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Distribution of pleurocerids (Gastropoda) of Illinois

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ABSTRACT

Freshwater mollusks are among the most rapidly declining groups of organisms on Earth. Several species of aquatic gastropods, especially those in the family Pleuroceridae, are rare globally, but not much was known about their distribution and status in Illinois. We inspected museum collection holdings, conducted literature reviews on Illinois mollusks, and sampled throughout the state to obtain data on distribution and abundance of the pleurocerid fauna with an emphasis on declining species. Eleven species of pleurocerids are known from Illinois. We collected eight species live during our three-year study, including the first collection of *Lithasia geniculata* in the state. We failed to find three species, one of which (*Leptoxis trilineata*) is believed to be extinct. In addition to the currently listed *Lithasia obovata*, we feel *Leptoxis praerosa* and *L. geniculata* should be listed as endangered at the state because of their limited distribution and small population size.

INTRODUCTION

Aquatic gastropods are a vital component of stream ecosystems. Not only does their sensitivity to stream habitats allow them to be biological indicators of stream integrity (Brown et al. 2008), but they also occupy a central position in food webs by grazing on periphyton and providing a food source for predators (Stewart 2006). Sadly, they are one of the most imperiled groups of animals in North America (Neves et al. 1997). More than 60% of the 842 freshwater snail taxa are imperiled, critically imperiled, or presumed extinct (Lysne et al. 2008). The primary factors responsible for their decline are anthropogenic disturbances to stream habitats (e.g., habitat destruction and environmental contamination) and invasions of exotic species (Neves et al. 1997).

Pleurocerids (Gastropoda: Mesogastropoda: Pleuroceridae) is one family of freshwater snails that exemplifies a loss of diversity. Of the approximate 150 currently recognized species, at least 32 (20%) are extinct and five (3%) are federally–listed as endangered or threatened (Minton and Lydeard 2003). Illinois was thought to have had 11 species of pleurocerids (Cummings 1991), but nothing was known of their status, nor had a diagnostic key been created for this group in Illinois. Surveys are needed by natural resource agencies to determine the state and federal statuses of organisms and to make predictions regarding management decisions, and diagnostic keys are needed to aid in the identification of this fauna. Our objectives were to 1) determine the distribution of Illinois pleurocerids, and 2) create a key to the pleurocerids found in Illinois.

STUDY ORGANISMS

Pleurocerids are prosobranch (gill breathing) snails that are restricted to North America (Burch 1989). There are seven recognized genera of pleurocerids, three of which occur in Illinois (Burch 1989). Pleurocerids have solid, dextral (right facing) shells with the mantle openings facing anteriorly; their spiral opercula are usually not circular (Burch 1989). Their colors vary from pale yellow to dark brown to near black. Pleurocerids are dioecious (separate sexes) with females often being larger than males (Richardson and Scheiring 1994). Males lack verges (external sex organs) and females lay eggs by having an egg-laying sinus on the right side of the foot (Burch 1989). Their eyes are on outward sides of bases of tentacles (Burch 1989).

Substrate complexity has been shown to be an important factor in pleurocerid assemblages. Pleurocerids commonly inhabit well oxygenated, perennial streams, although some species are known to inhabit lakes (Dazo 1965; Houp, 1970; Johnson and Brown 1997; Greenwood and Thorp 2001). They are most often found in rocky areas in various depths, but also can be present near shore in the shallow areas on firm sand or even slightly silted areas. Some species prefer swift currents, whereas other favor slow moving waters. They can be the dominant grazers in stream ecosystems and constitute 90% of the total invertebrate biomass (Newbold et al. 1983; Richardson et al. 1988; Huryn et al. 1994). They are feeding generalists, capable of scraping organic material (e.g., periphyton and detritus) from various benthic substrates, and, in turn, are consumed by many organisms, including fishes (Dazo 1965; Greenwood and Thorp 2001; Krist 2002; Haag and Warren 2006). In addition, they can affect nutrient dynamics and energy flow, and can be an important substratum for algal attachment (Richardson et al. 1988; Richardson and Scheiring 1994). However, pleurocerids exhibit relatively low rates of secondary production, especially when compared with other mollusks (Dazo 1965; Richardson et al. 1988). Pleurocerids are iteroparous organisms that have life spans to about 10 years (Dazo 1965; Houp, 1970). Size/age classes and growth patterns can be difficult to distinguish because pleurocerids growth can be continuous throughout the year but become asymptotic after about 2 years (Dazo 1965; Huryn et al. 1994).

METHODS

To determine the distribution of pleurocerids in Illinois, we followed the format Cummings and Mayer (1997) and Tiemann et al. (2007) used for the distribution of freshwater mussels in Illinois. The state was divided into 25 subunits that correspond to the major rivers and drainages within and bordering Illinois (Table 1, Figure 1). Information is given on the distribution and status of pleurocerids (arranged alphabetically by genus and species) in each basin. Data were taken from three sources:

1) *Field surveys*: We qualitatively sampled snails at 308 sites throughout the state since 2007 (Figure 2). Live snails and shells of dead specimens by hand-picking; an effort was made to sample areas that appeared likely to support snails. Snail shells also were picked-up incidentally during surveys for fishes, freshwater mussels, or amphibians/reptiles.
2) *Museum records*: We inspected museum collection holdings known to house pleurocerids from Illinois and border waters (e.g., Mississippi River in Iowa and Missouri, Ohio River in Kentucky, and Wabash River in Indiana). Over 1,500 lots were examined. Museum collections examined include the Chicago Academy of Science (CA), Chicago; the Field Museum of Natural History (FMNH), Chicago; the Illinois Natural History Survey (INHS), Champaign; the Ohio State University Museum of Zoology (OSM), Columbus; the University of Illinois Museum of Natural History (UIMNH), Champaign; and the University of Michigan Museum of Zoology (UMMZ), Ann Arbor. Data from the Florida Museum of Natural History (UF), Gainesville, were downloaded but specimens were not examined.
3) *Peer-reviewed literature*: We also conducted a literature review of publications that contained data on Illinois pleurocerids (e.g., Baker 1906;

Goodrich 1939; Goodrich 1940; Burch 1989) or those from border waters (e.g., Baker 1928; Goodrich and van der Schalie 1944; Wu et al. 1997; Stewart 2006).

Species names and their authorities are based on Turgeon et al. (1998). Included with each species are 1) global rank and state / federal status, if applicable (data taken from NatureServe 2008); 2); plate(s) of specimens; and 3) a distribution map with remarks on the historic and current distributions within the state. Numbers following "Drainage" indicate the drainage where a species has been recorded (see Table 1 for a key to the drainages), and numbers in **bold** designate that the species is still extant in the corresponding drainage. Because very few alcohol-preserved Illinois pleurocerid specimens exist prior to 1985, a cutoff date of 1985, as opposed to 1970 for freshwater mussels in Cummings and Mayer (1997) and Tiemann et al. (2007), was chosen to compare the current status of pleurocerids in the state with historical records. Therefore, a species was considered extant in the state if it was collect in 1985 or later.

To create a diagnostic key for Illinois pleurocerids (Appendix 1), we modified pleurocerid keys that were available in the literature (e.g., Goodrich and van der Schalie 1944, Branson 1987; Burch 1989). Pleurocerids are often highly variable in shell morphology both among and within populations, which can make identification difficult. Variability in shell morphology can be attributed to several factors, including environmental conditions (e.g., physicochemical parameters) and predator-prey interactions. Goodrich (1945) reported that, because of stream discharge, *E. livescens* inhabiting the downstream portions of streams in the Lake Erie basins had higher obesity indices than *E. livescens* from upstream portions. Also, predator-prey interactions have been shown to change snail morphology. Krist (2002) suggested that predator-induced morphological changes are induced as a defense against predation. Taxonomy of pleurocerids historically has been based nearly solely on shell morphology. However, because of the environmental plasticity of the group, the present classification is problematic and needs revision. Researchers are currently using a combination of reproductive anatomy and molecular data to resolve some of the taxonomic issues.

RESULTS

Distribution of Illinois Pleurocerids

Field surveys, examination of museum collections, and literature reviews revealed that at least 13 species of pleurocerids have been historically reported from Illinois; however, we question the legitimacy of records for the species. Baker (1906) stated *Elimia catenaria* (as *Goniobasis spartenburgensis*) Lea, was found in the Wabash River (part of the Hinkley collection), and Kennicott (1855) reported *E. catenaria* (as *Melania carinata*) from Cook County. We doubt the validity of these records because *E. catenaria* occurs in the southeastern United States in Tennessee River basin (Burch 1989). Also, we question the taxonomic validity of *Elimia costerifera*. It has been suggested that *E. costifera* inhabits tributaries of the Ohio River (Baker 1906; Goodrich 1940; Burch 1989); however, the type locality of *E. costifera* is Hennepin, [Putnam County] Illinois. Discounting the above two species, we conclude that 11 species of pleurocerids now or have been found in Illinois (Table 2).

