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Supplemental data on the diet of the longnose dace *Rhinichthys cataractae* (Valenciennes) in Illinois

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ABSTRACT

The longnose dace *Rhinichthys cataractae* (Valenciennes) is a small, elongated, slightly dorsoventrally compressed minnow that possesses the widest distribution of any North American cyprinid. We repeated sampling methods used at three sites by a previous study to support or refute those previous data that suggest that longnose dace may also be herbivorous. Our stable isotope analysis results reported here show the diet of *R. cataractae* to be highly variable and that plant matter or primary producers in stream ecosystems may be consumed by the species.

INTRODUCTION

The longnose dace *Rhinichthys cataractae* (Valenciennes) is a small minnow (Cyprinidae) that is elongated and slightly compressed (figure 1). Within Illinois, this species has been found only in a few of the streams of the Wisconsin Driftless Area in Jo Daviess and Carroll counties (Figure 2) and along the shores of Lake Michigan in Cook and Lake counties. Individuals occupy gravel/cobble riffles in small- to medium-sized cool-water streams and in the wave swept shallows of the Great Lakes (Smith, 1979; Becker, 1983). The dace is currently listed in the Illinois Wildlife Action Plan as a species in greatest need of conservation.

Previous dietary analysis (Gibbons and Gee, 1972; Pappantoniou and Dale, 1982) of the blacknose dace showed that their major food source was Hydropsychid larvae and other macroinvertebrates, however, little was known about the diet of *R. cataractae* in Illinois. To address that deficiency, the Illinois Department of Conservation (Tiemann et al. 2009) funded a study to examine diet of the species in the Driftless Region of Illinois using stable isotopes (Tiemann et al. 2009). That study suggested that plant matter in the form of periphyton

comprised almost half of the diet of longnose dace in two of the three sampling locations. Since Tiemann et al. (2009) used dace samples collected from two sites in early summer and one site in early fall, the objective of this study is to supplement the data of Tiemann et al. (2009). We use an additional sample for stable isotope analysis collected from the same three sampling sites of Tiemann et al. (2009) made during the same time of the year.

Stable isotope ratios of consumers reflect the isotope ratios of all food sources assimilated and ratios of carbon (C) and nitrogen (N) isotopes in animal tissue can aid in analyzing food web connections and food sources over days, week, or months (Peterson and Fry, 1987; Stenroth et al., 2006). This approach offers a much more robust view of the diet of an organism compared to the traditional method of gut-content analysis which contains only a "snap-shot" of information from the previous 12-24 hours.

METHODOLOGY

Fish sampling – Three sites were sampled in the streams within the Driftless Area on 19 September 2010. The three sites were as follows: 1) WI: Lafayette County, Shullsburg Branch (Galena River Drainage), N42.56964 W90.30843; 2) WI: Grant County (Grant River Drainage), Boice Creek, N42.72964 W90.75871; 3) IL: Carroll County, Camp Creek (Plum River Drainage), N42.14525 W90.12274. Sites were selected based on previous isotope studies (see Tiemann et al. 2009).

Stable isotope analyses of *Rhinichthys* and potential dietary components were conducted at three sites to determine isotopic signatures of each group. Potential dietary components sampled at each site included dominate macroinvertebrates at each site, leaf litter, fine particulate organic matter (FPOM) and periphyton. A top level fish predator (e.g., family Centrarchidae)

was also collected at each site. Fishes were collected for 45 minutes using a barge electro-shocker set at 200 volts. Muscle tissue taken from the caudal peduncle region fishes of each site was used for isotope analysis. For invertebrates, whole bodies were used; given their small size, generally five individuals of each species were combined into single samples to meet the 1 mg dry weight requirement for N and C isotope analysis. Fine particulate organic matter samples were vacuum-filtered through 1.5 μm glass microfiber filters (Whatman 934-AH). Leaf litter, periphyton, and FPOM samples were placed in a desiccator with a beaker containing 100 ml hydrochloric acid for six hours to remove inorganic carbonates. All sample types were dried at 55° C for 48 h and then ground with mortar and pestle. Samples were then packed into individual tin capsules and sent to the University of California at Davis Stable Isotope Lab for nitrogen and carbon isotope analysis. Dual isotope analysis was conducted on a Europa Scientific Hydra 20/20 continuous flow isotope ratio mass spectrometer (CF-IRMS). Stable isotope ratios are expressed in _ notation as parts per thousand according to the following:

$$\_ X = [(Rsample / Rstandard)-1] \times 1000,$$

Where X = 15N or 13C, R = ratio, 15N/14N or 13C/12C. Rstandard for 15N is atmospheric nitrogen, and for 13C it is Pee Dee belemnite. Samples were also analyzed for total carbon and nitrogen.

