Biological Assessments of Six Selected Fishes, Amphibians, and Mussels in Illinois

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BIOLOGICAL ASSESSMENT

NORTHERN HOGSUCKER, *Hypentelium nigricans*

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NORTHERN HOGSUCKER, *Hypentelium nigricans*

1.0 Taxonomy.

1.1 Scientific name: *Hypentelium nigricans*

1.2 Common name: Northern hogsucker

2.0 Identification.

2.1 General description: Suckers have large thick lips, protrusible premaxillae, soft rays in the fins, no teeth on the jaws, numerous comblike or molarlike teeth in a single row on each pharyngeal arch, 1 dorsal fin, 9 or more dorsal rays, and no scales on the head.

The northern hogsucker has a large rectangular head that is broad and flat (in young) or concave (in adult) between the eyes. The body is wide at front but abruptly tapers behind the dorsal fin. The back is dark olive, bronze or red-brown, often with light stripes along scale rows on the side. The venter is pale yellow or white. The snout is blue-black. Fins are olive to light orange. On the back are 3-6 dusky or brown saddles that extend obliquely forward on the upper side. The snout is long and blunt. The lips are large and fleshy with many large papillae; the two halves of the lower lip are broadly joined at the middle. Pectoral fins are large and fanlike. Large individuals have a black tip on the dorsal fin, and often there is a black margin on the dorsal and caudal fins.

The lateral line is complete; 44-54 lateral scales; usually 11 dorsal rays; 7-8 anal rays; 32-38 (both sides) pectoral rays. Maximum total length = 61 cm.

2.2 Diagnostic characteristics: The northern hogsucker is distinguished from other species of *Hypentelium* by its meristic counts, color, and general body shape (Raney and Lachner 1947, Page and Burr 1991). The Alabama hogsucker has usually 10 dorsal rays, the head only slightly concave between the eyes, more prominent stripes on the side, and red-orange fins. The Roanoke hogsucker has plicate (rather than papillose) lips, usually lacks the dark saddle present on the nape of the northern hogsucker, has 39-44 lateral scales, and 28-32 total pectoral rays.

3.0 Legal status.

3.1 National status: The northern hogsucker has no federal protection as a threatened or endangered species.

3.2 State status: The northern hogsucker has no state protection as a threatened or endangered species.

4.0 Migrating status.

The northern hogsucker ascends clean gravelly streams in spring to spawn and works its way downstream in summer and fall as water levels drop (Smith 1979).

5.0 Range map.

Total and state distributions of the northern hogsucker are shown on accompanying maps.

6.0 Habitat requirements.

6.1 General habitat: The northern hogsucker is most common in rocky riffles, runs and flowing pools of clear creeks and small rivers; it rarely is found in large rivers and impoundments. Individuals usually are found alone in fairly shallow water over rocky substrate and quickly dart into deeper water when disturbed.

6.2 Breeding habitat: In a study conducted in New York (Raney and Lachner 1946), the northern hogsucker was found to spawn over shallow gravel areas in early spring when water temperatures reached around 15°C.

7.0 Food and diet.

The diet of the northern hogsucker consists of insect larvae, crustaceans, diatoms, mollusks, and small amounts of vegetation. It feeds by scraping off the upper surface of large stones, and by turning over stones on the bottom and sucking up the ooze, which contains a host of small organisms (Raney and Lachner 1946). Typically, small fishes such as minnows and small bass gather downstream and feed as the hogsucker dislodges insects and other organisms (Reighard 1920, Greeley 1935).

8.0 Breeding ecology.

8.1 & 8.2 Reproductive behavior: In New York (Raney and Lachner 1946) spawning occurs in early spring at temperatures near 15°C over shallow rocky areas. Males congregate over these areas, and receptive females move in as they are courted by the males. All species of suckers typically spawn in trios, i.e., two males and one female. A female swims between two males who move and push against the female as eggs and sperm are released (Page and Johnston 1990).

In an observation in New York, hogsuckers gathered in groups of 3, 5, 7, and 12 fishes in a large pool, each group with a single female, and swam about the pool with the males attempting to crowd the female. When ready to spawn, the female would take a position over the bottom in a restricted area of sand and gravel about 3 feet in diameter where the water was about 3-5 inches deep. The males packed around the female and, as a male would position himself on either side, she released eggs. As spawning occurred, the males would stand on their heads with their thrashing tails protruding from the surface and beating the water into foam. Nests are not constructed by hogsuckers but the spawning activity clears sediment from the area and may result in the formation of shallow depressions in the gravel. Eggs and larvae receive no parental care.

Males generally mature in two years; females generally mature at three years of age (Etnier and Starnes 1993). Females become sexually mature at about 20 cm TL, males at about 15 cm (Becker 1983). Nuptial tubercles develop on both sexes. Those on the male are large on the fins and some parts of the body, and small on the head; on the female they are smaller and absent on the head and body (Scott and Crossman 1973).

8.3 Eggs: Eggs are nonadhesive and settle between stones as they are released by the female. Eggs hatch in 10 days at a mean water temperature of 17.4°C (Becker 1983).

9.0 Population ecology

9.1 Abundance: No density estimates have been published for northern hogsuckers. Maximum longevity in the northern hogsucker is thought to be about 11 years (Etnier and Starnes 1993).

9.2 Trends: The northern hogsucker is common throughout large parts of its range. In areas with clean gravelly streams, the species often is abundant (Page and Burr 1991, Etnier and Starnes 1993). In Illinois, the species is generally distributed in rocky streams in the northern and eastern parts of the state; it is absent in most western and southern Illinois drainages (Smith 1979). Smith (1979) commented that the species was much less common than it once had been in Illinois because of stream degradation associated with siltation and pollution.

10.0 Genetics.

Hubbs (1930) found little geographic variation in morphology throughout the range of the species. Buth (1980) used allozyme frequencies to examine the evolutionary genetics and systematic relationships of all species of *Hypentelium*. Smith (1992) used allozymic and morphological data to examine the phylogenetic relationships, modes of speciation, and historical biogeography of all sucker species. Included in the analysis were allozyme data from Smith and Koehn (1971), Ferris and Whitt (1978), and Buth (1979).

11.0 Predation.

Predators of hogsuckers include smallmouth bass. Minnows, including blacknose dace and creek chubs, are known to feed on the eggs of hogsuckers (Scott and Crossman 1973).

12.0 Diseases and parasites.

Parasites recorded by Hoffman (1967) for northern hogsuckers were protozoans, trematodes, cestodes, nematodes, spiny-headed worms (Acanthocephala), crustaceans and a mollusk. General synopses on fish parasites, in addition to that by Hoffman (1967), are Bangham (1972) and Margolis & Arthur (1979).

13.0 Area sensitivity.

The northern hogsucker is most common in creeks and small rivers. As do most suckers, this species ascends clean gravelly streams in spring to spawn and gradually moves downstream in summer and fall to overwinter in deeper water. Populations may be unable to complete their life cycle when their ability to migrate is hampered by mainstream impoundments, channelization, and other forms of stream modification.

15.0. Threats to species.

Smith (1971) ranked the causes of extirpation or declines in fish species in Illinois as follows: siltation (as the primary factor responsible for the loss of 2, and decimation of 14, species), drainage of bottomland lakes, swamps, and prairie marshes (0, 13), desiccation during drought (0, 12), species introductions (2, 7), pollution (2, 5), impoundments (0, 4), and increased water temperatures (0, 1). All of these factors render habitats unsuitable for many aquatic species throughout the Midwest, cause extirpations, and lead to the isolation of populations thereby increasing their vulnerability to extirpation.

16.0 Preserve design.

Preserves, areas where biotic communities are more or less intact and are managed to protect their natural characteristics, are mostly dedicated around terrestrial communities. In the Midwest biological reserves tend to be small and rarely, if ever, protect an entire watershed. A new concept being developed in Illinois is the recognition and management of resource rich areas, areas that are large and contain the best remaining biological resources. Although use of the land for recreation, agriculture, and other consumptive activities will continue, management will strive to reverse whatever forms of degradation have effected the area.

Management strategies for aquatic ecosystems must consider the entire watershed. Attempting to correct problems locally without consideration of upstream activities and downstream implications will result in partial and, probably, temporary improvement at best.

17.0 Management and restoration efforts.

Much information is now available on stream hydrodynamics, habitat preferences of aquatic species, and which habitats or stream reaches support the highest species diversity in a given region. Given the opportunity, streams will restore themselves and, often, the best approach to restoration may be to encourage restoration of the native vegetation of the drainage basin, in particular the riparian zone, correct any additional existing pollution problems, and let the stream return to natural conditions. Over time, even channelized ditches will begin to meander and develop the riffle and pool habitats that are necessary for restoration of normal stream biodiversity.

Correction of some factors that have led to species loss and stream habitat fragmentation in past decades is relatively easy. Important initiatives that society has taken include building sewage treatment plants and avoiding the construction of mainstream impoundments. Other initiatives, such as stopping the removal of riparian vegetation, cessation of stream channelization and dredging, and the drainage of bottomland lakes, require more public education and governmental action including, perhaps, providing better initiatives to landowners. Assuming that pollution will be held at current levels or reduced, nothing will be more beneficial to the biota of Midwestern streams than to have natural riparian vegetation restored. Siltation, desiccation, and higher than normal temperatures would all be reduced to acceptable levels if streams were lined with native plants that shaded the stream, stabilized the banks, and filtered sediment and chemicals from runoff before they reached the stream.

Most introductions of exotic fishes have been done in an effort to improve sport or commercial fishing, and usually governmental agencies have been responsible for the introductions. However, non-native species alter ecosystems and the long-term effect of any introduction is likely to be negative rather than an improvement.

A more activist approach to stream restoration, i.e., adding structures that imitate natural stream habitats, has been successful in a number of restoration projects (Newbury and Gaboury 1993). The fish and invertebrate fauna in channelized streams has been shown to be improved by the addition of weirs or structures that increase pool habitat (Borchardt 1993, Shields et al. 1995). Other recommendations for fish habitat improvements are described by Poddubny and Galat (1995), including construction of islands, diking, and restoration and preservation of preferred habitats in the main channel. Restoration of streams requires imitating the hydraulic habitat units of that geologic region to produce habitat heterogeneity of pool, riffle, and run development (Rabeni and Jacobson 1993). However, modifications for habitat improvement such as in-channel structures requires knowledge of the resulting hydrological changes to the channel to avoid creating more damage (Rosgen 1994).

For hogsuckers, substrate composition and stream size appear to be the most distributionally restrictive habitat characteristic; however, it is difficult to distinguish among substrate composition, water velocity, and water depth because in streams all three usually vary concomitantly. The vast majority of sucker species inhabit only running water; for that reason the transformation of a flowing stream into an impoundment soon eliminates all or almost all populations of suckers originally present in the stream.

18.0 Monitoring protocols.

Genetic monitoring of isolated populations is a necessary method for conservation of fishes (Bruton 1995) and detection of fragmented populations. Meffe and Vrijenhoek (1988) described a model for examining the population structure of fishes that results from varying degrees of the connectivity of streams. Their model is intended to describe population structure in streams that are de-watered, resulting in reduced gene flow between isolated populations. However, it appears to be useful for detecting effects of any natural or anthropogenic causes of population fragmentation. The model generates a hierarchical population structure of genetically defined groups in isolated populations.

Shuter (1990) suggested that population monitoring of smaller fish species can provide early evidence of environmental degradation. Small fishes are usually lower in a food web, often dependent on sensitive invertebrate species, and respond more rapidly to stresses (Shuter 1990). In addition to genetic monitoring programs, mark-recapture studies are badly needed to understand normal movements of fishes and other aquatic organisms and, hence, the impacts of degradation or restoration efforts.

19.0 Current research programs.

No ecological or life-history studies on the species currently are known to be in progress.

20.0 Research needs.

Research needed to assess the success of watershed protection on stream fish populations is the monitoring of the abundance and distribution of selected species in order to ascertain how species abundances change over time. From that we can assess what landuse changes, conservation practices, and physical/chemical parameters are correlated with, and possibly responsible for, the biological changes.

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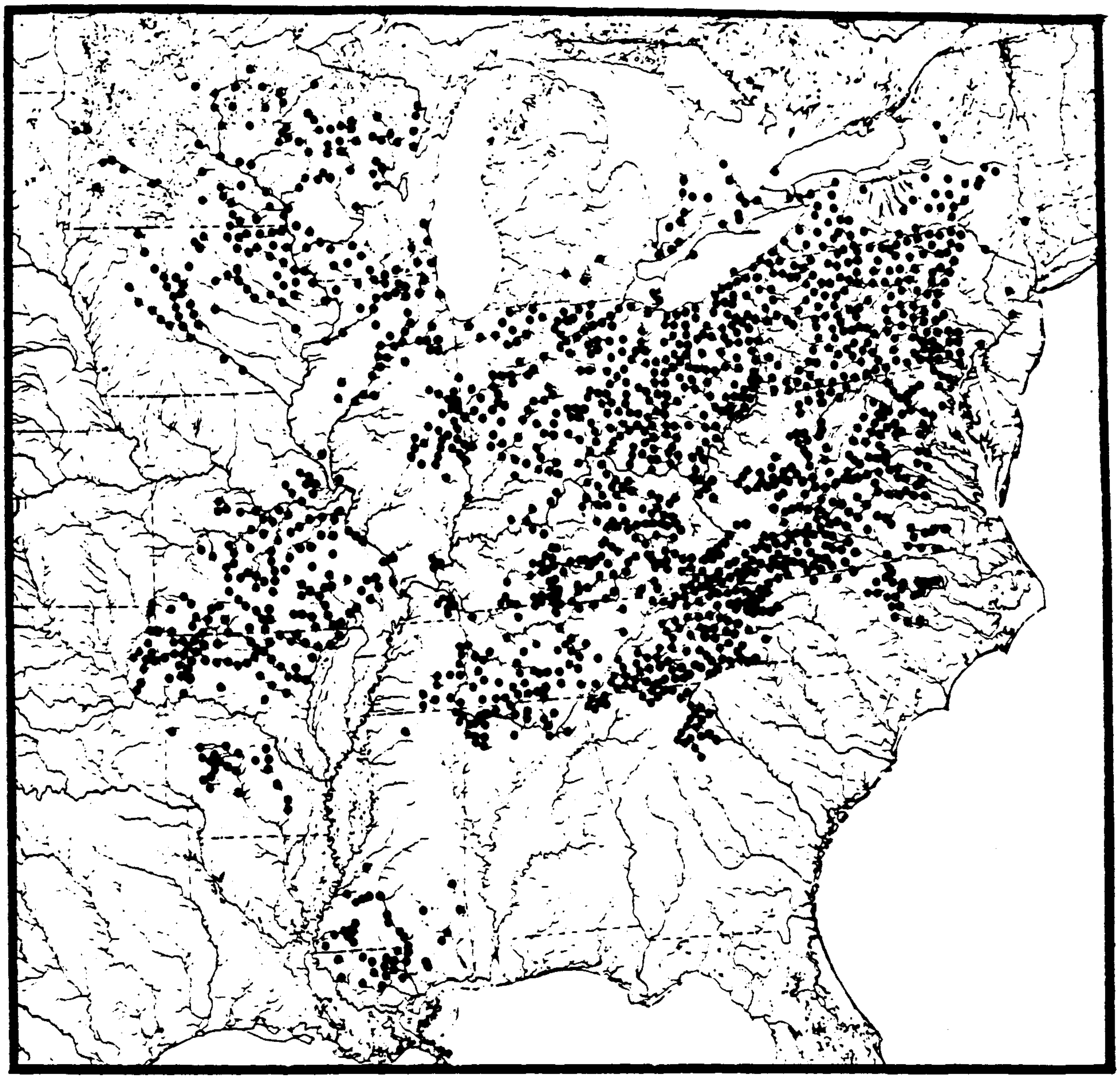

Figure 1. Distribution of the northern hogsucker, *Hypentelium nigricans* in North America (from Buth & Murphy 1980).

