1). There were also relatively large quantities of palmitic ($C_{16\ 0}$), linoleic ($C_{18\ 2}$) and linolenic ($C_{18\ 3}$) acids. (There is an excellent account of lipid classification and its biological significance, written for the non-biochemist, in an article on "Fish Nutrition" by C. B. Cowey & J. R. Sargent in *Advances in Marine Biology* vol. 10, 1972). Differences in the percentages of individual acids in the fat body and the tail were small and are almost certainly not significant, although a possible exception is that of linolenic acid, which comprised 10.46% of the neutral fatty acids in the fat body, but only 6.95% of those in the tail.

Component glycerides

Chromatographic separation of glycerides by argentation TLC is based on the degree of unsaturation in the molecule; consequently each component does not usually represent an individual glyceride, but a number of glycerides having the same degree of unsaturation.

Eleven saturation groups were found in both tissues; the percentages of each are shown in Table 2. The differences are almost certainly not significant, with the possible exceptions of those in groups 8 and 9. Triglycerides comprised 88% of the fat body neutral lipids and 91% of the tail neutral lipids (Table 3), whilst diglycerides comprised 9% and 4% respectively. The larger amounts of glyceride in groups 8 and 9 in the fat body neutral lipid fraction were possibly related to the high amounts of linolenic acid ($C_{18\ 3}$) and diglycerides in this fraction.

Sterols estimated as cholesterol comprised less than 1% of the total neutral lipid in both tissues.

DISCUSSION

There have been very few studies of reptile lipids, and none of those of the tail. Nearly all of the reptile lipids which have been analysed have a high proportion of unsaturated C_{18} acids, with oleic acid predominating (Hilditch & Williams, 1964; Grenot, 1968). Zain & Zain-ul-Abedin (1967) have noted that the fat bodies of the desert lizard *Uromastix hardwickii* contain 90% of esterified fatty acids, and are therefore more equivalent to white adipose tissue than to the brown fat which is associated with mammalian hibernation, since brown fat contains relatively more glycogen, phospholipid and cholesterol, and relatively less neutral lipid. Our resuts are consistent with both of these findings.

Although the abdominal fat bodies and the fat deposits around the tail vertebrae are quite distinct sites, there are no major differences in their composition. Since only one analysis of each tissue has been made, we are not able to determine whether the small differences in the percentages of linolenic acid and diglycerides are significant, but the related differences in the percentages of glyceride groups provide circumstantial evidence that they are. It is interesting in this context that amounts of fat body linolenic acid fluctuated more widely between four North African lizard species than those of six other major fatty acids which were measured (Grenot, 1968).

Since the composition of the deposits in the two tissues is essentially similar, it is perhaps not surprising that their lipids are utilised during the course of hibernation to a similar extent (Avery, 1970). A more detailed account of lipid storage and release in lizards of different age, sex and weight at different times of the year, will be published elsewhere.

REFERENCES

AVERY, R.A. (1970). Utilisation of caudal fat by hibernating common lizards *Lacerta vivipara*. *Comp. Biochem. Physiol.* **37**, 119-21.

GRENOT, D. (1968). Sur la constitution chimique de la graisse de dépot chez certains reptiles sahariens. *Bull. Mus. Natn. Hist. nat., Paris* 2e serie, **40**, 906-11.

HILDITCH, T P. and WILLIAMS, P. N. (1964). *The chemical constitution of natural fats*. Chapman & Hall, London, 4th Edition.

MOORE, P. R. C. and BAUMANN, C. A. (1952). Skin sterols. I. Colorimetric determination of cholesterol and other sterols in skin. *J. biol. Chem.* **195**, 615-21.

NICHOLS, B. W. (1964). Separation of plant phospholipids and glycolipids. In *New Biochemical Separations* (Eds. James, A. T. & Morris, L. J.). Van Nostrand, London.

SHEWRY, P. R., PINFIELD, N. J. and STOBART, A. K. (1972). The glycerides and acyl fatty acids of germinating hazel seeds. *Phytochemistry* **11**, 2149-154.

STOBART, A. K. and PINFIELD, N. J. (1970). Glycerol utilisation in seeds of *Corylus avellana* (L.). *New Phytol.* **69**, 939-49.

THOMAS, D. R. and STOBART, A. K. (1970). Lipids of tissue cultures of *Kalanchoë crenata* L. *J. exp. Bot.* **21**, 274-85

ZAIN, B. K. and ZAIN-UL-ABEDIN, M. (1967). Characterisation of the abdominal fat pads of a lizard. *Comp. Biochem. Physiol.* **23**, 173-77.

