Where Bowfin Lurk: Unnatural Habitations from 1875 to the Present

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> "*. . . For the convenient performance of these and other experiments, a fish must be of moderate size, hardy, and indisposed to bite. All these advantages are presented by the* Amia, *and I suggest to those who live where the fish is abundant the complete investigation of its habits . . .*"
> — B.G. Wilder, 1877
> Cornell University

Occasional Aquarium Oddity

Professor Wilder's recognition of the bowfin (*Amia calva*) as a species ideally suited for aquarium study was crucial for understanding the biology of this peculiar fish. In the late 19th century, the bowfin was a species of considerable interest to zoologists, and it was sometimes featured prominently in natural history works (Fig. 1). Its life history was little known and very small specimens (<50 mm) had not yet been collected. Its ability to breathe air and its decidedly primitive attributes were topics of discovery, ongoing study, and, in some cases, polite debate. The bowfin's readiness to adapt to life in captivity, however, made possible all manner of investigations not only by researchers, but by professional aquarists and hobbyists. Despite this fact, bowfin-keeping was, and is, a relatively uncommon practice.

Traditional references on aquarium fishes have not typically included bowfin, but a few authors have written about them suggesting persistent interest by a dedicated few. German aquarium writer Hans Frey discussed the bowfin (or "mudfish"), stressing its adaptability and hardiness, but noting that it was best suited for show tanks (Frey, 1961). T. W. Julian's paperback encyclopedia of "tropical" fishes depicted a handsomely marked juvenile and stated that the bowfin was "kept as a curiosity by some hobbyists" and that it was "easily tamed" (Julian, 1974). Native fish specialists emphasized its voracious appetite, unpleasant disposition, cannibalistic tendencies, and large size as an adult (60 cm), all of which necessitated spacious, minimally decorated, single-species tanks (Quinn, 1990; Katula, 1998). Writers have also indicated that the bowfin has no special demands for food or water quality (e.g., Frey, 1961) and "deserves more heightened interest by the aquarium hobby" (Schleser, 1998). These factors explain why the bowfin, while infrequently seen in the tanks of hobbyists, were often seen in the tanks of public aquaria, sometimes for very long periods. One at the New York Aquarium in 1936 had been there 30 years (Breder, 1936).

Bowfin are found throughout the lowlands of the eastern United States, including the Great Lakes Region, Mississippi River Basin, and Atlantic and Gulf Coast Plains from the Susquehanna River, Pennsylvania, to the Colorado River, Texas, and are described as "locally common" (Page and Burr, 1991). We found adult bowfin to be abundant in the sluggish streams and backwaters of Bayou Meto, Arkansas. It is not unusual to encounter them in gillnets or see them wriggling in muddy shallows of receding water. On 2 May 2001, while sampling small floodplain pools for fishes and amphibians, we discovered a large group of juveniles, presenting us with a perfect opportunity to take Professor Wilder's advice of long ago: an investigation of the bowfin's habits.

Denizen of Floodplain Pools

The pool in which we collected our juvenile bowfin was the largest of four pools situated between a campground and a gravel road in Jefferson County, approximately 16 miles

