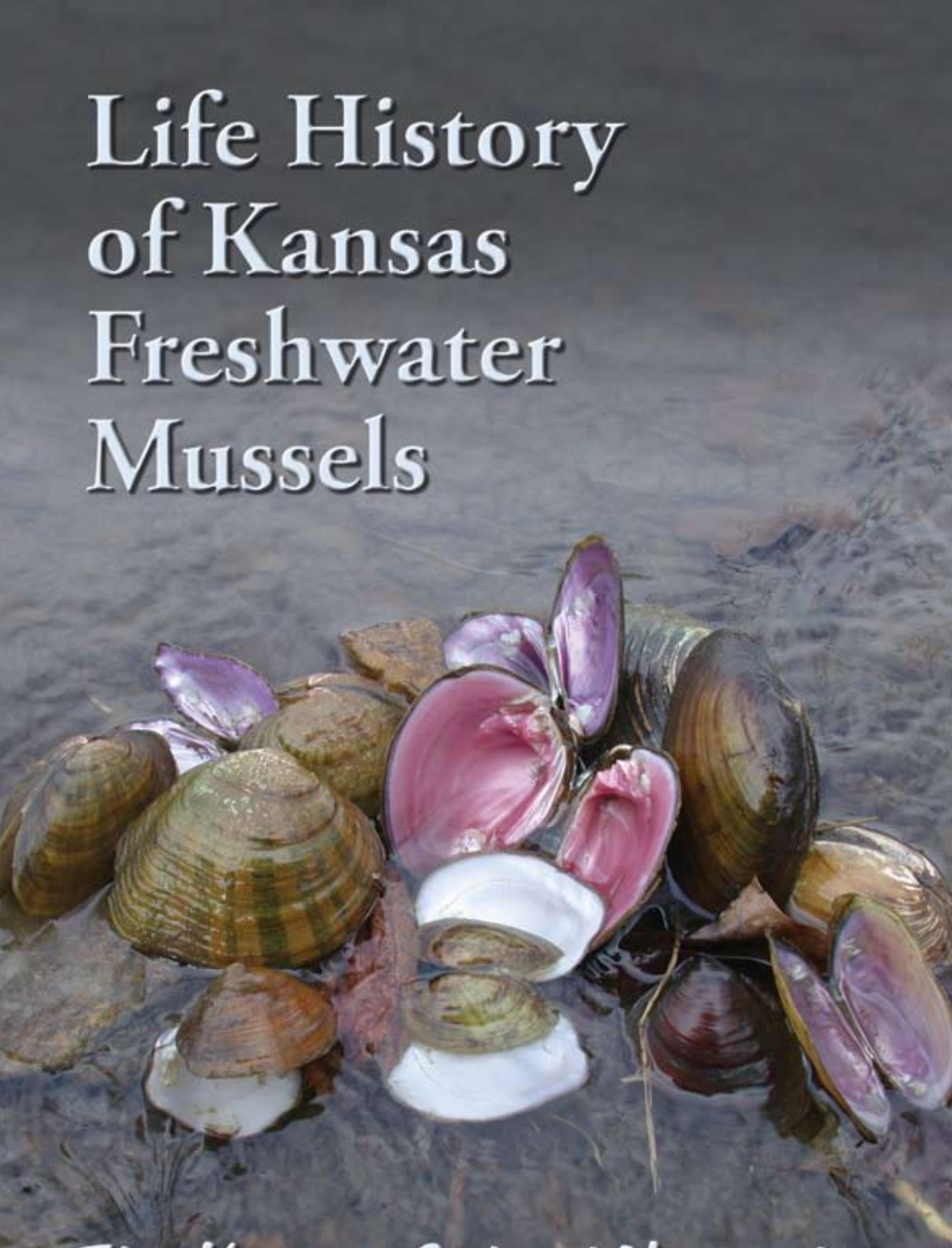
Life History of Kansas Freshwater Mussels



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Front cover: Verdigris River shell midden.

