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Distribution and Systematics of *Notropis wickliffi* (Cypriniformes: Cyprinidae) in Illinois

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ABSTRACT

The channel shiner, *Notropis wickliffi*, has long been confused with the mimic shiner, *Notropis volucellus*. Prior to this study, the distribution and systematics of *N. wickliffi* in Illinois were poorly known. *Notropis wickliffi* is distinguished from Illinois specimens of *N. volucellus* in having postdorsal melanophores randomly distributed, rather than concentrated on scale edges, fewer mean lateral line scales and vertebrae, more mean pectoral rays, a longer jaw length and anal fin height, and relatively reduced snout tuberculation in nuptial males. *Notropis wickliffi* in Illinois is confined to the Wabash, Ohio, and Mississippi rivers and the lower reaches of some of their tributaries. The range and abundance of *N. wickliffi* has increased in the Illinois portion of the Mississippi River. Anthropogenic changes to the Mississippi River may have created more favorable conditions for *N. wickliffi*.

INTRODUCTION

Notropis wickliffi (Cypriniformes: Cyprinidae), the channel shiner, is a small (maximum 78 mm TL, Etnier and Starnes, 1993) minnow inhabiting large river habitats in the Ohio and Mississippi River basins. The biology of this fish is poorly known, although it is thought to spawn in summer (Trautman, 1931; Etnier and Starnes, 1993). Gong (1991) reported Ohio *N. wickliffi* feed primarily on blue-green algae, diatoms, and immature aquatic insects.

Notropis wickliffi is a member of the *N. volucellus* species group (Mayden, 1989). This species group is characterized by modally eight anal fin rays, 0,4-4,0 pharyngeal teeth, a subterminal mouth, pallid coloration, and vertically heightened anterior lateral-line scales. In addition to *N. wickliffi*, this species group contains *N. cahabae* (Cahaba shiner), *N. buchanani* (ghost shiner), *N. volucellus* (mimic shiner), and probably *N. saladonis* (Salado shiner) (Jenkins and Burkhead, 1994). *Notropis wickliffi* is most similar to and often confused with *N. volucellus*, which is itself polymorphic and in need of a detailed systematic analysis (Mayden and Kuhajda, 1989; Gong, 1991, Etnier and Starnes, 1993). Because the systematics of *N. wickliffi* have been somewhat unclear, its range and status in many states is unknown. Smith (1979) treated *N. wickliffi* as a subspecies of *N.*

volucellus, and indicated it to be common in the Wabash, Ohio, and Mississippi rivers in Illinois. However, the ranges of the two subspecies were not distinguished nor were diagnostic characters provided to identify the two forms.

The channel shiner was originally described as a subspecies of *Notropis volucellus* (Trautman, 1931), with the presence of many putative intergrades in some Ohio rivers noted (Trautman, 1931, 1957). Trautman (1957, 1981) also provided dot-range maps of both *N. volucellus volucellus* and *N. v. wickliffi* in Ohio. Jenkins (1976) elevated the channel shiner to species, without comment. Becker (1983), unable to distinguish *N. wickliffi* and *N. volucellus*, disagreed with Jenkin's elevation of *N. wickliffi* to species. Trautman (1981) later accepted that *N. wickliffi* was a valid species based on then unpublished data collected by D. Etnier and students. Mayden and Kuhajda (1989) treated *N. wickliffi* as a species and found *N. volucellus* to be monophyletic and sister to a clade containing *N. cahabae* and *N. wickliffi*. They also provided morphological and biochemical characters to distinguish *N. cahabae*, *N. wickliffi*, and southern populations of *N. volucellus*. The systematics and geographic variation of morphology of *N. wickliffi* and *N. volucellus* were studied by Gong (1991). He noted several areas of sympatry and failed to find morphological evidence of intergradation. Neither Mayden and Kuhajda (1989) nor Gong (1991) examined any specimens of *N. volucellus* or *N. wickliffi* from Illinois for their morphological studies. Etnier and Starnes (1993) mapped the distributions of *N. volucellus* and *N. wickliffi* in Tennessee and provided additional morphological characters useful in distinguishing the two species.