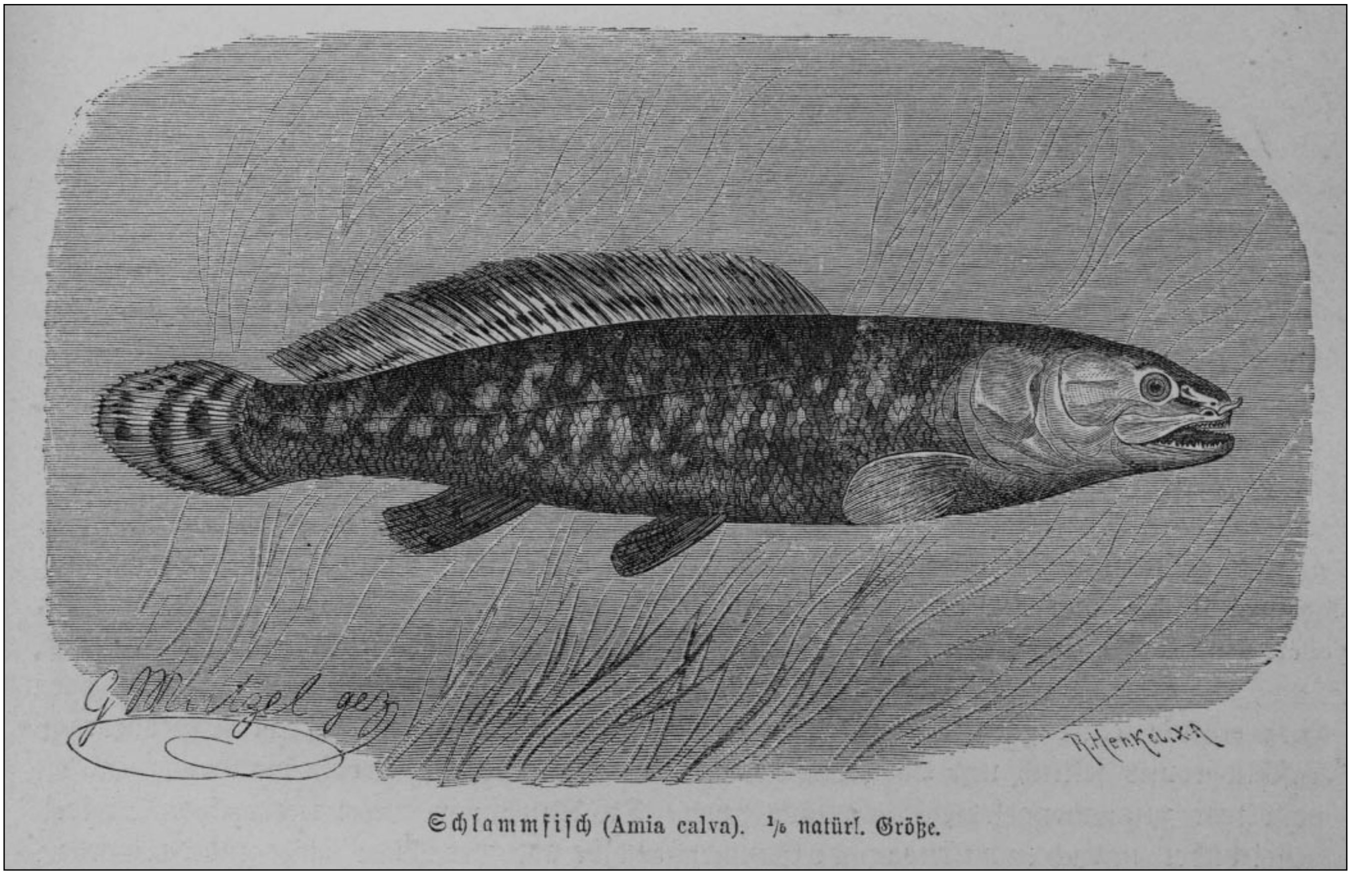

Fig. 1.
Nineteenth-century illustration of a bowfin (Brehm and Hacke, 1892).

west of De Witt, Arkansas. Pools were located just outside Wrape Plantation, Bayou Meto Wildlife Management Area. GPS coordinates for the bowfin pool were: N 34° 12.407’ W 091° 34.957’. The pool in question—the middle pool in a chain of three pools connected by culverts—measured 7 m by 36 m. Depth was 8 to 30 cm. Water was a bit murky (21 NTUs), basic (pH=8.2), with low conductivity (<70 μS/cm). Dissolved oxygen was low and varied little between early morning (3.7 mg/l) and late afternoon (4.1 mg/l). Water temperature, however, was cool in the morning (20.3°C) and warm in the afternoon (27.5°C). Pool vegetation consisted of emergent grasses and forbs, pondweed (*Potamogeton* sp.), and thick clumps of filamentous algae. The pool was located near the edge of some woods, but no canopy was directly overhead.

Other pool inhabitants were banded pygmy sunfish (*Elassoma zonatum*), western mosquitofish (*Gambusia affinis*), golden topminnow (*Fundulus chrysotus*), starhead topminnow (*Fundulus dispar*), and green sunfish (*Lepomis cyanellus*). The banded pygmy sunfish and western mosquitofish were all comparatively large specimens, which we suspect was a result of size-specific predation by the bowfin on smaller fishes. Absent were larval marbled salamanders (*Ambystoma opacum*), which were found in nearby fishless pools, but we did collect frog tadpoles (*Rana* sp.) and spotted newt (*Notophthalmus viridescens*). Co-occurrence of bowfin with tadpoles and newts was interesting in light of a recent study demonstrating that the fish is not a significant predator on amphibians (Jordan and Arrington, 2001).