Obermeyer

Brian Obermeyer is the the Flint Hills Initiative Director for the Kansas Chapter of The Nature Conservancy, a non-profit organization that strives to protect Earth's biodiversity. Obermeyer leads a community-based conservation program dedicated to preserving the Flint Hills, the last large expanse of tallgrass prairie, through a collaborative approach with ranchers, landowners and other stakeholders.

Barnhart

Chris Barnhart is Professor of Biology at Missouri State University. He received his M.S. degree from the University of Kansas at Lawrence and Ph.D. from the University of California, Los Angeles. Barnhart studies the life history and reproductive biology of unionid mussels and has authored more than 50 publications and reports on the physiology, ecology, and husbandry of mollusks and other invertebrates.

Miller

Edwin J. Miller has been employed by Kansas Department of Wildlife and Parks since 1989. Miller's position is Threatened and Endangered Species Program Coordinator. He is intrigued with the diversity and function of the native mussels in Kansas and enjoys getting others interested in this important faunal group. He coordinates a Kansas Pearly Mussel Workshop each summer and is currently preparing a pocket guide to the mussels of Kansas. His formal education includes a M.S. in Wildlife Science from Virginia Tech and a B.S. in Animal Ecology from Iowa State University. He lives with his wife and two daughters in Independence, KS.

Life History of Kansas Freshwater Mussels

Brian K. Obermeyer, Edwin J. Miller and M. Christopher Barnhart
Photos by M. Christopher Barnhart

The world's greatest diversity of freshwater mussels (Unionoida) is concentrated in North America, with approximately 300 species and subspecies (31).

MANY THREATENED

This rich historical mussel fauna is in serious jeopardy. Freshwater mussels are considered the most imperiled group of animals in North America (1). The U.S. Fish and Wildlife Service lists 70 species as endangered or threatened, and 17 more are presently candidates for listing. At least 36 species are believed to be extinct (22). Kansas mussels have undergone a similar decline. Of the 46 species known to have occurred in the state, seven are now state-listed as endangered, four as threatened, 11 as SINC (species in need of conservation), and at least five species are probably extirpated from the state (8, 14, 25).

	Kansas status		Kansas status
Margaritiferidae		*Lampsilis rafinesqueana* - Neosho mucket	*E*
Cumberlandia monodonta - spectaclecase	*X*	*Lampsilis teres* - yellow sandshell	*SINC*
Unionidae		*Lasmigona costata* - flutedshell	*T*
Actinonaias ligamentina - mucket	*E*	*Ligumia recta* - black sandshell	*R*
Alasmidonta marginata - elktoe	*E*	*Megalonaias nervosa* - washboard	*SINC*
Alasmidonta viridis - slippershell mussel	*X*	*Obovaria olivaria* - hickorynut	*X*
Anodonta suborbiculata - flat floater	*E*	*Pleurobema sintoxia* - round pigtoe	*SINC*
Anodontoides ferussacianus - cylindrical papershell	*SINC*	*Ptychobranchus occidentalis* - Ouachita kidneyshell	*T*
Arcidens confragosus - rock pocketbook	*T*	*Quadrula cylindrica* - rabbitsfoot	*E*
Cyclonaias tuberculata - purple wartyback	*U*	*Quadrula fragosa* - winged mapleleaf	*X*
Cyprogenia aberti - western fanshell	*E*	*Quadrula nodulata* - wartyback	*SINC*
Ellipsaria lineolata - butterfly	*T*	*Strophitus undulatus* - creeper	*SINC*
Elliptio dilatata - spike	*SINC*	*Truncilla donaciformis* - fawnsfoot	*SINC*
Epioblasma triquetra - snuffbox	*X*	*Truncilla truncata* - deertoe	*SINC*
Fusconaia flava - Wabash pigtoe	*SINC*	*Venustaconcha ellipsiformis* - ellipse	*E*
Lampsilis siliquoidea - fatmucket	*SINC*		

