Texas horned lizard (*Phrynosoma cornutum*) in Texas. Texas Journal of Science 46:97–113.

FAIR, W. S., AND S. E. HENKE. 1997. Efficacy of capture methods for a low density population of *Phrynosoma cornutum*. Herpetological Review 28: 135–137.

FAIR, W. S., AND S. E. HENKE. 1999. Movements, home ranges, and survival of Texas horned lizards (*Phrynosoma cornutum*). Journal of Herpetology 33:517–525.

GOULD, F. W. 1962. Texas plants, a checklist and ecological summary. Texas Agricultural Experiment Station Miscellaneous Publication MP-585, Austin, Texas.

HENKE, S. E., AND M. MONTEMAYOR. 1998. Diel and monthly variation in capture success of *Phrynosoma cornutum* via road cruising in southern Texas. Herpetological Review 29:148–150.

SAS INSTITUTE. 1989. SAS/STAT user's guide, version 6, fourth edition, volume 2. SAS Institute, Inc., Cary, North Carolina.

STEEL, R. G. D., AND J. H. TORRIE. 1980. Principles and procedures of statistics: a biometrical approach, second edition. McGraw-Hill Book Company, New York.

TEXAS PARKS AND WILDLIFE CODE. 1987. 31 T. A. C. Section 65.171–65.177. Austin, Texas.

Submitted 8 January 2002. Accepted 10 June 2002.
Associate Editor was Geoffrey C. Carpenter.

FORAGING MODE OF THE RETICULATE COLLARED LIZARD, *CROTAPHYTUS RETICULATUS*

JERRY F. HUSAK* AND EMILY N. ACKLAND

Department of Zoology, Oklahoma State University, Stillwater, OK 74078
**Correspondent: husak@okstate.edu*

ABSTRACT—The reticulate collared lizard (*Crotaphytus reticulatus*) is a large, crotaphytid lizard restricted to the lower Rio Grande Valley of southern Texas and northern Mexico. Our objectives were to determine the foraging mode of this species and test predictions made by other investigators about foraging behavior. We conducted focal observations on 10 male and 10 female lizards in Falcon State Park, Starr County, Texas, to quantify the number of movements per minute (MPM), the proportion of time spent moving (PTM), and the proportion of attacks made on prey items while moving (PAM). We removed foraging movements followed by social displays from the data and recalculated and reanalyzed foraging activity values. With ''display'' movements removed, there was a significant difference between MPM values and PTM values for males and for the sexes combined, but there was no significant difference in MPM values or PTM values for females. The foraging measures calculated for *C. reticulatus,* with and without ''display'' movements removed from the calculations, suggest that it is a ''sit-and-wait'' ambush forager like its congener *C. collaris*.

RESUMEN—La lagartija reticulada de collar (*Crotaphytus reticulatus*) es una lagartija grande restringida al valle bajo del Río Bravo del sur de Texas y del norte de México. Nuestros objetivos fueron determinar el modo de buscar comida y probar algunas hipótesis hechas por otros investigadores referentes al comportamiento de búsqueda de comida. Realizamos observaciones focales de 10 machos y 10 hembras de la especie en el Parque Estatal de Falcón, condado de Starr, Texas, para cuantificar el número de desplazamientos por minuto (MPM), la proporción del tiempo utilizada desplazándose (PTM), y la proporción de ataques a presas mientras se movían (PAM). Descartamos los desplazamientos seguidos de exhibiciones sociales de los datos y calculamos y analizamos nuevamente los valores de búsqueda de comida. Con estos desplazamientos removidos, hubo una diferencia significativa entre los valores de MPM y PTM para los machos y para ambos sexos juntos, pero no hubo una diferencia significativa de los valores ni de MPM o de PTM para las hembras. Las medidas de búsqueda de comida para *C. reticulatus,* con o sin los desplazamientos de ''exhibición,'' sugieren que es una especie que busca la comida por medio de emboscadas de ''sentarse y esperar'' como su congénere *C. collaris*.

