MN. USGS/WRD/ HD-81/089.

		Susp. Sediment (mg/l)			Discharge (m^3/s)		
Drainage — Stream	Nearest Town	Feb. 21	Apr. 11	Jul. 09	Feb. 21	Apr. 11	Jul. 09
Minnesota River							
Whetstone River	Big Stone City	56	23	57	0.2	2.3	0.1
Yellow Bank River	Odessa	42	36	46	0.1	2.5	0.3
Minnesota River	Mankato	60	263	197	26.1	252.3	66.3
Lower Mississippi River							
Zumbro River	Kellogg	15	169	98	11.2	36.0	9.2
Whitewater River	Beaver	77	77	94	4.0	5.1	3.5
Root River	Houston	109	185	217	10.9	28.9	16.4
St. Croix River							
Kettle River	Cloverdale	—	2	2	—	51.3*	2.6*
Snake River	Pine City	2	1	1	3.1	53.8	2.7
St. Croix River	St. Croix Falls	2	12	6	52.4	270.2	40.8

*Discharge data taken from Kettle River near Sandstone, MN, rather than near Cloverdale. Same report as above.

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References

1. Gerking, S.D. 1945. The distribution of the fishes of Indiana. *Invest. Indiana lakes and Streams.* 3:1-137.
2. Harlan, J.R., and Speaker, E.B. 1956. *Iowa Fish and Fishing.* 3rd edition. Ames: Iowa State Conservation Commission.
3. Smith, P.W. 1971. Illinois streams: A classification based on their fishes and an analysis of factors responsible for disappearance of native species. *Ill. Nat. Hist. Surv. Biol. Notes* No. 76.
4. Burr, B.M. 1980. A distributional checklist of the fishes of Kentucky. *Brimleyana.* 3:53-84.
5. Page, L.M. 1983. *Handbook of darters.* Neptune City: TFH Publications, Inc.
6. Roosa, D.M. 1977. Endangered and threatened fish of Iowa. Special Rep. No. 1. Des Moines: Iowa State Preserves Advisory Board.
7. Smith, P.W. 1979. *The Fishes of Illinois.* Urbana: Univ. Ill. Press.
8. Trautman, M.B. 1981. *The Fishes of Ohio.* Revised edition. Columbus: Ohio State Univ. Press.
9. Miller, R.R. 1972. Threatened freshwater fishes of the United States. *Trans. Amer. Fish. Soc.* 101:239-52.
10. Branson, B.A. 1977. Threatened fishes of Daniel Boone National Forest, Kentucky. *Trans. Ky. Acad. Sci.* 38:69-73.
11. Lutterbie, G.W. 1979. Reproduction and age and growth in Wisconsin darters (Osteichthyes. Percidae). Univ. Wisc. Mus. Nat. Hist. *Reports on the Fauna and Flora of Wisc.* No. 15.
12. Margulies, D., Burch, O.S., and Clark, B.F. 1980. Rediscovery of the gilt darter (*Percina evides*) in the White River, Indiana. *Amer. Midl. Nat.* 104:207-8.
13. Eddy, S., and Underhill, J.C. 1974. *Northern Fishes With Special Reference to the Upper Mississippi Valley.* 3rd edition, revised. Minneapolis: Univ. Minn. Press.
14. Denoncourt, R.F. 1969. A systematic study of the gilt darter *Percina evides* (Jordon and Copeland) (Pisces, Percidae). Ph.D. Thesis. Ithaca: Cornell Univ.
15. Becker, G.C. 1983. *The Fishes of Wisconsin.* Madison: Univ. Wisc. Press.
16. Erickson, J.E. 1980. Winter sampling of benthic stream fishes in Minnesota with a one-man net. *J. Minn. Acad. Sci.* 46:2-3.
17. Waters, T.F., and Knapp, R.J. 1961. An improved stream bottom fauna sampler. *Trans. Amer. Fish Soc.* 90:225-26.
18. Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. *Fish. Res. Bd. Canada. Bull.* 191.
19. Anderson, C.P., Erickson, J.E., Ross, M.J., and Underhill, J.C. 1977. Revised distribution records of some Minnesota fishes. *J. Minn. Acad. Sci.* 43:3-6.
20. Erickson, J.E. 1977. The life history of the banded darter, *Etheostoma zonale zonale* (Cope), in the Cannon River, Minnesota. Ph.D. Thesis. Minneapolis: Univ. Minn.
21. Underhill, J.C. 1957. The distribution of Minnesota minnows and darters in relation to Pleistocene glaciation. *Occas. Pap. Minn. Mus. Nat. Hist.* No. 7.
22. Pflieger, W.L. 1975. *The Fishes of Missouri.* Missouri Dept. Conservation.
23. Kuehne, R.A., and Barbour, R.W. 1983. *The American Darters.* Lexington: The Univ. Press Ky.
24. Hatch, J.T. 1982. Life history of the gilt darter, *Percina evides* (Jordan and Copeland), in the Sunrise River, Minnesota. Ph.D. Thesis. Minneapolis: Univ. Minn.
25. Page, L.M., and Smith, P.W. 1971. The life history of the slenderhead darter, *Percina phoxocephala,* in the Embarras River, Illinois. *Ill. Nat. Hist. Surv. Biol. Notes* No. 74.
26. Page, L.M., and Smith, P.W. 1970. The life history of the dusky darter, *Percina sciera,* in the Embarras River, Illinois, *Ill. Nat. Hist. Surv. Biol. Notes* No. 69.