Diet Evaluation of Large Blue Catfish and Flathead Catfish from Lake Ellsworth, Oklahoma

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Abstract: Blue Catfish (*Ictalurus furcatus*) and Flathead Catfish (*Pylodictis olivaris*) are the largest Ictalurids in Oklahoma's rivers and reservoirs. Their native ranges are within the Arkansas and Red River basins in Oklahoma, however they are found almost statewide due to introduction as a sportfish. Few studies have documented their diet composition within Oklahoma's waters, particularly for large fish. Winter diets were evaluated for Blue Catfish and Flathead Catfish captured using large mesh gillnets set overnight at Lake Ellsworth, Oklahoma. Sampling occurred during February and March of 2019. A total of 159 catfish were evaluated for stomach content analysis. Stomach contents were observed in 79 of the fish (63 Blue Catfish and 16 Flathead Catfish) and only six different prey fish species were observed in diets. The combined stomach content weight (from 206 prey items [182 from Blue Catfish and 24 from Flathead Catfish]) for both species was 17.1 kg (15.8 kg for Blue Catfish and 1.3 kg for Flathead Catfish). Of the six prey species consumed, Gizzard Shad (*Dorosoma cepedianum*) occurred most often in Blue Catfish diets, whereas Freshwater Drum (*Aplodinotus grunniens*) occurred most often in Flathead Catfish diets. Cannibalism among and within species was observed for Blue Catfish, but at low rates. Of the 182 fish consumed by Blue Catfish, 144 fish total lengths were reconstructed using the linear relationship between backbone length to total length or standard length to total length. These lengths were then plotted against Blue Catfish total length (for fish ≥ 600 mm), which suggested that Blue Catfish ≥ 600 mm TL consumed similar sized prey as the largest fish in the sample. An expansion of research to other Oklahoma reservoirs is needed to better understand catfish diets and the effects of large catfish on fish communities in Oklahoma.

Introduction

Blue Catfish (*Ictalurus furcatus*) and Flathead Catfish (*Pylodictis olivaris*) are both large-bodied predators that are relatively long-lived and can weigh in excess of 50 kg (Graham 1999, Jackson 1999, Boxrucker and Kuklinski 2006, Schmitt et al. 2017). These two catfish species are the largest members of Ictaluridae in Oklahoma. Due to their trophy potential, angling interest for these large-bodied catfish has increased in recent years (Boxrucker and Kuklinski 2006). Although Blue Catfish and Flathead Catfish are native to the Arkansas and Red River basins, they are now found in most of Oklahoma because the Oklahoma Department of Wildlife Conservation (ODWC) has introduced them into many reservoirs to create recreational angling opportunities (Miller and Robinson 2004).

In most aquatic systems, Blue Catfish

and Flathead Catfish occupy different tropic niches. Blue Catfish are considered omnivores, consuming vegetation, mollusks, insects, crustaceans, and fish (Bonvechio et al. 2011, Hogberg and Pegg 2016, Schmitt et al. 2017, Jennings et al. 2018). However, Flathead Catfish are almost exclusively piscivorous, transitioning to fish prey when they reach 250 mm TL (Turner and Summerfelt 1971, Layher and Boles 1980, Herndon and Waters 2002, Schmitt et al. 2017). Feeding strategy likely drives these differences, as Flathead Catfish are considered an ambush predator that are not gape limited (Slaugther and Jacobson 2008), foraging non-selectively with respect to prey abundance within microhabitats that they occupy (Pine et al 2005). Whereas Blue Catfish are a pelagic species that move up-river in spring for spawning and retreat back down-river into reservoirs when water temperatures cool in the fall, feeding opportunistically through these seasonal habitat shifts (Phflieger 1997, Graham 1999, Snow at el. 2018).

Diets of Blue Catfish and Flathead Catfish have been described for native and introduced populations (Turner and Summerfelt 1971, Layher and Boles 1980, Herndon and Waters 2002, Bonvechio et al. 2011, Hogberg and Pegg 2016, Schmitt et al. 2017, Jennings et al. 2018). However, few of these evaluations have described diets of large individuals (≥ 600 mm). Diet information in Oklahoma Reservoirs, particularly for Blue Catfish is limited. The ODWC standard sampling protocol for Blue Catfish and Flathead Catfish uses low-frequency pulsed DC electrofishing to sample these species. However, collection of large (≥ 600 mm) Blue Catfish or Flathead Catfish during these surveys is rare, which limits a meaningful description of diet across the entire size structure of the population due to small sample size of large individuals (Boxrucker and Kuklinski 2006, Ford et al. 2011, Bodine et al. 2013, ODWC *unpublished data*). In this paper we describe diets of large Blue Catfish and Flathead Catfish caught using large mesh gillnets during winter (February through March of 2019) at Lake Ellsworth, Oklahoma.