Table 1. Kansas mussel species considered to be at risk (E - endangered, T - threatened, SINC - species in need of conservation, X - extirpated, R - rare but not listed, U - under review)

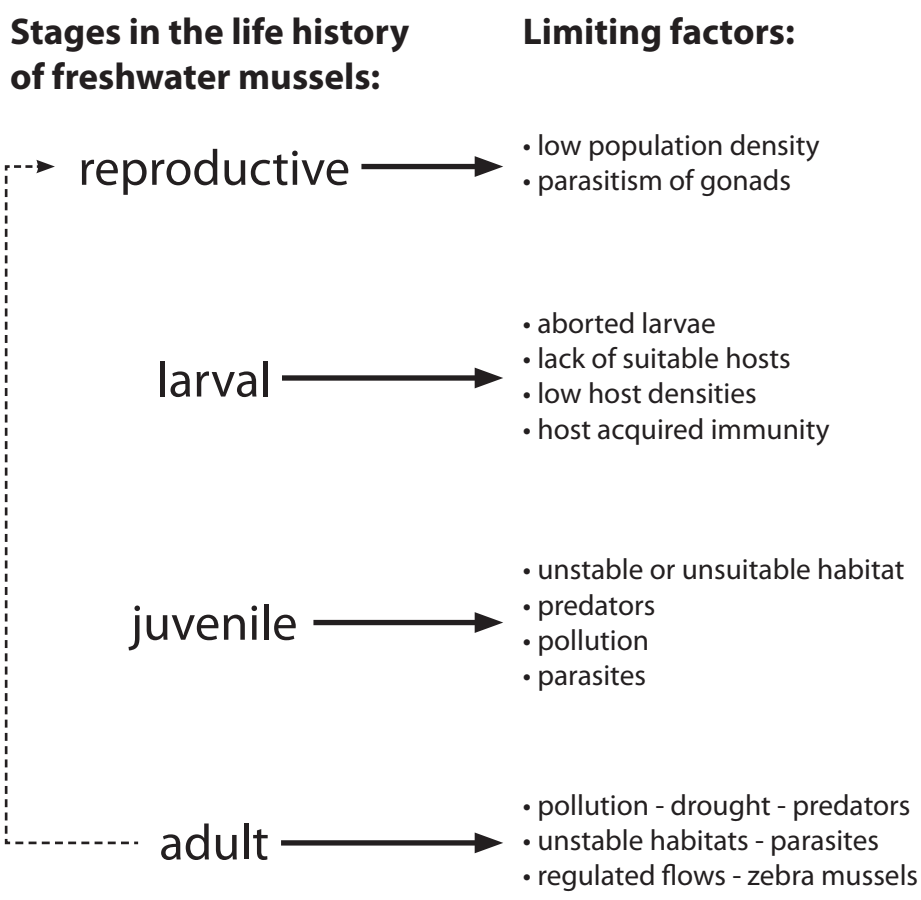

Figure 1: Four basic life stages of freshwater mussels.

LIFE STAGES

The life history of freshwater unionid mussels is fascinating and complex, and consists of four basic life stages: reproductive, larval or parasitic, juvenile, and adult (Figure 1). Most mussels are **dioecious** (having separate sexes). Males release sperm into the water, and the sperm are filtered from the water by the female. Fertilized eggs are brooded within the female's marsupial gills, which contain hollow spaces for this purpose. Fecundity varies among species, ranging from 75,000 to 3,000,000 larvae per female (13, 29). Mussel larvae, called **glochidia**, may be released soon after they are mature, or may be retained in the gills for several months or until the next season (26). Species that release **glochidia** soon after they are mature are called short-term brooders (**tachytictic**), whereas species that retain their glochidia for extended periods of time are referred to as long-term brooders (**bradytictic**). Tachytictic species generally spawn in the spring or early summer, whereas bradytictic species usually spawn during late summer or fall months.