The reticulate collared lizard (*Crotaphytus reticulatus*) is a large, crotaphytid lizard that exhibits strong sexual dimorphism in body size, with adult males reaching larger sizes than females (Smith, 1946). Male and female adult lizards are both tan in color, with a white, reticulated dorsal pattern enclosing 7 or 8 transverse lines of black spots (Montanucci, 1976; McGuire, 1996). Males have a bright yellow coloration on the front limbs and on the anterior dorsum and ventral region of the trunk during the breeding season (McGuire, 1996). The species is restricted to the lower Rio Grande Valley of southern Texas and northern Mexico. The reticulate collared lizard is primarily saxicolous and mainly occurs in rolling terrain with shallow, gravelly soils, but it has been known to utilize flatland habitats where rocks are not present (Montanucci, 1971). Because of its limited geographic distribution and because the area in which it lives is disturbed by humans and introduced grasses, *C. reticulatus* is listed as a state-threatened species in Texas (Dixon, 2000).

Little of the natural history of this species has been quantitatively studied. Smith (1946) commented that the reticulate collared lizard is 1 of the least known lizards in the United States, and little has been done since then to remedy that situation. Montanucci (1971) anecdotally reported diel and seasonal activity patterns. Accounts of diet suggest that adult and juvenile lizards are opportunistic foragers, consuming a wide variety of arthropods and plant tissue (Klein, 1951; Montanucci, 1971). Montanucci (1971) reported that individuals were observed foraging during early morning and evening hours, but no mention was made as to how foraging was conducted.

Two common lizard foraging strategies have been described as distinct ''modes'' (MacArthur and Pianka, 1966; Huey and Pianka, 1981), but it has been suggested that foraging modes might vary along a continuum between the 2 extremes from ambush (sit-and-wait) to active (wide) foraging (Magnusson et al., 1985; Pietruszka, 1986; Perry et al., 1990; Cooper and Whiting, 1999). There is still debate on which of these concepts is a better explanation of foraging modes (McLaughlin, 1989; Perry, 1999; Cooper et al., 2001). The foraging mode of *C. reticulatus* is of particular interest because this species is the basal taxon in this genus (McGuire, 1996) and, therefore, represents a lineage that is the closest extant relative of all *Crotaphytus,* an ambush foraging group, and *Gambelia,* a genus composed primarily of more active foragers (Montanucci, 1978; Tollestrup, 1983). Reticulate collared lizards, like other *Crotaphytus* species, spend the majority of their time in stationary positions for thermoregulatory and social purposes (Husak and Ackland, unpubl. data), suggesting that they are ambush foragers. Our objectives were to determine foraging mode and test predictions made by other investigators about foraging behavior.

The study site was a sandstone outcropping in Falcon State Park, Starr County, Texas, vegetated by a honey mesquite (*Prosopis glandulosa*) and acacia (*Acacia rigidula* and *A. berlandieri*) thornscrub community. Other common plants on the site included huisache (*A. minuta*), retama (*Parkinsonia aculeata*), and prickly pear cactus (*Opuntia lindheimeri*). During 20 through 22 May 2001, 20-min focal observations were conducted on adult lizards throughout the study site to quantify foraging behavior. Lizards were located by walking the site slowly until a subject was found, waiting for 2 minutes to minimize disturbance effects, then initiating the focal observation. All activities of lizards were quantified from a distance of at least 20 m, using binoculars and a hand-held microcassette recorder, including (following Cooper et al., 2001) time (to the nearest second) spent moving and stationary, feeding attempts, and whether feeding attempts were made while sedentary or actively searching. Successful attempts at predation were not distinguished from unsuccessful attempts, because such observations are difficult to make from long distances. Postural adjustments of the body were not counted as movements; only unambiguous movements from 1 location to another were recorded.

