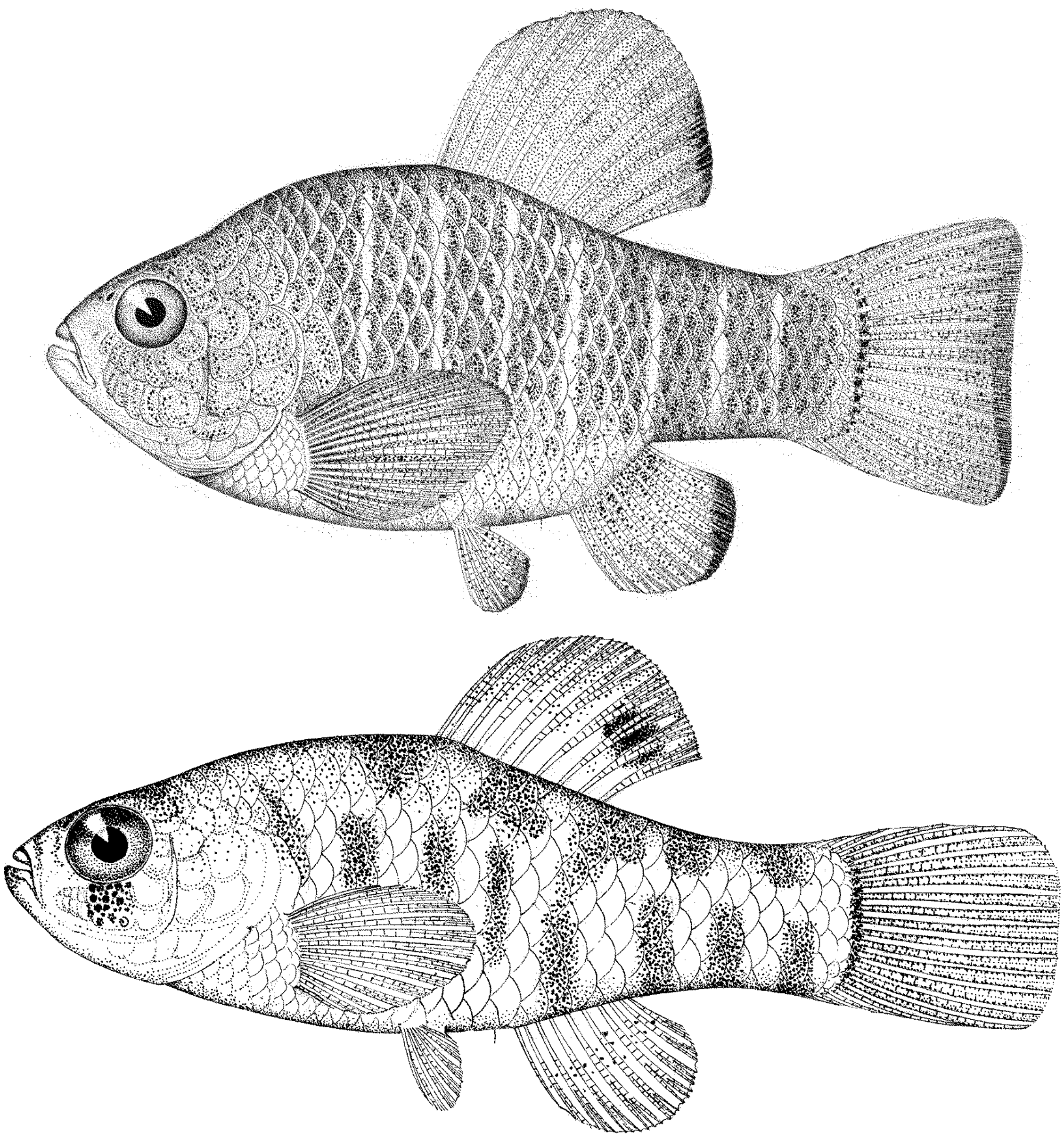
American Currents

Publication of the North American Native Fishes Association

Volume 31 • Number 2 • Spring (May) 2005



In this issue:

The North American Native Fishes Association

est. 1972 · John Bondhus, founder

Mission: The North American Native Fishes Association (NANFA) is dedicated to the appreciation, study and conservation of the continent's native fishes. NANFA is a not-for-profit, tax-exempt corporation chartered in the State of Maryland. The purposes of the organization are: • to increase and disseminate knowledge about native North American fishes; • to promote practical programs for their conservation and the protection/restoration of their natural habitats; • to advance the educational, scientific and conservation benefits of captive maintenance and husbandry; • to encourage the legal, environmentally responsible collection of native fishes for private aquaria as a valid use of a natural resource; and • to provide a forum for fellowship and camaraderie among its members.

Board of Directors

Jan Jeffrey Hoover
Secretary/Board Chair
Librarian, AC Back Issues
Waterways Experiment Station ER-A
3909 Halls Ferry Road
Vicksburg, Mississippi 39180-6199
601-634-3996
hooverj@wes.army.mil

Leo S. Long, Vice President
2629 Sparta Dr.
Troy, Michigan 48083
248-689-8375
lscalong@wideopenwest.com

Christopher Scharpf, AC Editor & Membership Coordinator
1107 Argonne Drive
Baltimore, Maryland 21218
410-243-9050
ichthos@comcast.net

Dustin W. Smith
1229 Walnut Street
Newberry, South Carolina 29108
803-405-1847
dsmith73@hotmail.com

Bruce Stallsmith, President
Conservation Grant Chair
8200 Hickory Hill Lane
Huntsville, Alabama 35802
256-882-2231
fundulus@hotmail.com

Jeremy Tiemann
Illinois Natural History Survey
607 E. Peabody Drive
Champaign, Illinois 61820
217-244-4594
jtiemann@inhs.uiuc.edu

Tom Watson
2408 S. 359th Street
Federal Way, Washington 98003
253-838-6745
onefish2fish@comcast.net

Member Services

Todd Crail
Website Content Administrator
2404 Country Squire
Toledo, Ohio 43615
419-539-6810
todd@farmertodd.com

Rob Denkhaus, Education Grant Chair
Fort Worth Nature Center & Refuge
9601 Fossil Ridge Rd.
Fort Worth, Texas 76135
817-237-1111
Robert.Denkhaus@fortworthgov.org

Bob Muller, Chair,
Breeders Award Program
625 S. Altadena
Royal Oak, MI 48067
248-398-0195
michiganfish@wideopenwest.com

Peter Unmack, Web Technologies Host and Email List Administrator
peter.lists@unmack.net

Stephanie Scharpf, Treasurer
(see Scharpf address under Board)

Nick Zarlinga, Website Contact
njz@clevelandmetroparks.com

Regional Representatives

Charles A. Nunziata, coordinator

AL: Bruce Stallsmith
(see address under Board)

AZ-NV: Peter Unmack
P.O. Box 1454
Tempe, Arizona 85280-1454
480-965-8352
peter.web@unmack.net

FL (central): Charles A. Nunziata
6530 Burning Tree Drive
Largo, Florida 33777
727-393-3757
epiplaty@tampabay.rr.com

GA: Steven A. Ellis
1500 D Diplomat Lane, NW
Kennesaw, Georgia 30144
678-581-9603
sellis@earthlink.net

IL-IN: Ryan DePauw
Spring Brook Nature Center
130 Forest Ave.
Itasca, Illinois 60143
630-773-5572
rdepauw@core.com

MA: Rick Rego
109 McArthur Road
Swansea, Massachusetts 02777
508-678-8306
mummichog@naisp.net

MD: Robert Bock
1602 Tilton Drive
Silver Spring, Maryland 20902
bockhouse@earthlink.net

MI: Leo S. Long
(see address under Board)

MN: Jenny Kruckenberg
1354 Courthouse Blvd.
Inver Grove Hts., Minnesota 55077-3309
651-457-2302
jennyk@usfamily.net

MS: Jan Jeffrey Hoover
(see address under Board)

NY (eastern): Norman Soule
P.O. Box 535
Cold Spring Harbor, NY 11724-0535
516-692-8731
normansoule@optonline.net

NY (central/western): Scott Schlueter
U.S. Army Corps of Engineers
1776 Niagara Street
Buffalo, New York 14207
716-879-4325
Scott.L.Schlueter@lrb01.usace.army.mil

OH: Todd Crail
(see address under Member Services)

SC: Dustin W. Smith
(see address under Board)

TN: Casper Cox
1200 B. Dodds Ave.
Chattanooga, Tennessee 37404-4754
423-624-0721
prizma@aol.com

TX: Rob Denkhaus
(see address under Member Services)

VA: Michael Thennet
5419 Galley Ct.
Fairfax, Virginia 22032
thennet_michael@tmac.com
703-425-5046

WI: Ray Wolff
6510 Helke Road
Wisconsin Rapids, Wisconsin 54494
715-424-0259
choupiqu@wctc.net

NANFA Fellows

John Bondhus
Gerald C. Corcoran (deceased)
Casper Cox
Ray Katula
Christopher Scharpf

American Currents

Publication of the North American Native Fishes Association

Volume 31 ✿ Number 2 ✿ Spring (May) 2005

Christopher Scharpf, editor
Robert Bock, guest editor
Susan Binkley, Rob Denkhaus and Bruce Lilyea, associate editors

SPECIAL THANKS: The editor wishes to thank Bob Bock for serving as guest editor of this issue. Wanting to see more articles about aquarium care, Bob simply went out and got them! Thanks also to the authors who delivered excellent manuscripts within a short period of time.

FRONT COVER: Two images of sheepshead minnow (*Cyprinodon variegatus*) from the files of the Smithsonian Institution, National Museum of Natural History, Division of Fishes. The top fish is an adult male, the bottom fish is a juvenile. Both illustrations are by A. H. Baldwin from specimens collected at St. George Island, Maryland. Thanks to Lisa Palmer for helping us get these images (as well as the madtom images on the back cover).

ARTICLE UPDATE:: Just as Christopher Gutmann's article, "Treasure Hunting in the Suburbs: Discovery of the State-Endangered Iowa Darter (*Etheostoma exile*) in DuPage County, Illinois," in the Winter 2005 *American Currents* was going to press, the Illinois Department of Natural Resources downlisted the Iowa darter from endangered to threatened.

IS YOUR ADDRESS CHANGING? If you're going to move, or have moved since receipt of this issue, you must let us know of your change of address. Since *American Currents* is mailed bulk rate, copies mailed to your old address will *not* be forwarded.

American Currents (ISSN 1070-7352) is the quarterly publication of the North American Native Fishes Association (NANFA). Aquarist, ichthyological or conservation groups may reprint items or articles from this publication (except for copyrighted and reprinted material), provided notice and credit are given to "*American Currents*, Publication of the North American Native Fishes Association," in those words. Other organizations and publications wishing to reprint material from *American Currents* should contact Christopher Scharpf, *AC* Editor, 1107 Argonne Dr., Baltimore, Maryland 21218, ichthos@comcast.net. Article manuscripts, letters to the editor, book reviews, artwork, photographs, news items, and Trading Post ads are welcome. Forward items and direct inquiries to the Editor at the address above. Viewpoints of authors expressed in *American Currents* do not necessarily represent opinions or positions of NANFA.

printed on 20% post-consumer waste paper

Breeding the Southern Sheepshead Minnow, *Cyprinodon variegatus variegatus*

Charles A. Nunziata
6530 Burning Tree Dr., Largo, FL 33777
epiplaty@tampabay.rr.com

The southern sheepshead minnow (*Cyprinodon variegatus variegatus*) is extremely numerous throughout its range, along the southern Atlantic Coast from Virginia, around the Florida peninsula, and along the Mexican Gulf coast to eastern México. Along with the mummichog (*Fundulus heteroclitus*) in the northern half of its range, and the Gulf killifish (*Fundulus grandis*) in the southern, it is one of the most common fishes the collector will find in estuaries of the east and Gulf coasts of the United States. *C. v. variegatus* is found in virtually every kind of shoreline habitat, in both brackish and full-strength sea water.

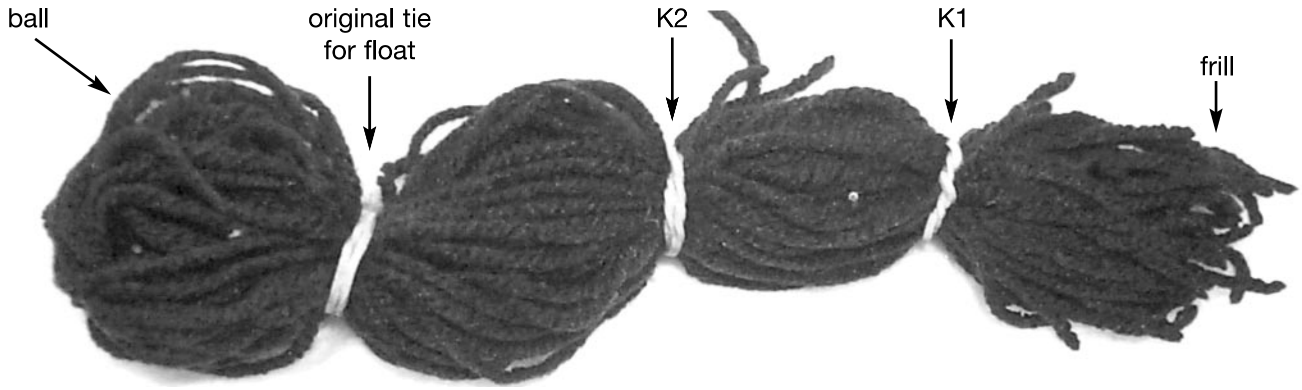
C. v. variegatus is a stocky fish which, for its body depth, is quite short, with a total length of 2.0-3.5 inches. When in breeding color, the male exhibits a silver body that reflects light blue or even green, appearing as a metallic sheen. A breeding male in good condition exhibits a sparkling slash of light blue on the upper body directly behind and below the nape. Breeding coloration also includes light to moderately bright orange on the lower jaw and the ventral fins. The dorsal fin has a dark spot posteriorly and is otherwise gray to bluish, as is the anal fin. The anal fin tends to be darker at the margins and is bordered by a yellow band. The caudal fin is whitish to light blue, with a black to dark gray border. The non-breeding male exhibits 6-10 irregular grayish to slate cross bars. These are generally not visible when the male is in breeding color. The unpaired fins of the females are without color but the dorsal fin has a black spot posteriorly. The body is silver with several greenish to brown cross bars and occasional spots on the flanks.

I've found that *C. v. variegatus* are easy to breed, both in sea and brackish water, and, after appropriate conditioning, in hard, alkaline fresh water. Although I prefer to keep *C. v. variegatus* in brackish water, acclimation to fresh water is not difficult and can be accomplished over a period of 2-3 weeks. Simply replace small amounts of tank water every other day with hard, alkaline, aged water. The fish can be maintained at 7.5 to 8.0 pH and at least 150 ppm of carbonate hardness. A word of caution here: Once the acclimation process has begun, conversion back to sea water is not recommended because of the potential for ammonia spikes. Clear, clean well-aerated water and good filtration is needed to keep *C. v. variegatus* in peak condition.

The spawning group described in this article was part of a larger group seined in clear salt water, with a specific gravity of 1.016. The habitat contained isolated clumps of kelp and algae, but there was no significant plant matter at the shore. The substrate was a clean, light-colored sand. The location was a quiet lagoon near the mouth of Tampa Bay, where the bay empties into the Gulf of Mexico. The air temperature was in the mid-80s, the water temperature a few degrees cooler.

To prevent damage to females, a small breeding group of two males and three females were selected and housed in a 20-gallon long aquarium, acclimated to a specific gravity of 1.008 and a temperature of 76°F. The set-up was basic, consisting of only four small box filters set to a vigorous airflow. The sexes were isolated by a tank divider, and conditioned on live foods for a day prior to each spawning session. Although the wild fish voraciously attacked live foods, they readily took frozen and freeze-dried foods immediately after capture.

Sheepshead topminnow are known to spawn among aquatic plants. For this reason, I decided to try spawning them in yarn mops, trying different mop configurations to see which they liked best. The mops were made with dark green acrylic yarn, the most common material used for this purpose.



The yarn is wrapped 100 times or so around a 9 or 10 inch object (usually a book), then tied off on one end and the loops cut at the other. The tied end is draped over a small foam sphere and secured with a rubber band or a short length of yarn. The result is a yarn-covered float that makes the mop hang vertically from the surface, simulating strands of plant material. If the foam sphere is removed, the mop sinks to the bottom in a clump. The section from which the foam sphere is removed is now a loose ball of yarn with an empty center. One mop of each type was used in the initial spawning session.

