Belg. J. Zool., 130 (Supplement 1): 87-91 November 2000

Variation in body temperatures of the African Chameleon *Chamaeleo africanus* Laurenti, 1768 and the Common Chameleon *Chamaeleo chamaeleon* (Linnaeus, 1758)

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ABSTRACT. Data on the thermal ecology of the African Chameleon *Chamaeleo africanus* Laurenti, 1768 and the Common Chameleon *Chamaeleo chamaeleon* (Linnaeus, 1758) are reported from Greece.

In the field the Tb values ranged from 10.4°C to 31.6°C for *C. africanus* and 23.5°C to 31°C for *C. chamaeleon*.

There was a significant correlation between Tb and Ta in spring and summer for both species. There was also a significant correlation between Tb and Ts only in the spring and only for *C. africanus*. Cloacal temperatures differed significantly between spring and summer and so did substrate temperatures and air temperatures. As the months became hotter the animals reached higher temperatures.

In a laboratory temperature gradient, the preferred body temperatures of *C. africanus* and *C. chamaeleon* were measured and compared with field body temperatures.

The preferred body temperature in the laboratory gradient ranged from 26.0°C to 36.0°C for *C. chamaeleon* and from 25.0°C to 35.0°C for *C. africanus*.

The mean Tb for *C. africanus* in the laboratory was 31°C while for *C. chamaeleon* it was 31.6°C.

The results indicate that both chameleon species are thermoconformers.

Cloacal temperatures differed significantly between the two species in the field but not in the laboratory. There was no difference between the Tb of the two sexes, both in the field and in the laboratory.

INTRODUCTION

Few field records of Chameleon body temperatures exist and there are no data from the Mediterranean region. STEBBINS (1961) gave body temperature records of captive *C. dilepis* and *C. namaquensis*. BURRAGE (1973) has done most of the work on both field and laboratory thermoregulation of *C. pumilus* and *C. namaquensis*. AVERY (1982) referred to BURRAGE's and STEBBINS' studies.

The distribution of the African Chameleon ranges from the Red Sea to western Mali (Central Africa) (BÖHME, 1985); to the north it has reached Egypt (JOGER, 1981). The presence of the species at Ramleh, close to Alexandria in Egypt, was first recorded by Anderson (1898). The African Chameleon is a new species of the Greek and European herpetofauna (BÖHME et al., 1998 & KOSUCH et al., 1999). In Greece this species has been observed only at Divari lagoon, Gialova near Pylos, in the southwestern Peloponnese (21° 40' E, 36° 58' N).

The Common Chameleon has the broadest distribution of all chameleon species, found from Morocco and the southern Iberian Peninsula over the whole of North Africa, to the Near East, Turkey, Cyprus and Southern Arabia and – perhaps with a gap in Iran – to India and Sri Lanka (HILLENIUS, 1959, 1978). The distribution of this species in Greece includes the Aegean islands of Samos, Chios and Crete (ONDRIAS, 1968; CHONDROPOULOS, 1986).

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In the present study, data on the thermal ecology of the African Chameleon *Chamaeleo africanus* Laurenti, 1768 and the Common Chameleon *Chamaeleo chamaeleon* (Linnaeus, 1758) are reported from Greece. The present preliminary results are the first on the thermal ecology of the two European chameleon species.

The preferred body temperatures in a laboratory temperature gradient of the African Chameleon and the Common Chameleon were measured and compared with field body temperatures.

METHODS AND STUDY AREA

Fieldwork at Gialova, Pylos was carried out in August 1997, April, May, June and August 1998 and June 1999. The study area of the African Chameleon at Pylos is a coastal area with sea inlets (20 ha). The habitat in which this species has been observed consists of salt marshes, sand dunes, agricultural land, maquis and phrygana formations and some reeds.

The study area for the Common chameleon is situated on the island of Samos, which has the greatest population of this species in Greece (Ioannides et al., 1994).

On Samos island, fieldwork was done in May 1997, June 1998 and July 1999. At Samos the study area was a riverside with riverine vegetation, olive groves and other cultivation on the eastern part of the island.

Most of the fieldwork was carried out during the afternoon, evening and night, between 18:30-03:00, while a few data were also collected during the daytime. Most of the data were collected when it was dark, since at that time it is more effective to find the animals using flashlights (Cuadrado, 1997). The animals were first observed when they were starting to climb on plants at about 18:50, and at 21:00 when they were sleeping on them. All of the data were taken when the animals were resting. After the taking of temperature measurements the specimens were released where they were caught. Only subadult and adult individuals were measured.

