

ECOMORPHOLOGY OF LIZARDS IN THE GENUS DICRODON

A Senior Scholars Thesis

by

DONALD WAYNE HARDEMAN JR.

Submitted to the Office of Undergraduate Research
Texas A&M University
in partial fulfillment of the requirements for the designation as

UNDERGRADUATE RESEARCH SCHOLAR

April 2010

Major: Wildlife & Fisheries Sciences

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ABSTRACT

Ecomorphology of Lizards in the Genus *Dicrodon*. (April 2010)

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Ecological theory suggests morphology should be linked to foraging mode and strategy. This study was conducted to determine the possible relationship between morphology and diet of a monophyletic group of lizards in the genus *Dicrodon*. Field anecdotes indicate two of the three species are herbivorous and arboreal, while the third is an insectivorous species found in the coastal deserts of Peru. We tested for differences in morphology among the three species using an Analysis of Covariance, while dietary data was tabulated and frequency of occurrence and percent composition was calculated for stomach contents. Our results confirmed *D. heterolepis* is in fact an insectivorous species with the potential to be a generalist, whereas, *D. holmbergi* and *D. guttulatum* are herbivorous. Theory predicts morphological differences should exist in correspondence with major dietary modes. Our morphological analyses showed the herbivorous species were very similar in body plan, and the insectivore had relatively larger head and front limbs.

ACKNOWLEDGMENTS

Sincere thanks goes to Dr. Lee A. Fitzgerald for collaborating on the idea for this project and to both him and his lab associates for their work in the lab and intellectual input while conducting this research. We would also like to thank Dr. Mary Wicksten for her assistance in identifying our insect samples. Special thanks to Dr. J.R. Dixon and the Texas Cooperative Wildlife Collection and the Natural History Museum of Los Angeles County for allowing the use of their specimens.

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CHAPTER I

INTRODUCTION

Employing a successful foraging strategy and subsequently obtaining adequate nutrition for survival is one of the most fundamental challenges affecting fitness (Cooper & Vitt, 2002). Optimal foraging theory states that a species' choice of food would be such that maximizes its energy intake, while minimizing the amount of time and energy spent foraging (MacArthur & Pianka, 1966; Pyke et al., 1977). Furthermore, ecological theory suggests morphology should be linked to foraging mode and strategy. Therefore, morphological traits should correspond to a major foraging mode, such as, active or sit-and-wait foraging. An active forager could potentially survive better in an open habitat where obstacles do not impede its movements, whereas, a sit-and-wait forager may prefer an environment that provides not only an abundant food source, but shelter from predators (Germano et al., 2007). Although optimal foraging theory has been studied and applied to numerous species, there is still little information regarding the evolutionary history of diets in most taxa (Cooper & Vitt, 2002). Most lizards are predators, consuming small animals and rarely plant material, but there are exceptions (Cooper & Vitt, 2002). Although about 3% of all lizard species are estimated to be herbivores (Iverson, 1982), no comprehensive literature has been published to determine the degree of plant consumption (Cooper & Vitt, 2002). Cooper & Vitt (2002) suggest ecological

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factors could be integral in determining shifts to plant consumption by lizards because omnivory and herbivory occurs within several families that consist primarily or exclusively of carnivorous species. This is illustrated in their study of plant consumption in lizards, where they determined that the proportion of omnivorous or herbivorous species in the family Teiidae, a family consisting primarily of carnivorous species, is 14.29%. Rand (1978) and Perez-Mellado & Corti (1993) proposed that the occupation of habitats with restricted availability of prey could cause the evolution of herbivory in a species.

Since their discovery, little research has been conducted exclusively on the Genus *Dicrodon*. We have virtually no documented information concerning their feeding ecology, behavior, reproduction, distribution, evolution, etc. Therefore, determining the diet of these three species will allow for a better understanding of their natural history of which little is known, as well as, play an intricate role in understanding the trophic levels each species occupies and the structure of habitat necessary for its survival (Germano et al., 2007).

Obtaining quantitative dietary information from literature widely scattered and in different languages has impeded the investigations of herbivory in lizards (Cooper & Vitt, 2002). Therefore, numerous hypotheses about the importance of lizard diets, its evolution, and about relationships between, plant consumption, ecological factors, and

phylogeny have remained unanswered. Since field anecdotes state *Dicrodon holmbergi* and *Dicrodon guttulatum* are said to be herbivorous, conclusively determining their validity will not only allow for a better understanding of the natural history of this genus of teiid lizards, but it will allow us to start asking questions about the evolution of plant consumption and the ecological factors that potentially make this the dominant foraging mode in the Genus *Dicrodon*.