Identity	$^{c}12:0$	$^{c}14:0$	$^{c}16:0$	$^{c}16:1$	$^{c}18:0$	$^{c}18:1$	$^{c}18:2$	$^{c}18:3$	others
Position relative to palmitate	0.31	0.56	1.00	1.24	1.78	2.07	2.80	3.91	4.0
Percentage in fat body	0.91	1.63	13.08	5.85	4.13	51.40	11.88	10.43	2.0
Percentage in tail	1.23	2.28	14.85	6.41	3.91	52.13	11.64	6.95	2.0

Table 1. Neutral fatty acid content of the fat body and the tail. Results are expressed as percentages of the total neutral lipid fatty acid.

Glyceride group number	1	2	3	4	5	6	7	8	9	10	11
Relative front (Rf)	0.89	0.83	0.76	0.65	0.57	0.47	0.37	0.31	0.25	0.19	0.15
Percentage in fat body	3.49	14.90	23.57	11.77	10.12	12.42	5.33	5.65	6.76	3.50	2.49
Percentage in tail	2.42	14.54	27.22	13.09	12.19	12.92	5.67	3.13	3.90	2.70	2.22

Table 2. Glycerides of the fat body and tail. Glyceride group numbers refer to the relative positions of the glycerides on $AgNO_3$-impregnated TLC plates; the results are expressed as percentages of total glyceride.

Spot number	1	2	3
Identity	diglyceride	unknown	triglyceride
Relative front (Rf)	0.30	0.35	0.74
Percentage in fat body	9.10	3.09	87.81
Percentage in tail	4.07	3.51	91.42

Table 3. Total diglyceride and triglyceride in the fat body and tail, expressed as percentages of the total glyceride.

INFLUENCE OF PHOTOPERIOD AND LIGHT INTENSITY ON LIZARD VOLUNTARY TEMPERATURES

By

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(*Received* 23/3/73)

Regal (1967) and Gehrmann (1971) have shown that reptiles kept in temperature gradient chambers exhibit a 24-hour rhythm in their voluntary temperatures (body temperatures associated with normal activity), which is synchronised with a light dark cycle. Although this phenomenon has been considered in detail and although several explanations proffered, the parameter of light intensity has not been discussed in connection with reptile voluntary temperatures.