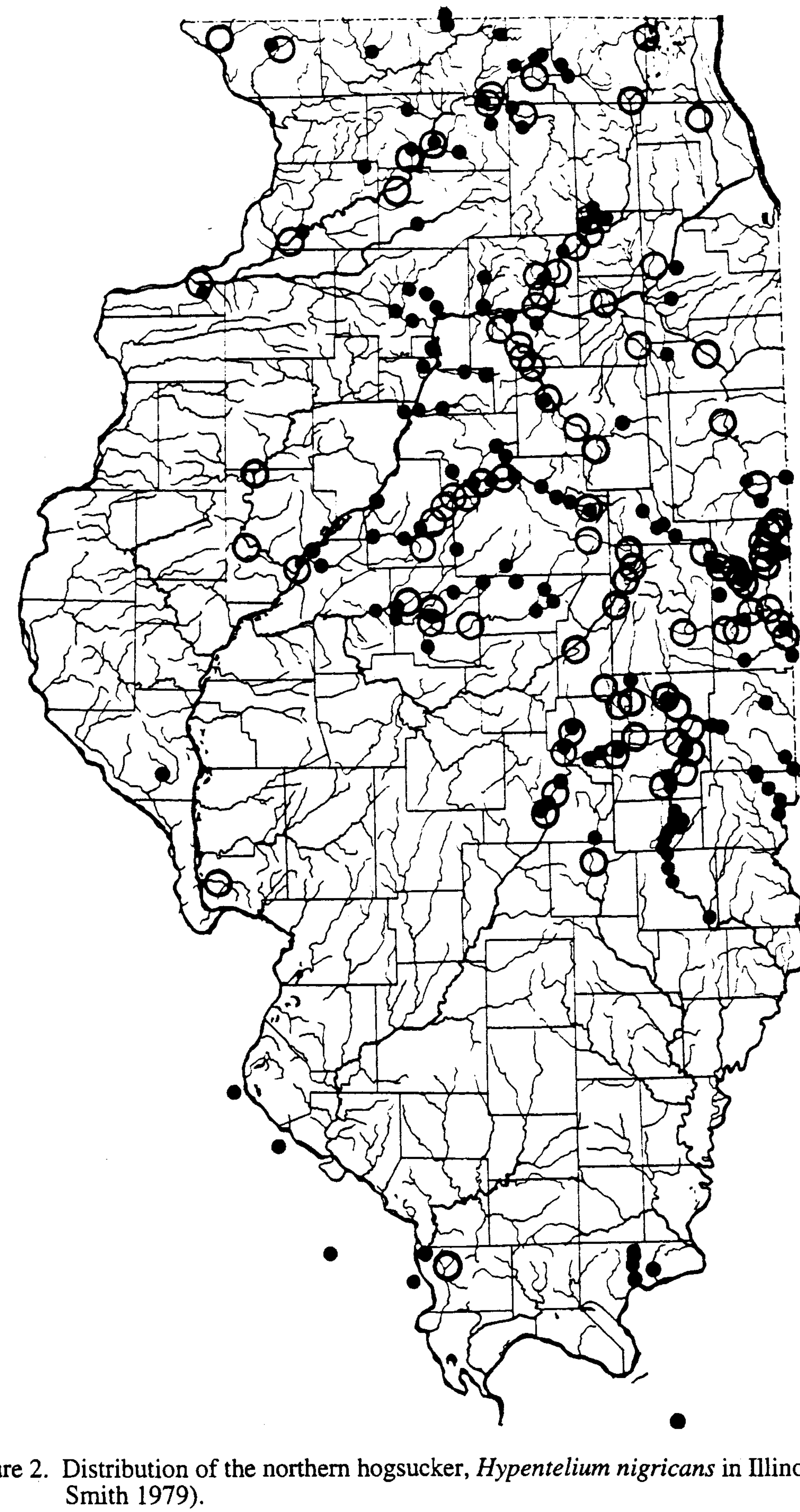

Figure 2. Distribution of the northern hogsucker, *Hypentelium nigricans* in Illinois (from Smith 1979).

BIOLOGICAL ASSESSMENT

ORANGETHROAT DARTER, *Etheostoma spectabile*

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1.0 Taxonomy.

1.1 Scientific name: *Etheostoma spectabile*

1.2 Common name: Orangethroat Darter

2.0 Identification.

2.1 General description: The orangethroat darter is olive to brown dorsally with 6-11 dark green dorsal saddles. On the side of the body are dark blue vertical bars, variable in shape geographically, and separated by yellow, orange, or red pigments (much brighter in males). Over much of the range of the species the anterior side has short horizontal rows of dark dots. The venter is white to orange. The branchiostegal membranes and often the breast of the adult male are bright orange. Orbital bars are black and prominent. In the male the first dorsal fin is red basally and blue marginally and often (varies geographically) has clear and red intermediate bands. The second dorsal fin is mostly orange and often (varies geographically) blue basally. The anal fin is blue, green, or clear. The pelvic fins are blue; caudal and pectoral fins are clear or yellow. Fins of the female are mostly clear or have light brown bands.

The breeding male is beautifully colored with brick-red and blue-green alternating bars on the side of the body, bright orange branchiostegal membranes, and in some populations a red belly. Tubercles develop on the male on the anal, pelvic, lower portion of the caudal, and pectoral fins, as well as on the ventral scales. Females develop somewhat more vivid colors during the breeding season and develop a long and tubular genital papilla.

Lateral scales 32-61 (40-53), 10-42 (20-34) pored; scales above lateral line 5-6; scales below lateral line 7-9 (8); transverse scales 12-16 (14); scales around caudal peduncle 17-20 (18-19); dorsal spines 8-12 (9-10); dorsal rays 10-15 (12-13); pectoral rays 10-14 (11-12); anal spines 2; anal rays 4-8 (6-7); vertebrae 35-37 (36). Maximum total length = 72 mm.

2.2 Diagnostic characteristics: The orangethroat darter is a member of the subgenus *Oligocephalus,* established by Bailey & Gosline (1955) and diagnosed by Bailey & Richards (1963) and Page (1981).

Oligocephalus is characterized by a first dorsal fin with a blue (green in *E. lepidum* and *E. hopkinsi*) marginal band and a well-defined submarginal, medial, or basal red band (except in *E. grahami* and *E. pottsi*); the presence of prevomerine and palatine teeth; and males that average larger than females. The lateral line is incomplete (rarely complete in *E. whipplei* and nearly straight; a premaxillary frenum is present; branchiostegal membranes are narrowly to moderately joined; and modally there are 10 preoperculomandibular pores and 6 branchiostegal rays.

Within *Oligocephalus*, the orangethroat darter is distinguished by having an arched predorsum (especially prominent in older individuals), an interrupted infraorbital canal, no red in the anal fin, and a blue margin on the first dorsal fin. The supratemporal canal is usually uninterrupted (except in the subspecies *E. s. uniporum).* The breeding male has tubercles on the fins and on the ventral body scales. The nape, cheek, and opercle are unscaled to fully scaled. The belly is scaled. The breast is usually unscaled but may have embedded scales posteriorly.

3.0 Legal status.

3.1 National status: The orangethroat darter has no federal protection as a threatened or endangered species.

3.2 State status: The orangethroat darter has no state protection as a threatened or endangered species.

4.0 Migrating status.

The orangethroat darter does not undergo long-distance migrations. After hatching the young drift downstream into pools and feed on small insects and crustaceans. Individuals migrate back upstream into headwaters as they grow.

5.0 Range map.

Total and state distributions of the orangethroat darter are shown on accompanying maps.

6.0 Habitat requirements.

6.1 General habitat: The orangethroat darter lives in shallow gravel riffles, less often in raceways and pools, of small to moderate-sized streams. Larimore, *et al.* (1952) and Trautman (1957) commented on the ecological relationship between rainbow darters (E. *caeruleum)* and orangethroat darters; the former inhabit large deep riffles in the same streams in which orangethroat darters inhabit small shallow riffles. Pflieger (1971) likewise noted this ecological distinction in Missouri, and Clark (1974) investigated the morphological and ecological consequences of the syntopic occurrence of these two species in western Indiana.

6.2 Breeding habitat: Winn (1958a, 1958b), in observations in Michigan, Kentucky, and Tennessee, found the orangethroat darter to breed in shallow (10-35 mm) gravel riffles in April and May.

7.0 Food and diet.

Cross (1967) found that adults feed on immature flies, caddisflies, other insects, and fish eggs. In general, darters feed mainly on microcrustaceans (cladocerans, copepods, and ostracods) as juveniles and on immature aquatic insects (mostly midge flies, black flies, mayflies, and caddisflies) as adults (Page 1983).

8.0 Breeding ecology.

8.1 & 8.2 Reproductive behavior: In Texas spawning occurs from November through July (C. Hubbs, 1961a; C. Hubbs & Bailey, 1977); in Missouri from March through May (Pflieger, 1975); in Indiana from March into June (Clark, 1974); and in Kansas from March through May at 15-21 °C in shallow riffles (Cross, 1967). As described by Cross (1967), males do not establish territories but, at the initiation of the spawning season, congregate on riffles. When ready to spawn a female enters the riffle, is mounted by a male, and both vibrate as eggs and sperm are released into the gravel substrate. As Winn (1958a, 1958b) described the behavior, a male establishes a territory around a female, mounts her, and the pair vibrate as eggs and sperm are released into the gravel substrate into which the female has partially buried herself; from three to seven eggs are laid and the sequence is repeated. Several females may spawn with the same male.

After hatching the young drift downstream into pools and feed on small insects and crustaceans. In Missouri Pflieger (1966) discovered that the fry of orangethroat darters move into the nests of smallmouth bass *(Micropterus dolomieu,* where they benefit from the protection of the male bass guarding the nest and feed on the abundant microorganisms in the nest. Cross (1967) noted that sexual maturity is reached at one year of age. C. Hubbs, *et* al. (1968) observed a ripe female only 27 mm SL. Winn (1958b) counted 430-896 ova (of all sizes) in four one-year-old females (30-33 mm), 938-1,480 ova in four two-year-olds (36-42 mm), and 1,758-2,070 ova in two three-year-olds (45-46 mm).

8.3 Eggs: Eggs average 1.2 mm in diameter and hatch in 9.5-10 days at 16.5-18.5°C. C. Hubbs (1958b) found a range from fewer than 50 to slightly more than 200 eggs in ripe females. C. Hubbs, et al. (1968) recorded an average egg diameter of 1.5 mm. Clark Hubbs has investigated several facets of reproduction in *E. spectabile* and found, among other things, geographic variation in the size but not number of eggs produced (C. Hubbs, 1958b), that the number but not the size of eggs increases geometrically with the size of the female (C . Hubbs, *et al.,* 1968), that eggs and larvae survive a temperature range of 10-27°C (C. Hubbs, 1961a; C. Hubbs & Armstrong, 1962), and that eggs and larvae from Missouri and Arkansas survive higher temperature maxima than do those from central Texas (C. Hubbs & Armstrong, 1962).

Darter eggs hatch in about 27 days at 10°, in about eight days at 20°, and in about two and a half days at 30°C. Actually 10° and 30°C appear to be close to the limits of tolerance for embryonic development in darters (C. Hubbs, 1961a, 1961b; Burr & Page, 1978, 1979).

9.0 Population ecology

9.1 Abundance: The density of individual darters per unit area varies interspecifically and, within species, seasonally and by habitat. In general, and with a few notable exceptions *(e.g., P. sciera* and *P. nigrofasciata),* species of *Percina* tend to be present in smaller populations than do species of *Etheostoma.* Species of *Ammocrypta* usually exist in small populations in the north and in relatively large populations in the south. The highest (postlarval) density recorded for a darter is for *E. microperca,* for which Burr & Page (1979) calculated a density of 33 individuals/m2 in a small stream in Illinois in October. *E. microperca* was most dense in late summer and fall (12-33 individuals/m2) when the water level was low and the number of juveniles was at a peak. Because of high mortality (*E. microperca* lives a maximum of only 1+ years) and a rising water level, the density declined throughout winter and early spring. In May the density began to increase.

Lachner, *et al.* (1950), Schwartz (1965b), and Reed (1968) found multispecific densities of 1.2, 1.4, and 10.8 darters/m2, respectively, in various riffles in Pennsylvania. Wickliff (1941) found densities up to 16.8 darters/m2 in riffles in Ohio, or about one darter per 600 cm^2 of riffle.

9.2 Trends: The orangethroat darter remains common throughout most of its range. Extirpation has occurred in heavily degraded streams.

10.0 Genetics.

Distler (1968) investigated geographic variation in *E. spectabile* and recognized five morphologically distinguishable subspecies. Wiseman et al. (1978) analyzed variation at the LDH-1 locus in selected populations and found general agreement with Distler's morphological data. Both studies concentrated on populations west of the Mississippi River.

The conclusion of Distler (1968) and Wiseman et al. (1978) that at least five taxonomic entities exist within *E. spectabile* has been universally accepted, although recent studies (e.g., Robison and Buchanan 1988; Ceas and Page, in press) suggest that one or more of the populations may warrant recognition as species rather than subspecies.

Etheostoma s. spectabile is the only subspecies presently recognized in drainages east of the Mississippi River and also occurs in the Osage River system in Missouri and Kansas, the White River system in Missouri and Arkansas, the upper Black River system in Missouri, the Gasconade and Meramec River systems in Missouri, and other smaller streams in Missouri that drain directly into the Mississippi or Missouri rivers.

Etheostoma s. pulchellum has an extensive range encompassing several river systems. It is found in the Brazos, Colorado, and Guadalupe rivers on the Commanche and Edwards plateaus southeastward to the Balcones Escarpment in Texas; northern tributaries of the Red River from the Wichita Mountains eastward to the Little River in Arkansas; the Arkansas River system near Garden City, Kansas, to the Ozark escarpment west of Little Rock, Arkansas (except on the Springfield Plateau); the Republican River system of Kansas, eastern Colorado, and southern Nebraska; and the North Platte River of western Nebraska.

The three remaining subspecies have small ranges. *E. s. fragi* is restricted to tributaries of the Strawberry River (Black River system) in northeastern Arkansas. *E. s. uniporum* occurs in upland tributaries of the Black River system from Cane Creek, Butler County, Missouri, south to Flat Creek, Lawrence County, Arkansas. *E. s. squamosum* occurs on the Springfield Plateau in the lower Neosho-Spring River system in northeastern Oklahoma and southwestern Missouri, and in the Illinois River system of eastern Oklahoma and northwestern Arkansas.

11.0 Predation.

Known predators of darters include the following species: American eel, *Anguilla rostrata* (Ogden, 1970); brown trout, *Salmo trutta* (Copes, 1976); grass pickerel, *Esox americanus* (Page, 1 974b); northern pike, *E. lucius* (Greeley, 1927); creek chub, *Semotilus atromaculatus* (Copes, 1976); burbot, *Lota lota* (Evermann & Kendall, *1896);* rock bass, *Ambloplites rupestris* (Adams & Hankinson, 1928); white crappie, *Pomoxis annularis* (Cahn, 1927); green sunfish, *Lepomis cyanellus* (Wall & Williams, 1974); largemouth bass, *Micropterus salmoides* (Hankinson, 1911); spotted bass, *M. punctulatus* (Smith & Page, 1969); walleye, *Stizostedion vitreum* (Raney & Lachner, 1942); yellow perch, *Perca flavescens* (Hauer, 1975); banded sculpin, *Cottus carolinae* (Howell & Dingerkus, 1978; Hickman & Fitz, 1978); mudpuppy, *Necturus maculosus* (Howell & Dingerkus, *1978);* water snakes, *Nerodia* spp. (feeding on P. *sciera* in the Brazos River, Texas, 24 April 1964, *P.W.* Smith, pers. obs.); king eider, *Somateria spectabilis* (Embody, 1910); red-breasted merganser, *Mergus serrator* (Evermann & Clark, 1920); and river otter, *Lutra canadensis* (Lauhachinda & Hill, 1977).

