Long Term Resource Monitoring Program

Special Report

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Taxonomic and Distributional Status of *Notropis volucellus* and *Notropis wickliffi* in the Mississippi River Drainage:

A Literature Review

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July 1996

Taxonomic and Distributional Status of *Notropis volucellus* and *Notropis wickliffi* in the Mississippi River Drainage: A Literature Review

by

Robert A. Hrabik
Missouri Department of Conservation
Open River Field Station
Jackson, Missouri 63755

Prepared for

National Biological Service
Environmental Management Technical Center
575 Lester Avenue
Onalaska, Wisconsin 54650

Project Leader: Steve Gutreuter

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Contents

Tables

Figures

Preface

The Long Term Resource Monitoring Program (LTRMP) was authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the U.S. Army Corps of Engineers' Environmental Management Program. The LTRMP is being implemented by the Environmental Management Technical Center, a National Biological Service Science Center, in cooperation with the five Upper Mississippi River System (UMRS) States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The U.S. Army Corps of Engineers provides guidance and has overall Program responsibility. The mode of operation and respective roles of the agencies are outlined in a 1988 Memorandum of Agreement.

The UMRS encompasses the commercially navigable reaches of the Upper Mississippi River, as well as the Illinois River and navigable portions of the Kaskaskia, Black, St. Croix, and Minnesota Rivers. Congress has declared the UMRS to be both a nationally significant ecosystem and a nationally significant commercial navigation system. The mission of the LTRMP is to provide decision makers with information for maintaining the UMRS as a sustainable large river ecosystem given its multiple-use character. The long-term goals of the Program are to understand the system, determine resource trends and effects, develop management alternatives, manage information, and develop useful products.

This report was prepared under Strategy 2.2.8, *Monitor and Evaluate Fish Communities, Guilds, and Populations*, Task 2.2.8.4, *Evaluate and Summarize Annual Results*, as specified in Goal 2 of the Operating Plan of the LTRMP for the Upper Mississippi River System (USFWS 1993). This report was developed with funding provided by the Long Term Resource Monitoring Program.

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By Robert A. Hrabik

Abstract

Notropis volucellus was described in 1864 and underwent a confusing taxonomic synonymy with *Notropis blennius*. By the 1930s, *N. volucellus* was recognized as a full species with three subspecies. The subspecies *N. v. wickliffi* was described in 1931 but was not generally recognized as a full species until 1991. *Notropis volucellus* is widely distributed in the Mississippi River drainage, where it may be found in large creeks and rivers. *Notropis wickliffi* inhabits large Midwestern rivers from Louisiana to Wisconsin to Pennsylvania. In the Upper Mississippi River, *N. volucellus* and *N. wickliffi* occur sympatrically. Biologists with the Long Term Resource Monitoring Program (LTRMP) initially identified *N. wickliffi* as *N. volucellus*. I began examining LTRMP voucher specimens in 1991 and determined that specimens from Pool 13 to the Mississippi River's confluence with the Ohio River identified as *N. volucellus* were actually *N. wickliffi*. Above Pool 13, cursory separation of *N. wickliffi* from *N. volucellus* becomes increasingly difficult. Specimens from Pool 8 were mostly *N. wickliffi*, but several appeared to be intergrades. The purpose of this literature review is to describe the taxonomic and distributional status of *N. volucellus* and *N. wickliffi* in the Mississippi River drainage and to present supporting biological information that may help to define the taxonomy and distribution of both species.

Introduction

Biologists working on the Upper Mississippi River have encountered a significant taxonomic problem with *Notropis volucellus* (mimic shiner) and *N. wickliffi* (channel shiner), which ichthyologists have attempted to resolve over the years. For example, in 1931 Trautman described *N. wickliffi* from the Ohio and Mississippi Rivers where it sympatrically occurs with *N. volucellus*. Subsequently, Jenkins (1976) and Gilbert (1978) were the first to elevate *N. wickliffi* to full species rank but neither published justification for the action. Trautman (1981) also suggested that *N. wickliffi* was specifically distinct from *N. volucellus*. Mayden and Kuhajda (1989) elevated *N. wickliffi* to full species status and gave morphological and electrophoretic characters. Robins et al. (1991) recognized *N. wickliffi* as a full species, elevating it from a subspecies of *N. volucellus*. Several ichthyologists, including T. M. Cavender, D. A. Etnier, and C. R. Gilbert (*in* Robins et al. 1991), have expressed confidence that these taxa are full species. Etnier and Starnes (1994) recognized and distinguished *N. wickliffi* from *N. volucellus* in their treatise on Tennessee fishes.

The Long Term Resource Monitoring Program (LTRMP) is an element of the U.S. Army Corps of Engineers' Environmental Management Program for the Upper Mississippi River. Original authorization for the LTRMP provided for a 10-yr Program starting in 1987; this authorization was extended for another 5 years in 1990. Six remote state-operated field stations have been established for data collection. Water quality, fish, vegetation, wildlife, and invertebrates are being monitored in five separate reaches of the Mississippi River and one reach of the Illinois River.

During routine monitoring, LTRMP biologists collected numerous specimens of the *N. volucellus*-*N. wickliffi* group but all were assigned to *N. volucellus*. In 1991, I began to examine voucher specimens retained by the six field stations in the Program (Fig. 1). Using meristic and morphometric information provided in the literature, I determined that all records from the open river listed as *N. volucellus* were actually *N. wickliffi*. By 1992, I concluded that *N. wickliffi* was the dominant form of the *N. volucellus* species-group in the Upper Mississippi River from Pool 13, to the Ohio River (Fig. 1). However, cursory separation of *N. wickliffi* from *N. volucellus* becomes increasingly difficult above Pool 13, where meristic characters and melanophoric patterns begin to overlap. Specimens from Pool 8 were mostly *N. wickliffi* but several appeared to be intergrades. *Notropis volucellus-wickliffi* intergrades have also been noted by other ichthyologists (G. Seegert and D. Fago, personal communication) in Pools 8 and 9.