This study was conducted to determine the possible relationship between morphology and diet in a monophyletic group of teiid lizards in the Genus *Dicrodon*. Two of three species are known to be arboreal, while the third species occurs in the coastal deserts of western South America. Field anecdotes indicate *Dicrodon guttulatum* and *Dicrodon holmbergi* are herbivorous *Dicrodon heterolepis* is insectivorous, but the diet of these lizards has never been heavily studied. The two principal objectives of this particular research were as follows:

- Quantify the diet of all three species.
- Quantify morphological traits presumed important for a successful foraging strategy and compare them between the three species.

CHAPTER II

METHODS

To quantify the morphological differences among the three species, alcohol-preserved specimens were obtained from the Texas Cooperative Wildlife Collection and the Natural History Museum of Los Angeles County (*D.heterolepis*, $n=94$; *D. holmbergi*, $n=51$; *D. guttulatum*, $n=38$). Digital calipers were used to measure twenty-one of the twenty-two different morphological characters (0.01 mm). Due to the length of the lizards, total tail length was taken using measuring tape. From the morphological measurement taken, we focused on five morphological characters perceived important to understanding foraging mode and strategy: Head length (HL, mm), Head width (HW, mm), Head depth (HD, mm), Front limb span (FLS, mm), and Hind limb span (HLS, mm; includes pelvic region). All morphological data was log-transformed to homogenize variances between morphological characters and meet assumptions of normality. Log-transformed data was analyzed using an Analysis of Covariance to test for relationships between Snout-vent length, head size (HL, HW, HD) and limb span (FLS, HLS) of the three species. As part of the data collection we determined the sex of each lizard by documenting the presence or absence of either testes or ovaries. Specimens whose genitalia were not as developed were deemed juveniles.

We dissected 183 individuals, making a u-shaped incision around the abdomen, excising the entire gastrointestinal tract of each lizard, and placing their stomachs into 70% ethanol until further examination. For *D. heterolepis*, frequency of occurrence (the total

number of *Dicrodon* with a particular prey taxon in their stomach) and percent composition (total number of prey belonging to a particular taxon) were calculated and prey items were identified to taxonomic order (family level where possible) following Triplehorn and Johnson (2005) and Zug et al., (2001). Data gathered from *D. holmbergi* and *D. guttulatum* was tabulated and frequency of occurrence for each type of dietary item was calculated. The methods of data collection were based on similar dietary studies conducted by Leavitt and Fitzgerald (2009), as well as, Germano, et al. (2007). Therefore, each step of the data collection process, as stated above, is done in a specific order, in order to maximize the precision of the collected data and minimize overall time spent on each lizard. Data collection began in January of 2009 and ended in February of 2010.

CHAPTER III

RESULTS

Morphological analysis of raw data quantified several consistent differences among the three species of *Dicrodon* (Table 1). Descriptive statistics of characters measured showed that when compared to the other two species, *D. heterolepis* had an overall smaller body plan. After all morphological characters were log-transformed to satisfy the assumption of normality, and the Analysis of Covariance was performed, there were significant interactions between SVL and the five individual morphological characters tested. When compared between all three species, *D. heterolepis* differed from its congeners by having a relatively long and wider head, wider front limb span, and shorter hind limb span compared to *D. holmbergi* and *D. guttulatum* (Table 2).

Approximately 86% (81) of *D. heterolepis* stomachs lacked insects, suggesting the stomachs may not have been preserved immediately following collection. However, empty stomachs may also be related to sex (males too busy with finding mates to eat), seasonality (i.e., mating season, season of low food abundance), or highly patchy food resources (as one might expect with ants and termites) (Biavati et al., 2004). A total of 35 prey items were identified from the *D. heterolepis* stomachs representing 9 unique taxonomic orders (Table 3). The most frequently occurring prey items (F) were beetles and spiders, which comprised 57.14% of the total number of prey items. Vegetative matter was found in 6 (6.38%) of the 94 dissected *D. heterolepis* stomachs. The presence

of vegetative matter in the stomachs could be due to incidental intake while foraging. In the pooled stomachs, beetles were most abundant, followed by ants and spiders.

Approximately 7.84% (4) of *D. holmbergi* and 26.32% (10) of *D. guttulatum* stomachs were empty. Dietary items found represented two distinct groups (Table 4). The most frequently occurring dietary item in *D. holmbergi* was vegetative matter, appearing in 90.2% of the dissected stomachs. The diet of *D. guttulatum* was comprised of mainly seeds, which occurred in 57.90% of the stomachs.