Mixing Model - The mixing model IsoSource ® (Phillips and Gregg, 2003; available at http://www.epa.gov/epahome/Data.html) was used to model diet composition most likely to explain *Rhinicthys*'s stable isotope profiles. This mixing model was designed to be used when *n* isotopes are measured and more than *n*+1 sources may be contributing to the mixture (Phillips and Gregg, 2003), and has been shown to be useful for understanding food webs with multiple organic matter sources (Benstead et al., 2006). In this case, two isotopes (N and C) and five

potential sources were used. The five sources were: fish tissue of *Rhinicthys*, invertebrate tissue, FPOM, leaf litter, and periphyton. Source increment was set at 1% and tolerance was set at 0.1%. To normalize potential food items for trophic enrichment, a value of +3.4 was used for Δ15N (Minagawa and Wada, 1984) and +0.5 was used for Δ13C (France, 1996). In Isosource calculations, each individual fish was analyzed separately as a mixture, but the average corrected15N and 13C for all fish collected at a site was used as the value for fish as a food source. Percentages of source contributions to diet are presented as means of all iterations for an individual fish.

RESULTS

Nine longnose dace were analyzed for stable isotope signatures from Camp Creek and Shullsberg Branch while 11 individuals were analyzed from Boice Creek. Stable isotope analysis showed the diet of *R. cataractae* varied between the sampled sites (Table 1, figures 4-6). Other fish and macroinvertebrates were the dominant food sources across all sites. Periphyton was also a dominate food item (29%) at Shullsburg Branch. Macroinvertebrates (Hydrophychid caddisflies) accounted for about 26.4% of the average diet in 9 individuals from Shullsburg Branch, 30.4% in 9 individuals from Camp Creek, and 65.5% in 11 individuals from Boice Creek (Table 1, figures 4-6). Fish accounted for about 13.9% of the average diet in individuals from Shullsburg Branch, 37.3% in individuals from Camp Creek, and 22.4% in individuals from Boice Creek (Table 1, figures 4-6). Periphyton accounted for 29.0% of the mean diet of *R. cataractae* in Shullsburg Branch, 7.2 in Camp Creek, and 18.2% in Boice Creek (Table 1, figures 4-6). Leaf litter accounted for almost 21.1% of the mean diet of Shullsburg and less than10% for the other two sites (Table 1, figures 4-6). Fine particulate organic matter was highly variable across sites accounting for 16.3% of the diet at Camp Creek, 9.3% at Shullsburg Branch, and

0.6% at Boice Creek (Table 1, figures 4-6). Standard deviations around the mean values for food sources were generally higher at Boice and Camp creeks and low at Shullsburg Branch (Table 1).

DISCUSSION

Using data from single site visits, Tiemann et al. (2009) found that macroinvertebrates accounted for a significant portion (>20%) of the diet of longnose dace at two of their sampling sites (Boice and Camp creeks, Figs. 4B, 5B), thus partially supporting the results of previous studies (Gibbons and Gee, 1972; Pappantoniou and Dale, 1982). However, they also found that lower tropic level food items such as periphyton accounted for a larger portion of the longnose dace's diet at all three sites. While our results support both of those previous results, they also document other aspects of *R.cataractae* diet not seen in Tiemann et al. (2009). Results from 2010 samples showed that the consumption of the lowest level of production sampled by us (Fine Particulate Organic Matter) was high for the species at two sites. FPOM accounted from an average of 9% of the diet of longnose dace at Shullsburg Branch and 16% at Camp Creek. Our 2010 results also show that consumption of the highest trophic level food item analyzed by us in Isosource (fish tissue from other longnose dace collected at the site) was higher at two sites than in 2009. Fish accounted for an average of 14% of longnose dace diet at Shullsburg Branch and 22% at Boice Creek. Fish accounted for 37% of the diet of individuals collected at Camp Creek in 2010. However, a very high level of fish consumption by longnose at Camp Creek was also observed in 2009.

