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## Diet of Western Slimy Salamander, *Plethodon albagula* (Caudata: Plethodontidae), from Two Mountain Ranges in Arkansas

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**Abstract** - We identified stomach contents of 80 *Plethodon albagula* (Western Slimy Salamander) from two mountain ranges in Arkansas (Ozark and Ouachita) to examine if regional differences in diet occur. Museum specimens from 1985 to 2005 were used from locations throughout each mountain range. Although a wide variety of prey were found in stomachs, Hymenoptera: Formicidae and Coleoptera: Carabidae were found to be the most important food items in the diet of *P. albagula*. Ants and beetles constituted 85% abundance of their total diet (79.6% Ozark and 90.1% Ouachita) and 52.2% of their total biomass (42.6% Ozark and 64.1% Ouachita). Seventy-eight and 87% of individuals examined from the Ozark and Ouachita Mountains, respectively, consumed ants (65% total, 83% for animals with food items in their stomachs), whereas 55% in the Ozarks and 58% in the Ouachitas consumed at least one family of beetle. Occurrence and biomass of prey items that did not include ants and beetles showed *P. albagula* to be a euryphagic predator, with 9.7% of diet being comprised of other prey types (27.3% biomass). Furthermore, importance values indicate ants were the most important prey item for *P. albagula* in both the Ozark and Ouachita samples, with carabid beetles (Ozark) and all beetles (Ouachita) being second most important. Jaccard Index indicated Ozark and Ouachita specimens shared 80% similarity in diet. Our data suggest *P. albagula* in Arkansas have high dependence upon ants and beetles, yet appears to be an opportunistic and euryphagic predator.

### Introduction

The Ozark and Ouachita Mountains of Arkansas are two distinct and dissimilar regions. The Ozark Mountains in northern Arkansas underwent a series of uplifting and eroding events, creating plateaus of horizontal layers consisting of sandstone, shale, and limestone. The Ouachita Mountains in southern Arkansas were formed by folding and faulting events, creating long parallel ridges consisting primarily of sandstone, shale, and chert (Smith et al. 1984). The Arkansas Valley is an intermediary zone between the two mountain ranges and acts as a natural separation of the two regions, which collectively are considered the Interior Highlands. One difference between these regions can be seen in flora and fauna. The Ozark Mountains are primarily oak-hickory forests and contain cave-dwelling vertebrate and invertebrate species (Robison and Allen 1995, Smith et al. 1984). In

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contrast, the Ouachita Mountains are dominated by oak-pine forest habitat and are much drier when compared to the Ozark Mountains. Both regions contain vertebrates and invertebrates endemic to Arkansas (Robison and Allen 1995), and the Ouachita region is home to three endemic salamander species not found in the Ozarks (Smith et al. 1984, Trauth et al. 2004). The disparity in habitat between these two regions led us to question if there are differences between diets of *Plethodon* that occur in both mountain ranges.

We examined *Plethodon albagula* Grobman (Western Slimy Salamander), a large woodland salamander common in parts of Texas and throughout the Interior Highlands of Arkansas, Oklahoma, and Missouri (Baird et al. 2006, Conant and Collins 1998, Trauth et al. 2004). Diet studies throughout North America have been performed on or included *P. glutinosus* Green (Slimy Salamander) (Britton 1981, Davidson 1956, Hamilton 1932, Jensen and Whiles 2000, Powders and Tietjen 1974), the sister species of *P. albagula* (Highton et al. 1989); however, few studies have examined the diet of *P. albagula*. Oliver (1967), Britton (1981), and Crowell (1981) conducted diet analysis on *P. glutinosus* (currently *P. albagula*) from central Texas and northwest Arkansas, but these studies were limited to specific localities and covered few counties of *P. albagula*'s range. Our study investigated the diet of *P. albagula* across two ecoregions and covered the majority of its range. Our goal was to quantify gut contents of *P. albagula*, an abundant salamander within both the Ozark and Ouachita Mountains of Arkansas (Trauth et al. 2004), and assess differences between populations in the two ecoregions.