Gaps presently exist in the LTRMP database because biologists are not able to accurately identify members of the *N. volucellus* species-group. I prepared this literature review in anticipation of a morphometric, meristic, and electrophoretic study to determine the taxonomic validity and distribution of each species in the Mississippi River drainage. The purpose of the literature review is to describe the taxonomic and distributional status of *N. volucellus* and *N. wickliffi* in the Mississippi River drainage and to present supporting biological information that may help to define the taxonomy and distribution of both species.

Taxonomic History

Both *N. volucellus* and *N. wickliffi* belong to the teleost family Cyprinidae (minnows) and the genus *Notropis* (shiners, in part). Both are included in the subgenus *Notropis* and have been assigned to the *volucellus* species-group by Mayden (1989). Other members of this species-group according to Mayden (1989) are the following: *Notropis buchanani*, *N. cahabae*, *N. heterolepis*, *N. maculatus*, *N. ozarcanus*, *N. rupestris*, *N. spectrunculus*, and *Opsopeodus emiliae*. However, Amemiya and Gold (1990) suggested that the *Volucellus* species-group is not monophyletic. They demonstrated that *O. emiliae* is more closely related to the genus *Cyprinella* on the basis of chromosomal nucleolus organizer regions phenotypes. Furthermore, Page and Johnston (1990) demonstrated that the breeding behavior of *O. emiliae* is unique among North American minnows belonging to a clade comprising the genera *Opsopoeodus*, *Codoma*, and *Pimephales*.

Etymology, Nomenclature, and Type Localities

Notropis is a compound word derived from *notus*, meaning back, and *tropis*, meaning keel. The correct spelling should be *Nototropis*; however, a ruling by the International Rules of Zoological Nomenclature upholds the current spelling (Smith 1985). *Volucellus* is derived from *volucer*, meaning winged or swift, and *wickliffi* is a patronym for Edward L. Wickliff, an Ohio naturalist and colleague of Milton B. Trautman. The type locality for *N. volucellus* is the Detroit River at Grosse Ile, Wayne County, Michigan (Cope 1864). The type locality for *N. wickliffi* is at the mouth of the Miami River, Hamilton County, Ohio (Trautman 1931).

The vernacular names for *N. volucellus* and *N. wickliffi* are mimic shiner and channel shiner. The term mimic shiner was applied to *N. volucellus* because the species superficially resembles many North American cyprinids. Channel shiner was applied to *N. wickliffi* to describe its primary habitat—the main channel of large rivers.

Systematics

The phylogenetic relationships of North American cyprinids are poorly understood. Some have called cyprinid phylogeny "chaotic" (Hubbs and Miller 1977) because their genetic and ontogenetic characters are complex and difficult to classify.

