Madtoms: Some Cool Cats

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Dr. Robert Wallus, co-author of *Reproductive Biology and Early Life History of Fishes in the Ohio River Drainage Volume 3: Ictaluridae—Catfish and Madtoms*, described catfishes as "fun to catch, good to eat, and the little ones are cute. A catfish is a gift from God in a slimy suit." The "little ones" Dr. Wallus is referring to are madtoms.

My first exposure to madtoms occurred during my undergrad days while I was working as a fisheries biologist aide. One of my duties was teaching kids how to fish. During one outing to a nearby lake, I helped a youngster reel in his first fish. He grinned from ear to ear and shouted, "Mr. T! Mr. T! I caught a catfish!" As he brought his catch to me, I realized his fish was not a "normal" catfish, but a stonecat, a species of madtom. Awestruck by this tiny, yet magnificent, creature, I brought the fish back to the office for public display. Ever since then, madtoms have had a special place in my heart, and are at the center of my fascination with fishes.

Diversity, Distribution, Habitat, and Conservation Threats

Madtoms are small (typically <12.5 cm), short-lived (typically <3 years) catfishes belonging to the genus *Noturus* of the North American catfish family Ictaluridae. Madtoms have long and low adipose fins joined to, or slightly separated from, their caudal fins, which distinguishes them from other ictalurids (e.g., bullhead catfishes, channel catfish).

Endemic to eastern North America, madtoms occur east of the Rocky Mountains (except for the tadpole madtom, *N. gyrinus*, which was introduced into the Snake River Basin in the Pacific Northwest). Depending on the species, madtoms can be found in just about any aquatic habitat, from lakes and stream pools to stream riffles with clean substrate and moderate current (Table 1). Over half of the *Noturus* species have highly restricted ranges, with some being found in only one stream basin (Burr and Stoeckel, 1999). Madtoms hide in or beneath objects during the day, and come out to prey mainly on aquatic macroinvertebrates during the night.

Noturus, the largest genus in the family Ictaluridae, contains three subgenera: *Noturus*, *Schilbeodes* and *Rabida* (Page and Burr, 1991). Distinguishing characteristics among these groups include premaxillary tooth patch (backward extension vs. no backward extension); pectoral spine (straight and without well-developed saw-like teeth on front edge vs. curved and with saw-like teeth on front and rear edges); dark blotches on back and fins (present vs. absent); and upper jaw (equal with lower jaw vs. projecting beyond lower jaw).

With the recent addition of the piebald madtom (*N. gladiator*), there are now 26 described species of madtoms (Thomas and Burr, 2005). Five of these species (Table 1) are federally listed either as threatened or endangered by the U.S. Fish and Wildlife Service (Burr and Stoeckel, 1999). There are approximately 10 undescribed forms of *Noturus* species (Burr and Stoeckel, 1999).

One of the greatest threats to madtoms is habitat destruction from anthropogenic (man-caused) disturbances, including environmental contaminants (Wildhaber et al., 2000) and impoundments (Tiemann et al., 2004). Management efforts, including understanding madtom reproductive behaviors and habits, are important for the conservation of *Noturus* species (Burr and Stoeckel, 1999). However, data on reproduction are limited for this secretive genus. Several groups, including government agencies, universities, and private not-for-profit organizations, are working hard to understand madtom reproduction.

Madtom tidbits

Data taken from Page and Burr (1991) and Burr and Stoeckel (1999).

- The pygmy madtom (*N. stanauli*) is the smallest madtom (maximum size: 5 cm), whereas the stonecat (*N. flavus*) is the largest (maximum size: 30 cm).
- Some madtom species are annual species, whereas other species can live 5+ years.
- *Noturus* dates to the Pleistocene of South Dakota.
- The Scioto madtom (*N. trautmani*) was last seen alive in 1957.
- The southern Ohio River basin has the highest species diversity for *Noturus*.
- The tadpole madtom (*N. gyrinus*) and the stonecat (*N. flavus*) are the most widely distributed madtoms.
- Five species of madtoms have ranges extending into Canada, and one species extends to the U.S.-Mexican border in the Rio Grande.