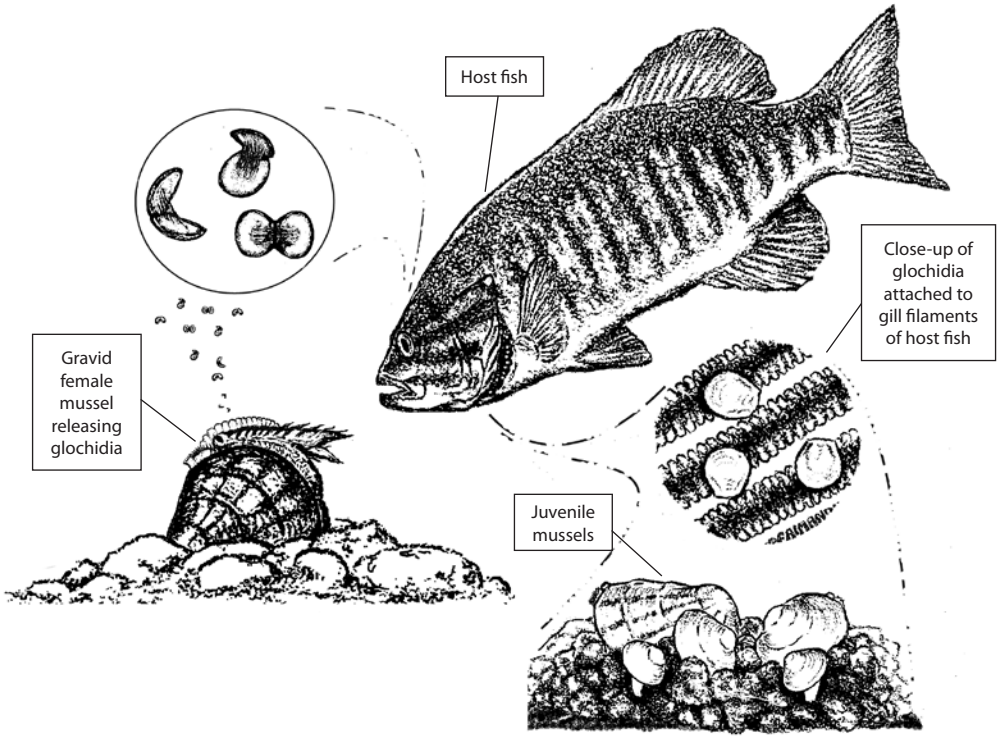

Figure 2. A fish usually serves as the host to mussel glochida. Drawing courtesy of Scott Faiman.

PARASITIC STAGE COMMON

Glochidia must briefly parasitize a vertebrate host (usually a fish) to complete their development[1] (Figure 2). The primary function of larval parasitism on fish appears to be transport to upstream habitats (30). Larvae attached to fish may be carried upstream, whereas adult mussels are not very mobile, and unattached larvae can only drift downstream.

Glochidia must come in contact with a fish host soon after leaving the female mussel. Only a small percentage of glochidia actually make contact with a suitable host. Upon contact with a gill filament, a fin, or the epithelium of a fish, a glochidium clamps on. However, glochidia cannot discriminate between suitable and non-suitable hosts, and may snap shut in response to just about any stimulus. If the glochidium attaches to an unsuitable host, it will be rejected and sloughed off. On a suitable host, the tissue encapsulates the glochidium by migration of epithelial cells (Figure 3). In most species the encapsulation period lasts from 2 to 3 weeks, although it can range from 6 days to 7 months depending on species and temperature (19).

[1] Only one North American species, the green floater (*Lasmigona subviridis*), is positively known to bypass the parasitic life phase (2, 21).