The range and identification of *N. wickliffi* is uncertain in Illinois, and only limited attempts have been made at separating Illinois collections of *N. wickliffi* from *N. volucellus*. Many large river cyprinids are jeopardized in Illinois or have experienced apparent recent declines in abundance or restriction in range including *Hybognathus argyritus* (western silvery minnow), *H. placitus* (plains minnow), *Macrhybopsis gelida* (sturgeon chub), *M. meeki* (sicklefin chub), and *Platygobio gracilis* (flathead chub) (Pflieger and Grace, 1987; United States Fish and Wildlife Service, 1994; Cross and Collins, 1995). Population and distributional changes in a big river cyprinid fauna can provide insight into the quality of big river ecosystems. Thus, a distributional study of *N. wickliffi* is warranted in Illinois. Herein, I distinguish the channel shiner, *N. wickliffi*, from Illinois populations of the mimic shiner, *N. volucellus*, and describe the ranges of both of these species in Illinois.

METHODS

Regional museums (FMNH, INHS, SIUC, UMMZ, UT) were canvassed to find Illinois records of *N. volucellus* and *N. wickliffi*. Museum abbreviations follow Leviton et al. (1985). A total of 152 lots of *N. volucellus* and *N. wickliffi* from Illinois was examined. Pigmentation was quantified on specimens larger than 34 mm SL. Methods used for scale counts follow Mayden (1988). Vertebrae were visualized with the aid of soft x-rays (3A, 30 millivolts, 15 seconds) and were counted using the methods of Jenkins and Lachner (1971). Twenty-nine measurements were taken from 29 specimens of *N. wickliffi* and 42 specimens of *N. volucellus* and used in a multivariate analysis of shape (Table 5). Measurements followed the methods of Hubbs and Lagler (1974).

Truss-geometric protocol (Humphries et al., 1981; Strauss and Bookstein, 1982; Bookstein et al., 1985) was used in part to define body form and included 18 measurements distributed among three sagittal truss cells with an appended anterior triangle. Ten additional measurements were included in the morphometric analysis. Multivariate analysis of the morphometric data was accomplished using sheared principal component analysis (PCA) (Humphries et al., 1981; Bookstein et al., 1985) to eliminate overall size effects. Principal components were factored from the covariance matrix of log-transformed morphometric characters following recommendations of Bookstein et al. (1985). Multivariate analyses were conducted on the Southern Illinois University at Carbondale mainframe computer using programs available in SAS 6.01 (SAS Institute, Inc., 1982) and as modified by David L. Swofford.

RESULTS

Morphological variation. Pigmentation characters were the most useful for discriminating *N. wickliffi* and *N. volucellus* in Illinois; consequently juveniles (< 35 mm SL) and poorly preserved specimens were the most difficult to identify. Pigmentation is generally darker in *N. volucellus*. The postdorsal scales in adult *N. wickliffi* were generally uniformly pigmented while these scales in *N. volucellus* tended to have melanophores more heavily concentrated posteriorly (Fig. 1, Table 1). A narrow postdorsal streak was present in many specimens of *N. wickliffi* examined, but absent in most *N. volucellus* from southern Illinois (Table 1). A distinct predorsal streak or blotch was generally present in specimens of *N. volucellus* from the upper Illinois and Wabash River drainages, but was weak or absent in *N. wickliffi* and southern Illinois *N. volucellus*.

The few meristic differences between *N. volucellus* and *N. wickliffi* were most useful in identification when large series were available because of overlapping counts. Meristic counts are presented in Tables 2-4. *Notropis wickliffi* differed from *N. volucellus* in having modally more pectoral rays, fewer mean lateral line scales, and fewer mean vertebrae. Although circumferential scale counts have been found to be useful in discriminating these species in other parts of their ranges (Mayden and Kuhajda, 1989; Gong, 1991), nearly identical circumferential counts were found in Illinois specimens of *N. volucellus* (mean = 21.92, n = 60) and *N. wickliffi* (mean = 22.06, n = 35). All specimens of *N. volucellus* and *N. wickliffi* from Illinois examined in this study lacked breast scales.