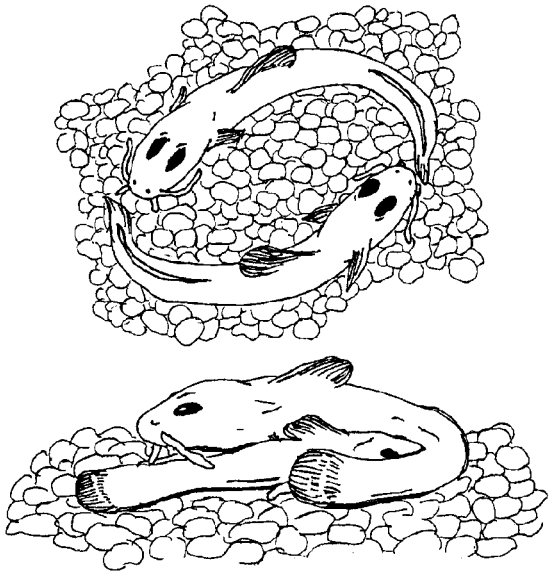

Fig. 1.
Top: "Carousel courtship" behavior of Neosho madtom, *Noturus placidus*; male and female swim in circles head to tail near substrate. Bottom: "Tail curl" courtship behavior of Neosho madtom; male and female lie above substrate with tail of male wrapped around head of female while both quiver. Text and illustration from Bulger et al., 2002.

Madtom Reproduction

Certain reproductive traits seem fairly consistent within *Noturus* congeners (an organism belonging to the same genus as another organism) (Burr and Stoeckel, 1999). Madtoms are believed to:

1) develop secondary sexual characteristics (spawning males have enlarged cephalic epaxial muscles, swollen lips, and swollen genital papillae, whereas spawning females have distended abdomens and distinctive genital papillae shapes); sexual dimorphism happens as the water temperature approaches 20°C;
2) create cavities for spawning, either in human refuse (e.g., cans or bottles) or underneath natural structures (e.g., rock slabs) that they excavate either by moving substrate in their mouths or by fanning substrates with their caudal fins; nest building (e.g., selection and preparation) often is the responsibility of the male and occurs as the water temperature approaches 20°C;
3) display courtship behaviors that include "carousel" and "tail curl" displays (Fig. 1) in which the male and female spin in circles head-to-tail, then quiver with the male's tail wrapped around the female's head[1]; spawning occurs as the water temperatures approaches 25°C;
4) deposit relatively few (typically <100 eggs), but relatively large (typically ~3.5 mm) eggs for their body size that are amber in color, spherical in shape, and adhere to one another in irregular masses; egg-laying occurs within three days following the embracing display, and the male usually chases the female out of the nest after the pair finish spawning;
5) exhibit parental care of eggs, usually by the male, with egg care behaviors including mouthing, rubbing, fanning, and possibly rolling; parental care takes place up to three weeks following egg-laying;
6) produce well-developed young that hatch in the mesolarval stage; hatching occurs after about seven days at water temperatures of 25°C; and
7) demonstrate parental care of the larvae, usually by the male, by fanning nests but not escorting free-swimming juveniles outside of nests; larvae absorb yolk sacs by 15 days at 25°C.

Madtom reproductive studies typically involve direct observations in order to document behaviors and habits. The above

[1] A female can use her head to systematically rub the male from the abdomen to the urogenital pore, thus possibly stimulating the male for sperm production (J. L. Albers and M. L. Wildhaber, per comm.).

Table 1. The 26 species of madtoms, their ranges, and their habitat preferences; data from Page and Burr (1991) and Thomas and Burr (2005). [1] Introduced into MA & NH and into Snake River basin (ID & OR). [2] Introduced into Merrimack River (NH) and Tennessee River basin (VA & TN); absent in Appalachian and Ozark Highlands. [3] Introduced into James River (VA). [FE] = federally endangered. [FT] = federally threatened.

