Aquaculture Potential for Hornyhead Chubs

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The hornyhead chub *(Nocomis biguttatus)* is one of the most valuable baitfish species in Minnesota. Culturing hornyhead chub supplies valuable baitfish to anglers and generates income for fish farmers and baitshop owners in Minnesota and other northern states. Hornyhead chubs can be reared in aquaculture facilities and sold through baitshops to anglers, who are often willing to pay $5 to $6 per dozen.

Because it is illegal to import baitfish into Minnesota, such prices put harvesting pressure on wild populations. Culturing hornyhead chubs relieves pressure on wild populations while keeping the market adequately supplied with this desirable bait.

This technical bulletin describes how to spawn and grow hornyhead chubs produced in an outdoor spawning system and an indoor over-winter growout facility.

Where do hornyhead chubs live?

As you can see on the map below, hornyhead chub occupy the Great Lakes drainages of the United States and the central Mississippi drainage area.

From Becker (1983)

What do they look like?

Dorsal colors range from black to olive or brown. Their sides can be silvery or brassy to yellow-brown, with or without a dark lateral stripe. The belly is primarily white. A prominent caudal spot is visible on most specimens, particularly on young hornyhead chubs.

The reddish tail of juveniles, a trait retained by many adults, gives rise to the name redtail chub *(Nocomis effusus)* used in the baitfish industry. The fish's more broadly used common name, hornyhead chub, comes from the white wart-like bumps that can develop spines that grow on the heads of breeding males.

Photo by Konrad Schmidt

The male's circular pectoral fin is much larger than the female's elliptical egg shape one. Some males will also have a reddish ear spot on the gill cover and orange tints on the dorsal and caudal fins. Adult females frequently range from 7.6 to 10.2 cm (3 to 4 in) in length with some specimens exceeding 15.2 cm (6 in). Males are generally longer, reaching 17.8 cm (7 in) or more.

How do they reproduce?

Hornyhead chubs reach sexual maturity by 2 or 3 years of age. A mature male builds a dome-shaped nest of stones for spawning during a breeding season that lasts from April through July. He excavates a concavity in a gravely streambed then moves stones to this depression from as far away as about 25 m (80 ft).

After the mound is complete, the male excavates a spawning pit at or near the leading edge.

Should a female deposit eggs in this volcano-shaped structure, the male will fertilize them and fill in the crater with stones after several spawning sequences. A new pit is often excavated in the same mound, sometimes within a few inches of the preceding one. Females can release between 450 to 1,000 eggs through the breeding season.

Where are they found?

Hornyhead chubs inhabit riffle/pool sections of small streams to medium-sized rivers. They are more commonly found in clear water at depths of 60 to 181 cm (2 to 6 ft). Adults are generally not found in vegetation, but the young use vegetation extensively, at least for several weeks through the first month of life.

How long do they live?

Hornyhead chubs can live for 4 years, but most do not live beyond 3 years in the wild. Males grow larger and more rapidly than females but appear to have a higher mortality rate. Growth rates vary with temperature and food supplies. Young-of-the-year (YOY) in Minnesota and Wisconsin reach 4.2 cm (1.7 in) by the end of their first year, 6.5 cm (2.6 in) during their second year, and about 9.5 cm (3.7 in) during their third year.

Surveys from the southern part of their range suggest growth can be much faster there. Hornyhead chubs in an Oklahoma river grew to 8.9 cm (3.5 in) by age 1, 13.5 cm (5.3 in) by age 2, and 16.0 cm (6.3 in) by age 3. This suggests that hornyhead chubs can attain market size (approx. 8.1 cm (3 in)) within one growing season in our region.

What do they eat?

The hornyhead chub is a visual feeder, active primarily during daylight. They eat a variety of plant and animal food items. Animal food items for the young include: rotifers, cladocerans (waterfleas), copepods, chironomids (midge), and aquatic insect larvae. Older hornyhead chubs are known to consume: clams, snails, crayfish, worms, aquatic insect larvae, and fish.

What do you need to culture hornyhead chubs?