We collected eight species alive during our three-year study (Table 2). Our data suggests only 6 pleurocerid species, or 54.5%, currently have stable populations, which is comparable to the 34% reported for the state's freshwater mussels fauna (Cummings and Mayer 1997). Our work resulted in the first collection of *Lithasia geniculata* in the state (Tiemann and Cummings 2010). We failed to find three species, one of which (*Leptoxis trilineata*) is believed to be extinct (NatureServe 2008). We did not collect *Pleurocera alveare* or *Leptoxis praerosa* in the current study. The INHS Mollusk Collection has one lot containing one live *L. praerosa* collected from the Wabash River at the Rochester riffle (INHS 31551), but no live records of *P. alveare* are known. As a result, we feel *P. alveare* has been extirpated from the state and that *L. praerosa* should be listed as endangered at the state level because of its limited distribution and small population size. We also feel *L. geniculata* should be listed as endangered in Illinois based on the same reasoning. We formally nominated *Lithasia obovata* as endangered for inclusion on the state list by the Illinois Endangered Species Protection Board due to the species' shrinking distribution and rarity within the state; the species was recognized as such in 2010 (IESPB 2010).

Based on the fact that very few alcohol-preserved Illinois pleurocerid specimens are known prior to 1985, a cutoff date of 1985 was chosen to consider a species extant at a site opposed to the 1970 cutoff used for mussels (Cummings and Mayer 1997). In the following distribution maps, red triangles indicate that a species has been collected alive at that site since 1985, whereas a black dot means a historical record exists (data taken from the INHS Mollusk Collection).

Table 1. Extant and historic pleurocerid species counts known from Illinois by drainage. 'No.' is the drainage number in Figure 1. Species count data were taken from field surveys, museum collections, and literature reviews. Drainages are the same reported in Tiemann et al. (2007) and modified from Cummings and Mayer (1997).

No.	Drainage	Extant species	Historic species
1.	Galena River, Apple River, and Plum River	0	1
2.	Rock River	1	2
3.	Middle Mississippi River tributaries	0	0
4.	Des Plaines River and Lake Michigan tributaries	1	2
5.	Fox River and Aux Sable Creek	2	2
6.	Middle Illinois River tributaries	1	1
7.	Kankakee River-Iroquois River	2	2
8.	Vermilion River and Mazon River	2	2
9.	Spoon River	1	1
10.	LaMoine River	0	0
11.	Mackinaw River and Quiver Creek	1	2
12.	Sangamon River	2	2
13.	Lower Illinois River tributaries	0	0
14.	Kaskaskia River	0	1
15.	Big Muddy River	1	1
16.	Cache River	0	0
17.	Ohio River tributaries	2	2
18.	Saline River	1	4
19.	Little Wabash River and Bonpas Creek	3	4
20.	Embarras River and Wabash River tributaries	2	3
21.	Vermilion River and Little Vermilion River	2	2
22.	Illinois River	2	2
23.	Mississippi River	1	1
24.	Ohio River	5	7
25.	Wabash River	4	7

Table 2. Pleurocerid distribution by drainage in Illinois (see Table 1 and Figure 1 for drainage number information). 'D' = species historically present in that drainage with voucher specimens present, 'L' = species found alive in that drainage in 1985 of later, and 'X' = literature records exist for that species but voucher specimens could not be located. Column A shows the number of drainages that the species is historically known from and column B shows the number of drainages that the species has been found alive in 1985 of later (included in total are literature records).

Species / Drainage	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	A	B
Elimia livescens		D		L	L	L	L	L			L	L						D	L	L	L	L				11	13
Elimia semicarinata																	L									1	1
Leptoix praerosa																								D	L	2	1
Leptoxis trilineata																									X	1	0
Lithasia armigera																								L	L	2	2
Lithasia geniculata																								L		1	1
Lithasia obovata																		D	L	D				L	D	5	2
Lithasia verrucosa																								L	L	2	2
Pleurocera acuta	D	L		D	L		L	L	L		D	L		D	L						L	L	L			14	10
Pleurocera alveare																		X	D					D	D	4	0
Pleurocera canaliculata																	L	L	L	L				L	L	6	6

Elimia livescens (Menke, 1830) – Liver Elimia.

Global Rank: G5 – Secure. Common; widespread and abundant.

Federal Status: none.

State Status: CS – Currently Stable. A species whose distribution and abundance may be stable, or one that might have declined in portions of its range but is not in need of immediate conservation management actions.

Drainages: 2, **4**, **5**, **6**, **7**, **8**, **11**, **12**, 18, **19**, **20**, **21**, **22**.

Illinois Distribution: *Elimia livescens* is known from the Lake Michigan drainage, throughout the Illinois River basin, and the headwaters of the Wabash River basin, including the Vermilion and Embarras rivers (Calkins 1874a; Calkins 1874b; Calkins 1874c; Baker 1902; Baker 1906; Baker 1912; Zetek 1918; Baker 1922; Richardson 1925a; Richardson 1925b; Richardson 1928; Baker 1930; Goodrich 1940; Dexter 1956; Dexter 1961; Dazo 1965; Stewart 2006). Baker (1922) reported that *E. livescens* was abundant in the Vermilion River (Wabash) basin, and occurred throughout the Salt Fork Vermilion River. However, Dexter (1961) suggested that there had been a decrease in *E. livescens* abundance by the 1950s in the Vermilion River (Wabash) basin. Currently, this species is common in the Middle Fork and North Fork, but uncommon in the Salt Fork and mainstem of the Vermilion River (Wabash) basin. It is likely the reduction in *E. livescens* in the Salt Fork and mainstem is attributed to the pollution of the Salt Fork by sewage and manufacturing wastes reported by Baker (1922) prior to the passage of the Clean Water Act. Baker (1922) stated that chemical pollution draining into the Salt Fork has altered the assemblages of many aquatic groups, including mollusks.

Preferred habitat: *Elimia livescens* occurs in a variety of perennial, clear waters ranging from open lakes to swift-flowing streams (Dazo 1965; Burch 1989). It can be found crawling on rocks, buried in the sand, or occasionally in muddy substrates (Baker 1902; Zetek 1918; Dexter 1956; Dazo 1965). The species appears to be herbivorous because it prefers areas often densely covered with diatoms, algae, and waterweeds (Baker 1902; Zetek 1918; Dazo 1965).

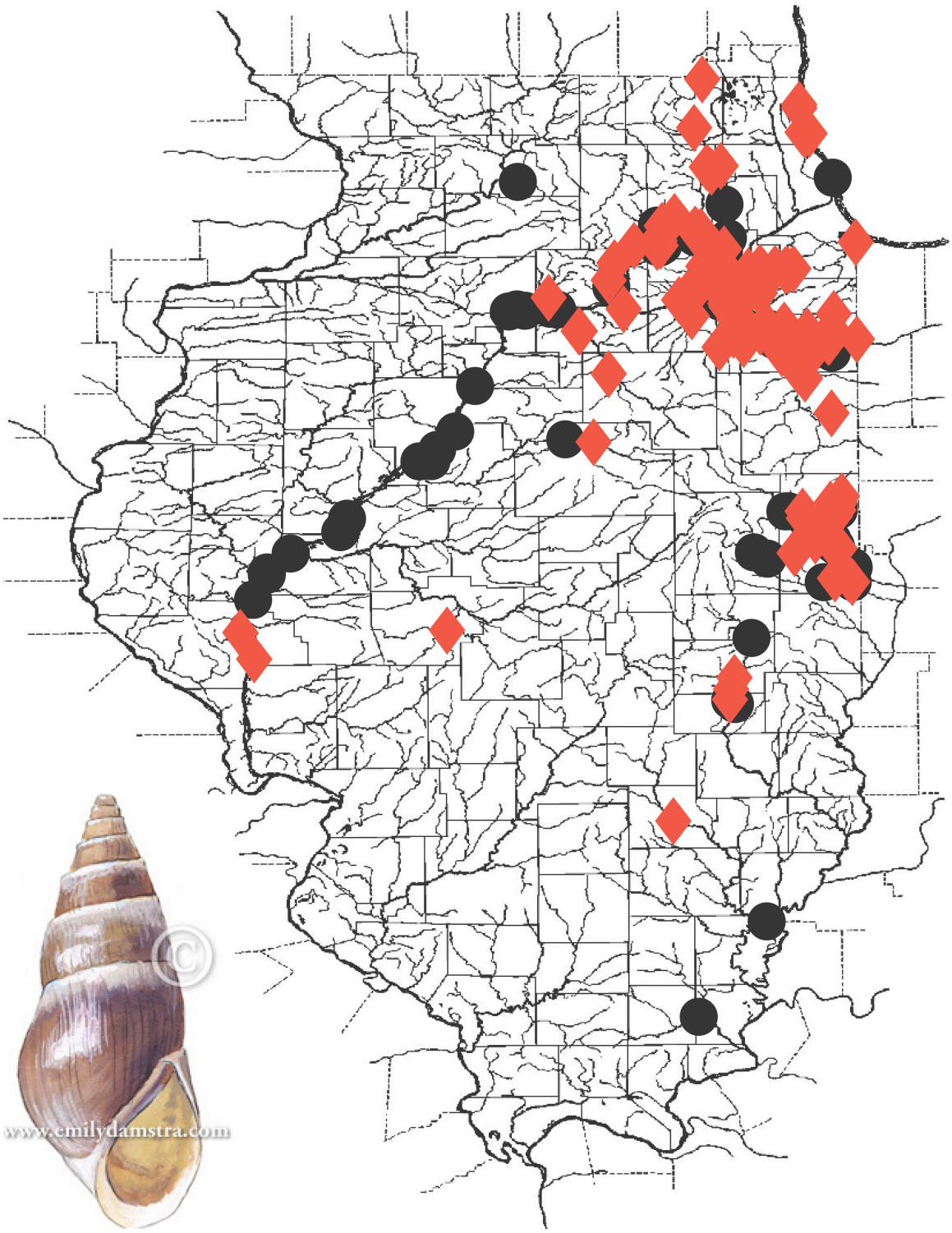

Figure 3. Distribution of *Elimia livescens* in Illinois.