The bowfin were abundant, our fieldwork was almost complete, and some of our tanks back at Waterways Experiment Station were uninhabited. So we decided to collect some live specimens for observation in our laboratory streams. We half-filled a large cooler with water from the pool, equipped it with battery-operated aerators, and used that to bring 43 of the fish to Vicksburg, Mississippi. Since this would be our first laboratory study of bowfin, we took special interest in laboratory accommodations provided by previous bowfin biologists.

Ganoid Under Glass

Burt Green Wilder, a scientist of dazzling versatility[1], was the first professor of zoology at Cornell University and the first biologist on record to maintain bowfin in laboratory aquaria (Fig. 2). During the 1870s, he studied development, anatomy, behavior, and physiology of ganoid[2] fishes (Wilder 1875, 1876a, 1876b, 1877a, 1877b). Professor Wilder fed his bowfin crayfish, pea crabs, chicken liver, and tadpoles. His holding tanks and experimental chambers, unfortunately, are not described in any detail, but the latter apparently consisted of a hodgepodge of tubs, glass funnels, and bell jars. He used these to house bowfin for brief periods and to collect exhaled bubbles of gas which he chemically analyzed to prove that the fish extracted oxygen from gulped air. These chambers were sufficiently portable, and the behavior and the physiology of the bowfin sufficiently predictable, that Professor Wilder was able to perform a "road-show" demonstrating this aspect of his research. On 3 April 1878, at the general meeting of the Boston Society of Natural History, Professor Wilder exhibited "living examples of the western mud-fish," where he collected and analyzed exhaled air in front of an audience of scientists (Anonymous, 1878).

During the last two decades of the 19th century, Professor Wilder's interests were increasingly dominated by his neurological work, not the least of which was the creation of the Cornell Brain Collection, one of the largest (and most celebrated) collections of bottled human brains ever assembled. The professor had one final fling with the bowfin, however, and it was a follow-up to an anatomical discovery he had made nearly a decade earlier. Back in 1875, he reported finding a pair of small "serrated organs" behind the operculum of the bowfin, which he theorized were degenerative structures (Wilder, 1876a). In subsequent years, other biologists were able to observe these same structures, but they disagreed with Wilder saying that the structures assisted with gill movements. In 1885, Professor Wilder rose to the challenge by devising an experiment that required surgical modification of a bowfin. He took a live fish and removed the structures, now called serrules, but only from one side of the fish's head. After a brief period of post-surgical recovery, the fish was placed in "long jars suspended over the heads of observers" who then looked for impaired gill movements on each side of the fish (Wilder, 1886). No difference could be seen consistently by the observers and the diagnosis of the little bones as degenerative organs was demonstrated. Those bones are now known to be remnants of the clavicle ("collarbone") and either the interclavicle or scales (Grande and Bemis, 1998).