Methods

Study Area: Lake Ellsworth is a flood control reservoir that was formed in 1961 by impounding Chandler Creek, East Cache Creek, and Tony Creek, which are tributaries of the Red River in Caddo and Comanche Counties in Southwestern Oklahoma (Cofer 2011, Figure 1). At normal pool elevation, Lake Ellsworth is 2,069 ha with 86.1 km of shoreline. It is considered to be mesotrophic, but can shift to hypereutrophic

Figure 1. Map of Lake Ellsworth in Caddo and Comanche Counties in Southwestern Oklahoma.

during warm weather months (Oklahoma Water Resources Board 1994). Lake Ellsworth has a mean depth of 4.82 m and a maximum depth of 16.5 m. The water storage is managed by the City of Lawton and serves as a municipal water supply (Cofer 2011).

Blue Catfish were stocked into Lake Ellsworth in 1961 and 1979 (Cofer 2011). Reproduction was first documented by ODWC during sampling in 1968 (Bennett 1968). Reproduction appears to be consistent but growth is slow compared to other reservoir populations in Oklahoma (Boxrucker and Kuklinski 2006). Flathead Catfish were not stocked into Lake Ellsworth. A remnant population occupied the existing creek systems prior to impoundment, were introduced by anglers, and/or stocked unintentionally. Sampling conducted during 1991-1993 determined Flathead Catfish were abundant and reproducing (Cofer 2011).

Sampling: Fish sampling occurred at 29 sites selected randomly from areas associated with creek channels within Lake Ellsworth, however due to standing timber or large woody debris, some sites had to be adjusted to avoid entangling gear. Sampling occurred during February and March 2019 at water temperatures ranging from 3.9 – 11.2 °C and depths from 2.1 – 12.2 m. Single-panel sinking gillnets of two different bar mesh sizes (net 1 - 152.4 mm bar mesh x 182.9 m length x 7.3 m depth and net 2 - 127 mm bar mesh x 91.4 m length x 7.3 m in depth) were set overnight to capture both catfish species. Fish from each sampling event were transported to the Oklahoma Fishery Research Laboratory in Norman, Oklahoma for processing. Fish were weighed to the nearest kg, measured for total length (TL, mm), sexed, and stomachs excised.

Once stomachs were extracted, prey items were removed and identified, enumerated, and individual prey items were weighed to the nearest gram. All prey items were identified to species when possible using scientific taxonomic keys to identify aquatic invertebrates (Merrit et al.2008), fish fillets and scales (Oats et al. 1993), cleithra (Traynor et al. 2010), and fish dichotomous keys (Miller and Robison 2004) to identify fish prey items when possible. Once the prey was identified, we reconstructed TL of all prey fish (when possible) using the linear relationship between backbone and TL or standard length and TL (Table 1).

Diet analysis: Prey importance was assessed by using percent occurrence (O_i; total number of occurrences of a specific prey group/ total number of stomachs containing any prey items), percent composition by number (N_i; total number of a specific prey group/total number of prey items counted), and percent weight of prey items (W_i; total weight of each prey group/total weight of prey consumed; Bowen 1996). Stomach fullness was calculated (total stomach content weight/fish body weight x 100) and reported as a percent of both Blue Catfish and Flathead Catfish weight (Pine et al. 2005). To describe the relationship between predator and prey size, we fit quantile regression representing the 5th, 50th, and 95th percentile of reconstructed prey length for dominant prey groups relative to Blue Catfish TL (Cade and Noon 2003). ANCOVA was used to test the difference among slopes of quantile regressions. Quantile regressions relating prey size and Flathead Catfish TL could not be constructed because prey items were

Table 1. Linear relationships between backbone/total length and standard length/total length used to reconstruct total lengths of prey items consumed by Blue Catfish and Flathead Catfish during wintertime from Lake Ellsworth, Oklahoma.