Predation on other fishes by longnose dace has not been reported in the literature and we are cautious about drawing firm conclusions from our data. We used other longnose dace as a representative of the stream communities with a higher trophic level than the dominate

macroinvertebrate found at each site (Hydropsychid caddisflly larvae). As Isosource predicts percent of diet of each sample type entered, as each of those sample types has a unique C and N signature. Our results indicate that fish make up a significant component of longnose dace diet at our sampling sites. An alternative is that another high trophic level stream community member not sampled by us are consumed by longnose dace. As an example, large predatory insects such as larval Odonates could be a prey item for dace.

A significant result of our 2010 samples, when coupled with those of Tiemann et al. (2009), is that the diet of the longnose dace is, at the very least, variable both within and between sites. Additionally, our findings support previous work that lower tropic level plant or organic matter makes up a significant portion of the species' diet. Periphyton/FPOM /leaf litter made up 60% of the diet of individuals at Shullsburg Branch, 33% at Camp Creek, and 12% at Boice Creek. At a minimum, the belief that longnose dace feed primarily on invertebrates can be challenged with our data and the species' impacts on stream food webs may warrant additional attention. Additional sampling is also necessary to determine more finite estimates of diet in the species given the amount of variation we report here.

ACKNOWLEDGEMENTS

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Table 1. Means and standard deviations of portion of diet for *Rhinichthys cataractae* from each sample site in September of 2010. Potential dietary components sampled included dominate macroinvertebrates at each site, other fish, leaf litter (LL), fine particulate organic matter (FPOM) and periphyton.

		Fish	Inverts	Periphyton	FPOM	LL
Shullsburg Br. *n*=11	Mean	0.139	0.264	0.290	0.093	0.211
	Std Dev	*0.016*	*0.026*	*0.027*	*0.010*	*0.041*
Camp Creek *n*=9	Mean	0.373	0.304	0.072	0.163	0.096
	Std Dev	*0.083*	*0.074*	*0.041*	*0.103*	*0.038*
Boice Creek *n*=11	Mean	0.224	0.655	0.082	0.006	0.027
	Std Dev	*0.107*	*0.155*	*0.039*	*0.007*	*0.021*

Figure 1. The longnose dace *Rhinichthys cataractae* (Valenciennes) (drawing by Joseph Tomelleri).