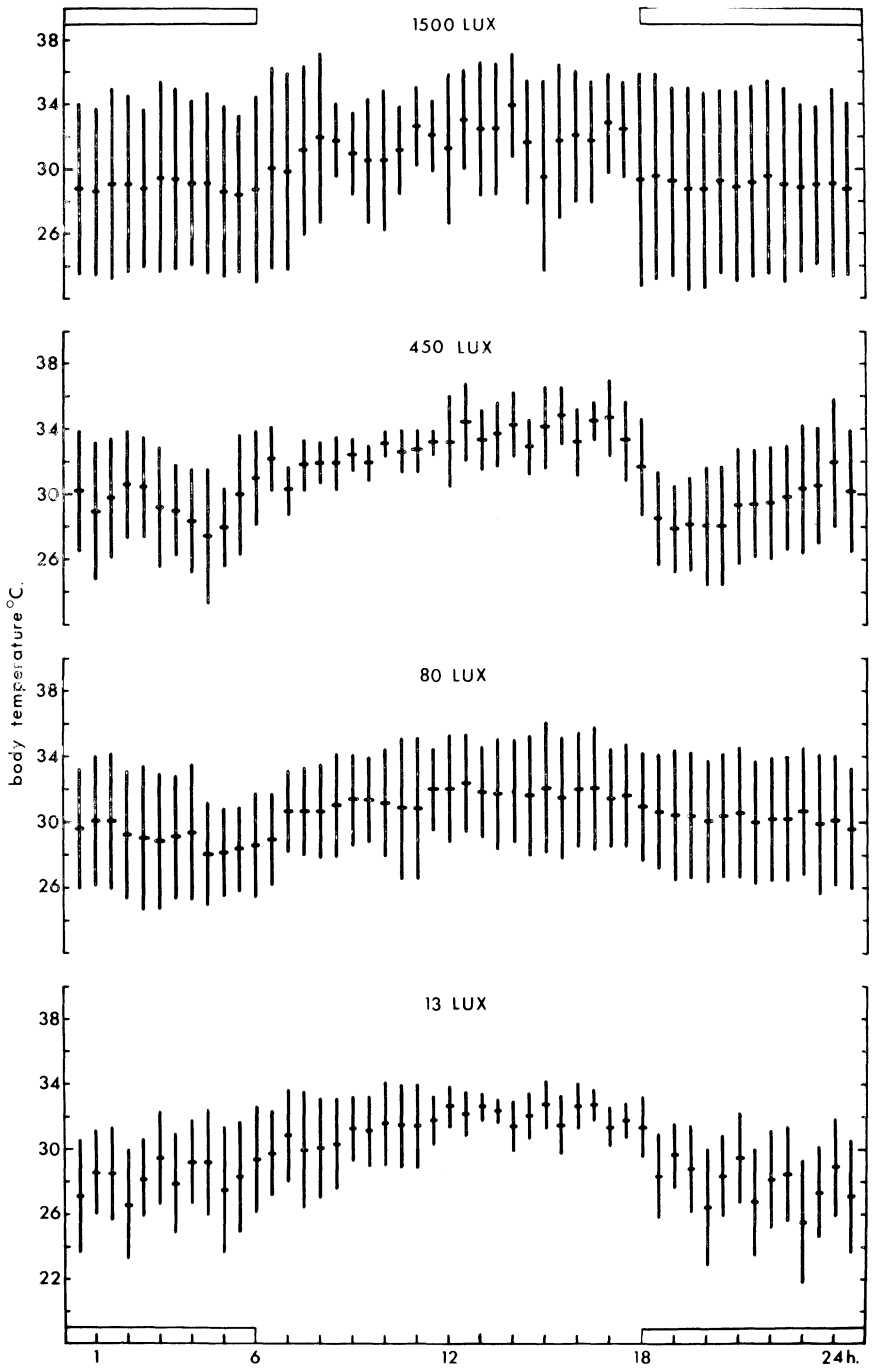

FIG. 1

A complex relationship exists between reptile activity periods and both ambient temperatures and photoperiods. Photoperiods do in part alter activity periods of some reptiles (see Cloudsley-Thompson, 1971 for a review). Further, it has been shown that increased light intensity will decrease spontaneous activity period lengths of *Lacerta sicula* kept in continuous light (Hoffmann, 1960).

As both the nature and the duration of light appear to influence reptile activity periods, and in view of the possible ecological and physiological importance of "voluntary hypothermia" (Regal, 1967), it seemed valuable to investigate the influence of these parameters on lizard voluntary temperatures.

MATERIALS AND METHODS

Lizards from a cool temperate thermal zone (*Lacerta agilis*) were collected in the vicinity of Erling-Andechs, Upper Bavaria and lizards from a warm temperate thermal zone (*Lacerta viridis*) were supplied commercially. The mean weight of *L. agilis* was 13 gms; *L. viridis* was 28 gms. Results from both males and females were combined.

A long box was used as a thermal gradient chamber and this was placed in a room where the room temperature of 5°C set the lowest temperature of the chamber. Heat lamps were placed under the chamber and provided a thermal gradient from 45°C to 5°C. The chamber had two identical compartments so that the temperatures of two lizards were monitored simultaneously. Dimensions of each compartment were: length 200 cm; width 25 cm; depth 33 cm.

Three pairs of water dishes and food dishes were spaced equidistant in each of the compartments. Three cardboard ledges (36 x 5 cm) in each compartment were placed one cm above the base and attached to the central partition. These were located at each end and in the middle of the chamber and they provided submergence localities for the lizards.

One lizard was placed in each compartment and the body temperature (large intestine) of each was recorded continuously with thermocouples. Once the lizard was instrumented it was allowed a 72 hour adjustment period prior to the experiments.

For both species there were four experiments and a different pair of lizards was used for each. The four experiments differed only in the light intensities used. A light-dark cycle (LD) was used for 9-11 days and this was followed by a period of 4-6 days continuous light (LL). Standard room lighting was used and the light source was 120 cm above the chamber. The LD schedule was on a 12 : 12 hour basis with 1,500, 450, 80 or 13 lux in the light phase and 0.01 lux in the dark phase.

Temperatures of a model lizard made from plasticine were used as a control. The model resembled *L. viridis* and was placed at about the centre of the thermal gradient chamber. Temperatures were recorded and treated as if for a real animal.