				Slope			Y-intercept		
Species	Variable	*n*	r^2	Estimate	95% LCI	95% UCI	Estimate	95% LCI	95% UCI
Freshwater Drum	Back Bone Length	22	0.81	1.941	1.715	2.167	-63.244	-80.766	-45.721
	Standard Length	22	0.89	0.984	0.846	1.122	23.705	17.330	30.080
Gizzard Shad	Back Bone Length	24	0.88	1.283	1.211	1.354	35.039	23.910	46.167
	Standard Length	24	0.93	1.211	1.161	1.260	4.952	-3.699	13.603
White Crappie	Back Bone Length	16	0.85	0.947	0.752	1.142	111.277	76.825	145.729
	Standard Length	16	0.86	0.800	0.620	0.980	94.520	53.498	135.543

limited as a result of fish regurgitating upon capture (Richard Snow, visual observation). This also applies to the diet analysis of the Flathead Catfish, however we are reporting this information due to diet evaluations of large Flathead Catfish being limited in Oklahoma.

Results

A total of 159 catfish (82 Blue Catfish and 77 Flathead Catfish) was captured and analyzed for diet contents. The sizes and weights of Blue Catfish (263-1132 mm TL; 0.14 - 21.2 kg) and Flathead Catfish (635 to 1146 mm TL; 3 - 23.2 kg) evaluated in this study were similar. Prey items were found in 76.8% (63 of 82) of Blue Catfish stomachs and 20.8% (16 of 77) Flathead Catfish stomachs. The 79 catfish having diet items contained 206 individual prey items (182 items in Blue Catfish and 24 items in Flathead Catfish stomachs) and the combined stomach content weight was 17.1 kg (15.8 kg for Blue Catfish and 1.3 kg for Flathead Catfish). Only two prey items found in the catfish diets could not be identified. Both species were exclusively piscivorous during February and March 2019, foraging on six different fish species (Table 2). Mean stomach fullness for Blue Catfish was 3.6% and ranged from 0.02% to 22.6%. Flathead Catfish stomach fullness was lower and less variable with a mean of 0.7% and ranged from 0.03% to 2.2%.

Blue Catfish diets were largely composed of Gizzard Shad (*Dorosoma cepedianum*), which dominated diets by N_i (58.2%) and O_i (57.3%; Table 2). Gizzard Shad had the highest W_i (43.1%), followed closely by White Crappie (*Pomoxis annularis,* W_i = 41.6%) even though White Crappie only occurred in 27.8% of the diets (Table 2). White Crappie and Freshwater Drum (*Aplodinotus grunniens*) were both similar by N_i (18.7% and 19.2%). However, Freshwater Drum only occurred in 13% of the diets. Cannibalism of Blue Catfish and Channel Catfish (*Ictalurus punctatus*) was observed by Blue Catfish, but occurred infrequently (1.9% and 1.6% for Blue Catfish and Channel Catfish, respectively). Sunfish were also consumed by Blue Catfish, but at low rates (Table 2).

Flathead Catfish consumed similar prey items as Blue Catfish, however indices values differed. Freshwater Drum dominated Flathead Catfish diets by N_i (45.83%) and O_i (49.70%; Table 2), although White Crappie had the highest W_i (43.40%) followed by Freshwater Drum 36.30%. Gizzard Shad (25%) and White Crappie (16.70%) followed Freshwater Drum (45.83%) in N_i. Unidentified fish (4.7%) and sunfish (3.13%) occurred in Flathead Catfish diets at low rates.

Total lengths at time of consumption were estimated for 144 prey items using measurements taken from 62 backbone to TL or standard length to TL measurements (Table 1). These relationships were then used to build the three quantile relationships between total prey length and Blue Catfish TL. Blue Catfish consumed prey with a mean TL of 220 mm (range = 89 to 387 mm). Outcomes of linear regression models

Table 2. Diet composition (percent occurrence [%O_i], percent by number [%N_i], and percent by weight [%W_i]) of prey groups in the stomach contents of Blue Catfish (N = 63) and Flathead Catfish (N = 16) sampled from Lake Ellsworth, Oklahoma, during February - March 2019.

Species	Prey Species	%O_i	%N_i	%W_i
Blue Catfish	Blue Catfish *Ictalurus furcatus*	1.90	1.10	0.32
	Channel Catfish *Ictalurus punctatus*	1.58	0.55	0.48
	Freshwater Drum *Aplodinotus grunniens*	13.02	19.23	13.65
	Gizzard Shad *Dorosoma cepedianum*	57.32	58.24	43.10
	Sunfish *Lepomis* sp.	1.58	2.20	0.89
	White Crappie *Pomoxis annularis*	27.76	18.68	41.58
Flathead Catfish	Freshwater Drum	49.70	45.83	36.30
	Gizzard Shad	14.40	25.00	16.50
	Sunfish	3.13	4.20	2.70
	White Crappie	21.90	16.70	43.40
	Unidentified fish	4.70	8.33	1.15