Body temperatures (Tb) were obtained using a Weber quick-reading cloacal thermometer. A total of 109 cloacal temperatures were recorded in the field, 93 for the African Chameleon and 16 for the Common Chameleon. Air temperature (Ta) at 1-1.5m above the ground surface and substrate temperature (Ts) were measured at the site of each animal capture. Tb was measured within 10 seconds after capture. For analysis of the data, the study period was divided into two seasons: spring (April- May-June) and summer (July-August).

Seven adult individuals of the African Chameleon (two males and five females) and two of the Common Chameleon (males) were housed in a temperature gradient to study the preferred body temperatures. In order to create a laboratory temperature gradient a 100cm x 20cm terrarium was marked at 5cm intervals without places for animals to hide. At one side of the gradient there was a heating lamp and at the opposite side ice caps. The temperature gradient ranged from 14 to 60° C. The chameleons were placed one at a time in the terrarium and temperatures were taken every 20 minutes. Air (Ta) and substrate temperatures (Ts) in the terrarium were measured at the site of capture. Four hundred and sixteen cloacal temperatures were recorded from individuals in the laboratory, 300 for the African Chameleon and 116 for the Common Chameleon.

For statistical comparisons of temperature values t-tests and Mann-Whitney U tests were used. The latter was used for the field data where the number of measurements was small. We also used regression analysis to examine the possible correlation between Tb and Ta and between Tb and Ts.

RESULTS

The results of the field temperature measurements are shown on Table 1. Cloacal temperatures differed significantly between spring and summer for both species (U test for *C. chamaeleon* z=-2.91 p< 0.0 1, for *C. africanus* z=-5.79 p< 0.0 1) and so did substrate temperatures (U test for *C. chamaeleon* z=-2.91 p< 0.0 1, for *C. africanus* z=-7.13 p< 0.0 1) and air temperatures (U test for *C. chamaeleon* z=-2.91 p< 0.0 1, for *C. africanus* z=-6.77 p< 0.0 1). As the months became hotter the animals reached higher temperatures (Fig.1).

Correlation analysis indicated that for both species there was a significant positive correlation between Tb and Ta both in spring and summer (Table 2).

There was a significant positive correlation between Tb and Ts only in the spring and only for *C. africanus* (Tb=4.02+0.86 Ts, r=0.97).

Cloacal temperatures differed significantly between the two species in the field (U test, z=4.72 p< 0.01), as did substrate temperatures (U test, z=3.18 p< 0.01) and air temperatures (U test, z=4.60 p< 0.01). However cloacal temperatures did not differ significantly between the two species in the laboratory (t-test, t=1.43 p=0.15).

The results of the temperatures in the laboratory are shown in Table 1. The preferred body temperature (80% of the values) in the laboratory gradient ranged from 26.0° C to 36.0° C for *C. chamaeleon* and from 25.0° C to 35.0° C for *C. africanus*. The median Tb for *C. africanus* was 31° C while for *C. chamaeleon* it was 32.7° C (Fig. 2).

For both species there was no difference between the Tb values of the two sexes in the field (U test for *C. chamaeleon*, z=0.22 p> 0.05 for *C. africanus,* z=-0.07 p> 0.05) and laboratory (U test for *C. africanus* z=-. 74 p> 0.05).

TABLE 1

Body (Tb), substrate (Ts) and air temperatures (Ta) measured in the field and laboratory for *Chamaeleo africanus* and *C. chamaeleon* in the spring and summer (N= number of measurements, S.D. = standard deviation).

FIELD									
				Chamaeleo africanus					
	Spring				**Summer**				
Variable	N	Mean	Range	S.D.	N	Mean	Range	S.D.	
Tb	39	20.80	10.40-31.60	3.38	54	24.71	20.10-31.00	2.40	
Ts	39	19.58	10.20-32.60	3.81	54	26.24	19.90-33.00	3.11	
Ta	39	19.22	11.60-25.00	2.95	54	24.00	18.80-28.10	2.43	
				Chamaeleo chamaeleon					
	Spring				**Summer**				
Variable	N	Mean	Range	S.D.	N	Mean	Range	S.D.	
Tb	4	24.17	23.50-25.00	.66	12	28.34	27.00-31.00	1.13	
Ts	4	21.85	19.60-23.80	1.84	12	29.57	27.80-31.00	.93	
Ta	4	22.10	20.20-24.00	1.60	12	28.13	27.00-29.80	.90	
LABORATORY									
	Chamaeleo africanus				***Chamaeleo chamaeleon***				
Variable	N	Mean	Range	S.D.	N	Mean	Range	S.D.	
Tb	300	30.96	15.60-38.20	3.77	116	31.56	23.00-39.60	3.89	
Ts	300	29.80	14.50-50.00	5.97	116	31.71	19.70-59.90	6.92	
Ta	300	25.74	15.80-31.00	3.47	116	29.43	20.00-36.00	4.32	

