ECOLOGICAL STUDY OF OXYGEN CONSUMPTION IN THREE SPECIES OF RATTLESNAKES, *CROTALUS ATROX*, *C. LEPIDUS*, AND *C. MOLOSSUS* (VIPERIDAE) FROM THE NORTHERN CHIHUAHUAN DESERT

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Abstract

The purpose of this study was to compare oxygen consumption of three species of rattlesnakes, *Crotalus atrox*, *C. lepidus* and *C. molossus*, that inhabit the Chihuahuan Desert within the Indio Mountain Research Station (IMRS), Hudspeth County, Texas. The resting metabolic rates (RMR) of 39 rattlesnakes (*C. atrox*, N = 17; *C. lepidus*, N = 8; and *C. molossus*, N = 14) were determined at four experimental temperatures (20°, 25°, 30°, and 35°C). The body masses ranged from 47 to 660 g for all three rattlesnake species.

The temperature coefficient of metabolism (Q_{10}) averaged 2.8 between temperatures of 20°-30°C and 2.15 between temperatures of 25°-35°C, these are similar to other coefficients reported for large rattlesnakes such as *C. adamanteus*. The Q_{10} values for *C. atrox* ranged from 1.77 to 2.35, *C. lepidus* ranged from 2.54 to 3.32, and *C. molossus* ranged 2.13 to 2.75 from temperatures that ranged from 20°C through 35°C Interspecific differences in Q_{10} were slight or insignificant. A multiple regression relating oxygen consumption (VO_2) to mass and temperature indicated that RMR increased with body mass and temperature. Interspecific oxygen consumption was statistically significant between the three species. Oxygen consumption varied between the three species due to size differences. Metabolic rates of males and females at comparable body mass for the three species of rattlesnakes were found to have no significant differences.

The results indicate oxygen consumption is greatly affected by temperature and body mass. Incremental increases in temperature resulted in increased resting metabolic rates, with Q_{10} values within the range reported for most squamates. Assessing how environmental parameters affect physiological processes is critical to further understand the ecology and natural history of these organisms.

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Chapter 1

General Introduction

1.1 Introduction

Arid regions demonstrate limitations in resources, and the organisms that inhabit them are well known to reduce their usage of resources in several ways. These organisms exhibit a series of biological modifications in response to limitations associated with these arid regions, such as deserts. Over evolutionary time, endothermic organisms respond to such restrictions by reducing demanding behaviors, morphological, and physiological characteristics to decrease total energy expenditure (McNab, 1994). Although ectothermic organisms require less energy than do similar sized endotherms by virtue of lower resting metabolic rates (RMR), it is reasonable to expect that ectotherms might respond to periodic limitations in resources by reducing energy expenditure in similar ways (Pough, 1980; Bennett, 1980).

Energy expenditure in ectotherms can be reduced in a number of ways. Andrew and Pough (1985) suggested that prey type and foraging strategies influence metabolic rates in serpents. The most obvious effects are changes in body temperature, body size, sexual activity, acclimation to temperature, and time of their activity period (Bennett and Dawson, 1982; Andrews and Pough, 1985; Patterson and Davies, 1989). For example, large-heavy bodied snakes from different families, including viperidae, have evolved a series of morphological and behavioral characteristics that enable them to ambush prey successfully (Ayers and Shine, 1997). Beaupre (1995a) indicates energy budgets in rock rattlesnakes, *Crotalus lepidus*, varied in relation to energy acquisition and allocation between two populations in the Big Bend region, Texas. Intraspecific differences, such as sexual dimorphism in many squamates, are also affected by energy acquisition and expenditure. Non-reproductive and vitellogenic females of western diamondbacks, *Crotalus atrox*, from the Sonoran Desert were shown to differ in metabolic rates (Beaupre and Duvall, 1998a), yet there were no differences between non-reproductive females and

males. They hypothesize that the adult female body may represent a compromise between selections for increased frequency of producing offspring as previously suggested for other ectotherms.

Snakes also have different behavior and activity capacities directly influenced by physiology and morphology. Studies comparing metabolic physiology of prey acquisition and escape in racers, rattlesnakes, and boas show that they depend on different metabolic capacities (Ruben, 1976). Racers tend to be fast, highly mobile snakes during prey pursuit and escape. Rattlesnakes cannot attain high speeds to pursue their prey and escape predators, but rely on a "sit and wait" ambush strategy with intense striking behavior (Ruben, 1976; Beaupre and Duvall, 1998b; Bennett, 1980). Rosy boas, *Lichanura travirgata*, are slow moving snakes that rely on constriction to immobilize and kill their prey. However, they rely on an escape defense such as rolling into a ball and releasing secretions from their cloaca (Ruben, 1976). These type of behavioral and activity patterns are evident in other ectotherm group, such as amphibians (Andrews and Pough, 1985).

Knowledge of snake temperature relationships to their environments contribute to understanding many aspects of their behavior, physiology, development, ecology and evolution (Peterson *et al*., 1993). Snake body temperature are regulated by heat obtained directly from the physical environment and can be constrained by the range of thermal conditions present. One of the direct effects of body temperature on the physiology of the snake is the rate of oxygen consumption, which is also affected by physical activity and body mass. The thermal ecology of pit vipers, especially the effects on oxygen consumption and metabolic rates has experienced a renewed interest in recent years through the work of Dorcas, *et. al.* (2006), Beaupre (1993), McCue and Lillywhite (2002), and Zaidan (2003), among others. In those studies, oxygen consumption was used as the estimation of the resting metabolic rate and the terms are often used interchangeably. In practice, measuring oxygen consumption is the standard choice in estimating metabolic rates in reptiles. The significant periods of activity used predominately for these measurements are if the organism is at a "resting" state.