Multivariate analysis of the morphometric data indicated *N. wickliffi* had a longer upper jaw and shorter anal fin height than *N. volucellus* (Table 5). Most separation occurred along sheared PC 2, although there was considerable overlap between these species (Fig. 2). Much of the overlap resulted from a specimen of *N. volucellus* from Clear Creek with typical *N. volucellus* pigmentation and meristic counts, but unusually short fins, resulting in its relatively high score on sheared PC 2. Sheared PC 3 provided some additional discrimination between the species, with highest loadings on anal base length, pectoral and pelvic fin length, anal fin origin to dorsal origin of caudal fin, and caudal peduncle depth (Table 5). Other morphometric analyses showed *N. wickliffi* to have a larger eye (Mayden and Kuhajda, 1989; Gong, 1991), but no meaningful taxonomic difference in eye size was detected in this study.

Specimens of nuptial male *N. volucellus* examined from the Clear Creek system in Illinois and the Little River system in southeast Missouri had one to two rows of tubercles along pectoral rays 1-7, with typically three tubercles present on each segment. Tubercles covered most of the head and were most prominent on the snout. Nuptial male *N. wickliffi* from the Mississippi and Wabash rivers had similar pectoral fin tuberculation. However, only scattered tubercles were present on the dorsum of the head, and snout tubercles were absent or greatly reduced in size and coverage. A single nuptial male *N. volucellus* in peak condition (SIUC 23969, collected 29 July 1994) from the upper Illinois River drainage differed from *N. wickliffi* and southern populations of *N. volucellus* in having well developed tubercles on the predorsal midline, and relatively smaller tubercles on the pectoral rays arranged in 3-6 irregular rows with typically 6-12 tubercles per segment. Males of *N. volucellus* from the upper Illinois River drainage collected from late April to early June had reduced tuberculation.

Distribution and abundance. Records of *N. wickliffi* are available in Illinois from the mainstem Mississippi, Ohio, and Wabash rivers and the lower reaches of the Embarras, Big Muddy, and Cache rivers (Fig. 3). Twenty years of intense collecting in the Mississippi River at Grand Tower (Jackson County) by B. M. Burr and students indicate *N. wickliffi* to be uncommon, but persistent there. Numerous recent collections of *N. wickliffi* in the Mississippi River from Alexander County to Pike County by B. Atwood and the Illinois Department of Natural Resources (IDNR) suggest *N. wickliffi* to be more widespread in the Mississippi River than indicated by Smith (1979). Only two collections are available for *Notropis wickliffi* in the middle Mississippi River before 1963 (UMMZ 87202 and MCZ 31908, St. Louis Co., MO, May 1853 and FMNH 48057, Monroe Co., IL, 15 October 1922). This species was absent in the middle Mississippi River in collections (vouchered at UMMZ) of cyprinids made by Barnickol, Bauman, and others in the 1930s and 1940s, and present in only seven of the numerous collections (vouchered at INHS and KU) made during the 1960s by Braasch and Smith, Miller and Newton, and Pflieger. *Notropis wickliffi* (reported as *N. volucellus*) has also recently invaded the lower Missouri River (Pflieger and Grace, 1987).

Large collections made by A. C. Bauman in 1940 and P. W. Smith and M. E. Braasch in the 1960s indicate *N. wickliffi* was widespread in the Wabash River and often common (e.g. UMMZ 221378, n = 630). The only vouchered material from the Illinois portion of the Wabash River since 1967 includes 23 specimens from Lawrence County collected in 1979 (UT 44.1910 and UT 44.1991) and a single specimen from White County collected in 1995 (SIUC 25114). However, the apparent recent rarity of *N. wickliffi* in the Illinois portion of the Wabash River may reflect the paucity of recent vouchered collections, rather than changes in distribution and abundance.

Records of *N. volucellus* are available in Illinois from the upper Illinois River drainage (Kankakee River system and Cedar Lake), some tributaries of the Wabash River drainage, including the Vermilion River system and Little Wabash River, the Big Muddy River drainage, and several small streams draining the Shawnee Hills in southern Illinois (Fig. 3). No records of *N. volucellus* are available from the Illinois portion of the Mississippi River, although specimens of *N. volucellus* have been collected from the Missouri side of the Mississippi River (SIUC 25379 and SIUC 25838). Trautman (1981) recorded *N.*

volucellus in the Ohio River mainstem only in the winter. The lack of *N. volucellus* from the Mississippi River may result from collection efforts being concentrated almost entirely in the summer and fall. These species are sympatric in the lower Big Muddy River and possibly the Mississippi River.

