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ACTIVITY AND THERMOREGULATION PATTERNS IN TWO SPECIES OF LACERTIDAE: PODARCIS HISPANICA (STEINDACHNER, 1870) AND PODARCIS BOCAGEI (SEOANE, 1884)

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SUMMARY

A study has been carried out on the activity rythms and thermoregulatory behaviour of Podarcis hispanica and Podarcis bocagei in the western region of the Sistema Central (Spain) where both species live together. P.bocagei occupies the least favourable environment, from a thermal point of view (oak forest flours and their subserial stages) and P.hispanica inhabits rocky zones reaching body temperatures wich are cleary greater than those of P.bocagei. In both cases, the body temperatures are higher than the surrounding air temperatures and ground temperatures. Both species, therefore are eurythermic with a wide range of voluntary temperatures. Their small body size permits them to remain active for a large part of the year and in P.hispanica, winter aggregations are reported and possible reasons for their existence are discussed.

INTRODUCTION

Thermoregulatory behaviour and activity rythms are without doubt the least known aspects in the ecology of the Lacertidae. In the case of the two species to be discussed below, only the reduced data of (4) are known for P.hispanica.

We have thought it of interest then to present new data relating to daily and annual activity and the thermoregulatory behaviour of P.hispanica and P.bocagei since those are two species which are closely linked and difficult to distinguish morphologically (1,2) though which do have differential ecological caracteristics (9).

MATERIALS AND METHODS

The area covered included the whole of the western zone of the Sistema Central of the Iberian Peninsula and observations were thus made in the "Sierras" of Francia and Gata (Spain) and the Serra da Estrela (Portugal) at variables altitudes between 800 and 1200 m. with a vegetation cover of oaks and their subserial stages (for greater details, see 9).

For the purposes of studying activity rythms, a total of 1081 observations were used of which 781 corresponded to P.hispanica and 301 to P.bocagei. The observations in both cases, were carried out throughout the period of annual activity. Daily rythms, then, should be considered as average annual values. The percentage corresponding to each hourly period has been corrected according to the relative number of observations in the period described.

The principal period of daily activity takes place during the first few hours after moon(Figure 2).One is therefore dealing with an unimodal rythm,though during the months of July and August a greater bimodality may be seen with periods of total inactivity during the central hours of the day.The evening phase coincides with the beguinning of main hunting behaviour during the day(10).

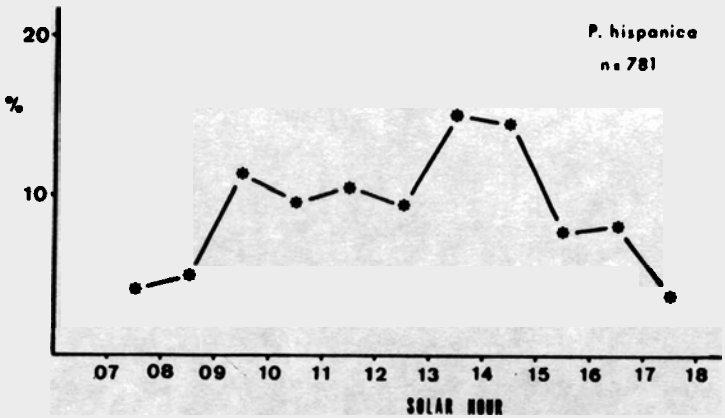


Figure 2.Daily activity rythm of P.hispanica %:the corrected percentage of individuals in each hourly period with respect to the total number of individuals observed(n=781).

A total of 157 cloacal recordings were obtained in all kinds of situations.The active individuals(category a)show CT's with an average of $\bar{x}$=35.08°C (n=40, s=3.35, interval:26.5-41°C).Thermoregulation in this species is achieved by sun-bathing,combined in some cases with thygmothermia on the rocky substrates which are usually occupied.During this mode of behaviour(situation b) P.hispanica achieves an average cloacal temperature of 28.03°C (n=67, s=5.53, interval:15-40°C).Finally,the inactive individuals,found in hides,showed much lower CT's:$\bar{x}$=24.20°C (n=10,s=6, interval:16-34.5°C).

Also measured separately were the CT values of adults males and females individuals and active juveniles,with the following results:

♂♂	♀♀	Juveniles
$\bar{x}$=23.1	$\bar{x}$=36.28	$\bar{x}$=30.25
s=5.26	s=2.86	s=6.28
Interval:20-41	Interval:31.5-41	Interval:20.1-41
n=18	n=16	n=19

There are no statistically significant differences between both sexes and ages(Student's t test,12)(♂♂ and ♀♀:t=1.76, adults versus subadults:t=2.04).