Although darters usually comprise an almost incidental component in the diet of a predator, *E. olmstedi* was found to be the most commonly ingested fish in Ogden's (1970) study on *Anguilla rostrata* in New Jersey and in Raney & Lachner's (1942) study on *Stizostedion vitreum* in New York, and P. *caprodes* formed the bulk of fish remains found scattered among the nests of terns on Rattle Snake Island in Lake Erie (McCormick, 1892).

Ellis & Roe (1917) described extensive feeding by white suckers *(Catostomus commersoni* on the eggs of *P. caprodes* in Douglas Lake, Michigan. Cannibalism in *E. barbouri* was mentioned by Flynn & Hoyt (1979).

12.0 Diseases and parasites.

Commonly reported parasites of darters are flukes, nematodes, leeches, spiny-headed worms (Acanthocephala), and copepods *(Lernaea).* Darters are often heavily infested with metacercarial trematodes (blackspot disease). General synopses on fish parasites are by Hoffman (1967), Bangham (1972), and Margolis & Arthur (1979).

13.0 Area sensitivity.

The orangethroat darter is most abundant in headwaters and creeks, and only occasionally is found in larger streams. The species is not known to undergo long-distance migrations. The life cycle is completed in small streams.

15.0. Threats to species.

Smith (1971) ranked the causes of extirpation or declines in fish species in Illinois as follows: siltation (as the primary factor responsible for the loss of 2, and decimation of 14, species), drainage of bottomland lakes, swamps, and prairie marshes (0, 13), desiccation during drought (0, 12), species introductions (2, 7), pollution (2, 5), impoundments (0, 4), and increased water temperatures (0, 1). All of these factors render habitats unsuitable for many aquatic species throughout the Midwest, cause extirpations, and lead to the isolation of populations thereby increasing their vulnerability to extirpation.

16.0 Preserve design.

Preserves, areas where biotic communities are more or less intact and are managed to protect their natural characteristics, are mostly dedicated around terrestrial communities. In the Midwest biological reserves tend to be small and rarely, if ever, protect an entire watershed. A new concept being developed in Illinois is the recognition and management of resource rich areas, areas that are large and contain the best remaining biological resources. Although use of the land for recreation, agriculture, and other consumptive activities will continue, management will strive to reverse whatever forms of degradation have effected the area.

Management strategies for aquatic ecosystems must consider the entire watershed. Attempting to correct problems locally without consideration of upstream activities and downstream implications will result in partial and, probably, temporary improvement at best.

17.0 Management and restoration efforts.

Much information is now available on stream hydrodynamics, habitat preferences of aquatic species, and which habitats or stream reaches support the highest species diversity in a given region. Given the opportunity, streams will restore themselves and, often, the best approach to restoration may be to encourage restoration of the native vegetation of the drainage basin, in particular the riparian zone, correct any additional existing pollution problems, and let the stream return to natural conditions. Over time, even channelized ditches will begin to meander and develop the riffle and pool habitats that are necessary for restoration of normal stream biodiversity.

Correction of some factors that have led to species loss and stream habitat fragmentation in past decades is relatively easy. Important initiatives that society has taken include building sewage treatment plants and avoiding the construction of mainstream impoundments. Other initiatives, such as stopping the removal of riparian vegetation, cessation of stream channelization and dredging, and the drainage of bottomland lakes, require more public education and governmental action including, perhaps, providing better initiatives to landowners. Assuming that pollution will be held at current levels or reduced, nothing will be more beneficial to the biota of Midwestern streams than to have natural riparian vegetation restored. Siltation, desiccation, and higher than normal temperatures would all be reduced to acceptable levels if streams were lined with native plants that shaded the stream, stabilized the banks, and filtered sediment and chemicals from runoff before they reached the stream.

Most introductions of exotic fishes have been done in an effort to improve sport or commercial fishing, and usually governmental agencies have been responsible for the introductions. However, non-native species alter ecosystems and the long-term effect of any introduction is likely to be negative rather than an improvement.

A more activist approach to stream restoration, i.e., adding structures that imitate natural stream habitats, has been successful in a number of restoration projects (Newbury and Gaboury 1993). The fish and invertebrate fauna in channelized streams has been shown to be improved by the addition of weirs or structures that increase pool habitat (Borchardt 1993, Shields et al. 1995). Other recommendations for fish habitat improvements are described by Poddubny and Galat (1995), including construction of islands, diking, and restoration and preservation of preferred habitats in the main channel. Restoration of streams requires imitating the hydraulic habitat units of that geologic region to produce habitat heterogeneity of pool, riffle, and run development (Rabeni and Jacobson 1993). However, modifications for habitat improvement such as in-channel structures requires knowledge of the resulting hydrological changes to the channel to avoid creating more damage (Rosgen 1994).

For darters, substrate composition appears to be the most distributionally restrictive habitat characteristic; however, it is difficult to distinguish among substrate composition, water velocity, and water depth because in streams all three usually vary concomitantly. The vast majority of darters inhabit only running water; for that reason the transformation of a flowing stream into an impoundment soon eliminates all or almost all populations of darters originally present in the stream.

18.0 Monitoring protocols.

Genetic monitoring of isolated populations is a necessary method for conservation of fishes (Bruton 1995) and detection of fragmented populations. Meffe and Vrijenhoek

(1988) described a model for examining the population structure of fishes that results from varying degrees of the connectivity of streams. Their model is intended to describe population structure in streams that are de-watered, resulting in reduced gene flow between isolated populations. However, it appears to be useful for detecting effects of any natural or anthropogenic causes of population fragmentation. The model generates a hierarchical population structure of genetically defined groups in isolated populations.

Shuter (1990) suggested that population monitoring of smaller fish species can provide early evidence of environmental degradation. Small fishes are usually lower in a food web, often dependent on sensitive invertebrate species, and respond more rapidly to stresses (Shuter 1990). In addition to genetic monitoring programs, mark-recapture studies are badly needed to understand normal movements of fishes and other aquatic organisms and, hence, the impacts of degradation or restoration efforts.

19.0 Current research programs.

Geographic variation in the orangethroat darter is the doctoral dissertation topic of Mr. Patrick A. Ceas, and his research is ongoing at the Illinois Natural History Survey and Eastern Kentucky University. No ecological or life-history studies on the species currently are known to be in progress.

20.0 Research needs.

Research needed to assess the success of watershed protection on stream fish populations is the monitoring of the abundance and distribution of selected species in order to ascertain how species abundances change over time. From that we can assess what landuse changes, conservation practices, and physical/chemical parameters are correlated with, and possibly responsible for, the biological changes.

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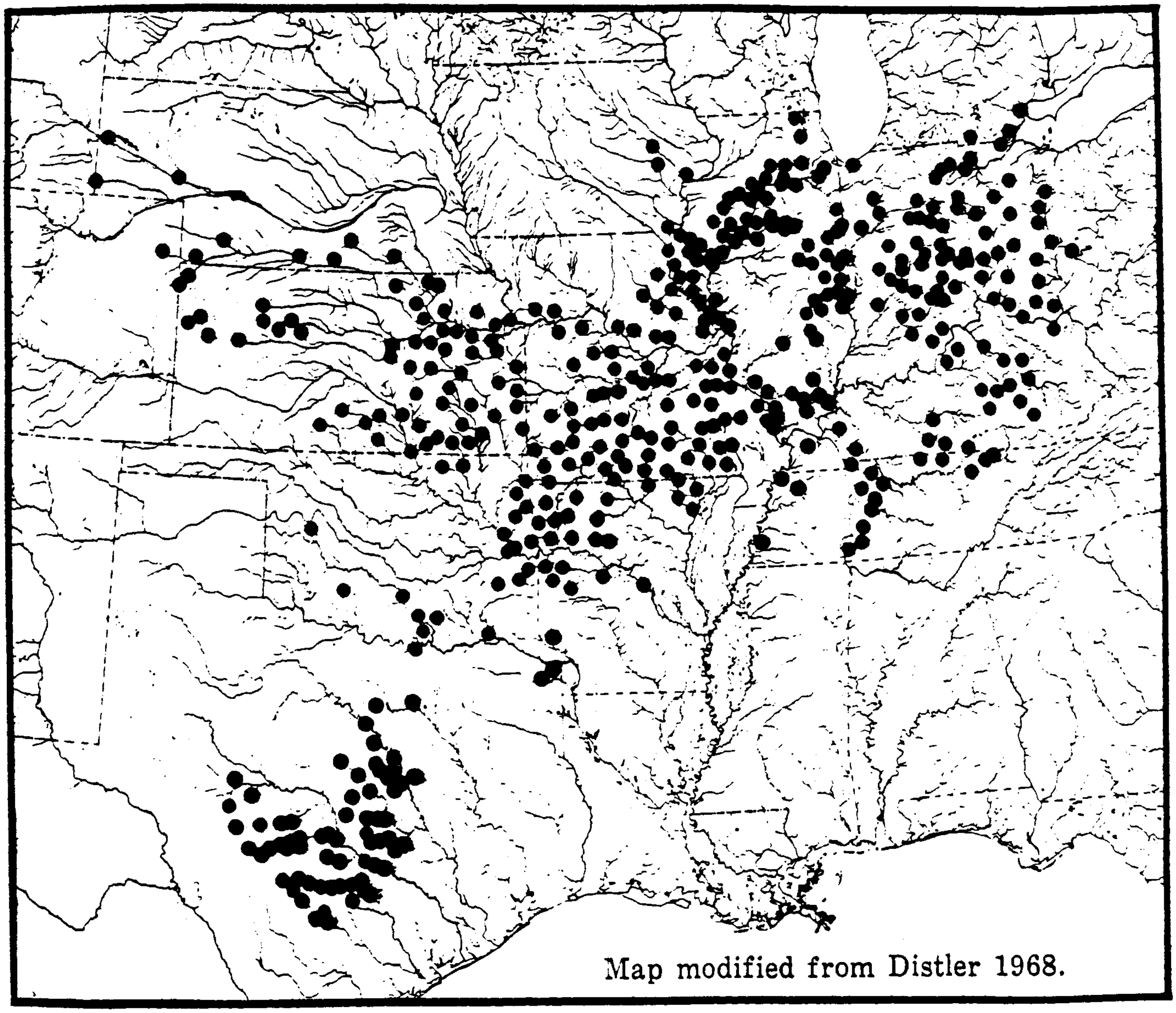

Figure 1. Distribution of the orangethroat darter, *Etheostoma spectabile* in North America (from Bruner 1980).

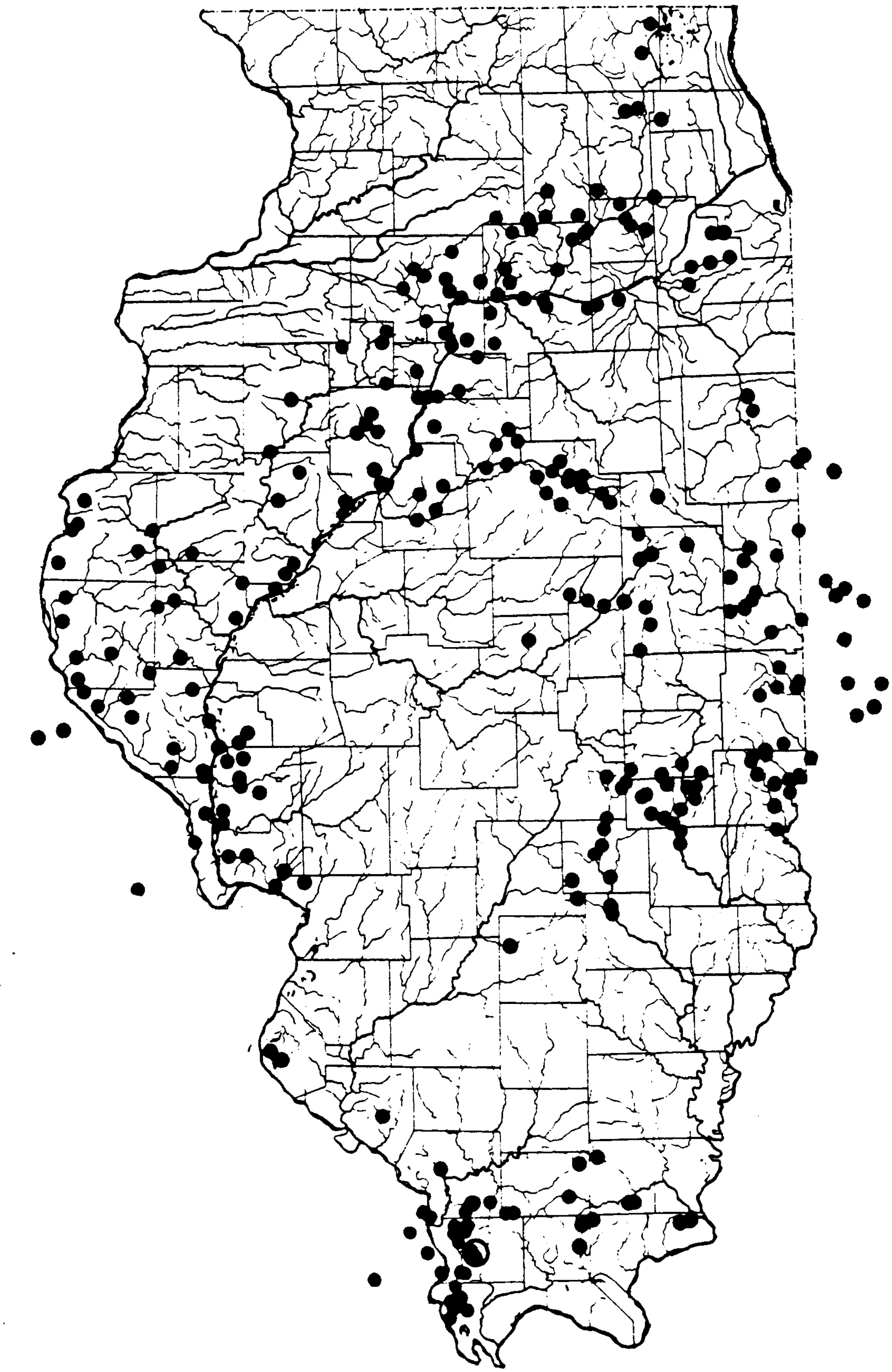

Figure 2. Distribution of the orangethroat darter, *Etheostoma spectabile* in Illinois (from Smith 1979).

BIOLOGICAL ASSESSMENT

SLENDER MADTOM, *Noturus exilis*

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for the

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15 November 1996

SLENDER MADTOM, *Noturus exilis*

1.0 Taxonomy.

1.1 Scientific name: *Noturus exilis*

1.2 Common name: Slender madtom

2.0 Identification.

2.1 General description: The slender madtom is olive, gray or brown dorsally, and cream white ventrally. A light yellow band crosses the back behind the head and another crosses the back immediately behind the dorsal fin. The dorsal, caudal and anal fins have dusky to black margins; other fins have light margins. Upper barbels are dark; lower barbels are white.