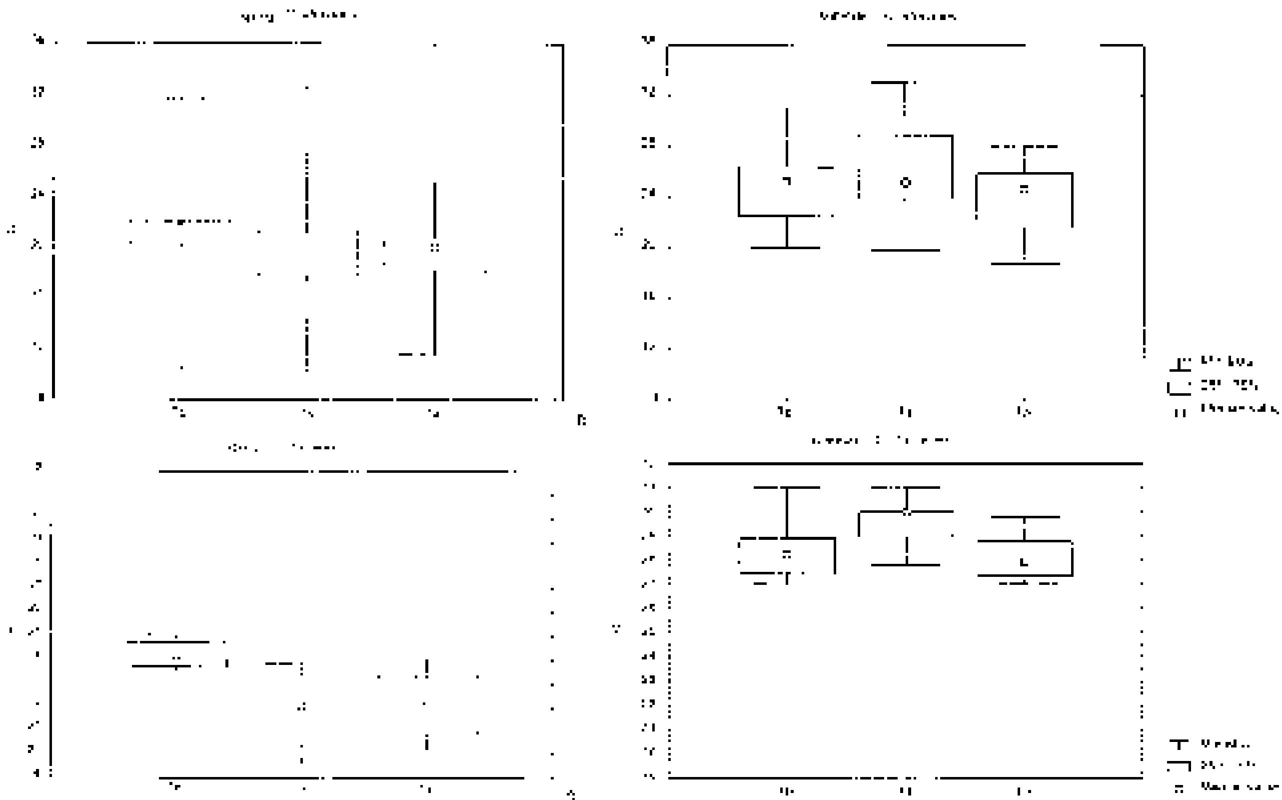

Fig. 1. – Body (Tb), substrate (Ts) and air temperature (Ta) measured in the field for *hamaeleo africanus* and *C. chamaeleon* in spring and summer.

TABLE 2

The correlation between Tb and Ta in spring and summer for the two chameleon species.

Tb vs. Ta	spring	summer
Chamaeleo africanus	Tb= 0.24+1.1 Ta, r=0.93	Tb= 1.98+0.95 Ta, r=0.96
Chamaeleo chamaeleon	Tb= 15.16+0.41 Ta, r=0.98	Tb= -1.87+1.07 Ta, r=0.85