Using the whole set of CT's registered, a s.s. correlation may be seen between CT and ST(r=0.72, p<0.01, regression line y=0.59x-15.71, Figure 3)and between CT and AT(r=0.72,p<0.01, regression line : y=0.59x-18.46, Figure 4).

The correlation are also significant in thermoregulating individuals (CT-ST: r=0:66,p<0.01 and CT-AT:r=0.70,p<0.01)and in individuals in hides (CT-ST: r=0.93,p<0.01 and CT-AT:r=0.91,p<0.01)and as may be seen,the correlation in both cases is ever closer.

Cloacal temperatures(CT),air temperatures(AT) at one meter above the ground and soil temperature(substrate temperature)(ST) were measured with an ICE platinum thermal probe with flat base, 2 mm. in diameter and 2 cm. long,connected to a digital thermometer constructed specifically for this purpose with a liquid crystal display and an Intersil ICM 7106 integrated circuit powered by a 6v battery.Accuracy was up to 0.1 °C.

The individuals observed was divided into three groups according to their situation at the time of observation:
a) Individuals involved in locomotion,hunting,territorial fighting or other dynamic behaviour.
b)Individuals involved in thermoregulatory behaviour.
c)Inactive individuals in hides,under stones,in rocky fissures or buried.

The voluntary range of temperatures was considered as that shown by individuals in situation a) and the arithmetic mean of this as voluntary average temperature(3,11,13).

RESULTS

Activity and thermoregulation

P.hispanica:This is one of the few species of Lacertidae which remains active all the year round in the northern half of the Iberian Peninsula Figure 1 shows the results of the analysis of annual activity expressed as

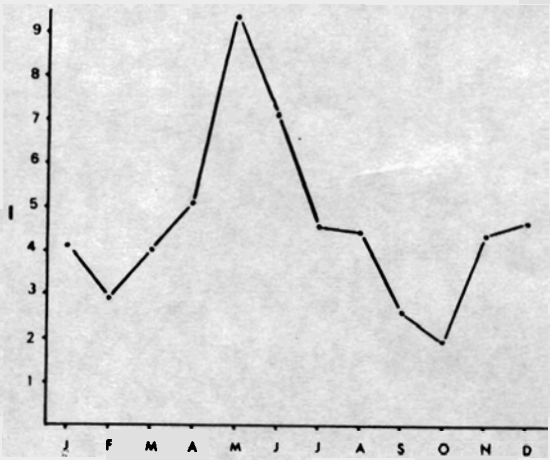


Figure 1.Annual activity of P.hispanica.I:Index of capture and observation.This index is calculated from the expression I=n/t,where n is the number of individuals observed during the month and t is the time of observation of the same month with respect to the annual total.

the percentage of individuals observed in each month.Maximum activity is to be seen in May during the period of the most intense sexual activity.Minimum activity is observed in October.Both periods,then,coincide with the times of greatest availability of trophic resources in the environment,respectively(10).

Busack(4) records similar values to our own for active individuals

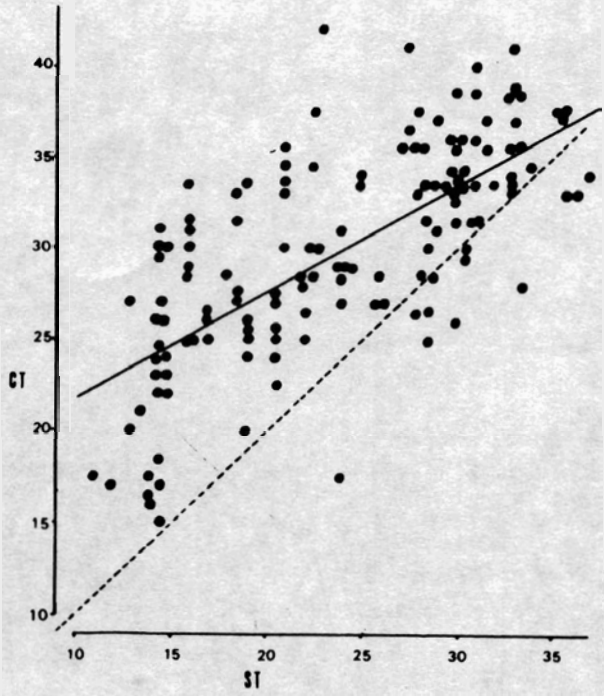


Figure 3.Relationship between body temperature(CT) and substrate temperature(ST) in P.hispanica,both in °C.The dotted line is called the line of perfect poikilothermy(an absolute correlation between CT and the other temperature considered).

