A Fish Health Assessment and Liver Lipid Content Examination of Catfish Populations in the Coosa River, Alabama

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Abstract: A modified fish health assessment index (mHAI) and liver lipid concentration was used to determine condition of individual blue catfish (*Ictalurus furcatus*), channel catfish (*I. punctatus*), and flathead catfish (*Pylodictus olivarus*) in tailwater and reservoir habitats of the Coosa River, Alabama. Our goal was to describe and compare condition using a mHAI and liver lipid analyses of catfishes from the Coosa River. Tissues and organs of fish were collected, evaluated and scored for deviations from normal appearances to derive a mHAI score for each fish. Percent liver lipid content was also determined. Health of all catfish, based on mHAI, was generally good. No differences in health were found for blue catfish and channel catfish by season or habitat. Flathead catfish health varied seasonally. No seasonal or habitat differences in percent liver lipids were found for any species. The mHAI may have failed to capture subtle differences in health that may have existed for habitat generalists such as catfishes. Further adaptation of the mHAI may be necessary; however, it is plausible that conditions in the productive Coosa River were conducive to overall good health of individuals and populations of catfishes. Liver lipids may not be the best metric for measuring condition; specific lipids (e.g. triglycerides) should be investigated. Recent interest in managing catfish stocks warrants the need for population health and condition assessments.

Key words: condition, catfishes, health assessment, lipids, livers

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Catfishes (Ictaluridae) represent an important group of fishes, both recreationally and commercially, throughout many regions of the United States (USDI and USDC 2006). Recent concerns regarding sustainability of catfish populations that support large fish have increased because of abundant media images of large catfish and recent technological improvements in specialized fishing equipment (Arterburn 2001). Information regarding biology and management of catfishes has lagged behind that of other fish families (Irwin and Hubert 1999).

Measures of fish health and condition have been of interest to biologists because extrinsic factors such as temperature, food availability, and competition may be reflected in the general health or well-being of individual fish (Goede and Barton 1990). In addition, anthropogenic stressors (e.g., contaminant loading or habitat alterations) may further induce changes in condition. Direct measures of physiological condition through application of a fish health assessment and determination of energy reserves through determination of liver lipid content were applied to three catfish species in the Coosa River, Alabama. The fish health-condition assessment was originally developed (Goede 1988) for evaluation of hatchery-produced trout (Salmonidae), and later Goede and Barton (1990) developed a necropsy-based method for evaluating individual fish health for monitoring fish response to environmental stressors. This method was modified to provide a quantitative health assessment index (HAI) that would allow statistical comparisons among populations (Adams et al. 1993). The HAI, which is an empirical autopsy-based system of organ and tissue indices, assumes that normal appearances of vital organs will indicate a fish population that is in harmony with its environment. When applied to wild fish populations, departures from normal growth and general homeostasis can be detected (Goede and Barton 1990). The modified procedure has been applied to various wild fish populations (Novotny and Beeman 1990, Coughlan et al. 1996, Robinson et al. 1998, Sutton et al. 2000, McKinney et al. 2001, Schleiger 2004). An advantage of the modified health assessment index (mHAI) is rapid, gross evaluation of a small sample of fish with minimal training required by the observer (Goede and Barton 1990).

Lipid content and dynamics may be useful to further evaluate population health. Lipids are critical to the survival and fitness of individuals; they are vital to successful reproduction and recruitment of future year classes within a population (Adams 1999). Lipids are a more direct measure of energetic status as they are ultimately derived from prey; major storage sites are the liver and

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red muscle (Mommsen 1998). As such, declines in condition (i.e., liver lipid concentration) may indicate a depletion of energy reserves related to stress. Abiotic or biotic stressors may induce a behavioral response in feeding patterns (Brown et al. 1987) or increased metabolism in response to stress (Schreck 1982, Barton et al. 1986). Although more inference may be derived from whole body lipid analysis, prohibitive large body size (e.g., catfishes) may dictate analysis of specific tissues (e.g., liver or muscle).