There appear to be two forms of *N. volucellus* in Illinois, differing in nuptial male tuberculation and pigmentation. A northern form is represented by specimens from the upper Illinois River drainage and Vermilion River system (Wabash River drainage). A southern form, represented by specimens from southern Illinois, is similar to specimens of *N. volucellus* examined from southeast Missouri and western Kentucky, Tennessee, and Mississippi. A range wide study of *N. volucellus* incorporating biochemical methods has been undertaken by B. Kuhajda (pers. comm.), and will greatly clarify the systematics of the *N. volucellus* group.

DISCUSSION

In the lower Duck River, both species occur together and can apparently be easily separated (Gong, 1991; Etnier and Starnes, 1993). However, no single character can reliably separate Illinois specimens of *N. wickliffi* and *N. volucellus*, resulting in considerable difficulty of identification of individual specimens collected from areas of potential sympatry. Other researchers (Mayden and Kuhajda, 1989; Gong, 1991, Etnier and Starnes, 1993) have listed several characters, including postdorsal streaks, circumferential or transverse scale counts, breast squamation, and eye size for distinguishing these species that apparently are not useful or of limited use for Illinois specimens. Although the lack of utility of these characters for Illinois populations is disappointing, it is not surprising given the recognized variability of *N. volucellus* (Gong, 1991; Etnier and Starnes, 1993).

Recognition of *N. wickliffi* as a distinct species is supported by the results of this study. Specimens of *N. wickliffi* were more phenotypically similar to geographically distant populations of *N. wickliffi* than to more proximate populations of *N. volucellus*. Gong (1991) obtained similar results with specimens from Ohio and Tennessee.

The status of *N. wickliffi* in most areas is poorly known, although Trautman (1981) and Gong (1991) indicated that this species has remained fairly common in Ohio. The distribution and abundance of *N. wickliffi* in Illinois has apparently increased in the Mississippi River. Other big river shiners, including *Cyprinella lutrensis* (red shiner), *Notropis atherinoides* (emerald shiner), *Notropis blennius* (river shiner), and *Notropis shumardi* (silverband shiner) are also stable or increasing in distribution or abundance in the Missouri and middle Mississippi rivers (Pflieger and Grace, 1987; Pflieger, 1989). This is in contrast to the general decline of big river cyprinids (*H. argyritus*, *H. placitus*, *M. gelida*, *M. meeki*, and *P. gracilis*) adapted for life in turbid rivers. Anthropogenic changes to the Missouri River, including channelization and construction of mainstem reservoirs, wing dikes and levees, have resulted in reduced turbidity, altered flow regimes, and increased phytoplankton densities (Cross and Huggins, 1975; Pflieger and Grace, 1987). These changes have apparently led sight-feeding fishes to expand their ranges at the expense of other cyprinids (Cross and Huggins, 1975; Cross and Haslouer, 1984; Pflieger and Grace, 1987). The middle Mississippi River has experienced similar disturbances (Dobney, 1975; Pflieger, 1989), possibly allowing *N. wickliffi* to expand its distribution and abundance.

Changes in fish distributions in large midwestern rivers, particularly for cyprinids, suggest recent anthropogenic changes to these rivers may have affected habitats critical to the ecology of these fishes. Unfortunately, life history information is poorly known or completely lacking in most big river cyprinids, including *N. wickliffi*. Ecological studies of these cyprinids may provide information critical in the analysis of cyprinid community changes in big rivers.

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LITERATURE CITED

Becker, G. C. 1983. Fishes of Wisconsin. Univ. of Wisconsin Press, Madison.

Bookstein, F. L., B. Chernoff, R. L. Elder, J. M. Humphries, Jr., G. R. Smith, and R. E. Strauss. 1985. Morphometrics in evolutionary biology. Acad. Nat. Sci., Philadelphia Special Pub. 15:1-277.

Cross, F. B., and J. T. Collins. 1995. Fishes in Kansas, 2nd ed. Univ. Kansas Mus. Nat. Hist. Pub. Ed. Ser. 14:1-315.

Cross, F. B., and S. G. Haslouer. 1984. *Pimephales vigilax* (Pisces, Cyprinidae) established in the Missouri River basin. Trans. Kansas Acad. Sci. 87:105-107.

Cross, F. B., and D. G. Huggins. 1975. Skipjack herring, *Alosa chrysochloris*, in the Missouri River basin. Copeia 1975:382-385.