The body is elongate, cylindrical anteriorly and compressed posteriorly. The snout is blunt. The upper jaw is only slightly longer than the lower jaw. One long barbel extends on either side of the head from the corner of the mouth, a shorter barbel extends from the collar surrounding each posterior nostril, and four barbels extend in a row across the chin. Numerous small teeth occur in broad bands on the upper and lower jaws; the tooth patch on the upper jaw lacks elongate lateral backward extensions. The dorsal fin origin is in front of the midpoint between the pectoral and pelvic fins; the dorsal fin is swollen at its base, has a short spine and 6-7 soft rays. The adipose fin is continuous with the caudal fin and delimited posteriorly by only a shallow notch. Anal fin rays 17-22; pelvic fin rays 8-10. Pectoral fin spine short, strongly notched on its anterior edge from tip of spine to at least its midpoint; posterior edge of the spine has well-developed serrae. The caudal fin is rounded to squarish in outline. Scales are absent. Lateral line is incomplete. Maximum total length = 150 mm.

2.2 Diagnostic characteristics: The slender madtom is a member of the subgenus *Schilbeodes,* as diagnosed by morphological, chromosomal, and allozyme data (Taylor 1969, LeGrande 1981, Grady 1987, Grady and LeGrande 1992).

Schilbeodes contains all of the dark, nearly uniformly colored species of *Noturus* except *flavus*. They usually have 8 or 9 pelvic fin rays, 6-10 soft pectoral rays, and 10 or 11 preoperculomandibular pores. They lack anterior serrae on the pectoral spine. The premaxillary tooth patch is a short, rectangular band without prominent posterior projections.

Within *Schilbeodes*, the slender madtom is distinguished by having the combination of a terminal (or slightly subterminal) mouth, jaws about equal in length, a single internasal pore, 9 pelvic rays, and 10 preoperculomandibular pores. Most individuals have black borders on the median fins.

3.0 Legal status.

3.1 National status: The slender madtom has no federal protection as a threatened or endangered species.

3.2 State status: The slender madtom has no state protection as a threatened or endangered species.

4.0 Migrating status.

The slender madtom does not undergo long-distance migrations.

5.0 Range map.

Total and state distributions of the slender madtom are shown on accompanying maps.

6.0 Habitat requirements.

6.1 General habitat: The slender madtom is most common in rocky riffles, runs and flowing pools of clear creeks and small rivers; it sometimes is found in springs and wave-swept margins of large impoundments. A study in southern Illinois (Mayden and Burr 1981) found that the habitat occupied by slender madtoms varies with age and, for mature individuals, varies with season. Most adults inhabit rocky pools during all months except June and July, when most individuals are found in riffles. The shift by adults from pools to riffles in June and July is related to nest-building and spawning. Young slender madtoms are found mostly in shallow riffles but also are found in shallow margins of pools. During daylight, slender madtoms are usually found under large rocks and other objects or in the interstices of gravel. At night and during twilight, young and adults are more active and likely to be found swimming about in the stream.

Elsewhere, the slender madtom has been reported to occur primarily in small to medium-sized streams (Taylor 1969) and is most common in riffles or pools having enough current to keep the bottom free of silt (Pflieger 1975, Vives 1983).

6.2 Breeding habitat: The nesting habitat for slender madtoms is shallow rocky areas, including riffles and pools. Most nests found by Mayden and Burr (1981) were in rocky pools with little current and depths ranging from 12.5 to 40.0 cm.. Nests were in cavities beneath large rocks. Nest rocks were always the largest rocks in the area and were usually flat on the underside.

7.0 Food and diet.

Mayden and Burr (1981) found that in southern Illinois slender madtoms feed primarily on immature flies, mayflies, caddisflies, and crustaceans. In Oklahoma, Vives (1983) found the major food items to be mayflies and fly larvae. Studies elsewhere have found essentially the same diet (Curd 1960). Larger individuals feed on a larger variety of food items than do small individuals. Feeding activity is greatest between dusk and dawn (Mayden and Burr 1981, Becker 1983).

8.0 Breeding ecology.

8.1 & 8.2 Reproductive behavior: In southern Illinois (Mayden and Burr 1981), the spawning period occurs from mid-June though late July. At more southern latitudes, breeding may occur as early as April. Both sexes generally mature in two years; some individuals may mature at one year of age. Females become sexually mature at about 50 mm SL, which includes some first- and second-year individuals; by their third year, all females are mature.

Nests are constructed by males in cavities beneath large rocks in flowing pools and riffles. The male guards the cavity and courts females. Receptive females deposit eggs on the floor of the cavity. Numbers of eggs found in nests in southern Illinois averaged 51 (Mayden and Burr 1981). The eggs adhere to one another and form a clump that is guarded by a male or by a male and female.

8.3 Eggs: The number of eggs produced by a female ranges from 26-150 and is positively correlated with length, weight, and age of the female. Eggs are spherical and amber in color, range in diameter from 3.9 to 4.5 mm, and are adhesive. Eggs incubated at 25°C hatch in 187-210 hours (Mayden and Burr 1981).

9.0 Population ecology

9.1 Abundance: The only data available for the slender madtom are for a stream in southern Illinois. The density of individual madtoms per unit area varies interspecifically and, within species, seasonally and by habitat. Mayden and Burr (1981) found the number of individuals in riffles to vary from $0.6/m^2$ in November to $12.9/m^2$ in December, and in pools to vary from 0.0 in January and March to $2.3/m^2$ in August. They noted that individuals showed highly clumped distributions and that sampling error probably contributed to the wide variation in results.

Maximum longevity in the slender madtom is 5 years; other species of madtoms, e.g., the stonecat (*Noturus flavus*), are known to live up to 9 years (Scott and Crossman 1973).

9.2 Trends: The slender madtom is common throughout most of its range. However, in Illinois, the species is sporadically distributed and generally uncommon (Smith 1979). The only large populations in the state are in Union County in extreme southern Illinois. The largest populations are found in drainages of the Ozarks (Taylor 1969, Page and Burr 1991).

10.0 Genetics.

There is considerable morphological variation in slender madtoms over their range as noted by Hubbs and Raney (1944) and Taylor (1969). The degree of pigmentation of the fins varies; fins typically have dark margins, but may have black margins in the White River system in Arkansas and often lack dark margins in many other drainages. Average meristic differences for different geographic regions are given by Taylor, who concluded that although populations can be separated meristically, recognition of subspecies is not warranted. The greatest differences were found among Arkansas River, White River, and Missouri River populations in the Ozarks, with Illinois samples being most similar to those from the Missouri River. The Little Red River, Arkansas, population is karyotypically distinct (Robison and Buchanan 1990).

Grady and LeGrande (1992) used allozymic, chromosomal and morphological data to examine the phylogenetic relationships, modes of speciation, and historical biogeography of all madtom species. Included in the allozyme data set were genotypes for 25 presumptive loci.

11.0 Predation.

Madtoms are protected from predation by their large fin spines and associated toxins, and predation pressure may be lower on madtoms than on most fishes. Predation on adult slender madtoms has not been recorded. In contrast, crayfishes, minnows and darters are known to feed on eggs and larvae of madtoms (Fowler 1917, Mayden et al. 1980), including slender madtoms (Mayden and Burr 1981).

12.0 Diseases and parasites.

Parasites recorded (Mayden and Burr 1981) for slender madtoms are nematodes, leeches, spiny-headed worms (Acanthocephala), and copepods *(Lernaea)*. General synopses on fish parasites are by Hoffman (1967), Bangham (1972), and Margolis & Arthur (1979).

13.0 Area sensitivity.

The slender madtom is most common in creeks and small rivers, and rarely is found in larger rivers. The life cycle is completed in small streams. The species is not known to undergo long-distance migrations.

15.0. Threats to species.

Smith (1971) ranked the causes of extirpation or declines in fish species in Illinois as follows: siltation (as the primary factor responsible for the loss of 2, and decimation of 14, species), drainage of bottomland lakes, swamps, and prairie marshes (0, 13), desiccation during drought (0, 12), species introductions (2, 7), pollution (2, 5), impoundments (0, 4), and increased water temperatures (0, 1). All of these factors render habitats unsuitable for many aquatic species throughout the Midwest, cause extirpations, and lead to the isolation of populations thereby increasing their vulnerability to extirpation.

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Preserves, areas where biotic communities are more or less intact and are managed to protect their natural characteristics, are mostly dedicated around terrestrial communities. In the Midwest biological reserves tend to be small and rarely, if ever, protect an entire watershed. A new concept being developed in Illinois is the recognition and management of resource rich areas, areas that are large and contain the best remaining biological resources. Although use of the land for recreation, agriculture, and other consumptive activities will continue, management will strive to reverse whatever forms of degradation have effected the area.

Management strategies for aquatic ecosystems must consider the entire watershed. Attempting to correct problems locally without consideration of upstream activities and downstream implications will result in partial and, probably, temporary improvement at best.

17.0 Management and restoration efforts.

Much information is now available on stream hydrodynamics, habitat preferences of aquatic species, and which habitats or stream reaches support the highest species diversity in a given region. Given the opportunity, streams will restore themselves and, often, the best approach to restoration may be to encourage restoration of the native vegetation of the drainage basin, in particular the riparian zone, correct any additional existing pollution problems, and let the stream return to natural conditions. Over time, even channelized ditches will begin to meander and develop the riffle and pool habitats that are necessary for restoration of normal stream biodiversity.

Correction of some factors that have led to species loss and stream habitat fragmentation in past decades is relatively easy. Important initiatives that society has taken include building sewage treatment plants and avoiding the construction of mainstream impoundments. Other initiatives, such as stopping the removal of riparian vegetation, cessation of stream channelization and dredging, and the drainage of bottomland lakes, require more public education and governmental action including, perhaps, providing better initiatives to landowners. Assuming that pollution will be held at current levels or reduced, nothing will be more beneficial to the biota of Midwestern streams than to have natural riparian vegetation restored. Siltation, desiccation, and higher than normal temperatures would all be reduced to acceptable levels if streams were lined with native plants that shaded the stream, stabilized the banks, and filtered sediment and chemicals from runoff before they reached the stream.

Most introductions of exotic fishes have been done in an effort to improve sport or commercial fishing, and usually governmental agencies have been responsible for the introductions. However, non-native species alter ecosystems and the long-term effect of any introduction is likely to be negative rather than an improvement.

A more activist approach to stream restoration, i.e., adding structures that imitate natural stream habitats, has been successful in a number of restoration projects (Newbury and Gaboury 1993). The fish and invertebrate fauna in channelized streams has been shown to be improved by the addition of weirs or structures that increase pool habitat (Borchardt 1993, Shields et al. 1995). Other recommendations for fish habitat improvements are described by Poddubny and Galat (1995), including construction of islands, diking, and restoration and preservation of preferred habitats in the main channel. Restoration of streams requires imitating the hydraulic habitat units of that geologic region to produce habitat heterogeneity of pool, riffle, and run development (Rabeni and Jacobson 1993). However, modifications for habitat improvement such as in-channel structures requires knowledge of the resulting hydrological changes to the channel to avoid creating more damage (Rosgen 1994).

For madtoms, substrate composition appears to be the most distributionally restrictive habitat characteristic; however, it is difficult to distinguish among substrate composition, water velocity, and water depth because in streams all three usually vary concomitantly. The vast majority of madtoms inhabit only running water; for that reason the transformation of a flowing stream into an impoundment soon eliminates all or almost all populations of madtoms originally present in the stream.

18.0 Monitoring protocols.

Genetic monitoring of isolated populations is a necessary method for conservation of fishes (Bruton 1995) and detection of fragmented populations. Meffe and Vrijenhoek (1988) described a model for examining the population structure of fishes that results from varying degrees of the connectivity of streams. Their model is intended to describe population structure in streams that are de-watered, resulting in reduced gene flow between isolated populations. However, it appears to be useful for detecting effects of any natural or anthropogenic causes of population fragmentation. The model generates a hierarchical population structure of genetically defined groups in isolated populations.

Shuter (1990) suggested that population monitoring of smaller fish species can provide early evidence of environmental degradation. Small fishes are usually lower in a food web, often dependent on sensitive invertebrate species, and respond more rapidly to stresses (Shuter 1990). In addition to genetic monitoring programs, mark-recapture studies are badly needed to understand normal movements of fishes and other aquatic organisms and, hence, the impacts of degradation or restoration efforts.

19.0 Current research programs.

No ecological or life-history studies on the species currently are known to be in progress.

20.0 Research needs.

Research needed to assess the success of watershed protection on stream fish populations is the monitoring of the abundance and distribution of selected species in order to ascertain how species abundances change over time. From that we can assess what landuse changes, conservation practices, and physical/chemical parameters are correlated with, and possibly responsible for, the biological changes.

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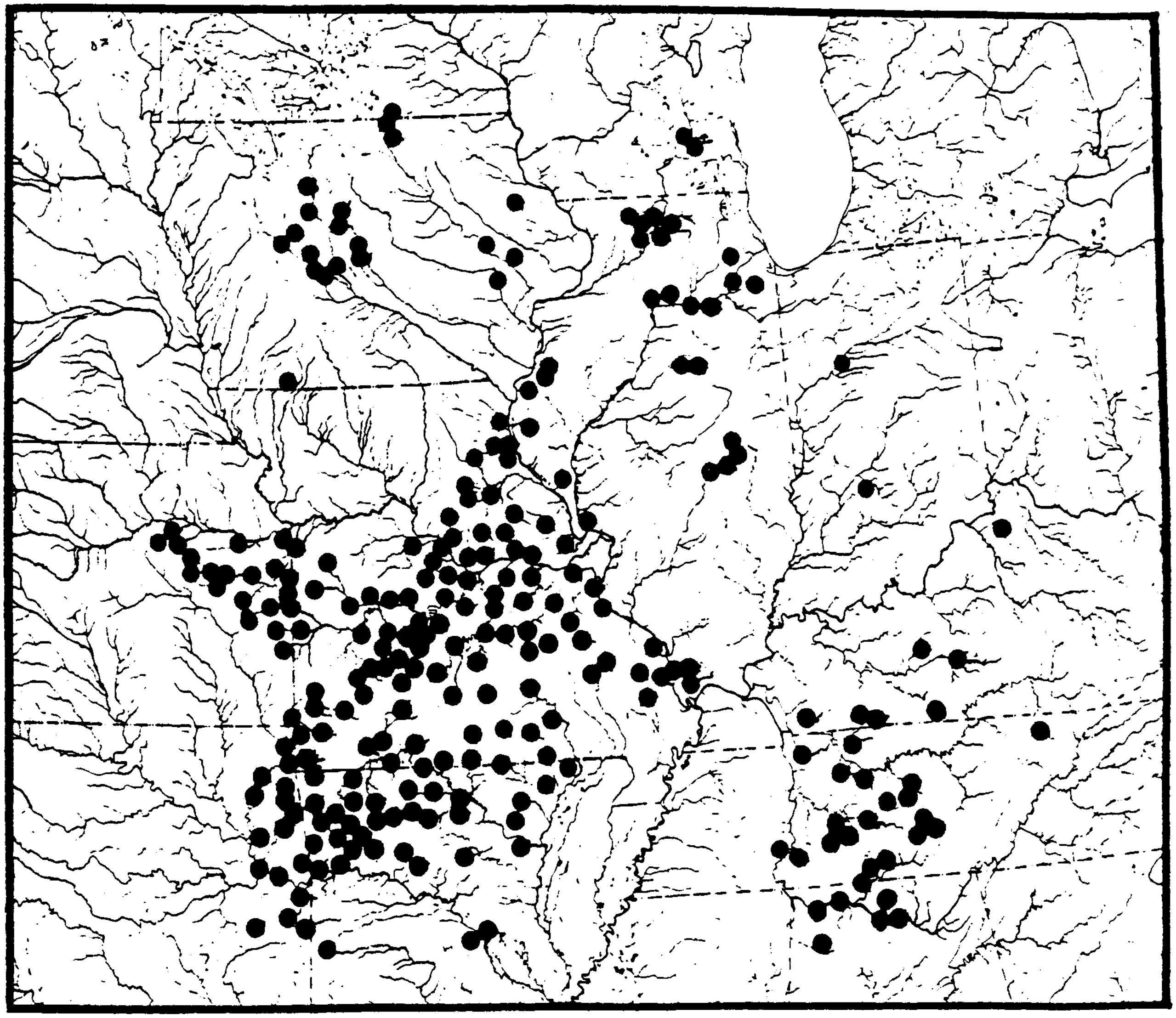

Figure 1. Distribution of the slender madtom, *Noturus exilis* in North America (from Rohde 1980).