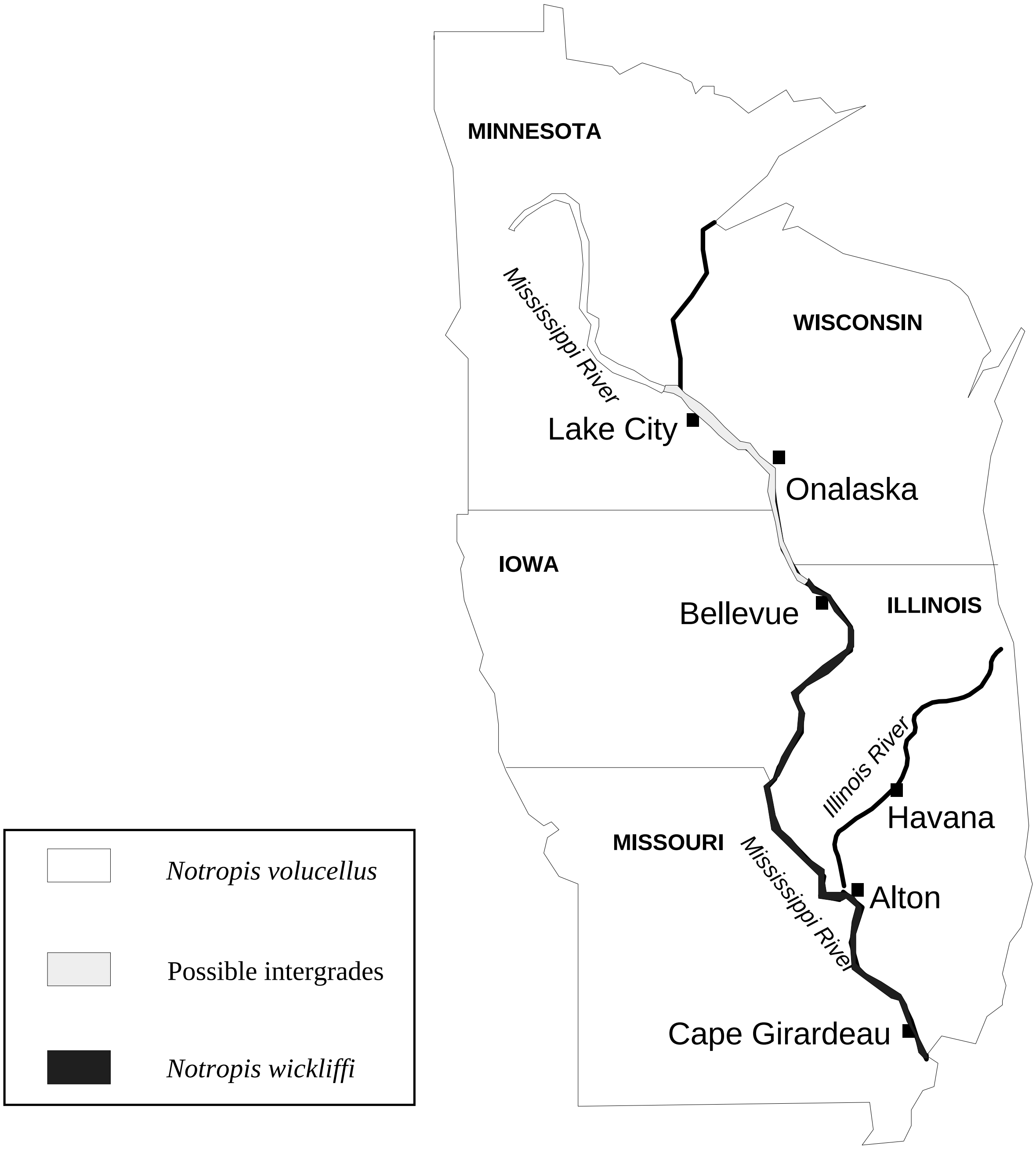

Figure 1. Location of Long Term Resource Monitoring Program field stations where Program biologists are collecting long-term resource data on the Upper Mississippi River. Distribution of *Notropis volucellus*, *Notropis wickliffi*, and possible intergrades in the Upper Mississippi River is shown, based on meristic and morphometric characters.

However, Mayden (1985, 1989) conducted monumental work in this area, setting the course for clarification of some of the most confusing relationships in the Cyprinidae. Mayden (1989) recognized three subgenera and two species-groups in the genus *Notropis:* *Notropis*, *Alburnops*, and *Hydrophlox*; and *volucellus* and *texanus*, respectively. The relationships between these groups are unresolved with the exception of the subgenus *Notropis* and the species-group *texanus*, which are sister clades.

Similarly, the relationships between clades and among species in the *volucellus* species-group are unclear (Mayden 1989). *Notropis volucellus* is probably a complex of species, meaning that several closely related sympatrically and allopatrically occurring species have been assigned to *N. volucellus* because insufficient data exist to separate them. I concur with other ichthyologists that this complex exists. For example, Burr and Warren (1986) stated that "several forms masquerade under the name *N. volucellus*." Etnier and Starnes (1994) summed up the confusion this way: "an understanding of the phylogeny of this group and the number of species or subspecies involved is seen as one of the most interesting, needed, and difficult problems remaining in the systematics of North American freshwater fishes."

Notropis volucellus was originally described by Cope (1864), who assigned it to the genus *Hybognathus* (*H. volucella*). Others placed the species in *Hybopsis*, *Alburnops*, and *Notropis* (Nelson 1876; Jordan 1878; Gilbert 1978). The species epithet *deliciosus*, an early name for *Notropis stramineus* (sand shiner), is believed to be a senior synonym of *volucellus* (Hubbs 1926; Smith 1979). *Volucellus* and *deliciosus* have both been misapplied to various genera (O'Donnell 1935). From its description in 1864 until 1928, *N. volucellus* was often in synonymy with the *Notropis blennius* (river shiner) complex, which consisted of the sand, mimic, and ghost shiners (Hubbs and Greene 1928). Systematics of the river shiner are also confusing. It was described by Girard (1856) as *Alburnops blennius*. Jordan (1878) redescribed the species and named it *Episema jejuna*. Forbes (1884) placed it in *Notropis* (*jejunus*). The sand shiner was named *blennius* by Jordan and Evermann (1896–1900) and by Forbes and Richardson (1920). Essentially, Forbes' *jejunus* became *blennius* and Forbes and Richardson's *blennius* became *stramineus*.

Species epithets were resurrected by Hubbs and Greene (1928), separating this complex into the sand shiner (*deliciosus*—i.e., *stramineus*) and mimic shiner (*volucellus*), and recognizing two subspecies of the mimic shiner, *volucellus* and *buchanani*. Later, Suttkus (1958) relegated *deliciosus* to the synonymy of *N. texanus*. When Trautman (1931) described the channel shiner, a third subspecies, *wickliffi*, was added.

Although many forms of *N. volucellus* exist (e.g., the Neosho River form; *in* Hubbs and Bonham 1951), only one subspecies, *N. v. volucellus*, is recognized today. Bailey (*in* Harlan and Speaker 1951) reelevated the ghost shiner (Gilbert 1980), and Jenkins (1976), Gilbert (1978), and finally Robins et al. (1991) elevated *N. wickliffi* to full species rank.

Notropis wickliffi was originally described by Trautman (1931) as a subspecies of *N. volucellus*. Trautman (1931, 1981) noted intergrades between *wickliffi* and *volucellus*, especially in tributaries to large rivers, and seasonally in the Ohio River. Etnier and Starnes (1994) reported that in some Tennessee streams, *N. wickliffi* and *N. volucellus* sympatrically occurred and were distinguishable. Becker (1983), however, expressed reservations about his ability to distinguish the two taxa from Wisconsin waters. Overall, there seems to be little disagreement among ichthyologists that *N. wickliffi* warrants full species rank and that intergrades may occur where they are sympatric (Trautman 1981; Robins et al. 1991; Etnier and Starnes 1994).

Taxonomic studies involving *N. volucellus* and *N. wickliffi* are few. Gong and Cavender (1991) used univariate and multivariate techniques to describe the taxa from Ohio. While finding *N. wickliffi* only in the Ohio River, Gong and Cavender (1991) found a north–south cline in several morphometric and meristic variables and suggested that if a total geographic analysis was conducted, more taxonomic forms of *N. volucellus* could be revealed.