Dobney, F. J. 1975. River engineers on the middle Mississippi: A history of the St. Louis District, U.S. Army Corps of Engineers. U.S. Government, Washington, D.C.

Etnier, D. A., and W. B. Starnes. 1993. The fishes of Tennessee. Univ. of Tennessee Press, Knoxville.

Gong, L. 1991. Systematics of two morphologically similar fish species *Notropis volucellus* and *Notropis wickliffi* (Cyprinidae). M.S. Thesis, Ohio State Univ.

Hubbs, C. L., and K. F. Lagler. 1974. Fishes of the Great Lakes regions. Univ. Michigan Press, Ann Arbor.

Humphries, J. M., F. L. Bookstein, B. Chernoff, G. R. Smith, R. L. Elder, and S. L. Poss. 1981. Multivariate discrimination by shape in relation to size. Syst. Zool. 30:291-308.

Jenkins, R. E. 1976. A list of undescribed freshwater fish species of continental United States and Canada, with additions to the 1970 checklist. Copeia 1976:642-644.

Jenkins, R. E., and N. M. Burkhead. 1994. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, Maryland.

Jenkins, R. E., and E. A. Lachner. 1971. Criteria for analysis and interpretation of the American fish genera *Nocomis* Girard and *Hybopsis* Agassiz. Smithsonian Contr. Zool. 90:1-15.

Leviton, A. E., R. H. Gibbs, Jr., E. Heal, and C. E. Dawson. 1985. Standards in herpetology and ichthyology: Part 1. Standard symbolic codes for institutional resource collections in herpetology and ichthyology. Copeia 1985:802-832.

Mayden, R. L. 1988. Systematics of the *Notropis zonatus* species group, with description of a new species from the Interior Highlands of North America. Copeia 1988:153-173.

Mayden, R. L. 1989. Phylogenetic studies of the North American minnows, with emphasis on the genus *Cyprinella* (Teleostei: Cypriniformes). Misc. Publ. Mus. Nat. Hist. Univ. Kansas. 80:1-189.

Mayden, R. L., and B. R. Kuhajda. 1989. Systematics of *Notropis cahabae*, a new cyprinid fish endemic to the Cahaba River of the Mobile Basin. Bull. Alabama Mus. Nat. Hist. 9:1-16.

Pflieger, W. L. 1989. Aquatic community classification system for Missouri. Missouri Dept. Conserv. Aquatic Series 19, Jefferson City.

Pflieger, W. L., and T. B. Grace. 1987. Changes in the fish fauna of the lower Missouri River, 1940-1983. In: W. J. Matthews and D. C. Heins (eds). Community and evolutionary ecology of North American stream fishes. Univ. of Oklahoma Press, Norman.

SAS Institute, Inc. 1982. SAS user's guide: statistics, 1982 edition. SAS Institute, Inc. Cary, North Carolina.

Smith, P. W. 1979. The fishes of Illinois. Univ. Illinois Press, Urbana.

Strauss, R. E., and F. L. Bookstein. 1982. The truss: body form reconstruction in morphometrics. Syst. Zool. 31:113-135.

Trautman, M. B. 1931. *Notropis volucellus wickliffi*, a new subspecies of cyprinid fish from the Ohio and upper Mississippi rivers. Ohio J. Sci. 31:468-474.

Trautman, M. B. 1957. The fishes of Ohio. Ohio State Univ. Press, Columbus.

Trautman, M. B. 1981. The fishes of Ohio, 2nd ed. Ohio State Univ. Press, Columbus.

United States Fish and Wildlife Service. 1994. Endangered and threatened wildlife and plants; animal candidate review for listing as endangered or threatened species; proposed rule. Federal Register 59(219):58982-59028.

APPENDIX

Specimens of *N. volucellus* and *N. wickliffi* used in quantitative analyses. Parenthetical numbers after catalog numbers refer to numbers of specimens used in pigmentation, meristic, and morphometric analyses respectively.