The sexes were reunited and spawning displays and chases immediately began. The mops were removed after a day. No eggs were found in the floating mop, while 15 eggs were found in the sunken mop, all concentrated in the "ball" section, and jammed in the tight strands around the rubber band. Eggs deposited in this fashion are reminiscent of the behavior of crevice-spawning killifish species of the genus *Cubanichthys* and *Procatopus*, among others. Crevice spawning species characteristically place their eggs in the most inaccessible place they can find; if no suitable sites are available, they may refuse to spawn.

To test this observed preference, additional "sites" were provided by tying off the mop in sections along its length. The resulting mop had the original ball end, two tied off points along its length (designated K1 and K2 in the figure above), and a remaining section of free strands beyond the K1 tie that fanned out. This section is noted as "frill." After a day, the mop was picked and the following data was recorded:

location on mop	**session 1**	**session 2**
frill to K1	1	0
K1	16	18
between K1 and K2	6	8
K2	22	16
between K2 and ball	4	2
at or in ball	12	12
total eggs	**61**	**56**

To confirm the initial results, the spawning session was repeated after the sexes were separated for a few days of rest and live food conditioning.

The data show a definite preference for depositing eggs in the tightest portions of the mop. It is inappropriate to read any significance into this observation other than an apparent preference under the artificial conditions of the aquarium. However, given artificial conditions, *C. v. variegates* should provide a significantly greater number of eggs if such hiding sites are provided in the spawning media.

The eggs of the Tampa Bay population of *C. v. variegatus* are quite large, measuring about 1.5 mm. Although the surface of the eggs was somewhat opaque with scattered surface pigmentation, a beating heart and spine development was observed 72 hours after spawning, at a storage temperature of 78°F. At this temperature, all eggs hatched in 7-9 days. Typical of a plant-spawning killifish, an adhesive thread attached to the surface of the egg was also observed.

The eggs are firm and easily handled without damage. Incredibly, every one of the hundreds of eggs obtained from wild fish were fertile. Subsequent generations were nearly as fertile, with only the occassional egg being lost. Incubation can be as short as eight days or as many as 16 days, depending on the storage temperature. The fry are large and immediately take newly hatched brine shrimp. Within a week, most appropriately sized floating and sinking foods will be taken. Juveniles eat everything offered. Growth is fairly rapid, with sexual maturity at about six months.

Spawning through three generations did not appear to reduce fertility or brilliance of color, nor alter the behavior of this tough and beautiful killifish. Those who have access to wild *C. v. variegatus* are truly fortunate, but those who do not share in this bounty can nonetheless share in the experience of maintaining and propagating a true North American original, the sheepshead minnow.

Are Temperate Fishes More Difficult to Spawn Than Tropicals?

Bob Muller
Naturalist, Royal Oak Nature Society, 625 S. Altadena, Royal Oak, MI 48067
michiganfish@wideopenwest.com

In the early years of the aquarium hobby, many attractive fishes from the United States were regularly available in the trade. But natives fell out of favor and pretty much disappeared from the hobby as fishes from other countries became increasingly available. Today, the vast majority of fishkeepers keep tropical fishes. This may simply be due to the old saying that the grass is always greener on the other side of the fence.

When I was a boy, I too favored tropicals over natives. It excited me to know that a fish I kept came from the Amazon, Borneo, or Africa. North American natives were just bait. I did, however, from time to time bring home "minnows" from trips to the lake. Eventually, native fishes began to interest me far more than the imports. Although tropicals were from exotic places, there was a greater sense of the unknown when it came to natives. Back in the 1960s, there was very little in print on local fishes. Even identification was difficult. I remember once trying to key out a fish I had put in my aquarium. All was going well until I ran into this diagnostic character: "Intestine spirally wound about the air bladder." I either had to kill the fish to identify it, or keep it alive but never know what it was.

The Key to Temperate is Temperature

Many aquarists believe that native (temperate) fishes are harder to keep than tropicals. In one respect they are easier—temperature. The temperature range of tropical fishes is very narrow compared to most temperate fishes. The temperature in my native tanks have ranged from 35-95°F. Yes, my rainbow darters (*Etheostoma caeruleum*) start to die at 95°F, but they can survive at 85°F for short periods of time if necessary. Exceptionally cold water is not a problem. I once returned from a weekend trip to discover that my furnace had broken down. The tropicals had all died, but the temperate fishes were enjoying the 40°F water. As long as you avoid prolonged high temperatures and change the water regularly, maintaining temperate fishes is not difficult.

Breeding and raising temperate fishes, however, is more complicated. Most tropical fishes that are common in the hobby tend not to have a fixed spawning season and, if well conditioned, breed continuously. Temperate fishes are harder to breed for three reasons. One, so few people have worked with these fishes and published information on them is so sparse, you may be working with a difficult species without knowing it. Two, you often have to guess as to what the breeding requirements of the fish are. (Do they need plants, gravel, caves, etc.?) And three, most temperate fishes, especially those from the north, need to have a change of season to trigger spawning behavior.

Being from Michigan, the local fishes I work with need a low temperature and short daylength during the winter to reset their spawning clocks. I am lucky in that I have a room in my home where the temperature in winter can easily be maintained in the 40-50°F range. I know several other native fish breeders in my area who keep tanks in unheated garages and get the same results. When maintaining aquaria in unheated rooms exposed to outside temperatures, make sure the aquariums do not freeze.

I also vary the lighting hours to match natural conditions. In Michigan, daylight hours vary from 12 hours in September to nine hours in December, back to 12 hours by March. I can either leave the fishes in the cold room until spring, or speed up the change of season by increasing the temperature and light, which gets my fish to spawn between February and April. Interestingly, the only Michigan fishes for which a change of season is not necessary are killifishes, blackstripe topminnow (*Fundulus notatus*), starhead topminnow (*F. dispar*), and banded killifish (*F. diaphanus*). These fishes start breeding at 60°F even when kept at 15 hours of light per day.

Southern temperate fishes also sometimes do not require an extreme change of seasons. For example, flagfin shiner (*Pteronotropis signipinnis*) from Louisiana and lowland shiner (*P. stonei*) from South Carolina, even with long light periods, will spawn at 72°F as long at the temperature dips down into the 60s. I would think that other southern fishes react this way too, but I still put them through a cold-temperature, low-light cycle just to be safe.

It is always a waiting game with fishes you have not worked with before. Last winter I had rainbow shiner (*Notropis chrosomus*) set up to spawn for two months and nothing happened. I had a board meeting of Greater Detroit Aquarium Society at my home and commented that maybe I only had one sex. The next morning when I turned on the lights to feed the fish they were showing their brilliant spawning colors. A lot of spawning then occurred over the next month. Why? Presumably, the unheated aquarium temperatures in my basement had just reached a key temperature for triggering spawning in my rainbow shiner specimens—70°F. I will closely watch the related yellowfin shiner (*N. lutipinnis*) and saffron shiner (*N. rubricroceus*) to see if a 70°F spawning temperature works for them as well.

For darters, my experience indicates that spawning is completed by the time the temperature reaches the 70°F mark. I therefore start getting my darters into breeding condition when the room temperature is about 60°F.

Finding the Right Spawning Media

How should you set up a breeding tank for a minnow you've just collected and brought home? If you had purchased a tiger barb at your local aquarium shop, you could look in books dating back to the 1930s and find explanations of several breeding set-ups. There are few such resources for native fish aquarists, but one place to start is with the "Fishes of …" books that are available for many states. Combing though these books can provide clues regarding the fish's wild breeding habits. Maybe it's known that your minnow spawns on the nests of other minnows, or spawns on plants, or merely scatters its eggs. If you can't find information on the species you have, read the sections on close relatives. Closely-related species often have similar if not identical spawning requirements.

Of course, fish do not read fish books and sometimes spawn in ways contrary to what's reported in the literature. For example, many books report that northern redbelly dace (*Phoxinus eos*) spawn in plants. Mine only spawned over gravel. Sometimes captive fish spawn in media that's not found in their natural habitat. Blacknose shiner (*Notropis heterolepis*) I collected from a mud-bottomed weedy lake ignored plants and used the gravel.

The important lesson I learned is: Be prepared to offer alternate spawning media if nothing seems to be happening. For example, the first spawning medium I presented to Kentucky darters (*Etheostoma rafinesquei*) was rejected. It was a 4" x 6" ceramic tile mounted with silicone sealer vertically on a piece of plate glass. The female was heavy with eggs and the male was paying her lots of attention, but spawning did not occur. I added a stream-rounded stone etched with dozens of pockmarks approximately 2.0 mm x 1.0 mm deep. I leaned it against the tile and within hours eggs appeared in the pockmarks. Spawning occurred for over a month.

If I don't know the preferred spawning medium of a particular fish, I set up a tank that includes a choice of spawning media: a pile of one-inch diameter stream-rounded stones, and some plants (usually java moss or hornwort). Then I look for eggs. If I find them in the stones, I remove the plants. If I find them in the plants, I remove the stones.

Foods, Feeding, Raising the Fry

After the eggs hatch, what do you feed them? This is a little easier. I do nothing in this area that's different from what I do with tropicals. I keep green water, live microworms, newly-hatched brine shrimp, and powdered commercial fry foods on hand. I also feed the fry one of the oldest homemade foods in the hobby, powdered hard-boiled egg yoke. Before I started keeping green water (heavy *Euglena* culture), small darter and minnow fry often had very high mortality rates. The green water has corrected most of that. The size of the fry may give you an indication as to first food, but make sure to watch closely. Know that the fry have full bellies and are eating. Feed good quality foods and feed them often.

I condition temperate breeders just as I do tropicals, with daily feedings of frozen bloodworms, frozen brine shrimp, live blackworms, and, for fishes that will eat it, flake food. Many temperate fishes I have worked with take two years to reach full adult size. A few can breed at one year, but many are

Fig. 1.
The author in his fish room. At far left (author's far right) are a 50-gallon tank of tropical Peru fishes, a 10-gallon breeding set-up for Arkansas fishes, and a 15-gallon tank for Sipsey darter. On the cabinet at the author's immediate right are (top) a 20-gallon high with Peruvian fishes and a 5-gallon pirate perch tank, (middle) a 15-gallon breeding set-up for yellowfin shiner and a 5-gallon least killifish tank, and (bottom) a 15-gallon breeding set-up for gilt darter. To the author's immediate left are a 60-gallon native community tank featuring flagfin shiner, lowland shiner, rainbow shiner, burrhead shiner, longnose shiner, ironcolor shiner, silverjaw minnow, greenside darter, blackspotted topminnow, and a group of miscellaneous darters; a 10-gallon tank of stripetail darter (possibly all males), and a 15-gallon tank containing last year's young Tuskaloosa and Kentucky daters. On the table at far right is a 5-gallon breeding set-up for snubnose darter. Not shown is a breeding set-up for saffron shiner. Photo by Tim Turner.

still too small. Two years worth of feeding fishes frozen foods is expensive. This is one reason why I believe captive-raised natives for the aquarium trade is not a realistic enterprise.

The Adventure of Collecting, and the Importance of Sharing What You Learn

Of course, why would you buy native fishes when you could jump in a creek and catch your own? Collecting lets you experience first hand the natural habitat of the fish and see what else lives with it. All you can learn about fish from a fish store is that they come from glass boxes. I recently had the opportunity to collect in Peru, where I saw the natural habitat of angelfish and what lives with wild neon tetras—something I've never learned from reading tropical fish books! When collecting natives you can't help but learn about—and begin to appreciate—a fish's relationship to its environment and its role in the ecosystem.

The adventure of collecting and keeping temperate fishes is exploring the unknown. But from the names of authors I see on articles, it seems that only a handful of native fishkeepers are actually spawning and raising natives. If you spawn a fish you need to write about it—new knowledge is worthless if you don't share it with the world. The best reason to keep natives is to learn about them and pass on what you have learned. This is the greatest service a hobbyist can provide.

If you get a North American native fish to breed, write it up and get it into *American Currents* so that rest of us can benefit from your accomplishment.

The Changing Role of Aquarists in Aquatic Conservation

Peter J. Unmack
P.O. Box 1454, Tempe, AZ 85280-1454
peter.web@unmack.net

For many years aquarists have been frustrated about the loss of aquatic biodiversity. Many fishes around the world are disappearing, in part due to a lack of resources. Meanwhile, many hobbyists spend considerable amounts of time, energy and money keeping and breeding fishes both rare and common. Why not organize dedicated and skilled aquarists to help maintain endangered species and assist with reintroduction programs and species conservation? The Aquatic Conservation Network (ACN) attempted to do just that.

The ACN had its humble beginnings with the inaugural publication of its journal *Aquatic Survival* in 1992. (You can view back issues at www.peter.unmack.net/acn/as). Finally, there was an organization dedicated to the conservation of aquatic species by aquarists. For five years, ACN's Board of Directors (primarily through the efforts of Rob Huntley) kept the organization afloat by regular production of *Aquatic Survival*. However, ACN's original goals of establishing captive breeding programs were never fully met (although there was some short-term success with two Malagasy killifishes). This review seeks to examine why the ACN never lived up to its promise, and to discuss how amateur aquarists can still contribute to fish conservation.

The Elements of a Successful Captive Breeding Program

Four elements are necessary for a breeding program to succeed. You need 1) scientific information on which to base it, 2) a priority list of species to focus on, 3) permits (where necessary) for legal captive rearing, and 4) personnel to administer the program.

Scientific information on captive breeding programs exists in the form of the 1994 publication *Captive Breeding Guidelines* by Rob Huntley and Roger Langton. According to this publication, in order to maintain a high degree of genetic diversity for 40 years or so, one would need to maintain a breeding group of 16 males and 16 females of a given species in 20 aquaria. Even if the number of aquaria or fish were scaled down to one quarter, the volume would still represent a large undertaking by most fishkeeping standards. Moreover, aquarists must worry about introducing diseases into the captive population, keeping the gene pools pure (i.e., avoiding hybridization), or failing to persist in maintaining fishes over the long haul.

Determining which species are the best candidates for captive propagation by amateur aquarists is an important step. A species' conservation priority needs must certainly be considered, but so does the species' suitability for home aquaria. It is important to keep in mind that some species may be difficult (if not impossible) for the average aquarist to breed and raise. This could be due to cold water requirements, large size, difficulties in having the appropriate triggers to induce spawning, or a host of other problematic factors. The species that are easiest to maintain come from warmer water, tend to be small bodied, and are easily spawned and raised (e.g., pupfishes, goodeids, poeciliids, some cichlids). There are also problems with obtaining suitable broodstock that have not already been genetically compromised by inbreeding.

Legal issues also exist. The U.S. Fish and Wildlife Service is generally unwilling to grant aquarists permits to keep species listed under the Endangered Species Act (nor will they work with aquarists on grandfathered species legally obtained prior to listing). Mexican permits may even be more difficult to obtain. These legal problems effectively eliminate most North American species from consideration.

Finally, you need qualified people to administer the breeding program and help organize the efforts of contributing aquarists. All told, these issues conspire to make such programs difficult, as demonstrated by the failure of ACN to permanently establish a breeding program despite five years of concerted effort.

A Practical Approach to a Conservation Breeding Program

Despite these obstacles, it is my opinion that a breeding program can still be developed. However, I feel the following conditions must be met for it to succeed. Ideally, the program should deal with local species on a short-term basis (a few generations at most) with specific, well-defined goals (unless the species are extinct in the wild). For example, a program could involve breeding a locally rare species to in order to establish local refuge populations. Such a program would involve aquarists within the same region with backups ready to step in should some participants drop out. Additionally, the program would involve the relevant governmental authorities.

The best example of this approach is Conservation Fisheries, Inc. (CFI) in Knoxville, TN (www.conservationfisheries.org). CFI is a non-profit organization dedicated to the preservation of aquatic biodiversity in the southeastern United States. CFI has a large facility with over 300 aquaria. They maintain over a dozen species of rare fishes, and several non-threatened species are under culture as surrogates for endangered species they anticipate working with in the future. In addition to captive breeding, CFI also undertakes population monitoring and ecological surveys for locating potential broodstock and to determine the success of reintroductions. One of CFI's best success stories is the reintroduction of duskytail darter (*Etheostoma percnurum*) into Abrams Creek (TN), where reproduction and recruitment of captive-born progeny has been documented.

While a set-up of CFI's scale is beyond any one aquarist's capabilities, it is not beyond the combined capabilities of a group of aquarists if they agree to work on a single species. A good example is the International Killifish Conservation Program (IKCP, www.ikcp.org). IKCP is a conglomerate of several killifish clubs and independent breeders from around the world who are trying to combine their efforts towards the long-term captive maintenance of certain killifishes. However, this program is still trying to get off the ground as this type of program requires considerable time and effort to establish. Many IKCP members are already busy trying to run these programs within their respective clubs, such as the American Killifish Association Killifish Conservation Program (ikcp.killi.org/ikcp.pdf). The bottom line is, captive breeding is not a trivial undertaking for any organization to attempt.