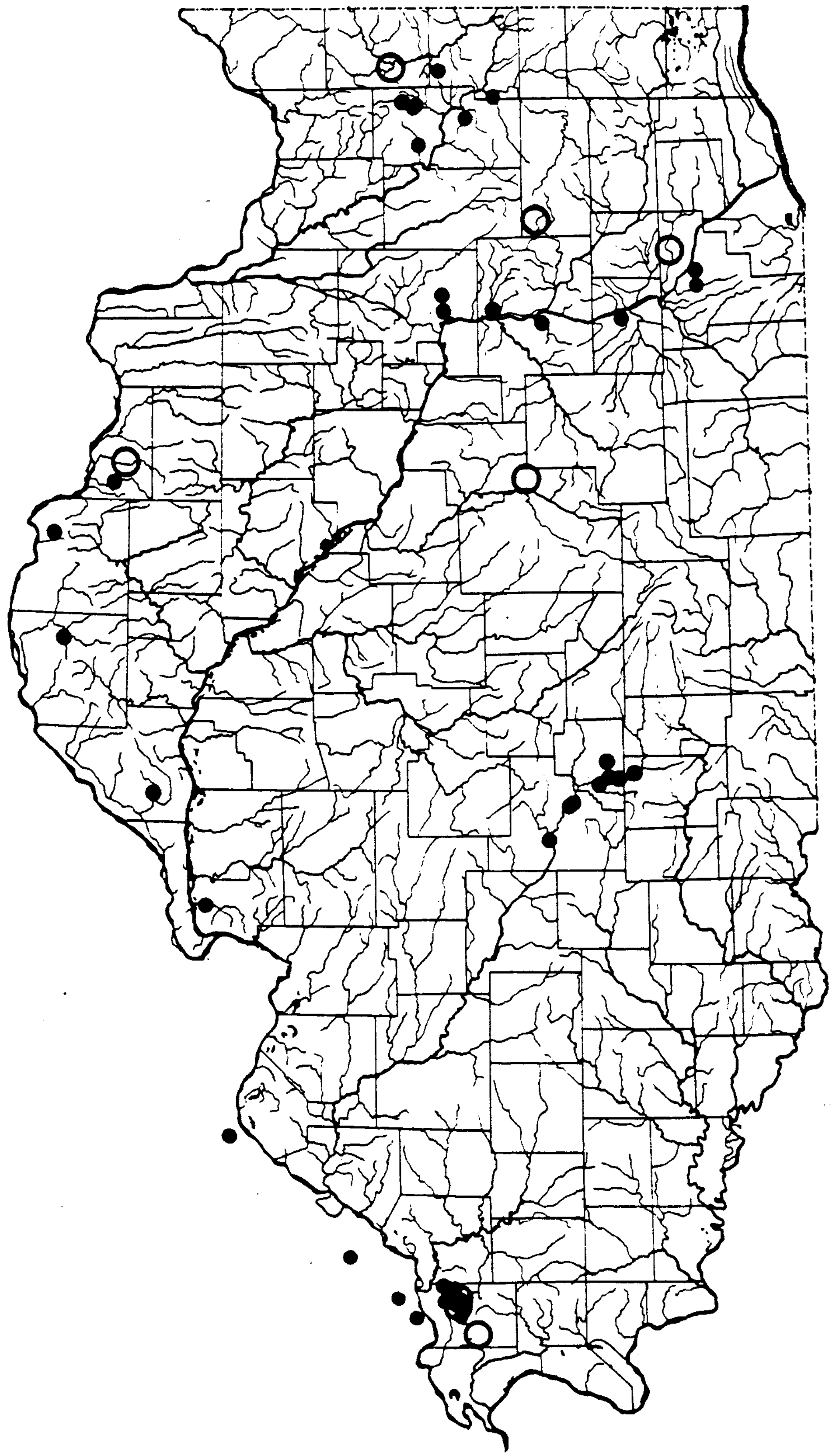

Figure 2. Distribution of the slender madtom, *Noturus exilis* in Illinois (from Smith 1979).

BIOLOGICAL ASSESSMENT

NORTHERN LEOPARD FROG, *Rana pipiens*

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15 November 1996

1.0 Taxonomy

1.1 Scientific name: *Rana pipiens*

1.2 Common name: Northern Leopard Frog

1.3 Comment: Only in the 1970s was the northern leopard frog recognized as a species distinct from the plains (*R. blairi*), southern (*R. sphenocephala*), and Rio Grande (*R. berlandieri*) leopard frogs, among others (Moore 1944; Littlejohn & Oldham 1968; Brown 1973; Mecham et al. 1973; Moore 1975). Therefore, much of the early literature on *Rana pipiens* may actually refer to one or a combination of these or other forms. See Brown (1975) for a review of this controversy.

2.0 Identification

2.1 General description: A medium-sized, somewhat slender frog 50 to 90 mm in snout-to-vent length. The dorsum is green to brown with two to three rows of dark brown or black spots. The sides are green to brown with irregularly scattered dark spots. The legs are green to brown above with small dark spots on the front legs and dark bars on the hind legs. The ventral surfaces are white. Then skin is smooth except for two prominent dorso-lateral ridges; the snout is blunt. The male is smaller than the female, has enlarged thumbs, and stouter forelegs (Smith 1961). Juveniles have longer, narrower heads than adults and weaker bars on the hind legs (Smith 1961). Geographic variation in external characters of adults was documented by Smith (1961).

2.2 Diagnostic characters: Dark dorsal spots are usually edged with pale yellow or cream; there is usually a spot above each eye and one between the nares; the tympanum is coppery and without a distinct light center; paired vocal sacs are not visible in resting males.

3.0 Legal status

3.1 National status: Not listed at the federal level.

3.2 State(s) status: Not listed in Illinois but protected as a game species (fishing license required). Listed as "rare" in Missouri, "special concern" in Indiana, "Category A-Priority Species" in Idaho, and a candidate for listing in Arizona.

4.0 Migrating status

The northern leopard frog does not undergo long-distance migrations. Shorter seasonal migrations take place from the breeding pond to the surrounding grasslands in summer and then to overwintering sites in the fall.

5.0 Range map

Total and state distributions are shown on accompanying maps.

6.0 Habitat requirements

6.1 Breeding: Breeding occurs in marshes, lakes, ponds, sloughs, and quiet backwaters of streams with emergent and/or submergent vegetation. After breeding, adult leopard frogs spend a considerable amount of time foraging in grassy meadows and hay fields, especially in summer.

6.2 Winter: In the fall, they migrate to hibernation sites in permanent bodies of water, usually within 1.5 km of a breeding site. Hibernation takes place under the water.

7.0 Food and diet: The northern leopard frog is an opportunistic feeder and will eat a wide variety of invertebrates. Importance of food items varies by season and specific locality. Terrestrial isopods, spiders, beetles, and orthopterans are the most important food items for adults, especially in summer (Drake 1914; Moore & Strickland 1954; Linzey 1967). Juveniles feed on virtually the same prey items as adults (Whitaker 1961). Tadpoles scrape algae and soft plant material.

8.0 Breeding ecology

8.1 Reproduction phenology: In Illinois, this species usually breeds from March to May. The male call, a low snore punctuated by grunts and squeaks (Conant & Collins 1991), attracts females to breeding males. Competition for females can be fierce and one female may occasionally be amplexed by several males simultaneously. Breeding occurs at a water temperature of at least 10 degrees C (Hine et al. 1981).

8.2 Territory: Leopard frogs are not known to be territorial but individuals have very specific home ranges (68 to 503 square meters in one Indiana study, Dole 1965). Individual adults and juveniles frequently use the same nocturnal hiding places several days to weeks at a time. Displacement experiments have demonstrated that individual leopard frogs are capable of finding their home without the use of hearing or smell (Dole 1972).

8.4 Eggs: Eggs are laid in flattened, submerged spheres, three to six inches across andusually attached to vegetation (Smith 1961). The individual eggs are black and measure 1.0 to 1.8 mm in diameter (Vogt 1981). A single female may lay 6,000 eggs in a season (Vogt 1981).

8.5 Young: Tadpoles hatch in 5 to 20 days and transform in 70 to 100 days (June to August, (Smith, 1961; Vogt 1981). Leopard frogs normally reach sexual maturity in two years at about 60 mm snout-to-vent length (Merrell, 1968).

9.0 Population Ecology

9.1 Abundance: No estimates have been published. I have seen more than 300 adults along the shore of a 0.6 acre lake in Illinois in early fall. The frogs were presumably preparing to enter the pond for hibernation.

9.2 Trends: Declines have been reported in Michigan (Harding and Holman 1992), Wisconsin (Hine et al. 1981), Indiana, (Minton et al. 1983), and Colorado (Corn and Fogleman 1984).

10.0 Genetic issues: Hillis et al (1983) investigated the biochemical systematics of the entire *Rana pipiens* complex. No subspecies are recognized.

Two single-gene color mutants, the Burnsi and Kandiyohi morphs, exist in Minnesota and adjacent states. These were originally described as different species by Weed (1922) but Moore (1942) showed that they were simply color variants of *R. pipiens*.

11.0 Predation

Predators of adults include fish, bullfrogs, snakes, herons, mink, raccoon, and snapping turtles. Tadpoles are eaten by snakes, fish, and larval salamanders.

12.0 Diseases and parasites

Nothing has been published on this topic concerning *R. pipiens*.

15.0 Threats to species

High mortality has been observed during fall hibernation (Hine et al. 1981). Anoxia has been implicated in these die-offs.

16.0 Preserve design

16.3 Habitat structure: An "ideal" breeding site has been characterized as follows: 1) located within 1.6 km. of hibernaculum; 2) water depth is 1.5 m. or more; 3) emergent vegetation (sedges, cattails, arrowhead) on 2/3 circumference of site; submergent vegetation covers 50% of surface area; 4) there is a gradual slope of bottom; 5) the site receives sunlight most of the day; 6) meadows, marshes, unmowed pastures, or hayfields are surrounding habitat; and 7) standing water is present through transformation of tadpoles, but site dries up at least once per decade, eliminating fish.

17.0 Management and restoration efforts

17.2 Best management practices: Generally, practices which increase and stabilize permanent, quiet water with emergent or submergent vegetation will help this species.

17.3 Detrimental management practices: Detrimental practices include mowing right up to the edge of wetlands, stocking fish or bullfrogs, application of herbicides, pesticides and poisons such as rotenone. A Wisconsin study reported that Atrazene adversely affected larval growth and development (Hine et al. 1981).

18.0 Monitoring protocols

Male calling surveys and line transect counts of adults on shoreline (Heyer, et al. 1994).

19.0 Current research programs

No active research programs currently focus on *Rana pipiens* in Illinois. Dr. Lauren brown at Illinois State University has studied the *Rana pipiens* complex over the past 30 years.

20.0 Research needs

The primary research need in Illinois is a more thorough documentation of the distribution of the northern, southern, and plains leopard frogs in the State. The extent to which these three species overlap is not known (see Redmer, 1996 for one of the first attempts). Other needs include analysis of geographic distribution of genetic variation and investigation of possible declines in abundance, especially in the northern tier of Illinois counties.