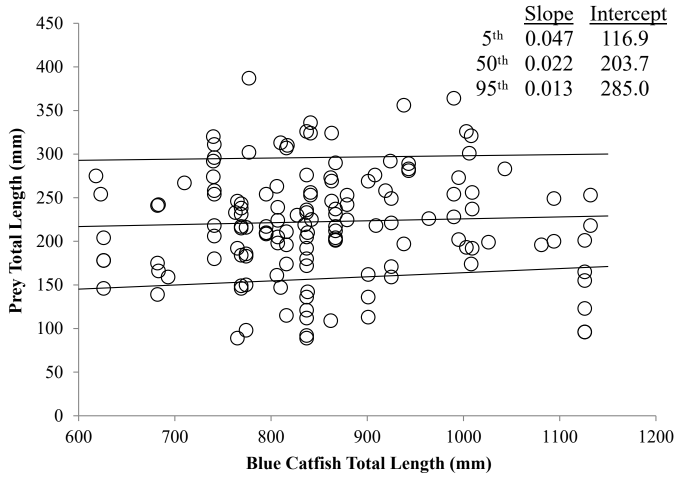

Figure 2. Quantile regressions representing the 5th, 50th, and 95th percentiles of TL of all prey sizes consumed by Blue Catfish ≥ 600 mm TL from Lake Ellsworth, Oklahoma. All prey TL were reconstructed from backbone/total length and standard length/total length linear relationships.

suggest that the 5th, 50th, and 95th quantiles of prey sizes consumed by Blue Catfish ≥ 600 mm were not significantly greater than zero (5th P = 0.31, 50th P = 0.68, and 95th P = 0.35; Figure 2). Further, we found no significant difference between the slope of prey size against Blue Catfish TL for the three quantile regressions ($F_{0.32,}$ df = 29, P = 0.73).

Discussion

The large (≥ 600mm TL) catfish collected during February and March 2019 in this study were exclusively piscivorous. This is consistent with the Flathead Catfish literature, which suggests that Flathead Catfish transition to piscivory when they are > 250mm TL (Turner and Summerfelt 1971, Layher and Boles 1980, Herndon and Waters 2002, Schmitt et al. 2017). Blue Catfish in this evaluation also only consumed fish. Blue Catfish are typically considered omnivores, consuming vegetation, mollusks, insects, crustaceans, and fish (Bonvechio et al. 2011, Hogberg and Pegg 2016, Schmitt et al. 2017, Jennings et al. 2018). Jennings et al. (2018) found that mussels, fish, and insects dominated diets of Blue Catfish during winter and spring in Lake Oconee, Georgia. Although our sampling also occurred in late winter and early spring, we found no evidence of invertebrate consumption by Blue Catfish in Lake Ellsworth. The differences in prey consumption between these studies may be related to the length distribution of Blue Catfish evaluated, which ranged from 150 to 1050 mm TL in Jennings et al. (2018), and diets were not presented by fish length groups. Conversely, Bonvechio et al. (2011) found that Blue Catfish ≥ 600 mm TL consumed mussels (50% by occurrence) and fish were present in 25% of the diets, although only nine fish of this size class were evaluated and the sample was collected during summer. Blue Catfish experience diet shifts throughout the year (Jennings et al. 2018), which could explain the lack of invertebrates in diets from Lake Ellsworth. However, Schmitt et al. (2017) found as Blue Catfish size increased the occurrence of fish in their diets also increased.

Differences in habitat and foraging behavior between the two catfish species may explain variations in diet observed in this study. Although, the prey types consumed by Blue Catfish and Flathead catfish were similar, Flathead Catfish consumed Freshwater Drum at a higher rate. Turner and Summerfelt (1971) found Freshwater Drum to be the second most preferred prey species in an evaluation of Flathead Catfish diets in six Oklahoma reservoirs. Turner and Summerfelt (1971) speculated that the benthic habitat preference of these two species resulted in niche overlap, which resulted in the consumption of Freshwater Drum by Flathead Catfish. Our observation of Flathead Catfish being caught consistently within 1 m of the bottom of the net supports the findings of Turner and Summerfelt (1971). Conversely, Blue Catfish were often captured in the top half off the gill nets. In reservoirs, Blue Catfish prefer open water habitats. Shifts in habitat use occur seasonally when Blue Catfish reside in upper ends of reservoirs during summer, and move to the lower portion of reservoirs as water temperatures cool in the fall (Graham 1999, Grist 2002). Gizzard Shad also return to deeper water in the lower end of reservoirs in the fall when water temperature decreases (Porath 2006, Jennings et al. 2018), allowing for habitat overlap between these species that may be driving higher consumption rates of Gizzard Shad by Blue Catfish.

