J. King Saud Univ., Vol. 8, *Science* (1), pp. 49-57 (A.H. 1416/1996)

Thermal Selection of *Chamaeleo chamaeleon* from South-western Arabia

Awadh M. Al-Johany
Department of Zoology, College of Science, King Saud University, Box 2455, Riyadh 11451, Saudi Arabia

(Received on 11 October1994; accepted for publication on 22 May 1995)

Abstract. The selected body temperature (SBT) of *Chamaeleo chamaeleon* was measured in a thermal gradient. Critical thermal maximum (CTMax) and critical thermal minimum (CTMin) were also determined. The range of SBT is wide. The selected range of temperature is broader and higher at night than during the day. Females selected higher temperatures during the night period. A significant difference was observed between individual SBTs. The CTMax and CTMin obtained have a different breadth of scale than reported for other species of chameleons.

Introduction

From the early investigations of Cowles and Bogert [1] to the present time, various researchers have conducted thermal studies on many species of reptiles [2, 3; pp. 167-221, 4; pp. 44-315, 5; pp. 58-79]. Of the lizard families, most of the work has been on terrestrial forms such as Iguanids, Agamids, Gekkonids, Scincids and Lacertids [6]. Negligible work has been carried out on the family Chamaeleonidae: [7, 8] provide general information about chameleon biology. An extensive field and laboratory thermal study of two species of African chameleons was reported by Burrage [9]. Some information is also available from studies by Hebrard *et al.* [10] and Reilly [11].

Effects of temperature on colour change were reported by Durve and Sharma [12] and, most recently, by Walton and Bennett [13]. In Arabia, studies on this family are limited to distribution [14] and metabolic rate measurement by the oxygen consumption method [15, 16]. Some sketches of the thermal requirements of chameleons are found in literature pertaining to captive breeding and care of these reptiles--see reports by Bustard [17], Halfpenny [18], Langerwerf [19] and Ferguson [20].

This report presents the thermal selection and tolerance of *Chamaeleo chamaeleon,* from South-western Arabia. This arboreal oviparous species is distributed in Saudi Arabia from Abha (Asir province) in the South-west to Haql in the North-west, while

much of the population is concentrated in the South-western heights above 2000 m [14, 21]. The species occupies a unique habitat of the Arabian peninsula which is characterized by mild summers and cool winters with the possibility of frosts during winter at high altitudes. Rainfall is expected all year round, especially during spring and summer. The highest mean maximum temperature is 29°C recorded during June and the lowest mean minimum temperature is 6°C recorded during January.

Chameleons have been termed as 'difficult' animals with respect to captive breeding by Avery [22, pp. 45-60]. Owing to the difficulty of obtaining thermal data on these animals in the field, gradient studies may help to elucidate the termal requirements of the species. Furthermore, such studies are likely to be beneficial especially if the ecology of the species is not known. Knowledge of thermoregulatory strategies can help in designing accommodation in which animals themselves can select conditions for their well being. Understanding thermoregulatory behavior also helps in interpreting the behavior observed in the field and in captivity.

Materials and Methods

Chaemeleons were collected from Abha in the South-west of Saudi Arabia. A total of 12 specimens (5 males and 7 females) were utilized in this study (Mean mass = 44.6 g, SD±16.8; mean SVL=115 mm, SD±15.5; mean VTL=119 mm, SD±20.4). Experiments were conducted within a month of capture. The animals were housed in large plexiglass mesh-covered boxes. Twigs and small branches enabled them to climb and move about. Room temperature was maintained at 23 ± 1.5°C. Light and heat were provided by a 100 W tungsten bulb. The chameleons were fed on a mixed diet of mealworms, assorted adult insects and grasshoppers.