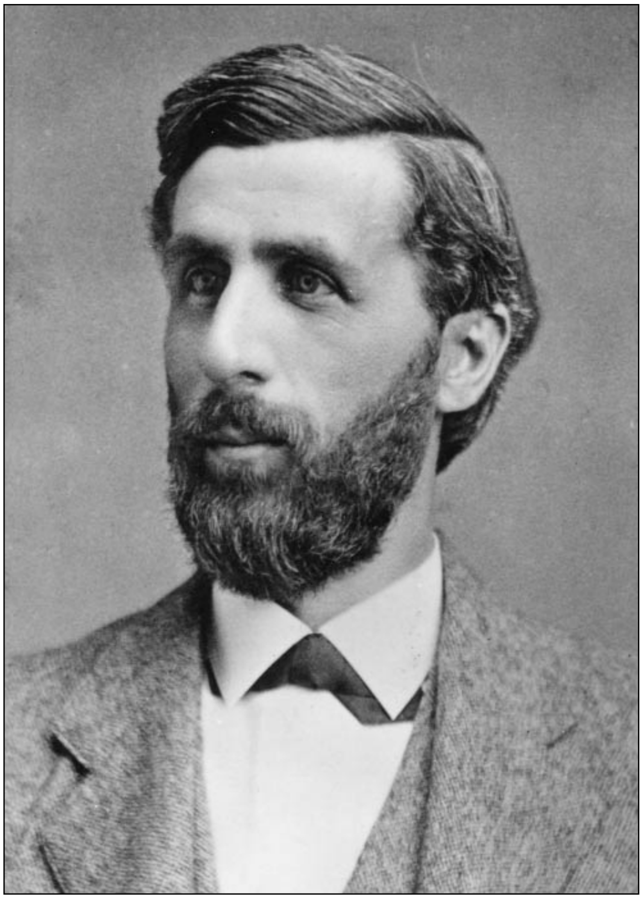

Fig. 2. Burt Green Wilder, bowfin aquarist and advocate. Photograph courtesy of Division of Rare and Manuscript Collections, Cornell University Library (source: Burt Green Wilder Faculty Biography Folder, Wilder Quarter Century book, QL3 W66).

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[1] Burt Green Wilder (1841-1925) published more than 130 scientific papers during a career spanning more than 50 years. He is best remembered for his work with spiders and vertebrate brains, but he also served as a Civil War surgeon, wrote how-to articles, invented a system for taking and organizing notes, and created a museum of natural history. Of fishes (other than bowfin), he conducted research and published articles on sharks, rays, chimeras, paddlefish, sturgeon, and gars. One of his papers on gars was a monographic popular article on development and biology (Wilder, 1877b). His technical papers on aerial respiration in the bowfin were ground-breaking (Wilder, 1875, 1877a), and they were soon summarized in scholarly European references (e.g., Brehm and Hacke, 1892) and are still cited in modern publications (e.g., Hedrick and Jones, 1993). A definitive biography of Professor Wilder has not been written, but a "biographical sketch" was published during the Professor's lifetime (Watson, 1896). Also, the entertaining story of Professor Wilder's acquisition of the brain of the first gorilla to travel to North America was published in *Natural History* magazine (Kennedy and Whittaker, 1976).

[2] The term "ganoid" was formerly used to collectively refer to bowfin, gars, paddlefish, and sturgeons (Hildebrand, 1944). These groups are all ancient, and although very different from each other they share several characteristics. They have a gas bladder that connects directly to the gut, a spiral valve in the intestine, and a tail in which the upper lobe of the caudal fin is longer and thicker than the lower lobe. Three of the groups have distinctive rhomboid enamel-covered scales. Bowfin, however, have round, cycloid scales like many groups of modern fishes. The term ganoid is now used principally to describe the prominent scales of gars and, to a lesser extent, the inconspicuous caudal scales of paddlefish and sturgeons. Although phylogenetically and taxonomically imprecise, it is still a convenient term for referring to the ancient fishes of North America.

After demonstrating that the serrules had no function, a vindicated Professor Wilder wrote: "Useful organs are common enough. The morphological significance of useless organs is so great that their number should not be diminished through error of observation or interpretation" (Wilder, 1886). It's an odd quote, but a highly appropriate one for a fish that is perceived by many as useless, but which actually possesses a biological significance sufficiently great to repeatedly captivate the interest and imagination of experimental ichthyologists.

Occupant of Experimental Chambers

Michael Horn and Carl Riggs were interested in the respiration of bowfin and maintained six adults (400-480 mm TL) in separate 190-liter aquaria for a 77-day experiment (Horn and Riggs, 1973). The tanks were covered and ventilated but had no mechanical aeration. Water temperature was raised at regular intervals from 4.4°C to 35.2°C to evaluate effects of temperature on rate of air breathing. Because it was not feasible to keep all six bowfin under constant surveillance, a ping-pong ball was suspended on the water's surface and connected to a recording device. This documented each time a fish surfaced. Surfacing made ripples that made the ball bounce, which jiggled a thread connected to a photoelectric cell and physiograph. The Horn and Riggs study showed that bowfin were relatively inactive at temperatures <10°C, but above that air-breathing increased with temperature. Mortality occurred at 35°C. Horn and Riggs also showed that bowfin surfaced more at night than during the day.