### Materials and Methods

Using museum specimens from the Arkansas State University herpetological collection (ASUHC), we examined the stomach contents of 40 *P. albagula* from the Ozark Mountains and 40 individuals from the Ouachita Mountains. Collection dates ranged from 30 October 1985 to 17 September 2005 and were primarily during spring and fall months ( $n = 58$  in March, April, and May;  $n = 20$  in September, October, and November; and  $n = 2$  in December, January, and February). Samples represented the entire range of *P. albagula* in Arkansas and included 18 counties.

Salamanders were sacrificed using a 20% chloretoe solution, fixed in 10% formalin, and stored in 70% ethanol within 48 h of capture (only specimens preserved by S.E. Trauth were used to minimize variability of preservation techniques). For each specimen, we measured snout-vent length (SVL) using a ruler, determined sex (when  $SVL > 50$  mm) by locating testes or ovaries, and recorded season of capture. Stomachs were dissected and placed in 70% ethanol until contents were identified. Gut contents were identified, if an entire organism or a head alone were present, to the lowest possible taxon (Triplehorn and Johnson 2005). Prey items were totaled for both the Ozark and Ouachita specimens to determine abundance (total number of prey) and frequency (number of animals which consumed each prey item) of prey. Biomass (volume of prey item) was estimated by measuring maximum width



(widest lateral points) and length (widest anterior to posterior points) for some prey items using a dissection microscope. Volume ( $\text{mm}^3$ ) was estimated as a cylinder using length as the axis and width as the diameter (Maerz et al. 2005). Whenever possible, volume was estimated for up to five individuals from each family, and a mean volume was used to calculate biomass. Due to the limited number of whole-body specimens for some prey families, biomass could not be estimated for eight families. Biomass estimates were used to assess the extent to which each prey item could be used for caloric intake.

To compare the importance of prey items between the two regions, importance values (Anderson and Mathis 1999, Powell et al. 1990) were calculated for each prey taxon where volume could be determined. Importance values ( $I_x$ ) were calculated using the equation:

$$I_x = [(n_x/N) + (v_x/V) + (f_x/F)]/3,$$

where  $n_x$ ,  $v_x$ , and  $f_x$  are the number, volume, and frequency of prey item  $x$ , and  $N$ ,  $V$ , and  $F$  are the summations of the number, volume, and frequency of all prey items, respectively. Importance values range between 1 and 0 and represent the relative importance of a single prey taxon in the entire diet. Jaccard's index of similarity (Jaccard 1912) was calculated between the Ozark and Ouachita diet samples. The Jaccard index (JI) produces a value in the form of a percentage, which represents the degree to which two samples are similar. JI values were calculated using the equation:

$$JI = j/r * 100,$$

where  $j$  is the number of taxa found in both samples, and  $r$  is the number of taxa found in one sample or the other.

## Results

For specimens examined, SVL ranged from 30 to 75 mm (mean  $\pm$  SD = 58.9  $\pm$  9.4). Ozark specimens ranged from 39 to 72 mm SVL (mean  $\pm$  SD = 59.3  $\pm$  7.2 mm), whereas Ouachita specimens ranged from 30 to 75 mm SVL (mean  $\pm$  SD = 58.4  $\pm$  11.3). The Ozark sample included 21 females, 14 males, and 5 juveniles; the Ouachita sample included 18 males, 14 females, and 8 juveniles. Seventeen specimens (21%) had empty stomachs (8 Ozark, 9 Ouachita) and were omitted from further analysis.

In total, 538 prey items were identified (186 in Ozark and 352 in Ouachita samples) from 18 different prey taxa. Gut contents consisted primarily of hymenopteran and coleopteran prey, particularly ants of the subfamilies Myrmicinae and Formicinae (Fig. 1). Overall, ants comprised the majority of prey items in terms of abundance, frequency, and biomass (Fig. 1). Ants were found in 83% of stomachs that contained food items (78% in Ozark and 88% in Ouachita). They accounted for 82% of abundance (70% in Ozark and 88% in Ouachita) of prey items and 34% of total biomass. In both ecoregions, beetles were found to be the second-most frequently consumed prey (Fig. 1), with carabid beetles being the most frequent coleopteran prey item consumed.