RESULTS

Mean body temperatures for each half hour interval over a 24-hour period are shown in Figs. 1 and 2. Lizard body temperatures are higher in the light phase than in the dark phase and the difference between light phase and dark phase means (mean of half hour interval means) was 1.6°C-3.7°C for *L. agilis* and 1.9°C-3.7°C for *L. viridis*. (Table 1). During LL the greatest difference between mean temperatures of the equivalent "light phase" and "dark phase" was 0.8°C for *L. agilis* and 1.3°C for *L. viridis* at a light intensity of 450 lux (Table 1). Although temperature records for LL were examined carefully for spontaneous rhythms, no 24-hour cycle was detected, although under natural conditions both *L. agilis* and *L. viridis* exhibit a diurnal monophasic period of activity (Marx & Kayser, 1949; St. Girons, 1971).

A sudden increase in body temperatures at the onset of the light phase is particularly noticeable at 1500 lux and 450 lux for both species while decrease in body temperatures at the termination of the light phase is more gradual. During the light phase and in some half-hour intervals as many as

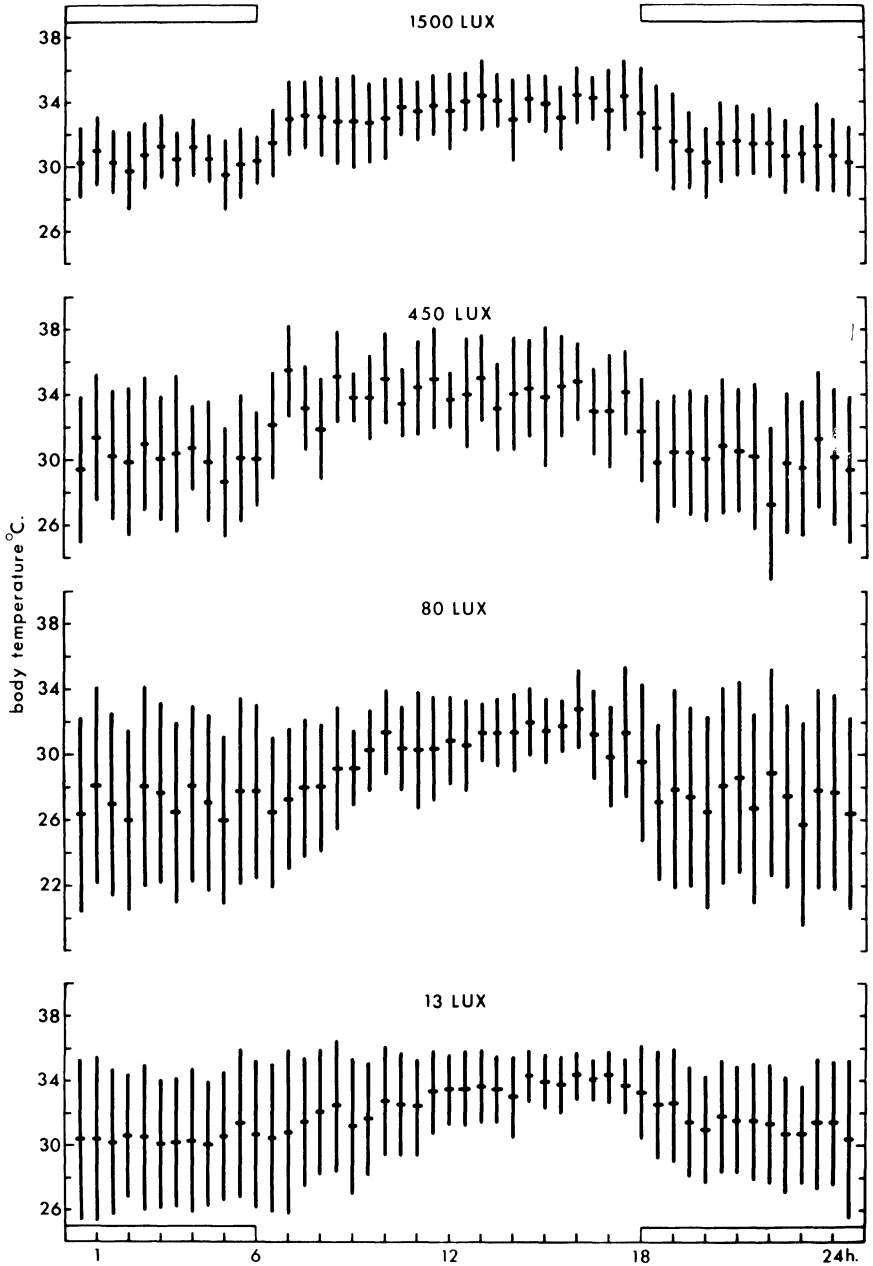

FIG. 2

68.3% of the recorded temperatures might be spread over 13 centigrade degrees (as indicated by one standard deviation) and the spread of body temperature values in each light phase half-hour interval is less than that recorded in each dark phase interval.