Elimia semicarinata (Say, 1829) – Fine-ridged Elimia.

Global Rank: G5 – Secure. Common; widespread and abundant.

Federal Status: none.

State Status: CS – Currently Stable. A species whose distribution and abundance may be stable, or one that might have declined in portions of its range but is not in need of immediate conservation management actions.

Drainages: **17**.

Illinois Distribution: *Elimia semicarinata* is known from tributaries to the Ohio River (Baker 1906; Goodrich 1940; Burch 1989), including Bay, Lusk, Big Grand Pierre, Big, and Peters creeks. This distribution pattern also is seen in some Illinois fishes, including *Lampetra lamottei* (Lesueur) and *Etheostoma kennicotti* (Putnam) (Smith, 1979).

Baker (1906) and Zetek (1918) stated that *E. semicarinata* was known from the Illinois River basin, and Kennicott (1855) reported it from Cook County. However based on the locations given by the authors, we believe these reports are erroneous identifications, and attributable to either *E. livescens* or *Pleurocera acuta*. Also, Baker (1906) and Zetek (1918) noted that *E. semicarinata* was reported from the Vermilion River (Wabash) basin, but Baker (1922) stated these were erroneously identified *E. livescens*.

Preferred habitat: Johnson and Brown (1997) suggested that adult *E. semicarinata* prefer slow-flow habitats, whereas juveniles favor areas with swift current. We found *E. semicarinata* in clear streams with cherty gravel and little to moderate flow.

Figure 4. Distribution of *Elimia semicarinata* in Illinois.

Leptoxis praerosa (Say, 1821) – Onyx Rocksnail.

Global Rank: G5 – Secure. Common; widespread and abundant.

Federal Status: none.

State Status: SC – Special concern. A species for which there is substantial evidence to suggest listing at the state level. Recommendation: SE – State-endangered (a species that is in danger of extinction as a breeding species in Illinois).

Drainages: 24, **25**.

Illinois Distribution: *Leptoxis praerosa* is known from the lower Wabash (downstream of its confluence with the White River near Mt Carmel) and Ohio rivers (Baker 1906; Goodrich 1940; Goodrich and van der Schalie 1944; Burch 1989). In these large streams, *L. praerosa* can be found on algae-cover rocks in swift current (Goodrich and van der Schalie 1944). Although globally stable, this species is rare in Illinois with only one individual having been collected alive since 1985. We recommend it be listed as endangered on the state list of endangered and threatened species for Illinois.

Preferred habitat: *Leptoxis praerosa* can be found on algae-cover rocks in swift current in large streams (Goodrich and van der Schalie 1944).

Figure 5. Distribution of *Leptoxis praerosa* in Illinois.

Leptoxis trilineata (Say, 1829) – Broad Mudalia.

Global Rank: GX – presumed extinct. Not located despite intensive searches and virtually no likelihood of rediscovery

Federal Status: Extinct.

State Status: ET – Extirpated. No longer a breeding species in Illinois.

Drainages: 25.

Illinois Distribution: Although no voucher specimens could be found, Baker (1906) stated the species was known from the Wabash River. Neither Goodrich and van der Schalie (1944) nor Burch (1989) listed *L. trilineata* as occurring in Illinois; however, both papers reported that *L. trilineata* occurred in a portion of the Ohio River from Cincinnati, Ohio, to Louisville, Kentucky. Regardless, this species appears to be extinct. *Leptoxis trilineata* was known to feed on algae on rocks in swift current (Goodrich and van der Schalie 1944). Without a voucher specimen, the validity of *L. trilineata* in Illinois remains in question.

Preferred habitat: Not much has been reported for habitat preferences of *L. trilineata*, but we assume its habitat requirements are similar to *L. praerosa* (e.g., algae-cover rocks in swift current in large streams).

Lithasia armigera (Say, 1821) – Armored Rocksnail.

Global Rank: G3G4 – rank ranges from apparently secure to vulnerable. Uncommon but not rare; some cause for long-term concern due to declines or other factors. However, at moderate risk of extinction due to a restricted range, relatively few populations, recent and widespread declines, or other factors.

Federal Status: none.

State Status: CS – Currently Stable. A species whose distribution and abundance may be stable, or one that might have declined in portions of its range but is not in need of immediate conservation management actions.

Drainages: **24**, **25**.

Illinois Distribution: The lower Ohio River basin in Illinois is on the northwestern range for *L. armigera.* The snail is currently known from the lower Wabash (downstream of Mt. Carmel) and Ohio rivers (Baker 1906; Goodrich 1940; Goodrich and van der Schalie 1944; Burch 1989) and still can be found in these areas. *Lithasia armigera* is believed to be globally vulnerable, which means it is at moderate risk of extinction partially due to a restricted range and relatively few populations (Minton and Lydeard 2003). Although we cannot compare historical population size to current population size, the range of *L. armigera* appears to be unchanged based on historical and current data.

Preferred habitat: *Lithasia armigera* can be found on rocks and occasionally woody debris in large streams.

Figure 6. Distribution of *Lithasia armigera* in Illinois.

Lithasia geniculata (Haldeman, 1840) – Ornate Rocksnail.

Global Rank: G3 – Vulnerable. At moderate risk of extinction due to a restricted range, relatively few populations, recent and widespread declines, or other factors.

Federal Status: none.

State Status: SC – Special concern. A species for which there is substantial evidence to suggest listing at the state level. Recommendation: SE – State-endangered (a species that is in danger of extinction as a breeding species in Illinois).

Drainages: **24**

Illinois Distribution: Within Illinois, we collected *L. geniculata* at only one site (Ohio River near Mound City). The species was previously known from only the Cumberland and Tennessee rivers in Kentucky and Tennessee (Tiemann and Cummings 2010). We recommend it be included as state-endangered on the state list of endangered and threatened species for Illinois.

Preferred habitat: Not much has been reported on the habitat preference of *L. geniculata*. We found our specimens in a sandy gravel bar that was exposed due to a drop in water levels from the previous day.

Figure 7. Distribution of *Lithasia geniculata* in Illinois.

Lithasia obovata (Say, 1829) – Shawnee Rocksnail.

Global Rank: G4 – Apparently Secure. Uncommon but not rare; some cause for long-term concern due to declines or other factors.

Federal Status: none.

State Status: SE – State-endangered. A species that is in danger of extinction as a breeding species in Illinois.

Drainages: 18, **19**, 20, 24, **25**.

Illinois Distribution: Illinois is on the northwestern range for *L. obovata*. The snail is known from the lower Wabash (downstream of its confluence with the Embarras River, near Vincennes) and Ohio rivers, in addition to the lower portions in a few of their tributaries such as the Embarras, Little Wabash, and Saline rivers (Baker 1906; Goodrich 1940; Goodrich and van der Schalie 1944; Burch 1989). *Lithasia obovata* appears to be declining in Illinois, and it is becoming more rare, which prompted us to nominate it as state-endangered on the state list of endangered and threatened species for Illinois. It still can be found in the Little Wabash River and Ohio rivers.

Preferred habitat: *Lithasia obovata* can be found on rocks and occasionally woody debris in large streams. Greenwood and Thorp (2001) suggested that *L. obovata* utilizes these areas to maximize the nutritious, ephilithic microalgal foods while minimizing wave displacement and exposure to molluscivorous fishes. The species affinity to isolated, shallow habitats and its inability to reach deep-water dispersal pathways make it vulnerable to extirpation (Greenwood and Thorp 2001).

Note: Goodrich and van der Schalie (1944) stated that *L. obovata* "takes several confusing forms, from delicate and slender to thick and low-spired." Minton (2002) and Minton and Lydeard (2003) suggested that *L. obovata* is not a *Lithasia* species based on mitochondrial DNA and morphological data, and should be studied in greater detail for proper taxonomic placement.