Additional Ways Aquarists Can Help

So far I have painted a bleak picture of aquarist involvement in conservation breeding programs (which themselves are unlikely to ever become a common thing). That is not to say aquarists cannot continue to make other contributions to aquatic conservation while still enjoying fishkeeping. In my mind, two areas stand out as having real potential.

First, aquarists can use closely related non-threatened species as surrogates to gain information about the captive husbandry of threatened species. CFI has been using warrior darter (*Etheostoma bellator*) as a surrogate for vermillion darter (*E. chermocki*), and streamline chub (*Erimystax dissimilis*) and blotched chub (*E. insignis*) as surrogates for slender chub (*E. cahni*; see *American Currents*, Fall 2001). Aquarists who breed surrogate species should document their results so other researchers can use this information as a basis for breeding imperiled species. Unfortunately, few aquarists take notes, and most are generally unwilling to write articles regarding their experiences. This is the greatest failure of fishkeepers the world over, despite an abundance of suitable outlets for publishing their observations.

Secondly, some species are already extinct in the wild. The only hope for their survival is captive breeding. Some will argue that if their native habitats are destroyed, what is the point of keeping them? My response is one cannot predict future events. Once a species is lost, it is lost forever; there are no second chances. Granted, there are still problems relating to issues regarding breeding programs (e.g., gene pool size), but any effort directed towards keeping fishes that are extinct in the wild is better than none at all. Several species of fishes now only exist as captive populations (Table 1).

Other Ways Aquarists Can Make a Difference

Two alternative possibilities exist that might allow aquarists to become more involved in aquatic conservation. The first is *in situ* conservation projects. Fishes do not only exist behind panes of glass; they live in the waterways that surround us all. Many of these waterways have problems of one type or

Table 1. Fishes known or believed to be extinct in the wild that still exist as captive populations. This list is complete for North America, but documentation for many species is lacking in other regions, thus it should not be considered comprehensive. Common names are included where possible.

Family Cyprinidae (carps and minnows)
Hemigrammocypris lini, garnet minnow (China)
Tanichthys albonubes, white cloud mountain minnow (China)

Family Poeciliidae (poeciliids)
Xiphophorus couchianus, Monterrey platyfish (México)

Family Goodeidae (goodeids)
Empetrichthys latos latos, Manse Spring poolfish (Nevada)
Skiffia francesae, golden skiffia (México)

Family Cyprinodontidae (pupfishes)
Cyprinodon alvarezi, Potosi pupfish (México)
Cyprinodon longidorsalis, La Palma pupfish (México)
Cyprinodon veronicae, Charco Palma pupfish (México)
Megupsilon aporus, Catarina pupfish (México)

Family Cichlidae (cichlids)
Haplochromis lividus (Lake Victoria basin)
Haplochromis (*Labrochromis*) *ishmaeli* (Lake Victoria basin)
Haplochromis (*Prognathochromis*) *perrieri* (Lake Victoria basin)
Haplochromis (*Yssichromis*) *"argens"* (Lake Victoria basin)
Paretroplus menarambo, pinstripe damba (Madagascar)
Platytaeniodus degeni (Lake Victoria basin)

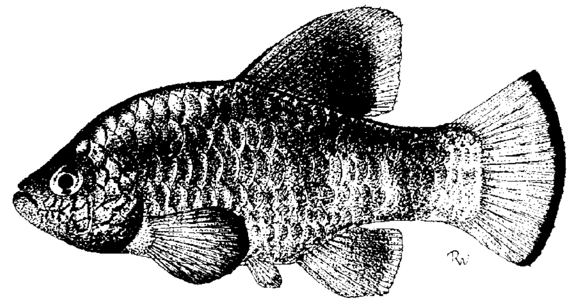


Fig. 1.
La Palma pupfish, *Cyprinodon longidorsalis*.

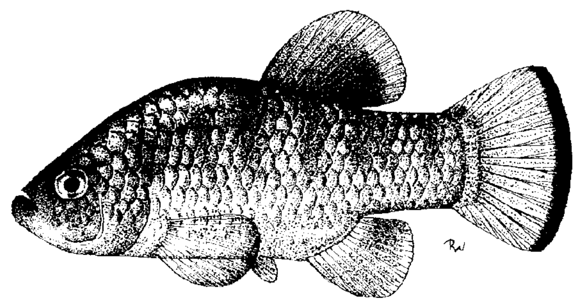


Fig. 2.
Charco Palma pupfish, *Cyprinodon veronicae*.

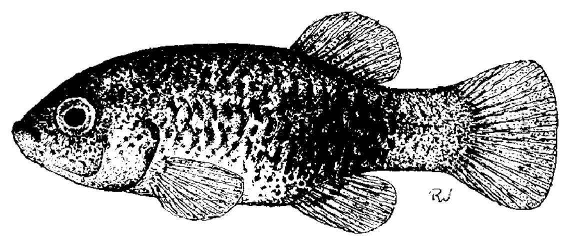


Fig. 3.
Catarina pupfish, *Megupsilon aporus*.
Illustrations by Rudolf H. Wildekamp from *A World of Killies: Atlas of the Oviparous Cyprinodontiform Fishes of the World*.

another. Aquarists can get involved in projects to tackle some of these issues.

The Desert Springs Action Committee (DSAC, www.pupfish.net/dsac) has taken the *in situ* approach to heart. The organization began when the Bay Area Killifish Club approached the Nevada Division of Wildlife in 1992 to assist with local killifish conservation projects. Within a few years other individuals and clubs became involved and the organization grew. DSAC now undertakes two trips a year to Nevada localities where exotic organisms are removed, vegetation is managed, and populations are counted, among other tasks. These activities provide aquarists with an opportunity to see and handle rare fishes they would otherwise be prevented from doing so due to legal issues. They also get to enjoy the outdoors and, more importantly, do something to help these fishes persist. As far as I am aware, DSAC is the only aquarist organization to undertake this type of work.

If anyone is interested in starting an organization like the DSAC, I would suggest finding a half dozen interested people, then approaching the non-game fish biologist(s) at your local Game and Fish Department. It would also be wise to try and seek out people at your local university who might be working on local fishes. Expect to get some rejections and to volunteer for lesser projects until the authorities develop a trusting relationship with your group. Gently persist and you may eventually succeed.

A second possibility is to establish conservation grants. These grants are given to people undertaking work that will further the conservation status of the target organism(s). The following groups have established grant programs: American Cichlid Association, American Livebearer Association, NANFA, Native Fish Conservancy, and the Pacific Coast Cichlid Association. Each organization typically funds work relating to the species that interest them. The advantages of such grants is that clubs can dictate the type of projects to support, choose from a variety of proposals submitted, and can require recipients to publish results in club journals. NANFA has also established a second grant program specifically for environmental education purposes.

The bottom line is, even just a few hundred dollars can go a long way towards getting projects off the ground. It is not going to solve the world's conservation problems, but is a small step in the right direction. Let's get started with small steps of this sort.

Madtoms: Some Cool Cats

Jeremy S. Tiemann
Illinois Natural History Survey, 607 E. Peabody Dr., Champaign, IL 61820
jtiemann@inhs.uiuc.edu

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.

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 20ºC;
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 20ºC;
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 25ºC;
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 25ºC; 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 25ºC.

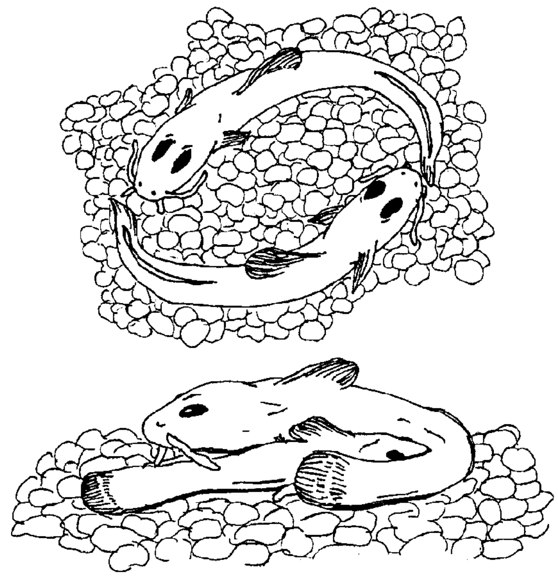


Fig. 1.
Top: "Carousel courtship" behavior of Neosho madtom, *Noturus placidus*; male and female swim in circles head to tail near substrate. Bottom: "Tail curl" courtship behavior of Neosho madtom; male and female lie above substrate with tail of male wrapped around head of female while both quiver.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

Madtom 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

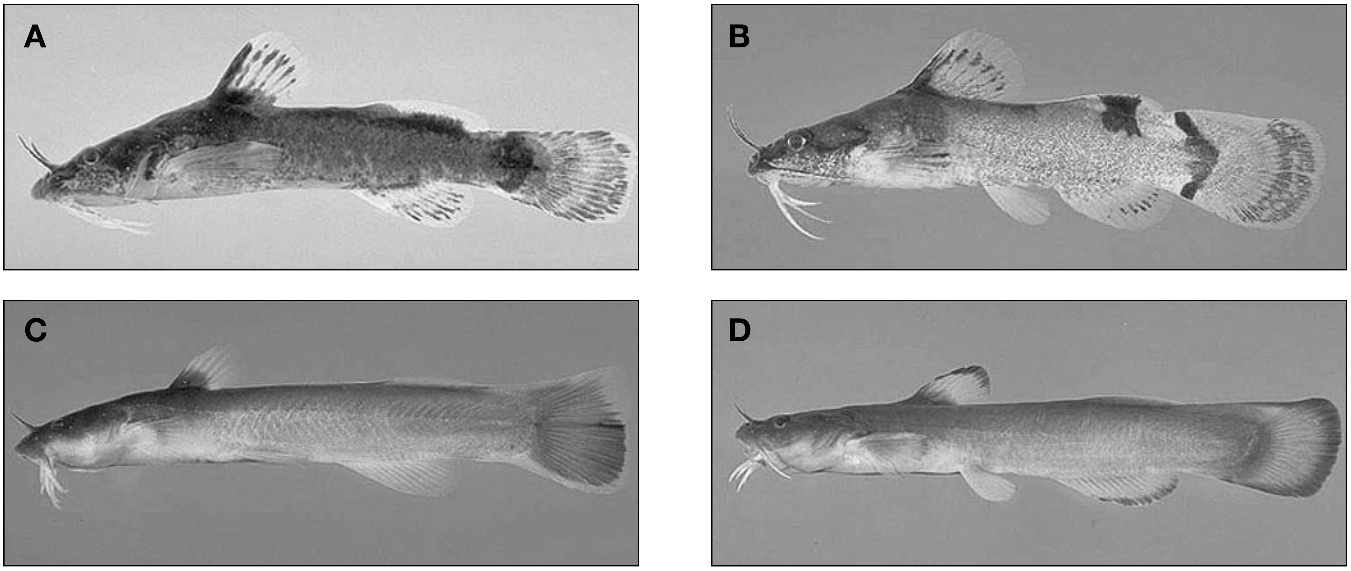


Fig. 2.
(A) mountain madtom, *Noturus eleutherus*. (B) yellowfin madtom, *Noturus flavipinnis*. (C) orangefin madtom, *Noturus gilberti*. (D) margined madtom, *Noturus insignis*. All photos courtesy: The Virtual Aquarium of Virginia Tech (http://www. cnr.vt.edu/efish) and Virginia Department of Game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

Acknowledgments

D. R. Edds (Emporia State University), A. G. Bulger (PBS&J), and J. L. Albers and M. L. Wildhaber (Columbia Environmental Research Center) shared experiences of *N. placidus* breeding. C. A. Taylor (Illinois Natural History Survey) and G. A. Schuster (Eastern Kentucky University) collected the Kentucky *N. miurus* brood; members of the 2003 IL/IN NANFA outing to the Middle Fork of the Vermilion River assisted in collecting the Illinois *N. miurus* brood. My amazing wife B. L. Tiemann assisted in fish care and in collecting the Kansas *N. flavus* brood and the Illinois *N. miurus* brood.

Literature Cited

Bulger, A. G., C. D. Wilkinson, D. R. Edds, and M. L. Wildhaber. 2002. Breeding behavior and reproductive life history of the Neosho madtom, *Noturus placidus* (Teleostei: Ictaluridae). *Transactions of the Kansas Academy of Science* 105 (3-4): 106-124.

Burr, B. M., and J. N. Stoeckel. 1999. The natural history of madtoms (genus *Noturus*), North America's diminutive catfishes. *In*: E. R. Irwin, W. A. Hubert, C. F. Rabeni, H. L. Schramm, Jr., and T. Coon (Eds.). *Catfish 2000: proceedings of the international ictalurid symposium.* American Fisheries Society Symposium 24: 51-101.

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

Stoeckel, J. N. 1993. Controlled cultivation techniques for the recovery of threatened fishes in Virginia. Ph.D. dissertation. Virginia Polytechnic Institute and State University, Blacksburg, VA.

Thomas, M. R., and B. M. Burr. 2005. *Noturus gladiator*, a new species of madtom (Siluriformes: Ictaluridae) from Coastal Plain streams of Tennessee and Mississippi. *Ichthyological Explorations of Freshwaters* 15 (4) :351-368.

Tiemann, J. S., D. P. Gillette, M. L. Wildhaber, and D. R. Edds. 2004. Effects of lowhead dams on riffle-dwelling fishes and macroinvertebrates in a Midwestern river. *Transactions of the American Fisheries Society* 133 (4): 705-717.

Wildhaber, M. L., A. L. Allert, C. J. Schmitt, V. M. Tabor, D. Mulhern, K. L. Powell, and S.P. Sowa. 2000. Natural and anthropogenic influences on the distribution of the threatened Neosho madtom in a Midwestern warmwater stream. *Transactions of the American Fisheries Society* 129 (1): 243-261.

Sampling New York State's Bashakill Marsh and Stream

Norman Soule
P. O. Box 535, Cold Spring Harbor, NY 11724-0535
normansoule@optonline.net

On November 13, 2004, Matt Draud and I left Long Island for the first field trip of NANFA's New York State chapter. We went to the Bashakill Marsh and Stream in Sullivan County, about 80 miles from New York City. If you're not familiar with the area, the marsh is about 2700 acres of wetlands and associated uplands owned by the New York State Department of Environmental Conservation. The marsh is on the southern edge of the Catskill Mountains.

Matt is a professor of biology at the C.W. Post of Long Island University and had arranged the use of a university van for the trip. Not knowing what the weather would be like after we reached the Bashakill, and not being sure of how many people would attend, we thought the van was a good idea. If the weather was bad, we could always hold a meeting in the van. As it turned out, only a few brave souls came out to face the elements, so we could have held a meeting in almost any car.

The trip from Long Island to the Bashakill usually takes a little over two-and-a-half hours. Matt and I left C.W. Post at 8 a.m. thinking we had three hours to do a 2.5 hour trip—plenty of time to make an 11 a.m. start at the marsh. Well, it didn't work out that way. A light snow fell that morning and a car accident in New Jersey tied up traffic on the Palisades Parkway for an hour, delaying our arrival at the marsh.

At about 11:30 am, Matt and I arrived at what is called the causeway, located approximately in the middle of the marsh. There, we met Dick Manley and Mike Lucas. Both Dick and Mike had had pleasant rides from their homes and had been at the causeway since the elusive scheduled 11 a.m. meeting time. The weather was nice and warm for that time of the year, topping out at about 45°F. We talked about a few things for a while and then started to sample the fish and other life along the causeway.

Mike used a large dipnet while Matt and I used a 10-foot seine. We caught many bluespotted sunfish, a few ironcolor shiners, a few small chain pickerel, a brown bullhead or two, a small madtom, and many different types of aquatic beetles and other invertebrates. One of the most notable memories of the trip was the dozens of large newts we captured. Nearly every dipnet and seine pull turned up more than one newt. Mike also managed to catch a tiny hatchling musk turtle.

While enjoying the fish collecting, we were fortunate enough to watch both a juvenile and adult bald eagle flying together just to our west. To see if we could find any other species, I decided to try my backpack electrofishing gear, for which I have a New York Department of Environmental Conservation collecting permit. I wasn't all that successful, but I did manage to catch a few more bluespotted sunfish, a larger brown bullhead, and, one of the highlights of the day—a five-inch long bowfin. He had been lurking near one of the large culverts that distribute water flow evenly through the marsh under the causeway.