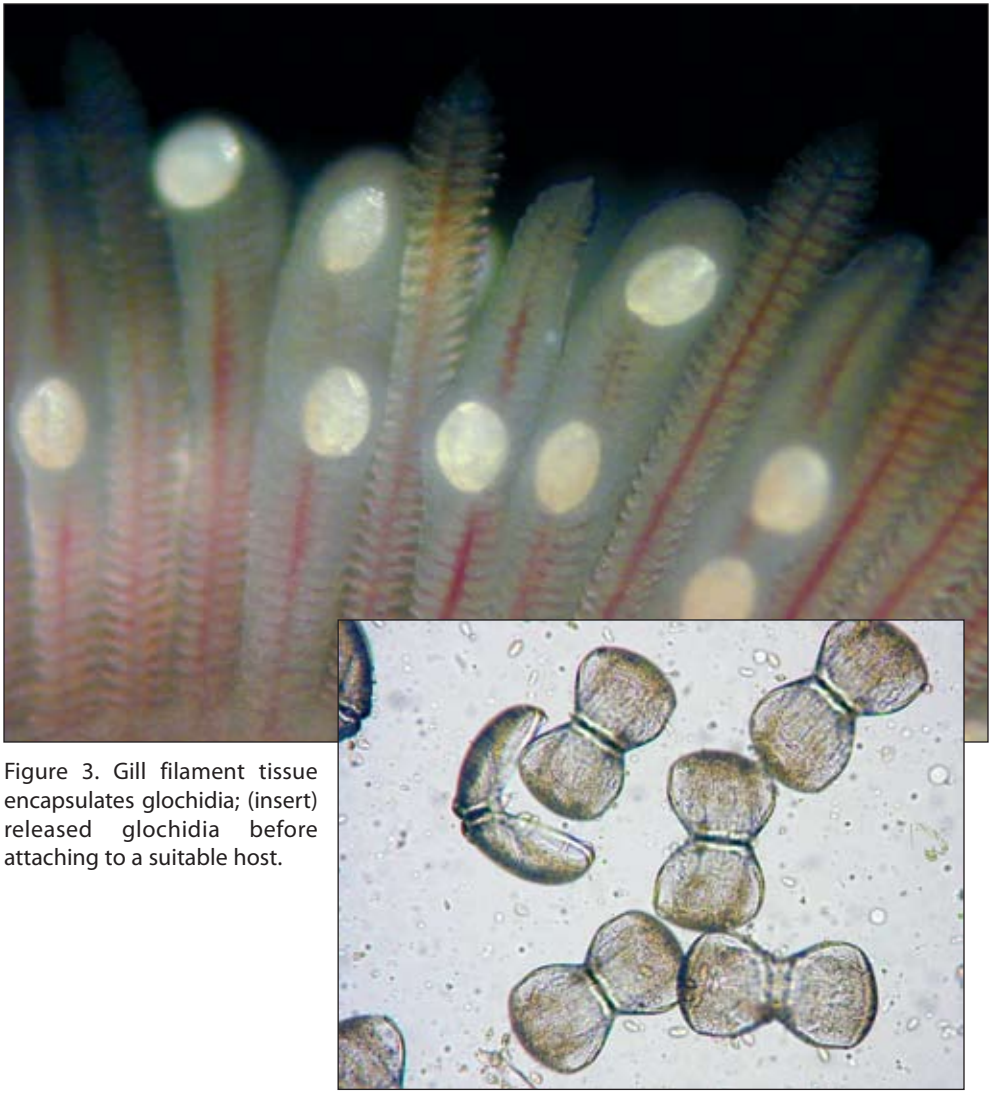

Figure 3. Gill filament tissue encapsulates glochidia; (insert) released glochidia before attaching to a suitable host.