N. volucellus. Clear Creek system, Illinois. Alexander County: SIUC 10936 (0,10,0), SIUC 19453 (6,0,0), SIUC 20541 (1,1,0), SIUC 22588 (7,7,8), SIUC 22688 (4,0,0). Union County: SIUC 19469 (10,2,6), SIUC 20642 (1,0,0). Illinois River drainage, Illinois. Iroquois County: SIUC 23969 (2,0,0). Lake County: INHS 4197 (5,11,0), SIUC 19754 (2,0,0). Will County: INHS 65468 (16,10) Middle Fork Vermilion River (Wabash drainage), Illinois. Ford County: FMNH (4,4,0). Vermilion County: INHS 11858 (11,11,9), INHS 11806 (8,7,5), FMNH (2,2,0). Little Wabash River, Illinois. White County: UMMZ 22148 (42,0,4).

N. wickliffi. Wabash River drainage, Illinois. Clark County: INHS 2572 (4,8,2) INHS 2563 (6,4,0). Crawford County: INHS 11398 (1,15,1). Wabash County: UMMZ 221378 (1,3,6). Ohio River, Illinois. Hardin County: INHS 948 (2,11,6). Mississippi River, Illinois. Calhoun County: SIUC 25407 (11,0,0), SIUC 25454 (2,0,0), SIUC 25471 (3,0,0). Jackson County: SIUC 6272 (3,0,3), SIUC 6318 (1,0,0), SIUC 6400 (0,3,0), SIUC 6506 (4,5,0), SIUC 6525 (2,2,3), SIUC 8374 (2,2,0), SIUC 8830 (0,2,0), SIUC 22843 (1,1,2), SIUC 22849 (4,2,4), SIUC 22926 (2,1,2), SIUC 24825 (1,0,0). Madison County: SIUC 23882 (4,0,0), SIUC 24555 (2,0,0), SIUC 24950 (1,0,0), 25405 (4,0,0).

Table 1. Postdorsal pigmentation in selected Illinois samples of *Notropis volucellus* and *N. wickliffi*.

	postdorsal streak			postdorsal melanophores	
	complete	interrupted	absent	evenly distributed	concentrated on scale edges
N. volucellus					
Clear Creek	1	3	36	1	39
Little Wabash River			42		42
Illinois drainage	8	9	5	4	18
Vermilion River	11	9	5	7	18
N. wickliffi					
Wabash/Ohio rivers	8	4	2	13	1
Mississippi River	21	16	10	45	2

Table 2. Frequency distribution of pectoral fin rays in selected Illinois samples of *Notropis volucellus* and *N. wickliffi*.

	13	14	15	16	17	N	mean	SD
N. volucellus								
Clear Creek	6	12	2			20	13.80	0.616
Illinois drainage	10	14	3			27	13.74	0.656
Vermilion River	13	10	1			24	13.50	0.590
N. wickliffi								
Wabash River	1	10	14	4	1	30	14.80	0.847
Ohio River		3	5	2	1	11	15.09	0.944
Mississippi River	1	5	13	4	1	25	14.95	0.859

Table 3. Frequency distribution of lateral-line scales in selected Illinois samples of *Notropis volucellus* and *N. wickliffi*.

	30	31	32	33	34	35	36	37	38	39	N	mean	SD
N. volucellus													
Clear Creek					2	9	7	2			20	35.45	0.826
Illinois drainage					1	7	7	3	1		19	35.79	0.976
Vermilion River					2	5	7	4	-	1	19	35.89	1.197
N. wickliffi													
Wabash River		1	2	5	12	2					22	33.55	0.963
Ohio River	1	-	1	1	1						4	32.30	1.708
Mississippi River			1	12	7	5					25	33.54	0.860

Table 4. Frequency distribution of vertebrae in selected Illinois samples of *Notropis volucellus* and *N. wickliffi*.

	33	34	35	36	37	38	39	N	mean	SD
N. volucellus										
Clear Creek				7	5	-	1	13	36.62	0.870
Illinois drainage				5	8	5		18	37.00	0.767
Vermilion River				2	8			10	36.80	0.422
N. wickliffi										
Wabash River		1	7	7				15	35.40	0.632
Ohio River			10	4				14	35.29	0.469
Mississippi River	1	3	10	4				18	34.94	0.802

Table 5. Sheared principal component loadings for 29 morphometric variables for *Notropis volucellus* and *N. wickliffi* in Illinois.