Species	Range	Habitat
stonecat, *Noturus flavus*	basins of Great Lakes, Mississippi River, and Hudson River (QC east to AB, south to AL, west to OK)	rocky riffles and runs of creeks and small to large rivers; rocky shoals of lakes
tadpole madtom, *Noturus gyrinus* [1]	basins of Great Lakes, Mississippi River, and Hudson River; Atlantic & Gulf Slope drainages (QC, east to AB, south to FL, west to TX)	muddy/rocky bottomed pools and backwaters of lowland creeks and small to large rivers; lakes
Ouachita madtom, *Noturus lachneri*	Upper Saline River basin and a small trib of Ouachita River (AR)	rocky pools, backwaters, and runs of clear swift creeks and small rivers
speckled madtom, *Noturus leptacanthus*	Atlantic & Gulf Slope drainages (LA, east to SC, south to FL)	near vegetation in sandy/rocky runs and rocky riffles of creeks and small to medium rivers
brown madtom, *Noturus phaeus*	tribs of lower Mississippi River and Tennessee River; Gulf Slope drainages (LA, east to MS, north to KY)	sandy/rocky riffles and runs along debris, rocks, and undercut banks of springs, creeks and small rivers
black madtom, *Noturus funebris*	Gulf Slope drainages (MS, east to MS, south to FL)	near vegetation in moderate to fast, clear water over sand/rocks in springs, creeks and small rivers
freckled madtom, *Noturus nocturnus*	Mississippi River basin; Gulf Slope drainages (IA, west to IN, south to AL, west to TX)	sandy/rocky riffles and runs near debris and among tree roots along undercut banks in creeks and small to large rivers
slender madtom, *Noturus exilis*	sporadic throughout Mississippi River basin (MN, southeast to AL, west to OK)	rocky riffles, runs, and flowing pools of clear creeks and small rivers
margined madtom, *Noturus insignis* [2] (Fig. 2d)	Atlantic Slope drainages (ON, south to GA)	rocky riffles and runs of clear, fast creeks and small to medium-sized rivers
orangefin madtom, *Noturus gilberti* [3] (Fig. 2c)	Upper Roanoke River basin (VA & NC)	rocky riffles and runs of clear, swift small rivers
least madtom, *Noturus hildebrandi*	Mississippi River tribs (KY, south to MS)	sandy/rocky riffles and runs of clear lowland creeks and small rivers, often near debris
pygmy madtom, *Noturus stanauli* [FE]	Tennessee River basin (TN)	moderate to swift rocky riffles of clear medium-sized rivers
Smoky madtom, *Noturus baileyi* [FE]	Little Tennessee River basin (TN)	clear, cool rocky riffles, runs, and flowing pools of creeks
Ozark madtom, *Noturus albater*	White River basin (MO & AR)	clear, cool, swift rocky riffles and pools of creeks and small to medium-sized rivers
elegant madtom, *Noturus elegans*	basins of Green River and Tennessee River (KY, southwest to AL)	rocky riffles and runs of clear creeks and small rivers
Caddo madtom, *Noturus taylori*	Ouachita River basin (AR)	rocky riffles and pools near shorelines of small to medium-sized rivers
Scioto madtom, *Noturus trautmani* [FE]	Big Darby Creek (OH)	downstream end of sandy/rocky riffle
Neosho madtom, *Noturus placidus*[FT]	Neosho River basin (KS, MO & OK)	rocky riffles and runs along of small to medium-sized rivers
northern madtom, *Noturus stigmosus*	sporadic throughout Lake Erie and Ohio River basins; lower Mississippi River tribs (MI, east to PA, southwest to MS)	sandy/rocky riffles and runs with debris in small to large rivers, often in swift current
piebald madtom, *Noturus gladiator*	Mississippi River tribs (TN, south to MS)	sandy/rocky riffles and runs of creeks and small rivers
frecklebelly madtom, *Noturus munitus*	sporadic throughout Gulf Slope drainages (TN, south to LA, east to GA)	rocky riffles and runs of medium-sized to large rivers, often near vegetation

Table 1. Cont.

Carolina madtom, *Noturus furiosus*	Neuse River & Tar River basins (NC)	sand-, rock-, detritus-bottomed riffles and runs of small to medium-sized rivers
mountain madtom, *Noturus eleutherus* (Fig. 2a)	sporadic throughout Mississippi River basin (IL, east to PA, south to AL, west to AR)	clean rocky riffles and runs of small to large rivers, often near vegetation
checkered madtom, *Noturus flavater*	upper White River basin (MO & AR)	pools and backwaters of clear small to medium-sized rivers with moderate to high gradients
brindled madtom, *Noturus miurus*	basins of Great Lakes and Mississippi River; Gulf Slope drainages (ON east to NY, south to MS, west to OK)	sandy/rocky riffles, runs, and pools containing woody debris of creeks and small rivers; lakes
yellowfin madtom, *Noturus flavipinnis* FT (Fig. 2b)	Upper Tennessee River basin (VA, southwest to GA)	pools and backwater around slab rocks, bedrock ledges, and tree roots in clear creeks and small rivers

data are generalizations and will vary among species. Video of the spawning of one madtom species, the Neosho madtom (*N. placidus*), can be viewed online at:

www.cerc.cr.usgs.gov/pubs/spawning_movies/Neosho_Madtom_Spawning.html

Noturus are broadly sympatric (occurring in the same or overlapping geographic areas without interbreeding) and normally syntopic (different species found sharing the same habitat within the geographic range of the two), but often are separated by slight habitat differences. As a result, they have evolved reproductively associated morphological features and extremely complex breeding behaviors (Burr and Stoeckel, 1999). Because of this, it is unclear whether all madtoms have the style of breeding behavior described above or displayed in the video. Understanding the reproductive biology and behavior is critical for recovery of imperiled madtoms.