Ranked importance values indicated that ants were the dominant prey category for both the Ozark and Ouachita samples (Table 1). For the Ozark samples, the importance value for ants was about three times greater than the next-most important prey categories, carabid beetles and all beetles combined (Table 1). All other prey items were less important than both ants and beetles

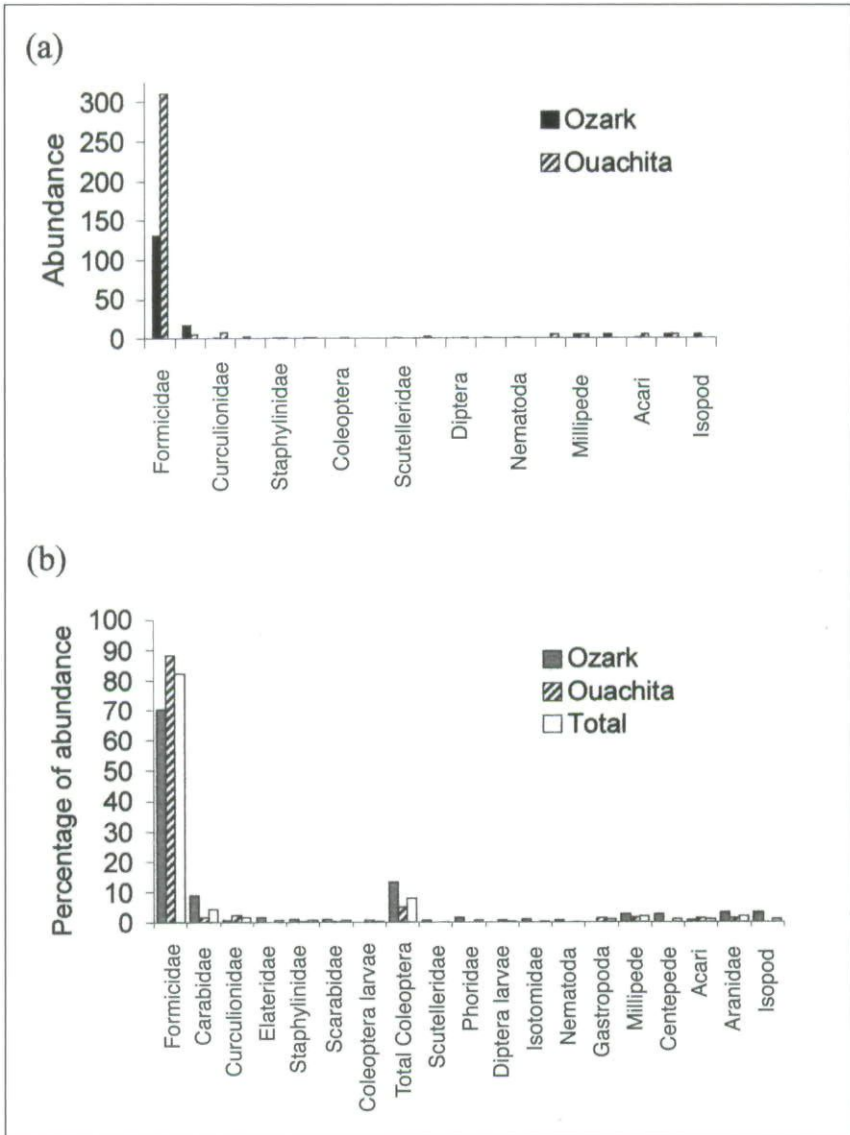
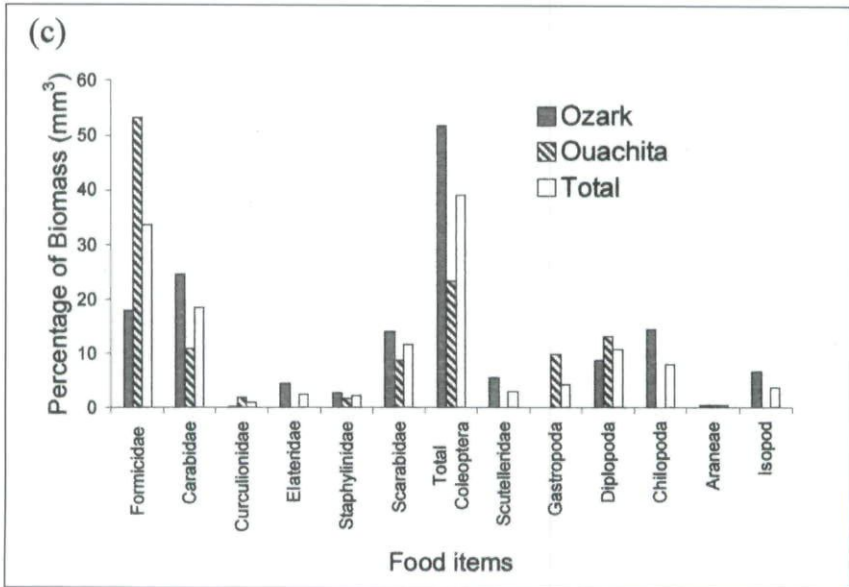