Measurement	sheared PC 2	sheared PC 3
Standard length	-0.026	-0.121
Anal fin base length	-0.192	-0.348
Head length	0.029	-0.031
Upper jaw length	0.382	0.164
Pectoral fin length	-0.258	0.375
Pelvic fin length	-0.220	0.303
Dorsal fin height	-0.157	0.238
Anal fin height	-0.359	0.134
Snout to occiput	0.099	0.188
Snout to pectoral fin origin	0.023	0.091
Occiput to dorsal fin origin	-0.191	-0.114
Dorsal fin base length	0.096	0.150
Pectoral fin origin to pelvic fin origin	0.105	-0.178
Pelvic fin origin to anal fin origin	0.157	-0.174
Dorsal fin insertion to dorsal leading procurrent caudal ray	-0.104	-0.181
Anal fin origin to ventral leading procurrent caudal ray	-0.279	-0.292
Occiput to pelvic fin origin	0.045	-0.051
Pectoral fin origin to dorsal fin origin	-0.033	-0.130
Dorsal fin origin to anal fin origin	0.291	0.117
Pelvic fin origin to dorsal fin insertion	0.118	-0.150
Dorsal fin insertion to ventral leading procurrent caudal ray	-0.044	-0.108
Anal fin origin to dorsal leading procurrent caudal ray	-0.247	-0.175
Occiput to pectoral fin origin	0.067	0.021
Dorsal fin origin to pelvic fin origin	0.151	-0.086
Dorsal fin insertion to anal fin origin	0.277	0.089
Caudal peduncle depth	-0.177	0.316
Head width	0.101	0.052
Body width below dorsal fin	0.233	-0.067
Fleshy orbit length	-0.027	0.224

Figure 1. Dorsal pigmentation of *Notropis volucellus* (left, INHS 65468, 36 mm SL) and *N. wickliffi* (right, SIUC 24565, 39 mm SL).

Figure 1 is not available in this on-line version. Please contact library or author for a hard-copy of this figure.

Figure 2. Morphometric scores on sheared PCA axes 2 and 3 for 42 *Notropis volucellus* (solid squares) and 29 *N. wickliffi* (open squares) from Illinois.

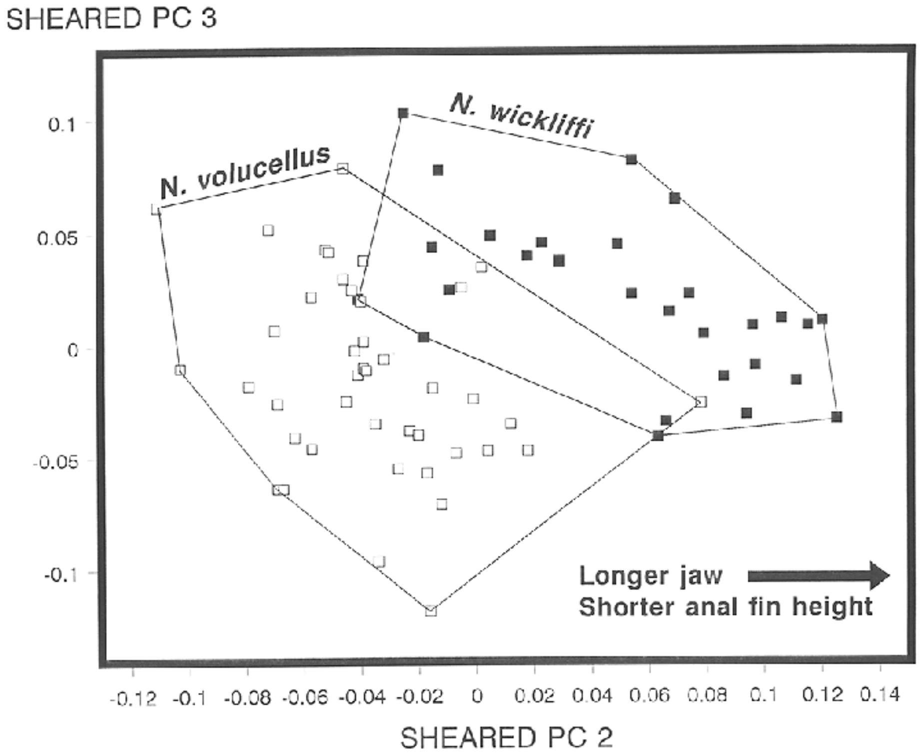

Figure 3. Distribution of *Notropis volucellus* (open circles) and *N. wickliffi* (solid circles) in Illinois. A locality with both species present is represented by a half-filled circle.