- A spawning system,
- culture facilities for early growth of fry and fingerlings, and
- a place for growout to market size.

Spawning System

Spawning systems can take a variety of forms. Water can be circulated along the edge of a pond prepared with appropriately sized gravel or circulated through an earthen raceway-like system. A technique similar to a system used to spawn creek chubs (*Semotilus atromaculatus*) may also encourage hornyhead chubs (a species with similar spawning requirements) to spawn. In this system, gravity moved water down a gravel-lined outdoor raceway.

Behavior Note

A male hornyhead chub defends his nest well, but appears willing to share the responsibility with a male common shiner *(Luxilus cornutus).* In this commensal relationship, the chub seems to be the mover of stones, builder of nests, and protector of the territory, while the shiner further secures the safety of the nest. Male hornyhead chubs will intercept and drive off intruding males while the male shiner might specialize in driving off marauding females foraging for freshly deposited eggs. It is unknown whether adding male common shiners to an artificial spawning system will increase spawning success, but the possibility is intriguing. For more details, refer to Appendix A in Gunderson et al. 2008 at www.seagrant.umn.edu/aquaculture/redtail.

Water depth, flow rate, water temperature and quality, and gravel size are the key parameters determining the success of a system. Other considerations include how large the system must be to produce the desired number of fry, water availability (for filling the system and to compensate for evaporation or seepage), broodstock procurement, and the ability to remove adults and/or fry from the system with minimal stress and mortality.

Past researchers have used two spawning systems. First, side channel backwater areas were incorporated to provide habitat for fry. Secondly, researchers connected the artificial spawning area to a pond, so fry could move out of the flowing water of the spawning system. These additions to a flowing water system may improve hornyhead chub spawning systems as well.

Remember that culture conditions can vary greatly. These suggestions and facts might help when setting up an artificial spawning system:

Water depth: 30 to 46 cm (12 to 18 in). Spawning occurs at depths of 18 to 48 cm (7 to 19 in).

Flow rate: Surface water flowing approximately 10 to 20 cm/sec (0.33 to 0.66 ft/sec).

Male hornyhead chubs appear to choose nest-building areas related to water velocity. In artificial spawning systems, nests are more likely to be built in areas with a velocity of 10 cm/sec (0.33 ft/sec). In one study, water velocity over nests was measured from 2 to 36 cm/sec (0.07 to 1.2 ft/sec) (Mean: 18.3 cm/sec (0.6 ft/sec)). Adding cement blocks or other current deflectors can create areas of differing velocities, which may encourage successful nest building.

Water temperature: Spawning typically occurs when water warms to 18.3° C (65° F), but has been reported at water temperatures from 16 - 26° C (61 - 79° F). Pre-spawn broodstock should be held in water colder than 18.3° C (65° F) and introduced into an artificial spawning system before the water reaches this temperature.

Water quality: Hornyhead chubs require silt-free, clear water for successful spawning. See Table 1 for water quality parameters for collaborator spawning systems.

Gravel size: Males use 5 to 12.7 mm (¼- to ½-in) diameter gravel to build the nest and 19 mm (¾-in) gravel to "cap-off" the nest. This gravel size reflects the size used by wild fish. Males will need sufficient gravel of this size range for successful nesting.

Broodstock

- Aim for an initial stocking ratio of 10 females for every male
- Each male needs 1 m^2 (11 ft^2) of defensible territory, but note that males may not utilize all the space in a spawning system due to variations in water flow
- Minimize supplemental feeding to maintain water quality
- Although adults don't seem to eat newly hatched fry, it may be wise to remove broodstock from the spawning system when spawn-

Table 1. Average water quality conditions from June through September in hornyhead fry spawning/growout systems. System 1 was a small raceway, System 2 was a large raceway, and System 3 was a pond where spawning took place along a gravel lined edge of the pond.