Mussels have evolved some fascinating reproductive adaptations to increase the chances that glochidia will make contact with a suitable host. Females of the genus *Lampsilis* extend a pair of mantle flaps (actually an extension of the inner lobe of the mantle edge; 20) that, from a side angle, remarkably resembles a small fish (Figure 4). Each mantle flap, in addition to its fish-like shape, has pigmentation that resembles an eyespot as well as a fish's lateral line. Muscular contractions of the mantle flaps create an undulating or "swimming" motion that apparently acts as a lure to attract potential fish hosts (6, 18). If a fish strikes at the lure, it ruptures the swollen marsupial gills, which extend between the two mantle flaps, releasing a cloud of glochidia.

Figure 4. Mantle flaps of this mussel resemble a small fish.

MUSSELS THAT BAIT FISH

A number of species are what might be referred to as "bait fishermen," releasing masses of eggs called **conglutinates** to be fed upon by host fish. When the conglutinate is bitten, glochidia are dislodged from the eggs and attach to the host's gills. Many riverine mussel species use this strategy. Conglutinates of some species, such as fanshells, consist mostly of sterile eggs that are often brightly colored and relatively opaque. They appear to serve to make the conglutinate more visible and perhaps more palatable to the host fish.

The female western fanshell releases a particularly long conglutinate or lure (as much as 8 cm in length) to attract its host fish (Figure 7). Each conglutinate consists of approximately 30,000 eggs (3, 4). Only the eggs along the periphery of the conglutinate are fertilized (~15–20 percent of the total). The marsupial gills of this species are coiled (9, 10, 11, 12) (Figure 6), which function to accommodate the long, worm-like conglutinates (3, 12, 27).

Figure 5. Kidneyshell, conglutinates, and orangethroat darter, a probable host.

Figure 6. Marsupial gills in this species are coiled to produce the long lure.

The female Ouachita kidneyshell releases glochidia packets that strikingly resemble larval fish (Figure 5). Each packet contains 200-plus glochidia housed inside a membranous sheath, measuring 1 to 1.5 cm in length (6). Glochidia packets are readily taken as food by darters, which, during the process of consumption, infect themselves with glochidia.

While many species attach primarily to the gills of the host, others attach to fins or the epithelia of fish. The creeper mussel utilizes the "leghold trap" strategy to make contact with a host. Conglutinates are adhesive and stick to the substratum. Each conglutinate consists of roughly 1–15 eggs, usually arranged in single-file. The glochidia "hatch" shortly after release of the conglutinate, but remain tethered to it by short larval threads (similar to the chain of a leg-hold trap (Figure 8).

Figure 7. Western fanshell releasing conglutinates; (insert) conglutinates of Wester fanshell come in several colors.

The glochidia are large and have prominent hooks, and they attach readily to the fins of benthic fishes. The larval thread is quite strong, and the whole conglutinate may be pulled along if even one glochidium attaches to a fin. At that point, it becomes the "tar baby" strategy as more glochidia may attach to the fin.

While attached to its fish host, the glochidium undergoes a metamorphosis, transforming from the glochidial stage to a juvenile. Some species grow during this period but in most species there is no noticeable change in size. The changes in anatomy are profound, however, with most of the organ systems developing for the first time. Following metamorphosis, the juvenile mussel will excyst, drop from the fish, and as it matures, eventually take up life as a sedentary filter feeder (Figure 9). The percentage of glochidia that reach this stage is extremely small.

Figure 8. Glochidia "hatch" from the conglutinate but remain briefly tethered by larval threads.

The juvenile or post-parasitic stage represents the period from metamorphosis to when a young mussel produces gametes, which usually occurs from two to six years of age for most species in Kansas. This stage, especially during the first few months, is thought to be a vulnerable link in the life cycle of freshwater mussels (15, 23, 28). Specific ecological requirements of juvenile mussels remain unknown for most species. Attempts to raise juveniles have only recently yielded acceptable results (5, 16, 17, 23).