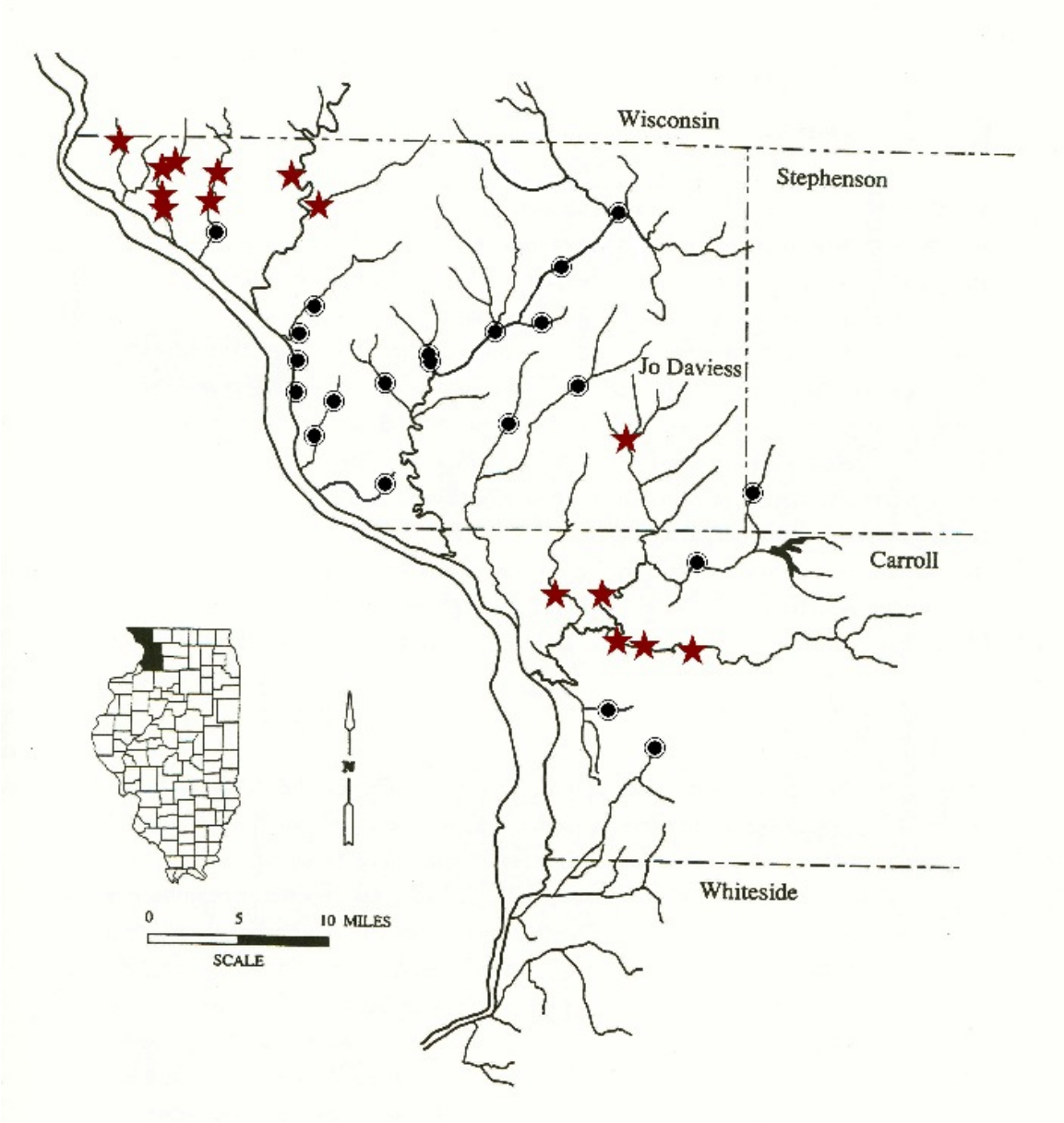
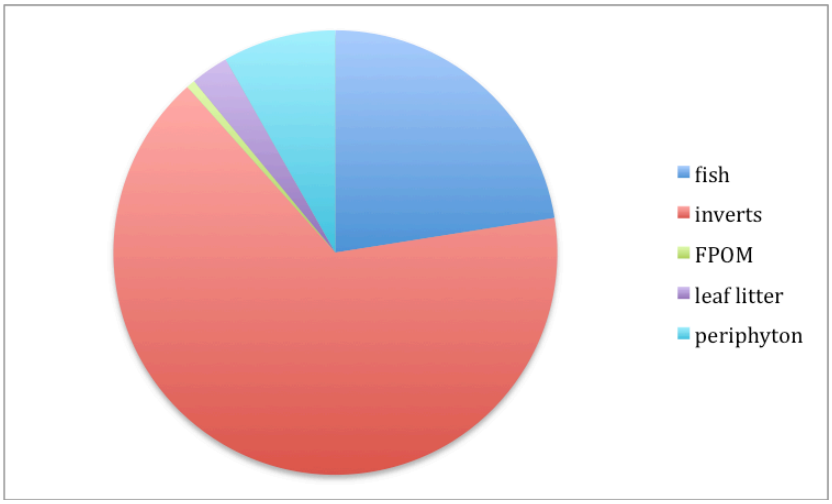


Figure 2. Map of the range of *Rhinichthys cataractae* in the Driftless Area of Illinois. Stars indicate sites where *R. cataractae* have been confirmed and circles designate those sites where the species was absent during Tiemann et al. (2009) surveys.