The Selected Body Temperature (SBT) was determined in a metal thermal gradient which measured 200 x 25 x 40 cm. Evenly spread sand on the bottom of the gradient provided the substratum. A temperature gradient from 8-48 ± 2°C was achieved by placing a thermostatic hotplate below one end and fitting an insulate dice container, kept frozen by an immersion refrigerant coil on the other. A timer-controlled photoperiod of LD 12:12 h was provided by three 60 watt tungsten lamps suspended 80 cm from the surface of the sand. The animals were left in the gradient for one day prior to the experiment. The body temperatures (T_b) of the animals were monitored with #511 (Yellow Springs Inc.) tissue implantation thermister probes connected to a multichannel YSI telethermometer. This in turn was attached to a (Houston Instruments) continuous chart recorder. The flexible tip of the precalibrated probe was inserted for a distance of 1 cm into the cloacal opening, and held in place with 5 mm wide bands of adhesive tape. Continuous recording of T_6 was obtained for three days with each animal. The charts thus obtained were analyzed by running them under a calibrated scale of the thermister probes. One reading for each hour was recorded where the chart showed a straight line and an average of three readings an hour was taken when the chart showed fluctuations.

The Critical Thermal Maximum (CTMax) and the Critical Thermal Minimum (CTMin) were measured in a sheet metal box (25x20 cm) filled with a layer of sand. Each animal was gradually heated or cooled inside the experimental chamber (1°C increase or decrease per minute). To determinet he CTMax and CTMin the animal was observed until it had lost its righting response.

Statistical analysis was carried out by using a Minitab (v8.2) Statistical package on an IBM AT486 computer. Two-way analysis of variance (ANOVA) was performed by the GLM procedure.

Results

Figure 1 represents the characteristic SBT of *C. chamaeleon* shown as a frequency distribution of body temperature selected by male and female animals during the day (0600-1800) and night (1800-0600). Male animals (n=5) exhibited a mean SBT of 31.2°C (SD±3.4) on the day and 31.4°C (SD±4) at night, while the female (n=7) mean SBT was 29.6°C (SD±2.9) and 30.8°C (SD±5) for the day and night respectively. The frequency distribution shows that female chameleons select significantly (P=0.001) higher temperature during the night period. Hourly mean SBT against a 24 hour time scale has been plotted in Fig. 2. The mean temperature selected lies in a narrow range of 29-33°C for the males and 27-33°C for the females. The mean body temperatures of both males and females show a gradual rise during the day until 1800 hours. It then decreases to its lowest value at 0600 hours (Fig. 2). Moreover, the overall range of SBT of both sexes showed a wide range (Table 1).

Two-way analysis of variance (ANOVA) using the GLM procedure yielded the following result. As a group, both male and females showed no significant difference (P=0.366), between day and night temperature selection, while a highly significant difference (P=0.002) was observed in selection by individual animals during both day and night. Male chameleons exhibited no significant difference (P=0.566) between the temperature selected in the day and night, but a highly significant difference (P=0.001) was observed in females.

In CTMax experiments, the animals began to exhibit a color change from dark gray to yellowish-green when they reached 40°C. They started panting at 42°C, CTMax was 46.8°C, and the lethal temperature 47°C. One chameleon was allowed to cross the CTMax limit temperature for a minute, which resulted in paralysis of the limbs of the side on which the animal had collapsed. Although the animal recovered from the thermal shock, the paralytic effect remained. Bulging of body by accumulating air took place when body temperature reached 5°C. CTMin was 3.8°C. All the animals recovered after the CTMax and CTMin procedures.

Discussion

The range of SBT of *C. chamaeleon* is wide. This is probably an advantage for desert dwelling lizards which experience temperatures that fluctuate widely during the