In another taxonomic study, Mayden and Kuhajda (1989) compared meristic, morphological, and genetic characters of *N. wickliffi*, *N. volucellus*, and *N. cahabae*. They concluded that *N. volucellus* is a complex of more than one taxon, and *N. wickliffi* is a distinctive and sister species to the newly described *N. cahabae*.

Description of the Taxa and Similar Sympatric Species

Diagnostic Characters

Selected diagnostic characters for *N. volucellus* and *N. wickliffi* appear in the Table. Some *N. volucellus* characters are ambiguous—possibly reflecting more than one taxon or geographical variation. The *N. volucellus* characters showing the most variation are lateral-line scales, scales above and below the lateral line, pectoral fin rays, anal fin rays, gill rakers, and maximum size.

Lateral-line scales ranged from 32 to 40. Smaller scaled *N. volucellus* (35–40) were from Louisiana (Douglas 1974), New York (Smith 1985), and Illinois (Smith 1979). Scales above the lateral line were generally 8–10, with 7–9 below. However, Smith (1985) reported that New York specimens had only about four scales above and below the lateral line. New York *N. volucellus* also had fewer pectoral fin rays (12–15) and gill rakers (5–6). The largest average maximum size (65 mm) was reported from Illinois (Smith 1979) and Tennessee (Etnier and Starnes 1994), but larger specimens have been documented elsewhere (Trautman 1981). The smallest *N. volucellus* specimens were found in Louisiana (Douglas 1974) and Wisconsin (Becker 1983).

In general, *N. wickliffi* can be distinguished from *N. volucellus* and its forms by having larger scales (fewer in the lateral line); more scales above and below the lateral line (less elevated scales); and a nonexistent to lightly pigmented predorsal stripe and spot. Mayden and Kuhajda (1989) noted that the typical *N. wickliffi* has a larger eye, longer mouth, more posteriorly placed anal fin, a longer and more anteriorly placed dorsal fin, shorter predorsal length, and a narrower caudal peduncle than either *N. volucellus* or *N. cahabae*. In addition, Etnier and Starnes (1994) noted that *N. wickliffi* has a less arched back and more prominent nuptial tubercles on the head. However, Etnier and Starnes (1994) stated that *N. wickliffi* had a deeper caudal peduncle than *N. volucellus*, opposite of the observations of Mayden and Kuhajda (1989). Collections from the Upper Mississippi River vary in several physical attributes, including body depth, in which *N. wickliffi* is sometimes deeper than *N. volucellus* (Hrabik, unpublished data). Etnier and Starnes (1994) noted that *N. wickliffi* from Tennessee have a continuous postdorsal dark streak, but that sympatric *N. volucellus* have a discontinuous or no postdorsal streak. Conversely, *N. wickliffi* from the Upper Mississippi River rarely have a postdorsal streak, but *N. volucellus* I have examined from several upper Midwest localities may have a continuous postdorsal streak (Hrabik, unpublished data).

Similar Sympatric Species

Notropis volucellus and *N. wickliffi* are most often confused with *N. stramineus* (sand shiner), *N. buchanani* (ghost shiner), *N. shumardi* (silverband shiner), and *N. amnis* (pallid shiner). *Notropis volucellus* and *N. wickliffi* can be distinguished from *N. stramineus* by having eight anal fin rays (seven in *N. stramineus*), poorly developed pre- and postdorsal fin stripes (prominent in *N. stramineus*), a more rounded snout, and elevated scales in the anterior portion of the lateral line. They differ from *N. buchanani* in having

Table. Selected diagnostic characters of *Notropis volucellus* and *Notropis wickliffi* from the Mississippi River drainage.

Character	*Notropis volucellus*	*Notropis wickliffi*
Lateral-line scales	32–40	32–34
Scales above lateral line	4–10	10–11
Scales below lateral line	3–9	9–11
Circumferential scales	17–22	21–24
Predorsal scales	13–16	12–15
Breast squamation	None to fully scaled	Usually none or a few scales
Scale form	Elevated anteriorly 2–4 times height over width	Elevated anteriorly 2–3 times height over width
Pectoral fin rays	12–17	14–17
Pelvic fin rays	8–9	8
Dorsal fin rays	8	8
Anal fin rays	7–9	8
Gill rakers	5–10	5–8
Teeth	2,4–4,2 and 4–4	Not known
Maximum size	50–76 mm	≃65 mm
Body depth—greatest point	20%–25% of standard length	About 20% standard length
Head length	3.5–4.0 times into standard length	3–4 times into standard length
Eye diameter	2.6–3.5 times into head length	2–3 times into head length
Lateral stripe	Variable; well developed to vague; usually more intense posteriorly; expanded on caudal peduncle usually with ventral lobe; spot reported on some specimens	Less variable; moderately developed and more intense posteriorly; expanded on caudal peduncle usually with ventral lobe; no spot
Predorsal stripe and spot	Heavily pigmented and evident	Nonexistent to lightly pigmented
Caudal peduncle scales	More heavily pigmented posteriorly	Usually uniformly pigmented
Preoperculo-mandibular canal	Usually complete or interrupted	Complete
Infraorbital canal	Uninterrupted and complete	Uninterrupted and complete
Vertebrae	32–37	Unknown
Peritoneum	Silvery to scattered dark speckles	Lightly scattered dark speckles
Tubercles	Absent on fins, except dorsal surface of pectorals; well developed on snout; noted on specimens 40 mm or larger	Same except less developed on snout and not found on specimens less than 50 mm