A plausible hypothesis is that physical and biological conditions exist in tailwater habitats that are conducive to increased condition of catfishes (i.e., relative to reservoir habitats). Tailwater areas may provide an excellent foraging arena for catfishes, thereby enhancing growth and condition. Prey items may either be discharged through the turbines (Walburg 1971, Sorenson et al. 1998), be attracted to increased velocity in tailwaters (Jackson 1995, Graham and DeiSanti 1999), or have upstream migrations blocked by dams (Hoyt and Kruskamp 1982). Entrained fish may be injured or disoriented after they are passed through the turbines and may be more susceptible to predators.

Catfishes may be more abundant in dam tailwaters (Walburg et al. 1981, Jackson 1985, Jacobs et al. 1987, Jackson and Dillard 1993, Graham and DeiSanti 1999) than other areas of rivers and reservoirs. Some observations suggest that tailwater catfishes are larger (Jackson 1995) and in better condition with increasing flow (Jackson 1985). Tailwater areas are often popular for catfishing (Graham and DeiSanti 1999) and seemingly produce larger fish (Richards 1988, Chambers 1993). However, given that the observations are largely anecdotal, they should be substantiated if we are to increase our ability to manage catfish fisheries.

To this end, our objective was to describe and compare the health of populations of blue catfish (*Ictalurus furcatus*), channel catfish (*I. punctatus*), and flathead catfish (*Pylodictus olivarus*) from selected reservoir and tailwater (i.e., habitat) locations within a section of the Coosa River, Alabama, using a modified fish health assessment and measures of liver lipid content.

Methods

Study Area

Blue catfish, channel catfish, and flathead catfish were collected from six sites on the Coosa River in central Alabama (Mobile River drainage, Figure 1). Tailwater sites were located below hydropower peaking facilities: Walter Bouldin Dam, Jordan Dam, and Mitchell Dam. Tailwater sites were highly regulated and discharge ranged from 0 to 1,100 cubic meters per second (cms). Jordan Reservoir is 29.6 km long (from Mitchell Dam to Jordan Dam), and is 2,754 ha at full pool, draining 26,326 km^2. Three reservoir sites were chosen systematically based on access and ability to capture catfishes. The reservoir sites were in the Bouldin Canal, the Shoals