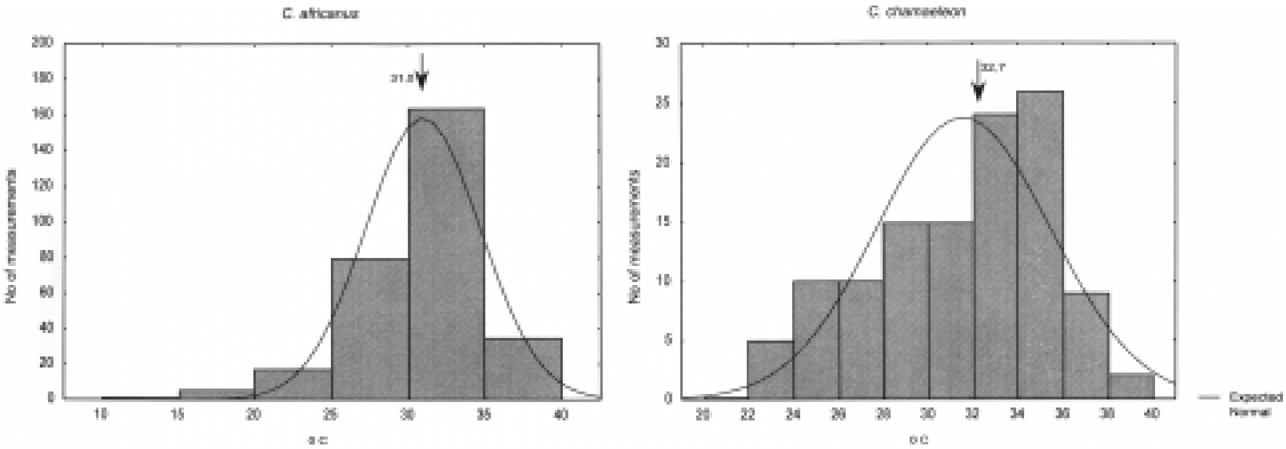

Fig. 2. – Body temperatures (Tb) for *Chamaeleo africanus* and *C. chamaeleon* measured in the laboratory. Arrows indicate the respective median values.

DISCUSSION

It should be noted that differences in the Tb between the two chameleon species studied have been found only in the field. Also Ts and Ta were different at the two different study areas. So it is possible that the difference between the Tb of the two species are due to the different environmental conditions, however, more controlled experiments are needed to clarify this possibility.

According to the range of the values of the two chameleon species studied, *C. chamaeleon* has a greater minimum value, both in the field and laboratory, while the maximum values are similar.

The preferred body temperature in the laboratory gradient is similar between the two examined species (Fig. 2).

The values of BURRAGE (1973) for *C. pumilus* and *C. namaquensis* at rest are lower than ours for *C. chamaeleon* and *C. africanus* (Table 3), although our data cover only two seasons (Fig. 1).

Body temperatures are lower when animals are at rest (Burrage, 1973) however our values are similar to the range of values for active *C. dilepis*, *C. pumilus* and *C. namaquensis* (Table 3).

The mean Tb for *C. namaquensis* at rest is much lower than for *C. chamaeleon* and *C. africanus* (Table 3). Both

TABLE 3

Body temperatures of chameleon species mentioned in the literature.

Species	Field		Laboratory		
	Range °C	Mean °C	Range °C	Mean °C	
C. dilepis	21.0-36.5	31.2			Stebbins, 1961
C. pumilus	3.5-37.0	22.4			
	(asleep 0.5-26.5)	—	7.0-30.0	25.0	Burrage, 1973
C. namaquensis	14.0-39.7	28.7	18.5-36.2	29.3	Burrage, 1973
	(rest 7-13 coastal, 9-16 inland)	(rest 10.6 coastal 12.3inland)			
C. namaquensis				33.5	Stebbins, 1961
C. africanus	10.4-31.6	23.1	15.6-38.2	31.0	Present study
C. chamaeleon	23.5-31.0	27.3	23.0-39.6	31.6	Present study

our values are more similar to those of active chameleon species from literature (Table 3), but our data cover only two seasons.

According to the laboratory data *C. namaquensis* is within the range of the two species we studied, while *C. pumilus* values are lower than those of the two Greek chameleon species (Table 3).

Stebbins (1961) gives a preferred body temperature range of 28.5-36.5°C for *C. namaquensis*. These values are within the range of the two studied species (Fig. 2). According to BURRAGE (1973), the mountainous species *C. bitaeniatus* and *C. hohnelii* are "active" in a similar thermal range in the laboratory, like *C. pumilus* and *C. namaquensis*.

The mean Tb values for *C. africanus* and *C. chamaeleon* in the laboratory, are similar to those for *C. namaquensis* but greater than those for *C. pumilus* (Table 3).

It seems that both chameleon species of the present study are thermoconformers because the slope of the equation Tb Vs Ta is near to 1. This is in accordance with HUEY & SLATKIN (1976). Thus, we are continuing this study because more data are needed.

ACKNOWLEDGMENTS

We wish to thank the Hellenic Ornithological Society, which carries out the LIFE-Nature project B-3200/97/244 "Implementation of Management Plans for Pylos Lagoon and Evrotas Delta, Natura 2000 Sites, Greece" (funded be EU and the Ministry of Environment, Physical Planning and Public Works) for accommodation during some of the field trips. Also many thanks to I. Schogolev, Y. Ioannidis, G. Chiras and A. Bonetti for assistance in the field work.

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