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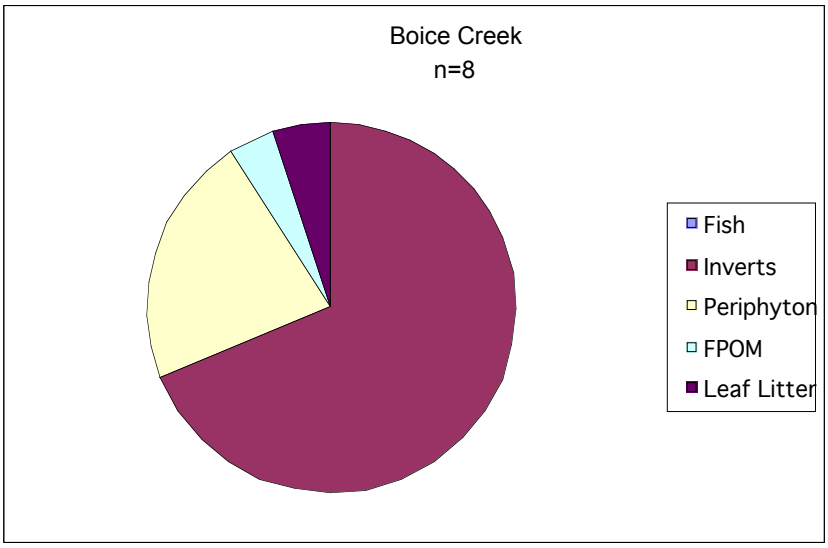
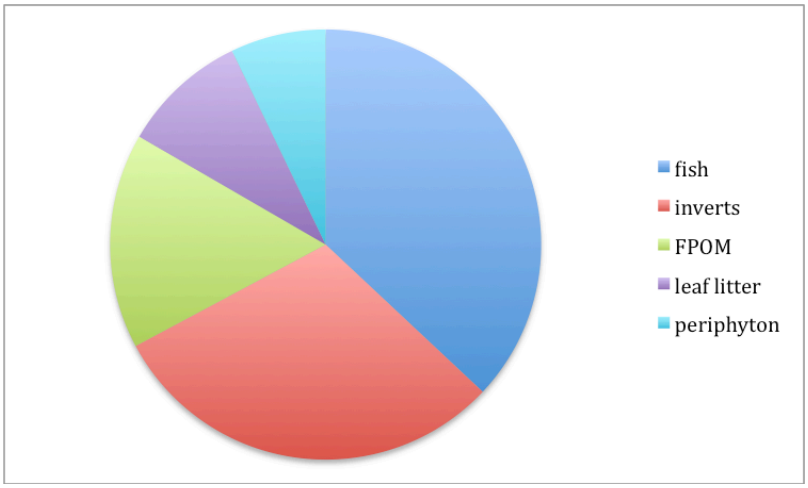


B.

Figure 4. A) Average contribution of diets items of *Rhinichthys cataractae* (*n* = 11) from Boice Creek, Grant County, WI, collected on 19 September 2010. **B)** Average contribution of diets items of longnose dace (*n* = 8) from Boice Creek, Grant County, WI, collected on 20 June 2008 (Tiemann et al. 2009).