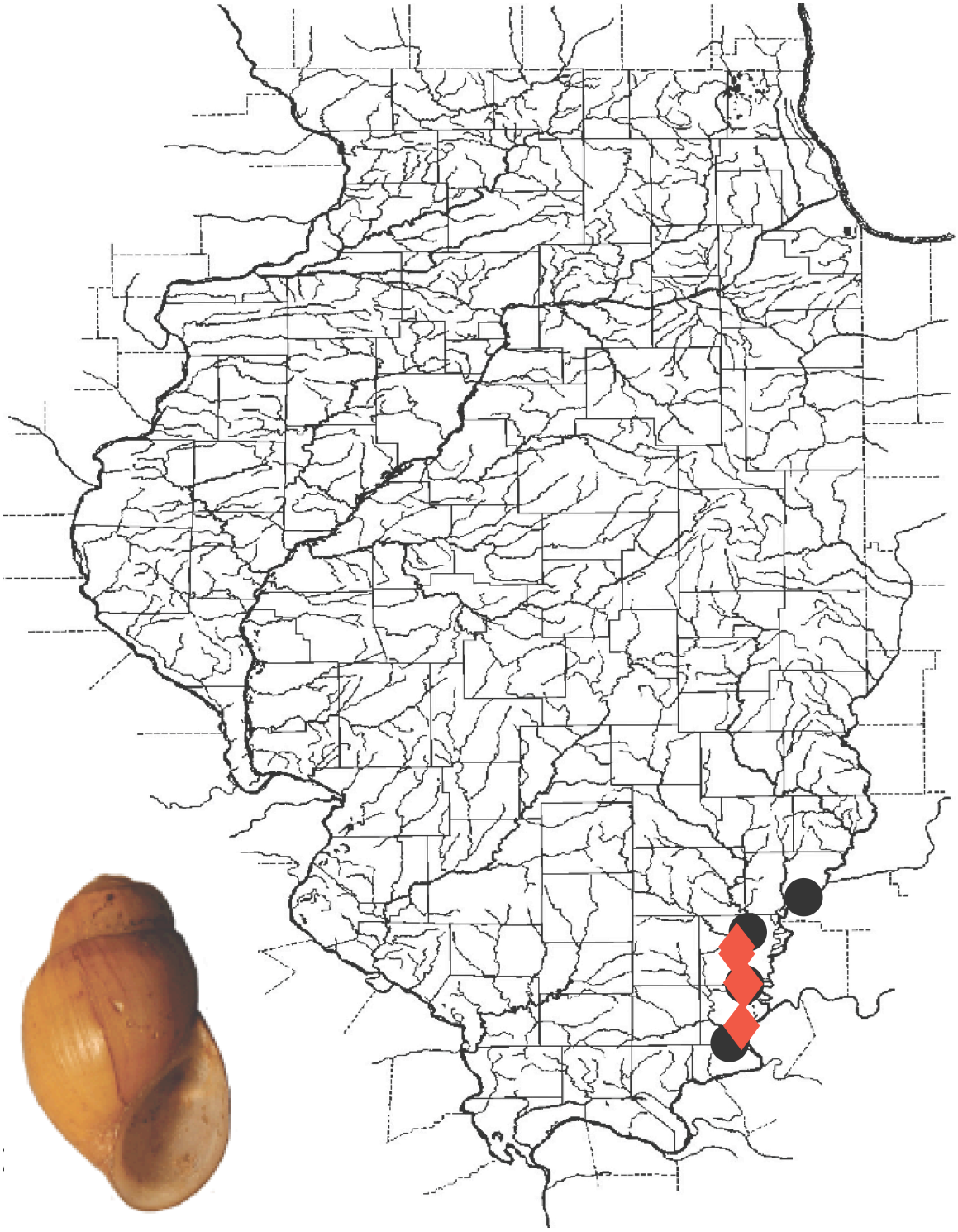

Figure 8. Distribution of *Lithasia obovata* in Illinois. The species also has been recorded from the Embarras and Saline rivers, but specific location was not given (data taken from INHS Mollusk Collection).

Lithasia verrucosa (Rafinesque, 1820) – Vericose Rocksnail.

Global Rank: G4Q – Apparently Secure. Uncommon but not rare; some cause for long-term concern due to declines or other factors. Taxonomic distinctiveness of this entity at the current level is questionable.

Federal Status: none.

State Status: CS – Currently Stable. A species whose distribution and abundance may be stable, or one that might have declined in portions of its range but is not in need of immediate conservation management actions.

Drainages: **24**, **25**.

Illinois Distribution: The lower Ohio River basin in Illinois is on the northwestern range for *L. verrucosa.* The snail is known from the lower Wabash (downstream of Mt. Carmel) and Ohio rivers (Baker 1906; Goodrich 1940; Goodrich and van der Schalie 1944; Burch 1989) and still can be found in these streams. As with *L. armigera*, *L. verrucosa* is believed to be globally vulnerable, which means it is at moderate risk of extinction partially due to a restricted range and relatively few populations (Minton and Lydeard 2003). Also, although we cannot compare historical population size to current population size, the range of *L. verrucosa* appears to not have changed based on historical and current data.

Preferred habitat: *Lithasia verrucosa* can be found on rocks and occasionally woody debris in large streams.

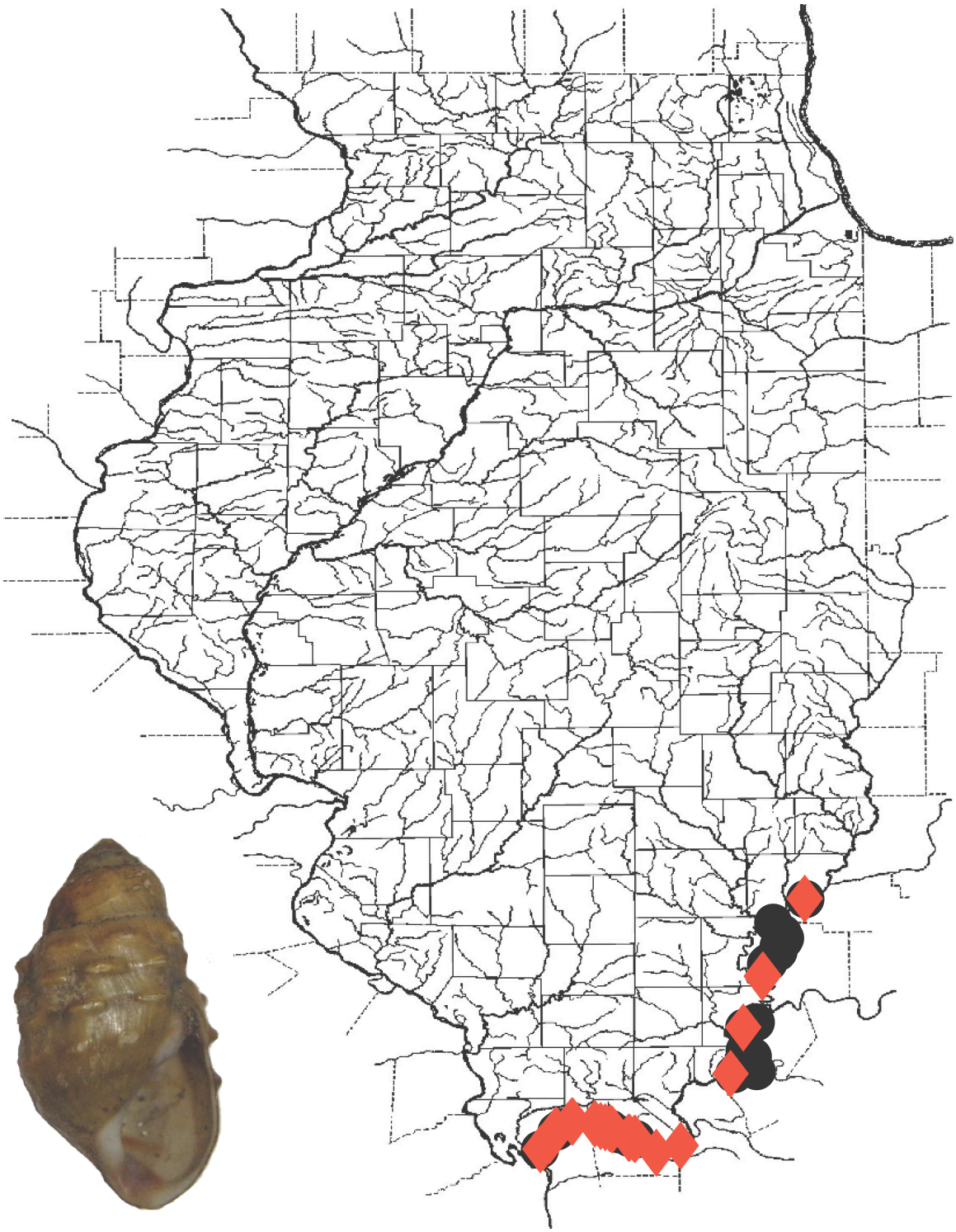

Figure 9. Distribution of *Lithasia verrucosa* in Illinois.