System	Conductivity	Alkalinity	Hardness	Toxic NH3	pH	Temperature		O_2
	µS/cm	mg/L	mg/L	mg/L		°F	°C	mg/L
#1	0.10	70.0	68.0	0.08	8.62	73	22.8	6.9
#2	0.10	111.4	110.7	0.10	9.37	76	24.4	8.9
#3	0.13	99.6	102.9	0.04	8.25	70	21.1	6.9

ing is complete to prevent losses from predation as the fry get larger, or from competition for food or space

Eggs

- A female lays about 660 eggs per yr (so with 10 females per male, 6,600 eggs could be deposited in a territory)
- Eggs are very small at about 528,000/L (500,000 per qt)
- Hatching occurs in 7 to 10 days

Early Growth

Upon hatching, fry can be kept in the artificial spawning system. If the system isn't connected to a larger growout area, the fry eventually need to be moved to a pond or an indoor recirculating aquaculture system (RAS).

Fry:

- Swim to the surface to fill their gas bladder after hatching, then hide in gravel
- Become more active and form small schools once their yolk sac is absorbed
- Tend to occupy areas in the wild without current and with higher concentrations of aquatic plants

Feeding of fry and fingerlings:
Copepods, cladocerans, and chironomid larvae, will colonize an artificial stream and/or could be seeded. Other favored prey organisms can also be added to a system. Water quality must be maintained at acceptable levels for optimum production of natural prey items.

Young-of-the-year:
While YOY readily accepted formulated feed in outdoor systems, they were not typically fed on a regular basis by collaborators or university researchers. Consider use of formulated commercial feeds if natural food items are insufficient for growth, but with caution.

Overfeeding of commercial feeds can cause water quality to decline rapidly and may encourage the growth of undesirable algae. Decaying feed lying on the bottom of a pond can deplete oxygen, killing fish. Rates of consumption can be best monitored by using floating feed.

Growth of YOY hornyhead chubs in outdoor systems varied but YOY grew to about 38 mm (1.5 in) by September in Minnesota (Figure 1). However, in a warmer-than-normal summer, they grew to 58 mm [(2.3 in) not depicted in Figure 1]. Growth appeared to slow or stop in late August to early September, which was unexpected and probably a result of declining food resources. Formulated feed was not regularly provided in these systems.

Growout

Hornyhead chubs have been grown to market size 89 mm (3.5 in) within a year in a combined outdoor and indoor recirculating aquaculture system. Densities of fish were low when they

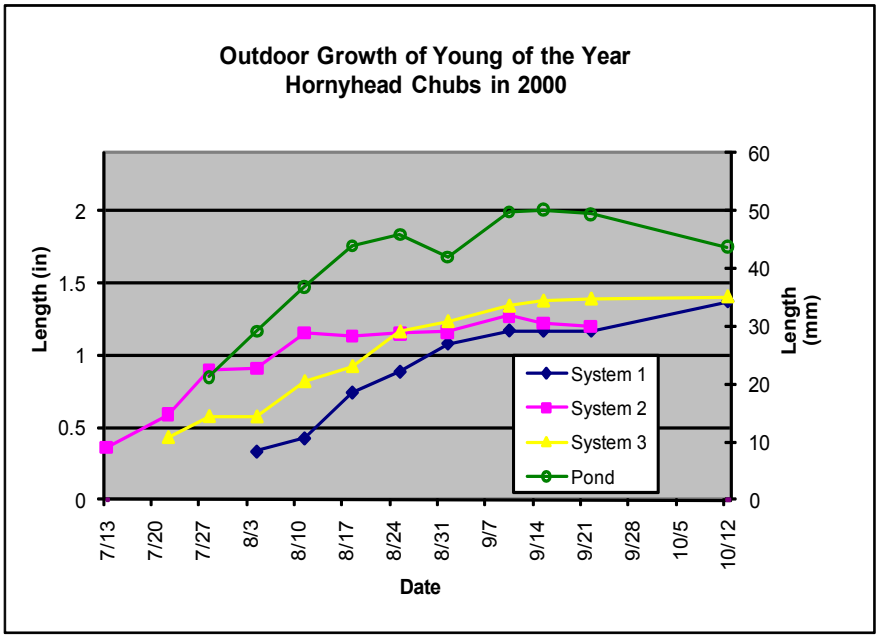

Figure 1. Growth of young-of-the-year hornyhead chubs in four outdoor systems in 2000. Details of the spawning systems are proprietary; however, System 1 was a small raceway, System 2 was a large raceway, System 3 created water flow along a gravel lined edge of a pond, and the pond was where some fish from System 2 were transferred on July 27.