($\bar{x}$=34.0°C-0.8, interval:25.4-38.4,n=16, microclimatic temperatures: 25.6-3.6, interval:19.5-34.5).

P.bocagei:Annual activity takes place from March to November.May is also the month of maximum activity and coincides with the reproductive cycles.The daily activity rythms cleary seems to be bimodal with a main peak during the morning immediately after the first thermoregulatory period after leaving the nocturnal hides(Figure 5).Evening activity is much less pronounced than in P.hispanica, probably due to the occupation of a microhabitat which is thermically less favourable than the rocky zones. Indeed,P.bocagei occupies in the zone of study oak forest flours and their subserial stages,while the rocky zones are only occupied by P.hispanica (9).

Active individuals show CTś with $\bar{x}$=32.28°C(n=78,s=3.73,interval: 25-39).The individuals in heliothermic thermoregulation, CT with $\bar{x}$=29.31°C (n=8,s=4.38,interval 24.5-38.5°C).Inactive individuals in hides, CT,$\bar{x}$= 24.24(n=5,s=3.59,interval:20.5-28.5).These last values correspond to period of thermal deficit.In the case of high environmental temperatures, P.bocagei also retires to its hides with CT,$\bar{x}$=34.50,n=4,s=1.96,interval: 32.5-37).

Neither does separate analysis for males and females adults and juveniles show any significant differences between the classes of sex

and age(males and females,t=1.18, adults and subadults t=1.66).

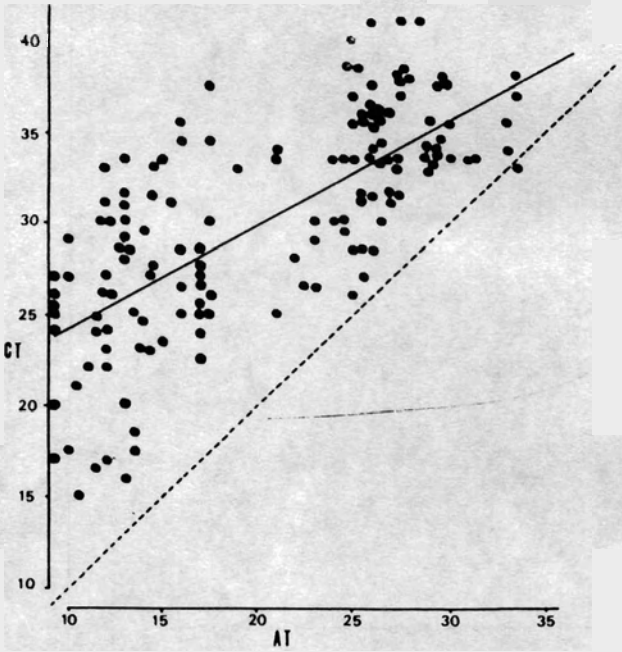
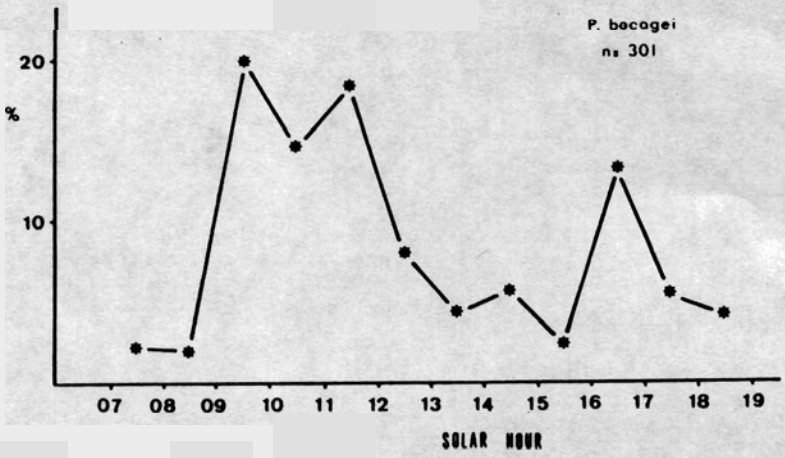


Figure 4.Correlation between CT and AT in P.hispanica.

The CT of active individuals in this species are also correlated with ST and AT(CT-ST,r=0.47,p<0.01,regression line: y=0.28x-24.70,Figure 6. CT-AT,r=0.35,p<0.01, regression line y=0.28x-25.98, Figure 7).



rity rythm of P.bocagei.

Hibernation

P.bocagei hibernates at the base of tree stumps and,principally, in small burrows dig in the root system at a depth of 5-20 cm. Of a total of 25 observations,only in two were 2 adults(♂ and ♀) found together, the rest contained only solitary animals.