To determine whether or not foraging mode calculations might be affected by social behavior, we also recorded whether or not movements were followed by displays. Observations were made when the substrate temperature was between 35 and 42°C, a temperature range similar to that used in a study of *Crotaphytus collaris* behavior (Baird and Timanus, 1998). Because the preferred temperature range for *C. reticulatus* is unknown, we used this range because it corresponded to the active behavior

of the lizards. On a few occasions, lizards left our field of view, so the total time of those focal observations was adjusted for the calculation of foraging measurements. Observations were made of the same population over several days, but our experience with the individually marked lizards in the population gave us confidence that no lizard was observed more than once. From focal observations, we calculated 3 measures of foraging activity as described in Cooper et al. (2001): 1) the number of movements per minute (MPM), 2) the proportion of time spent moving (PTM; amount of time spent moving divided by total time observed), and 3) the proportion of attacks made on prey items while moving (PAM; the number of attacks on prey discovered while actively searching divided by total recorded mobile or immobile attacks on prey).

Due to hot midday temperatures, the lizards had a bimodal daily activity pattern (Husak and Ackland, unpubl. data). Therefore, focal observations were conducted during morning and evening. Because there were no differences for any of the foraging activity measures during the morning and evening (Kolmogorov-Smirnov 2-sample test, $P > 0.75$), we combined these data for all analyses. Differences were tested between the sexes in the 3 measures using 2-sample *t*-tests. Because data were collected during breeding season, foraging movements followed by display were removed from the data and foraging activity values were recalculated and reanalyzed. Differences between foraging values with and without ''display'' movements were tested within each sex using paired *t*-tests, and differences between sexes were tested using 2-sample *t*-tests.

There were no significant differences between the sexes for any of the measures of foraging mode (Table 1). With and without ''display'' movements removed from the calculations, there was a significant difference between MPM values (Table 2) for males ($t = 2.81$, $P = 0.021$) and for the sexes pooled ($t = 2.62$, $P = 0.017$), and between PTM values (Table 2) for males ($t = 2.77$, $P = 0.022$) and the sexes pooled ($t = 2.46$, $P = 0.024$). There was no significant difference in MPM or PTM values for females when ''display'' movements were removed from or included in the analysis (Table 2). When ''display'' movements were removed, there were still no significant differences between the sexes in MPM or PTM values (Table 2).

TABLE 1—Mean (± *SE*) movements per minute (MPM), proportion of time spent moving (PTM), and proportion of attacks made on prey items while moving (PAM) for 10 adult male and 10 female reticulate collared lizards (*Crotaphytus reticulatus*) in southern Texas. No significant differences were found between sexes.

	MPM	PTM	PAM
Male	0.318 ± 0.082	0.018 ± 0.006	0.0
Female	0.318 ± 0.073	0.014 ± 0.003	0.0
Combined	0.318 ± 0.054	0.016 ± 0.003	0.0

The foraging measures calculated for *C. reticulatus* are similar to those calculated for its congener *C. collaris* (MPM 0.086, PTM 0.004, PAM 0.0; Cooper et al., 2001) and are within the range of foraging mode values for classification as an ambush forager (Cooper et al., 2001). Ecomorphological analysis of crotaphytid feeding (Lappin, 1999) suggests that lizards with robust heads should prey primarily on arthropods and occasionally on vertebrates, which agrees with findings on *C. reticulatus* (Klein, 1951; Montanucci, 1971). We only saw predation attempts on arthropods. Opportunistic ambush foraging seems to be the ancestral state for iguanians (Perry, 1999), with *C. reticulatus* and *C. collaris* being no exception (this study; Best and Pfaffenberger, 1987; Husak and McCoy, 2000). The foraging strategy of *Gambelia wislizenii* (and potentially *G. copei*; Lappin and Swinney, 1999) seems to be derived within the crotaphytids.