Satisfied that we had a representative sample of species at that site, we went south to the stream that leaves the marsh and leads to the Delaware River. We anticipated finding a few other species that we had not captured at the causeway. Mike, with large dipnet in hand, started into the stream. Matt, Dick, and I followed shortly after with the electrofishing gear. Within a few moments, we found more madtoms, bluespotted sunfish and ironcolor shiners. New to the species list for the day were both shield (Fig. 1) and tessellated darters, common shiner, redbreast sunfish, fallfish (Fig. 2), white sucker, and a few small largemouth bass and brown trout.

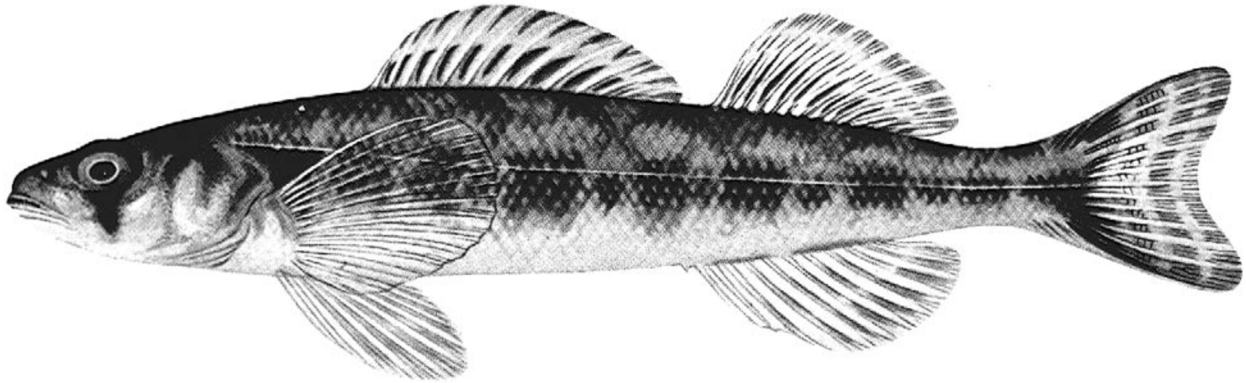


Fig. 1.
Shield darter, *Percina peltata*. Illustration courtesy New York State Department of Environmental Conservation.

Mike made out just as well with the shield darters using just the large dipnet as I managed with the electrofishing gear. And he collected more small ironcolor shiners than I could. In the shallows—and because of the shiners' small size—the electric current had little effect. But by kicking around and herding the shiners, Mike managed to catch some. It was now about 3 p.m. and Mike and Dick had to leave to make it home at a reasonable time.

With some daylight left, Matt and I tried the electrofishing gear in a large spring that flows into the southeastern side of the marsh. In this isolated spring I had hoped to find long-tailed salamanders, a species that I have never seen in the wild—or even alive, for that matter. But the amphibian and fish life in the spring turned out to be less diverse than we had hoped. We did catch amphibians, but only bullfrogs. The fish species were even less impressive—only a few largemouth bass and a 12-inch brown trout. We're planning a trip this spring in warmer weather, as I believe more species may be present in the warmer months.

At this point, it was dark enough to cut our visibility, so we stopped collecting and started the long ride home. This time there were no road delays and the trip took just a little over two hours. We arrived at C.W. Post to pick up my truck and to drop off Matt. We split up the few fish that we kept and I headed home. The next day I spread the fish into several aerated coolers. After waiting for the water temperatures to come up over the next three days, I put the shield darters into the New York Stream Exhibit at the Cold Spring Harbor Fish Hatchery & Aquarium. Other fish found new homes in other exhibit aquaria.

I hope that this won't be the last field trip for this chapter and am planning another one this summer at a stream or lake suggested by another member.

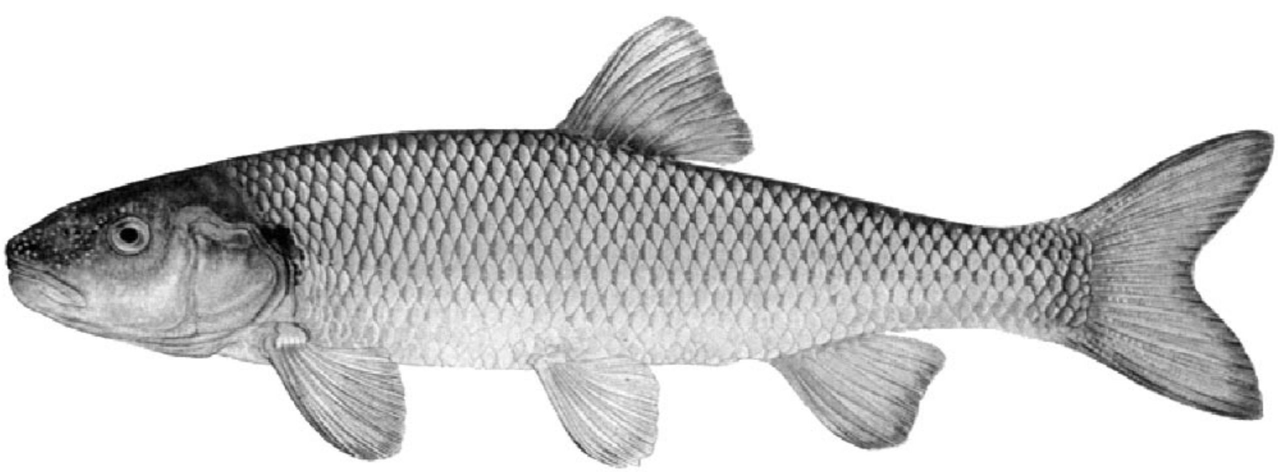


Fig. 2.
Fallfish, *Semotilus corporalis*. Illustration courtesy New York State Department of Environmental Conservation.

Fine Fare for Native Fishes: The Fairy Shrimp, *Streptocephalus seali*

Tyler Strange and Heather Smith
(TS) 11771 Highway 585, Oak Grove, LA 71263
(HS) 116 Eva Circle, Vicksburg, MS 33704

During our free time recently, we have been studying the animals that live in and around floodplain pools of the Mississippi River in Warren County, Mississippi. On 23 May 2004, while searching for alligator gar, we made a surprising discovery of some very different kinds of animals. With seines and dip nets, we checked out eight pools that we had sampled the previous year for fish. Because of unusually low water in the Mississippi River, most were fishless, but in two of the pools we collected dozens of small crustaceans: a clam shrimp, *Eulimnadia* sp., and a fairy shrimp, *Streptocephalus seali*. Neither species, we quickly learned, was well studied in the Mississippi River floodplain, so we immediately went back for collecting gear and began our own study that same evening. The fairy shrimp is particularly interesting to aquarists who collect and cultivate "natural" foods for their fishes.

S. seali is a very widely distributed species. It occurs in Canada, the United States, and México; in the U.S. it has been recorded from 24 states ranging from New Jersey to Oregon and from Minnesota to Louisiana (Moore, 1951; Anderson, 1984). Like other fairy shrimp, it usually appears in temporary pools in which there are no fish or salamander larvae. It swims upside-down, using its legs to filter detritus and microscopic organisms out of the water for its food. *S. seali* live as long as three months (one captive male lived five months), and females may produce as many as 1500 eggs in their lifetime. Although this fairy shrimp has been studied for more than 50 years, some basic aspects of its biology have not been determined. It is unknown, for example, if *S. seali* produces both summer eggs (which hatch almost immediately) or just their winter eggs or cysts (which tolerate drying and freezing before hatching). Mating has been observed, but it is unclear if mating is necessary for the females to produce fertile cysts since some populations of other fairy shrimp species are known to be parthenogenic (all females).

Fairy shrimp are closely related to the brine shrimp, *Artemia salina*, which has long been used in the pet trade as a source of food for tropical and marine fishes. As a group, they are an excellent source of food for aquarium fishes. *S. seali*, in particular, is slow moving, colorful, and large, typically reaching sizes of 30 mm, and as much as 42 mm (Moore, 1951). Unlike its famous relative the brine shrimp, *S. seali* is a true freshwater animal and will stay alive in a freshwater fish tank until it is eaten. We have fed them to bluegill, green sunfish and bantam sunfish, all of which eagerly fed on them, but almost all aquarium fishes will eat these animals either live or frozen (Anderson, 1984).

Our populations of fairy shrimp appeared in May shortly after pools formed, disappeared during the summer when predatory invertebrates (backswimmers and dragonflies) were abundant, and appeared again during October-December when floodplain pools reformed after drying out at the end of summer. The pools where we collected fairy shrimp were completely isolated from the river and other fish habitats. Pools were sometimes as large as 10,000 m^2, but most ranged from 2500 m^2 down to 450 m^2. Average depths were usually less than 25 cm. Most pools had abundant emergent vegetation and some canopy. Bottoms consisted of hard packed mud with overlying silt. The water quality in these pools was variable depending on location and time of year. Afternoon water temperature ranged from 11-33°C and turbidity from clear (<4 NTU) to moderately opaque (>80 NTU). Water was slightly acidic (morning pH=6.5) to neutral (morning pH=7.0). Our observations were similar to those made by

Fig. 1.
Processing light traps. Photo by Dena Dickerson/Jan Hoover.

Walter Moore in Louisiana. He found fairy shrimp from August through April in tree-lined ponds and roadside ditches (Moore, 1951). Water temperature ranged from 13.5-29.5°C and turbidity from fairly clear (25 ppm) to murky (3000 ppm). Water, however, was more acidic (pH= 5.2-6.1). Our own data suggested that dissolved oxygen was not an important factor in distribution of the fairy shrimp; morning dissolved oxygen ranged from hypoxic (<2 mg/l) to normoxic (>9 mg/l).

Collecting fairy shrimp is easy and can be done in different ways. We used Plexiglas light traps like those used to collect small fish (Killgore, 2003). The light traps we use have small, removable pans on the bottom that make it possible to place them in very shallow water. The traps are set out during late afternoon, baited with a yellow chemical light stick, and recovered the following morning (Fig.1). Pans are removed and the animals can be poured out and preserved for scientific study or kept alive for fish food. Fairy shrimp are strongly phototactic and abundance in light traps can be very high. One trap in October had so many fairy shrimp in it that we were able to fill two pint jars (Fig. 2). If you use light traps, it requires some planning (not to mention the traps themselves) and two separate trips (one to set the traps, another to pick them up), but one person can do it alone. You can also use a seine, which requires virtually no planning and very little time, but you need a partner to help. The easiest method of collecting fairy shrimp is probably the dip net, which requires nothing else but a little elbow grease.

Once fairy shrimp are collected, they can be transported just like fish—in water-filled buckets or coolers—avoiding overcrowding, temperature shocks, and drastic water changes (Anderson, 1984). They can be maintained alive for long periods in unfiltered, gently aerated aquaria of any size. Airstones, however, should be barely bubbling or suspended just beneath the surface of the water. Shrimp can be fed yeast or a combination of yeast with some other food, like algae, protozoa, or flake food (Moore, 1957; Kaczynski, 1971). Yeast is considered critical for long-term maintenance, fast growth, and egg-production, but we have also kept fairy shrimp for several weeks by feeding them nothing but a variety of finely ground flake foods.

Cultivation from eggs is also fairly simple and can be done either indoors in jars or aquaria, or outdoors in ponds or in children's wading pools (Moore, 1957; Anderson, 1984; Anderson and Hsu, 1990). Fairy shrimp eggs are best hatched if the eggs are preserved in a moist environment (wet mud) for short periods of time instead of being allowed to dry completely. Most fairy shrimp larvae hatch within 24-48 hours and continue hatching for several days. Shrimp can be maintained at room temperatures (21-27°C). These shrimp will reach a length of 12 mm in approximately 8-12 days, at which time they will be able to produce eggs. High summer temperatures (>30°C) usually reduce the productivity of a fairy shrimp culture, but growth is higher in warmer water

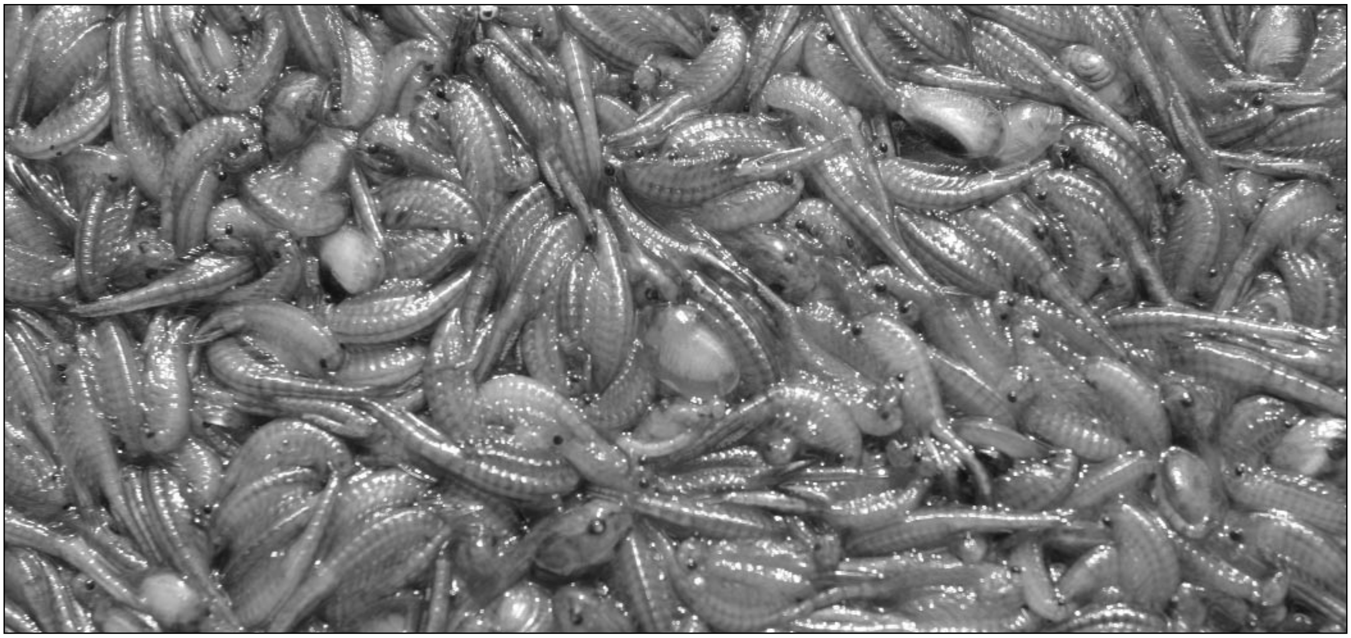


Fig. 2.
Fairy shrimp catch from a single light trap. Clam shrimp are also present. Photo by Dena Dickerson/Jan Hoover.

(25°C) than in water of variable temperature (21-27°C) or cooler water (18°C). *S. seali* can be maintained at a wide range of water hardness ranging from 60-130 $CaCO_3 l^{-1}$. It has been seen that lighting does not play a significant role in the survival or growth rates of fairy shrimp. Shrimp that have been maintained in "normal" photoperiods (approximately 12 hours light/dark) and shrimp that have been maintained in complete darkness have shown no differences in growth rates or survival.

Sometimes, though, successful cultivation is accidental. Walter Moore discovered this in the 1950s (Moore, 1957). He would sometimes set aside jars that once contained fairy shrimp before throwing them away. In many cases, a new hatch of fairy shrimp would appear 1-20 days after all of the adult shrimp had died or had been removed. We had a similar experience. After taking about 30 fairy shrimp home in a five-gallon bucket and removing them with a small net, the empty bucket was placed outside where it remained dry for several days. After some rain, we observed in the bucket, partially filled with rainwater, a thriving population of fairy shrimp.

We believe that the fairy shrimp, *Streptocephalus seali*, is a perfect natural food for the native fish aquarist. It is readily available, occurring throughout most of North America and in a wide range of habitat conditions. It is easy to collect and cultivate. And, when added to a fish tank, it will remain alive until eaten, which for most native fish aquaria will not be a very long time.

Acknowledgments

Help in the field was provided by Bruce Reid (Mississippi Audubon Society), Sandra Hindsman (St. Andrews Episcopal School), Dena Dickerson and Jan Hoover (U.S. Army Engineer Research and Development Center). Access to study sites, field vehicles, and information on site hydrology were provided by Wade and Betsy Creekmore. Shrimp were identified by Steven Weeks (University of Akron) and Christopher Rogers (EcoAnalysts, Inc.). Information on shrimp ecology was provided by Bill Stark (Mississippi College) and Gary Anderson (University of Southern Mississippi). Our thanks to everyone who helped.

Literature Cited

Anderson, G. 1984. The fairy shrimp *Streptocephalus seali*—a useful live food for the tropical fish culturist. *Freshwater and Marine Aquarium* 7 (8): 38-39, 51-52.