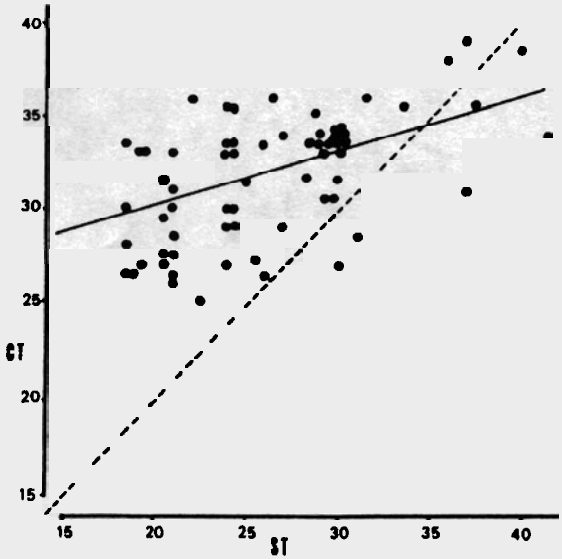


Figure 6. Correlation between CT and ST in P.bocagei.

As has been reported above,P.hispanica remains active all the year round though from the month of October to March substantial changes may be noted in the behaviour of the species.Indeed,during this period,all the animals of a given area congregate at particular points to spend the winter.Thus practically the whole population of P.hispanica from an area of some 10 hectares in the north of the "Sierra" of Francia gathered during the winter of 1980-81 in a zone measuring about 8.000 m^2, this area was particularly favourable since it was a granitic woolsack with numerous fissures and cracks.Most of the hides are horizontal fissures of 30-40 cm. in length and 50-60 cm. in depth found in granite breaks at a variable altitude between 0-120 cm. from the ground.In one case, a total of 45 adults and juvenile individuals of both sexes was observed in one of these hides.During the winter months,the individuals observed only appear at the mouth of the hides during the central daylight hours and then only when environmental temperatures are above 13°C with open sky and lack of wind.Hunting periods are then short in duration(2-6 min.) with long intermediate periods of thermoregulation at a few cm. from the mouth of the fissure.During this behaviour the individuals frequently maintain close body contact.

DISCUSSION

Both P.hispanica and P.bocagei behave as ectotherms(8) capable of a certain control over their body temperature thanks to their thermoregulatory behaviour(the "fine thermoregulators"in the sense of 7).Also, the species are eurythermic,that is, with a wide voluntary body temperature range.

Within the group of Lacertidae which inhabit the Sistema Central, those are the two species which exhibit the longest annual period of activity(see 9)probably due to their small size,on increasing the surface-mass relationship to a large extent the problem of their thermal control is simplified(5,6).

Because it occupies the most favourable niche from a thermal point of view(rocky zones) P.hispanica attains higher body temperatures than P.bocagei and also manages to remain active all year round.Finally,it is of interest that the winter agglomerations have been described for other species in more northerly latitudes(see, for example 14).There has been considerable controversy as to the hypothetical advantages of this kind of behaviour.According to Vitt(14) the individuals gather in the few places which are particularly suitable,for Spellerberg(13) however,the purpose behind this phenomenon is for the individuals to be able to find mate the following spring.Vitt's explanation seems more plausible since

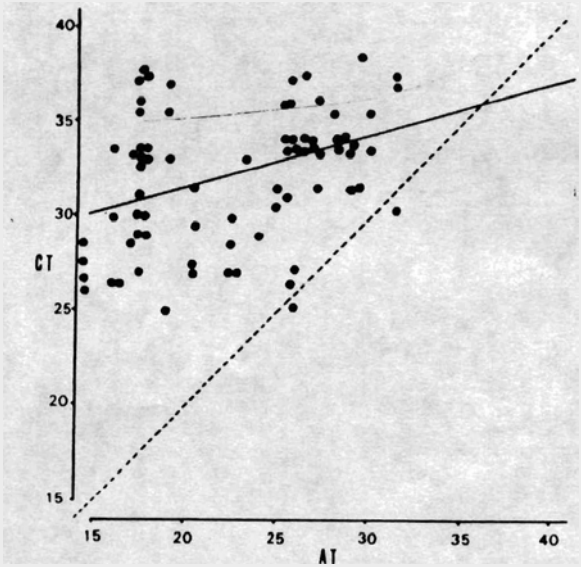


Figure 7.Correlation between CT and AT in P.bocagei.

such agglomerations help to achieve effective thermoregulation thanks to the close body contact.

Furthermore,the probability of a encounter the following spring would not increase since great dispersion takes place after wintering followed by the previous establishment of territory by the adult males before the reproductive behaviour begins.

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