The large catfish captured and evaluated for diet consumed a substantial biomass of fish prey. Little is known about how these large bodied catfish influence fish communities in Oklahoma reservoirs. Where Flathead Catfish are invasive, food web simulation modeling suggests that Flathead Catfish can reduce native species biomass by 50% (Pine et al. 2007). Blue Catfish are considered generalists that can adapt to a wide range of habitats and prey resources, so they may compete with native species without directly consuming them (Schmitt et al. 2017). However, large Blue Catfish appear to be more piscivorous as their size increases (Schmitt et al. 2017). Although our sample size of Blue Catfish used for diet analysis was fairly small (63), they consumed 15.8 kg of fish. For example, White Crappie comprised 42% of Blue Catfish diets by weight, however they only made up 18.7% of the sample by number. This finding makes us curious about the impacts that large catfish have on shaping fish communities in Oklahoma reservoirs and is a need for further research.

Although we were not able to construct quantile regressions relating prey size to Flathead Catfish TL because samples sizes were low due to regurgitation, previous research suggests that Flathead Catfish are not gape limited and can eat prey of almost any size (Slaughter and Jacobson 2008). For example, the world record Flathead Catfish (1549.54 mm TL) caught in Elk City Reservoir, Kansas contained a 711.2 mm TL Bigmouth Buffalo, which was 46% of the Flathead Catfish TL (Neely and Lynott 2016). The quantile regressions suggests that once Blue Catfish reach ≥ 600 mm they consume similar sized prey as the largest fish found in the sample. However, we could not find anything in the literature to compare our results, so this could be specific to Lake Ellsworth. Size structure of Blue Catfish in Lake Ellsworth is considered slow growing and maximum growth potential is smaller when compared to other reservoirs in Oklahoma (Boxrucker and Kuklinski 2006, Cofer 2011). Diet studies from other reservoirs in Oklahoma with a large Blue Catfish size structure would help to gain a better understanding of predator-prey dynamics.

We used gillnets (set overnight) to capture Blue Catfish and Flathead catfish for diet analysis. However, Bowen (1996) suggests that this technique could result in loss of diet items through regurgitation caused by capture stress. It was apparent to us that Flathead Catfish were regurgitating at high rates. Upon dissection we found that their swim bladders were inflated (likely from lifting fish in gillnets out of deep water), which pushed the stomach and contents out of most fish, and in some cases, the stomach was observed inverted in the mouths of fish. To avoid fish regurgitating, Bowen (2006) recommends setting gillnets for a shorter amount of time or using trammel nets. However, we did not observe the same effect on Blue Catfish, as only 23% of fish had empty stomach, which was similar to empty stomach rates in other studies (Bonvechio et al. 2011, Schmitt et al. 2017, Jennings et al. 2018). Jennings et al. (2018) speculated that using gillnets during warmer months influenced the number of Blue Catfish containing stomach contents. The use of gillnets is a potential bias in our study, however electrofishing is not effective during wintertime (Bodine and Shoup 2010), does not capture many large catfish (≥ 762 mm; Boxrucker and Kuklinski 2006), and could therefore be equally biased, just in different ways. Gillnets were our only option to describe winter catfish diets for large individuals. However, comparison of our results with diet studies collected by electrofishing should be made with caution given the possibility of different biases related to gears.

Our results describe the diet composition of large Blue Catfish and Flathead Catfish from a single Oklahoma Reservoir. This improves our knowledge regarding the diets of large catfish in Oklahoma, which was previously not well understood. Large Blue Catfish may have the potential to consume a large biomass of fish prey (250.4 g/fish). If the current ODWC Blue Catfish regulation (harvest of one fish ≥762 mm) is effective at increasing the number of large catfish in Oklahoma reservoirs, our results suggest that they may shape the fish communities through predation. Further research should expand diet analysis across several Oklahoma reservoirs and other times of the year to better understand seasonal and size structure effects, predator-prey relationships, ontogenetic shifts, and prey selectivity of large catfishes. Also, a multiple gear approach may be necessary to fully describe catfish diets, as a single gear type is not effective at collecting catfish across seasons.

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