Montanucci (1978) suggested that the cryptic dorsal pattern of leopard lizards (*Gambelia wislizenii*), similar to that of *C. reticulatus,* is an adaptation for efficient predation. Basically, a more cryptic predator is more likely to sneak up on prey than a more conspicuous predator, and this was supported by Montanucci (1978) with the observation that *G. wislizenii* exhibited a type of stalking behavior while pursuing prey. Montanucci (1978) alluded to the idea that reticulate collared lizards might also display this behavior. Indeed, *C. reticulatus* was observed by us to exhibit what might be considered stalking behavior. Before moving from a perch, lizards were in every case (with the exception of some movements by males that were clearly to chase

TABLE 2—Mean (± *SE*) movements per minute (MPM) and proportion of time spent moving (PTM), with and without "display" movements, for 10 adult male and 10 female reticulate collared lizards (*Crotaphytus reticulatus*) in southern Texas. Values with the same superscript were significantly different ($P < 0.025$).

	MPM			PTM		
	Male	Female	Combined	Male	Female	Combined
With "display" movements	0.318 ± 0.082[a]	0.318 ± 0.073	0.318 ± 0.054[b]	0.018 ± 0.006[c]	0.014 ± 0.003	0.016 ± 0.003[d]
Without "display" movements	0.178 ± 0.061[a]	0.308 ± 0.071	0.243 ± 0.048[b]	0.011 ± 0.005[c]	0.014 ± 0.003	0.012 ± 0.003[d]

off intruding rivals) observed to move slowly at first before making a dash to a new perch or to capture prey. However, this behavior could also be used to avoid predators. Moving slowly at first before quickly running to a new location would be strongly favored in an environment with high predation pressure, such as that estimated at our study site by our observations (0.442 predator sightings/hour).

There has been recent interest in the literature as to what measure of foraging mode is most appropriate for inter-species comparisons (see Cooper et al., 2001). For our data, MPM, PTM, and PAM all gave the same general conclusion that reticulate collared lizards are ambush foragers. However, we found that MPM and PTM were significantly affected by elimination of "social movements" but PAM was unaffected by definition. The modified measures of MPM and PTM, however, did not change our conclusions about foraging mode. We agree with Cooper et al. (2001) that PAM might have the least problems among measurements of foraging mode.

We would like to thank the staff of Falcon State Park and M. Lockwood and D. Riskind at Texas Parks and Wildlife for allowing us access to the study site and helping us to obtain permits. We would also like to thank M. Husak, S. Fox, and 2 anonymous reviewers for comments on earlier versions of the manuscript and S. Fox for writing the Spanish abstract. All work was conducted under Texas Parks and Wildlife Department Scientific Permit SPR0299-001 and Texas Parks and Wildlife State Park Scientific Permit 57-01.

LITERATURE CITED

BAIRD, T. A., AND D. K. TIMANUS. 1998. Social inhibition of territorial behavior in yearling male collared lizards, *Crotaphytus collaris*. Animal Behaviour 56:989–994.

BEST, T. L., AND G. S. PFAFFENBERGER. 1987. Age and sexual variation in the diet of collared lizards (*Crotaphytus collaris*). Southwestern Naturalist 32: 415–426.

COOPER, W. E., JR., AND M. J. WHITING. 1999. Foraging modes in lacertid lizards from southern Africa. Amphibia-Reptilia 20:299–311.

COOPER, W. E., JR., L. J. VITT, J. P. CALDWELL, AND S. F. FOX. 2001. Foraging modes of some American lizards: relationships among measurement variables and discreteness of modes. Herpetologica 57:65–76.

DIXON, J. R. 2000. Amphibians and reptiles of Texas. Texas A&M University Press, College Station.

HUEY, R. B., AND E. R. PIANKA. 1981. Ecological consequences of foraging mode. Ecology 62:991–999.

HUSAK, J. F., AND J. K. MCCOY. 2000. Diet composition of the collared lizard (*Crotaphytus collaris*) in west-central Texas. Texas Journal of Science 52: 93–100.

KLEIN, T., JR. 1951. Notes on the feeding habits of *Crotaphytus reticulatus*. Herpetologica 7:200.

LAPPIN, A. K. 1999. Evolutionary ecomorphology of the feeding biology of crotaphytid lizards. Unpublished Ph.D. dissertation, University of California, Berkeley.