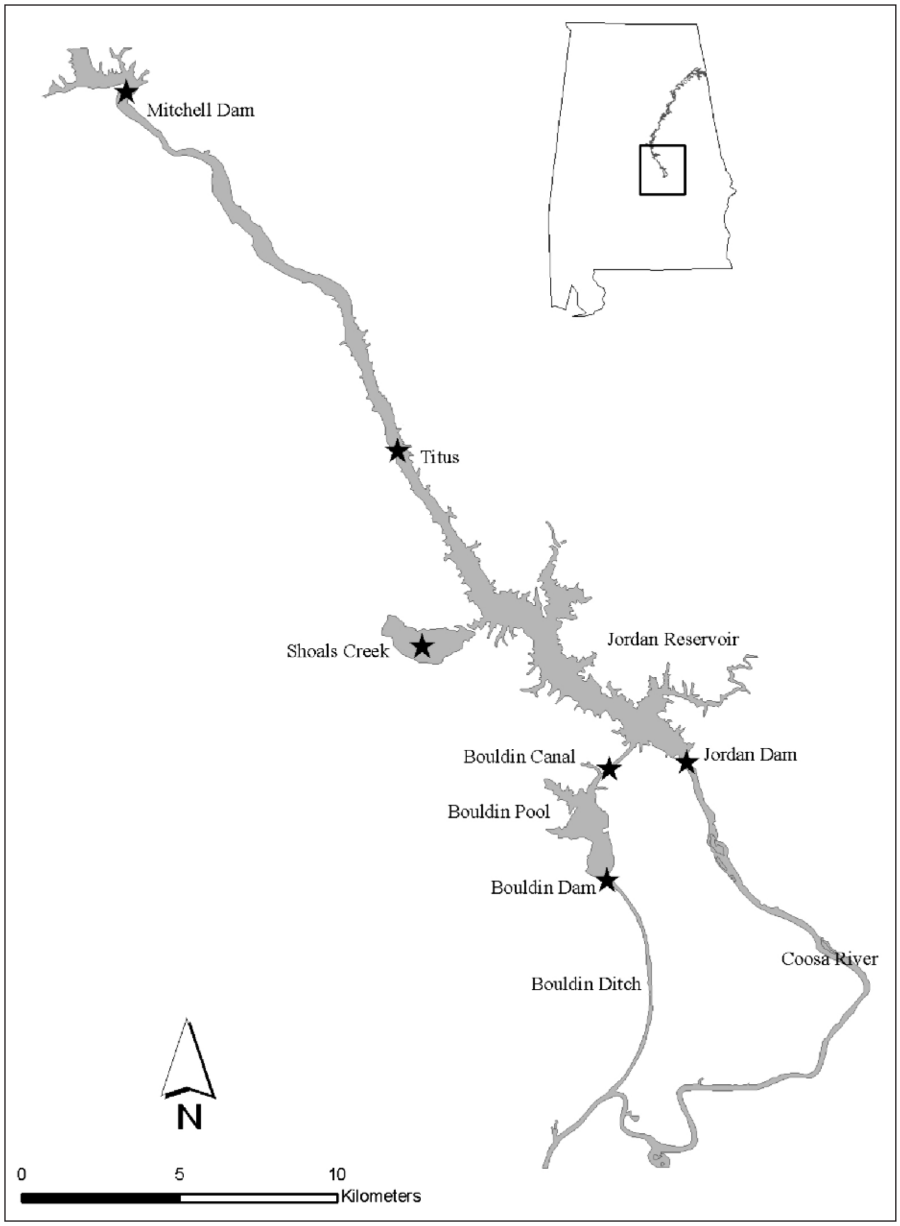

Figure 1. Location of catfish sampling sites in the Coosa River, Alabama, 2001–2002.

Creek embayment, and the mainlake of Jordan Reservoir near the town of Titus (Figure 1).

Data Collection

Blue catfish, channel catfish, and flathead catfish were collected seasonally from spring 2001 to fall 2002 primarily with boat electrofishing (Smith Root GPP, 15 pps, 2–5 amps). Hoopnets, slatboxes, and gillnets were employed to increase catches when electrofishing was ineffective (i.e., water temp <18 C). Catfishes were measured (TL, mm) and weighed (g). Large catfish (i.e., >6 kg) were weighed to the nearest 0.25 kg. Fish were euthanized, placed on ice, and returned to the laboratory for further processing.

Fish condition was assessed using two methods. The health assessment index (HAI; Goede 1988) was modified (mHAI) similar to that used by Goede and Barton (1990) and Coughlan et al. (1996). Fish were visually examined immediately upon return to the laboratory and ratings were assigned to various external characteristics and internal organs; higher values indicate poorer condition (Goede and Barton 1990). External ratings were determined for eyes, gills, fins, and operculum. Internal ratings were determined for spleen, hindgut, kidney, liver, bile, and mesenteric fat. The numerical values for each characteristic were then summed resulting in a mHAI value for each fish. Sex was determined by the presence of ovaries or testis. The occurrence of abnormalities was documented and photographed with a digital camera. External and internal parasites were identified when possible. After the necropsy, mesenteric fat was removed, weighed (nearest 0.01 g), and disposed, and the liver was removed, weighed (nearest 0.01 g), and frozen until further processing. Liver lipids were extracted using the procedures outlined by Folch et al. (1957) and expressed as percent content.

Statistical Analyses

The modified fish health assessment index (mHAI) was calculated from the necropsy ratings to allow statistical comparisons among sites and seasons (Adams et al. 1993). Catfish mean mHAI value-at-length data were analyzed using analysis of covariance (SAS 1999) to detect differences in mHAI values between habitats for each species while accounting for length-related effects. When no length-related effects were found the mHAI values were further analyzed using two-way analysis of variance (ANOVA) with pooled data by season and habitat. The habitat*season interaction was only examined for flathead catfish because blue catfish and channel catfish were only captured in the spring and summer. Post-hoc mean separation procedures were conducted using Tukey's Studentized Range test.