Anderson, G. and S.-Y. Hsu. 1990. Growth and maturation of a North American fairy shrimp, *Streptocephalus seali* (Crustacea: Anostraca): a laboratory study. *Freshwater Biology* 24: 429-442.

Kaczynski, V. W. 1971. Rearing fairy shrimp in the laboratory. *Limnology and Oceanography* 16: 586-588.

Killgore, K. J. 2003. Design and application of a larval fish trap. *American Currents* 29 (1): 3-4.

Moore, W. G. 1951. Observations on the biology of *Streptocephalus seali*. *Proceedings of the Louisiana Academy of Sciences* 14: 57-65.

———. 1957. Studies on the laboratory culture of *Anostraca*. *Transactions of the American Microscopical Society* 76: 159-173.

Naming Names (and Often Changing Them): A Native Fish Hobbyist's Guide to Zoological Nomenclature

Christopher Scharpf
1107 Argonne Dr., Baltimore, MD 21218
ichthos@comcast.net

Every species of plant, animal, fungus, moneran, and protist known to science has been assigned a formal scientific name uniquely its own. These names are recognized by scientists and naturalists, whatever their native language, all over the world. Over 1.4 million species have been named so far, but the job is nowhere near completion.

Depending on the estimate, another 10 million living species, perhaps as many as 100 million species, have yet to be discovered (Wilson, 1992). If we were to print the name of every *known* species one to a line in the same type size you see here, in the same page format, it would fill a book around 15,000 pages long. Subsequent volumes of newly described species could add another 1.1 million pages! Our planet is teeming with so many different forms of life that there is no practical way of compiling, nor publishing, a comprehensive "Life on Earth" catalogue.[1]

Every year around 15,000 new species are described (Bank, 2001). Most of them small and hard-to-find, such as bacteria, fungi, nematodes, and insects. In the comparatively small world of fishes, around 250 new species are described each year (Berra, 2001). Ichthyologists estimate that once poorly known geographic areas are surveyed, and new equipment (such as deep-sea submersibles) become more widely available, the total known fish fauna will rise from around 27,300 currently known species to around 31,500 (Berra, 2001). Each of these species will ultimately be assigned a name, using a system devised by Swedish naturalist Carl Linné (1707-1778).

The Father of Taxonomy

Linné was frustrated by the inconsistent ways his fellow naturalists referred to various plants and animals. Some of the names they used were long and unwieldy. Others were changed at whim. The name of a well-known species in one publication had a different name in another. With a large increase in the number of species being brought into Europe from Africa, Asia and the Americas, Linné saw a need for a workable and universal system of biological nomenclature. His solution was a binomial (two-part) name consisting of a genus (the first part of the name) and the species (the second part). Linné also devised a hierarchical taxonomic system (species, genus, family, order, etc.) in which organisms are classified based on anatomical similarities.[2] Although Linné was not the first to use binomials, he was the first to use them

---

[1] And this is only *extant* species we're talking about. Biologists generally believe that 99% of all plant and animal species that have ever lived on Earth have already gone extinct without fossil evidence of their existence.

[2] This was by no means a perfect system, as unrelated animals of similar appearance—eels, snakes and worms, for example—were classified together, but it was an important first step to bringing some semblance of order to classification. Although plants and animals are now classified based on evolutionary relationships, not anatomy, Linné's taxonomic categories remain.

consistently; for this reason the first validly described plants date from his *Species Plantarum* (1753), and the first validly described animals date from the tenth edition of his *Systema Naturae* (1758). Names proposed before these two works were invalidated unless Linné had chosen to retain them.[3] As the father of taxonomy (the science of naming organisms and their classification), Linné got first dibs at naming names.

Anatomy of a Scientific Name

Scientific names are often referred to as "Latin names." Since Latin was the language of scholarship in 17th-century Europe, scientific names were originally written in Latin. (Linné even Latinized his own name to Carolus Linneaus, by which he is officially known.) Today, nearly any word or name from any language can be used to form a scientific name as long as it's not offensive. Most scientific names attempt to denote a distinguishing characteristic of the species being described, whether it's a distinctive physical trait (such as color, size, or an anatomical feature), a behavior, a preferred habitat, or a geographic location.[4] Many names commemorate people. Known as patronyms, these names originally honored the patrons who financially supported the researcher's work (Winston, 1999). Now they may also honor anyone who's important to the author, be it a mentor, esteemed colleague, spouse, lover, child or grandchild, celebrity, or the person who discovered the species or first brought it to the author's attention. Events, organizations, institutions and local indigenous cultures may also be honored. (Naming a species after yourself is tacky and likely sets you up for ridicule among your peers.) Patronymic names are usually identified by the addition of the possessive suffixes *–ae* (for women) and *–i* or *–ii* (for men).

Sometimes the etymology of a name is enigmatic; the name has no obvious association to the organism it describes, and the author didn't bother to reveal its meaning. For example, what did Edward Drinker Cope have in mind when he named the Rio Grande chub *Clinostomus* (now *Gila*) *pandora*? No one knows. (Best guess: the fish's uncertain taxonomic placement was a Pandora's box, or a source of troubles for Cope and future taxonomists.) Fortunately, enigmatic names are pretty much a thing of the past as modern taxonomists are required —or at least consider it good manners—to fully explain their nomenclatural choices.

Sometimes, though, a taxonomist gets playful and may propose names based on puns, metaphors, literary allusions, and the occasional inside joke (often a good-natured jab at a colleague's expense). Such names tend to reveal more about the person doing the naming than the species being named, and as such are generally frowned upon, but there are no formal rules against them. Dinosaurs and obscure invertebrates tend to have the wackier names, but they do occur among fishes every now and again. The box on the next page has a few choice examples.

Whatever its etymology, a scientific name must always be shown in italics, underlined, or else set apart in some fashion so that you know it's a scientific name. The generic name always starts with a capital letter; the specific name is always lower case. Specific names can never have any diacritical marks (such as accent marks or apostrophes), but they may be hyphenated (like the gravel chub, *Erimystax x-punctatus*).

Often you will see scientific names with the author's name and the date of authorship following it. An author is the person (or persons) who first officially proposed the name in a publication. Sometimes listing the author's name helps in identifying the species, especially when two closely related species have similar looking epithets (silverjaw minnow, *Notropis buccatus* Cope 1865, and smalleye shiner, *Notropis buccula* Cross 1953). Having the date with the name helps researchers in locating relevant literature. Many times the author's name is given in parentheses. This means that the species has been assigned to a genus other than the one in which it was originally described.

When a species is divided into two or more subspecies, a third word is added to its name. The third name of the nominate, or original, form of the species repeats the specific name (as in Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus*). Any newly described subspecies are assigned a third name that's different, as in the Gulf sturgeon, *Acipenser oxyrinchus desotoi*.

The anatomy of a scientific name of a representative North American freshwater fish (yellow perch, *Perca flavescens*) is illustrated in Fig. 1.

[3] One exception: The first validly described spiders date from Carl Clerck's *Aranei Svecici*, also from 1758.

[4] Sometimes a descriptive name misrepresents the species it's attempting to describe. North America provides two examples (both cited in Jenkins and Burkhead, 1994). The name of the shiner genus *Notropis* means "keeled back," but shiners have backs that are smooth. When Rafinesque established this genus for the emerald shiner (*N. atherinoides*) in 1818, the specimen he used had a ridged, or keeled, back, probably due to shrinkage. When Lacapède described the black bass genus *Micropterus* (meaning "small fin") in 1802, the specimen he used had a damaged dorsal fin. Had Lacapède used a normal specimen, he likely would given the genus a different name. Although *Notropis* and *Micropterus* are descriptively misleading, the rules of nomenclature dictate that once a validly assigned name is attached to a fish, even a bad name, the fish is pretty much stuck with it forever.

Some curious fish names

Most scientific names denote a distinguishing physical attribute of the organism being described (e.g., color, size, unique anatomical feature). Many names honor the species' discoverer, a wealthy benefactor, a colleague, a spouse, someone famous in his or her field, or even an organization or institution. But sometimes names are proposed for less than purely academic reasons. Biology is rife with examples. Here are a few from the world of fishes:

- Smithsonian ichthyologist Charles F. Girard (1822-1895) was fond of naming minnow genera after Native American words (e.g., *Agosia*, *Dionda*, *Nocomis*) simply because he liked the sound of them and was tired of Latin and Greek. Don't look for meaning in these names. There is none.
- Goby taxonomist Edward O. Murdy named a genus of mudskipper from New Guinea *Zappa* in honor of rock legend Frank Zappa "for his articulate and sagacious defense of the First Amendment of the U.S. Constitution."
- New Zealand ichthyologist Chris Paulin named two viviparous brotulas—*Bidenichthys beeblebroxi* and *Fiordichthys slartibartfasti*—after characters in Douglas Adams' *The Hitchhiker's Guide to the Galaxy*. Both fishes have attributes that remind Paulin of these characters.
- Nijssen and Isbrucker named a *Corydoras* catfish *narcissus* because the discoverers had the temerity to insist that it be named after them.
- The robust size of Scripps Institution of Oceanography scientist Richard Rosenblatt inspired his colleagues to name a robust deepwater cardinalfish *Rosenblattia robusta*.

For more nomenclatural curiosities, visit this website: *home.earthlink.net/~misaak/taxonomy.html*.

A Few Simple Rules

Anyone can name (describe) a species or subspecies, even non-taxonomists. A *Boston Globe* columnist, for example, named a subspecies of cutthroat trout (*Oncorhynchus clarki behnkei*) in a book about fly fishing (Montgomery, 1995). Professional taxonomists usually discourage descriptions by amateurs because the descriptions often contain errors and, as in Montgomery's case, appear in non-scientific publications that many taxonomists overlook. But Montgomery's name is nevertheless available (acceptable for use) because it met criteria established by the International Commission on Zoological Nomenclature (ICZN):

1) The name appeared in a printed publication that is readily available. Theses and websites are not valid publications for taxonomic purposes. (After 1999, CD-ROMs and other non-printed media are acceptable if they are deposited in at least five major publicly accessible libraries that are identified in the work itself.)
2) After 1999, the name is explicitly indicated as being new.
3) The name is binomial (trinomial for subspecies), written in the Latin alphabet (as opposed to Arabic, Chinese, and other languages that use a different lettering system).
4) The name is accompanied by a statement that explains how the species (or subspecies) differs from other closely related species (or subspecies).
5) No other species or subspecies name had been previously published for the same taxon, accompanied by a valid description.
6) The name is unique to the genus; no two species or subspecies in the same genus can possess the same name.

That's it, really. Describing a species isn't all that complicated.

Making sure one has a species that *needs* describing, however, requires more work. Opinions differ on what constitutes a species (a topic for a future article). A literature search must be conducted in order to comply with item #5. And the description should be peer reviewed—critically examined by other experts in the field—before it is published, preferably in a reputable scientific journal. Regrettably, not every taxonomist adheres to these standards. Sometimes poor descriptions are rushed into print because of competitiveness, ego, or the academic pressure to publish. Sometimes taxonomists are mistaken about the distinctiveness of what they're describing. And sometimes they're just sloppy. At best their names are assigned to a nomenclatural purgatory called the synonymy—a list of names applied to a species but considered to be invalid. (Such names may rise out of synonymy when new data justifies their recognition.) At worst the taxonomist may suffer some professional embarrassment.

One of the grand old men of American ichthyology, Henry Weed Fowler (1878-1965), had to swallow his pride in

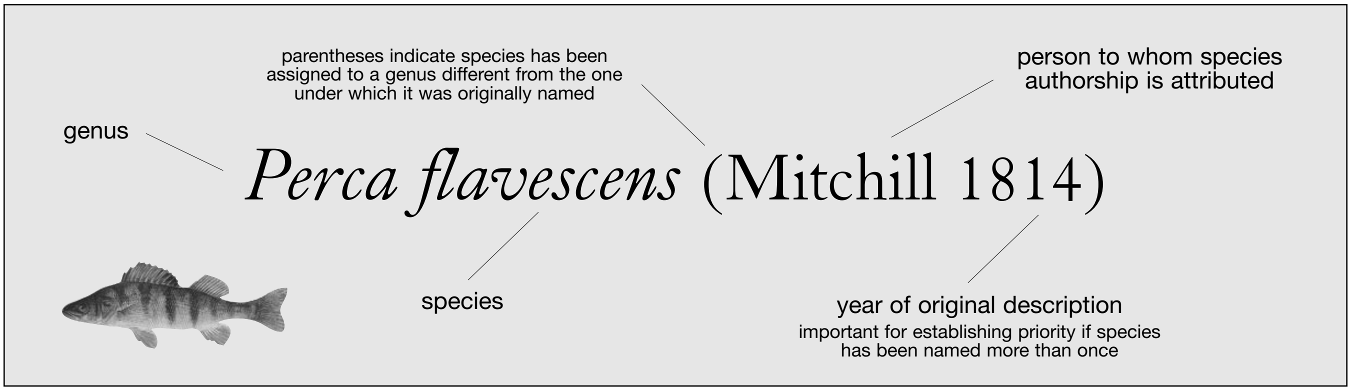


Fig. 1.
Anatomy of the scientific name of yellow perch. Illustration courtesy New York State Department of Environmental Conservation.

1938 when he described a new species of sea bass from Hong Kong. Fowler inexplicably did not recognize the fish for what it was, the common and familiar largemouth bass of North America, which had been introduced into several Hong Kong reservoirs before World War II (Smith-Vaniz and Peck, 1997; Hay and Hodgkiss, 1981). Fowler's reputation survived, but the name he proposed, *Pikea sericea*, will forever be a monument to the lesson that good taxonomists—even great ones like Fowler—can never be too careful.

Why Scientific Names Change

For all the work taxonomists put in making sure their names stand the test of time, many of them don't. Taxonomy is a dynamic process, which means, for better or worse, that names change. This can be frustrating to non-scientists and scientists alike. Still, such changes usually occur for good reason and not at the whim of a bookish academic with nothing better to do. Names changes occur for primarily three reasons:

1) A previously described but overlooked name has priority. Example: In 1968, James D. Williams described the pygmy sculpin (*Cottus pygmaeus*) from Alabama. Little did he know that a Finnish sculpin, *Cottus quadricornis pygmaeus*, had been described in an obscure Finnish journal in 1932. Although the Finnish sculpin's name is no longer used, it's considered "preoccupied" and forever fixed to its specimen. Dr. Williams redescribed the pygmy sculpin in 2000 and assigned it a new name, *Cottus paulus.* (Source: Williams, 2000.)
2) A species is shown to be the same species as one already described. Example: The rainbow trout was known for decades as *Salmo gairdneri*. But new biochemical and anatomical data revealed that the rainbow trout of the Pacific Northwest is the same species as the Kamchatka trout of Asia. Since the Asian species was described first (1792), its name has priority. *Salmo gairdneri* is now *Oncorhynchus mykiss*, and fly fishing publishers have been updating their texts ever since. (Source: Smith and Stearley, 1989.)
3) The species is placed in a different genus. This is the most common cause of nomenclatural changes, although it can be said that the name doesn't change, just the genus. Generic changes are usually the result of researchers continuing to explicate the phylogenetic relationships between closely related taxa. Sometimes when the genus is changed, a slight change in the spelling of the specific name is required if it does not agree with the gender of the new generic name. Example: the walleye, formerly *Stizostedion vitreus*, is now *Sander vitreum.* (Source: Nelson et al., 2004.)

Names may change for other reasons too arcane to discuss here. And names may change only to be changed back for the sake of nomenclatural stability. The Topeka shiner, an endangered minnow from the central U.S., is a case in point. Its name was changed from *Notropis topeka* to *Notropis tristis* when two ichthyologists rooting around a Paris museum found a specimen labeled *Notropis tristis* that had been described in 1856 but was later lost and forgotten. Examination showed it to be identical to *N. topeka*, which was described 27 years later. Since *tristis* was described first, its name had priority. Thus, the name was changed (Mayden and Gilbert, 1989). A petition was later filed with the ICZN to retain *topeka* since virtually every text on North American fishes uses it.[5] Unlike

[5] One prominent reference that doesn't use *topeka* is the commonly used volume on freshwater fishes in the Peterson field guide series (Page and Burr, 1991). This has caused *tristis* to live on longer than it deserves.

the change of *Salmo gairdneri* to *Oncorhynchus mykiss*, which reflected that rainbow trout naturally occurred on both sides of the Pacific, changing *topeka* to *tristis* demonstrated nothing and would cause more confusion than it was worth. Common sense prevailed and *N. topeka* was officially retained to keep the nomenclatural apple cart from tipping unnecessarily (ICZN, 1995).