Pleurocera acuta Rafinesque, 1831 – Sharp Hornsnail.

Global Rank: G5 – Secure. Common; widespread and abundant.

Federal Status: none.

State Status: CS – Currently Stable. A species whose distribution and abundance may be stable, or one that might have declined in portions of its range but is not in need of immediate conservation management actions.

Drainages: 1, **2**, 4, **5**, **7**, **8**, **9**, 11, **12**, 14, **15**, **21**, **22**, **23**.

Illinois Distribution: *Pleurocera acuta* is known from the Lake Michigan drainage, throughout the Apple, Rock, Illinois, Kaskaskia, and Big Muddy river basins, the Mississippi mainstem, and the Vermilion River basin of the Wabash River drainage (Calkins 1874a; Calkins 1874b; Calkins 1874c; Baker 1899; Baker 1902; Baker 1906; Zetek 1918; Baker 1922; Richardson 1925a; Richardson 1925b; Richardson 1928; Baker 1930; Goodrich 1940; Dexter 1956; Dexter 1961; Dazo 1965; Burch, 1989; Wu et al. 1997; Stewart 2006). Baker (1906) listed *P. acuta* from the Skillet Fork (Little Wabash basin) and Saline River basin. We believe these are erroneous identifications, and were likely *P. canaliculata*. *Pleurocera acuta* is experiencing a reduction in portions of its range (Angelo et al. 2002). Within Illinois, the species appears to be becoming rare in some basins including the Fox River and Sangamon River.

Preferred habitat: As with most pleurocerids, substrate is an important component in the distribution of *P. acuta*. In a study done in Silver Creek, Madison Co., Kentucky, substrates high in carbonate offered the most suitable habitats for *P. acuta*; distribution in this system also was affected by water depth and current, where largest concentrations occurred in shallow areas of relatively slow flow (Houp 1970). In Illinois, *P. acuta* most frequently occurs on sandy or rocky bottom in shallow areas of large rivers and lake where there is little or no current (Baker 1902; Zetek 1918; Dexter 1956; Dazo 1965). The snail also can borrow in sand or mud (Burch 1989).

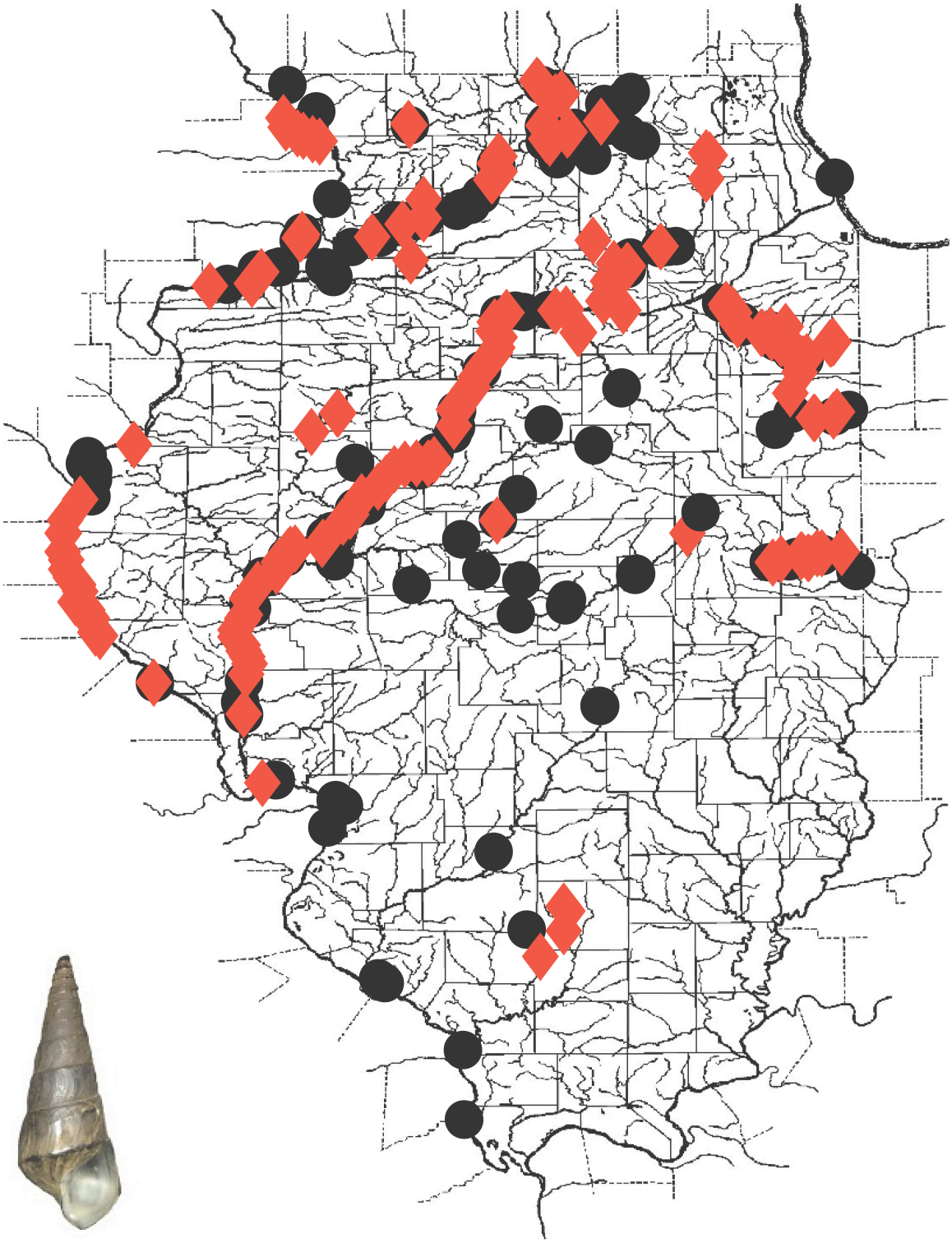

Figure 10. Distribution of *Pleurocera acuta* in Illinois.

Pleurocera alveare (Conrad, 1834) – Rugged Hornsnail.

Global Rank: G3 – Vulnerable. At moderate risk of extinction due to a restricted range, relatively few populations, recent and widespread declines, or other factors.

Federal Status: none.

State Status: EX – Extirpated. No longer a breeding species in Illinois.

Drainages: 18, 19, 24, 25.

Illinois Distribution: *Pleurocera alveare* was known from the lower parts of the Wabash and Ohio rivers, as well as the Saline and Little Wabash rivers (Baker 1906; Goodrich 1934; Goodrich 1940; Goodrich and van der Schalie 1944; Burch 1989). The voucher specimens we encountered lacked common locations (just stream names); therefore a map was not created for this species. This species has been extirpated from much of its historical range (Wu et al. 1997) and appears to have been extirpated from Illinois.

Preferred habitat: It was known to inhabit slow-moving and muddy substrates, as well as swift-flowing rocky areas (Goodrich and van der Schalie 1944).

Figure 11. *Pleurocera alveare*

Pleurocera canaliculata (Say, 1821) – Silty Hornsnail.

Global Rank: G5 – Secure. Common; widespread and abundant.

Federal Status: none.

State Status: CS – Currently Stable. A species whose distribution and abundance may be stable, or one that might have declined in portions of its range but is not in need of immediate conservation management actions.

Drainages: **17**, **18**, **19**, **20**, **24**, **25**.

Illinois Distribution: *Pleurocera canaliculata* is known from the Wabash and Ohio rivers, as well as the Embarras, Little Wabash, and Saline rivers and Bonpas Creek (Baker 1906; Goodrich 1938; Goodrich 1940; Goodrich and van der Schalie 1944; Burch 1989). Goodrich and van der Schalie (1944) stated that *P. canaliculata* had been collected in Wabash River basin in "the channel known as Fox River" and we assume they are referring to the stream in White County, Illinois, just south of Grayville. Baker (1906) reported *P. canaliculata* from the Fox and Illinois rivers, Goodrich (1939) stated that the Walker collection contained specimens from the Rock River, and Tucker (1994) reported it in the Mississippi River. We believe these are erroneous identifications. Some of the specimens were re-examined and were re-classified as *P. acuta* based on the fact that they were not as stout or heavily shouldered as *P. canaliculata* from the Wabash or Ohio Rivers. Furthermore, Burch (1989) and Stewart (2006) stated that *P. canaliculata* is restricted to the Wabash and Ohio river drainages.

Preferred habitat: *Pleurocera canaliculata* can occupy a variety of habitats, ranging from shallow and sandy to deep and rocky. Habitat selection is based on food availability, wave resistance, predator vulnerability, and dispersal abilities (Greenwood and Thorp 2001). The species feeds on algae obtained from mud (Goodrich and van der Schalie 1944).