My Experiences Spawning Madtoms

I have had limited success spawning *Noturus* species. My first attempt was in graduate school with the stonecat (*N. flavus*) collected from the Neosho River in Lyon County, Kansas. Following much trial and error with no success, the fish became pets more than they were study subjects. I relocated for my job and decided to try again after experimenting with other fishes—pirate perch (*Aphredoderus sayanus*) and slim minnow (*Pimephales tenellus*)—and reading nearly all literature on *Noturus*. My second attempt—with brindled madtom (*N. miurus*)—is currently in progress. I collected broodstock from two locations: 1) Obion Creek in Hickman County, Kentucky, and 2) the Middle Fork of the Vermilion River, Vermilion County, Illinois. Early results are promising, but still are a long way from complete success. (I have witnessed steps 1-5 listed above, but have yet to see step 6, the hatching of eggs.)

My experimental design I have three aquaria (50 L, 132 L and 150L) housed in rooms with minimal human traffic. All aquaria contain natural substrates (clay/silt, sand, gravel, pebble, and cobble); submerged woody debris (diameters range from ~1 cm to ~5 cm); freshwater mussel valves (paired valves positioned to mimic live freshwater mussels and single valves situated for use as potential shelters); submerged human refuse (0.35 L aluminum cans and 0.47 L plastic "wide-mouth" bottles; and six adult *N. miurus*. All aquaria are kept at ambient light conditions and are allowed an over-wintering period (water temperature down to 10°C for at least 30 days). All aquaria have minimal flow (approximately 0.25 m/s measured with a Swoffer Model 2100 current meter powered by a Fluval underwater filter approximately 7 cm above the substrate). Water temperature is monitored daily, and each aquarium is observed twice a week as water temperature approaches and exceeds 20°C. During each observation, the aquarium is watched twice a day: 0.5 hours after sunset and 0.5 hours before sunrise (even though spawning can occur both day and night). Red light, which has been used in the nighttime observations of many nocturnal fishes, including *N. placidus* (Bulger et al., 2002), is illuminated prior to the dark cycle to allow nighttime behavioral observations. Fish are fed in the evening with commercially available sinking foods five days per week, frozen or live chironomid larvae one day per week, and one day of fasting per week. Because diet and reproductive success have been positively correlated in fishes, the amount of food fed is increased as water temperatures rises above 15°C.

I am hoping to expand my "operation" as time, space, money, and resources permit, with hopes of modeling my