The adult life stage is typically what most people envision when they think about freshwater mussels (back cover). Consequently, past mussel research has largely focused on this life stage. Fortunately, researchers have recently begun to address the entire life cycle of

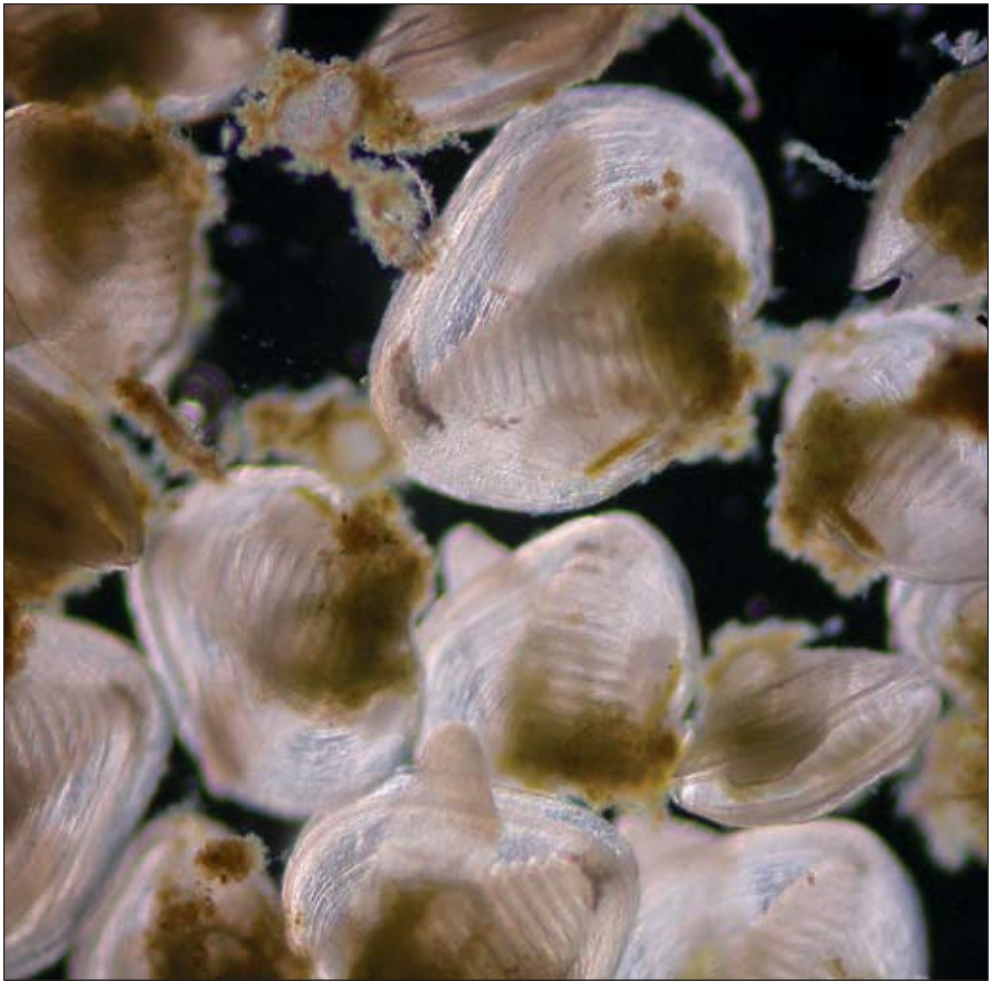

Figure 9. Juvenile mussels are smaller than the head of a pin.

freshwater mussels. Nonetheless, emphasis on the adult life stage is appropriate for certain aspects of mussel research, such as distributional assessments, especially because many species are long lived. For example, one washboard (*Megalonaias nervosa)* from the Neosho River was estimated to be nearly a century in age (based on an acetate peel count of approximately 95 annuli) (24). Interestingly, gonad samples from this specimen yielded spermatozoa. This observation is not particularly surprising since Bauer (7) found that the reproductive output of *M. margaritifera*, another long-lived freshwater mussel that commonly exceeds 100 years in age, does not decline significantly with age. The continued reproductive fitness of aged mussels may have important management implications (24).

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