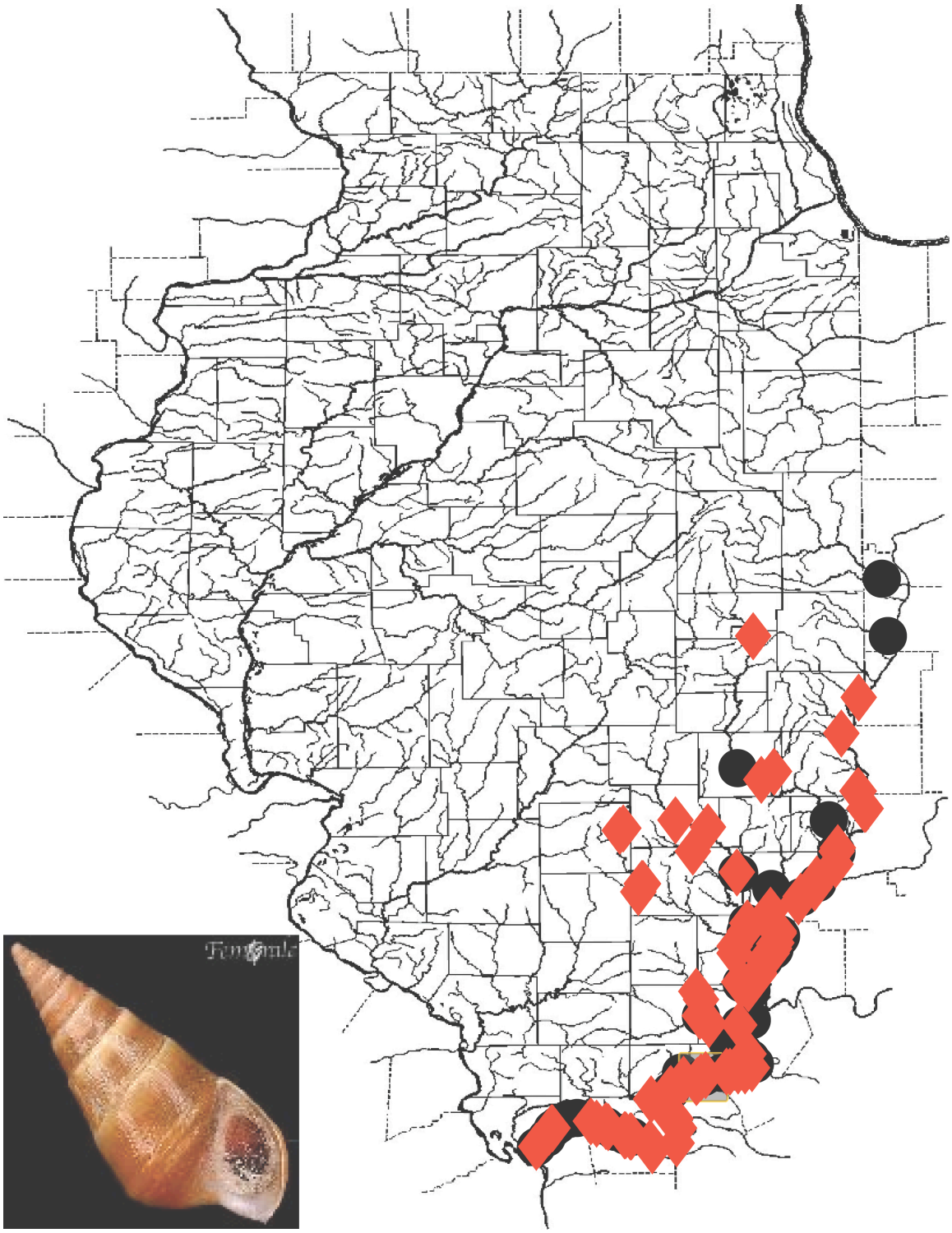

Figure 12. Distribution of *Pleurocera canaliculata* in Illinois.

DISCUSSION

Goodrich and van der Schalie (1944) stated there was a northern fauna (*E. livsecens* and *P. acuta*) and a southern fauna (*L. praerosa*, *L. armigera, L. obovata, L. verrucosa*, *P. alvearae*, and *P. canaliculata*) for pleurocerids in the Midwest. The authors listed Lafayette, Indiana (latitude = 40.41271 N), as the transition point from northern fauna to southern fauna. This pattern held true for Illinois pleurocerids; however, we add *E. semicarinata* to the southern fauna because in Illinois, the species only occurs in direct tributaries to the Ohio River. This pattern also has been observed in freshwater mussels (Goodrich and van der Schalie 1944; Cummings and Mayer 1997) and fishes (Smith 1979).

As with freshwater mussels (Cummings and Mayer 1997), historical and present-day pleurocerid diversity in Illinois is greatest in the Wabash and Ohio river basins (Table 1; Table 2). All 11 pleurocerid species occurred somewhere in the Illinois portion of the Wabash River basin. *Elimia livescens* occurs in the headwaters of the Vermilion and Embarras rivers, whereas *P. acuta* occurs in the headwaters of the Vermilion River. The Wabash and/or Ohio river mainstems contained the only known populations of five pleurocerid species (*L. praerosa*, *L. trilineata*, *L. armigera*, *L. geniculata*, and *L. verrucosa*). Three other pleurocerid species (*L. obovata*, *P. alveare*, and *P. canaliculata*) have been found throughout the Wabash and Ohio river basins but not in the Mississippi River basin, and one pleurocerid species (*E. semicarinata*) is known to occur only in direct tributaries of the Ohio River. A similar distribution pattern for these species also was reported for Indiana (Goodrich and van der Schalie 1944).

The Ohio – Mississippi confluence seems to form a dividing line for pleurocerid distributions (Calkins 1874c). In Illinois, the Mississippi River basin, exclusive of the Ohio River basin, historically support only two pleurocerid species (*E. livescens* and *P. acuta*). Based on data reported for Missouri (Wu et al. 1997), Iowa (Stewart 2006), Minnesota (Dawley 1947), and Wisconsin (Baker 1928), *E. livescens* and *P. acuta* are the only pleurocerids to occur in the middle-and upper-Mississippi River basin. Many sub-basins (e.g., lower and middle Illinois River tributaries and middle Mississippi River tributaries) have not been adequately sampled but additional collecting will likely result in discovering *E. livescens* and *P. acuta* in these drainages where habitat is suitable.

Many pleurocerids have naturally restricted, discontinuous distributions and are confined to fragmented, isolated populations (Dazo 1965; Angelo et al. 2002; Tiemann and Cummings 2007). Threats to pleurocerid populations are the same as those that affect all riverine assemblages. Pleurocerids are not only affected by environmental degradation (e.g., siltation, chemical pollution, impoundments, instream construction, gravel mining, dredging, channelization, etc.), but also by sporadic shifts in natural phenomena, including shifts in climate and evolving stream drainage patterns (Ahlstedt 1991; Neves et al. 1997; Angelo et al. 2002; Lydeard et al. 2004). Competition / predation from exotic species also is a threat, including the zebra mussel *Dreissena polymorpha* (Tucker 1994; Greenwood and Thorp 2001). Several live specimens we encountered were heavily infested by *D. polymorpha*. Pleurocerids have slow and restricted dispersal capabilities

(Brown and Johnson 2004); therefore, if a species experiences a drastic range reduction or becomes extirpated, natural recovery processes will be slow.

Few conservation and monitoring programs have explicitly incorporated gastropods. Data on the historical distribution of this group should be collected to ascertain species trajectories (Lydeard et al. 2004). This information can guide not only the geographic focus of conservation efforts but also appropriate management efforts. Brown and Johnson (2004) outlined a conservation plan for imperiled gastropods and suggested a two-prong approach. The first item suggested was obtaining detailed information on distributions and habitat requirements, and includes determining the necessary diet and physicochemical parameters needed. The second item suggested was developing adequate propagation methods, and included not jeopardizing the source population. Gastropod conservation and recovery efforts will face many challenges in the future. The continued survival of snails will require landowners and natural resource agencies to work together to protect the remaining assemblages while striving toward further improvements in restoration and preservation of aquatic ecosystems (Neves et al. 1997; Angelo et al. 2002; Brown and Johnson 2004; Lydeard et al. 2004).

If a pleurocerid species becomes extirpated from a stream, the chances it will recolonize naturally seem low due to the group's dispersal capabilities. One conservation technique used successfully for a number of organisms, including pleurocerids, is transplantations / relocations (Ahlstedt 1991). Some natural resource agencies are propagating pleurocerids to augment existing populations or reintroduce a species into historical portions of its range. For those pleurocerid species that are state-listed and experienced a range reduction (e.g., *L. obovata*), propagation might be one method to aid in their recovery.

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Appendix 1. Diagnostic key to the pleurocerids of Illinois. Key modified from Goodrich and van der Schalie (1944), Branson (1987), and Burch (1989). Juveniles (<15 mm in length) can be difficult to identify because characteristics used to distinguish among species are not always present/developed and might not key correctly.