LAPPIN, A. K., AND E. J. SWINNEY. 1999. Sexual dimorphism as it relates to natural history of leopard lizards (Crotaphytidae: *Gambelia*). Copeia 1999:649–660.

MACARTHUR, R. H., AND E. R. PIANKA. 1966. On optimal use of a patchy environment. American Naturalist 100:603–609.

MAGNUSSON, W. E., L. J. PAIVA, R. M. ROCHA, C. R. FRANKE, A. KASPAR, AND A. P. LIMA. 1985. The correlates of foraging mode in a community of Brazilian lizards. Herpetologica 41:324–332.

MCGUIRE, J. A. 1996. Phylogenetic systematics of crotaphytid lizards (Reptilia: Iguania: Crotaphytidae). Bulletin of Carnegie Museum of Natural History 32:1–143.

MCLAUGHLIN, R. L. 1989. Search modes of birds and lizards: evidence for alternative movement patterns. American Naturalist 133:654–670.

MONTANUCCI, R. R. 1971. Ecological and distributional data on *Crotaphytus reticulatus* (Sauria: Iguanidae). Herpetologica 27:183–197.

MONTANUCCI, R. R. 1976. *Crotaphytus reticulatus* Baird. Catalogue of American Amphibians and Reptiles 185.1–185.2.

MONTANUCCI, R. R. 1978. Dorsal pattern polymorphism and adaptation in *Gambelia wislizenii* (Reptilia, Lacertilia, Iguanidae). Journal of Herpetology 12:73–81.

PERRY, G. 1999. The evolution of search modes: ecological versus phylogenetic perspectives. American Naturalist 153:98–109.

PERRY, G., I. LAMPL, A. LERNER, D. ROTHENSTEIN, E. SHANI, N. SIVAN, AND Y. I. WERNER. 1990. Foraging mode in lacertid lizards: variation and correlates. Amphibia-Reptilia 11:373–384.

PIETRUSZKA, R. D. 1986. Search tactics of desert lizards: how polarized are they? Animal Behaviour 34:1742–1758.

SMITH, H. M. 1946. Handbook of lizards. Lizards of the United States and Canada. Comstock Publishing Associates, Ithaca, New York.

TOLLESTRUP, K. 1983. The social behavior of two species of closely related leopard lizards, *Gambelia silus* and *Gambelia wislizenii*. Zietschrift für Tierpsychologie 62:307–320.

Submitted 14 November 2001. Accepted 13 March 2002.
Associate Editor was Geoffrey C. Carpenter.

SURVEY OF BLOOD PARASITES IN ROSS' AND WHITE-FRONTED GEESE IN SOUTHERN TEXAS

CHRISTOPHER L. KLOSS, ALAN M. FEDYNICH,* AND BART M. BALLARD

Caesar Kleberg Wildlife Research Institute, Texas A&M University–Kingsville, 700 University Boulevard, MSC 218, Kingsville, TX 78363
**Correspondent: alan.fedynich@tamuk.edu*

ABSTRACT—Blood parasites have been known to cause morbidity and mortality in waterfowl, particularly in Canada geese (*Branta canadensis*). However, little is known about blood parasites infecting Ross' geese (*Chen rossii*) and greater white-fronted geese (*Anser albifrons*). This study examined wintering Ross' and white-fronted geese for blood parasites. Blood smears from 16 Ross' geese (13 juveniles, 3 adults) and 46 white-fronted geese (21 juveniles, 25 adults) collected in Kleberg County, Texas, during winter 1999–2000 were examined for blood parasites. *Leucocytozoon simondi* was found in 2 juvenile white-fronted geese; density of infection was <1 parasite/2,000 erythrocytes. Additionally, 3 adult and 1 juvenile white-fronted geese had microfilaria. No blood parasites were observed in Ross' geese. We concluded that low prevalence and density of *L. simondi* gametocytes circulating in host blood precluded or greatly reduced transmission of this parasite on the wintering grounds in southern Texas.