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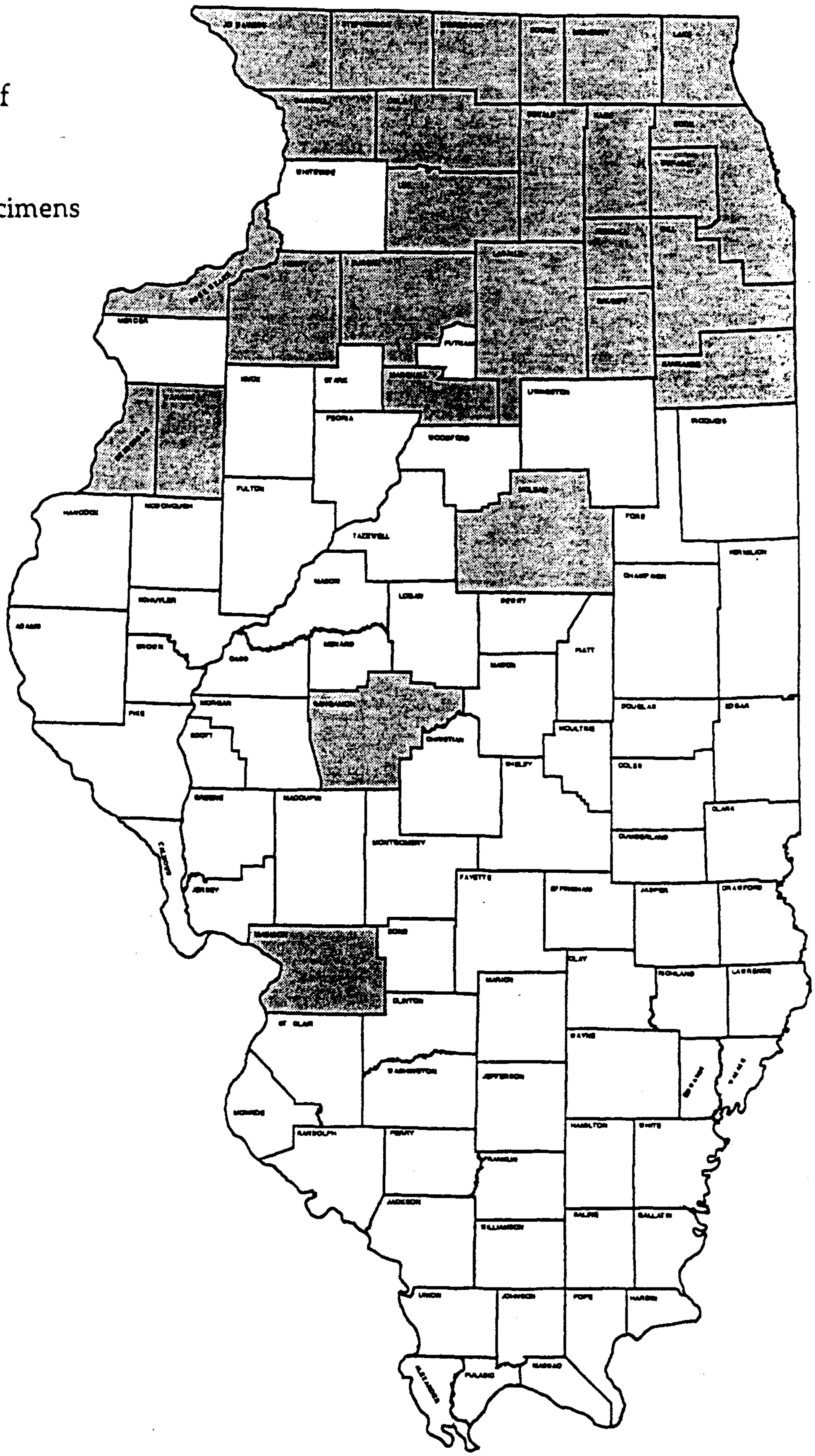
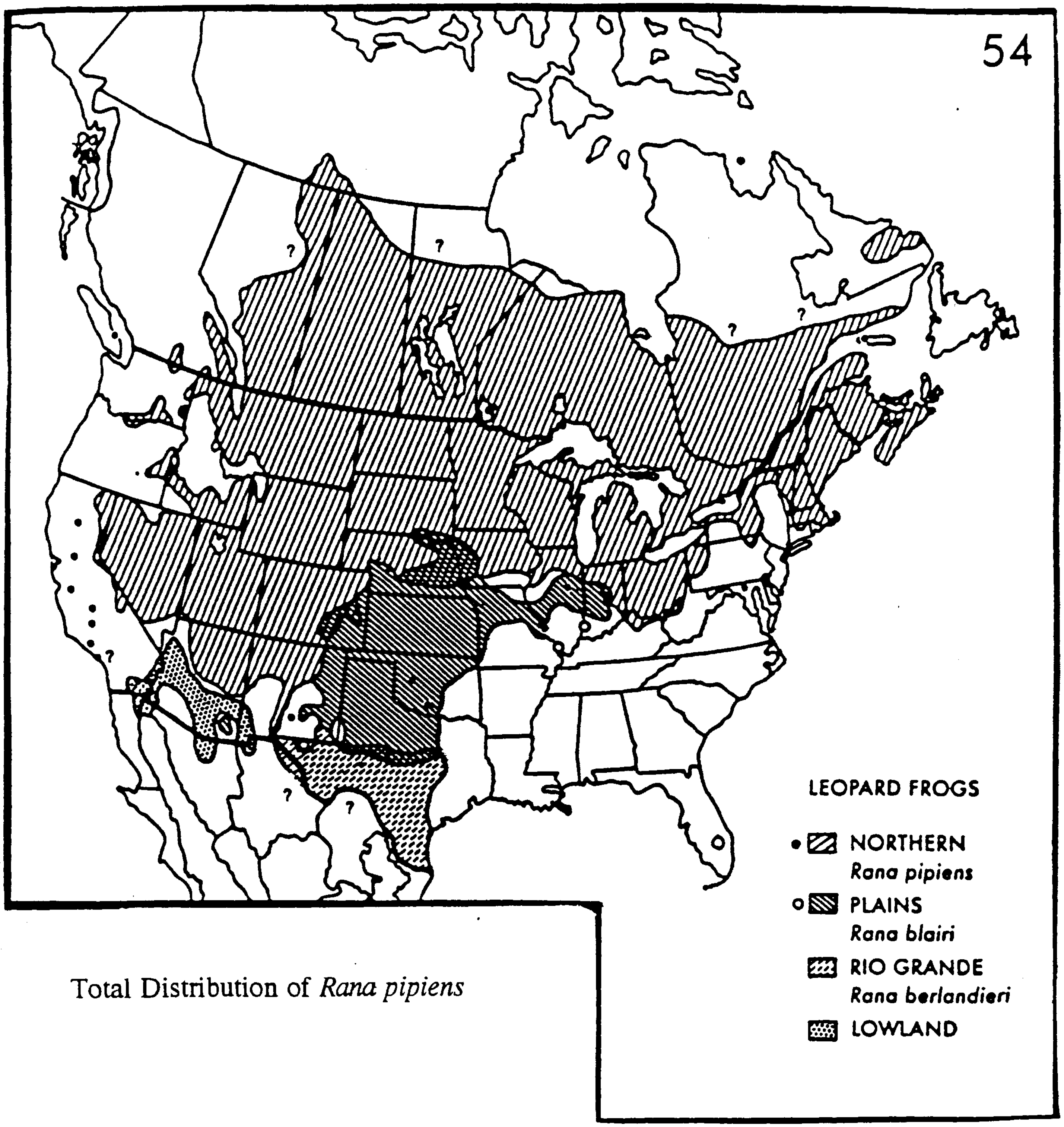
Illinois Distribution of

Rana pipiens

based on vouchered specimens



Map generated by
Illinois Natural History Survey
October, 1996



Total Distribution of *Rana pipiens*

BIOLOGICAL ASSESSMENT

CREEK HEELSPLITTER, *Lasmigona compressa* (Lea, 1829)

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15 November 1996

CREEK HEELSPLITTER, *Lasmigona compressa* (Lea, 1829)

1.0 Taxonomy.

1.1 Scientific name: *Lasmigona compressa* (Lea, 1829)

1.2 Common name: Creek heelsplitter

2.0 Identification.

2.1 General description: Description of the shell: Shell small to medium-sized, elongate, relatively thin, and compressed. Anterior end broadly rounded, posterior end bluntly pointed and squared at the tip. Posterior ridge prominent and broadly flattened with a small wing behind the umbo, usually more evident in small shells. Dorsal margin straight, ventral margin rounded, occasionally straight. Umbos projecting slightly above the hinge line. Beak sculpture of 5-8 double-looped ridges. Shell smooth and yellowish brown with numerous green rays in young individuals, becoming a darker green or brown in older shells. Length to 4 inches.

Pseudocardinal teeth well developed; two in the left valve, one in the right. Lateral teeth short, thin and finely serrated; two in the left valve, one in the right. Beak cavity very shallow. Nacre white to salmon-colored, especially near the beak cavities (Cummings & Mayer 1992).

Description of the animal: "Color of the animal whitish; mantle edged with black, especially near the siphonal openings; gills grayish-white; foot yellowish-brown; marsupium whitish in sterile, brownish or orange in gravid specimens.

Supra anal and anal openings separated by a amntle connection that is shorter than anal opening; branchial opening with papillae, anal opening with distinct crenulations on the inner edge; palpi small, subtriangular, united at the base for about half of their length; gills broad, the inner lamina of the inner gill connected to abdominal sac only at anterior end." (Baker 1928:264).

Description of glochidia: "Glochidium triangular-ovate, 0.275 mm in height, 0.344 mm in length, and 0.105 mm in single valve convexity. The valves are noticeably asymmetrical: the posterior margin is longer, the apicies are placed about 45% of the distance from anterior to posterior, and the area of maximum inflation is also slightly anterior of center. Surface of glochidium malleate and punctate except except for a narrow marginal band, about 20 um wide, which is sculptured with low collabral ridges. The malleation are about 6-10 um in diameter, polygonal, and distributed in irregular, subconcentric groups. The pits are about 2 to 3 um in diameter, located in the depressions, and generally distributed. The hinge is virtually straight and is about 0.243 mm long. The ligament is long and narrow, exposed externally along its whole length and internally within a narrow sinus, about 88 um long, which is nearly centrally located on the hinge.

The stylets are about 105 um long, 24 um wide at their bases, narrowly attenuate, with a narrow, rostrate apex, and supported on both sides for nearly their whole lengths by the mantle membrane. The microstylets are about 10 um long, 5 um wide at their bases, pyramidal, multifaceted, and arranged in single file on the distal ends of the stylet and 3 or 4 abreast on the proximal end. Slightly smaller (8 um x 4 um) microstylets project around the base of the stylets and continue as a dense band of micropoints (1-2 um long) along the outer edges of the shell. This area is brown in fresh specimens and contrasts with the yellowish color of the valves." (Clarke, 1985:44-45).

2.2 Diagnostic characteristics: A member of the Family Unionidae, subfamily Anodontinae. The subfamily is characterized by a more or less elongated, thin shell, pseudocardinal and lateral teeth absent or reduced, surface of the shell green, greenish-brown or black with or without fine green rays, beak sculpture usually double-looped occasionally concentric, sexual differences in the shell indistinct, found in ponds, lakes or the quiet water areas of streams.

The creek heelsplitter has a relatively thin elongate shell with well developed lateral teeth, prominent posterior ridge, double-looped beak sculpture. Similar to the fluted shell (*Lasmigona costata*) and the white heelsplitter (*Lasmigona complanata*).

3.0 Legal status.

3.1 National status: The creek heelsplitter has no federal protection as a threatened or endangered species. It is considered as "currently stable" by the freshwater mussel subcommittee of the endangered species committee of the American Fisheries Society (Williams, et al. 1993). In the Midwest, the creek heelsplitter is widespread but uncommon and is threatened in Iowa. (Cummings & Mayer 1992).

3.2 State status: This species was formerly listed as threatened in Illinois (IESPB 1989). Additional populations were found after its listing and it was removed from the list. This mussel should still be treated as a species of special concern in Illinois.

4.0 Migrating status.

Like other freshwater mussels, the creek heelsplitter does not migrate laterally. In *Elliptio complanata*, vertical migrations of up to 20 cm are known to occur in lakes (Amyot & Downing 1991).

5.0 Range map.

The state distribution and a generalized map of its distribution in the Midwest are shown on the accompanying maps.

6.0 Habitat requirements.

6.1 General habitat: Found in creeks and the headwaters of small to medium-sized rivers in fine gravel or sand. Rarely if ever found in large rivers. Typically found in fine sand or gravel, occasionally mud in pools or slow-flowing runs below riffles.

6.2 Breeding habitat: Data on mussel movement suggests that most mussels are sedentary, remaining in the same habitat throughout their life.

7.0 Food and diet.

No data are available on the diet of the creek heelsplitter and very little information exists for other mussel species. An examination of the stomachs and intestinal contents of various species in Lake Maxinkukee, Indiana showed no noticeable differences between the food of different mussels (Evermann & Clark 1920). There was a marked difference between the stomach contents of mussels found in streams compared to those found in lakes. Lake mussels were found to have a greater preponderance of organic matter present, whereas the stomach contents of river mussels was predominantly mud with a few diatoms and desmids intermixed. Fuller (1974) noted that the diet of mussels was "reasonably well understood" and consisted primarily of detritus and animal plankters. He also stated that the idea that mussels fed primarily upon diatoms was "a myth." Much remains to be learned about the dietary requirements of mussels, especially if we hope to raise them in captivity for conservation purposes.

8.0 Breeding ecology.

8.1 & 8.2 Reproductive behavior: In most mussel species the sexes are separate. Males release sperm into the water and enters the female via the incurrent siphon and fertilizes the eggs. The fertilized eggs develop into an intermediate larval stage termed a glochidium. The glochidia are stored in the female's gills which in addition to their use in respiration, also function as brood chambers. Freshwater mussels must pass through a parasitic phase to complete their life cycle. In the spring or summer, glochidia are expelled into the water and must come into contact with an appropriate host, usually a fish, to which they attach and form a cyst. The glochidia are either internal parasites on the gills or external parasites on the fins. Some species are host-specific, while others can use a wide variety of fishes as hosts. While encysted the larva changes form and, except for size, resembles an adult mussel. After metamorphosis, the young mussel breaks free from the cyst and drops to the substrate to begin an independent life. The period of attachment varies from about one to 25 weeks depending on the host, location of attachment, and temperature.

As a member of the subfamily Anodontinae, the creek heelsplitter is a long-term (bradytictic) brooder. Eggs are fertilized in the late summer or early fall and glochidia are released in the late spring or early summer the following year. Ortmann (1919) reported that *Lasmigona compressa* was hermaphroditic and that with very rare exceptions, all specimens are female. van der Schalie (1970) has reported this species as hermaphroditic.

Gravid specimens were found in Pennsylvania from August to October and again in May and June. The first records for glochidia was on September 7 and specimens were observed discharging on 23 May, and 2 and 7 June (Ortmann 1919). The creek heelsplitter was found gravid in the Kankakee River, Illinois on September 20th (Wilson & Clark 1912). Mature glochidia were found in individuals collected on 3 November in Wisconsin and 15 April in Michigan (Clarke 1985). The only known host reported for *Lasmigona compressa* is an exotic fish, *Lebistes reticulatus* (Tompa 1979). This transformation occured in a lab and *Lebistes* is obviously not a natural host for this mussel.

8.3 Eggs: Of the reproductive organs Ortmann (1912) says: "This species being normally hermaphroditic, the gills have always the female structure, that is to say, in the inner gill the septa are rather distant, and the water tubes are wider, and the outer gill is marsupial. When sterile, the septa are crowded, with marsupial epithelium, and the water tubes are narrow. When gravid this gill swells considerably, and at the edge the tissue distends, soas to render the edge rounded off or truncated. Within this gill, each water tube develops the characteristic lateral, or secondary, water tubes, while the middle portion forms the ovisac, which is also closed at the base of the gill. The eggs fill the ovisacs in densely crowded masses, and in certain places a placenta-like cohesion may be observed. But when the glochidia are mature they are perfectly free, and no indications of placentae are seen.

9.0 Population ecology

9.1 Abundance: No estimates of population size or abundance have been made for this species.

9.2 Trends: This species was formerly on the Illinois threatened list (IESPB 1989) and appears to be on the decline in Illinois. The creek heelsplitter was historically found in the northern half of Illinois, particularly in the northeastern part of the state. However, many streams in the northeasten negatively effected by urban development and agricultural impacts and many populations have been extirpated. Post-1970 records of live creek heelsplitters are fairly widespread but uncommon and include tributaries of the Rock, Spoon, Mackinaw, Vermilion (Illinois), Fox, Sangamon, Kankakee, Des Plaines, and Vermilion (Wabash) drainages. However, 24 of the 29 records are collections of single individuals; and only Piscasaw Creek (Rock River drainge) has more than two live individuals reported from a site.

10.0 Genetics.

No allozymic or other genetic data are available and the phylogenetic relationships of this species or genus to other lampsilines have not been investigated. Little variation in anatomy was found in a limited study of 11 specimens from two localities (one in Michigan and one in Wisconsin) of*Lasmigona compressa* by Clarke (1985).

11.0 Predation.

A few aquatic mammals, including raccoons, otter, mink, and muskrats, feed heavily upon freshwater mussels (Boepple and Coker 1912; Evermann & Clark 1918;

Parmalee 1967). Large piles of mussel shells can often be seen along the shoreline of streams where they have been deposited by raccoons or muskrats. These piles, termed middens, can be good places to find shells and can often provide an indication of species diversity at a particular site. Domestic animals such as hogs can root mussel beds to pieces (Meek & Clark 1912). Turtles and some birds will occasionally feed on mussels (Simpson 1899; Coker, et al. 1921; Snyder & Snyder 1969). Fishes, particularly catfish and freshwater drum (*Aplodinotus grunniens*), also consume large numbers of unionids.

12.0 Diseases and parasites.

Pauley (1968 a,b) described "spongy" disease of the foot in *Margaritifera falcata* where water lesions develop and reduce the epithelium to necrotic, squamous tissue or destroy it. Bacteria may attack glochidia while still in the marsupium (Ellis 1929). Freshwater mussels are afflicted with several members of several trematode families, most of which are diagenetic flukes. Some of these flukes are thought to be the organism whose irritating presence leads to the formation of pearls (Hopkins 1934). Some gasterostomes can affect mussels by damaging or destroying gonadal tissue (Kelly 1899; Wilson & Clark 1912; Lefevre & Curtis 1912).

The most common parasites of freshwater mussels are the non-marine mites of the family Unionicolidae, many of which are symbiotic with freshwater mussels. The symbiosis may be parasitic or commensalistic, depending on the species of mite and/or stage in its life cycle. A heavy mite infection may lead to shreading of portions of the gills, where many typically reside. Information on host relationships and natural histories of several mite species can be found in numerous papers by Vidrine (1974; 1980) and Mitchell (1954).

13.0 Area sensitivity.

The creek heelsplitter is most common in creeks and small rivers, and is rarely found in large rivers. The life cycle is completed in small streams. The species is not known to migrate.