Mean liver lipid content was compared between habitats and among seasons for each species using two-way ANOVA to detect differences in condition, followed by post-hoc comparisons with Tukey's Studentized Range test. Liver lipid content and mHAI values were examined for correlation using Pearson's correlation analysis. All statistical tests were conducted at an alpha level of 0.05.

Results

A total of 163 blue catfish, 62 channel catfish, and 171 flathead catfish were assessed using the mHAI from collections between 12 April 2001 and 24 July 2002 across both habitats. Of these, a total of 277 catfish were analyzed for percent liver lipid content. Blue catfish from the Jordan Dam tailwater were omitted from the analysis due to inadequate sample size ($n = 1$).

The mHAI for all species was variable and ranged from 0 to 90 (Table 1). The mHAI for blue catfish was variable (range 0–90, $n = 139$) and the most common abnormalities were fatty or mottled livers (50%) and granular kidneys (4%). The channel catfish health assessment was variable (range 0–60, $n = 62$); fatty or mottled livers (62%) and granular kidneys (2%) were the most common abnormalities. The flathead catfish mHAI was variable (range 0–90, $n = 171$); fatty or mottled livers (51%) and granular kidneys (19%) were the most common abnormalities. Winter samples were omitted from analyses due to low sample sizes of all species.

The incidence of parasites on fish was low. One fluke (Tremato-

Table 1. Mean health assessment index (HAI) value, standard deviations, range of values, and results of two-way ANOVA comparisons between habitats and among seasons for three species of catfish from the Coosa River, 2001–2002. Mean health assessment index values in columns followed by the same letter were not significantly different (between habitats and among seasons for each species; $P > 0.05$). Sample sizes are in parenthesis below mean values. Blue catfish and channel catfish from fall were omitted due to inadequate sample size.

	Species								
	Blue catfish			Channel catfish			Flathead catfish		
	Mean HAI	Standard deviation	Range	Mean HAI	Standard deviation	Range	Mean HAI	Standard deviation	Range
Habitat									
Tailwater	24[a] (51)	20	0–60	24[a] (48)	21	0–60	25[a] (133)	26	0–90
Reservoir	18[a] (88)	20	0–90	19[a] (14)	15	0–30	25[a] (38)	27	0–90
Season									
Spring	20[a] (135)	20	0–90	21[a] (48)	20	0–60	35[a] (86)	27	0–90
Summer	15[a] (4)	17	0–30	28[a] (14)	22	0–60	11[b] (61)	20	0–90
Fall	–	–	–	–	–	–	24[a] (24)	15	0–60

da) was attached to the caudal fin of a blue catfish and one channel catfish had tapeworms (Cestoda) in the body cavity. Three types of parasites occurred on flathead catfish. Tapeworms (*Corallobothrium* spp.), fish louse (*Argulus* spp.), and roundworms (*Contracaecum* spp. [Nematoda]) were present in low numbers.

Results of the analysis of covariance indicated that the slopes and intercepts of the mHAI-to-length regressions were similar between habitats for blue catfish (slope, $F = 0.18$, $df = 1{,}138$, $P = 0.67$; intercept, $F = 2.39$, $df = 1{,}138$, $P = 0.12$), channel catfish (slope, $F = 2.06$, $df = 1{,}61$, $P = 0.16$; intercept, $F = 0.53$, $df = 1{,}61$, $P = 0.47$), and flathead catfish (slope, $F = 2.23$, $df = 1{,}170$, $P = 0.14$; intercept, $F = 0.02$, $df = 1{,}170$, $P = 0.89$). All sizes were subsequently pooled for further analyses.