CHAPTER IV

SUMMARY AND CONCLUSIONS

Two prey categories consisting of 9 taxonomic orders in two classes of Arthropoda and the order Squamata were identified in the stomachs of *D. heterolepis*, confirming the anecdotal assumption that this species is in fact insectivorous, with the potential to be a generalist given the presence of one lizard (Table 3). The presence of seeds and vegetative matter likewise, confirm the anecdotal evidence that *D. holmbergi* and *D. guttulatum* are herbivorous species. The prevalence of vegetative matter in the diet of *D. holmbergi* (Table 4) could suggest this species is mainly herbivorous, feeding mainly on leaves and grass, while the high consumption of seeds in the diet of *D. guttulatum* (Table 4) could likewise lead to the assumption that this species relies heavily on frugivory. However, this particular dietary composition could be due to a few factors such as, seasonality of forage, as well as, a larger sample size of *D. holmbergi* compared to *D. guttulatum*. Theory predicts morphological differences should exist in correspondence with the major dietary modes. Our morphological analyses showed the herbivorous species were very similar in body plan, and the insectivore had a relatively larger head and front limbs. While *D. heterolepis* has a larger head and a wider front limb span, the overall body plan of all three species is similar. The wider front limb span does indicate that *D. heterolepis* is an active forager (McBrayer and Wylie, 2009), exploiting patchily distributed resources like other teiids (MacArthur and Pianka, 1966). Thus, we suggest front limb and head traits could be advantageous to *D. heterolepis* as it digs for insects buried in leaf litter and soil. This investigation into the diet and morphology of lizards in

the genus *Dicrodon* is the first step in understanding the natural history of these teiid lizards and the role they play in the tropical ecosystem.

As stated by Vitt (1991), conducting field research on tropical teiids has largely been restricted to the genera *Cnemidophorus* (Schall 1973; Magnusson et al. 1985; Vitt 1983) and *Ameiva* (Hirth 1963; Smith 1968; Leon and Ruiz 1971), with limited data available on the genera *Kentropyx*, *Tupinambis*, *Dracaena*, and *Crocodylurus* (Duellman 1978; Dixon and Soini 1975; Hoogmaed 1973; Magnusson 1987; Rand and Humphrey 1968). Future research will focus on several areas that will would bolster our understanding of the natural history of these lizards and further substantiate our ecomorphological hypothesis:

- Determining the extent to which the two herbivorous *Dicrodon* species are arboreal.
- Quantify foraging behaviors. Does *D. heterolepis* use its front limbs extensively while foraging for insects?
- Determining concordance between locomotor morphology and foraging mode.
- Gaining insight into the phylogenetic relationship between all three species of *Dicrodon* and their relationship to the other members of the family Teiidae.

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APPENDIX

Table 1. Descriptive statistics of characters measured from *Dicrodon* for this study.

Variable							
N; min - (mean) - max							
Species	SVL	TTL	HW	HL	HD	FLS	HLS
<i>Dicrodon heterolepis</i>	94; 11- (74.23)-124	92; 74- (236.69)-390	92; 5- (10.64)-22	93; 13- (21.92)-38	93; 4- (9.02)-17	92; 39- (158.15)-70	91; 68- (173.61)-114
<i>Dicrodon holmbergi</i>	51; 60- (100.01)-139	51; 138- (328.43)-485	51; 8- (12.56)-25	51; 16- (24.02)-37	51; 7- (10.60)-16	48; 54- (84.93)-121	47; 100- (155.15)-221
<i>Dicrodon guttulatum</i>	38; 65- (102.92)-141	38; 184- (355.58)-501	38; 8- (13.18)-21	38; 18- (26.24)-39	38; 8- (11.52)-18	38; 57- (89.11)-119	38; 113- (168.12)-228

Table 2. Comparison of morphological traits. Size-adjusted means (log-transformed).

Diet	Species	N	HL	HD	HW	FLS	HLS
Herbivorous	<i>Dicrodon guttulatum</i>	38	1.336	0.972	1.021	1.857	2.142
Insectivorous	<i>Dicrodon heterolepis</i>	92	1.365*	0.983	1.052*	1.870*	2.079*
Herbivorous	<i>Dicrodon holmbergi</i>	51	1.313	0.954*	1.017	1.858	2.128
	$F_{2,181}$		110.962	113.662	105.856	109.366	100.185
	P-value		<0.001	<0.001	<0.001	<0.001	<0.001

*Indicates significant difference in morphology compared to the two other species.

Table 3. Dietary composition of *Dicrodon heterolepis* from coastal deserts of South America (N=94).

Prey category	Count (N)		Frequency (F)	
	No.	%	No.	%
Coleoptera	18	51.43	7	33.33
Araneae	5	14.29	5	23.81
Diptera	1	2.86	1	4.76
Scorpiones	1	2.86	1	4.76
Orthoptera	2	5.71	2	9.56
Hymenoptera	5	14.29	2	9.56
Hemiptera	1	2.86	1	4.76
Blattodea	1	2.86	1	4.76
Gekkonidae	1	2.86	1	4.76

Table 4. Frequency of herbivory in two species of *Dicrodon*(N=51;38).

Diet	<i>Dicrodon holmbergi</i>		<i>Dicrodon guttulatum</i>	
	No.	%	No.	%
Vegetative matter	46	90.20	10	26.32
Seeds	10	19.60	22	57.90

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