Disease Prevention Note

Preventing disease is essential to successfully bringing pond fish indoors. Before introducing hornyhead chubs into the RAS, a quarantine period and prophylactic treatments should be used to guard against pathogens. Some chemicals commonly used include salt, formalin, hydrogen peroxide, and potassium permanganate. One method proven effective involved a 3- to 5-day quarantine/treatment period. During this time, 1-hr treatments of formalin were given on 3 consecutive days. The first was at 75 ppm, the second at 150 ppm, and the third at 200 ppm. If the fish were sluggish and showing signs of stress, they received the 3 treatments every other day. This treatment was used to successfully kill gill protozoan parasites that, untreated, caused high mortality in hornyhead chubs brought in from the wild.

were brought indoors in the fall but approached 30 g/L (¼ lb per gallon) by the following May when fish were market size. Since there are approximately 111 market-sized hornyhead chubs in a kg (50 fish/lb), there will be about 3 fish per L (13 fish/gallon) at that density. Depending upon mortality rates, consider stocking at least 4-5 hornyhead chubs/L (15-20 fish/gallon) in the fall. Hornyhead chubs were grown at 20.5° C (69° F) to balance growth rates with disease risks, which are known to increase at higher temperatures.

With appropriate water quality, hornyhead chubs appear to accept crowding, however, exceeding tank densities of 30 g/L (¼ lb per gallon) for baitfish may be difficult because of RAS limitations. See Table 2 for RAS water quality conditions during our growout experiments.

Annual production can be much greater than tank capacity if fish are harvested as they reach market size and then more fry/fingerlings are added. For example, one group of fish could be brought indoors while another is over-wintered in a pond. The fish in the RAS will grow to market size more quickly and, as those fish are sold, they could be replaced with fish from the pond. Using this approach, annual baitfish production from the RAS might approach 60 g/L (½ lb per gallon) or greater on an annual basis.

In one experiment, YOY hornyhead chubs were brought into a RAS facility in October from artificial spawning/growout facilities where they were produced. They were fed 3% (1.5 mm) particle size body weight 5 days per week of an extruded floating diet of 45% protein and 16% fat. Feeding was stopped occasionally during the study to regain water quality. Fish were held at a 12 hr light/dark photoperiod. Nearly all the fish were marketable by mid-May when the Minnesota walleye season opened and demand for baitfish was high. The yearling hornyhead chubs grew to an average of 8.0 cm (3.1 in) by May; 96% were retained on a #21 grader, and 62% were retained on a #23 grader (see Baitfish Grader Note next page).

During this trial, over 50% of the YOY hornyhead chubs brought indoors were marketable (retained on a #21 grader) by the end of December. This suggests that some hornyhead chubs could be graded and sold for the winter ice fishery. Selling chubs for ice fishing will depend on when and how large the juveniles are when they are brought indoors and whether the market will accept them at that time of year.

Economic Assessment Model

An economic viability analysis is available at www.seagrant.umn.edu/aquaculture/redtail and

Table 2. Average water quality conditions in RAS growout tanks.

System	Conductivity	Alkalinity	Hardness	Toxic NH3	pH	Temperature		O_2
	µS/cm	mg/L	mg/L	mg/L		°F	°C	mg/L
RAS	1.54	38.3	84.9	0.02	7.17	68	20	7.2

Baitfish Grader Note

Baitfish are graded for size using metal bars spaced at intervals of 64ths of an inch. Graders of 19/64, 21/64, and 23/64 in are examples; represented as #19, #21, and #23, respectively. The wider the gap in the bars, the larger the baitfish that are retained by the grader. Common market size for hornyhead chubs are those that are retained by #21 or #23 graders. Hornyhead chubs retained on a #21 and #23 grader are approximately 8.9 and 10 cm (3.5 and 4.0 in), respectively. Because graders select fish based on their thickness and wild fish tend to be leaner than cultured fish, wild hornyhead chubs tend to be longer than cultured ones for the same size grader.

suggests that hornyhead chub aquaculture that incorporates an outdoor spawning system with an indoor RAS can provide an excellent return on investment under certain conditions.