William Reynolds conducted another study of bowfin activity patterns and temperature responses, but instead of an ordinary tank he used an unusual test chamber called the Ichthyotron. The Ichthyotron was a large (approximately 600-liter) aquarium, equipped with electronic sensors and devices for raising and lowering temperatures in different sectors of the tank (Reynolds, 1977). Unlike other kinds of environmental chambers in which the scientist is in control, the Ichthyotron allowed the fish to regulate the temperature. The electronic gadgetry detected and kept track of the fish's movements as it shuttled between sectors of the tank, and raised and lowered water temperatures appropriate to the fish's preferences. With the Ichthyotron, Reynolds and two co-workers determined that the preferred water temperature of bowfin was a warm 30.5°C overall, 28.8°C at night, and 31.3°C during the day (Reynolds et al., 1978). Unlike Horn and Riggs, Reynolds and colleagues were not able to detect any diel differences in activity, but due to a "transient malfunction of the Ichthyotron" they were able to show that a bowfin could survive indefinitely after a two-hour exposure to a water temperature of 35.5°C.

Michael Hedrick and D. R. Jones (1993) also studied air-breathing in bowfin. They placed individual adult fish in a 68-liter aquarium, 60 x 30 x 38 cm. This aquarium, though, had a barrier at the water's surface with a single round hole, 196 cm^2 or 100 cm^2, through which the fish could surface to breathe air. The hole was covered with an inverted funnel, not too dissimilar from Professor Wilder's methodology of long ago. Instead of simply collecting exhaled air, however, changes in air flow were measured (i.e., with a pneumotachograph). A video camera recorded the fish's air-breathing antics and the time they occurred (via a clock placed within the camera's visual field). Hedrick and Jones discovered that bowfin have two types of breaths: Type I, exhalation followed by inhalation; and Type II, inhalation only. Subsequent experiments in which fish were exposed to various aerial and aquatic oxygen concentrations indicated that the breaths probably have different functions: Type I for gas exchange, Type II for buoyancy regulation.

Resident of the Laboratory

Our bowfin were housed in three types of laboratory aquaria: a) a 347-liter Ferguson flume, their principal residence for six months; b) a 300-liter Living Stream, in which they recovered from swimming tests for several weeks; and c) a 100-liter Blazka swim tunnel, in which they were tested once for swimming endurance (Hoover et al., 1999). In these aquaria, our bowfin exhibited all of the habits which endear them to their owners: air-breathing, slow swimming, inter-specific predation, intraspecific aggression, and hardiness. Individually, these habits may seem less than dramatic to the uninformed aquarist, but together they constitute a complex and distinctive behavioral repertoire that make the bowfin unique among aquarium fishes.

In any aquarium, as in nature, bowfin rise to the surface at varying intervals to gulp air which they can pass into their gas bladder. The long gas bladder, opening off from the gut, is highly subdivided and well-vascularized, so that it very much resembles a lung in appearance and function (Wilder, 1877b). When fish are surfacing, bubbles sometime escape from their mouth on ascent and from their operculum as they descend. Professor Wilder demonstrated the necessity of atmospheric air to bowfin by conditioning a fish to being hand-held about the middle of its body (Wilder, 1875). This fish, when manually restrained from surfacing, became uneasy, released a bubble of air into the water, relaxed, and then became uneasy again. It then "moved rapidly to and fro, turned and twisted, and lashed with its tail," escaping to the surface where it emitted no bubble but rather gaped widely apparently to gulp in a large quantity of air (Wilder, 1875). Wilder also noted that air-breathing increased in frequency when the water was foul or had not been changed recently.

Water in the Ferguson flume housing our bowfin was continuously circulating, but we observed that fish surfaced much more frequently when they were first collected rather than after they had become acclimated to their tank. The day after fish were first established in the flume, an average bowfin would surface up to three times/minute, the following week approximately two times/minute, but in later months might not surface at all for long periods of time. Professor Wilder noted that a bowfin in freshly drawn water would not surface for three hours, but would subsequently surface every 2-8 minutes, unless the water was aerated, in which case it would not surface again for another hour (Wilder, 1877a).