Mean mHAI did not vary among habitats for blue catfish ($F = 2.90$, $df = 1$; $P = 0.09$), channel catfish ($F = 0.19$, $df = 1$, $P = 0.67$), or flathead catfish ($F = 2.72$, $df = 1$, $P = 0.10$; Table 1) or among seasons for blue catfish ($F = 0.78$, $df = 1$, $P = 0.38$) and channel catfish ($F = 0.82$, $df = 1$, $P = 0.37$). Fall samples of blue catfish and channel catfish were omitted from this analysis due to inadequate sample sizes. Mean mHAI differed by season for flathead catfish and was higher in the spring and fall than in summer ($F = 7.50$, $df = 2$, $P < 0.01$; Table 1).

Blue catfish liver lipid content ranged from 1.2% to 6.9%, channel catfish liver lipid content ranged from 1.1% to 5.3%, and flathead catfish liver lipid content ranged from 1.0% to 8.5%. Mean liver lipid content did not differ between habitats for blue catfish ($F = 2.18$, $df = 1$, $P = 0.14$), channel catfish ($F = 0.52$, $df = 1$, $P = 0.47$), or flathead catfish ($F = 1.81$, $df = 1$, $P = 0.18$; Table 2), or among seasons for channel catfish ($F = 0.82$, $df = 2$, $P = 0.44$) or flathead catfish ($F = 0.52$, $df = 2$, $P = 0.60$; Table 2). The season*habitat interaction was not significant for flathead catfish ($P = 0.74$). Liver lipid content was determined for only blue catfish collected in spring and channel catfish collected in spring and summer due to inadequate sample sizes. Liver lipid content was not correlated to the mHAI for blue catfish, channel catfish, or flathead catfish ($r = -0.3$, $P = 0.76$).

Discussion

In wild fish populations, extrinsic factors (e.g., temperature, food availability, competition) that can affect health assessment are complex (Goede and Barton 1990). The Coosa River is a productive system (Bayne et al. 1989), and conditions for maintenance of healthy catfish populations appear stable based on the findings of our study. A concurrent study indicated the occurrence of more abundant flathead catfish, larger blue catfish, and faster growing channel catfish at tailwater versus reservoir sites on the Coosa River (Jolley 2003). The mHAI did not readily indicate differences in fish health among habitats (tailwater versus reservoir) or seasons (with the exception of flathead catfish). Based on the mHAI, flathead catfish were in relatively poorer health in the spring and

Table 2. Mean percent liver lipid content, standard deviations, range of values, and results of two-way ANOVA comparisons between habitats and among seasons for three species of catfish from the Coosa River, 2001–2002. Mean percent liver lipid content in columns followed by the same letter were not significantly different (between habitats and among seasons for each species; $P > 0.05$). Sample sizes are in parenthesis below mean values. Blue catfish from fall and winter and channel catfish from fall were omitted due to inadequate sample sizes.

	Species								
	Blue catfish			Channel catfish			Flathead catfish		
	Mean percent lipid content	Standard deviation	Range	Mean percent lipid content	Standard deviation	Range	Mean percent lipid content	Standard deviation	Range
Habitat									
Tailwater	3.04[a] (42)	0.98	1.69–6.62	2.98[a] (45)	1.23	1.05–5.28	3.12[a] (86)	1.17	1.03–8.54
Reservoir	2.83[a] (64)	0.83	1.19–6.94	2.79[a] (12)	0.87	1.46–4.71	2.72[a] (24)	0.62	1.47–3.83
Season									
Spring	2.88 (106)	0.90	1.19–6.94	3.00[a] (52)	1.14	1.46–5.28	3.00[a] (59)	0.99	1.24–5.97
Summer	–	–	–	2.37[a] (5)	1.31	1.05–2.96	2.95[a] (32)	1.26	1.03–8.54
Fall	–	–	–	–	–	–	3.28[a] (19)	1.07	2.55–5.99
Winter	–	–	–	2.75[a] (3)	0.65	2.37–3.49	–	–	–

fall versus the summer months, potentially related to physiological constraints imposed during the spawning season, but in general, health of all fish was robust.