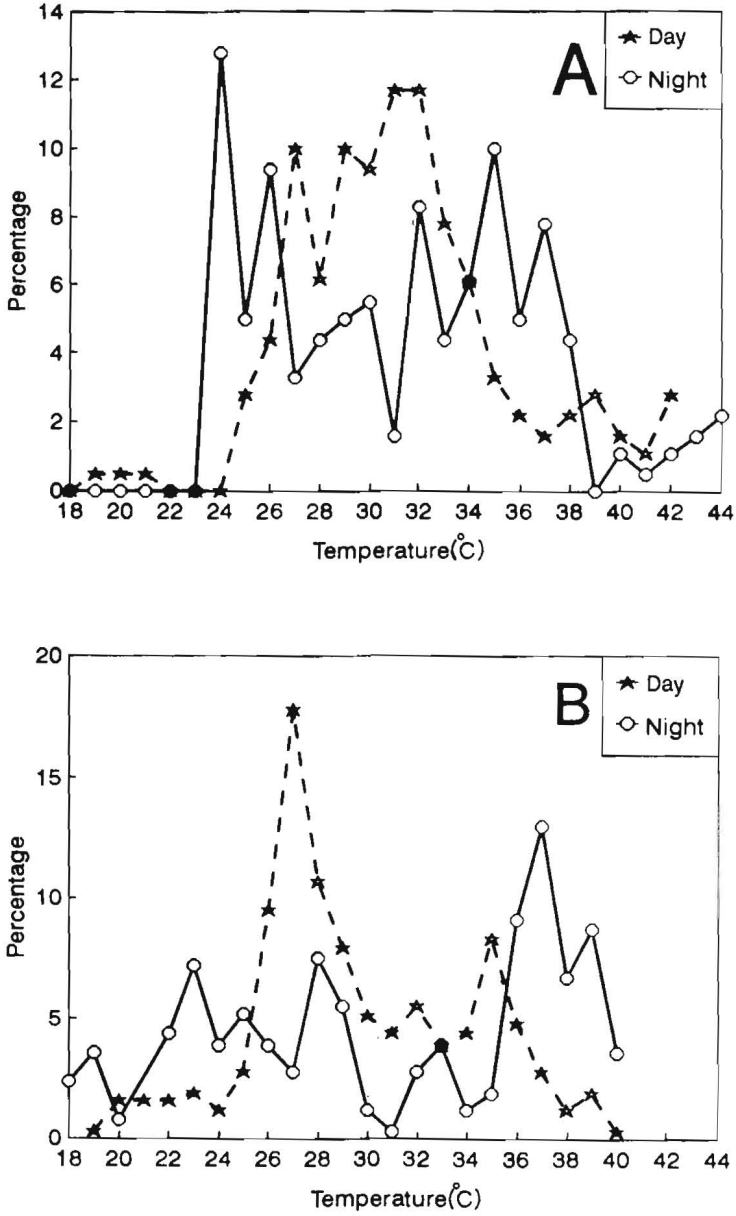

Fig. 1. Frequency distribution of body temperature selected by male chameleons (A) and females (B) during the day (0600-1800) and night (1800-0600) in the thermal gradient.