Data summarized from: Becker (1983); Burr and Warren (1986); Cross and Collins (1975); Douglas (1974); Etnier and Starnes (1993); Hrabik (unpublished data); Mayden and Kuhajda (1989); Pflieger (1975); Robison and Buchanan (1988); Smith (1979); Smith (1985); and Trautman (1981).

more pigment on the body; a less pointed dorsal fin; moderately elevated scales in the anterior portion of the lateral line; pelvic fins not reaching the anal fins when depressed; a dusky stripe on the caudal peduncle; speckled peritoneum; less deep, slab-sided body; and a complete infraorbital canal. They differ from *N. shumardi* in having elevated scales, eight anal fin rays (nine in *N. shumardi*), a more terminal mouth (as opposed to oblique), and no dark pigment along the lateral line. They differ from *N. amnis* in pharyngeal tooth count (1,4–4,1 in *N. amnis*); and in the mouth (upper lip) extending to the eye, being slightly more oblique, and level with the lower margin of the eye.

Distribution and Habitat

Notropis volucellus and its forms are widely distributed from southern Canada to Texas; they are widespread in the eastern drainages of the Mississippi River (Fig. 2) and extend westward through the Guadalupe and San Antonio river basins in southeastern Texas (Gilbert and Burgess 1980). Buchanan (1976) reported *N. volucellus* to be one of the most abundant minnows in the lower White River system of Arkansas. This conclusion is questionable because the lower White River flows through the Mississippi River Alluvial Plain, where habitat seems more suited to *N. wickliffi*. *Notropis volucellus* is also found in the Red River of the North, the Great Lakes, and St. Lawrence drainages and Lake Champlain system (Gilbert and Burgess 1980). This species has a curious distribution in Tennessee, where it is largely absent from direct tributaries to the Mississippi River (Etnier and Starnes 1994), and in southern Michigan where it is absent (Gilbert and Burgess 1980). The absence of *N. volucellus* from southern Michigan may be an artifact, as University of Michigan Museum of Zoology fish records may not have been available to all authors in the *Atlas of North American Freshwater Fishes* (D. Etnier, personal communication). Disjunct populations of *N. volucellus* occur in Missouri (Pflieger 1975), North Carolina, and Virginia (Gilbert and Burgess 1980). *Notropis volucellus* has been introduced to the Susquehanna River basin where it is rapidly spreading (Malick 1978; Gilbert and Burgess 1980; Cooper 1983), and has been reported to be declining in some Midwestern states, especially in Illinois (Smith 1979), Ohio (Trautman 1981), and southern Wisconsin (Becker 1983).

Because of the confusing taxonomy, the definition of *N. volucellus* and *N. wickliffi* zoogeography is tenuous. However, it seems plausible that both species evolved from stock in the Teays-Mississippi River system (Pflieger 1971).

Notropis volucellus avoids small headwater streams but may be found in a variety of other aquatic environments. In northern parts of its range, it is found in vegetated pools or backwaters of small streams and rivers (Black 1945; Becker 1983; Smith 1985). In Missouri, it is locally abundant in clear, vegetated, and flowing Bootheel ditches (Pflieger 1975; Hrabik, unpublished data). In Louisiana, it is more common in low gradient streams, especially of the Mississippi River Alluvial Plain, than in higher gradient streams of the surrounding Coastal Plain (Douglas 1974). Elsewhere, it is found in clear to moderately clear medium-sized streams to highly turbid, large rivers (Pflieger 1975; Trautman 1981; Burr and Warren 1986; Etnier and Starnes 1994). The small stream forms are generally found in clear pools over gravel substrate in moderate current. Large river forms are found along shorelines over gravel, sand, and mud substrates usually in slow to moderate current. Becker (1983) reported the presence of *N. volucellus* in the shallow bays of the Great Lakes, and Smith (1979) and Becker (1983) noted this species from glacial lakes in Illinois and Wisconsin. Etnier and Starnes (1994) noted that it has a "tolerance" for large reservoirs in Tennessee.

In comparison, *N. wickliffi* is seemingly restricted to large rivers, the lower reaches of direct tributaries, and some large creeks (Trautman 1981; Etnier and Starnes 1994). Cross (1967) referred to the Neosho River form as *N. wickliffi*, but I doubt the accuracy of that identification.