Fatty or mottled livers were the most common abnormality observed in our study. Schleiger (2004) reported that abnormal livers and kidneys were among the most common metrics correlated to fish health for largemouth bass (*Micropterus salmoides*) and bluegill (*Lepomis macrochirus*) from four Georgia reservoirs. The fatty-liver condition is typically a pathological condition in which excessive accumulation of fat in the cellular cytoplasm occurs (Takashima and Hibiya 1995). General discoloration of the liver (mottling) may occur if there was a significant lapse in time between death of the fish and the subsequent examination (Goede and Barton 1990). Although, we consistently examined fish within 4 h of capture, it is possible that liver mottling occurred before our examination, thus artificially inflating the health score. In our study, normal livers (i.e., solid red or light red coloration) were given a score of "0" and any deviation (e.g., mottled coloration) was given a score of "30". Coughlan et al. (1996) suggested the use of a graded scale (e.g., 0, 15, and 30) for reporting liver abnormalities. He noted many instances where only slight discoloration of the liver would easily have been categorized as "15" but instead receive a score of "30" along with livers that were grossly abnormal. Our observations concur with this recommendation and the use of this scale may have assisted in more accurately describing the health of individual catfish. Incidence of visible parasites was low and did not appear to be a factor contributing to poor health of individual fish.

Large catfish may receive poorer health assessment index values because of degenerative changes associated with old age which may confound the interpretation of the health assessment index results (Coughlan et al. 1996). We observed decreased health with increased age for blue catfish and the opposite pattern for channel catfish (Jolley 2003). Interpretation and possible causative factors of this observation remain unclear because of lack of ability to further analyze these data by size group as suggested by Coughlan et al. (1996).

Because the health assessment index was not correlated to liver lipid content, it appears in our study that these two metrics are unrelated. In addition, no other trends in liver lipid content were observed in our study, although observed values were within the range reported for channel catfish (Suppes et al. 1967, Webster et al. 1994). Low sample size may be partially responsible for this; however, liver lipid content may not be the most appropriate measure related to overall fish condition. Lipids are stored in the mesenteric fat and muscle, as well as in the liver in fish (Sheridan 1994). Liver and muscle lipids are a secondary store of lipids and are typically utilized for life history events (Sheridan 1994). In addition, specific determination of triglycerides may have better reflected catfish condition as those lipids are an important energy source during periods of stress. Other lipids (e.g., sterol esters, free fatty acids, sterols, and phospholipids) have slow mobilization rates and likely do not reflect fish condition (Fraser 1989, Hakanson 1989, Sheridan 1994). Several authors (Stickney and Andrews 1972, Kiessling et al. 1995) caution that lipid content cannot necessarily be used as a reliable index of nutritional status of a fish but certain fatty acid levels may indicate when starvation (or prolonged nonfeeding) may be occurring. They suggest that liver lipids may not be utilized for maintenance and metabolism until there is a severe reduction in food availability.

The health assessment index has been used for hatchery reared trout (Goede 1988), wild trout (Sutton et al. 2000), and salmon (Novotny and Beeman 1990) which are species adapted to a relatively narrow set of environmental conditions and habitats. Generalist species (i.e., catfishes) that are tolerant and adapted to a wide range of environmental conditions may require prolonged exposure to detrimental conditions before changes in the health assessment index become apparent. Blue catfish, channel catfish, and flathead catfish populations are generally common in Alabama with secure populations in most places (Boschung and Mayden 2004).

Adams et al. (1993) stressed that a HAI is simply a first-level assessment of the health profile of a fish population and is practical to identify concern areas where future study is warranted. The HAI is not designed to be diagnostic in character; however, we found the method easy to employ and it did describe broad trends in health of individuals. Schmitt (2002) reported that external lesion rate (i.e., presence of tumors, sores, or other abnormalities, including parasites) was a good metric to calculate, in addition to an HAI. We did not specifically quantify external body lesions; however, we observed few occurrences of parasites and no other external abnormalities other than "spawning scars." This provides more evidence that catfishes in the Coosa River are in overall good health. Further development of practical field techniques to adequately measure health and condition of catfishes is warranted, particularly in light of the recent emphasis on management of their stocks.

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