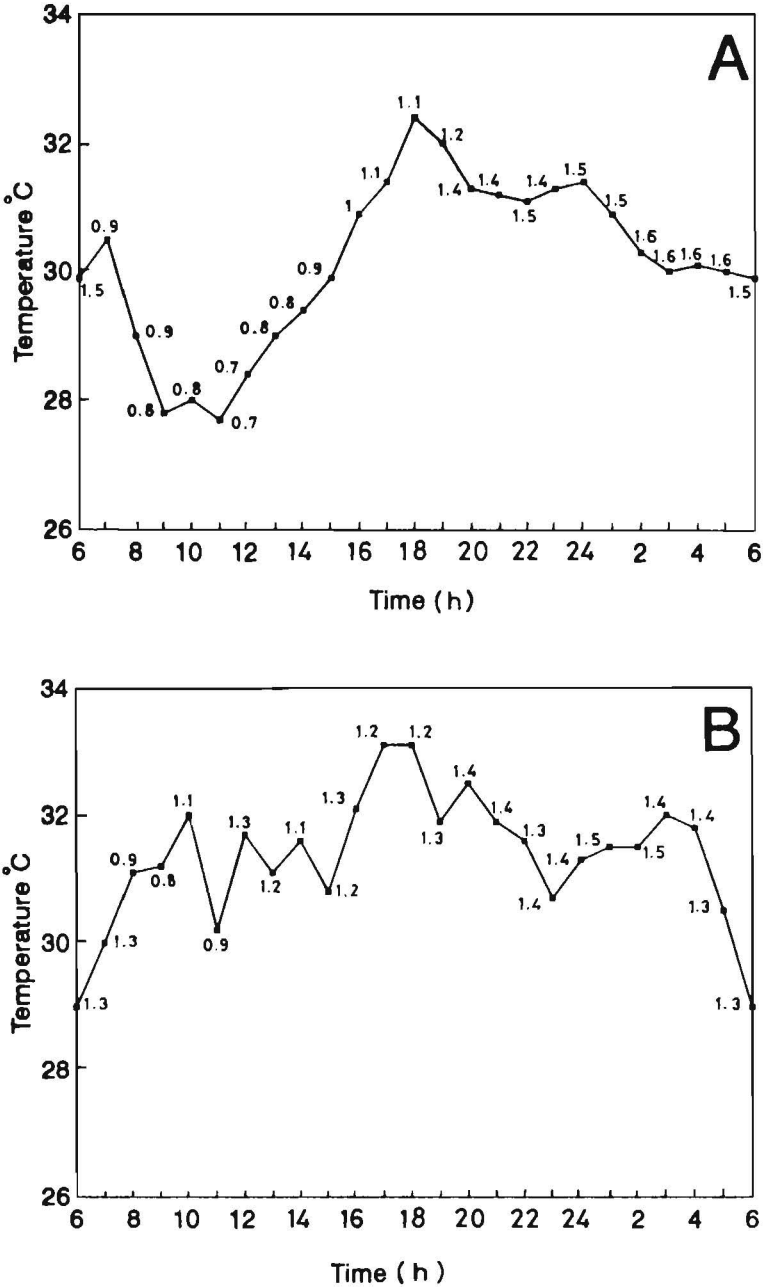

Fig. 2. Hourly mean selected body temperature over 24 hours by female chameleons (A) and males (B). Number at each point indicates standard error of the mean.

Table 1. Temperature range, mean body temperature, critical maximum and critical minimum and type of habitat of three chameleon species

Species	N	Range °C	X°C	CMin	CMax	Type of habitat	Reference
C. pumilus	20	7-30	25	-5	43	Mesic	Burrage, 73
C. namaquensis	18	18.5-36	29.2	0	47-48	Xeric	Burrage, 73
C. chameleon	12	18-44	30.2	3.8	46.8	Semi arid	Present study

year. Compared with other chameleons, such as *C. namaquensis,* which live in comparable habitats, the range of SBT is wider. Burrage [9] indicates that many desert reptiles, especially diurnal species, have different means of temperature control, and some employ physiological methods to increase their activity period. Similar to findings on *C. pumilus* and *C. namaquensis* [9], females of *C. chamaeleon* prefer a higher resting temperature during the night. More than 53% of females selected temperatures higher than their mean body temperature (30.8°C), while only 45% of males selected a temperature above their mean (31.5°C). This may indicate that females have a higher metabolic rate and energy requirement. *C. chamaeleon* females exhibited elevated mean body temperatures in the gradient during the night hours compared with lower temperatures selected during the day (Fig. 2). Field observations by Hebrard *et al.* [10] and Reilly [11] on chameleons dwelling at high elevations suggest the importance of rapid heating in the morning since the animals begin their activity at low temperatures which impose severe limitations. Mean SBT during the day and night period for male and female *C. chamaeleon* (30.2 and 31.2°C) obtained from the thermal gradient is similar to the mean gradient PBT reported for *C. dilepis* (33°C) by Walton and Bennett [13]. Abu-Ghalyun [23] recorded the mean PBT for *C. senegalensis* also to be 32°C. A similar result was obtained by Bustard [17] who found the rectal temperatures of basking *C. paradalis* to be between 32 and 33.8°C.

The mean SBT of *C. chamaeleon* recorded here is probably higher than what may be the eccritic temperature for the species. The range selection 18-44°C stretches well beyond the assumed (SBT) range (16-32°C) calculated for the same species by Al-Sadoon and Abdo [15] from metabolic rate measurements through oxygen consumption at varying temperatures. Further, those authors cound that the resting oxygen consumption value showed a sharp increase between 10 and 15°C, and steadly increased consumption between 15 and 35°C. Although the oxygen consumption was not measured above 35°C their results support the selected range of 18-44°C recorded here.

Mean SBT of *C. calyptratus* (a species inhabiting lower elevations, below 1000 m, in the same region as *C. chamaeleon*) has been found to be between 26.8 and 37.9°C, with a mean of 32.9°C [16]. This value is close to the mean temperature selected by *C. chamaeleon* although *C. calyptratus* inhabits different elevations and experiences

different seasonal temperature regimes. The lower limit of the SBT range is higher in *C. calyptratus*. This is related to the higher environmental temperatures available to *C. calyptratus* when compared with the high altitude temperate climate of the *C. chamaeleon* habitat.