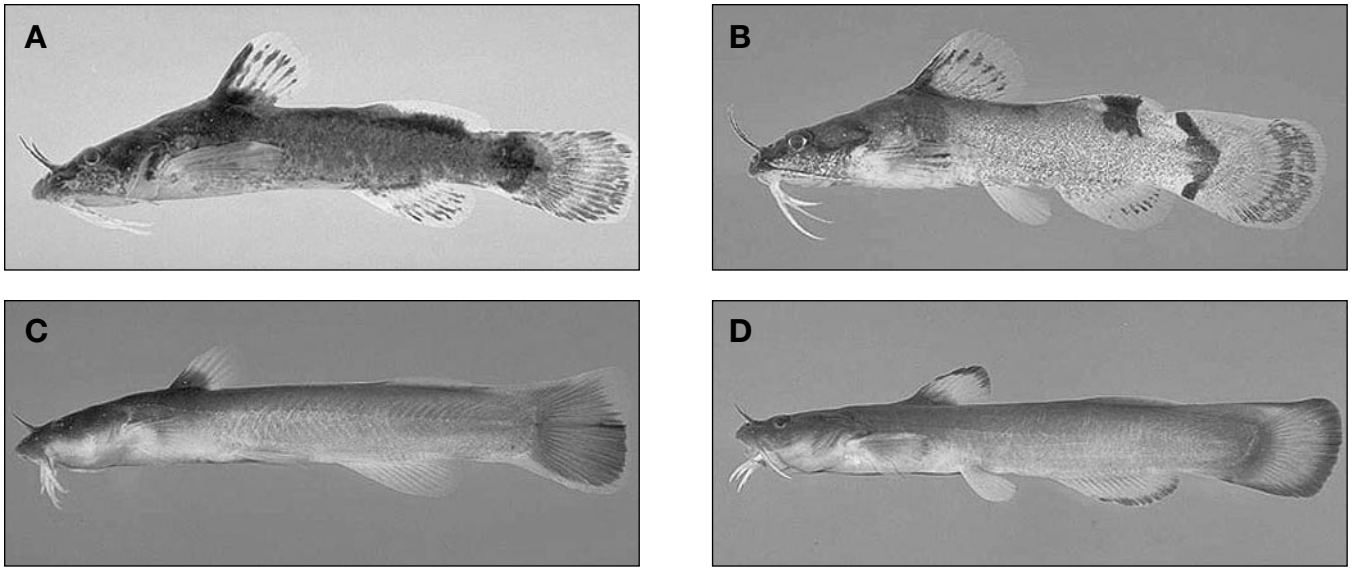

Fig. 2.
(A) mountain madtom, *Noturus eleutherus*. (B) yellowfin madtom, *Noturus flavipinnis*. (C) orangefin madtom, *Noturus gilberti*. (D) margined madtom, *Noturus insignis*. All photos courtesy: The Virtual Aquarium of Virginia Tech (http://www. cnr.vt.edu/efish) and Virginia Department of Game and Inland Fisheries.

studies after Stoeckel (1993). Depending upon my success, future work might include inducing spawning with daily hormonal injections, developing egg-hatching techniques, and developing methods for rearing madtom fry in the laboratory as Stoeckel (1993) did with margined madtom (*N. insignis*).

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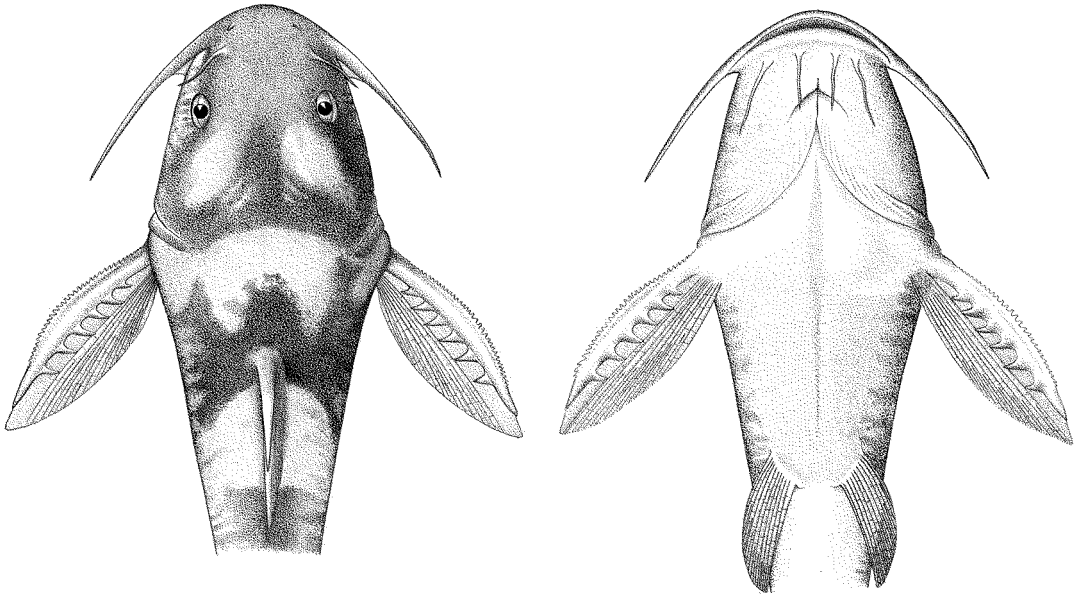

Dorsal and ventral views of the Carolina madtom (*Noturus furiosus*). Drawings by S. F. Denton from the type specimen collected by David Starr Jordan and party from the Neuse River, Raleigh, North Carolina. The name *furiosus* refers to its sting, which Jordan considered to be the most virulent of madtoms. For more on madtoms, see the article by Jeremy Tiemann starting on page 9. Illustrations courtesy of Smithsonian Institution, National Museum of Natural History, Division of Fishes.