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Geoffrey R. Smith
University of Nebraska-Lincoln

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GROWTH RATE AS A FUNCTION OF FOOD CONSUMPTION IN HATCHLING *SCELOPORUS VIRGATUS* (SAURIA: IGUANIDAE)

Geoffrey R. Smith*

School of Biological Sciences
University of Nebraska–Lincoln
Lincoln, Nebraska 68588-0118

*Present address: Kellogg Biological Station, 3700 E. Gull Lake Drive, Hickory Corners, Michigan 49060

ABSTRACT

The potential for food availability and consumption to produce variation in growth rates among hatchling striped plateau lizards (*Sceloporus virgatus*) was studied under laboratory conditions. Growth rate and survivorship were positively linearly related to the amount of food consumed. Differences in food consumption and availability created large differences in body size by the end of the experiment.

† † †

One of the most-studied categories of proximate causation of life history variation in lizards is resource availability. Several studies have correlated food availability (measured by arthropod abundance or by rainfall amounts which have been shown to influence arthropod abundance) with growth rates (Dunham, 1978; G. Smith and Ballinger, 1994b; Stamps and Tanaka 1981), reproduction (Ballinger, 1977; Dunham, 1981; but see Jones et al., 1987a), and survivorship (Ballinger, 1980, 1984; G. Smith and Ballinger, 1994c). Experimental studies, both in the field, and in the laboratory, have been conducted to more explicitly investigate the relationship between food availability and life history variation. Food supplementation experiments in nature have given mixed results. Increasing food supplies did not affect female reproduction in *Anolis acutus* (Rose, 1982) nor did it influence growth or survivorship in *Sceloporus undulatus* (Jones et al., 1987b) or *Anolis aeneus* (Stamps and Tanaka, 1981). However, Guyer (1988a,b) found that food supplementation did influence male growth, female reproduction, and short-term juvenile survivorship in *Norops humilis*. In a laboratory study, Stamps and Tanaka (1981) did find effects of food on growth in *Anolis aeneus*. In another laboratory study, Sinervo and Adolph (1994) found a 50% reduction in food supply caused a 50% reduction in growth in hatchling *Sceloporus occidentalis* and *S. graciosus*.

Information on hatchling lizards is lacking, especially detailed data on such important parameters as growth rates. Experimental studies on hatchling or neonate lizards allow for the examination of the potential factors influencing hatchlings, such as temperature (Sinervo and Adolph, 1989, 1994), density (Tubbs and Ferguson, 1976) and elevation (G. Smith et al., 1994). The growth rates of individuals in a population in the Chiricahua Mountains vary from year to year, and from habitat to habitat, in a manner consistent with fluctuations in food availability (G. Smith, 1995a). In this study, I examine the relationship between food availability, food consumption, and growth rate in hatchling striped plateau lizards (*Sceloporus virgatus*) raised in the laboratory under otherwise identical conditions.

MATERIALS AND METHODS

Study species

Sceloporus virgatus has been well studied in the Chiricahua Mountains of southeastern Arizona. Mating and courtship occur in April and May (Ballinger and Ketels, 1983; Rose, 1981) and oviposition occurs in early July with the onset of the monsoon rains (G. Smith et al. 1995; Vinegar, 1975a). *Sceloporus virgatus* retain their eggs for an intermediate period of time relative to other members of the genus (DeMarco, 1992, 1993; see also Andrews and Rose, 1994). Activity appears to be influenced by photoperiod (Stebbins, 1963) and food levels (Phelan and Niessen, 1989) and is not necessarily continuous throughout the activity season (i.e., individuals are not active every day; Rose, 1981). These lizards are terrestrial and prefer rock substrates (G. Smith, 1996). The mechanism of habitat selection is unknown, but preferences may be present at birth (G. Smith and Ballinger, 1995). *Sceloporus virgatus* maintain home ranges and are territorial to some extent (Vinegar, 1972, 1975b; Rose, 1982; D. Smith, 1985; G. Smith, 1995b), with individuals having a high degree of fidelity to habitat type, slope, and site, and to a lesser degree, substrate type (G. Smith, 1996). *Sceloporus virgatus* competes weakly and variably with *Urosaurus ornatus* (D. Smith, 1981). The thermal ecology of *S. virgatus* has been described by G. Smith and Ballinger (1994a) and the energetics studied by Ballinger and Holscher (1983), Merker and Nagy (1984), and Pough and Andrews (1985). G. Smith (1994) studied the allometry and morphometry of early hatchling growth.

Methods

Gravid female striped plateau lizards (*Sceloporus virgatus*) were collected in the Chiricahua Mountains of southeastern Arizona and transported to Lincoln, Nebraska, where they were allowed to oviposit on sand. Eggs were then incubated on a one-to-one mix (by mass) of vermiculite and water placed in glass dishes. The glass dishes were sealed in plastic bags and placed in an environmental chamber set at approximately 30°C. Moisture of the incubation substrate was periodically checked and maintained throughout incubation. On hatching, hatchlings were measured and placed in individual plastic cages (30 × 16 × 8 cm). Water was provided throughout the day and cages were periodically sprayed with water. Hatchlings had access to radiant heat for 10 h d^{-1} provided by a 75 W light bulb suspended 30 cm above the substrate. The position of the light bulb at one end of the cage provided a thermal gradient (20 to 40°C) in which hatchlings could thermoregulate. Additional UV light beyond ambient room light from an overhead fluorescent bulb was not provided.