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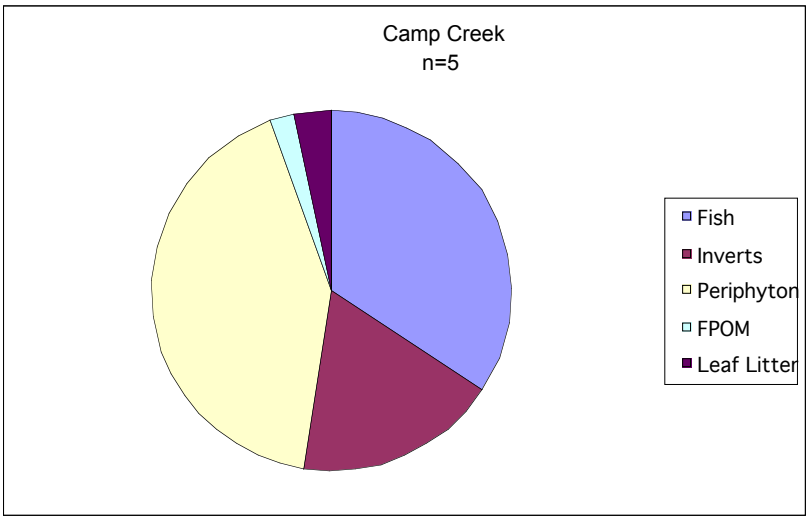
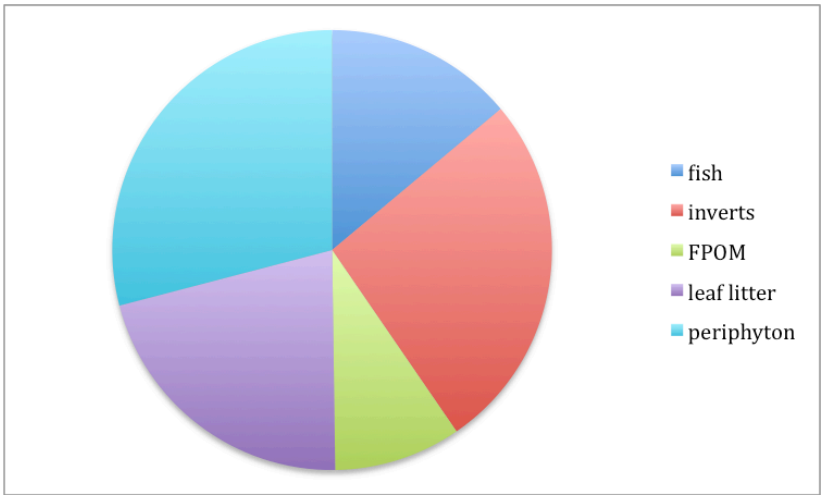


B.

Figure 5. A) Average contribution of diets items of *Rhinichthys cataractae* (*n*= 9) from Camp Creek, Carroll County, IL, collected on 19 September 2010. **B)** Average contribution of diets items of longnose dace (n= 5) from Camp Creek, Carroll County, IL, collected on 18 June 2008 (Tiemann et al. 2009).



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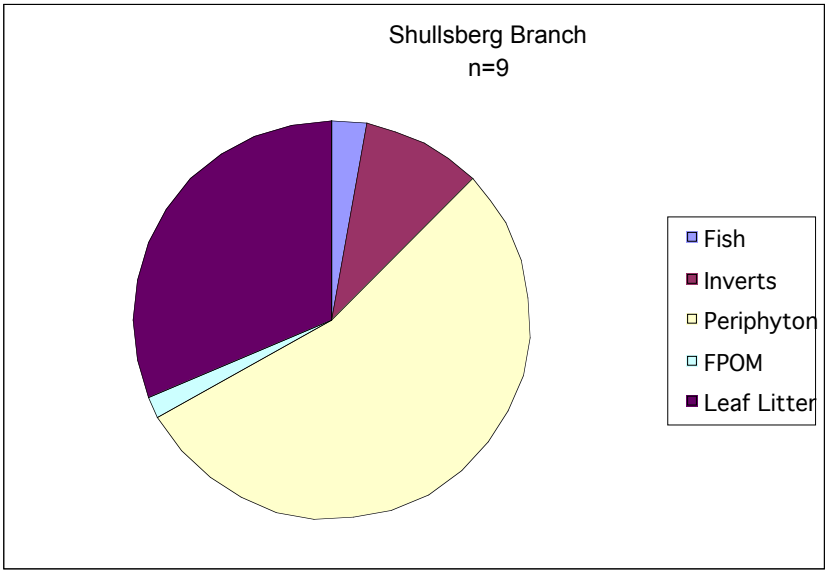

B.

Figure 6. A) Average contribution of diets items of *Rhinichthys cataractae* ($n = 9$) from Shullsburg Branch, Lafayette County, WI, collected on 19 September 2010. **B)** Average contribution of diets items of longnose dace ($n = 9$) from Shullsburg Branch, Lafayette County, WI, collected on 2 September 2008 (Tiemann et al. 2009).