Figure 1 (above and opposite page). (a) Abundance, (b) percentage of total food items, and (c) percent of biomass of food items found in *P. albagula* stomachs (n = 32 in Ozarks, n = 31 in Ouachitas). Individuals with empty stomachs were not included in analysis.

(IV range from 0.008 to 0.07; Table 1). The importance value for ants in the Ouachita specimens was nearly five times greater than that for all beetles combined (0.14). The Jaccard Index indicated an 80% similarity between diets of Ozark and Ouachita salamanders.

Table 1. Importance values (IV) for *P. albagula* in Arkansas. In parentheses, total number of prey, total volume of prey (ml), and frequency of each prey type, respectively.

Prey taxon	Ozark	Ouachita
Hymenoptera		
Formicidae	0.44 (131 / 0.57 / 25)	0.64 (311 / 1.36 / 27)
Coleoptera		
Total Coleoptera	0.16 (26 / 0.29 / 14)	0.14 (16 / 0.33 / 13)
Carabidae	0.18 (17 / 0.79 / 11)	0.07 (6 / 0.28 / 5)
Curculionidae	0.008 (1 / 0.01 / 1)	0.05 (8 / 0.05 / 6)
Elateridae	0.03 (3 / 0.14 / 2)	-
Staphylinidae	0.02 (2 / 0.09 / 2)	0.01 (1 / 0.04 / 1)
Scarabidae	0.06 (2 / 0.45 / 2)	0.04 (1 / 0.22 / 1)
Hemiptera		
Scutelleridae	0.03 (1 / 0.18 / 1)	-
Gastropoda	-	0.06 (5 / 0.25 / 3)
Diplopoda	0.06 (5 / 0.28 / 4)	0.07 (6 / 0.33 / 4)
Chilopoda	0.07 (5 / 0.46 / 3)	0.08 (5 / 0.46 / 3)
Araneae	0.04 (6 / 0.02 / 4)	0.03 (5 / 0.01 / 4)
Isopoda	0.05 (6 / 0.21 / 2)	0.01 (2 / 0.08 / 2)