Hatchlings were randomly assigned to one of three food levels: fed five crickets (dusted with a calcium and phosphorus supplement) (1) every day, (2) every other day, or (3) every third day. Crickets were left in cages for 24 h, and if any crickets remained at the end of the 24 h, they were removed from the cage. The number of crickets eaten in each 24 h period was recorded. Size of crickets fed hatchlings increased throughout the study. Initially, crickets fed to the hatchlings weighed on average 0.0043 g each. Later the average weight of the crickets used was increased to 0.0182 g, and finally to 0.0245 g. Similar crickets were selected for each feeding session to minimize variation in biomass due to cricket size. Food consumed was calculated by multiplying the number of crickets eaten by the average mass of the crickets provided. Hatchlings were measured weekly. Snout-vent length (SVL) was measured to the nearest 0.1 mm, and body mass (BM) was taken to the nearest 0.01 g. Hatchlings were sexed by the presence (male) or absence (female) of enlarged post-anal scales. The experiment was terminated after 53 days.

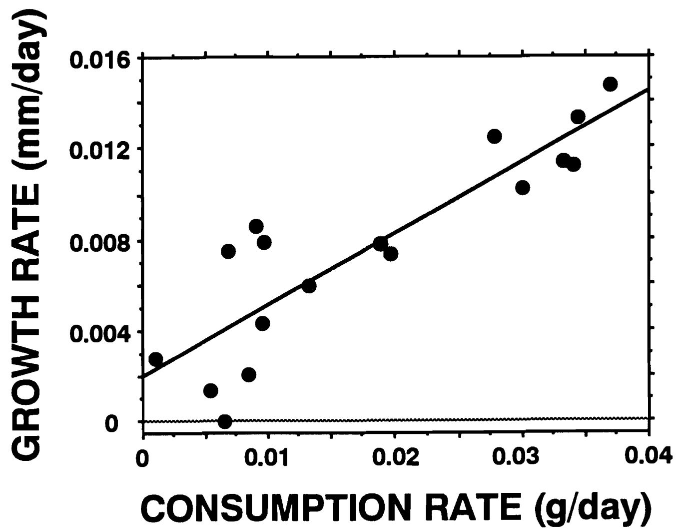

Figure 1. Relationship between per day food consumption and growth rate for hatchling *Sceloporus virgatus*.

Only individuals for whom the interval between first and last measurements were greater than 10 d are used to analyze growth rates (range = 14 to 49 d). Growth rate in SVL was calculated as: (final SVL - initial SVL)/ number of days between initial and final measurements. Calculation for BM changes was the same except BM was substituted for SVL.

RESULTS

Individuals that ate more total cricket biomass grew faster ($N = 17$, $r^2 = 0.74$, $P < 0.0001$). The same held true for those that ate more on a per day basis (Fig. 1; $N = 17$, $r^2 = 0.76$, $P < 0.0001$). Hatchlings that gained weight faster ate more total cricket biomass ($N = 17$, $r^2 = 0.52$, $P = 0.001$), and more cricket biomass per day ($N = 17$, $r^2 = 0.44$, $P = 0.003$). Those individuals that ate more cricket biomass per day survived longer (survivorship expressed as percent of days survived [i.e, an individual surviving the entire experiment would have a survivorship of 1.0)] ($N = 22$, $r^2 = 0.73$, $P < 0.0001$).

DISCUSSION

This study shows the importance of food consumption to the growth of hatchling *Sceloporus virgatus*. Nearly 75% of the variation in growth rate can be explained by food consumption (both total and per day). These results suggest that any factor influencing the distribution of hatchlings relative to the distribution and abundance of their prey could influence the life histories of individuals in nature. For example, Karasov and Anderson (1984) found that feeding rate, energy expenditure, and activity can differ between habitats in *Cnemidophorus hyperythrus* and these differences may result in different growth rates. Unfortunately, no data on the growth or food consumption of hatchling *S. virgatus* in the field have been published with which to compare the results of this study.

By the end of the experiment there was a 4.2 mm difference in SVL between the largest and smallest hatchlings despite both individuals beginning the experiment at similar sizes. Therefore, growth rate differences due to the amount of food available to an individual at the hatchling stage are liable to extend throughout the lifetime of that individual, ultimately influencing the reproductive success of the individual through the influence of body size on survivorship (e.g., Ferguson and Fox, 1984) and reproduction (e.g., the increase of clutch size with body size; for *Sceloporus virgatus* see G. Smith et al., 1995; Vinegar, 1975a).

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