Some fish, like gars, can breathe air like a bowfin, but no other fish in the freshwaters of North America moves like a bowfin. Its distinctive mode of swimming earned it special recognition, and special display tanks at public aquaria in the early 20th century (Pycraft, undated; Gillespie, undated). So distinctive is this method of locomotion that it is given the eponymous term "amiiform." Head-to-tail undulations of the dorsal fin are used to move the fish forward at low speed, and eel-like undulations of the body are used to move the fish forward at higher speed (Breder, 1926). This forward motion can be slowed by holding the body and dorsal fin straight; it can be stopped and reversed by undulating the dorsal fin backwards (from tail-to-head). Stopping can also take place by holding the pectoral fins out to "back water," which is somewhat like "applying the brakes."

At any single time, all of these behaviors were observable in the flume housing the fish. Some fish would creep forward using only their dorsal fin for propulsion; others would zip along rapidly wagging their tails in sloppy arcs; some would hold position by alternating the undulations of their dorsal fin. Fish rarely inhabited the upper water column, however, preferring to remain near or on the tank bottom. In the swim tunnel, bowfin used dorsal fin and body undulations together to maintain position, but this style of swimming worked best only in slow water. Bowfin exhibited sustained swimming (for hours) when water was barely moving forward at 5 cm/s, prolonged swimming (for minutes) at 10-35 cm/s, and burst swimming (for seconds) at 40-55cm/s.

In the flume and in the Living Stream, our bowfin fed almost exclusively from the bottom or near the bottom of the tank. Even after months in captivity, familiar foods, such as shrimp chunks and frozen bloodworms, could drift down directly in front of the bowfin, triggering little or no response. But once the food struck the bottom, or began to drift along the bottom, the same foods were eagerly devoured. Our bowfin accepted nearly all live prey offered to them, including dragonfly naiads, juvenile crayfish, minnows, mosquitofish, and young sunfishes. They also accepted live mealworms, but ate them with less enthusiasm than other kinds of prey.

Bowfin were able to ingest comparatively large pieces of food or feeder fish, easily engulfing them with their large gape, but it was not uncommon to see bowfin strike at and miss some minnows. Differences in swimming abilities may account for this and for the close co-existence of bowfin and their prey. Bowfin are adapted for slow, careful swimming, and most minnows for faster, sustained swimming. Bowfin can swim 25 cm/s only for about four minutes (unpublished data), but golden shiner can swim that speed for 30 minutes or longer (Boyd and Parsons, 1998). Golden shiner use bowfin nests as their own spawning sites (Katula, 1994; Katula and Page, 1998). They may be able to do so because of greater agility or greater swimming endurance than their predatory nestmates.

Intraspecific aggression among bowfin is well known. Ray Katula remarked that they are prone to snack on their siblings, trying to swallow others that are nearly their size (Katula, 1998). Jay Huner, raising 50 fish in a flow-through aquarium, lost many of his fish to aggression and/or cannibalism (Huner, 1994). Our experiences were less dramatic. We frequently saw face-offs among tankmates, particularly over choice food, but these did not result in death or injury beyond occasional torn fins. An exception to this took place 1 June 2001, nearly a month after collecting the fish. Two bowfin, recovering after swimming tests, were placed in the Living Stream. They had been fed early in the morning, but two hours later one of the fish, which was fairly robust, attacked another, which was fairly slender, grabbing its peduncle in its jaws and shaking it like a dog would with a rag. Shortly afterwards that fish was dead. On 20 June and again on 28 June 2001, we found a single bowfin head at the bottom of the flume, the body of the fish apparently having been eaten by its tankmates. These three instances were the only known cases of intraspecific attacks, and in the latter two instances it is unknown whether the bowfin was alive or dead prior to being eaten.

Mortality of the Bayou Meto bowfin was fairly low. During the May-November study period, 14 of the 43 fish

(32%) died. Of these 14 fish, however, all had died during a six-week period (17 May 2001 to 28 June 2001) during which 11 had been subjected to swimming endurance trials, and all but two were comparatively small (73-85 mm). Mortality may have resulted from combined effects (direct or indirect) of the trials and the small size of the fish. Swimming at high speeds or for long periods may be physiologically stressful to smaller bowfin. There was only a single instance, however, of a fish dying within 48 hours of a test, and a large majority (29/40 or 72%) of fish tested survived, and thrived, for months following the tests. Of the 29 survivors alive at the end of final swimming trials, all were still alive on 28 January 2002, almost nine months after collection, and seven months after their endurance trials.