The significant difference observed between the temperature selected by individual animals both during the day and at night could be due to the fact that the animals were of different sexes, weights and stages of maturity. Zari [16] reported metabolic rate to be higher in smaller chameleons than in larger ones, measured at the same experimental temperatures.

Other reports accord variable thermal behavior to different species from different geographical regions. The arboreal *C. pumilus* has a range of 3.5-37°C with a mean of 22.4°C, while the terrestrial *C. namaquensis* has a range between 14-39.7°C and a mean of 28.9°C [9]. Basking at high temperatures (40°C) has been reported in the giant Madagascar chameleon *C. lateralis* [17].

CTMax and CTMin obtained during this study have a wider variation than those reported for Kenyan species of chameleons. Walton and Bennett [13] reported CTMax and CTMin for *C. dilepis, C. jacksonii* and *C. ellioti* as 43.6-7.6°C, 41-5°C and 42-3.5°C respectively. The upper limit for *C. chamaeleon* is much higher than those of other species. The value obtained is almost the same as the CTMax of *Agama yemenesis* (47°C) (Al-Johany, in press) which lives in the same habitat. It is also similar to those of many terrestrial desert lizards [6]. The CTMin of *C. chamaeleon* is the same as that reported for *C. ellioti,* which also inhabits a high altitude habitat. Color change observed during the CTMax experiment on *C. chamaeleon* is in line with the observations on temperature affected color change in other species of chameleons [12, 13].

In summary, *C. chameleon* has been found to be an adaptable species tolerating a wide range of temperatures and having a well-developed thermoregulatory mechanism. Given suitable conditions in a vivarium, this species may prove to be suitable for captive breeding.

Acknowledgement. The author thanks Dr. M. Shafiq for statistical help and Mr. M. Yousuf for technical assistance and help in preparation of tables and graphs.

References

[1] Cowles, R.B. and Bogert, C.M. "A Preliminary Study of the Thermal Requirement of Desert Reptiles." *Bull. Am. Mus. Nat. Hist.*, 83 (1944), 259-296.

[2] Brattstrom, B.H. "Body Temperature of Reptiles." *Am. Midl. Nat.*, 73 (1965), 376-422.

[3] Templeton, J.R. "Reptiles." In: *Comparative Physiology of Thermoregulation.* Vol. 1 (Whittow, G.C. ed.). New York: Academic Press, 1970.

[4] Bradshaw, S.D. "The Maintenance of Physiological Homeostasis in the Desert Environment." In: *Ecophysiology of Desert Reptiles.* Australia: Academic Press, 1986.

[5] Cloudsley-Thompson, J.L. *Adaptations of Desert Organisms. Ecophysiology of Desert Arthropods and Reptiles.* Berlin: Springer-Verlag, 1991.

[6] Curry-Lindahl, K. "Thermal Ecology of the Tree Agama *(Agama atricollis)* in Zaire with a Review of Heat Tolerance in Reptiles." *J. Zool. Lond.* 188 (1979), 185-220.

[7] Gans, C. "The Chameleon." *Nat. Hist.,* 76 (1967), 52-59.

[8] Martin, J. *Nature's Masters of Disguise.* U.K.: Blandford, Cassell, 1992.

[9] Burrage, B.R. "Comparative Ecology and Behavior of *Chamaeleo pumilus* (Gmelin) and *C. namaquensis* A. Smith (Sauria:Chamaeleonidae)." *Ann. S. Afr. Museum,* 61 (1973), 1-158.

[10] Hebrard, J.L.; Reilly, S.M., and Guppy, M. "Thermal Ecology of *Chamaeleo hohnellii* and *Mabuya varia* in the Aberdare Mountains: Constraints of heterothermy in an Alpine Habitat." *J. East Afr. Nat. Hist. Soc.,* 176 (1982), 1-6.

[11] Reilly, S.M. "Ecological Notes on *Chamaeleo schubotzi* from Mount Kenya." *J. Herpetol. Assoc. Afr.,* 18 (1982), 28-30.

[12] Durve, V.S. and Sharma, H.S. "Some Observations on Color Changes of the Indian Chameleon." *J. Bombay Nat. Hist. Soc.,* 72 (1975), 107-112.