Key to the Pleuroceridae of Illinois

1a. Aperture forms an obvious canal; columella twisted.....2

1b. Aperture angled or rounded, not canaliculated; columella smooth and not twisted.....8

2a. Shell conical (cone-shaped); columella twisted like an auger and thickened above but not below; aperture lip angled; columellar margin of the aperture and posterior parietal wall not without a thickening..... Genus *Pleurocera* – 3

2b. Shell ovoid (egg-shaped), turban-shaped, or fusiform; columella thickened above and below..... Genus *Lithasia* – 5

3a. Shell elongated (its width much less than half the length) and sulcate (narrow, deep grooves) or nearly smooth 4

3b. Shell short (its width about half the length) and has lateral ribs, especially in apical whorls; body whorl angled with a row of tubercles along the angle; historically found in larger streams in the Wabash and Ohio river basins, but might be extirpated from Illinois . .....*Pleurocera alveare*

4a. Shell is broad and heavy; body whorl shouldered (in close proximity), obtuse (blunt), and undulating (wavy), and are sometimes nodulose (small knot-like protuberance) along the angle; found in larger streams in the Wabash and Ohio river basins..... .....*Pleurocera canaliculata*

4b. Shell is narrow and usually smooth; body whorl not shouldered, obtuse, or undulating, and does not have nodules; found in the Mississippi River basin exclusive Ohio river basin, except in the Vermilion River basin (Wabash)..... *Pleurocera acuta*

5a. Shell with row of nodules on periphery of body whorl; columellar margin of the aperture usually thickened, meeting the anterior lip with a channel; a calloused thickening usually occurs on the parietal wall at the posterior end of the aperture.....6

5b. Shell without nodules on the periphery of body whorl; compactly ovoid; without plicae (ridges); parietal wall not callus thickened; found in larger streams in the Wabash and Ohio river basins ..... *Lithasia obovata*

6a. Adults have a central row of tubercles or numerous small tubercles in parallel rows on body whorl 7

6b. Adults have a crown-like row of tubercles on body whorl; found in the Ohio River .....*Lithasia geniculata*

7a. Adults have a central row of tubercles on body whorl; found in the Wabash and Ohio rivers ..... *Lithasia armigera*

7b. Adults have numerous small tubercles in parallel rows on body whorl; found in the Wabash and Ohio rivers..... *Lithasia verrucosa*

8a. Shell ovoid or turreted; aperture angled below and entire (complete) above .....Genus *Elimia* – 9

8b. Shell globose or subglobose; aperture entire, rounded in front .....Genus *Leptoxis* – 10

9a. Shell turreted; spiral striae (thin, narrow groves) strongly raised; lower half of body whorl with plicae; found in direct tributaries of the Ohio River (e.g., Bay, Lusk, Big Grand Pierre, and Big creeks).....*Elimia semicarinata*

9b. Shell usually ovoid but can be conical; canal shorter than spire; columella smooth and not twisted like an auger; aperture lip curved; parietal wall with callus; found in the northern two-thirds of the state ..... *Elimia livescens*

10a. Shell globose (spherical), relatively thick and solid, and usually with color bands; shell generally without carinae (keel-shaped ridges); central denticles of radular teeth degenerate; laterals cleaver-like; found in the Wabash and Ohio rivers ..*Leptoxis praerosa*

10b. Shell subglobose, relatively thin and usually without color bands; shell generally with ≥1 carinae; central denticles of radular teeth not degenerate; laterals not cleaver-like; historically found in the Ohio River and possibly the Wabash River but might be extirpated from Illinois .....*Leptoxis trilineata*

New Record for the Freshwater Snail *Lithasia geniculata* (Gastropoda: Pleuroceridae) in the Ohio River, IL, with Comments on Potential Threats to the Population

Jeremy S. Tiemann[1,*] and Kevin S. Cummings[1]

Abstract - We report on a recently discovered population of the freshwater snail *Lithasia geniculata* (Ornate Rocksnail) (Gastropoda: Pleuroceridae) from the Ohio River, IL, the first documented occurrence for this species outside the Tennessee and Cumberland river basins. We collected 14 individuals on 26–27 August 2008 from the Ohio River, near Mound City, Pulaski County, IL. All of the specimens collected were discovered on an exposed shoal after the river dropped ≈0.5 m in a 24-hr period and had several (7–33) *Dreissena polymorpha* (Zebra Mussel) attached to their shells.

Freshwater snails (Gastropoda) are a vital component of many stream ecosystems. Not only does their sensitivity to perturbations allow them to be used as biological indicators of stream integrity, but they also occupy a central position in food webs by grazing on periphyton and providing a food source for predators (Brown et al. 2008). The family Pleuroceridae, a group of gill-breathing, operculate snails, reaches its greatest diversity in streams of the southeastern United States (Brown et al. 2008, Burch 1989, Minton and Lydeard 2003). Within North America, the group is composed of 7 genera and approximately 156 species, but has experienced a severe decline in diversity during the past century (Brown et al. 2008, Burch 1989, Graf 2001, Minton and Lydeard 2003, Turgeon et al. 1998). The entire genus *Gyrotoma* (6 species), endemic to the shoals of the Coosa River, Alabama–Georgia, and approximately 26 other species in the family are now presumed globally extinct due to inundation of riffle areas by impoundments and habitat degradation from poor land-use practices (Brown et al. 2008, Burch 1989, Lysne et al. 2008). The 32 extinct species plus the 5 that are on the federal endangered species list comprise roughly 20% of the known North American pleurocerid fauna. Freshwater gastropods remain an understudied fauna, and disseminating research findings (e.g., distribution and status records) so that all parties have access to the most up-to-date information is an important factor in snail conservation (Brown et al. 2008, Lysne et al. 2008, Perez and Milton 2008).

Illinois is on the northwestern edge of the range of many pleurocerids, but little is known about the group in the state (Cummings 1991). The last to compile information on the distribution and status of the family in Illinois was Baker (1906). In Illinois, 8 of the 11 pleurocerid species are found only in the Wabash/Ohio River basin (Baker 1906, Burch 1989, Cummings 1991). We have begun investigating the status of pleurocerids of Illinois by conducting literature reviews (e.g., Burch 1989, Goodrich 1940, 1941), examining museum specimens and data (e.g., Carnegie Museum of Natural History, Pittsburgh, PA [CM]; Chicago Academy of Science, Chicago, IL [CA]; Field Museum of Natural History, Chicago, IL [FMNH]; Florida Museum of Natural History, Gainesville, FL [UF]; the now combined Illinois Natural History Survey [INHS] and University of Illinois Museum of Natural History [UIMNH], Champaign, IL; Ohio State University Museum, Columbus, OH [OSUM]; and University of Michigan Museum of Zoology, Ann Arbor, MI [UMMZ]; acronyms follow Leviton et al. 1985, except for Ohio State), and qualitatively collecting snails throughout the state. While conducting surveys of the Ohio River, we found an undocumented population of *Lithasia geniculata* Haldeman (Ornate Rocksnail) (Fig. 1) and herein report about it and potential threats to the population.

We conducted turtle and qualitative snail surveys in the Ohio River downstream of Metropolis, IL, on 25–27 August 2008. While checking turtle traps near Mound City, Pulaski County on the 26th, we noticed the river had dropped approximately 0.5 m from the previous day. This drop in water level exposed a shoal that was not sampled on the 25th. We sampled the shoal for 0.5 person-hours on the 26th and 0.75 person-hours on the 27th. Fourteen live individuals of *L. geniculata* were collected during the 2-d period and were found in sandy areas with small amounts of gravel. The exposed pools on the shoals were large, and numerous individuals were observed but not collected; in addition, not all of the exposed pools were sampled. Individuals collected were preserved in 95% EtOH and deposited into the Illinois Natural History Survey Mollusk Collection, Champaign (INHS 32740). The 14 vouchered individuals varied in height from 17–25 mm (mean 21.1 ± 2.3 mm SD). Although *L. geniculata* can be phenotypically variable (Minton et al. 2008), the specimens we collected were distinctly shouldered with a single crown-like row of nodules on the upper portion of the body whorl (Fig. 1), typical of *L. geniculata* (Branson 1987, Goodrich 1941).

Prior to our survey, the only published records of *L. geniculata* (= *L. geniculata geniculata* and *L. geniculata fuliginosa*) were from the Tennessee River drainage (e.g., the mainstem Tennessee River and Duck River basin) in Kentucky, Tennessee,

Figure 1. *Lithasia geniculata* (Ornate Rocksnail) from the Ohio River, Mound City, Pulaski County, IL (INHS 32740). The specimen (24 mm in height) had 32 Zebra Mussels removed for identification purposes.

and Alabama, and the Cumberland River drainage (e.g., the mainstem Cumberland River and Red River basin) in Kentucky and Tennessee (Burch 1989, Gooch et al. 1979, Goodrich 1940, Minton 2002, Minton and Lydeard 2003). The closest populations of *L. geniculata* to the one we discovered appears to be in the Tennessee River downstream of Kentucky Lake at river mile 5.3 (Gooch et al. 1979), and in the Cumberland River downstream of Lake Barkley near river mile 9 (J. Sickel, Murray State University, Murray, KY, pers. comm.; INHS 33096). Our discovery expands the known range of *L. geniculata* into a new basin (Ohio River), a new state (Illinois), and documents its occurrence in the lower Cumberland River (Fig. 2).