Over a hundred years ago, Professor Wilder extolled the convenience of bowfin for experimental work, saying they were hardy and unlikely to bite. Our experiences confirmed this. Bowfin were very convenient to work with, they were very hardy, and not one of us has yet been bitten.

Acknowledgments

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Literature Cited

Anonymous, 1878. Prof. B. G. Wilder, of Cornell University exhibited to the Society, living examples of the western mud-fish, *Amia calva*. *Proceedings of the Boston Society of Natural History* 19: 337.

Boyd, G. L., and G. R. Parsons. 1998. Swimming performance and behavior of golden shiner, *Notemigonus crysoleucas*, while schooling. *Copeia* 1998 (2): 467-471.

Breder, C. M., Jr. 1926. The locomotion of fishes. *Zoologica* 4: 159-297.

———. 1936. Long-lived fishes in the aquarium. *Bulletin of the New York Zoological Society* 39: 116-117.

Brehm, A. E., and W. Hacke. 1892. *Die fische*. Leipzig: Brehm's Tierleben, Bibliographisches Institut.

Frey, H. 1961. *Illustrated dictionary of tropical fishes*. Jersey City, N.J.: TFH Publications. [Originally titled *Das aquarium von A bis Z*, published in East Germany in 1958 and 1959.]

Gillespie, T. H. Undated. Animal hands and feet—how the animals got them and what they did with them. Pp. 879-894 in *Wonders of Animal Life*, J. A. Hammerton (Ed.). London: Waverley Book Company, Ltd. [Estimated date of publication of this book by antiquarian book dealers ranges from 1930 to 1935.]

Grande, L., and W. E. Bemis. 1998. A comprehensive phylogenetic study of amiid fishes (Amiidae) based on comparative skeletal anatomy. An empirical search for interconnected patterns of natural history. Society of Vertebrate Paleontology Memoir 4: i-x, 1-690; supplement to *Journal of Vertebrate Paleontology* 18 (1).

Hedrick, M. S., and D. R. Jones. 1993. The effects of altered aquatic and aerial respiratory gas concentrations on air-breathing patterns in a primitive fish (*Amia calva*). *Journal of Experimental Biology* 181: 81-94.

Hildebrand, S. F. 1944. Fishes. Pp. 1-155 in *Fishes, amphibians, and reptiles—cold-blooded vertebrates*, C. G. Abbott (Ed.). Washington: The Smithsonian Series, Vol. VIII.

Hoover, J. J., K. J. Killgore, and S. R. Adams. 1999. Juvenile pallid sturgeon in laboratory aquaria. *American Currents* 25 (4) [Fall]: 1-6.

Horn, M. H., and C. D. Riggs. 1973. Effects of temperature and light on the rate of air-breathing of the bowfin, *Amia calva*. *Copeia* 1973: 653-657.

Huner, J. V. 1994. Bowfin culture at the University of Southwestern Louisiana. *Aquaculture Magazine* 20 (5) [Sept.-Oct.]: 28-37.

Jordan, F., and D. A. Arrington, 2001. Weak trophic interactions between large predatory fishes and herpetofauna in the channelized Kissimmee River, Florida, USA. *Wetlands* 21: 155-159.

Julian, T. W. 1974. *The Dell encyclopedia of tropical fish*. N.Y: Vineyard Books.

Katula, R. 1994. Golden shiner (*Notemigonus crysoleucas*) utilizing bowfin (*Amia calva*) nest as spawning site. *American Currents* Fall: 26-29.

———. 1998. The amazing Amiidae—bowfins of North America. *Tropical Fish Hobbyist* 48 (1) [Sept.]: 58-64.

———, and L. M. Page. 1998. Nest association between a large predator, the bowfin (*Amia calva*) and its prey, the golden shiner (*Notemigonus crysoleucas*). *Copeia* 1998 (1): 220-221.

Kennedy, K. A. R., and J. C. Whittaker. 1976. The ape in stateroom 10. *Natural History* 85 (9): 48-53.

Page, L. M., and B. M. Burr. 1991. *A field guide to freshwater fishes of North America north of Mexico*. Peterson Field Guide Series 42. Boston: Houghton Mifflin.