Conclusion

The hornyhead chub can sell for wholesale prices exceeding $8.25/kg ($3.75/lb) and prices that frequently reach $20.68 to $27.50/kg ($9.40 to $12.50/lb). Culturing hornyhead chub is a promising way to supply valuable baitfish to anglers and to generate income for fish farmers and baitfish owners in Minnesota and other northern states.

Information contained in this technical bulletin is based on:

Gunderson, J., P. Tucker, and C. Richards. 2008. Aquaculture Potential for Hornyhead (Redtail) Chubs. Minnesota Sea Grant Web-based technical report A 24. 38 p.

Suggested Readings/Citations

Becker, G.C. 1983. Fishes of Wisconsin. Univ. Wisconsin Press, Madison, Wisconsin. 1052 pp.

Boyd, C.E. 1979. Water Quality in Warmwater Fish Ponds. Agriculture Experiment Station, Auburn, Alabama. 359 pp.

Carlander, K.D. 1969. Handbook of Freshwater Fishery Biology. Vol. 1. The Iowa State University Press, Ames, Iowa. 752 pp.

Clark, C.F. 1943. Creek chub minnow propagation. Ohio Conservation Bulletin 7: 13.

Gunderson, J.L. and P. Tucker. 2000. The status and needs of baitfish aquaculture in the North Central Region. North Central Regional Aquaculture Center. Iowa State University, Ames, Iowa. 24 p.

Hubbs, C.L., and G.P. Cooper. 1936. Minnows of Michigan. Cranbrook Institutional Science Bulletin No 8. 95 pp.

Lachner, E.A. 1952. Studies of the biology of the cyprinid fishes of the chub genus *Nocomis* of northeastern United States. American Midland Naturalist 48: 433-466.

Marking, L.L., J.J. Rach, and T.M. Schreier. 1994. Evaluation of antifungal agents for fish culture. Progressive Fish-Culturist 56: 225-231.

Maurakis, E.G., W.S. Woolcott, and M.H. Sabaj. 1991. Reproductive-behavioral phylogenetics of *Nocomis* species-groups. American Midland Naturalist 126: 103-110.

Morris, J.E. and C.C. Mischke. 1999. Plankton management for fish culture ponds. North Central Regional Aquaculture Center. Technical Bulletin Series #114. Ames, Iowa. 8 pp.

Pennak, R.W. 1989. Fresh-water Invertebrates of the United States: Protozoa to Mollusca. John Wiley and Sons, Inc. 628 pp.

Pflieger, W.L. 1975. The Fishes of Missouri. Missouri Department of Conservation. Western Publishing Company. 343 pp.

Piper, R.G., I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler, J.R. Leonard. 1982. Fish Hatchery Management. U.S. Department of the Interior, Fish and Wildlife Service, Washington D. C., U. S. Government Printing Office: 1982-329-150. 517 pp.

Scott, W.B., and E. J. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada, Ottawa. Bulletin 184. 966 pp.

Vives, S.P. 1990. Nesting ecology and behavior of Hornyhead Chub, *Nocomis biguttatus,* a keystone species in Allequash Creek, Wisconsin. American Midland Naturalist 124: 46-56.

Washburn, G.N. 1948. Propagation of the creek chub in ponds with artificial raceways. Transactions of the American Fisheries Society 75: 336-350.

Check out www.seagrant.umn.edu/aquaculture/redtail for:

Technical Report
Economic Assessment:
Quick Start
User Guide
Hornyhead chub spawning video

Acknowledgements

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