The Importance of Biological Nomenclature

Careful and accurate nomenclature is needed to help us keep track of our planet's immeasurable biodiversity and communicate effectively about it. There's no doubt that many hobbyists and non-scientists avoid scientific names when shorter, easier-to-pronounce common (or vernacular) names are available. Indeed, for most everyday applications it makes little sense to use *Lepomis macrochirus* when bluegill gets the job done with 55% fewer letters.

The trouble is, common names have their limitations. With more than 1,100 fish species in our continental fresh waters, it's impossible to assign every one a short and pithy moniker. Is *Cottus hubbsi* any more difficult to pronounce or memorize than Columbia mottled sculpin? Another problem is that multiple common names are often used for the same species. Mexicans refer to the bluegill as *mojarra de agallas azules*. In Québec it's *crapet à oreilles bleues*. Even among speakers of English a fish can be known by several vernacular names. Ask a kid in the South what kind of panfish he's put on his stringer and he is just as likely to say bream as he is bluegill. Ask a kid in England if he's caught any bream and he'll think you're referring to a slimy brown relative of the carp (*Abramis brama*). Ask a Japanese biologist if nonindigenous bluegill are decimating the native fishes of his country and he may not know what you're talking about. Rephrase the question using *Lepomis macrochirus* and you've struck a common ground despite the difference in local names.

I hope that hobbyists can better appreciate a fish when they know something about how it was named. Take the Umpqua chub, *Oregonichthys kalawatseti*. It's a fairly drab and little-known minnow from the Umpqua River, a Pacific tributary, in the southwestern corner of Oregon. *Oregonichthys* simply means "fish of Oregon." Its specific name *kalawatseti* contains a provocative touch of poetry, history and even justice. Say its describers, "Oregon once had a remarkable diversity of native peoples with more native languages than all of Europe. The Kalawatset, a tidewater Umpqua people best known for attacking Jedidiah H. Smith in 1828, were part of this lost human diversity and serve to forewarn of a parallel decline in diversity of Oregon's native freshwater fishes" (Markle et al., 1991).

With this attempt to demystify scientific names, I hope they enjoy greater use among aquarium hobbyists and amateur naturalists in the same way gardeners casually use *Rhododendron* and *Chrysanthemum*.

Literature Cited

Bank, D. 2001. Taxonomists unite to catalog every species, big and small. *Wall Street Journal* 22 Jan. 2001: B1.

Berra, T. M. 2001. *Freshwater fish distribution*. New York: Academic Press.

Hay, M. S., and I. J. Hodgkiss. 1981. *Hong Kong freshwater fishes*. Hong Kong: The Urban Council.

ICZN (International Commission on Zoological Nomenclature). 1995. Opinion 1821. *Cliola* (*Hybopsis*) *topeka* Gilbert, 1884 (currently *Notropis topeka*; Osteichthyes, Cypriniformes): specific name conserved. *Bulletin of Zoological Nomenclature* 52 (3): 286-287.

Jenkins, R. E., and N. M. Burkhead. 1993. *Freshwater fishes of Virginia*. Bethesda, Md.: American Fisheries Society.

Markle, D. F, T. N. Pearsons, and D. T. Bills. 1991. Natural history of *Oregonichthys* (Pisces: Cyprinidae), with a description of a new species from the Umpqua River of Oregon. *Copeia* 1991 (2): 277-293.

Mayden, R. L., and C. R. Gilbert. 1989. *Notropis ludibundus* (Girard) and *Notropis tristis* (Girard), replacement names for *N. stramineus* (Cope) and *N. topeka* (Gilbert) (Teleostei: Cypriniformes). *Copeia* 1989 (4): 1084-1089.

Montgomery, M. R. 1995. *Many rivers to cross: of good running water, native trout, and the remains of wilderness*. Collingdale, Pa.: DIANA Publishing Co.

Nelson, J. S., E. J. Crossman, H. Espinosa-Pérez, L. T. Findley, C. R. Gilbert, R. N. Lea, and J. D. Williams. 2004. C*ommon and scientific names of fishes from the United States, Canada, and Mexico*. 6th ed. American Fisheries Society Special Publication 29.

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

Smith, G. R., and R. F. Stearley. 1989. The classification and scientific names of rainbow and cutthroat trouts. *Fisheries* 14 (1): 4-10.

Smith-Vaniz, W. F., and R. M. Peck. 1997. Contributions of Henry Weed Fowler (1878-1965), with a brief early history of ichthyology at the Academy of Natural Sciences of Phladelphia. *In*: Pietsch, T. W., and W. D. Anderson, Jr. (Eds.). *Collection building in ichthyology and herpetology*. American Society of Ichthyologists and Herpetologists Special Publication Number 3.

Williams, J. D. 2000. *Cottus paulus*: a replacement name for the pygmy sculpin, *Cottus pygmaeus* Williams 1968. *Copeia* 2000 (1): 302.

Wilson, E. O. 1992. *The diversity of life*. Cambridge, Mass.: The Belknap Press of the Harvard University Press.

Winston, J. E. 1999. *Describing species: practical taxonomic procedure for biologists*. New York: Columbia University Press.

Elassoma: Great Fish for Small Quarters

Dustin Smith
1229 Walnut St., Newberry, SC 29108
dsmith73@hotmail.com

I started keeping aquarium fish relatively late in life. Unlike a lot of aquarists, it wasn't until college that I set up an aquarium. A friend gave me an old copy of Innes' *Exotic Aquarium Fishes* and, like everyone else who is just getting started, I wanted to try a little of everything, from *Corydoras* species to dwarf cichlids.

One day, I came upon a photo of *Elassoma evergladei*. I immediately decided that I had to have one. After pestering all of the local pet shops and always getting told they didn't have any, I decided to try to find some on my own. Eventually, and with the help of others, I found some in my local waters and pygmy sunfishes have remained favorites ever since.

The pygmy sunfishes of the genus *Elassoma* are some of the more interesting and beautiful of all North American native fishes. Their diminutive size makes them great candidates for even the smallest quarters, and their stunning color and ease of breeding make them highly sought after.

There are six named species of pygmy sunfish, with possibly one or two more to come. These include *Elassoma alabamae* (Alabama pygmy sunfish), *E. boehlkei* (Carolina pygmy sunfish), *E. evergladei* (Everglades pygmy sunfish), *E. okatie* (bluebarred pygmy sunfish), *E. okefenokee* (Okefenokee pygmy sunfish), and *E. zonatum* (banded pygmy sunfish). Of these, *E. boehlkei*, *E. okatie* and *E. alabamae* are either state-protected or listed as species of concern.

Pygmy sunfish are found in stagnant or slowly flowing tannin-stained water. They're almost always found in or near dense submerged vegetation. This type of habitat—roadside ditches and borrow ponds—is susceptible to run-off pollution since there is little turnover of available water. Other fish that are normally found with them include your standard fare of "swampy" fish, such as topminnows, mudminnows, smaller sunfishes, darters, and pirate perch, among others.

All *Elassoma* species have the same captive care requirements. Fortunately, *Elassoma* habitat is easy to replicate in the home aquarium. They do best in smaller tanks of 10 gallons or less—great for desktop or countertop aquariums. Substrate can be whatever you like. Sand works well, but leaves or gravel, or even just a bare-bottom, work fine also. Java moss and hornwort are ideal plants for *Elassoma*, are easy to grow, and require no special attention.

Breeding *Elassoma* is quite simple if the tank is set up properly and the fish are well fed. Their tanks should be heavily planted, enough so that the fish do not have a lot of room to swim around and can barely see each other. This helps prevent territorial disputes from arising. A sponge or box filter works well in these tanks, and an aged sponge filter will provide first foods for the new fry.

Feeding the adults, however, it is a bit more labor intensive. *Elassoma* species will only take live foods at first. Later, they may learn to accept frozen bloodworms, daphnia or brine shrimp. Common live foods that they seem to relish include blackworms, mosquito larvae, whiteworms, grindal worms, and daphnia. Initially, the fry will be too small for baby brine shrimp and should be fed infusoria for the first couple of days. The fry will also pick at the sponge filter, so it's not a bad idea to leave it a little dirty while they are still small. After they get a little larger, they will then eagerly take microworms, vinegar eels and baby brine shrimp. They can be raised with the parents as long as the parents are well fed.

I hope this account has raised some interest in these unique fishes. They were the first native fishes I maintained and spawned, and to this day remain my favorite. If you have a small empty tank lying around, give them a try. They may become your favorite as well.

THE BEGINNER'S BUCKET

In Praise of Poeciliids Part I: *Heterandria* and *Gambusia*

Robert Bock
1602 Tilton Dr., Silver Spring, MD 20902
bockhouse@earthlink.net

Like those old Warner Brothers cartoons of the 40s and 50s, there's more to poeciliids than most of us remember through the haze of our childhood sensibilities. If you watch a Looney Tunes short as an adult, you'll quickly see that they're filled with subtleties that fly high over the heads of most children.

Similarly, poeciliids—the livebearing guppies, mollies, and swordtails that many of us kept as kids—are definitely worth another look if you haven't kept them since childhood.

Poeciliids are a large and diverse clan, found in North, Central and South America. Since NANFA is concerned with North American species, in this two-part article I'll concentrate on just a few: least killifish, mosquitofish, sailfin mollies, swordtails, and platies.

The Least Killifish is not a Killifish

The tiny least killifish (*Heterandria formosa*) is found in much of the southeast, from southern North Carolina down along the Coastal Plain through to Louisiana. The name is a misnomer; least killies are not killies at all, but actually live-bearers. I went into more detail about keeping least killies in a past Beginner's Bucket column, "The Least Amount of Trouble" (*American Currents*, Spring 2003). But since we're talking about appreciating the subtleties of poeciliids, some of the information is worth repeating here.

Least killies are a great aquarium fish because they don't take up much space and are so undemanding. Females will grow to an inch-and-a-half in length, whereas a large male would be lucky to reach half that size. They aren't particularly fussy about water chemistry, and will probably do alright if you keep them in water with some hardness. Since they're found in the southeast, it's probably a good idea not to let their tank temperature drop too far below the low 60s.

The great, underappreciated subtlety about the least killifish is how it gives birth. Unlike mollies, mosquitofish, and swordtails, which give birth periodically in a single large batch, least killies simultaneously incubate several fry at different stages of development. The fry are born one at a time, every few days.

Like other poeciliids, females store sperm and can give birth for months after mating. I once brought a female least killie home from a collecting trip and put her in a 40-gallon backyard tub in the early spring. By summer's end, I brought in at least 50.

Guppies Gone Bad

I have to admit that I haven't kept mosquitofish long enough to appreciate whatever subtleties they may have. But since most beginning native fish keepers are likely to encounter mosquitofish, they're worth talking about here.

These drab little livebearers have been introduced throughout the world because many believe they consume great quantities of mosquito larvae. Others bitterly dispute this view, contending that they not only don't eat that many larvae, but that they prey on the eggs and fry of other species, threatening native fish populatons.

The two most common species of *Gambusia* are the western mosquitofish (*G. affinis*) and the eastern mosquitofish (*G. holbrooki*), which, until fairly recently, had been recognized as a subspecies of *G. affinis*. The western mosquitofish is native to most of the south-central U.S., north to Indiana and Illinois, west to Texas, south to southern México, and

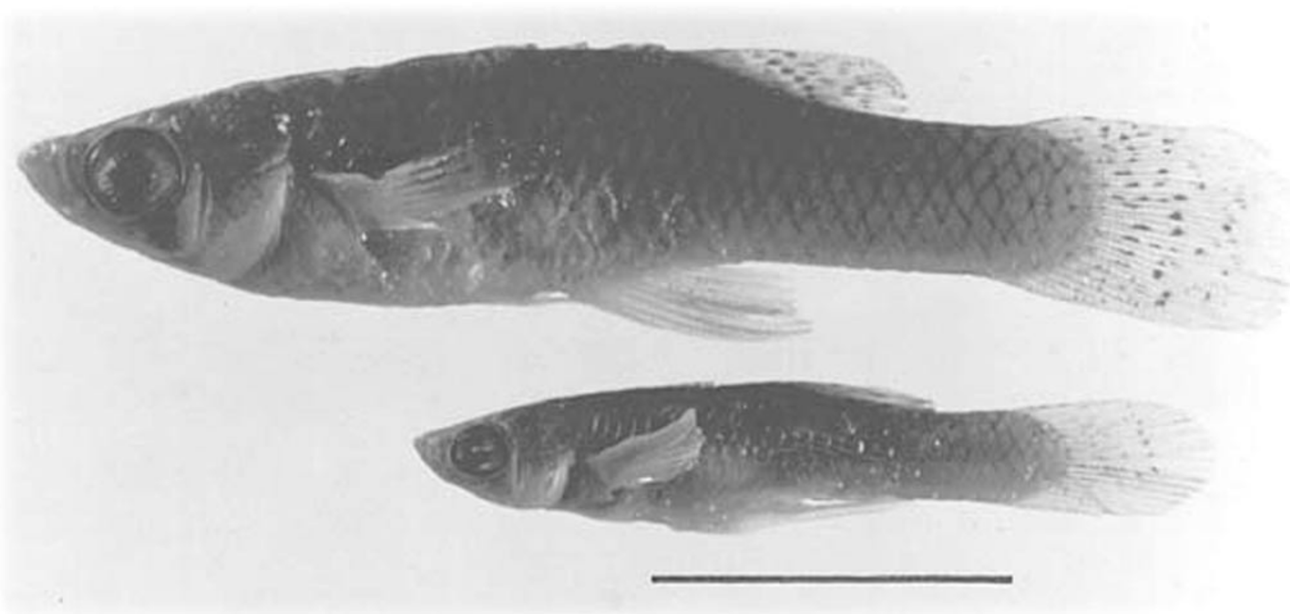


Fig. 1.
Eastern mosquitofish, *Gambusia holbrooki*. The upper fish is the female; note the gonopodium (a modified anal fin) on the male. Scalebar represents 1 cm. Photo courtesy Gambusia Control Homepage (www.gambusia.net).

east to the Mobile River system. The eastern mosquitofish is native to the southeastern U.S., east from the Mobile Bay drainage to Florida, north to southern New Jersey. Both species have been introduced far outside their native ranges.

Gambusia aren't much to look at. The females resemble oversize common guppies, and the males resemble common guppy males without the bright colors. In Florida, mottled males resembling marble mollies frequently occur.

I have to admit, though, that I've never taken the trouble to learn how to tell the two species apart, or to learn to recognize the other *Gambusia* species listed in my Peterson *Field Guide*. Although they may look like common guppies, this appearance is deceptive. I've kept them only briefly, having brought some back from trips to Florida and into the Maryland countryside. Like tiger barbs, they can be nasty little fin nippers. In fact, a few mosquitofish I had kept in a 10-gallon tank chewed the caudal fin off a blacknose dace several times their size.

In fairness to the mosquitofish, however, I have to admit that they didn't work out for me because I didn't give them the proper conditions: a species-only tank where they wouldn't bother tankmates.

But my failure doesn't mean they won't work out for you. If you provide them with a tank to themselves, you may observe subtleties about their behavior I had missed.

No introduction to North American poeciliids would be complete without a description on the two beautiful sailfin mollies found along the southeast Atlantic and Gulf coasts. I'll devote Part II of this column to these species and to the platy and swordtail species found in México.

How to join NANFA's email lists.

NANFA's email list is a great place to discuss native fishes as well as to receive the latest NANFA news. To join, send the phrase "subscribe nanfa-l" in the message (not subject) area of an email to:

`majordomo@nanfa.org`

You will be sent a follow-up confirmation email. A digest version, in which a day's postings are combined into one email, is also available. To join, send the phrase "subscribe nanfa-l-digest" to the same address as above.

NANFA's Board of Directors has its own list to discuss NANFA's day-to-day management and long-term goals. Every member is encouraged to join the list and the discussion. To join, send the phrase "subscribe nanfa-bod" to the same address as above.

Riffles

Notes on Captive Husbandry, Biology, Collecting, Conservation, Nomenclature, and Recent Publications

New and recent publications

• *Fishes of the Middle Savannah River Basin, with Emphasis on the Savannah River Site* by Barton C. Marcy Jr., Dean E. Fletcher, F. Douglas Martin, Michael H. Paller, and Marcel J. M. Reichert. Photographs by David E. Scott. University of Georgia Press, hardcover, 8 1/2 x 11", 480 pp., $64.95. Located along the Georgia–South Carolina border, the Middle Savannah River Basin comprises the portion of the Savannah River drainage area located on the Upper Coastal Plain and edges of the Lower Coastal Plain. The book identifies and discusses 100 native and introduced species from 26 fish families—approximately 70% of the native species in the entire Savannah River drainage area. Illustrated with more than 200 color photos of habitats and fishes, each species account describes the fish's appearance, meristic features, size, biology, habitat, conservation status, similarities to other species, and geographic range. The book also discusses the Savannah River, tributary streams, reservoirs, and ponds from the 1950s to the present showing ecological changes, detailed habitat descriptions, and associated fish assemblages. A taxonomic identification key is illustrated by 180 black-and-white photos. Save for a few brief mentions, aquarium care is not covered.