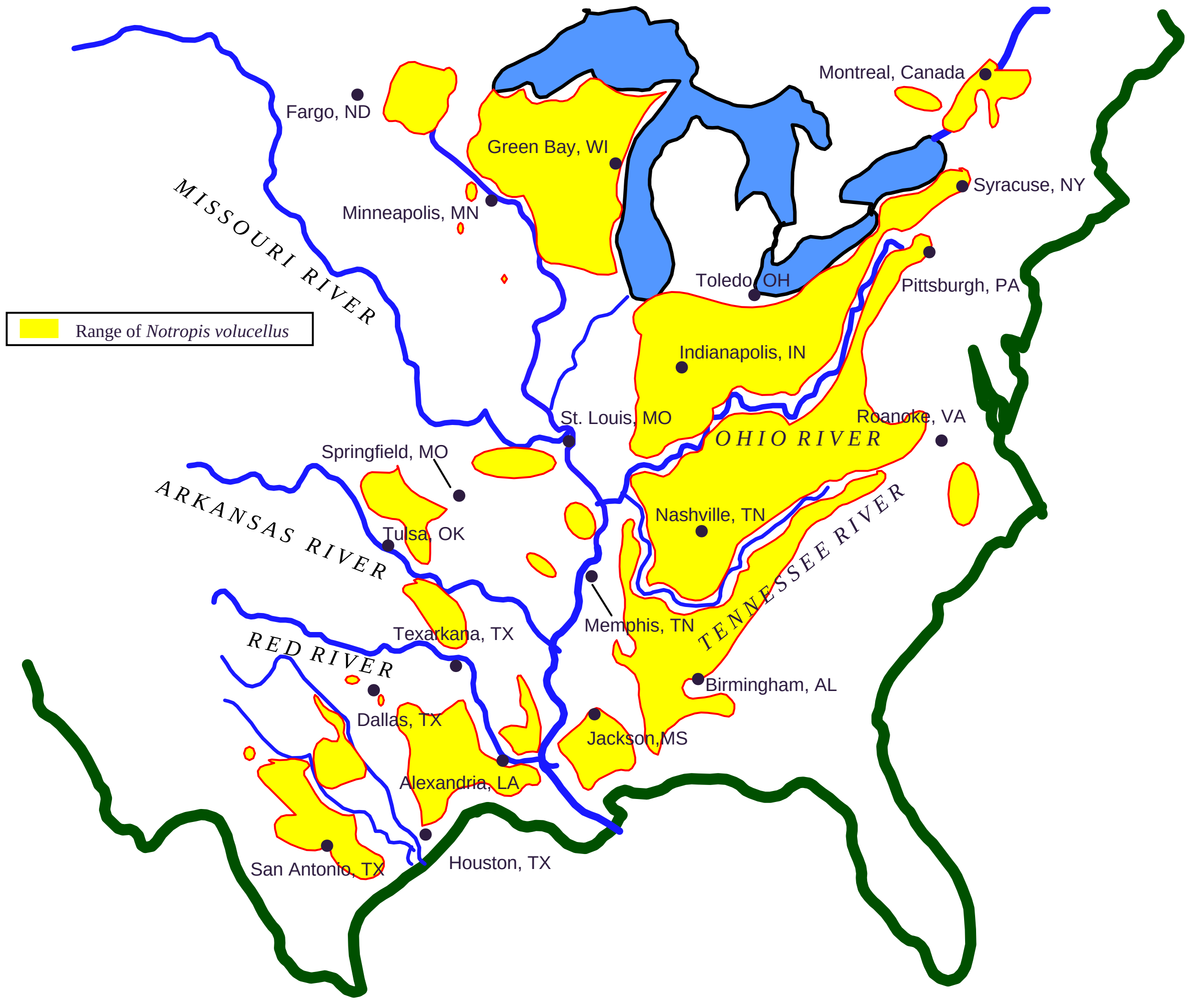

Figure 2. Generalized distribution of *Notropis volucellus* in North America, after Gilbert and Burgess (1980). Distribution extends into southern Canada and may include large rivers within its range.

The Neosho-Spring River form is probably an undescribed species or subspecies of *N. volucellus* (Pflieger 1975). Etnier and Starnes (1994) show *N. wickliffi* to be distributed in the Mississippi River from the mouth of the Missouri River to northeastern Louisiana, the Ohio River from Pennsylvania to its confluence with the Mississippi River, the Tennessee River, and the Wabash River (Fig. 3).

In Missouri, *N. wickliffi* has been collected in the lower Missouri River (Pflieger 1975), but is seemingly rare in the pooled portion of the Mississippi River above St. Louis (Pflieger 1975; Hrabik, unpublished data). However, *N. wickliffi* was collected in the lower Fabius River in northeastern Missouri in 1989 (Hrabik, unpublished data). Unfortunately, voucher specimens were mistaken for *N. stramineus* and discarded.

Biologists from the LTRMP field station at Bellevue, Iowa (Upper Mississippi River, Pool 13), commonly collect *N. wickliffi* during routine monitoring (S. Gritters, personal communication) and have retained numerous voucher specimens verified by B. Kuhajda and me. Specimens collected by biologists from the Onalaska, Wisconsin, LTRMP field station (Upper Mississippi River, Pool 8) have been identified as *N. wickliffi* and *N. wickliffi-volucellus* intergrades (Hrabik, unpublished data). G. Seegert (personal communication) has also collected *N. wickliffi* and intergrades from Upper Mississippi River pools in Illinois and Wisconsin.

Notropis wickliffi is found along shoreline and shoal habitats, with or without current, over mud, sand, and gravel substrates (Etnier and Starnes 1994; Hrabik, unpublished data; LTRMP, unpublished data). The species seems to tolerate high turbidity but is also found in moderately clear large creeks and rivers. Trautman (1981) noted that when the Ohio River becomes very clear during droughts and winter, *N. wickliffi* numbers decrease and intergrades increase.

Biology and Life History

Notropis wickliffi

Because *N. wickliffi* has only recently been recognized as a species, little is known about its biology and habits. In the Middle Mississippi River (Pflieger 1975; Hrabik, unpublished data), it is most often found in association with *Notropis buchanani*, *N. atherinoides*, *N. shumardi*, and *N. blennius*. Trautman (1957) reported spawning from June to August in Ohio. Etnier and Starnes (1994) collected tuberculate specimens during the same months in Tennessee, the nuptial tubercles verifying that the species were in a stage of breeding. In contrast with these few facts, much more is known about the biology and life history of *N. volucellus*.

Notropis volucellus

Habits

In Missouri streams, *N. volucellus* is most often found with *N. greenei*, *N. texanus*, *N. rubellus*, *Luxilus zonatus*, and *Lythrurus fumeus* (Pflieger 1975). In one Wisconsin stream, it was associated with relatively large populations of *Luxilus cornutus*, *Moxostoma erythrurum*, *Nocomis biguttatus*, *Pimephales notatus*, *Percina maculata*, and *Etheostoma nigrum* (Becker 1983). In Ontario, Hallam (1959) found it in warmwater sections of streams with *Ambloplites rupestris* and *Micropterus dolomieu*. In a Minnesota lake, Moyle (1973) found it at night with *Pimephales notatus*.