15.0. Threats to species.

Smith (1971) ranked the causes of extirpation or declines in fish species in Illinois as follows: siltation, drainage of bottomland lakes, swamps, and prairie marshes, desiccation during drought, species introductions, pollution, impoundments, and increased water temperatures. All of these factors render habitats unsuitable, cause extirpations, and lead to the isolation of populations thereby increasing their vulnerability to extirpation for many aquatic species (including mussels) throughout the Midwest. Although currently confined to the large navigable rivers in Illinois, the zebra mussel (*Dreissena polymorpha*) has the potential to severely threaten the creek heelsplitter and other mussel species if it makes its way into the smaller streams of Illinois.

16.0 Preserve design.

Preserves, areas where biotic communities are more or less intact and are managed to protect their natural characteristics, are mostly dedicated around terrestrial communities. In the Midwest biological reserves tend to be small and rarely, if ever, protect an entire watershed. A new concept being developed in Illinois is the recognition and management of resource rich areas, large areas that contain the best remaining biological resources. Although use of the land for recreation, agriculture, and other consumptive activities will continue, management will strive to reverse whatever forms of degradation that have effected the area.

Management strategies for aquatic ecosystems must consider the entire watershed. Attempting to correct problems locally without consideration of upstream activities and downstream implications will result in partial and temporary improvement at best.

17.0 Management and restoration efforts.

Much information is now available on stream hydrodynamics, habitat preferences of aquatic species, and which habitats or stream reaches support the highest species diversity in a given region. Given the opportunity, streams will restore themselves. The best approach to restoration may be to encourage restoration of the native vegetation of the drainage basin, the riparian zone in particular, correct any additional existing pollution problems, and let the stream return to natural conditions. Over time, even channelized ditches will begin to meander and develop the riffle and pool habitats that are necessary for restoration of normal stream biodiversity.

Correction of some factors that have led to species loss and stream habitat fragmentation in past decades is relatively easy. Important initiatives that society has taken include building sewage treatment plants and avoiding the construction of mainstream impoundments. Other initiatives, such as stopping the removal of riparian vegetation, stream channelization, and dredging, and the drainage of bottomland lakes, require more public education and governmental action (including initiatives to landowners). Assuming that pollution will be held at current levels or reduced, nothing will be more beneficial to the biota of Midwestern streams than to have natural riparian vegetation restored. Siltation, desiccation, and higher than normal temperatures would all be reduced if streams were lined with native plants that shaded the stream, stabilized the banks, and filtered sediment and chemicals from runoff before they reached the stream.

The introduction of exotic mollusks have had significant effects on native unionid populations, particularly in the Great Lakes and large navigable streams of the Midwest. The zebra mussel (*Dreissena polymorpha*) has all but eliminated mussel populations in Lakes Erie and St. Clair (Mackie 1993; Nalepa 1994; Nalepa, et al. 1996) and have had significant negative impacts on mussels in the Illinois, Mississippi, and Ohio rivers (Tucker, et al. 1993; Tucker 1994).

For the creek heelsplitter, stream order and substrate composition appears to be the most distributionally restrictive habitat characteristics; however, it is difficult to distinguish among substrate composition, water velocity, and water depth because in streams all three usually vary concomitantly. The vast majority of mussels inhabit running water and the transformation of a flowing stream into an impoundment soon eliminates or renders functionally sterile all or almost all populations of mussels originally present in the stream.

18.0 Monitoring protocols.

Periodic monitoring using the modified sampling methodology of Miller and Payne (1988) would be beneficial to understanding the population characteristics of this species in small streams.

19.0 Current research programs.

No ecological or life history studies on the creek heelsplitter are currently known to be in progress.

20.0 Research needs.

In order to effectively manage mussel species it is necessary to work out certain life history characteristics first. Because of their unusual life-cycle and dependence on fish for completion of that cycle, it is imperative that the host species for the creek heelsplitter be ascertained. Lfe history information for the creek heelsplitter has been limited to brief notes or sentances describing habitat or period of gravidity. Additional work needs to be done to identify age and size at sexual maturity, recruitment success, age class structure, and other important life history parameters.

Research is needed to assess the success of watershed protection on mussel populations. Abundance and distribution of selected species needs to be monitored in order to ascertain how species abundance's change over time. From that we can assess what land-use changes, conservation practices, and physical/chemical parameters are correlated with, and possibly responsible for, the biological changes.

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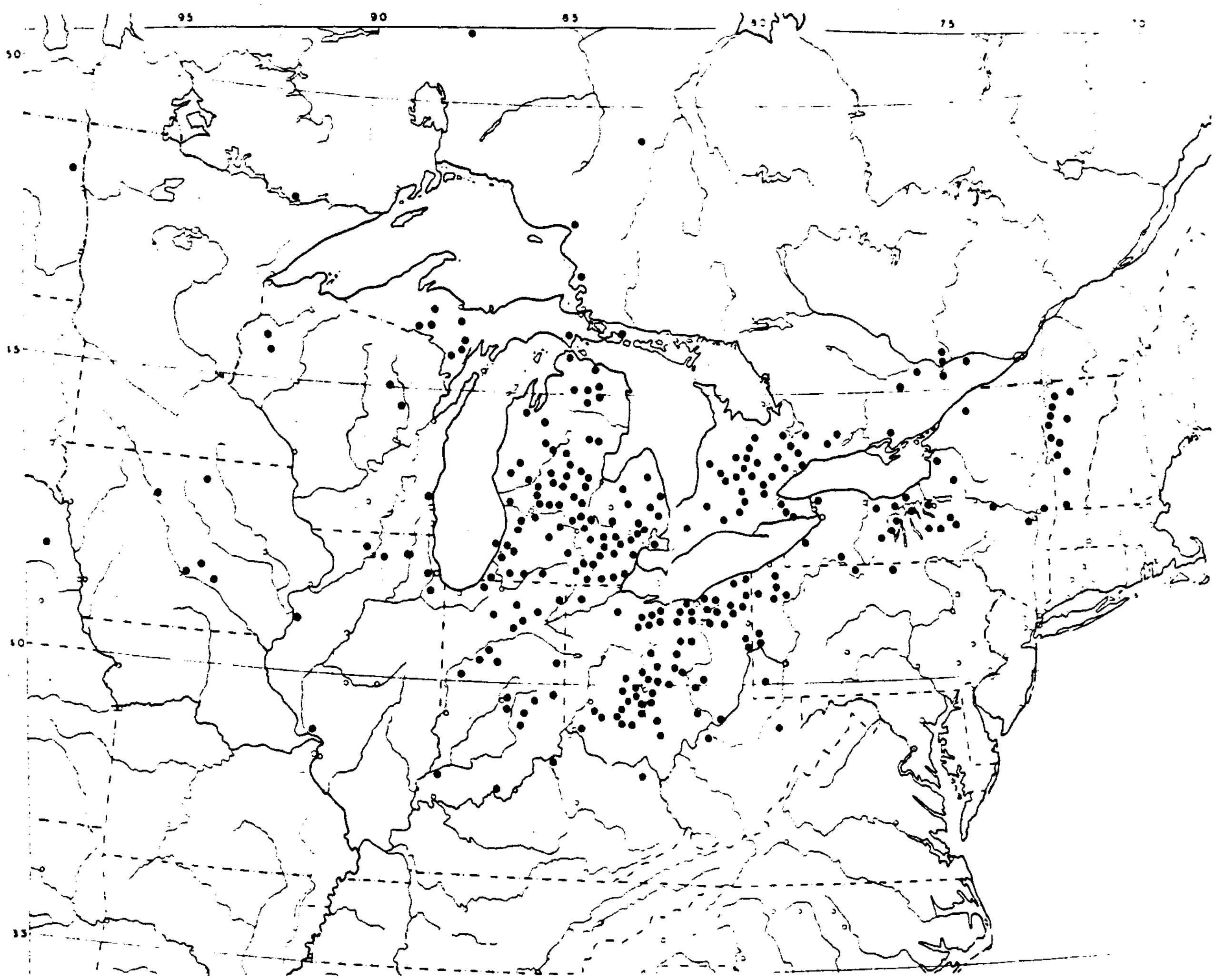

Figure 1. Distribution of the creek heelsplitter, *Lasmigona compressa* (Lea, 1829) in North America (from Clarke, 1985).

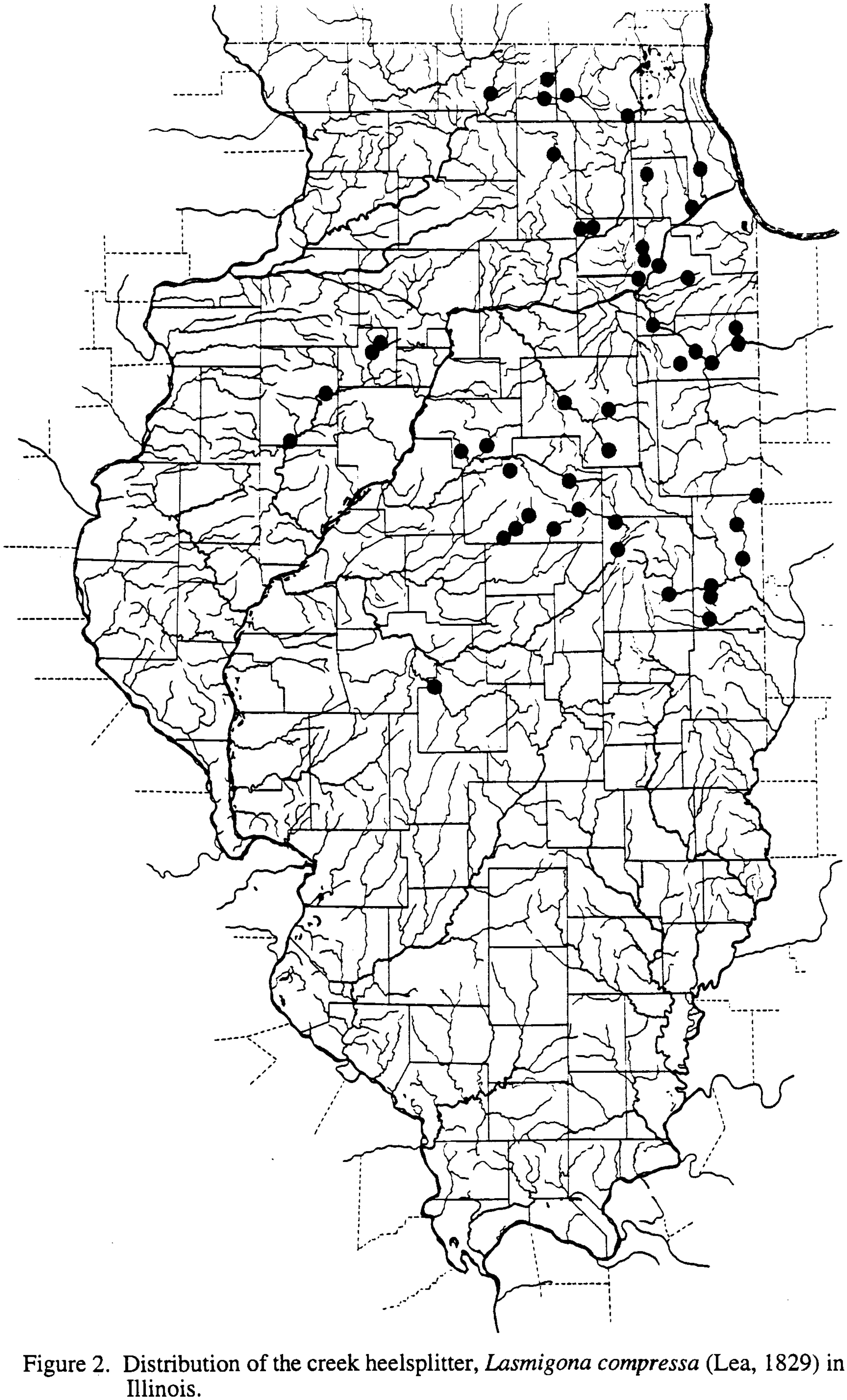

Figure 2. Distribution of the creek heelsplitter, *Lasmigona compressa* (Lea, 1829) in Illinois.

BIOLOGICAL ASSESSMENT

ELLIPSE, *Venustaconcha ellipsiformis* (Conrad, 1836)

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15 November 1996

ELLIPSE, *Venustaconcha ellipsiformis* (Conrad, 1836)

1.0 Taxonomy.

1.1 Scientific name: *Venustaconcha ellipsiformis* (Conrad, 1836)
1.2 Common name: Ellipse

2.0 Identification.

2.1 General description: Description of the shell: Shell small, solid, elliptical, and compressed. Anterior end rounded, posterior end bluntly pointed. Ventral margin straight to slightly curved. Umbos only slightly elevated above the hinge line. Beak sculpture of 3-4 very fine double-looped ridges. Shell usually smooth with a few wrinkles or folds on the posterior half in older shells. Periostracum green or greenish yellow with numerous dark green rays, becoming wavy on the posterior half of the shell. Length to 3 inches.

Pseudocardinal teeth triangular, heavy, roughened, and divergent; two in the left valve, one in the right (occasionally with a thin ridge-like tooth in front). Lateral teeth, relatively short, thick, and straight to slightly curved. Beak cavity shallow. Nacre white, iridescent posteriorly (Cummings & Mayer 1992).

Description of the animal: "Anal and supra-anal openings separated by small mantle connection; branchial opening with many yellowish papillae; anal opening with fine crenulations; supra-anal opening small; inner lamellae of inner gills entirely connected with visceral sac. Marsupium occupying posterior half of outer gills, consisting of about 20 ovisacs; when gravid extending to below edge of sterile gill; mantle edge anterior to branchial opening with papillae which extend to about the center of the mantle margin, terminating in fine crenulations; conglutinates not described." (Baker 1928:264).

2.2 Diagnostic characteristics: A member of the Family Unionidae, subfamily Lampsilinae. The subfamily is characterized by a moderately thick to relatively thin shell, rounded or oval to elongate in shape, most with the surface of the shell light yellow or tan with brightly colored rays or bands, beak sculpture generally double-looped but often indistinct, sexual differences in the shell apparent, pseudocardinal and lateral teeth usually well developed.

The ellipse has small shell (usually about 2 inches), elongate-elliptical, compressed, relatively thick for its size, with short, heavy lateral teeth. Outer surface with numerous green rays which are wavy on the posterio-ventral portion of the shell. Similar to the rayed bean (*Villosa fabalis*), rainbow (*Villosa iris*), fat mucket (*Lampsilis siliquoidea*), mucket, (*Actinonaias ligamentina*), and spike (*Elliptio dilatata*).

3.0 Legal status.

3.1 National status: The ellipse has no federal protection as a threatened or endangered species. However, it was listed as a species of special concern by the freshwater mussel subcommittee of the endangered species committee of the American Fisheries Society (Williams, et al. 1993). In the Midwest, the ellipse has been extirpated from Ohio, is threatened in Iowa and Wisconsin, and is a species of special concern in Indiana (Cummings & Mayer 1992).

3.2 State status: A species of special concern in Illinois.

4.0 Migrating status.

Like other freshwater mussels, the ellipse does not migrate laterally. Vertical migrations of up to 20 cm are known to occur in lakes (Amyot & Downing 1991).

5.0 Range map.

The state distribution and a generalized map of its distribution in the Midwest are shown on the accompanying maps.

6.0 Habitat requirements.

6.1 General habitat: Found in clear, small to medium-sized streams in gravel or mixed sand and gravel, in riffles or runs with a swift to moderate current. Rarely found in mud. Very rare in large rivers.

6.2 Breeding habitat: Data on mussel movement suggests that most mussels are sedentary, remaining in the same habitat throughout their life.