• *Sturgeons and Paddlefish of North America* by Greg T. O. LeBreton, F. William H. Beamish and R. Scott McKinley (editors). Fish and Fisheries Series Vol. 27. Boston: Klumer Academic Publishers, hardcover, $86, 323 pages. This collection of papers reviews the extensive science aimed at helping acipenserid species (sturgeons and paddlefishes) recover from the brink of extinction. Chapter subjects include Native American utilization of sturgeon; distribution, habitat and movements; environmental requirements, preferences and tolerance limits; ecology and functional morphology of feeding; ecomorphology; embryology; swimming and respiration; metabolism; growth, bioenergetics and age; genetics; multi-jurisdictional management of lake sturgeon; conservation; aquaculture; and key to identification. The introductory chapter, "The Decline of the North American Species," is adapted from Inga Saffron's 2002 book, *Caviar: the Strange and Uncertain History of the World's Most Coveted Delicacy.*

• *The Philosopher Fish: Sturgeon, Caviar, and the Geography of Desire* by Richard Adams Carey. Counterpoint Press, 332 pp., hardcover, $26. This book covers the same ground as Saffron's *Caviar*, mentioned above—a history of the caviar industry, the decline of sturgeon stocks worldwide, the rise of black market caviar, and the role of aquaculture to both rebuild wild sturgeon populations and provide a source of caviar. The main difference between the two books is that Saffron, a reporter specializing in culture and Russian affairs, does a better job of covering the Russian side of the industry, emphasizing the culinary appeal of caviar through the ages. Carey, an environmental journalist, uses the plight of sturgeon to illustrate the rift between the utilitarian and the conservationist factions of the environmental movement.

Feds accept petition to protect Puget Sound steelhead

On 5 April 2005, NOAA Fisheries announced that it had accepted a Washington state citizen's petition to list Puget Sound steelhead under the Endangered Species Act (ESA), saying that the petition describes significant short- and long-term downward trends for steelhead in a wide range of rivers emptying into the Sound.

Although acceptance of the petition doesn't guarantee that Puget Sound steelhead will ultimately be listed under the ESA, it does mean the fisheries agency will conduct a full-scale biological review of the population and solicit public comment on the status of the stock. A final decision about whether to propose listing will be made by Sept. 13, the one-year anniversary of when NOAA Fisheries received the petition from Sam Wright of Olympia, Wash., who once worked as a biologist for the state Department of Fish and Wildlife. Wright's petition presents information that says there may be "significant interbreeding and competition" between hatchery and wild steelhead in spite of efforts by the state's Department of Fish and Wildlife, which operates the hatcheries, to isolate the two.

If Puget Sound steelhead are proposed for listing, the listing wouldn't become final until September 2006.

Feds propose adding green sturgeon to endangered species list

On 5 April 2005, NOAA Fisheries announced that it was proposing to list green sturgeon (*Acipenser medirostris*) south of the Eel River, Calif., (southern distinct population segment or DPS) as threatened under the Endangered Species Act (ESA). The population of green sturgeon north of and including the Eel River (northern DPS) does not warrant listing under the ESA, although it is considered a Species of Concern.

In January 2003, NOAA Fisheries determined that neither the northern nor the southern DPS of green sturgeon warranted listing under the ESA. However, that determination was legally challenged, and in March 2004 the U.S. District Court for the Northern District of California set aside the decision and remanded the case for further evaluation by NOAA Fisheries. The proposed rule is a result of that re-evaluation.

Federal biologists used previous studies of salmon in California's Central Valley to examine the likelihood that spawning habitat has been lost within the range of the southern green sturgeon DPS. Green sturgeon are an anadromous species requiring similar habitat features as salmon for survival and reproduction. It was determined that dams built in the upper Sacramento and Feather Rivers likely blocked migration of green sturgeon, which led to a significant reduction of the southern DPS's historical habitat. The presence of two spawning populations in the northern DPS and the likely continued spawning in other rivers reaffirms the previous determination that this population does not warrant listing under the ESA.

Green sturgeon inhabit near-shore marine waters from México to the Bering Sea and are commonly observed in bays and estuaries along the western coast of North America with particularly large concentrations entering the Columbia River estuary, Willapa Bay, and Grays Harbor during the late summer. It is a long-lived, slow-growing fish and is the most marine-oriented of the sturgeon species. There is evidence that green sturgeon spawn in the Klamath-Trinity, Sacramento and Rogue Rivers, with most of the spawning thought to occur in the Klamath-Trinity River.

Two new books on Pacific salmon

- *Atlas of Pacific Salmon: The First Map-Based Status Assessment of Salmon in the North Pacific* by Xanthippe Augerot. University of California Press. 152 pp. Hardcover, $34.95. Using state-of-the-art GIS mapping tools, this book offers a map-based assessment of distribution and risk of extinction for seven species of Pacific salmon. More than 36 full-page maps overlay the human, climatic, geological, and environmental impacts on salmon populations. The author shows a consistent pattern of imperilment on both sides of the North Pacific and concludes that nearly one of four Pacific salmon populations assessed are at risk of extinction.
- *The Behavior and Ecology of Pacific Salmon and Trout* by Thomas P. Quinn. University of Washington Press. 378 pp. Hardcover, $60; softcover, $35. Quinn, a fisheries scientist, distills from the scientific literature the essential information on the behavior and ecology of Pacific salmon. The book introduces salmon and trout as a group, with a brief description of each species, and compares them to other fishes. The book then follows salmon on their homeward migration from the open ocean, through coastal waters, and upstream to the precise location where they were spawned years earlier. It explains the patterns of mate choice, the competition for nest sites, and the fate of the salmon after their death. It describes the lives of offspring during the months they spend incubating in gravel, growing in fresh water, and migrating out to sea to mature. The author emphasizes the importance of salmon to humans and to natural ecosystems, and the need to integrate sound biology into conservation efforts.

New genus and "new" species for leatherside chub

Ichthyologists have long scratched their heads over the leatherside chub, an imperiled desert minnow native to the Bonneville Basin and upper Snake River drainages of western North America. The fish has been classified in six different genera over the years, and recent molecular data hint that the fish could be composed of two distinct forms that are geographically separated into northern and southern species. Now an extensive study by three researchers promises to be the final untangling of the species' taxonomic knots. Writing in the journal *Systematic Biology* (Dec. 2004, vol. 53, no. 6), Jerald B. Johnson, Thomas E. Dowling and NANFA member Mark C. Belk provide three separate lines of evidence—phylogenetic, morphological and ecological—that support the hypothesis that the leatherside chub is composed of two species. In addition, all lines of evidence place these two species within the genus *Lepidomeda*, a group consisting of four additional species (one extinct) of endangered spinedace, all native to the Colorado River system.

Using mitochondrial and nuclear DNA sequences to test leatherside chub species boundaries, the authors found numerous fixed genetic differences between the northern and southern populations. The two hypothesized species also showed significant differences in cranial shape. Fish from the northern species on average had deeper heads with shorter noses than fish from the southern species. Finally, controlled growth and foraging experiments show that the two forms appear to be locally adapted to the thermal environments where they occur. At colder temperatures, fish from the northern population ate more and grew more rapidly than fish from the southern population. However, this was reversed at high temperatures, where fish from the southern population ate more and grew faster than fish from the northern population. Fish from the two populations also foraged at different rates under different temperatures. The conclusion? Two distinct species are involved.

But in what genus do the two species belong? Most fish books list the nominal leatherside chub in the western chub genus *Gila*, while some taxonomists have placed it in its own genus, *Snyderichthys*. Comparing leatherside chubs to other western minnows, the authors uncovered something of a surprise: Cranial shape data and molecular data clearly nestle the chubs within the spinedace genus *Lepidomeda*. In fact, these data show that the two leatherside chub species are more closely related to other spinedaces than they are to each other. The leatherside chubs lack the spinedaces' characteristic "spines"—a modification of the two front fin rays of the

Southern leatherside chub, *Lepidomeda aliciae*.
Photo by Mark C. Belk.

dorsal fin into enlarged, elongated, and solidified spinose rays, and a spinelike development near the base of the first few rays of the pectoral fin. The implication is that the missing spines are not phylogenetically important; for some reason, the leatherside chubs did not need them, so they were lost as the two species evolved independently from the rest of the genus.

The northern leatherside chub, which occupies tributaries to the upper Snake River and Bear River drainages in Idaho, Wyoming and Utah, will have the name *Lepidomeda copei*. The southern leatherside chub, which occupies Utah Lake and Sevier river drainages in Utah, will have the name *Lepidomeda aliciae*. This designation marks the reevaluation of *aliciae*, first described in 1881 by Jouy for a now-extinct population of southern leatherside chub from the Provo River.

Goldstripe darters spawn early at CFI

An unusually warm winter in the southeastern U.S. caught the aquarists at Conservation Fisheries, Inc. (CFI) in Knoxville, TN, slightly off guard. Since their hatchery is cooled by outside air, the air inside crept into the low 60s during a January warm spell. This jump-started the spawning of goldstripe darters (*Etheostoma parvipinne*), a relative of the extremely rare and imperiled rush darter (*E. phytophilum*). By studying and perfecting the captive propagation of the more common goldstripe darter, CFI hopes to apply these techniques on the rush darter over the next couple of years. The following is reprinted from the February 2005 issue (#26) of CFI's on-line newsletter:

"At this point [as the temperature climbed], we were seeing behavior in the goldstripe darters that was obviously romantically motivated. The males darkened considerably and developed an almost metallic blue cast. The females were very gravid.

"Soon, we were seeing males pursuing and occasionally mounting the females. The tanks were supplied with nylon yarn mops, the same ones we use with our topminnows. On 01/14/05, several mops were removed and checked for eggs.

Goldstripe darter, *Etheostoma parvipinne*, gravid female.
Photo courtesy Conservation Fisheries, Inc.

Numerous small (~1mm) eggs were found loosely adhering to the mops. We found that the eggs were easily dislodged from the mops by swirling them (the mops) in plastic shoeboxes filled with tank water. Using a light table, the eggs were removed from the shoebox and placed in small, plastic containers and floated in the tanks for temperature control. We removed 20-30 eggs in this first collection attempt.

"Within a day or two of this, the temperature outside began to fall back to temperatures you would expect for January. By the 19th, the water temperature had fallen to 50°F. However, the eggs still looked fine and the adults were still determined to continue spawning!

"Ten days later, the water temperature was 48°F and the eggs still had not hatched. The embryos were well pigmented and could be seen moving within the chorion. The first egg hatched on the 25th, 11 days after they were collected (probably 12 days after spawning). The larvae were tiny, approximately 3 mm in length. After about a day, they were very mobile and tended to spend the majority of their time swimming up from the bottom. Within a couple of days, they were clearly spending most of the time up in the water column.

"We are rearing them in the black rubber tubs that we have used for most of our pelagic darters. One of these [tubs] is pictured in CFI Newsletter #23. Now came the task of figuring out what to feed such small larvae! We were just starting our live food cultures up for the spawning season. These guys took us by surprise by starting so early!

"We started by 'greening-up' the tub with Instant Algae (*Nanochloropsis*). This is a wonderful concentrated algae solution that we dilute with filtered water. It can be stored in the refrigerator or frozen. It has eliminated our headaches associated with culturing large amounts of 'greenwater.' In the past, we have found that, for whatever reason, many of these tiny larvae do better when their culture containers are kept slightly green. We supplemented the algae feedings with powdered foods (primarily O.S.I. APR formula). In addition, we filter out the neonates from our *Ceriodaphnia* cultures. These are somewhat smaller than brine shrimp nauplii. We have a mixed rotifer culture that we use to feed these and other small larvae. (The Instant Algae has proven to be great for feeding our rotifers and cladocerans.) Finally, we have been supplementing this with microworm (nematode) feedings. This is the first year we have used microworms and are interested in seeing how they work out. I suspect they will be better for larvae that are more benthic.

"In any case, something in this mix has worked and the larvae have done well for us! As of this writing, we have transferred approximately 90 larvae into the tub and can count more than 40 swimming around in there. There are probably quite a few more as they are difficult to see against the dark background of the tub.

"The earliest larvae are still pelagic at this time! We did not expect this to be the case with these fish. One observation we have made in the past is that darter larvae that are pelagic tend to be virtually unpigmented. Larvae that are well pigmented tend to be more benthic. This, of course, makes sense—a clear larva is more difficult to see in the water column. But these guys didn't fit into our theory at all! But this probably makes sense, too. Goldstripe darters are found in heavily vegetated, often dark-stained waters. A darkly pigmented larva might be more invisible under these conditions. Indeed, like I said, against the black background of the rearing tub, these guys are extremely difficult to spot. Sometimes, we just have to adjust our thinking to fit the circumstances!"

CFI's newsletters, and photos of their operations, can be viewed on their website at www.conservationfisheries.org.

Wisconsin fish I.D. and mapping systems now online

A preliminary version of an innovative photo-based system for identifying the fishes of Wisconsin is online at:

`http://limnology.wisc.edu/`

Click on "Research" and then on "Online system for identifying fishes." You'll need a fast Internet connection (i.e., not a phone modem) to really use this system. Also available online is a fish distribution mapping program for Wisconsin fishes:

`http://infotrek.er.usgs.gov/fishmap`

Again, a fast Internet connection is needed.

NANFA News

Members, Events, Accomplishments, and Administrivia

NANFA funds two Conservation Grant projects

One of NANFA's programs is funding research that can benefit the conservation of North America's native fishes. This year NANFA received nine research grant proposals. The Conservation Research Grant committee (Todd Crail, Jeremy Tiemann and chair Bruce Stallsmith) recommended funding two of them. The Board of Directors agreed to the committee's recomendation and unanimously voted to award the following two grant proposals $1000 each:

- Michael Bessert and Chenhong Li (Nebraska): "Conservation Genetics of the Plains Topminnow (*Fundulus sciadicus*)." The objectives of this work are to establish conservation strategies and collect genetic and demographic data (i.e., effective population size, population growth and decline rates, and extant genetic variation) within and between *F. sciadicus* populations in Nebraska and Missouri. Bessert and Li hope to provide a foundation for plans to protect the plains topminnow in Nebraska and Missouri (if warranted), and provide a template for the development of regional conservation plan for species with similar habitat, range, and life history patterns.

- Jenjit Khudamrongsawat (Alabama): "Life History Study of Vermilion Darter (*Etheostoma chermocki*) from Turkey Creek, Jefferson County, Alabama, and Warrior Darter (*E. bellator*) from Gurley Creek, Blount County, Alabama." The federally endangered vermillion darter is only found in one 11 km stretch of a creek in suburban Birmingham, AL. Anthropogenic activities such as altered riparian vegetation, modified flow patterns, increased silt loading, and other pollutants may threaten the viability of this species. Many questions remain about the life history of *E. chermocki*, especially relating to spawning habits and movement dynamics. To better understand these habits, research involving mortality of individuals will be done on the closely related *E. bellator* as a surrogate. These studies will emphasize fecundity and feeding of *E. bellator*.

Congratulations, Heather!

NANFA member Heather Smith (MS) recently conducted a study of swimming performance of juvenile lake sturgeon maintained at the U.S. Army Corp of Engineers' fish lab in Vicksburg. Heather, a ninth grader, did her work after school and on weekends. Her data, along with newly developed mathematical models for suction forces generated by dredges, make it possible now to assess the risk of a dredge entraining a small sturgeon and, more importantly, how to minimize and maybe eliminate that risk.

Heather presented her data in February at the Mississippi Junior Academy of Science Meeting and won the Junior Division in "Environmental and Behavioral Studies." She gave an expanded version of her presentation in March at the Mississippi Regional Junior Science and Humanities Symposium (MRJSHS) at the University of Mississsippi and won first place and a sizeable scholarship to the University of Mississippi. Heather is planning to compete in the JSHS national finals in San Diego.

South Carolina NANFA members make three discoveries

Can amateur naturalists contribute to science? Just ask Chip Rinehart and Dustin Smith of NANFA's South Carolina chapter. When not working their days jobs (which have nothing to do with fishes), they run a side business called KSIAquatics, collecting fishes for public aquaria and performing nongame aquatic life surveys. During one survey near Hilton Head, SC, Chip and Dustin discovered a new population of bluebarred pygmy sunfish (*Elassoma okatie*). According to Chip, this population, less than 1.5 miles from a salt marsh, is the closest to the coast that *E. okatie* has ever been found.