Notropis volucellus is a schooling fish usually found at the surface or in midwater (Moyle 1973; Robison and Buchanan 1988). Moyle (1973) reported finding schools with as many as 20,000 individuals in a Minnesota lake.

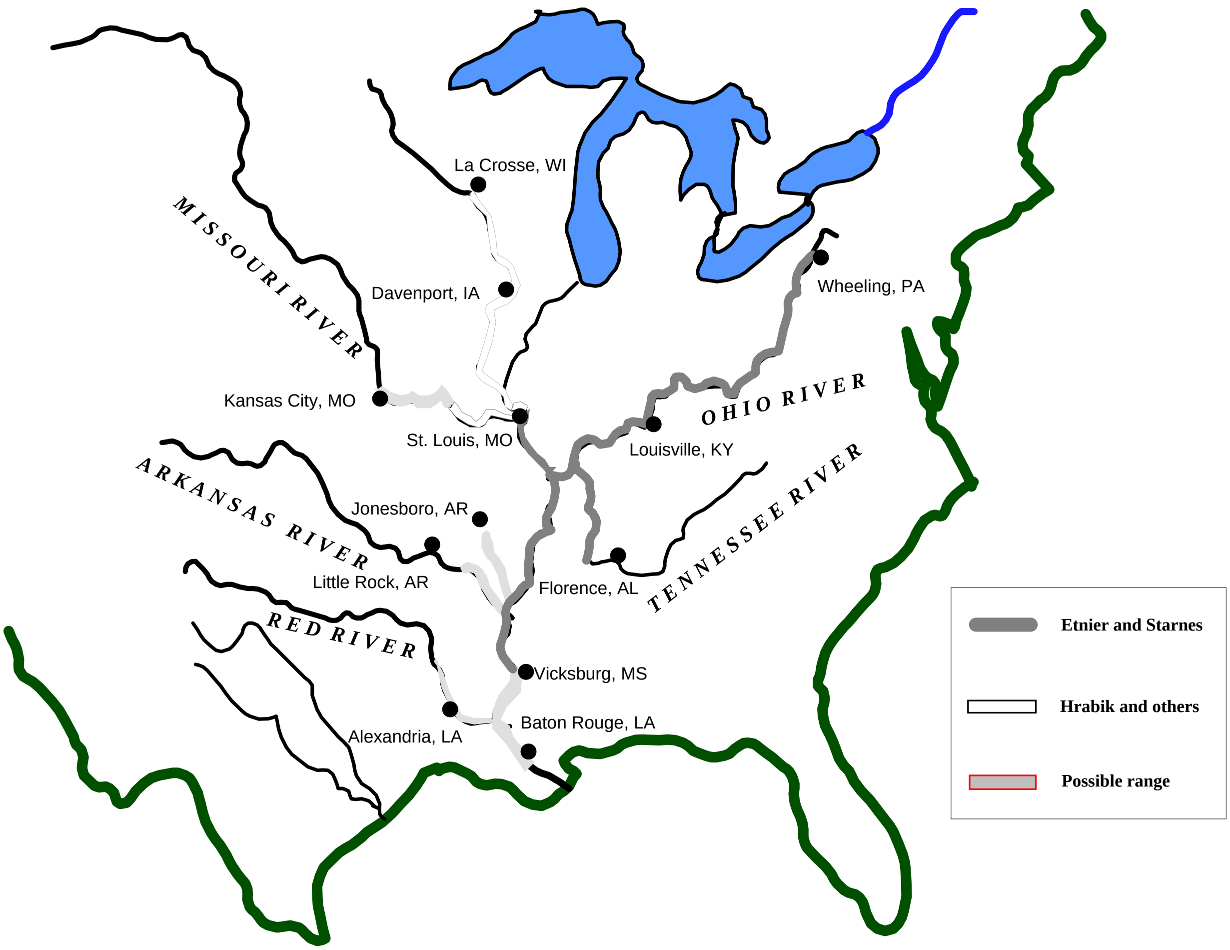

Figure 3. Generalized distribution of *Notropis wickliffi* in North America, based on Etnier and Starnes (1993) and Hrabik (unpublished data).

Diurnal movements have been observed by several researchers (Black 1945; Moyle 1973; Gascon and Leggett 1977; Becker 1983; Hanych et al. 1983). During the day, *Notropis volucellus* was found in large schools inshore. These schools break into smaller groups offshore at night in Indiana and Minnesota lakes (Black 1945; Moyle 1973). However, Hanych et al. (1983) found the reverse, with *N. volucellus* making movements inshore at sunset, nearshore at night, and offshore at sunrise. Hanych et al. (1983) explained this behavior as a predator-response mechanism.

Although *N. volucellus* has been observed in habitats containing aquatic vegetation (Black 1945; Becker 1983; Smith 1985; Etnier and Starnes 1994), it is often found in areas without cover and, in one Alabama study, did not seek cover at all (Kinsolving and Bain 1990).

Reproduction

Spawning takes place as early as June (Black 1945; Pflieger 1975; Becker 1983) and may continue into August (Moyle 1969; Cross and Collins 1975; Becker 1983). In Wisconsin, Becker (1983) found gravid females in June and ripe eggs in July.

Weather may influence spawning activity. Moyle (1969) found that *N. volucellus* did not spawn in a Minnesota lake exposed to low summer temperatures because these temperatures possibly affected food web dynamics and energetics.