Pycraft, W. P. Undated. Travelling without legs or wings. Pp. 603-616 in *Wonders of Animal Life*, J. A. Hammwerton (Ed.). London: Waverley Book Company, Ltd.

Quinn, J. R. 1990. *Our native fishes: the aquarium hobbyist's guide to observing, collecting, and keeping them*. Woodstock, Vt.: Countryman Press.

Reynolds, W. W. 1977. Fish orientation behavior: an electronic device for studying simultaneous responses to two variables. *Journal of the Fisheries Research Board of Canada* 34: 300-304.

———, M. E. Casterlin, and S. T. Millington. 1978. Circadian rhythm of preferred temperature in the bowfin *Amia calva*, a primitive holostean fish. *Comparative Biochemistry and Physiology* 60A: 107-109.

Schleser, D. M. 1998. *North American native fishes for the home aquarium*. Hauppage, N.Y.: Barron's Educational Series.

Watson, I. A. 1896. *Physicians and surgeons of America (illustrated). A collection of biographical sketches of the regular medical profession.* Concord, N.H.: Republican Press Association.

Wilder, B.G. 1875. Notes on the American ganoids. I. On the respiratory actions of *Amia* and *Lepidosteus*. II. On the transformations of the tail of *Lepidosteus*. III. On the transformation of the pectoral fins of *Lepidosteus*. IV. On the brains of *Amia*, *Lepidosteus*, *Acipenser*, and *Polyodon*. *Proceedings of the American Association for the Adancement of Science* 24: 151-193.

———. 1876a. On the serrated appendages of the throat of *Amia*. *Proceedings of the American Association for the Adancement of Science* 25: 259-263.

———. 1876b. On the tail of *Amia*. *Proceedings of the American Association for the Adancement of Science* 25: 264-266.

———. 1877a. On the respiration of *Amia*. *Proceedings of the American Association for the Adancement of Science* 26: 306-313.

———. 1877b. Garpikes, old and young. *Popular Science Monthly* 9: 1-12, 186-195.

———. 1886. Experiments antagonizing the view that the serrulae (serrated appendages) of *Amia* are accessory respiratory organs. *Proceedings of the American Association for the Adancement of Science* 34: 313-315.

Would You Want the "Freedom Darter" To Go Extinct?

A Vernacular Approach to Fish Conservation

North America's fishes need all the help they can get. And perhaps having common names that the general public can better relate to can help. Take, for example, the snail darter. Based on its common name alone, the fish doesn't sound particularly worth saving, does it? But suppose for a moment that its official common name was "freedom darter." Would you want a fish named for the very principle that defines our country to go extinct? Freedom's worth fighting for, isn't it? But who's willing to fight for a snail?

Suppose you were a corporation dumping chemical waste into the freedom darter's stream, or a power company building a dam that would destroy its habitat. Would you want to hear a TV news reporter saying your company's name and "causing the extinction of the freedom darter" in the same sentence? Would you want to go down in history books as responsible for the "freedom darter's" demise?

This got us to thinking. What if "cold slimies" like fish were given "warm, fuzzy" and patriotic common names as a form of public relations "protection"? No, we're not suggesting that already named fishes get new ones. Instead, what if the many undescribed fishes known from our waters were given more "popular" popular names from here on out? Forget whether these names have any descriptive value. We're talking conservation here!

We put the question to NANFA's e-mail list and asked list members to submit prospective fish names with built-in mass appeal. Here are some of the best ones:

- teddy bear topminnow
- cuddly sculpin
- Charlie Brown sucker
- charity shiner
- independence pupfish
- Lincoln logperch
- Bambi madtom
- Valentine dace
- yankee doodle darter
- hoosier chub
- Jordan jumprock
- coal miner's darter

Win a free NANFA membership. Can you think of any names to add to the list? If so, send them to us. We will review them and publish the best ones in the next *AC*. In addition, NANFA's Board of Directors will select the very best name and award its creator with a free NANFA membership for a year. (NANFA Directors and Officers may submit names, but are ineligible to win the prize.) Entry deadline is Sat., Sept. 14, 2002. Send them via e-mail to ichthos@charm.net, or via snail (freedom?) mail to NANFA, 1107 Argonne Dr., Baltimore, MD 21218.