During a survey at the Lynches River last July, Dustin and Fritz Rohde found what appears to be of a new species of mudpuppy (shown here, photo by Dustin Smith). In November, in Lexington County, Chip found another unusual and presumably undescribed mudpuppy. These two "new" *Necturus* were separated by three drainages and are completely different in appearance from the dwarf mudpuppy (*Necturus punctatus*) that is normally found at these locations.

The first mudpuppy is undergoing DNA testing at the University of South Carolina. Tail clippings of the second mudpuppy are needed for DNA tests to begin.

Board nominees wanted for 2006-2007 term

Any member may nominate his or her self to serve on NANFA's Board of Directors, or may nominate a fellow member as long as that member accepts the nomination. A nominee must meet two qualifications:

1) A nominee should ideally have demonstrated his or her ability and interest in the management of NANFA and/or the promotion or advancement of its objectives. Ability and interest can be measured by participation in one or more NANFA duties and/or programs, including but not limited to: serving as a Regional Representative or Contact; writing articles for *American Currents*, or helping with its editing, design, printing, and/or mailing; contributing to NANFA's website or helping manage it; helping maintain or manage NANFA's email list, treasury, or database; helping with annual election mailings and vote counting; hosting or helping the host(s) of an annual convention, regional meeting, or collecting trip; promoting NANFA and/or its objectives by writing articles for outside media, or by giving presentations at or leading trips for aquarium clubs, nature centers, schools, and other venues; by setting up or maintaining educational native fish aquaria; and by providing counsel to the Board.

2) At the time of assumption of office, a director shall have maintained a continuous membership in NANFA for not less than one year.

Nominees are required to submit a candidacy statement describing their qualifications and what they hope to accomplish as a board member to Board Chair Jan Hoover (see inside front cover for contact info) no later than Oct. 1, 2005. This statement will be distributed to the membership as part of an election ballot.

Board seats held by Jan Jeffrey Hoover, Christopher Scharpf, Bruce Stallsmith and Jeremy Tiemann are open for election for the 2006-2007 term.

Reaching Out: Notes from NANFA's Regional Outreach Program

As I write this, most parts of the country, aside from those in areas where there is almost no "down season," are just now emerging from the winter doldrums. With this annual reawakening comes plans for NANFA-related activities among our coordinators. We look forward to a robust year of activity and an effective broadcast of NANFA's message. If you have been considering participation in the Outreach Program, now is the time to come forward. There are a number of opportunities at every level for you to contribute in ways large and small to our effort. Remember, the ultimate goal of the Outreach Program is to educate with respect to both the conservation of our natural aquatic environment, and the role that NANFA plays in that process. It is the contribution of the individual member that makes any efforts of this nature work.

We recognize that some members do not prefer a commitment to the structure of the Outreach Program. Nonetheless, there are actions each of us can take that will provide big benefits. A few examples: A copy of *American Currents* at a local library, nature center or other public facility is an excellent way to introduce the native fish world and the NANFA organization. Chris Scharpf can help you obtain the copies to support such a program. If public speaking is of interest, slide shows featuring native fishes and habitat information find a ready audience at the local aquarium club, as well as 4H and other nature-oriented organizations. These groups are always looking for interesting speakers. Contact us for help in obtaining the necessary materials. If it's legal in your region, provide a pair or two of aquarium-friendly native fishes to the local aquarium club auction. Be sure to include a NANFA membership form along with the fish. Of course, none of these actions will independently have a significant impact, but taken together, the impact can be surprising.

Peter Unmack and the members of the Desert Fishes Council (www.desertfishes.org), are busily planning another weekend in the deserts of Nevada to clear exotics from some of our most important and fragile ecosystems. Usually occurring in May, this notice may not reach you in time to participate in the outing this spring. However, the annual October trip to Ash Meadows is also being planned, and will give you plenty of time to plan your participation in this most important activity. Please contact Peter directly for additional information.

The Hillsboro County, Florida Cooperative Extension, a University of Florida and Hillsboro County natural history-oriented complex, serves the greater Tampa area. This excellent facility is a central resource combining a natural history museum and educational demonstrations primarily aimed at primary and secondary students. The Cooperative installed a pond in their newly constructed commons area, and asked NANFA's Central Florida Region for ideas on how to populate it. A collecting trip in the immediate area ensued, resulting in a nice selection of local natives that now reside in the pond. The Cooperative also asked the group to supply a display that explains the pond, its inhabitants, and the importance of conservation and habitat protection. This display will be prominently housed in the lobby and will include NANFA promotional materials and membership forms. We are also discussing providing quarterly talks on native fishes and habitat conservation to student groups as part of the center's permanent educational series.

Lastly, our NANFA promotional display once again occupied a prominent position in the aquatic arts area located in the Family Center Building at the Florida State Fair. There was a lot of traffic past the display this year, and about 300 membership forms were taken. Who knows, maybe some new members will join as a result.

Although we look forward to reporting on a full slate of coordinator activities in the next installment, activity reports from members outside the Outreach Program are welcomed as well. Send your contributions to me by the 15th of each ending quarter month: March, June, September and December.

— *Charlie Nunziata*
Regional Outreach Program Coordinator

Welcome, new members

Bill Arthurs Bellingham, WA
Bill Becvar Rockford, IL
Herschel Beeman Chittenango, NY
Angela Capello Forest Hill, LA
Elizabeth Coughlin Lowell, MA
S. Cumberbatch Tallahassee, FL
Jim Forshey Placerville, CA
Jack William Gegenheimer II San Jose, CA
Edward R. Gimmi Lafayette Hill, PA
Duel Glass Overton, TX
Frank Glennon San Francisco, CA
Stephen Harasta Deptford, NJ
Scott Isbill Snellville, GA
Richard Kazmaier Canyon, TX
Alaine K. Knipes Lincoln, NE
John Kyriakides Rockville, MD
Clint Leonard Crescent City, FL
Greg Lindsey Gettysburg, PA
Ken Logsdon Frankfort, KY
Thomas Martin Cullowhee, NC
Joseph McLaughlin Dover, DE
Joseph Norman Lindsay, ON
Keri O'Neil Randallstown, MD
Derek Parr Chapel Hill, NC
Jim Patus Sellersburg, IN
Mark Roeyer Lawrence, KS
James Sanchez San Jose, CA
Michael Sandel Tuscaloosa, AL
Thomas Schrader Aurora, IL
William Seals Dallas, TX
Kent Semmen Aurora, IL
Lorianne Shealy Prosperity, SC
Jeff St. Pierre Ann Arbor, MI
Timothy Strakosh Manhattan, KS
Uland Thomas Chicago Heights, IL
Deborah Volk Cincinnati, OH
Tom Ward Burnsville, MN
Rachel Wilborn Pensacola, FL

Panacea & Tate's Hell:
A NANFA Expedition to the Floridian Gulf Coast
October 20-23, 2005

In March, I led a small group of NANFA members to the Floridian Gulf Coast. We stayed at the Florida State University (FSU) Marine Lab just outside of Panacea. The university's gated compound is located on the coastline looking south into the Gulf of Mexico. The objective of our visit was to explore and sample the area, the FSU facility, and its housing, both for ourselves and in preparation for a return visit this October. We had an excellent time exploring and relaxing for three full days and four nights. We seined and netted the rivers, backwaters, ponds, lakes, roadside ditches and swamps of Tate's Hell, which borders the vast Apalachicola National Forest to the north. We spent a day snorkeling the cool, clear waters of the Wakula River and a beautiful spring-fed slough lush with plants and fish. We walked and waded the beaches by morning, moonlight and lantern, finding coupling horseshoe crabs, sting rays, the oddly shaped batfish, schools of killifish, pulsing squid, and a green-eyed alligator. We cast nets for mullet and hooked speckled trout from the docks. We gathered and plunked tiny sunfish into moonshine for Fritz Rohde's DNA work. We marveled at the diversity in our nets and viewers. We watched the stars and planets by night and felt the sun's warmth by day. We measured Old Joe and found the gator's length decidedly exaggerated. We rode whales and fiberglass sharks and stuck our fingers, hands and arms into places we were told not to. No one was lost, forgotten or eaten. We ate the finest foods the sea has to offer, from grouper to freshly smoked mullet to bait-shop squid cleaned, ringed and fried. Saturday evening, surrounded by jars of preserved specimens, we sat before a gumbo of oysters, crab and shrimp with side helpings of salad and homemade bread, cherry cobbler and ice cream. We climbed the two towers, one for fire and the other of wood, and saw the Silver Lake and a vast stand of dwarfed bald cypresses. Fish, life and water were everywhere!

We spent three days enjoying all this and invite you to do the same.

From October 20-23 of this year, I will host a return visit to the FSU Marine Lab and Tate's Hell. The gathering will be limited to 12 dedicated and ethical fishheads. *Advance reservations are required.* The cost is $250 per person, which includes lodging, the makings for breakfast and roadside lunches, a variety of snacks and drinks, and a special evening meal on one selected night. On other nights we will visit nearby seafood restaurants or cook some fresh fish or crab in the house's kitchen or outdoor grill.

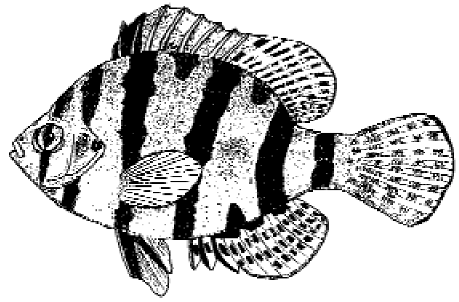
Waders are required for safety in the swamps and snorkel gear suggested for some amazing views in the clear waters of the Wakula. The weather should be dry, cool and bug-free this time of year. Alternate and backup plans for rainy or restful days are a visit to the Gulf Specimens Marine Lab or the Apalchicola Nature Center. We should encounter a wide variety of fishes from bluefin killies and golden topminnows to sailfin shiners. We observed well over 35 species of freshwater fishes during our short March stay.

Steven Ellis about to sample one of the many bald cypress backwater ponds of Tate's Hell. This pond contained least killifish, mosquitofish, bluespotted sunfish, pygmy sunfish, pickerel, lake chubsucker, and starhead topminnow.

A freshwater fishing license is required. All laws are to be respected and no over-collecting will be tolerated. This gathering is to be pleasantly experienced for its wonder and is not an opportunity for wholesale collecting. Alcohol is prohibited at the lab, but quiet discretion was accepted during our stay. No smoking in the house. Alligator wrestling, if desired, will be readily observed. The lodging is available as a four-bedroom house fitted with bunkbeds, two full baths, a nice kitchen, and a large living area opening to the sea.

Send a check for $100 to reserve your space as soon as possible. Remember, we are limiting this to 12 individuals to simplify logistics. So it's first come, first reserved! *Make your check out to NANFA but send it to Casper Cox, 1200 Dodds Ave., Chattanooga, TN 37404.* Include your address and email address so I can keep you updated. My phone number is 423-624-0721, if you have any questions. The deposit is nonrefundable as the house must be reserved in advance and expenses will be incurred. The remaining $150 is due upon your arrival. Any additional monies after expenses are paid will be given to NANFA.

This is a great region, with a wonderful facility, to experience and explore. Interesting opportunities are all about! If you can agree to the rules, then you are welcome to join us! — *Casper Cox*



The North American Native Fishes Association

Mission: dedicated to the appreciation, study and conservation of the continent's native fishes.

An invitation to join or renew.

The North American Native Fishes Association is a not-for-profit, tax-exempt corporation that serves to bring together professional and amateur aquarists, anglers, fisheries biologists, ichthyologists, fish and wildlife officials, educators, and naturalists who share an interest in the conservation, study, and captive husbandry of North America's native fishes. A portion of each member's dues helps support two important initiatives: NANFA's Conservation Research Grant Program, which funds research on the biology and conservation of North America's most neglected and imperiled fishes; and the Gerald C. Corcoran Education Grant, which funds educational outreach programs aimed at children and the general public.

MEMBER BENEFITS

- ***AMERICAN CURRENTS***, a quarterly, 40-page (minimum) publication featuring articles and news items on collecting, keeping, observing, conserving, and breeding North American fishes.
- **REGIONAL NANFA CHAPTERS**. State and regional aquarium groups where members may get together to collect and discuss native fishes, remove exotics, and perform conservation and stream restoration work.
- **NEW MEMBER PACKET.** An 8-page newsletter that's sent to new NANFA members introducing them to NANFA, and to the fascinating world of collecting, keeping and conserving North America's native fishes.
- **ANNUAL CONVENTION**. Where NANFA members from around the country meet for lectures, collecting trips, raffles, auctions, fun and finship. The 2005 meeting will be held June 9-12 in Little Rock, Arkansas.
- **GRANT FUNDING.** Only NANFA members can apply for NANFA's Conservation Research Grant and Gerald C. Corcoran Education Grant programs. For details, see NANFA's website (www.nanfa.org), or contact Dr. Bruce Stallsmith, Conservation Grant Chair, 256-890-6992, fundulus@hotmail.com, or Rob Denkhaus, Education Grant Chair, 817-237-1111, Robert.Denkhaus@fortworthgov.org.

DUES: USA, $20/yr. (US$); CANADA and MÉXICO, $25/yr. (US$); ALL OTHER COUNTRIES, $34/yr. (US$).

Please ❒ renew or ❒ begin my NANFA membership, or ❒ send a gift membership to the person named below. Enclosed are dues in the amount of US$ ___ for ___ year(s). ❒ In addition to my dues, I'd like to make a *tax-deductible* contribution in the amount of US$___ to help fund NANFA's education and conservation programs.
Mail check or money order made out to "NANFA" to: NANFA, 1107 Argonne Drive, Baltimore, Maryland 21218.

Mr./Ms./Mr./Dr. ______________________________

Address ______________________________

City ____________________ State/Prov. ____________________

Zip Code __________ Country (if not USA) __________ Phone __________

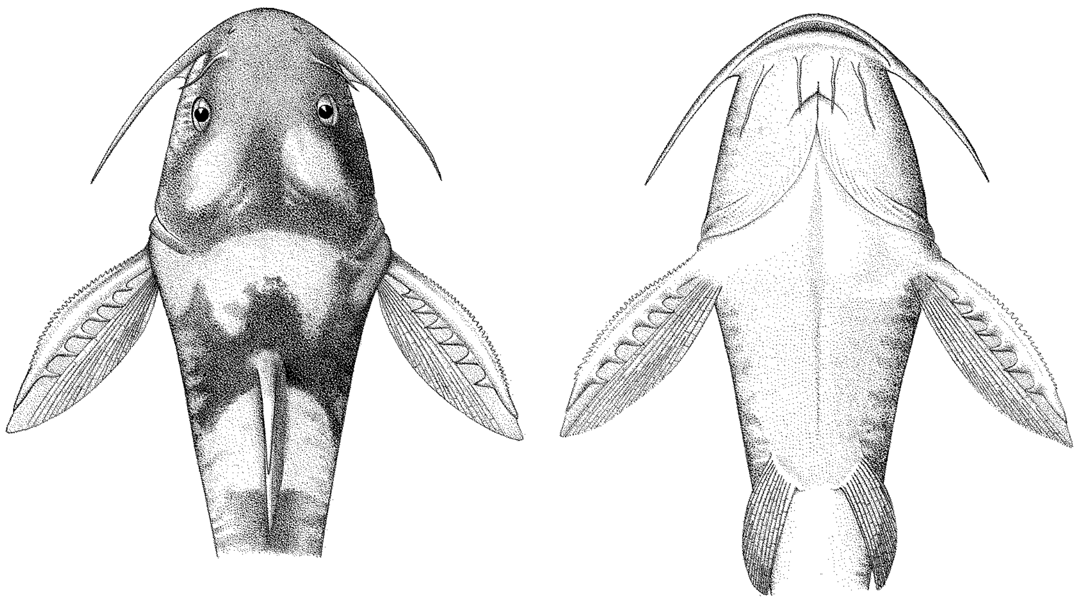
E-mail address ______________________________

Upon request, we send a membership directory to NANFA members. This is a way for members to meet each other. May we include your address in this directory? yes no May we include your phone number? yes no

If this is a gift membership, please say it is from: ______________________________

PDF

Feel free to photocopy and distribute to other native fish enthusiasts.



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.

North American Native Fishes Association

1107 Argonne Drive
Baltimore, MD 21218

Nonprofit Org.
U.S. Postage
PAID
Permit #1040
Leesburg, FL

IS YOUR MEMBERSHIP GOING **EXTINCT?**

This is your final issue of *American Currents* if the date above your name is:

5/1/05, 6/1/05, 7/1/05 or 8/1/05

Please take a moment to renew your NANFA membership today!