We did, however, encounter additional specimens in our museum search referable to *L. geniculata* from the Falls of the Ohio River, near Louisville, KY, collected in 1904 (FMNH 80314). OSUM has two lots from the Ohio River that are referable to *L. geniculata*: 22 miles upstream of Louisville collected by C. Stein in 1961 (OSUM 14378), and 10 river miles upstream of Louisville collected by Greenwood and Thorp in 1989 (OSUM 19823). Although the OSUM specimens were initially identified as *Lithasia obovata* (Say) (Shawnee Rocksnail), they were distinctly shouldered but lacked a definite row of nodules. Minton et al. (2008) suggested that *Lithasia* spp. can contain

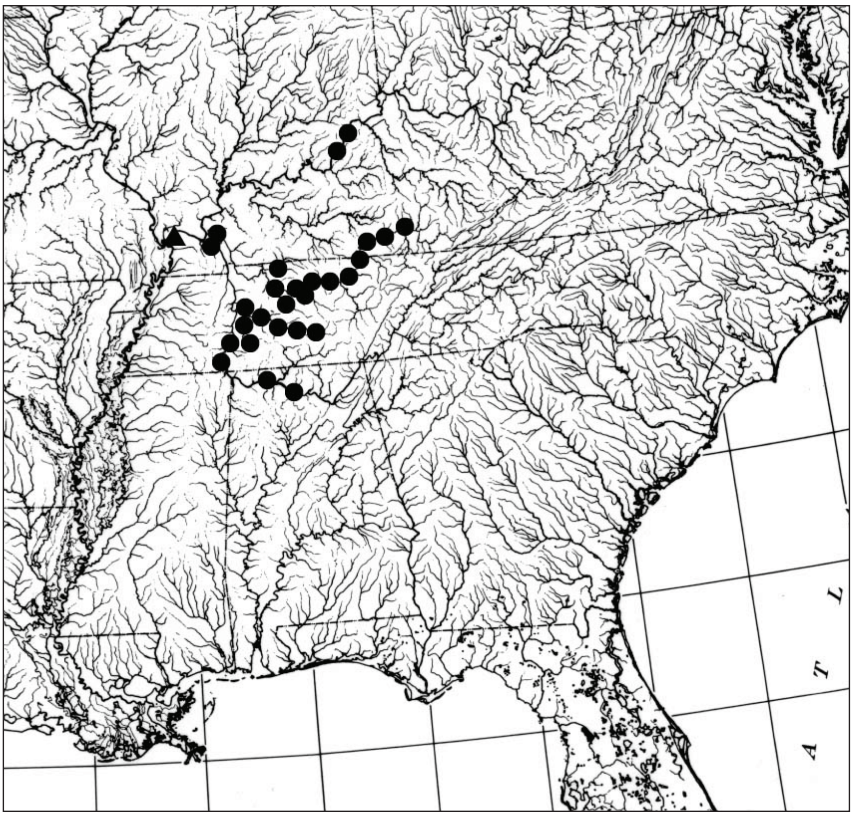

Figure 2. Distribution of *Lithasia geniculata* (Ornate Rocksnail). Triangle indicates where the Ohio River, IL, specimen was found, and circles indicate where the species was known prior to our survey. Historical information (= *L. geniculata geniculata* and *L. geniculata fuliginosa*) obtained through Gooch et al. (1979) and specimens located at CA, CM, FMNH, INHS (including UIMNH), OSUM, UF, and UMMZ.

substantial intraspecific variation in shell form. We believe that such ecophenotypic plasticity might help to explain the morphological form found in the upper Ohio River.

It seems doubtful that the Ohio River individuals were deliberately discarded through human activity. We know of no published studies documenting snail transport on barges or boats, nor do we know of any aquatic organisms (e.g., macrophytes) transported from Tennessee to the Ohio River. Furthermore, pleurocerids are not a component of the pet or bait trade. We also think it is improbable that the snails washed or moved downstream from extant populations upstream because of the lack of habitat in the intervening impoundments (Isom 1971) and the limited dispersal capabilities of freshwater snails (Brown et al. 2008). Greenwood and Thorp (2001) suggested that *Lithasia* spp. are vulnerable because of their affinity to specialized habitats (e.g., clean rocky substrates in larger streams) and their inability to disperse due to impoundments. Almost the entire area separating the Ohio River population from those upstream in Tennessee and Cumberland rivers has changed from lotic to lentic habitat through the creation of two large impoundments (Lake Barkley and Kentucky Lake). In addition, two locks and dams are present on the Ohio River between the population we discovered in Illinois and those in the nearby lower Tennessee and Cumberland rivers. It seems probable that the impounding of the lower Tennessee and Cumberland rivers eliminated historical intervening populations of *L. geniculata* in those rivers. Isom (1971) stated that the decline of pleurocerids throughout the Tennessee River Valley was associated with habitat alteration as a result of impoundments, but offered no substantiating data. Neves et al. (1997) stated that impoundments have had a detrimental effect on freshwater gastropods "although poorly documented." We have found no studies specifically documenting the effects of impoundments on gastropods. While speculation that impoundments have negative effects on riverine gastropods seems intuitive, data supporting such claims await further studies.

It is beyond the scope of our study to determine if the Ohio River population is native or introduced; however, based upon the FMNH and OSUM specimens, records from Gooch et al. (1979) in Kentucky Lake (river mile 145) and Pickwick Reservoir (river mile 257) and the fact that snails are an understudied group (Lysne et al. 2008), it seems likely that the populations upstream of Kentucky Lake and Lake Barkley were contiguous with the Ohio River population before the Tennessee and Cumberland rivers were impounded. We suspect that the native range of *L. geniculata* included the lower Ohio River from upstream as far as Louisville, KY, to the confluence with the Mississippi River at Cairo, IL, and that the Ohio River populations went undetected until our survey. Additional fieldwork is necessary to further elucidate the range of *L. geniculata* in the Ohio River.

Lysne et al. (2008) listed four conservation challenges that freshwater gastropods face, including negative effects from invasive species. The *L. geniculata* collected contained numerous (7–33) *Dreissena polymorpha* (Pallas) (Zebra Mussel) attached, as did other live snails present, including *Lithasia armigera* (Say) (Armored Rocksnail), *Lithasia verrucosa* (Rafinesque) (Verrucose Rocksnail), and *Pleurocera canaliculata* (Say) (Silty Hornsnail). In addition, we saw hundreds of dead snails (all species listed above) infested with Zebra Mussels. We can only speculate that the Zebra Mussels caused the snails' demise. Zebra Mussels have been known to colonize pleurocerids and pose a threat to their survival (Greenwood and Thorp 2001, Tucker 1994). Greenwood and Thorp (2001) suggested that Zebra Mussels might negatively affect gastropods by biofouling (e.g., impeding feeding, growth, movement, respiration, and reproduction), as has been reported for freshwater mussels (Hebert et al. 1991, Strayer and Malcom 2007). Greenwood and Thorp (2001) also suggested that Zebra Mussel infestations increase with water depth, and reported that very

few *Lithasia* they found were encrusted with Zebra Mussels. However, we noticed that all *Lithasia* spp. we encountered were fouled with Zebra Mussels in the shallows of the river. Some individuals resembled "golf balls" as reported by Greenwood and Thorp (2001) for *P. canaliculata* from the deeper portions of the Ohio River.

Another conservation challenge for aquatic gastropods is loss of habitat pertaining to water demand (Lysne et al. 2008). We observed several thousand pleurocerids (all species listed above) and other mollusks (both bivalves and gastropods) marooned at the Mound City site due to the drastic drop in water levels. The Ohio River is a highly regulated stream with over 20 locks and dams from the origin at Pittsburgh, PA, to the confluence with the Mississippi River at Cairo, IL. The fluctuation in water levels to regulate the navigation channel can leave shoals exposed, causing mollusks to be stranded and at risk of desiccation. As seen with freshwater mussels (Golladay et al. 2004, Metcalf 1983), it is assumed that drought-like conditions can cause movement restrictions, physiological stress, and even death for aquatic gastropods.

Given the global conservation status of G3 (vulnerable to extirpation or extinction) assigned to *L. geniculata* by Minton and Lydeard (2003) and the distance to the populations upstream of Kentucky Lake and Lake Barkley, efforts (e.g., listing at the state level) should be taken to protect the Ohio River population. Future studies could include additional sampling methods (e.g., trawling and diving) to assess the full range and habitat preference of the species, and genetic analysis to determine if the Ohio River population is unique.

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