### Discussion

The euryphagic diet of *P. albagula* is consistent with other *Plethodon*, including *P. glutinosus* (in some regions currently *P. albagula*: Altig and Brodie 1971, Britton 1981, Crowell 1981, Davidson 1956, Hamilton 1932, Jensen and Whiles 2000, Oliver 1967, Powders and Tietjen 1974, Whitaker and Rubin 1971, Wilson and Larsen 1988). Although the importance of ants and beetles has been shown in *Plethodon cinereus* Green (Redback Salamander) (Hamilton 1932), *Plethodon jordani metcalfi* Brimley (Southern Grey-cheeked Salamander), *Plethodon jordani shermani* Stejneger (Red-legged Salamander) (Whitaker and Rubin 1971), and *P. glutinosus* (Britton 1981, Davidson 1956, Jensen and Whiles 2000, Pope 1950, Powders and Tietjen 1974), no prior study has found such a significant consumption of ants by *Plethodon*. For example, the next-highest frequency and abundance of ants found in any large *Plethodon* diet samples were found by Powders and Tietjen (1974) and Davidson (1956), respectively, for *P. glutinosus*. Remaining studies on large *Plethodon* show ants range from 2 to 80% by frequency and 1 to 37% by abundance (Altig and Brodie 1971, Crowell 1981, Jensen and Whiles 2000, Pope 1950, Powders and Tietjen 1974, Reagan 1972, Whitaker and Rubin 1971, Wilson and Larsen 1988). Britton (1981) found ants in nearly 80% of *P. albagula* (formerly *P. glutinosus*) stomachs from northwest Arkansas, but ants combined for only 38% of total prey items found in hillside specimens. Crowell (1981) found ants were 23% (abundance) of all prey items and were found in 41% of the samples. Davidson (1956) found ants in 73% of *P. glutinosus* specimens, but they combined for only 42% of abundance.

With respect to beetles and other large *Plethodon*, frequency ranged from 13 to 80% and abundance from 5 to 26% (Altig and Brodie 1971, Crowell 1981, Jensen and Whiles 2000, Pope 1950, Powders and Tietjen 1974, Reagan 1972, Whitaker and Rubin 1971, Wilson and Larsen 1988). The highest abundance and frequency of beetles was found by Davidson (1956) for *P. glutinosus* and Oliver (1967) for *P. g. albagula*, respectively. Crowell (1981) found beetles in 80% of *P. albagula* stomachs, but they only amounted to 9% of total abundance, while Oliver (1967) found 64% frequency and 39% abundance of ants and 8% frequency and abundance for beetles in *P. g. albagula*. For *P. albagula* (formerly *P. glutinosus*) in Arkansas, Diptera were found to be more important than ants and beetles in other studies (38% abundance, 57% frequency; Crowell 1981).

Our data show ants and beetles to be the most consumed prey of *P. albagula* across Arkansas. One possibility for our findings is a difference between time since capture and sacrifice between our study and others, as chitinous prey (such as ants and beetles) are likely to take longer to digest and thus can appear to be a more common prey in diet samples. In comparable studies this time period ranged from immediately to 12 h after capture, while in our study the majority of animals were sacrificed within 24 hrs, although they were kept cool up until death, which limits digestion considerably.

The comparison of diet between the Ozark and Ouachita regions revealed differences in the importance of some individual taxa, but overall similarity of taxa preyed upon. Britton (1981) showed a relationship between availability of prey and prey selection in *P. glutinosus* (currently *P. albagula*) in Arkansas and found a disparity in diet composition between two different microhabitats. *Plethodon glutinosus* inhabiting hillside and seepage microhabitats fed on prey items that were found in higher abundance in those areas, suggesting this species is an opportunistic predator and highlighting differences in prey consumption among microhabitats. In this study, importance values confirmed the dominance of ants and beetles in the diet of *P. albagula* inhabiting both the Ozark and Ouachita Mountains. Ants were a more important prey item for salamanders inhabiting the Ouachita Mountains when compared to the Ozark Mountains. Overall, the importance of ants and beetles, and the similarity among importance values and regions (JI = 80%) for the remaining prey items, was comparable for *P. albagula* across Arkansas. This indicates that regional differences in diet exist on a fine scale, but become less important as the range of investigation increases.

Our study revealed slight variations in diet between *P. albagula* from the Ozark and Ouachita mountain ranges in Arkansas; however, throughout much of its range, abundance, frequency, biomass, and importance of prey appear to be similar. Therefore, although variation in diet composition may exist for *P. albagula* among microhabitats, differences appear to be smaller as the scales increases. Specific microhabitat differences in prey selection by *P. albagula*, and possibly many large *Plethodon*, appear to combine on a larger scale to lessen specific differences.

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