7.0 Food and diet.

No data are available on the diet of the ellipse and very little information exists for other mussel species. An examination of the stomachs and intestinal contents of various species in Lake Maxinkukee, Indiana showed no noticeable differences between the food of different mussels (Evermann & Clark 1920). There was a marked difference between the stomach contents of mussels found in streams compared to those found in lakes. Lake mussels were found to have a greater preponderance of organic matter present, whereas the stomach contents of river mussels was predominantly mud with a few diatoms and desmids intermixed. Fuller (1974) noted that the diet of mussels was "reasonably well understood" and consisted primarily of detritus and animal plankters. He also stated that the idea that mussels fed primarily upon diatoms was "a myth." Much remains to be learned about the dietary requirements of mussels, especially if we hope to raise them in captivity for conservation purposes.

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As a member of the subfamily Lampsilinae, the ellipse is a long-term (bradytictic) brooder. Eggs are fertilized in the late summer or early fall and glochidia are released in the late spring or early summer the following year. The ellipse was reported gravid on August 27th at Forked Creek (Kankakee River Drainage) near Wilmington, Illinois (Wilson & Clark, 1912). As part of their life history study on the ellipse in Michigan, van der Schalie and van der Schalie (1963) seined 16 species of fish and examined them for glochidia. None were found infected with glochidia, and the natural host(s) for the ellipse remains unknown (Watters 1994).

In the Michigan study sexual maturity was usually not attained until the third year. The size at sexual maturity was not reported. The sex ratio of 238 individuals examined was 130 males to 108 females. Of all specimens examined only one hermaphrodite was found (van der Schalie & van der Schalie 1963).

8.3 Eggs: The number of eggs and ovisacs appears to be a function of the age and size of the female. In the Michigan study, the number of ovisacs in one gill ranged from an average of nine in an individual 32 mm in length to 25 in a 55 mm female. The gonads of females examined in April were found to contain many eggs in the early stage of development. In June eggs began to show an encasing vitelline membrane and by July most of the eggs (still unfertilized) moved to the gills where they were fertilized and carried until the following spring or early summer. The average dimensions of seven glochidia measured with an occular micrometer was 0.237 x 0.285 mm (van der Schalie & van der Schalie 1963).

9.0 Population ecology

9.1 Abundance: No estimates of population size or abundance have been made for this species. In the Michigan life-history study, specimens were aged using visual inspection of annuli and reported to live to a maximum age of 12 years (van der Schalie & van der Schalie 1963).

9.2 Trends: This species appears to be on the decline in Illinois. The ellipse was historically found in the northern third of Illinois, particularly in the northeast. However, many streams in that part of Illinois have been negatively effected by urban development and agricultural impacts and many populations have been extirpated. The ellipse is now relatively uncommon in Illinois. A few apparently healthy populations can still be found in tributaries to the Kankakee, Fox, Mackinaw, and Vermilion (Illinois River drainage) rivers.

10.0 Genetics.

The ellipse was thought to exhibit considerable morphological variation thoughout its range and has been treated as three separate species (Ortmann 1918) or as one species with two subspecies (Oesch 1984). Today, two species are recognized, the ellipse, *Venustaconcha ellipsiformis* (Conrad, 1836) in the upper Midwest and the bleadingtooth mussel, *Venustaconcha pleasii* (Marsh, 1891) of the Ozarks (Turgeon et al. 1988). No allozymic or other genetic data are available and the phylogenetic relationships of this species or genus to other lampsilines have not been investigated.

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Smith (1971) ranked the causes of extirpation or declines in fish species in Illinois as follows: siltation, drainage of bottomland lakes, swamps, and prairie marshes, desiccation during drought, species introductions, pollution, impoundments, and increased water temperatures. All of these factors render habitats unsuitable, cause extirpations, and lead to the isolation of populations thereby increasing their vulnerability to extirpation for many aquatic species (including mussels) throughout the Midwest. Although currently confined to the large navigable rivers in Illinois, the zebra mussel (*Dreissena polymorpha*) has the potential to severely threaten the ellipse and other mussel species if it makes its way into the smaller streams of Illinois.

16.0 Preserve design.

Preserves, areas where biotic communities are more or less intact and are managed to protect their natural characteristics, are mostly dedicated around terrestrial communities. In the Midwest biological reserves tend to be small and rarely, if ever, protect an entire watershed. A new concept being developed in Illinois is the recognition and management of resource rich areas, large areas that contain the best remaining biological resources. Although use of the land for recreation, agriculture, and other consumptive activities will continue, management will strive to reverse whatever forms of degradation that have effected the area.

Management strategies for aquatic ecosystems must consider the entire watershed. Attempting to correct problems locally without consideration of upstream activities and downstream implications will result in partial and temporary improvement at best.

17.0 Management and restoration efforts.

Much information is now available on stream hydrodynamics, habitat preferences of aquatic species, and which habitats or stream reaches support the highest species diversity in a given region. Given the opportunity, streams will restore themselves. The best approach to restoration may be to encourage restoration of the native vegetation of the drainage basin, the riparian zone in particular, correct any additional existing pollution problems, and let the stream return to natural conditions. Over time, even channelized ditches will begin to meander and develop the riffle and pool habitats that are necessary for restoration of normal stream biodiversity. In fact, a few of the channelized streams in the North Fork Vermilion River drainage in Vermilion County have come back and now support some of the most diverse mussel populations in that watershed.

Correction of some factors that have led to species loss and stream habitat fragmentation in past decades is relatively easy. Important initiatives that society has taken include building sewage treatment plants and avoiding the construction of mainstream impoundments. Other initiatives, such as stopping the removal of riparian vegetation, stream channelization, and dredging, and the drainage of bottomland lakes, require more public education and governmental action (including initiatives to landowners). Assuming that pollution will be held at current levels or reduced, nothing will be more beneficial to the biota of Midwestern streams than to have natural riparian vegetation restored. Siltation, desiccation, and higher than normal temperatures would all be reduced if streams were lined with native plants that shaded the stream, stabilized the banks, and filtered sediment and chemicals from runoff before they reached the stream.

The introduction of exotic mollusks have had significant effects on native unionid populations, particularly in the Great Lakes and large navigable streams of the Midwest. The zebra mussel (*Dreissena polymorpha*) has all but eliminated mussel populations in Lakes Erie and St. Clair (Mackie 1993; Nalepa 1994; Nalepa, et al. 1996) and have had significant negative impacts on mussels in the Illinois, Mississippi, and Ohio rivers (Tucker, et al. 1993; Tucker 1994).

For the ellipse, substrate composition appears to be the most distributionally restrictive habitat characteristic; however, it is difficult to distinguish among substrate composition, water velocity, and water depth because in streams all three usually vary concomitantly. The vast majority of mussels inhabit running water and the transformation of a flowing stream into an impoundment soon eliminates or renders functionally sterile all or almost all populations of mussels originally present in the stream.

18.0 Monitoring protocols.

Periodic monitoring using the modified sampling methodology of Miller and Payne (1988) would be beneficial to understanding the population characteristics of this species in small streams.

19.0 Current research programs.

No ecological or life history studies on the ellipse are currently known to be in progress.

20.0 Research needs.

In order to effectively manage mussel species it is necessary to work out certain life history characteristics first. Because of their unusual life-cycle and dependence on fish for completion of that cycle, it is imperative that the host species for the ellipse be ascertained. Although some life history information has been published for the ellipse in Michigan (van der Schalie & van der Schalie 1963), additional work needs to be done to identify age and size at sexual maturity, recruitment success, age class structure, and other important life history parameters.

Research is needed to assess the success of watershed protection on mussel populations. Abundance and distribution of selected species needs to be monitored in order to ascertain how species abundance's change over time. From that we can assess what land-use changes, conservation practices, and physical/chemical parameters are correlated with, and possibly responsible for, the biological changes.

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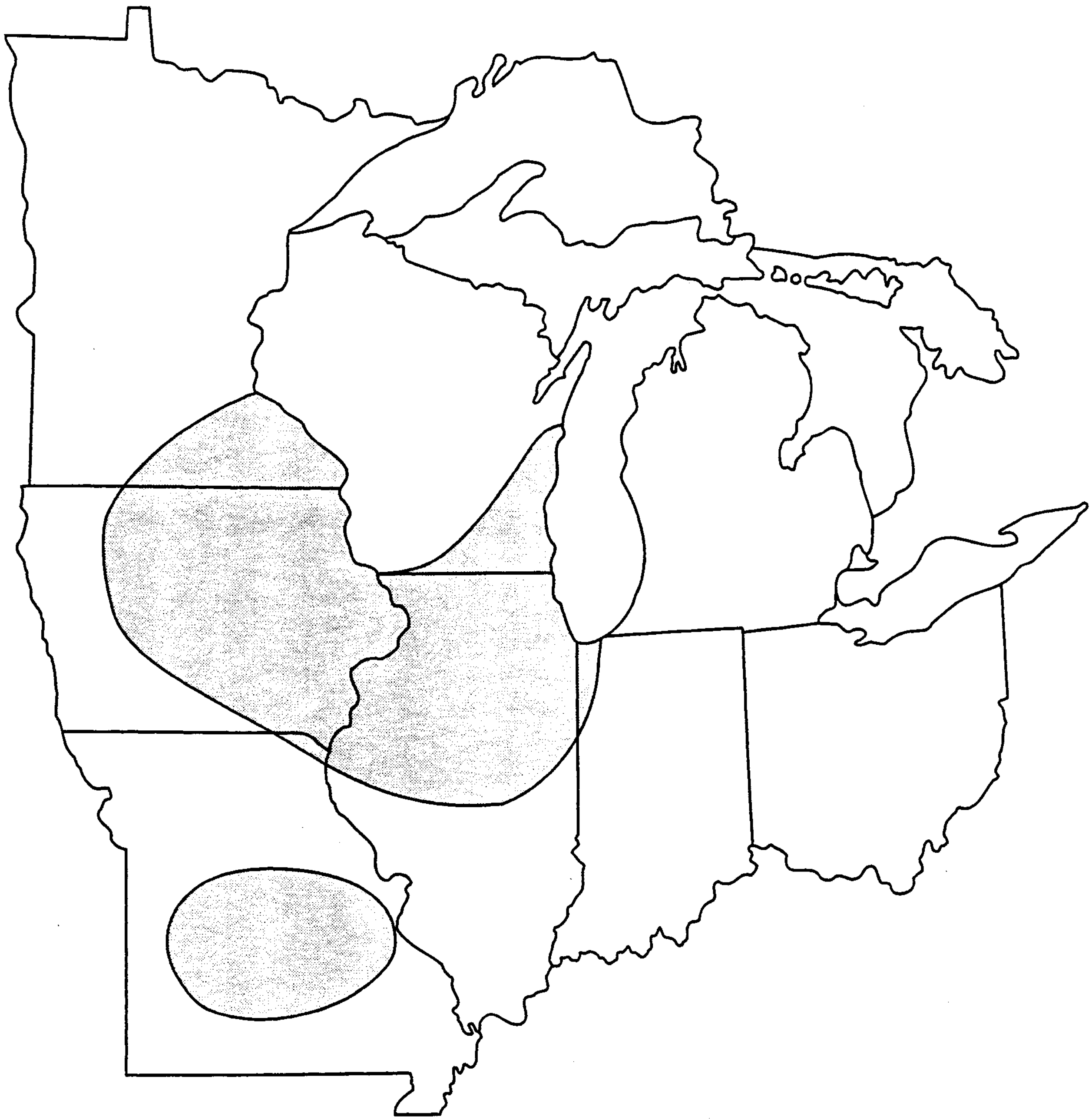

Figure 1. Distribution of the ellipse, *Venustaconcha ellipsifomis* (Conrad, 1836) in the Mississippi and Ohio river drainages (from Cummings & Mayer 1992).

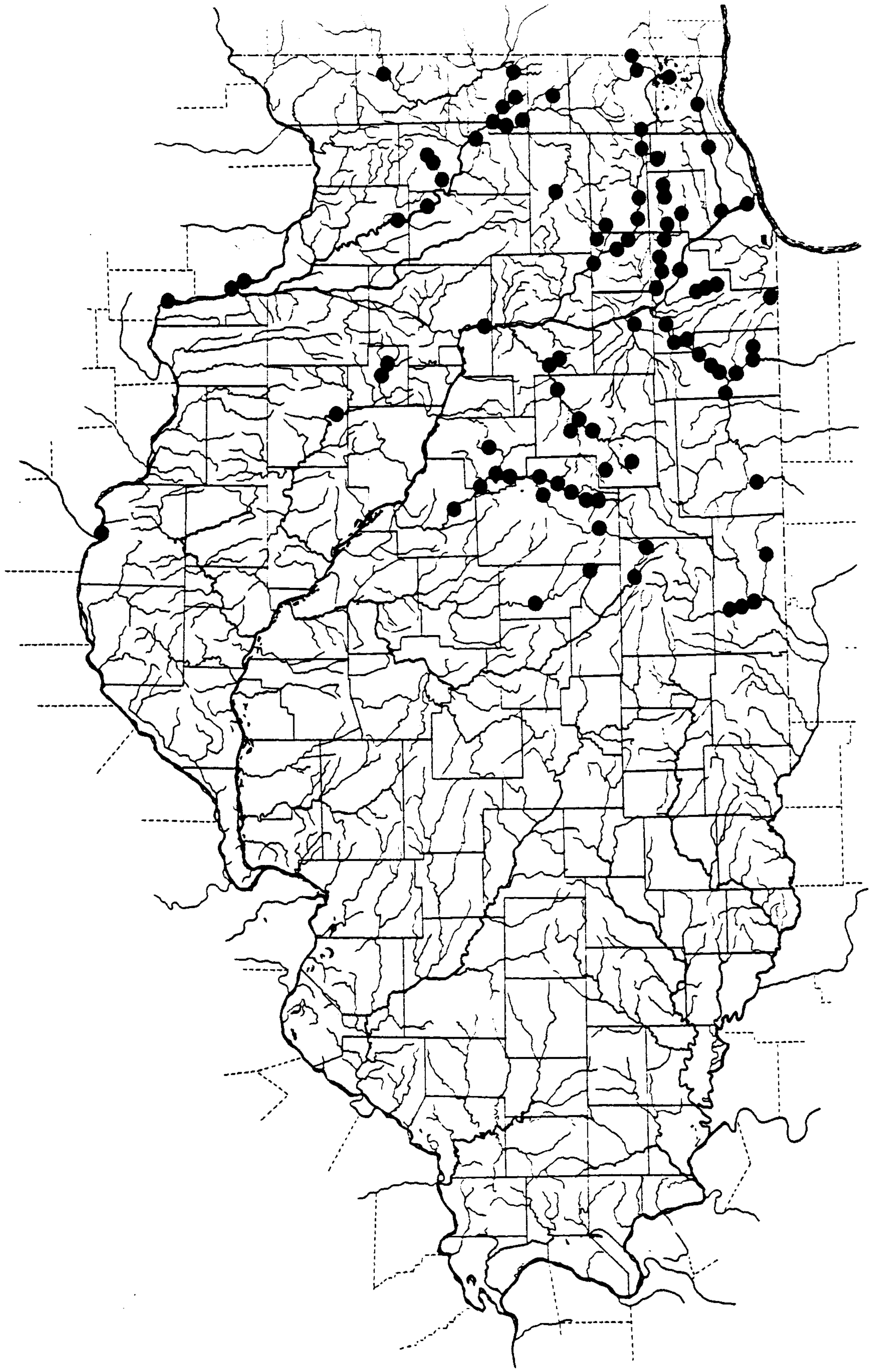

Figure 2. Distribution of the ellipse, *Venustaconcha ellipsifomis* (Conrad, 1836) in Illinois.