[13] Walton, B.M. and Bennett, A.F. "Temperature-dependent Color Change in Kenyan Chameleons." *Physiol. Zool.,* 66, No. 2 (1993), 270-287.

[14] Hillenius, D. and Gasperetti, J. "Reptiles of Saudi Arabia. The Chameleons of Saudi Arabia." *Fauna of Saudi Arabia,* 6 (1984), 513-527.

[15] Al-Sadoon, M.K. and Abdo, N.M. "A Comparative Study on the Metabolic Rates of Five Species of Lizards Belonging to Three Different Families." *Bull. Maryland Herpetol. Soc.,* 24, No. 4 (1988), 85-98.

[16] Zari, T.A. "Effects of Body Mass and Temperature on Standard Metabolic Rate of the Desert Chameleon *Chamaeleo calyptratus." J. Arid Environ.,* 24 (1993), 75-80.

[17] Bustard, R. "Keeping and Breeding Oviparous Chameleons." *Brit. Herpetol. Soc. Bull.,* 27 (1989), 18-33.

[18] Halfpenny, S.C. "The Care and Breeding of Johnston's Chameleon *Chamaeleo johnstoni,* in Captivity." *Brit. Herpetol. Soc. Bull.,* 39 (1992), 34-36.

[19] Langerwerf, B. "The Reproduction in Captivity of the Natal Midland Dwarf Chameleon *Bradypodion thamnobates"" Brit. Herpetol. Soc. Bull.,* 41 (1992), 15-18.

[20] Ferguson, G.W. "Ad-Libitum Feeding Rates. Growth, and Survival of Captive-hatched *(Chamaeleo paradalis)* from Nose be Island, Madagascar." *Herpetol. Rev.,* 22, No. 4 (1991), 124-125.

[21] Arnold, E.N. "A. Key and Annotated Check List to the Lizards and Amphisbaenians of Arabia." *Fauna of Saudi Arabia,* 8 (1986), 385-435.

[22] Avery, R.A. "Thermoregulatory Behavior of Reptiles in the Field and in Captivity." In: *Reptiles-breeding, behaviour and veterinary aspects* (Townson, S. and Lawrence, K. eds.) London) *Brit. Herpetol. Soc.,* 1985, 45-60.

[23] Abu-Ghalyun, Y.; Greenwald L.; Hetherington, T.E., and Gaunt, A. "The Physiological Basis of Slow Locomotion in Chameleons." *J. Exp. Zool.,* 245 (1988), 225-231.

الاختيار الحراري للحرباء *Chamaeleo chamaeleon* من جنوب غرب الجزيرة العربية

عوض متيريك الجهني

قسم علم الحيوان، كلية العلوم، جامعة الملك سعود، ص.ب ٢٤٥٥، الرياض ١١٤٥١، المملكة العربية السعودية

(سُلِّم في ٦ جمادى الأولى؛ وقُبل للنشر في ٢٣ ذي الحجة ١٤١٥هـ)

ملخص البحث. ينتشر هذا النوع على امتداد سلسلة جبال الحجاز من مدينة حقل شمالاً إلى شمال اليمن. ويحتل بيئة تمتاز بالبرودة شتاءً والاعتدال صيفًا ويتركز وجوده على ارتفاع ألفي متر فوق سطح البحر.

تمَّ تقدير درجة حرارة الجسم المفضلة للحرباء *C. chamaeleon* خلال النهار والليل باستخدام الحوض الحراري. وقد وجد أن معدّل درجة الحرارة المفضلة للذكور خلال النهار ٣١,٢°م و ٣١,٤°م خلال الليل بينما كانت ٢٩,٦°م و ٣٠,٨°م للإناث على التوالي. وقد ظهر أن مجال درجات الحرارة المفضلة واسع لهذا النوع من الحرابى وأنّ هذا المجال أكثر اتساعًا خلال الليل. وقد أظهرت البيانات الإحصائية فروقًا معنوية في الاختيار الحراري بين الأفراد. كذلك تمّ تقدير درجة الحرارة الحرجة العليا (٤٦,٨°م) والدنيا (٣,٨°م) وتوضح نتائج تقدير درجات الحرارة العليا والدنيا أن هناك اختلافًا ملحوظًا بالمقارنة بالأنواع الأخرى من الحرابى.