Spawning activity has never been observed. Black (1945) suggested that spawning takes place at night in deep, vegetated areas in lakes. Females outnumber males two to one at this time (Moyle 1969), and nesting or parental care do not seem to exist (Black 1945).

Sexual maturity is reached in its first year (Black 1945; Moyle 1973; Etnier and Starnes 1994). The average number of eggs per female in an Indiana lake was 367 (Black 1945), although Becker (1983) reported as many as 960. A description of the protolarvae is given by Potter and Potter (1981). *Notropis dorsalis*, *N. stramineus* (Becker 1983), and *N. atherinoides* (Mayhew 1983) have been documented to hybridize with *N. volucellus*.

Food and Feeding

Notropis volucellus has a varied diet generally consisting of small crustaceans, insects, algae, and detritus (Black 1945; Moyle 1973; Gascon and Leggett 1977; Magnin et al. 1978; Becker 1983). Johnson and Dropkin (1992) found it will also eat larval *Alosa sapidissima* (American shad) when this species is abundant.

Moyle (1973) observed *N. volucellus* in large schools feeding in midwater or at the surface of a Minnesota lake but saw no evidence of resource (food) competition with other cyprinids in that system. Black (1945) and Moyle (1969) observed similar diel feeding patterns in lakes they studied. *Notropis volucellus* fed on zooplankton in the early morning, switched to diptera and terrestrial insects during the day, and ate mayflies and amphipods in the evening. Strangely, copepods were ignored even when abundant. Some feeding may occur at night (Black 1945).

Gascon and Leggett (1977) studied the response of several littoral zone fishes to nutrient-production gradients in Lake Memphremagog (northern Vermont and southern Quebec). They found that *N. volucellus* had a rather specialized diet consisting mostly of cladocerans and diptera larvae, but would eat detritus when resource-limited. The distribution of *N. volucellus* in Lake Memphremagog was determined by the relative abundance of preferred food resources.

However, Olmsted et al. (1979) found *N. volucellus* to be less than particular in its food preferences. They presented two prey types in five densities and found large variations in prey preference. *Notropis volucellus* did not exhibit a "precise preference tactic based on prey availability."

In a Susquehanna River study, Johnson and Dropkin (1991) found that *N. volucellus* fed heavily on aerial aquatic and terrestrial insects. They concluded that dietary overlap was high with *Cyprinella spiloptera* (spotfin shiner) and that drifting prey was an important food item.

Growth

Females grow faster and attain a larger size than males (Black 1945). Length at age I was 48 mm and at age II was 55 mm in an Indiana lake (Black 1945), and 43–52 and 52–65 mm in Wisconsin (Becker 1983). Sexual maturity was reached at 42 mm in a Minnesota lake (Moyle 1973). Maximum age is 2–3 years (Black 1945; Moyle 1973).

Summary

Notropis volucellus is probably a complex of many forms. This may explain the variability in morphological and meristic characters, phenotypic expression, and the wide distribution across several North American drainages observed by many ichthyologists. On the basis of recent morphological and genetic evidence and known habitat preference, I conclude that *Notropis wickliffi* is probably a distinct species.

Because *N. wickliffi* has only recently been given specific status, its distributional limits and life history are poorly known. And because of the magnitude of the taxonomic confusion in this complex, it may be some time before new taxa are described after geographic-wide systematics studies.

In the Mississippi River drainage, the distributional limits and habitat requirements for *N. volucellus* (and its forms) and *N. wickliffi* are virtually unknown. Because biologists are not confident in their ability to identify these species, they can make no progress toward monitoring trends and understanding the ecology of these species. These constraints render decision makers powerless to pursue economic progress without the danger of destroying critical habitat.

The need for a definitive systematics analysis of the Mississippi River drainage complex is evident, and the ramifications of such a project are important. In this age of rapidly changing landscapes and reductions in species ranges, the time is right to solve this problem.

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Robert A. Hrabik

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13. ABSTRACT (Maximum 200 words)

Notropis volucellus was described in 1864 and underwent a confusing taxonomic synonymy with *Notropis blennius*. By the 1930s, *N. volucellus* was recognized as a full species with three subspecies. The subspecies *N. v. wickliffi* was described in 1931 but was not generally recognized as a full species until 1991. *Notropis volucellus* is widely distributed in the Mississippi River drainage, where it may be found in large creeks and rivers. *Notropis wickliffi* inhabits large Midwestern rivers from Louisiana to Wisconsin to Pennsylvania. In the Upper Mississippi River, *N. volucellus* and *N. wickliffi* occur sympatrically. Biologists with the Long Term Resource Monitoring Program (LTRMP) initially identified *N. wickliffi* as *N. volucellus*. I began examining LTRMP voucher specimens in 1991 and determined that specimens from Pool 13 to the Mississippi River's confluence with the Ohio River identified as *N. volucellus* were actually *N. wickliffi*. Above Pool 13, cursory separation of *N. wickliffi* from *N. volucellus* becomes increasingly difficult. Specimens from Pool 8 were mostly *N. wickliffi*, but several appeared to be intergrades. The purpose of this literature review is to describe the taxonomic and distributional status of *N. volucellus* and *N. wickliffi* in the Mississippi River drainage and to present supporting biological information that may help to define the taxonomy and distribution of both species.

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The Long Term Resource Monitoring Program (LTRMP) for the Upper Mississippi River System was authorized under the Water Resources Development Act of 1986 as an element of the Environmental Management Program. The mission of the LTRMP is to provide river managers with information for maintaining the Upper Mississippi River System as a sustainable large river ecosystem given its multiple-use character. The LTRMP is a cooperative effort by the National Biological Service, the U.S. Army Corps of Engineers, and the States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin.