Bullhead Catfish Family—Ictaluridae

Eight species of bullhead catfish in three genera are known from Wisconsin. The ictalurid catfishes are representatives of exclusively soft-rayed families of North American origin. In the United States and Canada, there are 5 genera and 39 species of catfish (Robins et al. 1980). Fossils occur in Miocene and Recent deposits.

The head of the catfish is often large and flattened. The teeth of the upper and lower jaws are minute and sharp, and are arranged in broad pads. The swim bladder is connected with the Weberian ossicles, and is involved in the reception and production of sound. An often elongate, adipose fin is a distinctive character. All members possess eight prominent, whiskerlike barbels, sensitive to touch and to chemical stimuli; in addition, many taste buds are distributed over the scaleless bodies of a number of species, enabling them to locate food at night when most members of the family are active.

A well-known feature of the bullhead catfishes is the spinous ray in the dorsal fin and in each pectoral fin. These spines are morphologically hardened bundles of soft-ray elements which have fused embryonically. The madtoms have poison glands associated with these spines, which are capable of inflicting a painful, but not dangerous, wound. According to Walden (1964:195), it is probable that all catfishes are so equipped: "The poison glands do not affect the flesh for eating purposes and do not seem to bother the predator fish whose powerful digestive juices dissolve any madtom or small stonecat in short order."

The spines of the different species of bullhead catfish can be used to distinguish one species from another, although, even within the same species, there may be considerable variation of the spine pattern in populations from different parts of its range. A useful key to the identification of Illinois bullhead catfishes through spines was prepared by Paloumpis (1963). The supraethmoid-ethmoid complex is also used for separating the larger members of the family (Calovich and Branson 1964, Paloumpis 1964).

Wisconsin catfishes can be divided into two groups: the small, secretive madtoms, and the large species which include the bullheads and the trophy-sized fishes. The bullheads and large catfishes provide considerable quantities of food for man. The most valuable commercial species in the Mississippi River is the channel catfish, which brings the highest price per kilogram and generally has the total highest value year after year.

All of the larger catfishes and bullheads provide excellent food, and in many restaurants along the Mississippi River catfish dinners are a specialty. The meat is white or beef colored. It is not necessary to skin the smaller catfishes before cooking them; skinning is a difficult task, which has discouraged many people from preparing these abundant fish for the table.

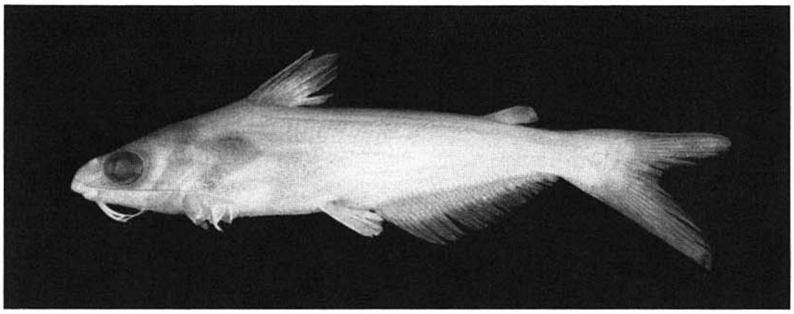
Bullheads are typical inhabitants of glacial lakes in central North America which are nearing extinction. They are adapted to lakes of low oxygen content, high carbon dioxide content, abundant vegetation, abundant food, low transparency, and increasing acidity. As the lakes of Wisconsin age, conditions generally will favor the warmwater fishes, and the bullheads in particular.

As a lake becomes silted in and weed-choked, bullheads explode numerically and dominate the waters, whereas the former sport and panfish disappear. This trend is inevitable, and the public should be aware that in such lakes the fishing has not "deteriorated," but shifted to another group of fishes, just as tasty as, if not more tasty than, the former inhabitants. Lakes reaching this stage are winterkill lakes. Bullheads are hardy, and among the last survivors before the lake is filled in and becomes extinct.

Bullheads often withstand domestic pollutants better than most fish. Also, along with the bowfins and the gars, they are best able to endure high concentrations of poisons, including 20 ppb of antimycin—a concentration at which other species are killed.

Because bullhead catfish require a minimum of attention and will eat any kind of food presented to them, including dog food, members of this family make interesting aquarium pets. Since they are hardy, they are able to survive aquarium conditions that would eliminate most other fishes.

The blue catfish, *Ictalurus furcatus*, was formerly included with the fishes of Wisconsin, based on two collections reported by Greene (1935) for lower Lake Pepin (Pepin County) and the Mississippi River near Lansing, Iowa (opposite Crawford County). Unfortunately, the specimens for these reports were not saved. R. Bailey suggested to me and to Dr. Greene that these probably were misidentified channel catfish, *Ictalurus* *punctatus*, which, during the spawning season, lose their characteristic spots and could easily be confused with the blue catfish. Dr. Greene concurred, and the blue catfish is herewith removed from the Wisconsin list.



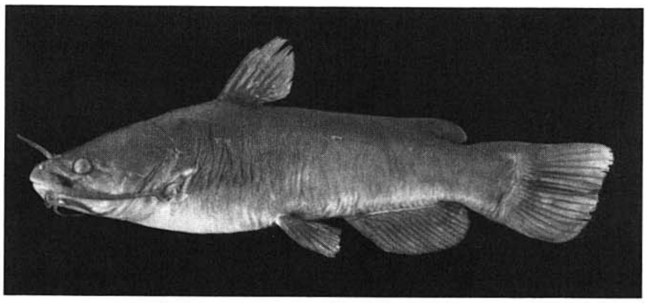
Imm. blue catfish 95 mm, Tensaw R. (Baldwin Co.), Alabama (specimen donated by H. A. Swingle)

The blue catfish is known from the Mississippi River, but rarely from above its juncture with the Missouri River. However, a specimen (INHS 2148), 23 cm SL, was taken in 1972 from the Mississippi River 2 km northeast of Bellevue, Iowa; this site is approximately 32 km (20 mi) from the Wisconsin-Illinois line, and its presence there supports the possibility that at some time the blue catfish may appear in Wisconsin waters. The blue catfish should be watched for, and I have included it in the taxonomic keys. Suspected specimens should be carried to the nearest Department of Natural Resources agency or museum for verification.

Black Bullhead

Ictalurus melas (Rafinesque). *Ictalurus*—fish cat; *melas*—black.

Other common names: bullhead, common bullhead, black catfish, black cat, yellow belly bullhead, horned pout, brown catfish, stinger, river snapper.



Adult 182 mm, tributary to Green Bay (Door Co.), 5 June 1962

DESCRIPTION

Body robust, rounded anteriorly, compressed posteriorly. Length 165–229 mm (6.5–9.0 in). TL = 1.19 SL. Depth into TL 4.0–5.1. Head length into TL 3.8–4.2. Snout bluntly pointed in lateral view, broadly rounded in dorsal view; elongated barbels of snout just anterior to posterior nostrils. Mouth short but wide, terminal and horizontal; very long barbel sweeping posteriorly from the upper jaw at each corner of the mouth; 4 shorter barbels attached in a transverse line on the lower chin. Numerous minute needlelike teeth in broad bands on upper and lower jaws. Dorsal fin origin about midway between pectoral and pelvic fins; dorsal fin with a stout spine and 5–6 rays; dorsal adipose fin free at posterior end. Anal fin rays including rudimentaries 15–21; pelvic fin rays 8; pectoral fin with a stout spine, slightly rough to irregularly toothed on posterior edge; caudal fin somewhat square and slightly notched at midpoint. Scaleless. Lateral line complete. Digestive tract 0.8–1.5 TL. Chromosomes 2n = 60 (LeGrande 1978).

Dorsal region of head, back, and upper sides olive to black; sides lighter; belly whitish to yellowish, with color usually extending up to base of caudal fin as a pale bar. Barbels black or gray. All fins dusky, with dark edges and black interradial membranes.

Breeding male black with bright yellow or white belly.

Sexual dimorphism. Male with distinctive urogenital papilla extending posteriorly; absent in female. One opening behind the vent in male, 2 openings behind the vent in female (Moen 1959).

Hybrids: Black bullhead × brown bullhead from Lost Lake and Crawfish River (Dodge County) (Wis. Fish Distrib. Study 1974–1975). Experimental black bullhead × channel catfish, black bullhead × yellow bullhead, black bullhead × white catfish, black bullhead × blue catfish (Dupree et al. 1966).

DISTRIBUTION, STATUS, AND HABITAT

In Wisconsin, the black bullhead is widely distributed in the Mississippi River, Lake Michigan, and Lake Superior drainage basins.

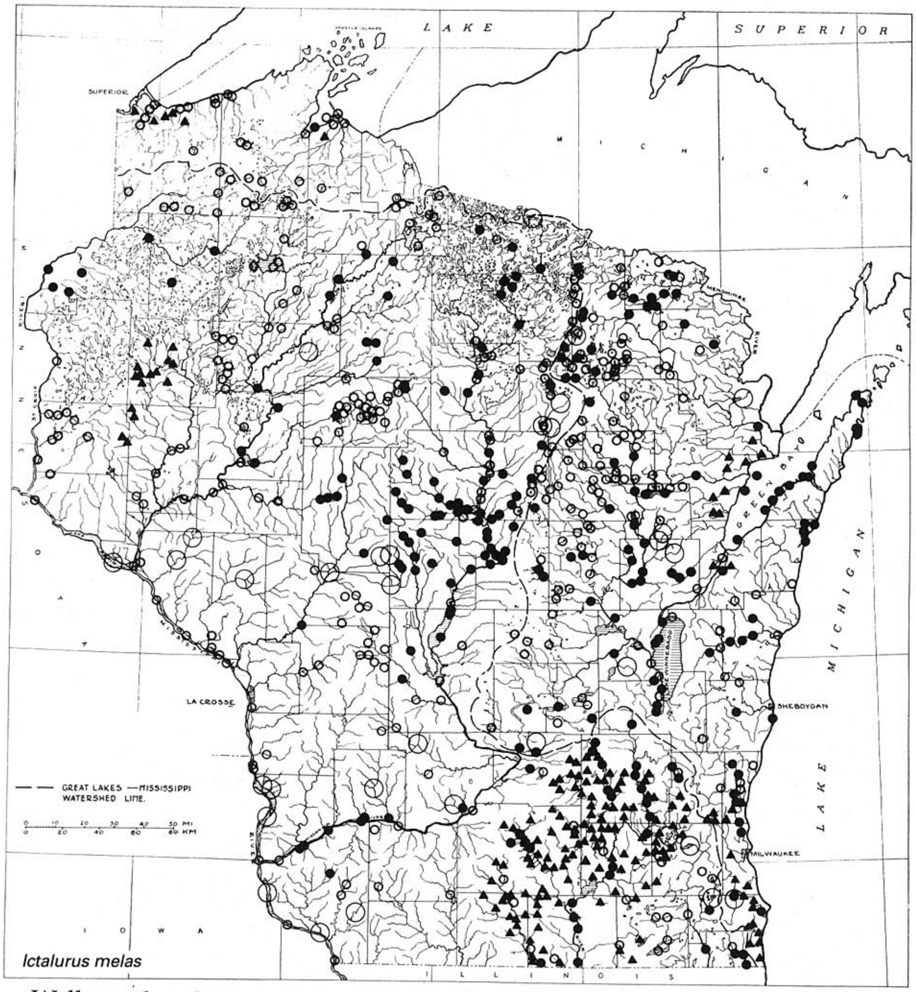
The black bullhead is the most abundant of Wisconsin's bullhead species. It is also the most tolerant of agricultural siltation, industrial and domestic pollutants, and warm water. In the Lake Superior basin, the black bullhead is classified as widespread and common in the streams of western Lake Superior (McLain et al. 1965). Its distribution, especially in northern Wisconsin, is much more extensive today than it was in the mid-1920s.

Quiet backwaters, oxbows, impoundments, ponds, lakes, and low-gradient streams are typical habitats of the black bullhead. In Wisconsin, it was encountered in water of varying turbidity, most frequently at depths of less than 1.5 m, over substrates of sand (24% frequency), gravel (20%), mud (16%), silt (15%), rubble (9%), boulders (9%), detritus (4%), clay (1%), hardpan (1%), and bedrock (1%). It was taken in streams of the following widths: 1.0–3.0 m (13% frequency), 3.1–6.0 m (15%), 6.1–12.0 m (12%), 12.1–24.0 m (31%), 24.1–50.0 m (18%), and more than 50 m (11%).

BIOLOGY

The spawning of the black bullhead usually occurs from April through June, but ripe females have been taken at Wisconsin's latitude as late as early August (Forney 1955). When the water temperature reaches 21°C (69.8°F), saucer-shaped nests 15–36 cm (6–14 in) diam are constructed in the mud or sand in water 0.6–1.2 m (2–4 ft) deep. The nests are built beneath matted vegetation, woody debris, or overhanging banks, or in muskrat burrows. The female constructs the nest (Wallace 1967:853):

> . . . The excavation was carried out by downward fanning of the pelvic fins, side-to-side fanning of the anal fin, and pushing of small pebbles toward the periphery of the depression with the snout. The male was nearby, but did not assist in the excavation. When the male swam over the nest the female butted him in the abdominal area as if to push him from the nest.



Range of the black bullhead
● Specimens examined
▲ Wisconsin Fish Distribution Study (1974–75)
○ Literature and reports
◯ Greene (1935)

Wallace also described the black bullhead's spawning behavior (p. 853):

> . . . While the male and female were oriented in opposite directions, the male twisted his caudal fin to one side toward the female so that it was over her head and eyes. . . . The male held the female in this way for a period of several seconds. The male's caudal fin was more tightly twisted over the female's head, and the ventral part of his body anterior to the twisted portion was arched almost in a 45° angle toward the abdomen of the female. The female's body was not arched, but her caudal fin was bent slightly toward and almost over the male's head. The male's mouth was widely opened as if "yawning," and his head was bent slightly downward. . . . During the fourth embrace, the female quivered for about one sec and the eggs were deposited. The male remained perfectly still with its mouth wide open. . . . After the female stopped quivering both fish moved apart and lay still for about one min on the bottom of the aquarium.

After a spawning session, both fish began to swim as before; the female passed back and forth over the center of the nest, fanning the eggs with her pelvic and anal fins, and butting the male's abdomen when he swam near the eggs. Spawning occurred five times within 1 hour. The female fanned and guarded the eggs during the first day, but on the second and third days after spawning the male guarded the nest.

The eggs are laid in gelatinous masses with a gelatinous coat. Eggs examined 21 hours after spawning had developed to the late gastrula stage (Wallace 1967). Incubation takes 5–10 days, depending on the water temperature.

A prespawning female black bullhead, 145 mm and 48 g, collected from the Yellow River (Wood County) on 25 May, had ovaries 3% of the body weight; she held yellow, maturing eggs 0.8–1.3 mm diam. A gravid female, 196 mm and 129 g, taken from Green Bay (Door County) on 6 June had ovaries 6.3% of the body weight; she held 4,005 yellow, almost mature eggs, 1.2–1.6 mm diam.

The care of eggs by adult black bullheads is undoubtedly similar to that of the brown bullhead (see p. 704), in which the pelvic fins slap up and down against the egg mass, or the anal fin swirls the mass about or even breaks it up. The process undoubtedly provides the developing eggs with needed aeration and water circulation.

After the eggs hatch, the activity of paddling with the pelvic fins stops and the parent fish become more gentle in their movements, swimming about over the young that huddle in a compact mass encumbered by large yolk-sacs. By the time the young are able to rise off the bottom, they have attained most of their coal black coloration. The young fish rise in a cloud-like mass, and the parents try to keep them in a compact school by swimming about them, more or less in circles; the involuntary orientation of the young themselves, which is almost entirely visual, also tends to keep them together.

Young black bullheads remain in compact, swirling schools for 2 weeks or longer; the conspicuous "balls" of black young move slowly near the surface in moderately deep water. When the young are about 25 mm long, the adults cease tending them, and the fry move into shallower water (Forney 1955). Their first food consists of cladocerans, other small crustaceans, and very small midge larvae.

The growth of young-of-year black bullheads in Wisconsin has been recorded as follows (Paruch 1979):

Date	No. of Fish	TL (mm) Avg	Range	Location
18 July	5	24	23–25	St. Croix R. (Burnette Co.)
29 July	45	29	22–39	Williams L. (Marquette Co.)
14 Sept.	4	29	26–31	Little Yellow R. (Juneau Co.)
19 Sept.	1	41		Little Sturgeon Bay (Door Co.)

Analysis of the annuli on the pectoral spines of 330 black bullheads, taken from the Wisconsin River below the Du Bay Dam (Portage County), showed the following growth: 1—67 mm; 2—148 mm; 3—181 mm; 4—209 mm; and 5—233 mm (Paruch 1979). These fish, collected 21 January 1977, showed the following length-weight relationship: $\text{Log } W = -10.811311 + 2.924228 \text{ Log } L$, where W is total weight (g) and L is total length (mm).

In Little Lake Butte des Morts (Winnebago County), black bullheads averaged 206 (147–295) mm TL. The length-weight relationship of the mid-October sample is expressed by $\text{Log } W = -0.60180 + 2.92398 \text{ Log } L$, where W is total weight (g) and L is total length (in). According to Priegel (1966a), no stunting existed in this population and the sample fell into three age-classes: II—198 (157–216) mm; III—211 (150–267) mm; and IV—267 (239–295) mm. The condition value (K_{TL}) calculated from Priegel's figures was 1.30.

The age of the black bullhead at maturity is variable. According to Cross (1967), maturity is reached in the second, third, or fourth summer, depending on the population density and the available food supply.

Most large black bullheads seldom exceed 318 g (0.7 lb). The largest known Wisconsin fish, caught in 1978 from Black Oak Creek (Vilas County), weighed 1.30 kg (2 lb 14 oz). The official record for a black bullhead caught on sporting tackle is a 610-mm, 3.63-kg (24-in, 8-lb) fish taken from Lake Waccabuc, New York, in 1951 (Walden 1964).

Black bullheads are opportunistic feeders that eat whatever food is available, including carrion. In the Wisconsin River below the Du Bay Dam (Portage County), the diet of this species consisted of *Daphnia*, cladocerans, *Cyclops* and other copepods, plant matter, and unidentifiable insect parts and eggs (K. McQuin, pers. comm.).

Black bullheads 40–60 mm SL from Cedar Creek (Ozaukee County) had eaten: *Hyallela azteca* (54.1% of volume), insect larvae (19.2%), organic detritus (15.1%), insect adults (4.5%), fungi and algae (3.4%), small crayfish (2.8%), and miscellaneous (0.9%) (Darnell and Meierotto 1962). In the Madison area (Pearse 1918), they had eaten, in addition to the above foods, snails, leeches, oligochaetes, silt, and debris. Midge larvae make up a considerable part of the black bullhead's insect food.

In Iowa (Harrison 1950), about 5% of the black bullhead's diet consisted of fish—scales and chunks of larger fish found dead on the stream bottom. Welker (1962) found that as many as 18% of the stomachs examined in August in Clear Lake, Iowa, contained small fish (common shiners and perch?). Larger bullheads also take frogs (Carlander 1969).

Young black bullheads exhibit two distinct feeding periods—one just before dawn, and another shortly after dark (Darnell and Meierotto 1962). Little food of any kind is taken during the middle of the day or around midnight. Nocturnal fishes, such as bullheads, rely largely on smell, taste, and touch and probably also use their lateral-line sense organs to locate and catch their prey (Lagler et al. 1977).

Bullheads are highly sensitive to touch on the head and on the barbels. Taste buds are densely concentrated on the barbels, but they also occur in the pharynx and the gill cavity, and cover the head and the body (Bardach et al. 1967); there are an estimated 100,000 taste buds on the body of a bullhead (Lagler et al. 1977). Taste alone can guide the black bullhead to sources of chemical stimuli many fish lengths away. Bullheads are also able to perceive both the intensity of, and the range of, vibrations from 16 to 13,000 cycles per sec (Lagler et al. 1977).

Subadult black bullheads avoided the effluent-outfall area of a power plant on Lake Monona (Dane County), where the maximum temperatures approached 35°C in summer and 14°C in winter (Neill and Magnuson 1974). When acclimated at 23°C (73.4°F), the upper lethal temperature for the black bullhead was 35°C (95°F) (Black 1953). At summer temperatures of 22–23°C (71.6–73.4°F), black bullheads survived for 24 hr at oxygen thresholds as low as 3.4 ppm (Moore 1942). In Michigan, this species was reported to survive winterkill oxygen concentrations of less than 0.2–0.3 ppm (Cooper and Washburn 1949).

Black bullheads are gregarious and travel in large schools. Adults apparently remain inactive in weed beds during the daylight hours, but they move around extensively at night. Trapping evidence suggests that the adults tend to forsake pools during the early hours of darkness, and return shortly before dawn (Darnell and Meierotto 1965). Carlander and Cleary (1949) noted that black bullheads came into shallow water more frequently between 0200 and 0600 hr than at other times. According to Darnell and Meierotto, feeding behavior is associated with periods of dim light, whereas schooling takes place during periods of bright light.

During late April and early May following a heavy rain, more than 2,500 sexually mature black bullheads engaged in a nocturnal movement from an Illinois reservoir, over the spillway, and into the stream below (Lewis et al. 1968).

In Cedar Creek (Ozaukee County), 50 black bullheads were associated with the following species: white sucker (4), central stoneroller (15), creek chub (10+), bluntnose minnow (1), fathead minnow (6), common shiner (20), sand shiner (1), tadpole madtom (15+), and green sunfish (1).

IMPORTANCE AND MANAGEMENT

Black bullheads are eaten by white bass (MacKay 1963), but predation by other fishes, even on young black bullheads, is apparently very low (Scott and Crossman 1973). This may be a result, in part, of the protection afforded by the bullhead's spines and its nocturnal habits. Turtles have purportedly preyed on bullheads, and there is a report of a 150-mm (6-in) bullhead being caught by a 0.6-m (2-ft) snake.

The black bullhead is a host to the glochidial stage of the mollusks *Megalonaias gigantea* and *Quadrula pustulosa*; it is one of several fish species responsible for the distribution and perpetuation of those clam species.

In Wisconsin, the black bullhead is used as setline bait for taking large catfishes, such as the flathead catfish. Fishing for the black bullhead is a sport valued by many fishermen; it bites readily on worms, liver, or almost any kind of meat. G. W. Peck, a former governor of Wisconsin and a noted humorist of his day, immortalized the bullhead (Peck 1943:17)

> . . . There is a species of fish that never looks at the clothes of man who throws in the bait, a fish that takes whatever is thrown to it; and when once it has hold of the hook never tries to shake a friend, but submits to the inevitable. . . . It is a fish that is a friend of the poor and one that will sacrifice itself in the interest of humanity. That is the fish that the state should adopt as its trade-mark and cultivate friendly relations with and stand by.

According to Wisconsin Fishing Regulations (1980), all bullheads are by definition game or sport fish. At present there are no restrictions on bullhead fishing—no closed season, no daily bag limit, and no minimum length.

The flesh of the black bullhead is firm, reddish or pink, and well flavored when taken from clean water. Connoisseurs compare the flavor to that of chicken. The flavor of bullheads from muddy waters can be improved by keeping them alive in clean water for a week or more.

Man has used the black bullhead extensively as a test fish. It adjusts readily to laboratory conditions, and does not jump from containers, although it does foul the water in holding tanks (Ward and Irwin 1961). Its desirability as a test animal for toxic chemicals stems from its ability to resist larger doses of toxins than most fishes (McCoy 1972, Ferguson and Goodyear 1967). As a test fish, the black bullhead has contributed to our knowledge of the function of the pituitary gland (Chidambaram et al. 1972).

In the Wisconsin waters of the Mississippi River, commercial fishermen take bullheads (all species) most effectively by setlines, which account for 64% of the total catch (Finke 1967). Next in effectiveness are bait nets and slat nets. During 1960–1965, a total of 123,000 kg (272,000 lb) of bullheads was taken; the best catches occurred in Pools 8 and 9 of the Mississippi River. During 1976 (Fernholz and Crawley 1977), 13,989 kg (30,841 lb) were taken; this catch was valued at $4,626, and the black bullhead probably constituted a large part of the catch.

During 1970, contract fishermen removed 30,800 kg (67,900 lb) of bullheads (all species) from inland waters of Wisconsin (N. J. Miller 1971). In 1974, the commercial harvest from fyke nets in southern Green Bay produced 15,085 kg (33,257 lb) of bullheads, which was valued at $4,165 (Wis. Dep. Nat. Resour.

1976c). An improved market could definitely lead to an increase in the total catch of bullhead species, as there are many other areas of Lake Michigan and Green Bay where bullheads could be harvested. In 1979 "bullheads" were bringing $2.20/kilo ($1/lb) on the retail market in Wisconsin food stores.

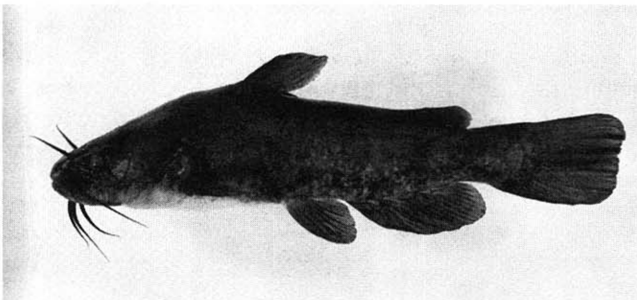
The black bullhead is a good farm pond species, and, in waters where winterkill is prevalent, it is frequently the only survivor. When bullheads are planted in a pond, only they should be planted, as they will probably overtake any other species present (Sharp 1950). When the black bullhead becomes overabundant, as it usually does, stunting occurs; the result is a fish which is too small to be desirable. Carlander (1969) noted that growth tended to be faster in clear water than in turbid water, and in uncrowded rather than crowded conditions. In Iowa, bullheads transferred from crowded to uncrowded conditions at age V grew from an average of 100 g (3.6 oz) to an average of 254 g (9 oz) in 3.5 months. In Kansas (Cross 1967), ponds in which fish were given a daily supplemental feeding of food pellets produced black bullheads 152 mm (6 in) or more in the year that they hatched; these fish weighed 450 g (1 lb) or more as yearlings. Allbaugh and Manz (1964) noted that when large amounts of food were artificially fed to bullheads there was greater growth in males than in females.

In the 1960s, Beaver Dam Lake (Dodge County) was treated with the toxicant rotenone to control carp. The result was an explosion of black bullheads by the mid-1970s, and in 1978 there was still a large, fishable bullhead population. According to Carlander (1969), after treatment of a reservoir in Iowa with rotenone, bullheads became very abundant; yet a few years later they were almost nonexistent in the area.

Brown Bullhead

Ictalurus nebulosus (Lesueur). *Ictalurus*—fish cat; *nebulosus*—clouded, in reference to mottled coloring.

Other common names: northern brown bullhead, marbled bullhead, marble cat, speckled bullhead, speckled cat, common bullhead, bullhead, brown catfish, common catfish, small catfish, catfish, mudcat, red cat, horned pout, bullpout.



Adult 275 mm, Half Moon L. (Eau Claire Co.), mid-Apr. 1978

DESCRIPTION

Body robust, rounded anteriorly, compressed posteriorly. Length 152–254 mm (6–10 in). TL = 1.20 SL. Depth into TL 3.8–5.7. Head length into TL 3.8–4.4. Snout bluntly pointed in lateral view, broadly rounded in dorsal view; elongated barbels of snout just anterior to posterior nostrils. Mouth short but wide, terminal and horizontal; upper jaw slightly longer than lower jaw, with very long barbel sweeping posteriorly from the upper jaw at each corner of the mouth; 4 barbels (outer 2 much elongated, inner 2 thinner and shorter) attached in a transverse line on the lower chin; numerous small, sharp teeth arranged in several irregular rows on upper and lower jaws. Dorsal fin origin at about midpoint between pectoral and pelvic fins; dorsal fin with a stout spine and 6–7 soft rays; dorsal adipose fin free at posterior edge. Anal fin rays, including rudimentaries, 21–24; pelvic fin rays 8. Pectoral fin with an elongated spine barbed on posterior edge, near tip with barbs inclined toward the base of spine, barbs becoming erect near middle, and barbs inclined toward the tip near base (see Key, p. 146). Caudal fin edge straight, occasionally slightly indented at middle. Scaleless. Lateral line complete. Digestive tract coiled, 1.1–1.4 TL. Chromosomes 2n = 60 (LeGrande 1978).

Dorsal region of head, back, and upper sides yellowish brown to almost black; lower sides mottled with lighter yellowish brown to gray; ventral region of head and belly pale yellow to white. Barbels dark brown to nearly black, except sometimes barbels on chin yellow to white. All fins dark colored, similar to body; interradial membranes slightly darker, but not black.

Hybrids: Brown bullhead × black bullhead from Lost Lake and Crawfish River (Dodge County) (Wis. Fish Distrib. Study 1974–75). Experimental brown bullhead × yellow bullhead, brown bullhead × blue catfish, brown bullhead × white catfish, brown bullhead × channel catfish (Dupree et al. 1966).

SYSTEMATIC NOTES

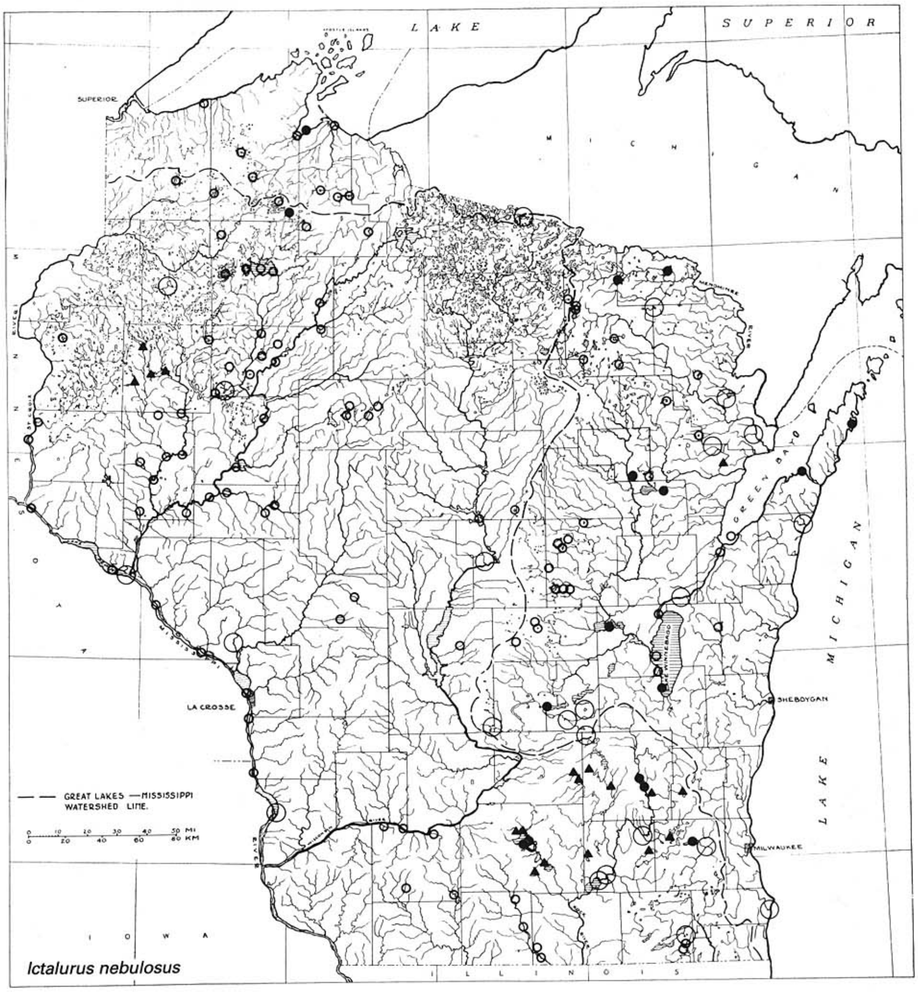
Two subspecies are recognized; *Ictalurus n. nebulosus* (Lesueur) is found in Canada, the Dakotas, Wisconsin, and the northern part of the Ohio Valley to Virginia; this form has been extensively introduced into western North America. *Ictalurus n. marmoratus* ranges from southern Illinois and northeastern Oklahoma to the Carolinas and Florida.

DISTRIBUTION, STATUS, AND HABITAT

In Wisconsin,the brown bullhead occurs in the Mississippi River, Lake Michigan, and Lake Superior drainage basins. Its major distribution is in the Rock and Fox-Wolf River systems of eastern Wisconsin, and the Chippewa River system of northwestern Wisconsin. It is present in the shallows of Lake Superior, Lake Michigan, and Green Bay, and in the lower courses of tributary streams. Although the brown bullhead has been reported frequently from a number of sources, some of these reports may be in error since this species is easily confused with other species of bullheads. I have plotted these reports on the distribution map when there was no opportunity to check them. As an example, I have not personally seen a specimen of the brown bullhead from the Wisconsin River basin, although it is commonly reported from that system.

According to McLain et al. (1965), the brown bullhead is widespread in the mouths of tributaries to Lake Superior; in these waters its numbers fluctuate widely from year to year, but the trend is toward increasing numbers. Priegel (1967) described the brown bullhead as abundant in Lake Winnebago. In general, its distribution over Wisconsin is sporadic and its numbers are low. It is the least common of the state's three species of bullheads, and its status has probably changed little since the 1920s.

The brown bullhead inhabits the weedy waters of warmwater lakes and sluggish streams. In the Mississippi River it occurs in sloughs and backwaters. It



Range of the brown bullhead
- ● Specimens examined
- ▲ Wisconsin Fish Distribution Study (1974–75)
- ○ Literature and reports
- ◯ Greene (1935)

inhabits vegetated shallows over sand, rock, mud, and silt, in lakes and low-gradient streams of varying size. It is tolerant of high turbidity and of waters modified by domestic and industrial effluents.

BIOLOGY

Spawning occurs in June and July in central and northern Wisconsin, and probably in May in the southern part of the state. Throughout the brown bullhead's range spawning occurs from late spring to August or later; it takes place from early morning to 1400 hr, at water temperatures of 21–25°C (69.8–77°F) (Mansueti and Hardy 1967).

The brown bullhead's nest is constructed by the female, occasionally by both parents. They suck pebbles up to 25 mm (1 in) diam into their mouths and transport them away from the nesting site (H. M. Smith and Harron 1903). Nests consist of open excavations in sand, gravel, or (rarely) mud, often in the shelter of logs, rocks, or vegetation. Occasionally these fish excavate holes in a bank, or make burrows up to 1 m long under roots of aquatic plants. Cavities of old stumps, stovepipes, old pails, and terra-cotta pots are occasionally used as nesting sites (Mansueti and Hardy 1967).

It is not clear how a male and female, instead of two fish of the same sex, come to occupy a single cavity (Breder 1935). That the brown bullhead is capable of sound production is well known, but there is no evidence that sounds have any significance in sex recognition. While the nest is being constructed, the male drives other bullheads away from the nesting area. Breder and Rosen (1966) described spawning behavior (pp. 252–253):

> After the nest has finally been completed the prospective spawners spend much time lying side by side with their tails to the opening of the nest. At such times they are usually in contact. This quietude is interrupted by swimming in a nearly circular path, the one fish following close to the other. Not infrequently at such times the tail of one fish, apparently accidentally, slips into the mouth of the other. If the latter closes down on the intruded tail, and it usually does, the bitten fish leaves the nest as though shot from a gun. After swimming about for a while it returns to resume the activities.

Finally they flatten so as to merge into a simple quiescent side to side position, with the fish facing in opposite directions and with their bodies in close contact. In this position spawning takes place. A large number of 'spawning acts' occur until the female is emptied of her eggs. . . . They are of a pale cream color, and average about 3 mm in diameter. . . . Between every spawning effort the fishes rest, the male in a seemingly exhausted state. The fishes separated slightly at this time, sometimes the male half falling to one side.

From 50 to 10,000 or more eggs are deposited per nest. The eggs are adhesive, and are deposited in clusters, similar to masses of frogs' eggs. One or both parents usually guard the clusters (Mansueti and Hardy 1967). According to Adams and Hankinson (1926), the guard fish, generally a male, suffers sores on his head when he locks jaws with another male while fighting for possession of the female brooding the eggs. However, this behavior has not been supported by more recent observations.

A partially spawned, 193-mm brown bullhead female, collected 15 July from Chippewa Lake (Bayfield County), had ovaries 9.6% of body weight (98 g); she held an estimated 2,190 yellow-white eggs, 2.2–2.7 mm diam. In Minnesota (Vessel and Eddy 1941), fecundity for females 267–330 mm (10.5–13 in) long was 6,180–13,000 eggs.

The brooding of the eggs, an elaborate procedure, has been described by Breder and Rosen (1966:253):

While it is difficult to be certain about the identity of the sexes of these fish, it appears that the female does most of the actual incubating and the male most of the guarding. . . . Both fishes were seen to defend their nest against other fishes. . . . Both parents were seen to incubate the eggs. . . . Most commonly the parent fish would settle down on the eggs with the ventral fins widespread so as to cover the mass as well as possible. Then these fins would be paddled up and down alternately, actually striking the eggs with considerable force. In a few days, generally, this action was sufficient to loosen the mass entirely from its place of attachment, so that subsequent fanning caused the entire mass to slap up and down against the floor of the tank in rhythm with the fins. Sometimes this kind of motion was alternated with a swimming movement in which the long anal fin served to swirl the mass about, or even break it up. At other times the mass of eggs, or part of it, would be taken into the mouth and 'chewed' in such a fashion as to roll them over and over, after which they would be ejected with considerable violence. Rarely at such times would the cluster be swallowed.

After the eggs hatch, the adults stop brooding activities but continue swimming over the young which are encumbered by large yolk-sacs. The time required for brown bullhead eggs to hatch is 6–9 days, at water temperatures of 20.6–23.3°C (69–74°F). The young remain on the nest for 7–10 days before they begin to swim. When the young rise off the bottom, the parents swim about them in circles to keep them in a compact school; strays are caught in their parents' mouths and returned to the school. In nature, it is probably at this point that the parents leave the young to fend for themselves. H. M. Smith and Harron (1903) observed young brown bullheads being sucked into the parents' mouths, but the parents did not always blow them out, ". . . the feeding instinct becoming paramount to the parental instinct."

The details of the brown bullhead's embryonic development from cleavage (1.2 hr) through hatching (8 days) to the 17-day stage are given by Armstrong (1962). The length at hatching is 4–8 mm (Mansueti and Hardy 1967). Fish (1932) illustrated and described the 22-mm stage.

Juvenile brown bullheads sometimes occur in schools throughout their first summer. Such schools are found among vegetation, or near other suitable cover over more or less muddy bottoms.

In Wisconsin, the growth of young-of-year brown bullheads has been recorded as follows (Paruch 1979):

Date	No. of Fish	TL (mm) Avg	TL (mm) Range	Location
14 July	16	36	25–39	La Motte L. (Menominee Co.)
2 Aug.	1	39		White Clay L. (Shawano Co.)
19 Aug.	1	51		L. Poygan (Winnebago Co.)
28 Aug.	1	57		L. Winnebago (Fond du Lac Co.)
12 Sept.	2	65	53–76	Rock R. (Dodge Co.)
26 Sept.	18	68	56–84	L. Mendota (Dane Co.)
15 Oct.	1	89		Rock R. (Dodge Co.)

In brown bullheads from Little Lake Butte des Morts (Winnebago County), Priegel (1966a) determined the following age-length relationships: II—152 mm; III—193 (157–246) mm; IV—241 (203–290) mm; and V—267 (257–290) mm. The condition value (K_{TL}) averaged 1.25. A 243-mm fish from Green Bay (Door County) showed the following growth at the annuli of the pectoral spine: 1—66 mm; 2—135 mm; 3—162 mm; and 4—216 mm (Paruch 1979). The age of the brown bullhead at maturity is 3 years (Mansueti and Hardy 1967).

In Wisconsin, the brown bullhead seldom attains a length of more than 356 mm (14 in). A 1.70-kg (3-lb 12-oz) brown bullhead was taken from Nelson Lake (Sawyer County) in 1972. The maximum length reported for this species from Florida lies between 508 and 532 mm (20 and 21 in) (Carlander 1969). A 2.50-kg (5-lb 8-oz) brown bullhead was reported from Veal Pond, Sandersville, Georgia, in 1975.

Fry and fingerlings up to 75 mm long eat zooplankton and chironomids; adult brown bullheads feed on insects, fish, fish eggs, mollusks, and plants (Carlander 1969). In lakes near Madison, Wisconsin, brown bullheads consumed dipteran larvae, amphipods, cladocerans, oligochaetes, a wide variety of aquatic insects in lesser amounts, and traces of plants and algae (Pearse 1918). In Green Lake (Green Lake County), they consumed these foods (in order of decreasing amounts): snails, crayfish, plants, oligochaetes, insect larvae, amphipods, algae, clams, mites, and cladocerans. In Lake Mendota brown bullheads ate insect larvae, algae, amphipods, plants, leeches, cladocerans, crayfish, ostracods, bottom ooze, insect pupae, snails, and sand (Pearse 1921a).

Availability frequently determines what kind of food is ingested. In Illinois (Forbes and Richardson 1920), the brown bullhead's diet consisted chiefly of "small bivalve mollusks, larvae of insects taken upon the bottom, distillery slops, and accidental rubbish. One of the specimens had eaten 18 leeches." In West Virginia (Klarberg and Benson 1975), the brown bullhead met its nutritional requirements with detritus, sewage, and acid-tolerant invertebrates. Small fishes are eaten occasionally. The brown bullhead has consumed the eggs of the cisco in Lake Ontario, of herring in the Potomac River, and of lake trout in Maine, Ontario, and Quebec (Emig 1966a).

Brown bullheads are able to find food by an elaborate sense of taste. Brown bullheads (19–27 mm) from Michigan lakes could find distant chemical clues by means of taste alone and moved in the direction of the chemical in the absence of a current (Bardach et al. 1967). Even inactivation of their sense of smell did not impair their searching ability. Typically, a bullhead showed that it had perceived a chemical by what is best described as a startled response: the barbels stiffened, the body became rigid for a moment, the head began a slow to-and-fro movement, and the fish almost immediately began swimming. Keast and Welsh (1968) noted that brown bullheads were exclusively nocturnal in their feeding habits in Canadian lakes. In Iowa, they are reported to feed at all times of the day and night (Harlan and Speaker 1956).

The brown bullhead prefers warm water. In Ontario (Hallam 1959), it is associated with rock bass and smallmouth bass in waters at temperatures of 20.8–21.4°C (69.3–70.6°F). At an acclimation temperature of 36°C (96.8°F), the upper lethal temperature for brown bullheads was 37.5°C (99.5°F)(Brett 1944); at an acclimation temperature of 21°C (69.8°F), the lower lethal temperature was −1.0°C (30.2°F).

The brown bullhead has been observed swimming in 37–38°C (98.6–100.4°F) water, and entering 40°C (104°F) water for worms (Trembley 1960). In a shallow Michigan pond (Bailey 1955), many brown bullheads died as a result of a 38°C (100.4°F) water temperature. In a thermal gradient trough, this species selected 27.3°C (81.1°F) (Richards and Ibara 1978).

The brown bullhead's metabolic rate is positively correlated with temperature, and inversely correlated with carbon dioxide concentrations. It tolerates relatively high carbon dioxide levels and low oxygen levels (Emig 1966a). In the Monongahela River of West Virginia, it is the most abundant species and is distributed over the widest pH range (3.4–7.7) of any species present (Klarberg and Benson 1975). It endures a maximum salinity of 7.6 ppt (Mansueti and Hardy 1967). In a southeastern Michigan winterkill lake, many brown bullheads survived with a minimum concentration of dissolved oxygen of 0.5–0.05 ppm, and some survived in another lake at 0.2–0.0 ppm (Cooper and Washburn 1949). In Minnesota (Moyle and Clothier 1959), the brown bullhead survived well when oxygen levels fell to near 1 ppm. This species, as well as the other bullheads, is known to gulp air at the surface when the oxygen level in the water becomes critically low.

In one study (Loeb 1964), the respiratory movements of the brown bullhead were more or less continuous at all temperatures, but were so weak at water temperatures below 2.8°C (37°F) that the pulsations could not be counted. At any temperature above 6.1°C (43°F), steady pulsations occurred, increasing as the temperature rose (e.g., 73 per min at 16.7°C).

In the late fall, brown bullheads become sluggish and cease feeding, often "mudding up," or burying themselves in soft, leafy ooze along the shore. This occurs at temperatures ranging from 0.0 to 18.3°C (32 to 65°F) (Loeb 1964). At water temperatures of 7.8°C (46°F) and above, the mouth could always be seen above the mud or in a funnel just below the surface, and breathing was more or less continuous. At 6.1°C (43°F) and below, sediment often covered the mouth for hours and some fish remained buried for up to 24 hours.

Loeb (1964) recorded the brown bullhead's method of entry into bottom sediments consisting of organic ooze, silt, and dead leaf material (pp. 120–121):

. . . Bullheads buried themselves by thrusting with the head in a strong swimming motion. The fish, which may have been meandering leisurely over the surface of the mud, quickly tilted the body to an almost vertical position and drove its entire body into the sediment with a few vigorous movements. . . . After burial the body was covered with from a fraction of an inch to 2 inches of sediment, the long axis of the body was horizontal or tilted slightly up toward the mouth, and the lateral axis was canted at an angle so that one gill more or less pointed up and the other down. . . . The mouth was brought into direct contact with the free water above the surface of the mud . . . [or] the buried fish often made contact with the free water by sucking in the inch or 2 of sediment covering its mouth and expelling the material in geyser fashion from the uppermost gill. In this way a small funnel was formed over the mouth and the material from the funnel was deposited over the gill in a volcano-like mound so that an open passage of water extended from the gill to the top of the mound.

Loeb noted that two bullheads were found buried for several hours beneath 5 cm of sediment without the presence of a funnel over the mouth, or of a passage over the gill. It was assumed that they were breathing through the 5 cm of organic botton ooze. Older literature references indicate that bullheads can survive several weeks in cocoonlike clods of nearly dried mud; however, this has not been substantiated.

In Folsom Lake, California, tagged brown bullheads released at the point of capture traveled an average of 2.7 km (1.7 mi) before they were recaptured by anglers. The longest distance traveled was 26.1 km (16.2 mi) (Emig 1966a).

The brown bullhead is chiefly nocturnal in its habits, and its activity increases with the approach of darkness. Normally, this species is not accused of stirring up bottom sediments and creating turbidity; however, when brown and yellow bullheads were removed from an Alabama pond which had been very muddy for years, the water clarified, and a dense growth of algae followed (Tarzwell 1941). Tarzwell concluded that the bullheads limited vegetation and food production by stirring the bottom and by keeping the water continually roiled.

In 1969, 35 brown bullheads were collected from Rebholz Creek (Door County) along with bluntnose minnow (35), fathead minnow (4), golden shiner (18), northern redbelly dace (24), common shiner (64), spottail shiner (3), blacknose shiner (50), sand shiner (6), mimic shiner (12), black bullhead (25), white sucker (3), smallmouth bass (1), rock bass (10), pumpkinseed (7), northern pike (2), central mudminnow (5), and banded killifish (10).

IMPORTANCE AND MANAGEMENT

The brown bullhead has been preyed on by lampreys, northern pike, snapping turtles, water snakes, and green herons. In Lake Winnebago during the fall of 1960, it was the third most important fish item consumed by the walleye; only perch and white bass were consumed more often (Priegel 1963b).

The brown bullhead is a host to the glochidial stage of the mollusks *Megalonaias gigantea* and *Quadrula pustulosa*; it is one of several fish species responsible for the distribution and perpetuation of those clam species (Hart and Fuller 1974).

Man catches the brown bullhead over soft bottoms where there is considerable aquatic vegetation. The hook is baited with raw beef, worms, or minnows. Hankinson has caught the brown and yellow bullheads with just a chunk of beef tied on a line and no hook (Adams and Hankinson 1926); often two fish were pulled in at one time, persistently clinging to the meat.

The name "red cat" for the brown bullhead comes from the red color of its flesh, and is used in areas where the dressed fish are sold commercially. The meat is very tasty, especially when the bullheads are taken from clean water in the spring and fall.

Man has used the brown bullhead extensively as a laboratory animal in assessing physiological changes involving factors such as temperature, taste, oxygen consumption, blood group agglutinins, and osmoregulation. It has also been subjected to toxicity bioassays, in which petroleum refinery effluents were used as toxicants (Bunting and Irwin 1965).

In the commercial harvest of bullheads in Wisconsin (see Black Bullhead, p. 700), the brown bullhead is categorized with the black and yellow bullheads, and probably constitutes only a small portion of the bullhead catch; it is probably of the least importance. Restaurants prefer to buy brown bullheads (called "red cats") which weigh 91–318 g (0.2–0.7 lb) alive, so that one or more fish can be included in one serving (Swingle 1957a).

In Connecticut (Marcy and Galvin 1973), brown bullheads constituted 12% of the estimated number of fish caught in the heated discharge canal of a nuclear power plant. The winter catch (January through March) at the canal was dominated by carp, followed by the brown bullhead. During this period the temperature of the canal water was about 14°C (57.2°F). There appeared to be a relationship between water temperature and the catch rate: on and immediately after days when the plant reduced its power level enough to lower the water temperatures considerably, the catch rate declined.

In Alabama (Swingle 1957), production of brown bullheads of marketable size, and up to 835 kg/ha (745 lb/acre), was obtained with supplemental feeding. The most successful method of commercial production was to stock fry or fingerlings in the spring, fertilize the pond until fall, feed the fish during fall and spring months, and drain the pond before reproduction could occur. Such fish were 151–227 g (0.3–0.5 lb)—the most desirable size for sale. Swingle (1957a) provided a summary of management procedures for the commercial production of brown bullheads; these methods should yield approximately 1,110 kg/ha (990 lb/acre).

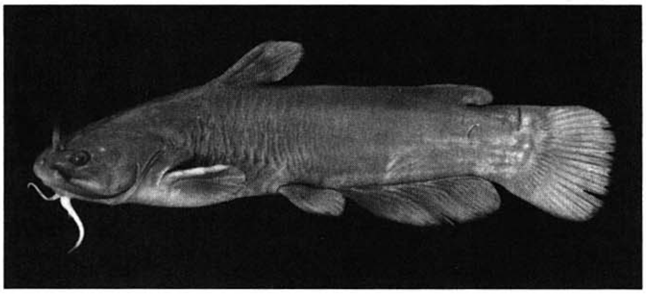
In Wisconsin, the potential exists for raising brown bullheads in the heated waters of power plants and in the tertiary pools of sewage plants.

Brown bullhead populations are subject to very limited management in most states. They are classified as sport fish in Wisconsin, California, Michigan, and Washington; as panfish in Massachusetts; and as rough or coarse fish in Minnesota, North Carolina, Alabama, and Florida.

Yellow Bullhead

Ictalurus natalis (Lesueur). *Ictalurus*—fish cat; *natalis*—having large nates, or buttocks.

Other common names: northern yellow bullhead, yellow catfish, yellow cat, yellowbellied cat, brown catfish, brown bullhead, white-whiskered bullhead, Mississippi bullhead, greaser.



145 mm, Plover R., Stevens Point (Portage Co.), 2 Oct. 1968

DESCRIPTION

Body robust, rounded anteriorly, compressed posteriorly. Length 165–235 mm (6.5–9.3 in). TL = 1.19 SL. Depth into TL 4–5.2. Head length into TL 3.7–4.5. Snout bluntly pointed in lateral view, broadly rounded in dorsal view; elongated barbels of snout just anterior to posterior nostrils. Mouth short but wide, terminal and horizontal; upper jaw slightly longer than lower jaw, with very long barbel sweeping posteriorly from the upper jaw at each corner of the mouth; 4 shorter barbels attached in a transverse line on the lower chin; numerous minute, needlelike teeth in broad bands on upper and lower jaws. Dorsal fin origin slightly anterior to midpoint between pectoral and pelvic fins; dorsal fin with a stout spine and 6 soft rays; dorsal adipose fin free at posterior end. Anal fin rays, including rudimentaries, 24–27; pelvic fin rays 8; pectoral fin with a stout spine, regularly barbed on posterior edge with barbs near tip inclined toward the base of spine; caudal fin rounded. Scaleless. Lateral line complete. Digestive tract about 1.3 TL. Chromosomes 2n = 62 (LeGrande 1978).

Dorsal region of head, back, and upper sides yellow, olive, or black; sides lighter; ventral region of head and belly yellow to white. Snout and upper jaw barbels dark pigmented, chin barbels whitish, occasionally grayish in large individuals. All fins dusky, with pencil-line black margins; the interradial membranes dark but not black; anal fin usually with dark horizontal median band.

Hybrids: Experimental yellow bullhead × channel catfish, yellow bullhead × blue catfish, yellow bullhead × white catfish, yellow bullhead × brown bullhead, yellow bullhead × black bullhead, yellow bullhead × flathead catfish (Dupree et al. 1966).

DISTRIBUTION, STATUS, AND HABITAT

In Wisconsin, the yellow bullhead occurs in the Mississippi River, Lake Superior, and Lake Michigan drainage basins. It does not generally occur in Lakes Superior and Michigan, except in Green Bay. It is widespread in inland waters, except in the southwest quarter of the state, where it is sporadic.

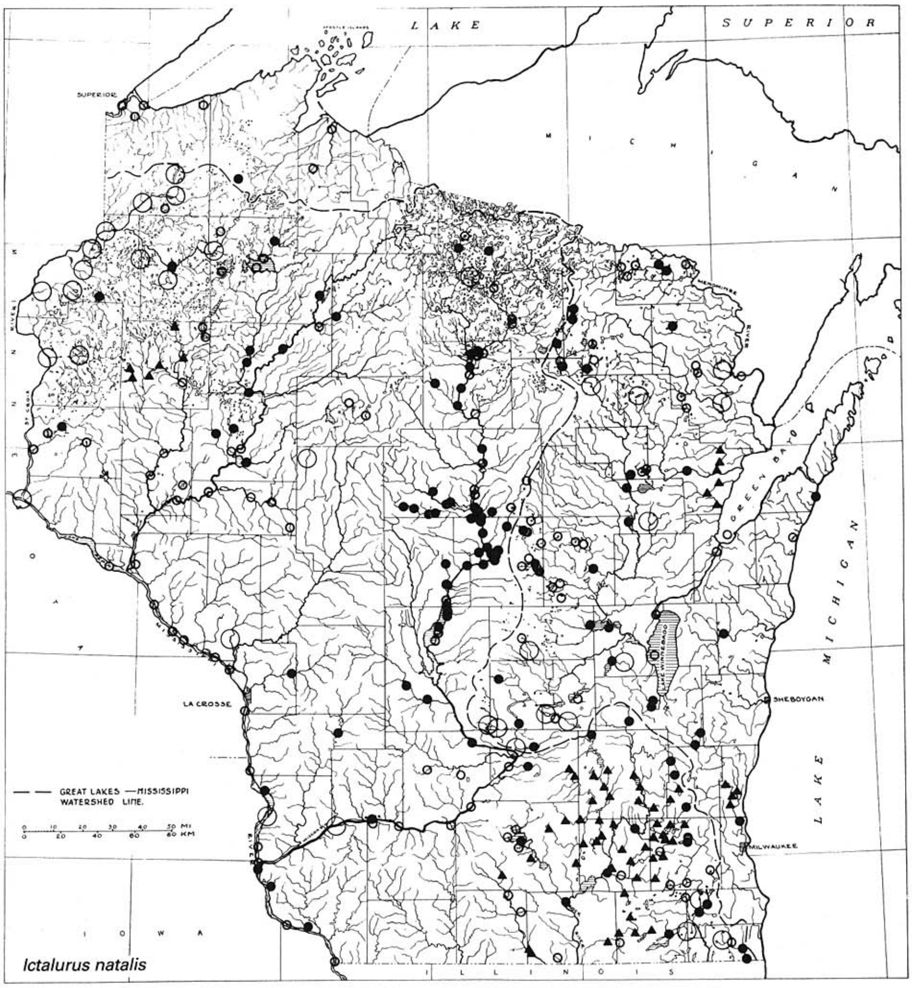
The yellow bullhead is generally uncommon in the Mississippi River, and common in the Wisconsin River and in Lakes Winnebago and Poygan. It is the typical bullhead in clear, medium-sized streams and clear lakes. Its status in Wisconsin appears to be secure.

In Wisconsin, the yellow bullhead was encountered most frequently in clear water at depths of 0.6–1.5 m, over substrates of sand (26% frequency), mud (21%), gravel (18%), silt (13%), boulders (13%), rubble (5%), detritus (3%), and bedrock (1%). It was occasionally found in slightly turbid to turbid waters. It occurred in quiet, weedy sectors of lakes and reservoirs, and in streams of the following widths: 1.0–3.0 m (13% frequency); 3.1–6.0 m (17%); 6.1–12.0 m (17%); 12.1–24.0 m (29%); 24.1–50.0 m (8%); and more than 50 m (17%). It has occasionally been taken from streams with gentle to fast currents.

BIOLOGY

The spawning of the yellow bullhead may begin in May, and in northern Wisconsin it extends into July. The nests are usually saucer-shaped excavations at depths of 0.5–1.2 m (1.5–4 ft), located beside or beneath a bank, a log, or a tree root. Nests also have been reported in burrows 0.6 m (2 ft) deep, under boards, in cans, under crockery, and in the entrances of deserted muskrat burrows (Adams and Hankinson 1926). In lakes, nests occur in heavy banks of weeds (Cahn 1927). The burrow may be excavated by both sexes. Often small roots from the surrounding vegetation are left in the burrow; these frequently serve as anchorage for the yellowish white, adhesive eggs. Usually 300–700 eggs are deposited in a nest.

A partially spawned, 172-mm yellow bullhead, collected 23 June from Sevenmile Creek (Florence County), had ovaries 13.6% of body weight (84 g); she held an estimated 1,190 yellow-orange, mature eggs 2.2–3.0 mm diam. A 171-mm, 77-g female, with ovaries 10.7% of body weight, held 860 eggs 2.5–3.0 mm diam.



Range of the yellow bullhead
- ● Specimens examined
- ▲ Wisconsin Fish Distribution Study (1974–75)
- ○ Literature and reports
- ◯ Greene (1935)

According to Mansueti and Hardy (1967), the fecundity rate per female is 1,650–7,000 eggs. In Minnesota, during the first week of July, three fish, 254–279 mm TL, had egg counts of 3,950–4,270 (Vessel and Eddy 1941).

The eggs hatch in 5–10 days. Fish (1932) described and illustrated the 17-mm stage, and Mansueti and Hardy (1967) provided a drawing of a 21-mm juvenile. The larvae and juveniles are guarded by parent fish until late July or August, or until the young are about 50 mm long (Mansueti and Hardy 1967). The estimated growth within a 30-day period early in the first summer's existence is 0.60 mm per day (Hubbs 1921).

In quiet water, schools of several hundred young yellow bullheads feed and move in compact groups near the surface; the guardian parent remains 0.3–0.6 m away, warding off all intruders (Harlan and Speaker 1956). In the autumn, the young hide under logs and stones in shallow water (Adams and Hankinson 1926).

The growth of young-of-year yellow bullheads in Wisconsin has been reported as follows (Paruch 1979):

Date	No. of Fish	TL (mm) Avg	TL (mm) Range	Location
12 July	9	19	15–20	Wolf R. (Langlade Co.)
14 July	4	26	22–29	La Motte L. (Menominee Co.)
10 Aug.	2	41	32–50	Collins L. (Portage Co.)
10 Aug.	2	57	53–60	McCartney Cr. (Grant Co.)
27 Sept.	4	46	35–63	Little Eau Pleine R. (Marathon Co.)
14 Dec.	1	76		Wisconsin R. (Portage Co.)

The age and growth of 102 yellow bullheads from Wisconsin (UWSP specimens) are summarized in the table on the following page (Paruch 1979).

In yellow bullheads from Little Butte des Morts (Winnebago County), Priegel (1966a) has determined the following age-length relationships: II—206 (180–244) mm; III—226 (193–274) mm; and IV—272 (226–295) mm. The condition value (K_{TL}) averaged 1.38. Maturity in yellow bullheads is reached during the third year of life (Harlan and Speaker 1956).

A 337-mm yellow bullhead weighing 508 g (1 lb 1.8

Age Class	No. of Fish	TL (mm) Avg	Range	Calculated TL at Annulus (mm) 1	2	3	4	5	6	7
0	28	35	16–76							
I	14	129	69–177	54						
II	34	167	122–244	43	109					
III	19	207	165–252	49	111	159				
IV	4	263	242–291	86	152	193	223			
V	2	263	226–300	69	135	197	214	235		
VII	1	345		145	200	218	236	272	290	309
Avg (weighted)				51	115	169	222	247	290	309

oz), was taken from Lake Wingra (Dane County) in 1945 (Noland 1951). A 1.4-kg (3-lb 3-oz) yellow bullhead was caught from Nelson Lake (Sawyer County) in 1972. The maximum known length reported is 465 mm (18.3 in) (Mansueti and Hardy 1967).

Young yellow bullheads feed principally on entomostracans and insect larvae; adults eat a wide variety of living and dead material in the water. In Lake Mendota (Dane County), yellow bullheads ate crayfish, amphipods, cladocerans, insect larvae, copepods, snails, and algae (Pearse 1921a). In Green Lake (Green Lake County), this species ate fish, insect larvae and adults, amphipods, cladocerans, and plant matter. In Sinissippi Lake (Dodge County), it consumed fathead minnows (H. Neuenschwander, pers. comm.).

In a northern Alabama pond (Tarzwell 1941), yellow bullheads ate largely chironomids, corixids, and golden shiners, and lesser amounts of many aquatic and terrestrial insects and oligochaetes.

According to Harlan and Speaker (1956), the yellow bullhead appears to be more selective and more nocturnal in its feeding habits than the other two species of bullheads. Like the other species, the yellow bullhead responds to odors in the water; when a food pellet is dropped into water frequented by a yellow bullhead, the bullhead's fins spread and its barbels stiffen; the timing of this response is roughly proportional to the fish's distance from the place where the food was dropped. The fish then swims to the pellet and picks it up.

In a Michigan lake, no homing or territorial tendency was noted in marked yellow bullheads (Fetterolf 1952). In Wisconsin, Greenbank (1956) observed movement of this species into and out of a shallow Mississippi River backwater lake. During January and February about twice as many yellow bullheads entered the lake as left it, most activity occurring when heavy snow covered the ice.

In winterkill lakes of southeastern Michigan, the yellow bullhead survived where the minimum oxygen concentrations were 0.3–0.1 ppm, and some individuals survived at 0.2–0.0 ppm (Cooper and Washburn 1949). In the laboratory, yellow bullheads were held to an average oxygen level of 2.7 ppm for 8 hr a day, for 9 days; they showed no significant stress patterns in serum protein fractions (Bouck and Ball 1965).

Although the yellow bullhead can endure severe environmental stresses, its taste buds erode and its swimming and feeding behavior are modified when it is exposed to concentrations of commercial detergents at 0.5 ppm (Bardach et al. 1965). In laboratory experiments, such fish found food pellets only when they accidentally swam over them or touched them with their lower jaws or their lips. The researchers concluded that fishes such as bullheads, that rely mainly on their chemical senses for finding food, feed less efficiently in waters which persistently contain 0.5 ppm of detergents.

Four yellow bullheads were collected from Sevenmile Creek (Florence County) along with white sucker (6), blacknose dace (1), creek chub (2), pearl dace (6), finescale dace (4), northern redbelly dace (54), blacknose shiner (16), black bullhead (2), central mudminnow (20), Iowa darter (6), pumpkinseed (2), mottled sculpin (1), and brook stickleback (1).

IMPORTANCE AND MANAGEMENT

No records have been found of the yellow bullhead being taken by other predators, although this doubtless happens.

The yellow bullhead is known as a host to the larval stage of the clam *Anodonta grandis* (Hart and Fuller 1974); it probably acts as an important link to future generations of clams.

The yellow bullhead is frequently taken on worms, liver, and meat scraps. It bites as dusk approaches, and continues biting well into the night. It is an excellent food fish; the flesh is fine in texture, firm, and delicious, and it has few bones. It is probably more difficult to skin than other bullheads because its skin is thin.

In experimental trawls in Green Bay, the yellow bullhead and 11 other species of fish composed only 0.7% of the total catch. Reigle (1969a) concluded that it has no potential commercial importance for bottom trawling. In that stretch of the Mississippi River from the Wisconsin line to Caruthersville, Missouri, yellow bullheads and brown bullheads are too scarce to be of any commercial importance (Barnickol and Starrett 1951).

In the commercial harvest in Wisconsin (see Black Bullhead, p. 700), the yellow bullhead is categorized with the black and brown bullheads, and probably constitutes only a small portion of the bullhead catch; it is perhaps second in importance to the black bullhead.

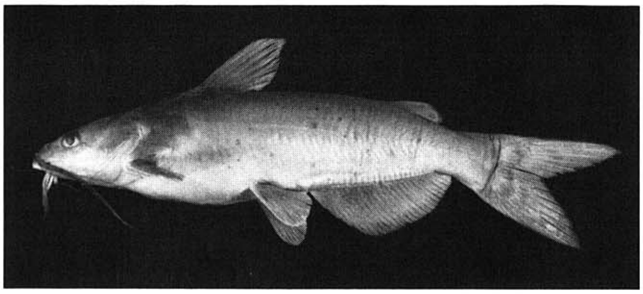
Little is known about management of yellow bullheads. In a shallow pond in northern Alabama, bullheads comprised 197 kg/ha (176 lb/acre) (Tarzwell 1941). Of the 521 bullheads from this pond that were measured, 127 were yellow and 394 were brown; the yellow bullheads attained a larger size than the brown bullheads. After the bullheads and golden shiners were removed from the pond, the muddy water cleared up and a dense algal growth formed in a few days. Tarzwell concluded that the usual turbidity of this pond was due to the bullheads stirring up the bottom and keeping the waters roiled.

Artificial habitats for the yellow bullhead were inadvertently produced along the banks of the Plover River (Portage County), which flows through a public park in Stevens Point, when the banks were riprapped with flat stones placed loosely together. The yellow bullheads frequented the cavities between the stone slabs, and were readily brought out of their hiding places with shocking gear.

Channel Catfish

Ictalurus punctatus (Rafinesque). *Ictalurus*—fish cat; *punctatus*—spotted.

Other common names: channel cat, spotted catfish, spotted cat, Great Lakes catfish, lake catfish, northern catfish, fiddler, white cat, blue cat, lady cat, chucklehead cat, willow cat, cat.



256 mm, Sugar R., near Brodhead (Green Co.), 15 Aug. 1963

DESCRIPTION

Body slender, somewhat compressed, especially posteriorly; not humpbacked before dorsal fin; the profile of the back from the dorsal fin forward gently sloping and curved. Length 305–508 mm (12–20 in). TL = 1.27 SL. Depth into SL 3.8–4.7 (6.6). Head small, length into SL 3.6–4.3. Snout profile bluntly pointed, broadly rounded in dorsal view; barbels of snout short, threadlike, and just anterior to posterior nostril. Mouth short but wide, subterminal and horizontal. Lower jaw much shorter than and included in upper jaw; long barbel (decidedly exceeding head length) sweeping posteriorly from the upper jaw at each corner of the mouth; 4 short barbels attached in a transverse line on the lower chin, with the median pair shorter. Numerous small, sharp teeth in broad bands on upper and lower jaws. Dorsal fin origin far anterior to midpoint between pectoral and pelvic fins; dorsal fin with a dorsal spine less than, to slightly greater than, distance from tip of snout to back of eye; dorsal fin soft rays 6–7; dorsal adipose fin free at posterior edge. Anal fin with free edge generally rounded and with 24–27 rays, including rudimentaries; pelvic fin rays 8; pectoral fin with a narrow spine about same length as dorsal spine, regularly barbed on posterior edge with barbs all inclined (and becoming smaller) toward the base of spine; caudal fin deeply forked. Scaleless. Lateral line complete. Chromosomes 2n = 58 (LeGrande 1978).

Dorsal half of head and body pale blue to pale olive with silvery overcast; ventral surface whitish; sides with spots of varying size and number. Old males become dark in color and lose their spots (these are commonly referred to as "blue catfish" and mistaken by some observers for *Ictalurus furcatus*, the bona fide blue catfish). Fins lightly pigmented. Maxillary barbels darkly pigmented; snout and chin barbels lightly pigmented, except bases of chin barbels generally unpigmented.

Sexual dimorphism: Males with a distinctive urogenital papilla extending posteriorly, which is absent in females; hence one opening behind the vent in males, and two openings behind the vent in females (Moen 1959). In males the head is wider than the body; in females the head is scarcely as wide as the body (Davis 1959). Breeding males are often a brighter blue or deep blue-black on the back and sides than females; the region above and behind the eye is swollen in breeding males.

Hybrids: Channel catfish × flathead catfish (Slastenenko 1957). Experimental channel catfish × blue catfish, channel catfish × white catfish, channel catfish × flathead catfish, channel catfish × brown bullhead, channel catfish × yellow bullhead, channel catfish × black bullhead (Sneed 1964, Dupree et al. 1966).

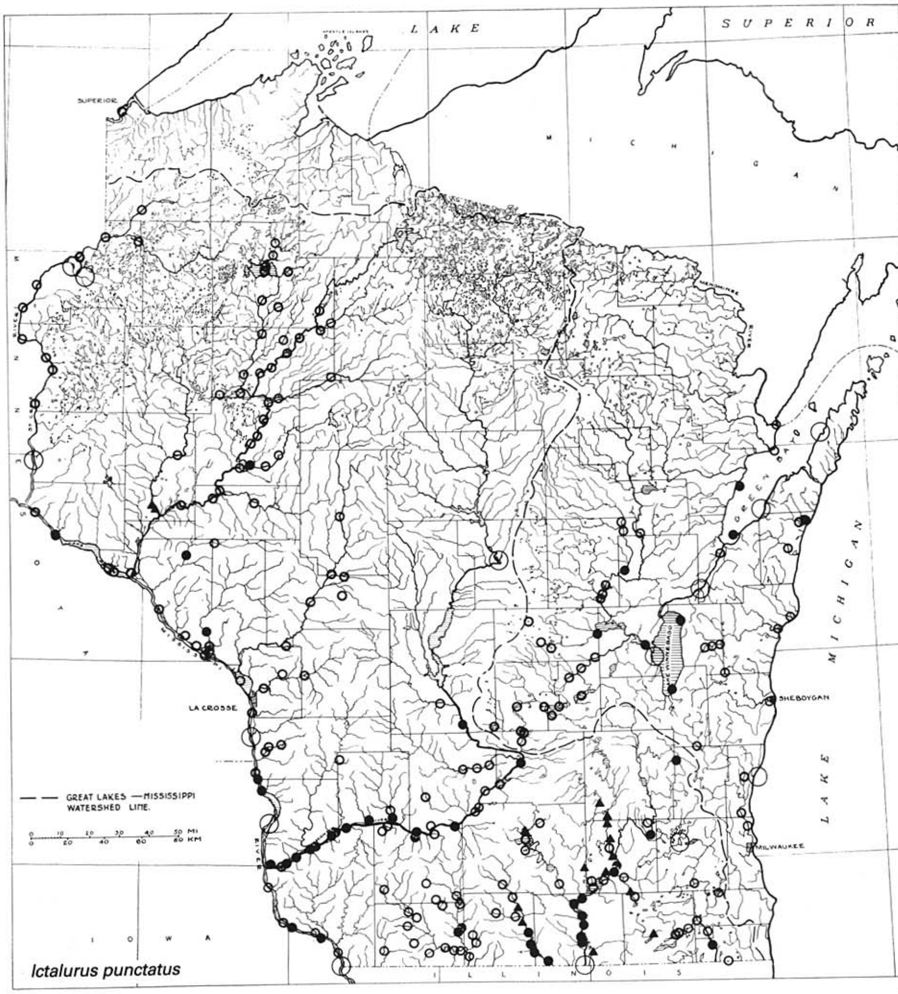
SYSTEMATIC NOTES

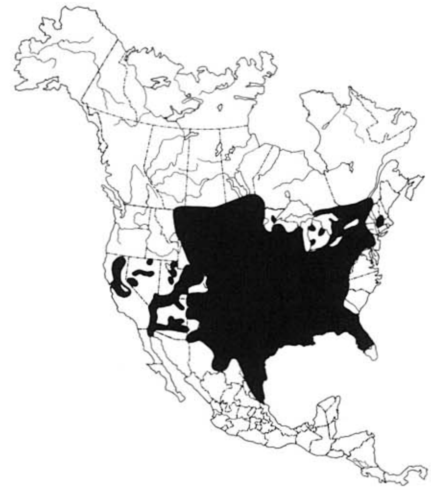
The northern catfish *Villarius lacustris* (Walbaum) of Green Bay and Lake Michigan (Greene 1935) is now recognized as a synonym of *Ictalurus punctatus*. Hubbs and Lagler (1964) noted that the former does not now appear to be sufficiently set off to be recognized, but the whole problem is in need of critical analysis.

DISTRIBUTION, STATUS, AND HABITAT

The channel catfish occurs in all three drainage basins in Wisconsin. In the Lake Superior basin, it is known only from the St. Louis River (Moore and Braem 1965, Eddy and Surber 1947, Eddy and Underhill 1974). In the lower two-thirds of the state it is widely distributed in the larger rivers, their lake systems, and the lower courses of their tributaries. In the Wisconsin River, it occurs regularly as far upstream as the Castle Rock Dam (Adams and Juneau counties), but rarely beyond this point. Greene (1935) noted a report from the mouth of the Plover River (Portage County), and S. Becker (1972) reported that a "28-pound catfish" (probably this species) was taken from the Wisconsin River near Stevens Point early in the century.

The channel catfish is not known from the Rock River above Hustisford (Dodge County); it was introduced between Hustisford and Watertown in 1954, although it is native in the Crawfish and Beaverdam





Range of the channel catfish
- ● Specimens examined
- ▲ Wisconsin Fish Distribution Study (1974–75)
- ○ Literature and reports
- ◯ Greene (1935)

rivers (Dodge County) (H. Neuenschwander, pers. comm.). It was introduced into Waukesha County lakes (Cahn 1927); in 1955 it was introduced into Lake Helen (Portage County), where it winterkilled by the following spring (Becker 1969).

The channel catfish was introduced into the West Twin River (Manitowoc County) in 1957, followed by plants in the Manitowoc, Sheboygan, Onion, and Mullet rivers (Manitowoc and Sheboygan counties) (Schultz 1969). Sustaining populations now occur in the East and West Twin rivers and in the Manitowoc and Sheboygan rivers. Apparently it was not found in these streams prior to introduction, although a small population has always existed in Lake Michigan and in Green Bay.

The channel catfish is uncommon to common in the larger waterways and their connecting lakes in the southern half of Wisconsin. It is less common northward, and rare to uncommon in Lake Michigan and Green Bay.

The channel catfish is found in a wide variety of habitats. It occurs in clear, rocky, well-oxygenated streams, as well as in slow-moving, silty streams; it is often found downstream from power dams where the water is fairly rapid. In streams, young channel catfish inhabit shallow riffles and turbulent areas near sand bars; adults spend the day under big rocks, in deep pools, or under log jams, and enter shallow water at night. Channel catfish may also be found in sluggish streams, lakes, and large reservoirs. They prefer warm water averaging 21.1°C (70°F). Not much is known about the habitat of young channel catfish in lakes.

In Wisconsin, the channel catfish was encountered in turbid water over substrates (decreasing order of frequency) of mud, sand, clay, gravel, silt, rubble, and boulders. It has been taken a number of times from large rivers and streams 12.1–24.0 m wide, in quiet water and in moderate currents.

BIOLOGY

Spawning occurs from May to July, when the water temperature reaches about 23.9°C (75°F); the optimum temperature for spawning is about 26.7°C

(80°F). Adult channel catfish may make extensive excursions upriver in the spring. The male locates a suitable dark cavity or crevice in the stream, under a ledge where rock strata outcrop in the channel, or beneath the roots of a tree undercut by the current. Under highly turbid conditions in a lake or a reservoir, nests may be made directly on the bottom in the mud. Neither a current nor a rocky substrate is necessary for spawning, or for normal development of the young channel catfish. In ponds and hatcheries, nail kegs, earthenware crocks, or milk cans are provided for the fish to spawn in. In clearwater ponds, it is necessary to produce a "hollow log" by telescoping two to three nail kegs together after the bottoms have been knocked out; the spawn is usually deposited in the middle keg (Marzolf 1957).

Prior to spawning, the male cleans the nest site by vigorous fanning with his fins and body, and waits for a female that is ready to deposit eggs (Davis 1959). Pairing may occur before the female is actually ripe, and she may stay nearby while the male cleans the nest. The female usually takes no part in preparing the nest, or in guarding the nest and the young. According to reports, the largest or oldest fish spawn first; the smallest fish are usually the last to spawn.

The following spawning behavior by channel catfish was observed in aquariums (Clemens and Sneed 1957); the female had been injected with fish pituitaries (p. 3):

> Any biting on the part of the female, directed towards other females or towards males, was accepted as a sign of readiness to spawn, since paired catfish (both male and female) usually drove other fish away. . . . In pairing acts in which aggressiveness occurred, it was observed that if the fish were going to pair, the bites of the male became progressively less severe until they were more like a nudge in the region of the vent.
>
> A few hours before the event, there were some rather positive signs that spawning was to take place. The female occasionally would make what we called "runs" along the bottom. In this type of behavior the female moved over the spot where the eggs were to be deposited in a wiggling motion, the pelvic and pectoral fins alternately beating against the bottom. These runs were short, about 4 to 6 inches. This same behavior was later a part of the spawning act and was repeated many times.

When a male attempted to spawn with a female, they were headed in opposite directions to one another (p. 5):

> . . . Then he wrapped his tail around her head so that his caudal fin covered her eyes. . . . Then the male's body quivered, during which time his pectoral fins beat, but his pelvics remained rather motionless and pointed backwards, and in some cases slightly to the side. . . . If the female responded, she usually did so within 5 seconds. When she participated she wrapped her tail around the head of the male and quivered in unison with him. Both her pelvic and pectoral fins were motionless during this act. With each reflex a contraction of the abdominal muscles of the female moved the eggs posteriorly and progressively produced a flattened area behind the pectoral fins. She then lunged forward about 3 to 5 inches as the eggs spurted out. A current of water, produced by the lunge, caused the eggs to swirl up before they settled to the bottom. . . .
>
> It was believed that the male released milt at the end of the reflex at the same moment that the female released eggs.

Clemens and Sneed noted that a spawning period lasted from 4–6 hr, and that about 150 eggs were laid about nine times each hour, for a total of 8,000 eggs. Generally, females weighing 0.45–1.81 kg (1–4 lb) produced about 8,800 eggs per kilogram of body weight. According to Clemens and Sneed, when female catfish spawn, they usually void all of their eggs.

The eggs of channel catfish average 3.2 mm diam with the chorion removed. They are light yellow, demersal, and adhesive; they adhere to each other.

The incubation period of the eggs is from 5 to 10 days, at water temperatures between 21.1 and 29.4°C (70 and 85°F). At mean water temperatures of about 26.7°C (80°F), the time from the first deposition of eggs to the time when the first egg hatches ranges from 6 to 7 days. Eggs that are laid first are the last to hatch; the gradient of the oxygen tension between the top and the bottom eggs probably accounts for the differences in hatching time. Clemens and Sneed (1957) noted that during the deposition period both parents provided aeration for the eggs (pp. 6, 8):

> . . . At the end of the spawning period the male for the first time began paddling on the top of the eggs, while the female rested quietly to one side. From then on the female was permitted less and less to be near the eggs. The male drove her away as he did any other intruder.
>
> The most striking activity was exhibited by the male when he vigorously wiggled his body and pressed and packed the eggs with the flat side of his pelvic fins in a manner that shook the entire egg mass. He moved forward from one end of the egg pile to the other, which gave the impression that he was walking on his fins. This action was similar to the "run" of the female during the spawning act.
>
> . . . Vigorous males worked the eggs every 5–10 min the first day or 2, but late in the incubation period the workings were less frequent. . . . The eggs were loosened more when the male pulled at the eggs with his mouth. . . . No channel catfish were observed taking the eggs completely

in their mouths. One male was seen trying to move a loose egg mass that had shifted from the center of the aquarium by placing his snout under the edge of the mass and carrying it a little forward as he swam.

Upon hatching, the channel catfish fry accumulated in a mass on the bottom of the aquarium, usually in a corner, where they remained for about 2 days; then they began to come to the surface. By the third day, they had started to feed and to move about the aquarium.

Marzolf (1957) noted that channel catfish fry in ponds normally remain in the nest about 7 days, and are defended by the male fish. When the nest no longer needs to be defended, the male fish is ready for the second spawn. The minimum size of the fry at hatching is about 6.4 mm. The early development of young channel catfish through the pectoral finbud stage at 34 hr was examined by Saksena et al. (1961). Yolk-sac larvae, larvae, and juveniles were described by Mansueti and Hardy (1967). Fish (1932) illustrated the 32.6 mm juvenile, which has the true channel catfish appearance, including the spots.

Channel catfish larvae which are guarded by the male initially mass on the bottom and later make excursions to the surface. They may travel in schools for several days or for weeks (Mansueti and Hardy 1967). After dispersal, the juveniles feed singly in quiet, shallow water over sand bars, around drift piles, and among rocks; some juveniles winter under boulders in rather swiftly flowing water.

In Lewis and Clark Lake, South Dakota, channel catfish yolk-sac larvae shorter than 15 mm were collected from the old river channel at depths of 10–12 m in early July (Walburg 1976). The young remained in schools for the first several weeks after hatching, but apparently dispersed when they were about 25 mm (1 in) long.

In Wisconsin, the growth of young-of-year channel catfish has been reported as follows:

Date	No. of Fish	TL (mm) Avg	Range	Location
13 July	1	35		Wisconsin R. (Crawford Co.)
14 Aug.	8	49	30–63	Sugar R. (Green Co.)
16 Aug.	2	54	50–57	Wisconsin R. (Richland Co.)
7 Sept.	9	67	64–73	Mississippi R. (Crawford Co.)
11 Sept.	5	68	61–73	Rock R. (Rock Co.)
16 Sept.	3	67	55–82	Yellow R. (Chippewa Co.)
26 Sept.	2	87	82–91	Mississippi R. (Pierce Co.)

For channel catfish taken from Pool 9 (Lansing, Iowa) of the Mississippi River, lengths calculated from the vertebrae at the end of each year of life were: 1—75 mm; 2—161 mm; 3—231 mm; 4—299 mm; 5—361 mm; 6—423 mm; 7—488 mm; 8—536 mm; 9—610 mm; 10—676 mm; 11—658 mm; and 12—709 mm (Appleget and Smith 1951). From the same collection the relationship of length to weight at selected size intervals was: 196 mm—54 g; 264 mm—136 g; 391 mm—526 g; 521 mm—1,510 g; 643 mm—3,588 g; and 721 mm—4,314 g.

A 506-mm channel catfish from Lake Poygan (Waushara County) had the following estimated growth at the annuli of the pectoral fins: 1—90.4 mm; 2—198.8 mm; 3—325.3 mm; 4—397.5 mm; and 5—469.8 mm (Paruch 1979).

In Virginia (Stauffer et al. 1976), channel catfish in the heated discharge (34.4°C) from a power plant had significantly lower condition than fish from an upstream reference area, where the temperature was 26.7°C. The condition factor (K_{FL}) for fish from the heated area was 1.18; for fish from the reference area it was 1.23.

The age of channel catfish at maturity varies greatly from one body of water to another. In Pool 9 of the Mississippi River, Appleget and Smith (1951) noted that no fish in their first 4 years of life were mature, but that in the fifth year both sexes (17.6%) showed some degree of sexual development. In the beginning of the ninth year of life, 100% of the males and 90% of the females were mature. Neither sex reaches maturity at less than 305 mm (12 in), but many fish in the 330-mm (13-in) group are mature. In the south, Davis (1959) noted that some channel catfish become sexually mature in their second year, and that most of them spawn for the first time when they are 3 years old.

Few channel catfish live more than 8 years, although occasionally large catfish over 15 years old are taken in Wisconsin waters (Finke 1964). Such fish may exceed 762 mm (30 in) in length and weigh 6.80 kg (15 lb) or more. A 19.96-kg (44-lb) channel catfish was taken from the Wisconsin River in 1962. The maximum size known, a 26.31-kg (58-lb) fish, was caught in the Santee Cooper Reservoir, South Carolina, in 1964.

Young channel catfish tend to feed primarily on aquatic insects or on bottom arthropods; after they reach 100 mm they are usually omnivorous or piscivorous (Carlander 1969). In Lake Oahe, South Dakota (Starostka and Nelson 1974), the diet changed from zooplankton to fish as the channel catfish increased in length.

In the Wisconsin River (Adams County) during September, adult channel catfish had eaten insects (including Diptera, Coleoptera, Hymenoptera, Trichoptera, Orthoptera, and Hemiptera), and annelids, seeds, plant materials, and detritus (K. Primmer, pers. comm.). There were no fish in the stomachs of the 22 catfish examined.

In Pool 19 of the Mississippi River, channel catfish stomachs contained 68% *Hexagenia* naiads and subimagos, but only 3% *Potamyia flava* larvae. Mayfly subimagos appeared only in channel catfish stomachs collected between 24 June and 16 July, and their presence always coincided with periods of peak mayfly emergence. The remainder of the contents included immature Plecoptera and Diptera, clams, snails, and algae (Hoopes 1960).

According to Finke (1964), items taken from channel catfish stomachs include insects, frogs, crayfish, snails, fish, clams, worms, algae, pondweeds, elm seeds, wild grapes, "cotton" from cottonwood trees, pieces of dressed rabbit, chicken necks, canned corn, shrimp, beef bones, and much more. Carlander (1969) listed such unusual items from catfish stomachs as a snake skin, an adult bobwhite, and hydroids.

In food preference studies (Lewis et al. 1965), channel catfish showed a pronounced preference for crayfish of the right size over fathead minnows, and a preference for fathead minnows over fingerling bluegills, green sunfish, and golden shiners. Fingerling carp and bullheads were poorly utilized, and tadpoles were killed but not eaten.

Dead fish and other animals are sometimes included in the channel catfish diet (Davis 1959). The occurrence of grasshoppers and other terrestrial insects in stomachs indicates that channel catfish take some food from the surface of the water, although they usually feed near the bottom. They have been known to eat refuse discarded by people, and to congregate near places where garbage is dumped into streams and lakes.

Adult channel catfish usually feed on the bottom in a random manner, detecting food by touch and smell. The eyes of the channel catfish, which are proportionately larger than those of other species of catfish, seem to be adapted to sight feeding to some degree (Davis 1959). This is consistent with its use of minnows as food when the water is the clearest (Bailey and Harrison 1948).

The channel catfish feeds most actively from sundown until about midnight, at water temperatures between 10 and 34.4°C (50 and 94°F) (Bailey and Harrison 1948). In the winter this species rarely feeds, and the available evidence indicates that adults do not feed during the breeding season.

Channel catfish are most active when water levels are rising—following a rain, for example, or the opening of a power dam. With rising water, these fish are on the move, searching for food washed into the stream. They often feed in submerged grassy areas, which act as strainers that catch and hold all kinds of food.

At temperatures of 25, 30, and 35°C (77, 86, and 95°F), the lethal oxygen levels for channel catfish are at 0.95, 1.03, and 1.08 ppm respectively (Moss and Scott 1961). At 25°C channel catfish embryos and the resulting larvae developed properly when the dissolved oxygen concentrations and control concentrations were near air saturation, but survival at 25°C was statistically less at 2.4 and 4.2 ppm oxygen (Carlson et al. 1974). No embryos hatched at 1.7 ppm oxygen. At all reduced oxygen concentrations at 25 and 28°C (77 and 82.4°F) embryo pigmentation was lighter, the hatch period was extended, feeding was delayed, and growth was reduced.

Channel catfish 6 days old and 11 months old, acclimated at 26, 30, and 34°C (79, 86, and 93°F), had upper lethal temperatures at 36.6, 37.3, and 37.8°C (97.9, 99.1, and 100°F), respectively (Allen and Strawn 1967). Kilambi et al. (1970) determined that the optimum conditions for raising channel catfish included a water temperature of 32°C (89.6°F) and a 14-hr photoperiod; they based their findings on an evaluation of growth, food consumption, food conversion efficiency, and mortality. In the Wabash River, Indiana, the optimum temperature range for this species was 30 to 32°C (86–89.6°F) (Gammon 1973). In the White River and Ipalco Discharge Canal, Indiana, the maximum temperature at which the channel catfish was captured was 37.8°C (100°F) (Proffitt and Benda 1971). Juvenile channel catfish exposed to rapid temperature changes have shown decreased swimming performance (Hocutt 1973).

A preliminary tagging study in the lower Wisconsin River indicated a general downstream movement of channel catfish into the Mississippi River during late summer and autumn (C. Brynildson et al. 1961). An upstream spawning run into the Wisconsin River was anticipated during the latter part of May and early June. One channel catfish tagged in the lower Wisconsin River moved 78 km (48 mi) to Avoca Lake (Iowa County); this was the greatest upstream movement recorded (C. Brynildson 1960). The greatest downstream movement was made by an individual tagged at Prairie du Sac (Sauk County) and captured in the Mississippi River near De Soto (Crawford County), a distance of about 190 stream km (118 stream mi). C. Brynildson (1964) noted that, in the lower Wisconsin River, the average downstream movement was 22 km (13.8 mi), and the average upstream movement was 12 km (7.3 mi).

In Kansas (Cross 1950), extensive upstream migrations of channel catfish were observed during high-water periods in June and July. In Lake Sharpe, South Dakota, channel catfish moved upstream from April through June, and a second peak of upstream movement occurred in September and October (Elrod 1974); most fish appeared to move downstream in November or early December.

There is no evidence to indicate that channel catfish will travel a great distance to return to home territory (Hubley 1963a). Channel catfish tagged in the upper Mississippi River between Lansing, Iowa, and upper Lake Pepin moved essentially downstream prior to capture. The greatest downstream movement was recorded for two fish released at Reads Landing, Minnesota, which were recaptured at Potosi, Wisconsin, 275 km (171 mi) downstream, 14 to 16 months after their release. The greatest upstream movement was recorded for a fish released at Lake City, Minnesota. It was recaptured 33 months later, 345 km (214 mi) upstream in the Minnesota River at New Ulm, Minnesota. The fastest movement was recorded for an individual that moved 179 km (111 mi) downstream in 36 days, at an average rate of 5 km (3.1 mi) per day. Three fish passed through eight dams before recapture.

Eighty-nine percent of the channel catfish tagged in Trempealeau Bay (Trempealeau County) were recaptured within 21 km (13 mi) of their release point. The remaining 11% were caught at distances of 32–185 km from the release sites (Ranthum 1971). One fish had traveled up the Trempealeau River a distance of 61 km (38 mi) from the point of release; another had gone up the Chippewa River within Eau Claire County a distance of 136 km (84 mi); and a third fish reached Pool 11 of the Mississippi River, 186 km (115 mi) from the point of release.

IMPORTANCE AND MANAGEMENT

Because of their long spines, larger channel catfish suffer little from predation. Young catfish, however, are vulnerable to predacious insects and other fish. In ponds, the young are especially preyed upon by bluegills and bass (Marzolf 1957). Bailey and Harrison (1948) found some cannibalism on young channel catfish by catfish 306 mm (12 in) or over which was directly proportional to the density of the young fish present.

The channel catfish is a known glochidial host to the following mollusks: *Amblema plicata*, *Megalonaias gigantea*, *Quadrula nodulata*, and *Quadrula pustulosa*. It is one of several fish species responsible for the distribution and perpetuation of those clam species (Hart and Fuller 1974).

The channel catfish ranks high as a sport fish in Wisconsin. In the upper Mississippi River, it was rated ninth in numbers taken in 1957, and third in 1962–1963 (Nord 1967). In 1967–1968, the estimated sport fishery catch of the channel catfish in Pools 4, 5, 7, and 11 of the Mississippi River was 39,494 individuals, with an average weight per fish of 586 g (1.29 lb) (Wright 1970). In the lower Wisconsin River, channel catfish make up almost 50% of the catch. On the Minnesota side of Lake Pepin, where snagging for channel catfish under the ice is allowed, 14,277 fish weighing 8,549 kg (18,847 lb) were harvested during 1962–1963 and the following 2 winters (Skrypek 1965).

The channel catfish takes a hook most readily on moonlit nights from about twilight on into the night. Baits used to catch channel catfish include minnows, worms, grasshoppers, crayfish, and uniquely odiferous concoctions calling for such ingredients as cheese trimmings, rolled oats, spoiled clams, liver strips, and fish and/or chicken entrails along with a volatile additive, such as anise or chicken blood. The flesh of the channel catfish is white, crisp, juicy, tender, and of excellent flavor.

In Wisconsin, fishing regulations pertaining to the channel catfish are liberal. In 1980 in inland waters and in Wisconsin-Minnesota boundary waters the daily bag limit was 10–25 fish; and there was no limit in Wisconsin-Iowa boundary waters.

According to Scott and Crossman (1973), the spines of the channel catfish and other species of catfish have always been found among Indian artifacts. The bases of the spines were rounded off, the barbs removed, and the spines used as awls for leather work; if the holes in the bases were intact, the spines were used as needles. One such artifact, from the shores of Lake Huron in Ontario, was carbon dated at 1,000 years B.C.

The channel catfish has become a basic test animal for determining chemical transfers, immune responses, and antibody formation. Channel catfish embryos can be obtained, even in the fall of the year, by injecting a female with pituitary materials.

The channel catfish is probably the most valuable commercial fish in the upper Mississippi River; it is the most sought-after fish in the river, and brings the best overall price. The channel catfish is harvested mainly for human consumption. Since 1960, the commercial catch has averaged 181–227 thousand kg

(400–500 thousand lb) yearly. The highest catch was made in 1964, when 277,659 kg (612,125 lb) were boated (Fernholz and Crawley 1977). In 1976, 194,261 kg (428,266 lb) of channel catfish, at 97¢/kg (44¢/lb), had an exvessel value of $188,437—the most valuable fishery on the river. In that year, the channel catfish were taken by the following gear: set lines, 130,597 kg; bait nets, 22,340 kg; slat nets, 14,371 kg; gill nets, 12,816 kg; buffalo nets, 10,092 kg; seines, 4,433 kg; and trammel nets, 66 kg.

Set lines are stationary lines stretched across a likely area, to which hooks are attached at intervals (Finke 1964). Regulations limit each commercial fisherman to a certain number of hooks; these are baited with various substances, including cut fish, cottonseed cake, dough balls with cheese, and other homemade products. One fisherman reported great success with pieces of white soap. Slat nets, or basket traps as they are frequently called, consist basically of wooden boxes of slats with flexible throats; this type of gear is very selective, and will usually catch only catfish. Set in a current during the spawning season, slat nets apparently attract the fish as they seek dark places in which to build their nests. Often the trap is baited with a live, gravid female, who attracts males searching for a mate.

In 1953 on Lake Poygan, 3,530 catfish made up 62.9% of the total catch in 64-mm (2½-in) trap nets. On the same lake, Wisconsin Department of Natural Resources research crews captured 4,100 catfish in the period between December 1958 and December 1959 (Becker 1964b).

In 1966, the gill net catch of channel catfish from the Wisconsin waters of Lake Michigan was 91 kg (200 lb); the catch was valued at $43. In 1974, catfish had a reported harvest of 791 kg (1,743 lb) and a value of $461 (Wis. Dep. Nat. Resour. 1976c).

Attempts to raise channel catfish usually resulted in failure until workers at the U.S. Bureau of Fisheries in Fairport, Iowa, discovered in 1916 that the species could be raised in ponds by providing proper nesting conditions (Davis 1959). Two methods of raising channel catfish have proved satisfactory (Davis 1959). In the pen method, a pair of fish is placed in an enclosure containing a nail keg or some other nest structure. After spawning has been completed, the female is removed so that she cannot eat the eggs, and the male is left to care for the eggs until they hatch. The young are then placed in troughs for the first stage of rearing. In the pond method of rearing, brood fish are allowed to pair of their own accord, in a pond that is supplied with nest structures. Eggs are removed from the nests as soon as possible after they are deposited; they are hatched in jars or in wire baskets through which water flows continuously.

In the South, channel catfish, grown at 7,500/ha (3,000/acre) in 0.04-ha (0.1-acre) ponds for a growth period of 220 days, produced 3,656 kg/ha (3,262 lb/acre). In Illinois, 113-g (4-oz) fingerlings, placed into warmwater ponds and fed a prepared fish food, averaged 340 g (12 oz) in 4 months; some fish weighed more than 450 g (1 lb) (L. H. Osman, *Milwaukee Journal*, 26 July 1964).

An objectionable, "earth-musty" flavor is frequently found in intensively cultured catfish which renders the fish unmarketable. Lovell and Sackey (1973) determined that blue-green algae could impart this undesirable flavor in the fish. When fish which had been in the algae tanks for 14 days were transferred to flowing, charcoal-filtered water, the unpleasant flavor disappeared after 10 days.

Roughly 40% of the weight of catfish which enter a processing plant turns up as waste at the end of the processing line. Conversion of this offal into a dry and/or moist swine and catfish food holds considerable promise (Lovell 1973).

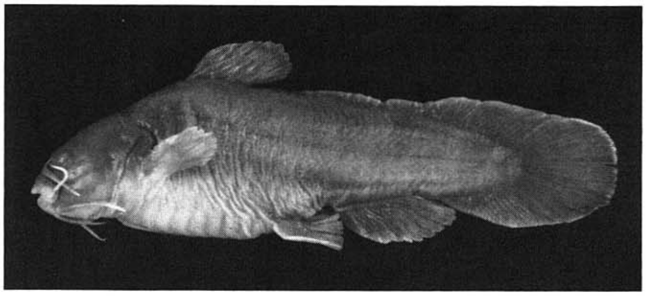
Impoundments with moderately turbid waters are less likely to require special management for channel catfish production than impoundments with clear waters. In clear waters, predatory fish and insects probably limit the survival of catfish by preying on the young. The survival of young catfish was not nearly as high in ponds containing adult largemouth bass and either bluegill or redear sunfish as it was in ponds containing only channel catfish (Marzolf 1957). In one instance, 15 25-mm (1-in) catfish were found in the stomach of a 178-mm bluegill taken from the nest of a channel catfish. Marzolf noted that the survival of fingerling catfish is directly correlated to the amount of turbidity in the water. It is assumed that turbid water furnishes cover for the fry and fingerlings. Heavy vegetation in clear ponds often conceals enormous numbers of predacious insects and insect nymphs, which may feed upon the fry.

The culture, stocking, and management of catfish in Arkansas and other southern states has led to a considerable amount of research in the private, state, and federal sectors. The outpouring of technical writing and bulletins has been extensive. Unfortunately, in Wisconsin the application of these techniques is made difficult by our long winters and short growing season; to realize a crop, an enterprising fish farmer must extend the growing season by heating the water. Heated discharge ponds at power plants hold some promise for catfish farming, although this idea needs a closer look.

Tadpole Madtom

Noturus gyrinus (Mitchill). *Noturus*—back tail, in reference to the connection between the adipose and the caudal fins; *gyrinus*—tadpole.

Other common names: madtom, tadpole stonecat, tadpole cat, bullhead.



Adult 109 mm, Pine R. (Florence Co.), 25 June 1965

DESCRIPTION

Body heavy, round, and potbellied anteriorly (rarely elongate); strongly compressed posteriorly. Length 64–89 mm (2.5–3.5 in). TL = 1.23 SL. Depth into TL 4.4–6.0. Head length into TL 3.8–4.4. Snout blunt, with a barbel arising from collar surrounding each posterior nostril; barbels long and reaching almost to back of head. Mouth short but wide, horizontal; lips fleshy. Lower jaw slightly shorter than upper jaw; barbel attached to upper jaw at each corner of mouth almost reaching to opercular opening; 4 barbels (outer 2 about length of maxillary barbels, inner 2 slightly shorter) attached in a transverse line on the lower chin. Numerous small, sharp, or peglike teeth in broad bands on upper and lower jaws; tooth patch on upper jaw without elongate, lateral backward extensions. Dorsal fin origin decidedly in advance of midpoint between pectoral and pelvic fins; dorsal fin swollen at base with a short spine (about one-third fin height), and usually 6 rays; dorsal adipose fin long, low, continuous with caudal fin and delimited from it by a shallow notch. Anal fin rays 14–16; pelvic fin rays usually 8. Pectoral fin spine about two-thirds fin length; notches on anterior edge delicate or absent; posterior edge of spine barbless; poison glands associated with dorsal and pectoral fins. Caudal fin broadly rounded posteriorly. Scaleless. Lateral line incomplete. Digestive tract 1.0–1.4 TL. Chromosomes 2n = 42 (LeGrande 1978).

Dorsal and lateral regions of head, back, and upper caudal peduncle dark slate brown; lighter brown on sides of caudal peduncle; ventral region of head and belly tan to yellow-brown. Fins generally darkly pigmented; paired fins usually less pigmented. Barbels darkly to lightly pigmented. Generally 3 dark, longitudinal streaks per side; the prominent middle streak follows the position of the vertebral column, and from this streak dark lines outline the muscle segments dorsally and ventrally.

Hybrids: Tadpole madtom × brindled madtom (the latter not found in Wisconsin) (Trautman 1957, Menzel and Raney 1973).

SYSTEMATIC NOTES

Synonyms: *Schilbeodes gyrinus* (Greene 1935), *Schilbeodes mollis* (Hubbs and Lagler 1947), *Schilbeodes gyrinus* (Hubbs and Lagler 1958), and *Noturus gyrinus* (Hubbs and Lagler 1964, Taylor 1969, Bailey et al. 1960 and 1970, Robins et al. 1980).

DISTRIBUTION, STATUS, AND HABITAT

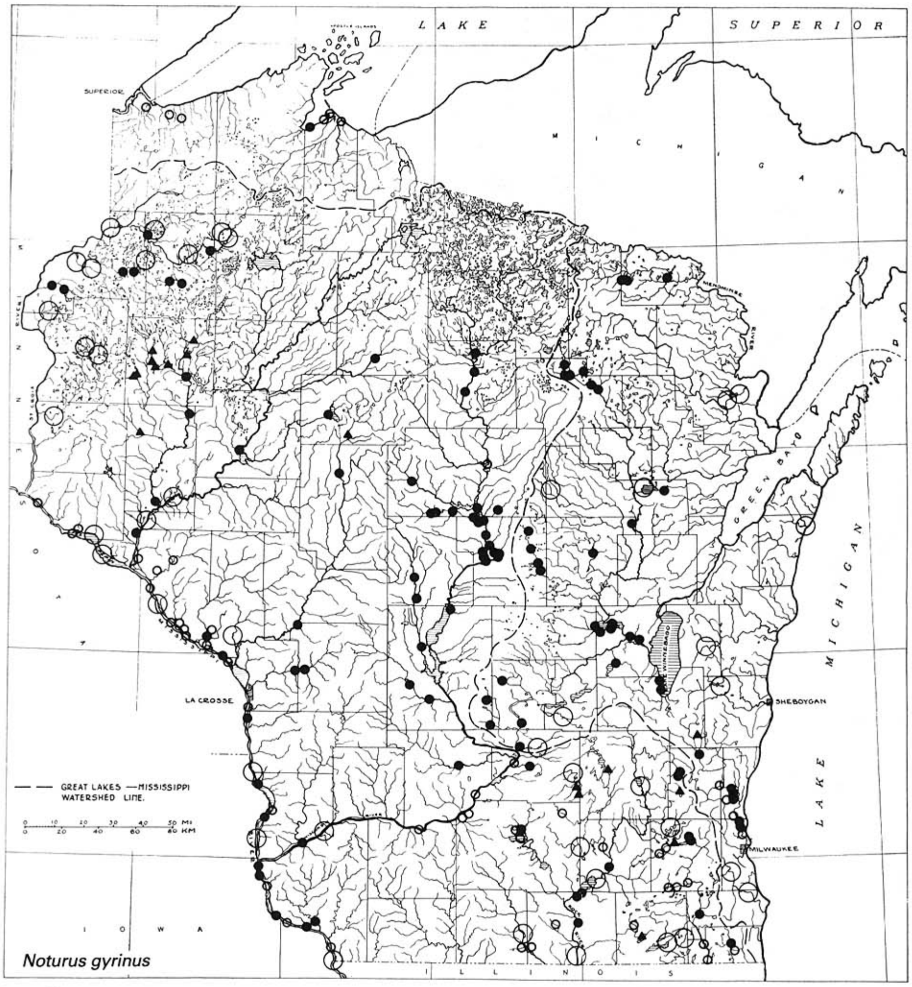
The tadpole madtom occurs in all three drainage basins in Wisconsin. It is present in sheltered bays of western Lake Superior, and it is distributed throughout Wisconsin except in the driftless area, where it is seldom taken.

In Wisconsin, the tadpole madtom is common in medium to large rivers. It is considered rare at the barriers in tributaries of Lake Superior (McLain et al. 1965). In large lakes it is rare to common. This species appears to be secure in Wisconsin.

In Wisconsin, the tadpole madtom was encountered most frequently at depths of 0.1–1.5 m in clear to slightly turbid water; it was also found in darkly colored water. This species occurred over substrates of sand (27% frequency), gravel (20%), mud (18%), boulders (16%), silt (10%), rubble (8%), clay (1%), and detritus (1%). It prefers thick growths of submergent plants, or accumulations of organic debris, including dense branches, leaves, trash, and empty mussel shells. It occurred in lakes, reservoirs, and sloughs, and in slow to moderate current in pools and riffles in streams of the following widths: 1.0–3.0 m (3%); 3.1–6.0 m (6%); 6.1–12.0 m (15%); 12.1–24.0 m (53%); and 24.1–50.0 m (24%). The tadpole madtom is more commonly found in natural and artificial lakes than either of the other two members of this genus in Wisconsin. In Canada, it has been taken as deep as 25 m (81 ft).

BIOLOGY

The tadpole madtom spawns in June and July. Spawning is known only for single pairs under objects or in cavities in the bottom. There is apparently little formal nest preparation. The eggs are deposited



Range of the tadpole madtom
- ● Specimens examined
- ▲ Wisconsin Fish Distribution Study (1974–75)
- ○ Literature and reports
- ◯ Greene (1935)

in clusters beneath boards or logs, in crayfish burrows, in holes in mud, under roots, and in old tin cans (Mansueti and Hardy 1967). The number of eggs varies; it has been reported to average 50 per fish, or as high as 117 per fish (Scott and Crossman 1973, Bailey 1938). Egg-guarding individuals are in most cases males (Taylor 1969). There is no evidence that parent tadpole madtoms care for their broods after hatching.

Unlike female bullheads and catfishes, which typically liberate all of their eggs in a single spawning, female madtoms normally mate several times during the breeding period (Menzel and Raney 1973). Evidence for this is indirect, and is based in part on published accounts which indicate that the number of eggs in a clutch may be considerably less than the number of eggs in the ovary in several species of madtoms. The available evidence also indicates that the mating pair bond is less enduring among madtoms than among other catfishes.

A maturing tadpole madtom female, 90 mm and 14.02 g, collected 25 June from the Pine River (Florence County), had ovaries 9.2% of the body weight, and held 159 orange eggs 2.0–2.5 mm diam. A mature female, 87 mm and 10.72 g, collected 12 July from the Hunting River (Langlade County) had ovaries 14.9% of the body weight, and held eggs 2.4–2.6 mm diam. In New York state, Menzel and Raney found 82–179 eggs in the ovaries of four females. Upon deposition, the eggs adhere to each other and to the substrate, and the whole egg mass is surrounded by another gelatinous envelope.

Young tadpole madtoms are essentially like adults when they have attained about 25 mm TL.

In Wisconsin, the growth of young-of-year tadpole madtoms has been reported as follows (Paruch 1979):

Date	No. of Fish	TL (mm) Avg	TL (mm) Range	Location
19 Aug.	2	22	21–23	L. Poygan (Winnebago Co.)
28 Aug.	4	43	35–50	L. Winnebago (Fond du Lac Co.)
9 Sept.	1	53		Pewaukee L. (Waukesha Co.)
18 Sept.	3	30	29–30	White Clay L. (Shawano Co.)
24 Sept.	27	38	30–46	Trempealeau L. (Trempealeau Co.)
4 Oct.	23	35	29–63	Milwaukee R. (Fond du Lac Co.)

In Iowa, young-of-year ranged from 18 to 56 mm at the end of August and the beginning of September (Griswold 1963).

The ages and growth of 145 tadpole madtoms from Wisconsin (UWSP specimens), aged by analysis of the pectoral spines, are summarized below (Paruch 1979):

Age Class	No. of Fish	TL (mm) Avg	Range	Calculated TL at Annulus (mm) 1	2	3
0	82	35.3	21–52			
I	34	45.0	35–89	45.2		
II	20	76.0	51–117	42.7	64.6	
III	9	86.9	80–95	35.6	66.5	86.9
Avg (weighted)				43.0	65.2	86.9

On 15 August, tadpole madtoms from a Minnesota lake (Hooper 1949), aged by analysis of vertebrae, were: 0—26.4 (15–38) mm SL; I—61.6 (43–85) mm SL; and II—89.1 (78–104) mm SL. Average weights were 0.32, 4.16, and 16.32 g respectively. Of more than 4,000 fish examined, only 270 were age II.

An age-II tadpole madtom 117 mm long (UWSP 5207) was collected from Mason Lake (Adams County) in 1975.

In Trempealeau Lake (Trempealeau County), the tadpole madtom consumed ostracods, cladocerans, Trichoptera, Coleoptera, unidentifiable insect and animal remains, algae, and eggs (K. Ball, pers. comm.). In the Madison area, it fed on insects (44% volume), oligochaetes (18.3%), small crustaceans (including amphipods, ostracods, and copepods) (28.3%), plants (5.9%), mites (+), snails (0.1%), algae (0.1%), and silt and debris (3%) (Pearse 1918). The tadpole madtom is also known to have consumed small fishes, a planarian worm, and dragonflies (Forbes and Richardson 1920, Scott and Crossman 1973). It feeds mainly at night. The items in the tadpole madtom's diet show that it gets its food on the bottom and from among aquatic plants. The smaller individuals apparently depend on crustaceans and oligochaetes; larger fishes rely more on insects.

At a high water temperature of 38°C (100.4°F), the tadpole madtom suffered an appreciable mortality in a shallow southern Michigan pond (Bailey 1955). In a winterkill lake of southeastern Michigan, with 0.2–0.0 ppm of dissolved oxygen in the upper 0.3–1.2 m of water, some tadpole madtoms survived but no largemouth bass or bluegills survived (Cooper and Washburn 1949).

The tadpole madtom tolerates at least a moderate amount of salinity; it has been reported from the tidal portions of Virginia rivers (Mansueti and Hardy 1967). It has also been taken from dark, stained water with a pH of 4.5 (Holder and Ramsey 1972).

Like all madtoms, the tadpole madtom is secretive, spending the daylight hours lurking in the protection of cavities, cutbanks, debris, or vegetation (Scott and Crossman 1973, Pflieger 1975). At night it leaves its cover and feeds actively in shallows.

In a rotenone kill project of a 5-ha (12.5-acre) lake in northern Minnesota, 40 kg (88 lb) of tadpole madtoms were recovered out of a total of 114 kg (251 lb) of fish of all species (Hooper 1949). Other species present were northern pike, pumpkinseeds, yellow perch, and black bullheads. Approximately 16,770 madtoms were present in the lake at the time of the rotenone poisoning, based on the counts of fish removed from the lake and on the counts of fish remaining in the lake that could not be efficiently recovered.

In Cedar Creek (Ozaukee County), 15 tadpole madtoms were associated with these species: white sucker (4), central stoneroller (15), creek chub (10+), bluntnose minnow (1), fathead minnow (6), common shiner (20), sand shiner (1), black bullhead (50), and green sunfish (1).

IMPORTANCE AND MANAGEMENT

Where they are abundant, tadpole madtoms probably contribute significantly to the food supply of sport fishes. The tadpole madtom is also known to have been eaten by a garter snake (Scott and Crossman 1973).

This madtom is a host to the glochidia for the mussels *Actinonaias carinata* and *Lampsilis radiata luteola* (Hart and Fuller 1974).

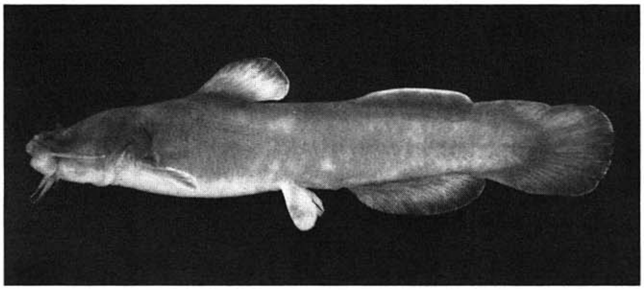
Tadpole madtoms are excellent bait for black bass, and a preferred bait for walleyes, along the Mississippi River. When hooked through the lips, madtoms survive for a long time, and several walleyes can be taken on a single madtom. In the late 1970s, madtoms sold for bait cost the fisherman about $1.50 per dozen. They are collected by digging into detritus with a hand scoop—a long handle affixed to a metal frame, which is covered with ⅜-in (9.5-mm) hardware cloth. Bait dealers use tin cans to extract the madtoms from holding tanks: the can is lowered into the tank, and the fish, seeking cover, voluntarily swim into the can. Often a piece of burlap is thrown into the holding tank to provide them with cover.

Its fondness for still water and its small size make the tadpole madtom an interesting aquarium resident (Walden 1964, Sterba 1973, Scott and Crossman 1973).

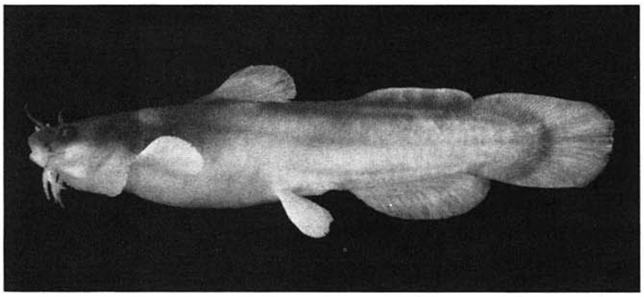
Slender Madtom

Noturus exilis Nelson. *Noturus*—back tail, in reference to the connection between the adipose and the caudal fins; *exilis*—slender.

Other common name: slender stonecat.



Adult male 123 mm, Oconomowoc R. (Waukesha Co.), 14 May 1977



Adult female 111 mm, Oconomowoc R. (Waukesha Co.), 14 May 1977

DESCRIPTION

Body elongate, cylindrical anteriorly, compressed posteriorly. Length 76–102 mm (3–4 in). TL = 1.17 SL. Depth into TL 5.2–6.8 (4.4). Head length into TL 3.9–4.7. Snout blunt, short barbels of snout arising from collar surrounding posterior nostrils. Mouth short but wide, horizontal lips thick. Upper jaw slightly longer than lower jaw, longest barbel (decidedly less than head length) attached to upper jaw at each corner of the mouth; 4 barbels (outer 2 almost as long as the upper jaw barbels, inner 2 slightly shorter) attached in a transverse line on the lower chin. Numerous small, sharp, or peglike teeth in broad bands on upper and lower jaws; tooth patch on upper jaw without elongate lateral backward extensions. Dorsal fin origin decidedly in advance of midpoint between pectoral and pelvic fins; dorsal fin generally swollen at base with a short spine (less than half of fin height), and 6–7 soft rays; dorsal adipose fin continuous with caudal fin and delimited posteriorly by a shallow notch. Anal fin rays 18–21; pelvic fin rays 8–9. Pectoral fin spine short, strongly notched on its anterior edge from tip of spine to at least its midpoint; well-developed barbs (generally inclined toward base) on posterior edge of spine. Caudal fin rounded to slightly squarish. Scaleless. Lateral line incomplete. Digestive tract coiled, 1.1–1.3 TL. Chromosomes 2n = 54 (LeGrande 1978).

Dorsal region of head, back, and caudal peduncle yellowish brown, dark olive, or slate gray; lower sides and belly cream white. Transverse light bands behind head and across back behind dorsal fin. Dorsal, caudal, and anal fins generally dark edged; other fins light edged. Paired fins often with dark pigment near base. Upper barbels dark pigmented; chin barbels white to light pigmented.

DISTRIBUTION, STATUS, AND HABITAT

In Wisconsin, the slender madtom occurs in the Rock and Pecatonica river systems, where it is at the northern limit of its distribution.

An early Wisconsin record of the slender madtom (USNM 1420) from the Root River in the Lake Michigan basin is doubted (Taylor 1969). Some confusion seems to have been associated with this report, and the specimens are not available.

Specimens examined: UWSP 5150 (4) Oconomowoc River T8N R18E Sec 19 (Waukesha County), 1975; UWSP 5151 (5) and 5344 (5) Bark River T8N R18E Sec 26 (Waukesha County), 1975; UWSP 5578 (30) Oconomowoc River T8N R18E Sec 19 (Waukesha County), 1977.

Taylor (1969) reported USNM 1412 Oconomowoc River, Lac La Belle; INHS (Cahn coll.) Honey Creek, tributary to Rock River, Watertown. The Wisconsin Fish Distribution Study during 1974–1977 made 19 collections of this species from Darien Creek, Little Turtle Creek, Bark River, Rock River, Oconomowoc River, and Mason Creek in the Rock River system; and 12 collections in East Branch Richland Creek (Illinois site), Dodge Branch, Unnamed Creek, Otter Creek, Wood Branch, Bonner Branch, Cottage Inn Branch, Pedler Creek, Mineral Point Branch, Livingston Branch, and the Pecatonica River in the Pecatonica River system.

Additional reports: Oconomowoc River at Stonebank (Waukesha County), and twice from Mukwonago River (Waukesha County) (Cahn 1927); (3) Bark River T5N R15E Sec 11 (Jefferson County) (T. Engel, pers. comm.); Oconomowoc River T8N R18E Sec 19 SE ¼ (Waukesha County), 1973 (M. Johnson, pers. comm.).

The slender madtom is rare in the upper Pecatonica basin, and rare to uncommon in the Bark and

Range of the slender madtom
▲ Wisconsin Fish Distribution Study (1974–78)
○ Literature and reports
◯ Greene (1935)

Oconomowoc rivers of the Rock River system. It has been accorded endangered status in Wisconsin (Les 1979).

In Wisconsin, the slender madtom is generally encountered in clear, moderate to swift water, at depths of 1–3 dm (4–12 in) over substrates of gravel and boulders interspersed with fine sand. It occurs in streams 9–12 m wide; however, a few records from large rivers support the concept that it may occur in large rivers where the current and the substrate are suitable. In Missouri, Pflieger (1971) noted that the slender madtom occurs in rocky pools where there is sufficient current to keep the bottom free of silt; and in Kansas (Cross 1967) it is sometimes found in deep leaf-litter of calm pools, if their waters remain clear and cool.

BIOLOGY

In Wisconsin, spawning occurs in late May and in June. The spawning habits of the slender madtom are not known, but are probably like those of the closely related margined madtom, *Noturus insignis* (Richardson). The margined madtom deposits a compact mass (up to 55 mm diam) of large, adhesive eggs in a nesting cavity which has been excavated beneath a flat rock 0.3 m diam or larger (Fowler 1917). The nest is positioned in such a manner that a current of water can percolate through the egg mass. The eggs apparently are cared for by the male. Newly hatched young crowd together in a constantly moving compact mass.

A prespawning slender madtom female, 106 mm and 16.99 g, taken 14 May from the Oconomowoc River (Waukesha County), had ovaries 5.5% of the body weight, and held 160 light yellow immature eggs, 1.7–2.5 mm diam. A 114-mm, 19.2-g fish had 181 eggs, 2.0 mm diam. A 106-mm, 16.55-g female in spawning readiness, taken on 28 May from the Bark River (Waukesha County), had ovaries 18.6% of the body weight, and held 169 mature eggs, 3.5 mm diam and yellow-orange in color.

Slender madtoms, collected on 14 May 1977 from the Oconomowoc River (Waukesha County), showed the following growth (Paruch 1979):

Age Class	No. of Fish	TL (mm)		Calculated TL at Annulus (mm)		
		Avg	Range	1	2	3
I	6	76.3	74–81	69.6		
II	6	99.7	88–113	42.4	99.7	
III	18	111.7	96–126	37.9	71.9	111.7
Avg (weighted)				45.2	78.9	111.7

Age-I and age-II fish each had condition (K_{TL}) means of 1.31, and age-III fish had a condition mean of 1.22 (1.04–1.62).

The largest Wisconsin specimen seen was a 126-mm (5-in) slender madtom from the Oconomowoc River sample. The largest slender madtom known was a specimen retained in an aquarium at the Museum of Zoology, University of Michigan, for 1½ years; it had attained 113 mm SL (estimated 132 mm TL) (Taylor 1969).

The slender madtom is insectivorous. In late May, the stomach contents of a fish from the Bark River contained mostly caddisflies, a trace of midgeflies, unidentifiable insects parts, filamentous algae, and debris. In aquariums this species will take a variety of foods, including earthworms, insect larvae, and dry rations. According to Miller and Robison (1973), it hides under stones and in weeds during the day, venturing forth after dark to feed on insect larvae and other small animals.

Several slender madtoms were studied in a large aquarium in the Museum of Natural History at Stevens Point, Wisconsin. In one end of the aquarium, a number of large stones was heaped up. Each of the six madtoms selected a niche for itself among the stones, and seldom ventured from this except when food was introduced into the aquarium. When one slender madtom followed food into another's occupied den, there was a struggle for at least a piece of the worm (W. Paruch, pers. comm.). The fish chased and nipped one another when territorial rights were violated.

With the lights on in the room and the aquarium bathed in light, there was little activity among the fish. Normally, each individual rested quietly in its crevice, and only at long intervals shifted its position. Sometimes a fish assumed a rigid headstand or tailstand position for 15–30 min or more, using a vertical side of a rock as a prop. An individual fish in physiological distress would swim frantically up and down the side of the aquarium opposite the mound of rocks, and, within hours, or up to a few days later, such fish died.

With the lights extinguished in the museum and the aquarium in darkness, the slender madtoms swam from their holes and soon cleaned up food from the floor of the aquarium just as they entered open shallows to feed during the night in their native waters. Bunting and Irwin (1965) noted that daylight seining for madtoms proved ineffective because the fish were located on the bottom among rocks and debris at that time; but at night, when madtoms moved into open water, more than 600 specimens were taken.

When the aquarium lights were turned on late at night, there was a frantic flurry of activity. Some individuals headed directly for the mound of stones, but others swam violently from one side of the aquarium to the other, their unscaled bodies undulating from side to side like oversized tadpoles. An occasional individual, totally disoriented, swam the entire length of the 50-gallon aquarium, and at full speed struck the glass with such a thud that it could be heard the length of the museum. On several occasions, an individual knocked itself senseless for a few seconds.

According to Bunting and Irwin (1965), during a holding period of 20 days, a number of slender madtoms died when the aeration pump stopped for 24 hours during a power failure. When aeration was reestablished, surviving specimens were in poor condition but recovered within a few hours.

When subjected to toxicity bioassay, using petroleum refinery effluent as a toxicant, the slender madtom exhibited little reaction to the test solutions. Only when the toxic concentrations were high was there an initial and brief distress.

IMPORTANCE AND MANAGEMENT

Predation on the slender madtom by fish or wading birds is probably low because of its secretive daytime habits. It may be more vulnerable at night when it leaves cover. However, the slender madtom can maneuver and swim quickly for short distances, and probably elude most pursuers. For their size, these madtoms are fast swimmers and quite energetic.

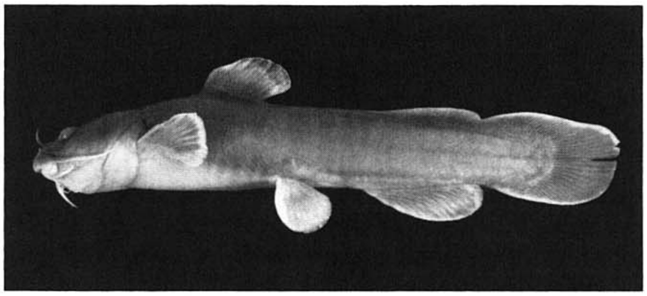
The slender madtom is much too small to be used as a food fish for people, although it is occasionally taken with worms on small hooks.

Several authors agree that the slender madtom is an interesting, adaptable aquarium fish. "Its loach-like form, serpentine swimming-motions, and odd poses when at rest add to its interest as a novelty in aquaria" (Cross 1967).

Stonecat

Noturus flavus Rafinesque. *Noturus*—back tail, in reference to the connection between the adipose and the caudal fins; *flavus*—yellow.

Other common names: yellow stonecat, stone catfish, stonecat madtom, catfish, white cat, doogler, beetle-eye, mongrel bullhead, deepwater bullhead.



Adult 162 mm, mouth of Plover R. (Portage Co.), 9 July 1958

DESCRIPTION

Body elongate, cylindrical anteriorly, slightly compressed posteriorly. Length 127–152 mm (5–6 in). TL = 1.18 SL. Depth into TL 4.6–7.8. Head length into TL 4.1–4.7. Snout pointed, fleshy; barbels arising from collar surrounding posterior nostrils, with tips reaching beyond middle of eyes. Mouth short but wide, horizontal; lips thick and fleshy. Lower jaw shorter than upper jaw; longest barbel (less than half of head length) attached to upper jaw at each corner of mouth; 4 barbels (outer 2 almost as long as the upper jaw barbels, inner 2 about ⅔ length of outer barbels) attached in a transverse line on the lower chin. Numerous small, sharp, or peglike teeth in broad bands on upper and lower jaws; tooth patch on upper jaw with elongate lateral backward extensions. Dorsal fin origin decidedly in advance of midpoint between pectoral and pelvic fins; dorsal fin swollen at base, dorsal fin with a short spine (¼–⅓ fin height) and 6–7 rays; dorsal adipose fin long, low, continuous with caudal fin and delimited from it by a shallow notch. Anal fin rays 15–18; pelvic fin rays 8–10. Pectoral fin spine short (¼–⅔ fin length), strongly notched on its anterior edge from tip of spine to more than half of its length; posterior edge of spine smooth and barbless; poison gland opening by pore above base of pectoral fin (Scott and Crossman 1973, Reed 1907). Caudal fin roughly rectangular in shape. Scaleless. Lateral line incomplete. Digestive tract coiled, about 1.3 TL. Chromosomes 2n = 48–50 (LeGrande 1978).

Dorsal region of head, back, and upper caudal peduncle brown to slate gray; sides yellow-brown; belly yellowish to whitish. Light rectangular patch between back of head and origin of dorsal fin; small light patch immediately posterior to base of dorsal fin. Pelvic fins generally unpigmented; all other fins lightly to heavily pigmented and light edged. Upper barbels lightly pigmented to mottled; chin barbels whitish.

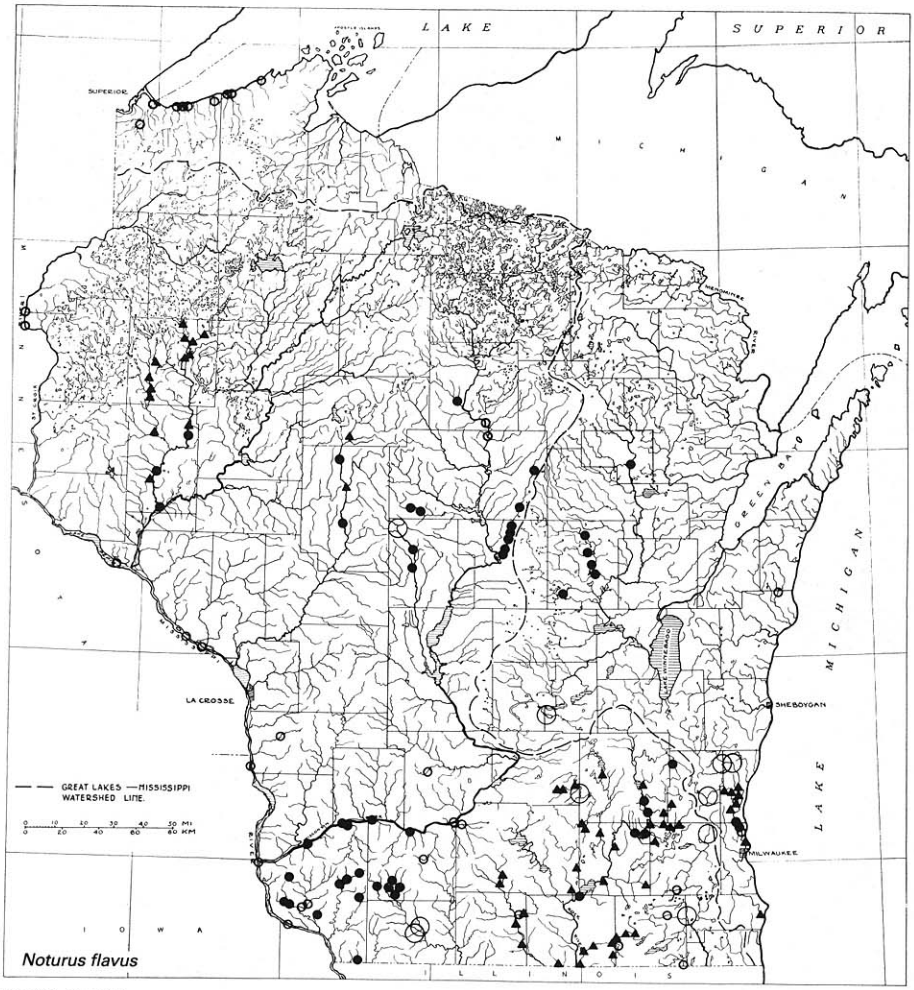
DISTRIBUTION, STATUS, AND HABITAT

In Wisconsin, the stonecat occurs in all three drainage basins. It is well distributed in streams within the southern one-third of the Mississippi River drainage in Wisconsin, and northward it appears in widely separated streams within the drainage systems of the Wisconsin, Black, and Chippewa rivers. In the Lake Superior basin, it appears mostly in the mouths of tributaries to the lake. In the Lake Michigan basin, disjunct populations occur in the Wolf, upper Fox, Milwaukee, and Root river systems. There are no records of the stonecat from Lakes Superior and Michigan. Because of its rubble-type habitat, this species is seldom captured by seine; the usual method is by electrofishing.

The stonecat is common in tributaries to Lake Superior (Moore and Braem 1965, McLain et al. 1965). In the southern two-thirds of Wisconsin, it is uncommon to common in medium-sized streams of moderate current. Its status is secure.

In Wisconsin, the stonecat was encountered most frequently in clear water at depths of 0.6–1.5 m, over substrates of gravel (34% frequency), rubble (24%), sand (12%), boulders (10%), mud (8%), silt (6%), clay (4%), and bedrock (2%). It occurs in moderate to fast current in riffles, in pools, and around the rock pilings of bridge abutments. It is found in streams of the following widths: 1.0–3.0 m (4%), 3.1–6.0 m (44%), 6.1–12.0 m (20%), 12.1–24.0 m (16%) 24.1–50.1 m (16%), and over 50 m (occasional). The crevices among rock slabs which have been loosely placed together to form a bank riprap, serve as habitat niches for this species. Its typical habitat is a stream with many large, loose rocks.

This species has been reported from Saginaw Bay in Lake Huron and from Lake Erie, where it occurs from shallows along the shore to depths of 9 m or more (Fish 1932, Scott and Crossman 1973), in areas where there is a minimum of current but much wave action (Taylor 1969).



Range of the stonecat
● Specimens examined
▲ Wisconsin Fish Distribution Study (1974–75)
○ Literature and reports
◯ Greene (1935)

BIOLOGY

In Wisconsin, the stonecat probably spawns in June or July, and possibly continues to spawn as late as August. Spawning begins when the water temperature reaches 27.8°C (82°F). The eggs are placed under stones, and are guarded by one or both parents.

In New York state, Greeley (1929) found two egg masses under flat stones on 13 July at a water temperature of 27.8°C. Two fishes, probably the parents, guarded one mass, and a male was hidden beneath the other. About 500 yellow, opaque eggs, 3.5–4.0 mm diam, were held together in a round mass by an adhesive jelly. In western Lake Erie, stonecats spawn in early June on bouldery shoals, or in the lowermost riffles of tributary rivers (Langlois 1954). The females had well-developed eggs on 27 June; each female held from 767 to 1,205 eggs.

M. Fish (1932) described and illustrated the 20-mm stage. In the Wisconsin River (Richland County), 14 young-of-year averaged 47 (21–61) mm TL in mid-August, and on the Platte River (Grant County), a single young fish was 32 mm TL on 24 September.

The age and growth of 74 stonecats from Wisconsin (UWSP specimens), aged by analysis of the pectoral spines, are summarized below (Paruch 1979):

Age Class	No. of Fish	TL (mm) Avg	TL (mm) Range	Calculated TL at Annulus (mm) 1	2	3	4	5
0	27	46	29–83					
I	20	102	49–142	55				
II	19	148	88–173	48	100			
III	5	159	146–169	42	88	124		
IV	1	199		54	90	145	163	
V	2	187	185–188	51	72	114	147	162
Avg (weighted)				51	95	124	152	162

In 10 stonecats, collected 9 August from Kuenster Creek (Grant County, the total lengths calculated, to the annuli were: 1—52.9 mm; 2—96.4 mm; and 3—102.9 mm (Paruch 1979).

In the Vermillion River, South Dakota (Carlson 1966), the stonecat averages 79 mm TL at the end of its first year of life, and attains lengths of 99, 114, and 137 mm by the ends of succeeding years. The largest specimen examined was 196 mm, and was in its seventh year of life.

In Ohio streams (Gilbert 1953), the calculated standard lengths of stonecats according to an analysis of the vertebrae were: 1—54mm; 2—73 mm; 3—89 mm; 4—104 mm; 5—116 mm; and 6—129 mm. In Lake Erie, the yearly growth was somewhat greater: 1—68 mm; 2—121 mm; 3—162 mm; 4—181 mm; 5—195 mm; 6—203 mm; 7—208 mm; 8—224 mm; and 9—237 mm. The more rapid growth in Lake Erie was believed to be due to the abundance of mayfly naiads as food. No difference in the growth of the sexes was noted.

The maximum known size for a stonecat is 312 mm (12.3 in) and 482 g (1 lb 1 oz) (Trautman 1957).

The food of the stonecat consists of aquatic insects, mollusks, minnows, crayfishes, and plant materials. In Iowa (Harrison 1950) the stonecat ate the following items: aquatic riffle insects (64% of volume); fish, including spotfin shiners, common shiners, and a bullhead minnow (14%); crayfish and earthworms (9%); filamentous algae and weed seeds of terrestrial origin (7%); and undetermined organic matter (5%). In Missouri, Pflieger (1975) found that stonecats consumed the immature stages of various riffle-dwelling insects, supplemented with an occasional darter or other small fish.

Stonecats seek food by their sense of smell or taste, and they use their barbels as they cruise along close to the bottom. They probably feed at night. During feeding, they may work their way into quiet water (Taylor 1969).

Compared to most other members of the family, the stonecat is a solitary catfish. During the warmer months stonecats may become common on riffles or shoals. As colder weather approaches, however, most stream stonecats leave the riffles and migrate to water as deep as 2.4 m (8 ft) (Gilbert 1953); only a few scattered individuals remain behind. As warm weather approaches, they again return to the riffles.

The stonecat tolerates pollution and oxygen depletion which few other fish can survive. Although a relatively northern species of *Noturus*, the stonecat is seldom found in water cold enough to maintain salmonids. In southern Ontario, a single stonecat was taken in association with the brook trout at an average water temperature of 15.7°C (60.3°F), but it occured more commonly with the rock bass and smallmouth bass at water temperatures of 20.7–21.5°C (69.3–70.6°F) (Hallam 1959).

In warmwater streams of southern Ontario with typical water temperatures of 23.9–26.7°C (75–80°F) during the summer months, the stonecat was an important member of a white sucker–blacknose dace–creek chub–common shiner association (M. G. Johnson 1965). In three stream sections studied, there were 58–410 stonecats per hectare, representing standing crops of 0.34–3.70 kg/ha (0.3–3.3 lb/acre).

In Kuenster Creek (Grant County), 10 stonecats were associated with these species: white sucker (+), central stoneroller (26+), hornyhead chub (26+), creek chub (1), bluntnose minnow (2), suckermouth minnow (19), common shiner (23), rosyface shiner (1), bigmouth shiner (1), johnny darter (1), fantail darter (18), and smallmouth bass (4).

IMPORTANCE AND MANAGEMENT

Although the stonecat is not subject to much predation, it has been eaten by smallmouth bass and a by a watersnake (Scott and Crossman 1973). In some areas, the stonecat is said to be of considerable importance as food for the smallmouth bass, and its level of abundance becomes an excellent index of smallmouth bass abundance (Trautman 1957). There exists a report of a healthy brown trout, 381 mm (15 in) long, that had disgorged a 100-mm (4-in), partially digested stonecat (Walden 1964).

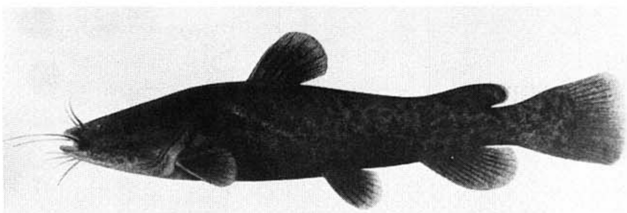
The stonecat is used as channel and flathead catfish bait by anglers fishing the lower Wisconsin River. Adams and Hankinson (1926) noted its value as a bass bait. On the Ohio River prior to 1925, commercial fishermen caught it in numbers to be used as trotline bait.

Jones (1964) has written of the stonecat, "Often mistaken for the black bullhead, the stonecat is a fair food fish and is taken in numbers by youthful fishermen who consider the sting of its poisonous spine inconsequential." Because of its secretive, nocturnal habits, the stonecat is not often seen, but like many fish it will go after a tempting bait that comes along during the day. Although it is of little value as a commercial fish or a sport fish, the flesh of the stonecat is excellent (Greeley 1929).

Flathead Catfish

Pylodictis olivaris (Rafinesque). *Pylodictis*—mud fish; *olivaris*—olive colored.

Other common names: flathead, Mississippi bullhead, Mississippi cat, Hoosier, goujon, shovelnose cat, shovelhead cat, mudcat, yellow cat, Johnny cat, Morgan cat, flatbelly, Appaluchion, pied cat, Opelousas cat, granny cat.



(Forbes and Richardson 1920:180)

DESCRIPTION

Body elongate, head and body depressed dorsoventrally. Length 508–762 mm (20–30 in). TL = 1.15 SL in adults; 1.21 SL in young-of-year. Depth into TL 5.3–7.6. Head broadly flattened; head length into TL 3.4–3.8. Snout pointed in lateral view; barbels arising from collar surrounding posterior nostrils and tips of barbels scarcely reaching back of eye. Mouth short but wide, horizontal. Lower jaw protruding beyond upper jaw; long barbel (almost reaching edge of opercular flap) attached to upper jaw at each corner of mouth; 4 barbels (outer 2 about ½ length of maxillary barbels, inner 2 decidedly shorter) attached on chin. Numerous small, sharp teeth in broad bands on upper and lower jaws; tooth patch on upper jaw with elongate lateral backward extensions. Dorsal fin origin barely in advance of midpoint between pectoral and pelvic fins; dorsal fin spine about ½ fin height; dorsal fin rays usually 6; dorsal adipose fin long (almost as long as depressed dorsal fin), separated from caudal fin and forming a free, flaplike lobe. Anal fin rays 14–16; pelvic fin rays 9; pectoral fin spine ½ to ⅔ fin length, saw-edged both anteriorly and posteriorly; caudal fin straight and slightly notched posteriorly, not forked. Scaleless. Lateral line complete. Digestive tract about 1.0 into TL. Chromosomes 2n = 56 (LeGrande 1978).

Color variable with size and habitat. Dorsal region of head, back, and sides light brown to yellow, mottled with dark brown or black (mottling tending to disappear in adults from turbid water); ventral region of head and belly yellowish to cream colored. Caudal fin darkly pigmented, except upper lobe, which has a distinct white patch along dorsal border (white patch disappears with age); other fins pigmented like adjacent parts of body. All barbels slightly to darkly pigmented. Young more contrastingly colored than adults.

Sexual dimorphism: In males, a single urogenital opening behind anus; in females, two openings urinary and genital; these openings more pronounced in adults than in young, especially during spawning season (Moen 1959).

Hybrids: Experimental flathead catfish × channel catfish, flathead catfish × yellow bullhead, flathead catfish × blue catfish, flathead catfish × white catfish (Sneed 1964, Dupree et al. 1966).

DISTRIBUTION, STATUS, AND HABITAT

In Wisconsin, the flathead catfish occurs in the Mississippi River and Lake Michigan drainage basins. In the Mississippi basin, it is known from the St. Croix, Red Cedar, Chippewa, La Crosse, Wisconsin, Pecatonica, and Sugar river systems. It reaches the northern limit of its distribution in the St. Croix River. According to Cahn (1927), the flathead catfish was taken from the Mississippi River overflows and introduced into Oconomowoc and Nagawicka lakes. The introduced fish did not spawn and are undoubtedly extirpated. In the Lake Michigan basin, this species occurs in the lower Wolf and upper Fox rivers and in their lakes. Greene (1935) did not report this species from the Lake Michigan drainage, and the possibility exists that he overlooked it in his survey. It probably entered the Lake Michigan drainage via the Fox-Wisconsin crossover connection or the canal at Portage.

In Wisconsin, the flathead catfish is rare to common in the Mississippi River and in the lower portions of its major tributaries. Priegel (1967a) listed it as common in Lake Winnebago. It is uncommon to common in sectors of the lower Wolf River and the upper Fox River.

In comparing his results on the Mississippi River with the earlier findings of Barnickol and Starrett (1951), Schoumacher (1968) concluded that flathead catfish are being exploited quite heavily by commercial fishermen. Many fishermen feel that fewer fish, especially large fish, are being taken now as compared with past years.

Little is known about the biology and the population structure of the flathead catfish in Wisconsin. To ensure sustained fishing and a viable population, a long-term, active research program is advised.

Young flathead catfish are often found among rocks on riffles, occupying the same habitat as the riffle-dwelling madtoms. Adults occur in deep pools cre-

Range of the flathead catfish
● Specimens examined
▲ Wisconsin Fish Distribution Study (1974–75)
○ Literature and reports
◯ Greene (1935)

ated by swirling currents. Cross (1967) found: "Many such pools now exist below concrete aprons of low dams, and adjacent to bridge-supports that trap driftwood. Such obstructions in the channel disrupt the streaming flow of the current, leaving deep pockets in the otherwise shallow beds. . . ." The flathead catfish prefers tangled timber, piles of drift, or other cover.

BIOLOGY

The spawning of the flathead catfish takes place in June and July in secluded shelters and dark places. Spawning occurs at water temperatures of 22.2–23.9°C (72–75°F). A large nest is built. Cross (1967) reported finding a bank nest that had been dug into a steep clay bank with an entrance about 355 mm (14 in) diam, which widened to 813 mm (32 in) inside the nest chamber. The bottom of the nest was silt free, and there was a ridge of clean gravel at the entrance.

Nest construction was observed at the Shedd Aquarium, Chicago (W. Chute in Breder and Rosen 1966). Both male and female (about 1.2 m long) used their tails and mouths to make a hollow in the sand down to the bare gravel and rock in one corner of the tank; the completed nest was approximately 1.5 m diam.

Spawning was witnessed in the Dallas Aquarium (Fontaine 1944:50–51):

> As breeding approached the male was often seen with the female, swimming over and beside her, gently rubbing his belly on her back and sides. His barbels apparently had some effect as they were brought into play almost constantly as he rubbed her. There was no apparent change in color during spawning, such as has been observed in many other species of fish. Presently the male came to rest on the bottom with his caudal peduncle and caudal fin encircling the head of the female. There was then a strong quivering movement on the part of the male. This was repeated from time to time and was observed at irregular intervals for almost two weeks. When the female was ready to spawn she began to deposit her eggs in a depression in the gravel that she and the male had prepared, behind an old tree stump on the ledge to the rear of the tank. The female expelled the eggs in masses of 30 to 50 which were

then fertilized by the male. At this time the two fish lay side by side, with heads in the same direction, turning their bellies together. At times the female quit the nest for a few minutes while the male fluffed and arranged the eggs. During this observation the egg-laying was carried out in about four and one-half hours. Within an hour after the female had quit spawning she was removed from the tank, as past experience had shown that she would crush or eat the eggs. The male took up guard over the nest at once.

Observers of flathead catfish spawning noted that when the male settled over the mass of eggs after spawning, he ventilated them strongly with his ventral fins, created a current of water with his anal fin, and fluffed the eggs by lifting the egg mass with his ventral fins; he also turned the eggs in a half-arc by using his mouth or ventral fins to move the egg mass, and by slipping his caudal fin under the egg mass he gave it a good shaking in a movement much more violent than one would expect to see. The male continued to drive away the female or any other fish coming near the nest: he fought fishes of his own size or smaller and gently eased the larger fishes away.

In Texas hatchery pens, the males were vicious while guarding eggs, and would "tear the female to pieces" if she attempted to enter the spawning jar containing the eggs (Henderson 1965). Henderson also noted that a number of females that had spawned had been killed by the male, even though laboratory workers tried to remove the female as soon as possible.

The egg mass of the flathead catfish in the Shedd Aquarium contained an estimated 100,000 eggs. The size of the flathead catfish spawn varies, depending on the size of the female. Snow (1959) reported an egg mass which weighed slightly less than 1,089 g (2.4 lb), and contained about 15,000 eggs. In small hatchery-reared brood fish, the spawns numbered from 3,000 to 5,000 eggs (Henderson 1965). In Kansas, three females, 305–610 mm TL, held 6,900–11,300 eggs, averaging 2.8–3.2 mm diam (Minckley and Deacon 1959).

In Oklahoma, estimates of the fecundity of flathead catfish ranged from 4,076 to 31,579 eggs for fish 1.05–11.66 kg (Summerfelt and Turner 1971). Ripe eggs averaged 3.7 mm diam. Forty-five percent of the sexually mature females probably did not spawn, and mature eggs of the unspawned females were resorbed.

Giudice (1965) reported that the hatching of flathead catfish eggs occurred in 6–7 days at 23.9–27.8°C (75–82°F); Snow (1959), reported hatching in 9 days at 24–25.9°C (75–78.6°F), into fry which were about 11 mm long.

The male flathead continues to guard the young after hatching. The young remain tightly schooled for several days while the large yolk-sac is being absorbed. Cross (1967) noted that by mid-June the young leave the nest, and are afterward found mostly on shallow riffles, beneath stones or other cover. Young-of-year flathead catfish feed mainly on aquatic insect larvae, including Chironomidae, Ephemeroptera, and Trichoptera.

The age and growth of flathead catfish are determined in most studies by analyzing the rings on sections of the pectoral spines. From one to three early annuli are missing on some of the spines from larger fish (Muncy 1957).

In the Mississippi River bordering Iowa (Schoumacher 1968), flathead catfish, ages II to XVI, demonstrated the following growth: II—356 mm; III—406 mm; IV—462 mm; V—533 mm; VI—556 mm; VII—686 mm; VIII—663 mm; IX—655 mm; X—620 mm; XI—734 mm; and XVI—864 mm. In an earlier study (Barnickol and Starrett 1951) of catfish from the Iowa-Illinois sections of the Mississippi River, the growth in older flatheads appeared to be substantially greater: I—193 mm; II—297 mm; III—373 mm; IV—429 mm; V—490 mm; VI—561 mm; VII—608 mm; VIII—795 mm; IX—895 mm; X—838 mm; XI—902 mm; XIII—940 mm; and XIV—978 mm.

A 1.12-m, 24.95-kg (44.1-in, 55-lb) flathead catfish, caught 23 August 1974 from the Fox River at Eureka (Winnebago County), had the following calculated lengths for each year of growth: 1—109 mm; 2—234 mm; 3—404 mm; 4—497 mm; 5—528 mm; 6—559 mm; 7—606 mm; 8—652 mm; 9—683 mm; 10—698 mm; 11—745 mm; 12—776 mm; 13—833 mm; 14—884 mm; 15—962 mm; 16—976 mm; 17—1,008 mm; 18—1,024 mm; 19—1,040 mm; 20—1,048 mm; 21—1,063 mm; 22—1,071 mm; 23—1,087 mm; and 24—1,100 mm (Paruch 1979).

In Oklahoma (Turner and Summerfelt 1971), the average K_{TL} for 124 females and 90 males was 1.30 and 1.25 respectively.

Carlander (1969) noted that the growth of flathead catfish was more rapid on shallow mud flats than in clear rocky areas. Minckley and Deacon (1959) suggested that in Kansas the flathead catfish grew faster in the Big Blue River than in the Neosho River, because it fed on fish at an early age.

In the Mississippi River, flathead catfish mature at ages IV or V (Barnickol and Starrett 1951). The size at maturity varies considerably: a few are mature at 381 mm (15 in), but most are not mature until they reach 457 mm (18 in). According to Minckley and Deacon (1959), the loss of the light patch at the tip of the upper lobe of the caudal fin may indicate sexual maturity.

Large flathead catfish are reported yearly from Wisconsin. In the Lake Michigan basin, individuals weighing 9.1–18.1 kg (20–40 lb) are common. A 27.7-kg (61-lb) fish was caught from the Fox River at Eureka (Winnebago County) in 1966. In the Mississippi River, commercial fishermen have reported specimens as large as 1.5 m (5 ft) and 45.4 kg (100 lb) (Harlan and Speaker 1956). In 1911, two flathead catfish weighing 53.5 and 56.7 kg (118 and 125 lb) were reported caught on setlines (Bachay 1944).

In Wisconsin, a 419-mm (16.5-in) channel catfish was taken from the stomach of an 18.1-kg (40-lb) flathead from the Pecatonica River, and a 457-mm (18-in) northern pike was taken from the stomach of a 7.26-kg (16-lb) flathead from Lake Puckaway. Unlike the channel catfish, the flathead is not a scavenger; it rarely eats dead or decaying matter. Stomachs usually contain small quantities of debris consisting of mud, sand, gravel, pieces of wood, and leaves. Bullhead and channel catfish spines have been found imbedded in the stomach wall or mesenteries of flathead catfish.

In flathead catfish measuring more than 250 mm (10 in) from the Big Blue River, Kansas (Minckley and Deacon 1959), fishes occurred in 90% of the stomachs that contained food and comprised 79% volume. The ingested fishes identified from Kansas collections were suckers, minnows, channel catfish, madtoms, darters, sunfish, and freshwater drums. In the Neosho River, crayfish constituted a large part of the diet of larger flatheads.

Flathead catfish feed most actively in May and early June, and from July to September; they feed less during the winter months and in late June and early July, when spawning occurs. The flathead is often a passive predator that lies in wait for its victim (Minckley and Deacon 1959:347):

> We twice observed the feeding behavior of a 14-inch specimen in an aquarium. The fish lay motionless, except for slight movements of the eyes and opercles, and allowed the food-fish (*Notropis lutrensis*) to draw near, on one occasion touching the barbels. Then, with a short lunge by the catfish, the minnow was eaten.

Trautman (1957) has observed flathead catfish feeding at night on riffles so shallow that their dorsal fins stuck out of the water; he has also seen them lying on the bottom, usually beside a log or other object, with their mouths wide open. Ohio River fishermen have reported that they have seen frightened fish dart into the open mouths of flatheads, to be swallowed immediately. The large numbers of such hiding species as rock bass, spotted black bass, and small catfishes found in the stomachs of large flatheads lend credence to these statements.

In the Wabash River, Indiana, the optimum temperature range for the flathead catfish was 31.5–33.5°C (89–92°F) (Gammon 1973). Gammon noted that the flathead catfish is sedentary, and that tagging studies suggest that it does not move about enough to encounter the other thermal possibilities. In 1971, electrofishing catches of flathead catfish were uniformly low among nearly all of the zones studied. In the same year the Cayuga power plant began releasing heated effluents into the river which, according to Gammon, was responsible for a "dramatic . . . increase . . . in the density of flathead catfish in the heated zones alone." He reported that in 1972 "the major increase came from large numbers of 100 to 200 mm long fish, presumably the result of a highly successful 1971 year class, the first year class to follow the introduction of heated effluents into the river."

According to Minckley and Deacon (1959), young-of-year flatheads move or are carried from the place of hatching to swift, rubble-bottomed riffles where they remain until they are 51–102 mm (2–4 in) TL. At that size, the young fish become more evenly distributed in the stream; some remain on the original riffles, but more move into pools, deeper riffles, and into almost all other habitats. This random distribution seems to be the rule among fish ranging from 102 mm (4 in) to approximately 305 mm (12 in) long. Large individuals, more than 406 mm (16 in) long, are found near the more massive logs and drift piles, and usually in or near deep holes in the stream bed. A drift pile usually yields only one, or at most two or three adults. Each individual has a favorite resting place where it can be counted on to be each day unless disturbed (Pflieger 1975). In the Mississippi River during the winter, the flatheads go into a "pseudo-hibernation state, embedding themselves in muddy holes in forty to sixty feet of water" (Bachay 1944).

Two out of three flathead catfish, implanted with ultrasonic transmitters and displaced a distance of 1.3–2.7 km (0.8–1.7 mi) from their site of capture, showed a strong tendency to return to the point of release (Hart 1974). Funk (1957) classified the flathead catfish as a semimobile species. He reported that 48.9% of tagged flathead catfish which were recaptured were found less than 1.6 km (1 mi) from the point of tagging; 72.1% were found less than 8.1 km (5 mi) from the point of tagging. No fish was recovered more than 80.7 km (50 mi) from the point of release.

Fighting between members of this species appears to be common. When a female flathead was returned to the tank with a male with which she had spawned previously, the two were soon fighting; after they were separated each returned to its respective place in the tank. However, fighting erupted once more (Fontaine 1944:51):

> . . . It was not until late in the afternoon that day that they started fighting again. After sparring for a few minutes the female backed away from the male a distance of about 18 inches, made one rush and struck him in the side. He rolled over and floated to the surface, belly up. He was removed to a reserve tank and lived for two days then died. An autopsy revealed that the blow had injured his intestine, stomach and several other organs.

IMPORTANCE AND MANAGEMENT

The flathead catfish is not particularly vulnerable to predators because of its rapid growth and secretive habits; however, the survival of 38–51-mm fingerling flatheads stocked in ponds containing adult sunfishes and fathead minnows (*Pimephales promelas*) was low—from 0 to 1.5% (Hackney 1966). In ponds where there were large numbers of crayfish present, the flathead fingerling mortality rate was very high (Henderson 1965).

The flathead catfish is host to the glochidia of a number of freshwater mussels, including *Amblema plicata*, *Megalonaias gigantea*, *Quadrula nodulata*, *Quadrula pustulosa*, *Quadrula quadrina*, and *Elliptio dilatata* (Hart and Fuller 1974).

Along the lower Wisconsin River, the flathead catfish is sometimes called the "candy bar," attesting to the superb flavor and texture of its flesh. It is a much sought-after prize, and some fishermen specialize in catching it by setline or bank pole. The methods used for catching flatheads are similar to those used for taking channel catfish, except that only live or freshly killed baits are effective with the flathead. J. Kincannon (pers. comm.), who kept a record of the flathead catfish he took from the lower Wisconsin River near Blue River (Grant County) from 22 May to 15 June 1963, caught 12 flatheads totalling 79.4 kg (175 lb); they ranged in size from 2.27 to 15.88 kg (5 to 35 lb), and were taken on bullheads and channel catfish up to 330 mm (13 in) long. They were caught along steep, grassy banks where old tree roots and logs were in evidence.

During 1960, on the Wisconsin River between Prairie du Sac and Lone Rock, sport fishermen creeled 11 flathead catfish (averaging 660 mm) out of 3,243 fish caught. Between Lone Rock and the mouth of the Wisconsin River, 16 flatheads (averaging 648 mm) were caught out of a total of 1,528 fish (C. Brynildson 1960). During 1967–1968, in Pools 4, 5, 7, and 11 of the Mississippi River, the estimated sport fishery catch was 1,909 flathead catfish weighing 1,280 kg (2,821 lb) (Wright 1970). Bachay (1944) reported that in a hole below a wing dam near Dresbach (Pool 7), Minnesota, the Kramer brothers took a yearly average of 3.2–4.5 thousand kg (7–10 thousand lb) of flathead catfish on setlines; their largest catch was taken from December through February. During the winter of 1942, the Kramer brothers took more than 5.4 thousand kg (12 thousand lb) of flathead catfish in gill nets.

In the upper Fox River, fishermen fish for flatheads with setlines and bank poles using large white suckers, redhorse suckers, carp, sheepshead, and yellow bullheads on 5/0 and 7/0 hooks. Fishing is done at night from 2000 to 0630 hr. B. Curless (pers. comm.) and another fisherman caught 28 flathead catfish ranging from 4.54 to 19.05 kg (10 to 42 lb) in the vicinity of Berlin (Green Lake County) and Eureka (Winnebago County) between 1 July and 14 September 1973.

In the commercial fishery statistics for the Mississippi River, the flathead catfish is included with the channel catfish under the caption "catfish." The ratio of flathead catfish to channel catfish is very low; in the Iowa waters of the Mississippi River (Schoumacher 1968), it is 1:49.

Some success in the propagation of the flathead catfish has been achieved since the 1950s (Giudice 1965, Henderson 1965, Sneed et al. 1961, and Snow 1959). Snow, citing Swingle, reported that in rearing ponds the flathead catfish grew at a rate of 905 g (2 lb) per year, had an excellent flavor, and appeared promising as a commercial species. Yearling flathead catfish stocked in May at 178 mm (7 in) and 45 g (0.1 lb), averaged 384 mm (15.1 in) and 635 g (1.4 lb) 6 months later (Stevenson 1964). From Oklahoma to Wisconsin, the standing crop of flathead catfish averaged 24.9 kg/ha (22.2 lb/acre); it ranged from 1.6 to 103.6 kg/ha (1.4 to 92.4 lb/acre) (Carlander 1955).

The flathead catfish has for some time been used as a fish-control species. Swingle (1964) noted that large flathead catfish are predatory and in several cases eliminated larger bluegills. Small flatheads (51–127 mm) eliminated almost all fathead minnows, while larger flatheads apparently preferred bluegills to fathead minnows; they eliminated all the large bluegills they could swallow, except for a few in the 178-mm (7-in) group, and left very few bluegills in the 102–152-mm (4–6-in) group. Hackney (1966) noted that 125 large flathead catfish per hectare (50/acre) did not completely correct the balance in a population of stunted bluegills in 320 days.