Apart from the diminished rate of change in body temperatures at the onset of the light phase with a decreased light intensity, there does not appear to be any change in the voluntary temperature levels over the four light intensities.

The distribution of body temperatures is shown in Figs. 3 and 4 as percentage frequency histograms. A control histogram is shown with data from the model lizard (Fig. 5). Generally the histograms are negatively skewed with some bimodal patterns (smaller peaks at lower body temperatures). The histograms for LL are all very similar but the LD histograms show that there is an increased frequency of higher body temperatures in the light phase of an LD cycle.

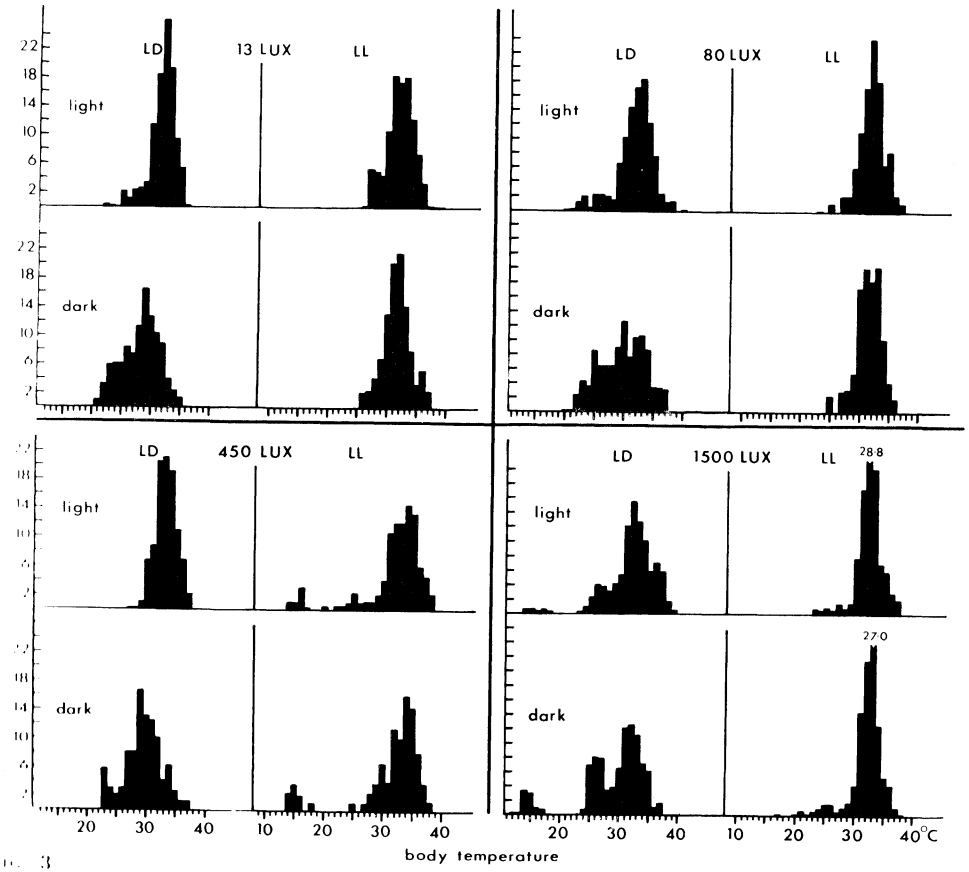

FIG. 3

DISCUSSION

The results show a difference between lizard mean body temperatures recorded in the dark phase and those recorded in the light phase of an LD cycle. This does not necessarily mean that the reptiles show voluntary hypo-

thermia and several possible contributing factors should be noted. At high light intensities in particular there was a sudden change in radiation in the overhead lights and thus a change in the amount of energy available from this source. That is could the lizards utilise the radiation from the light source and could this have an effect on the body temperature levels? This was not investigated but results from the plasticine model lizard suggest that if a lizard remained stationary, then changes in radiation levels would not alter the body temperature. Although there was a considerable range in the temperatures of the model this would have been caused by the fluctuating room temperature.

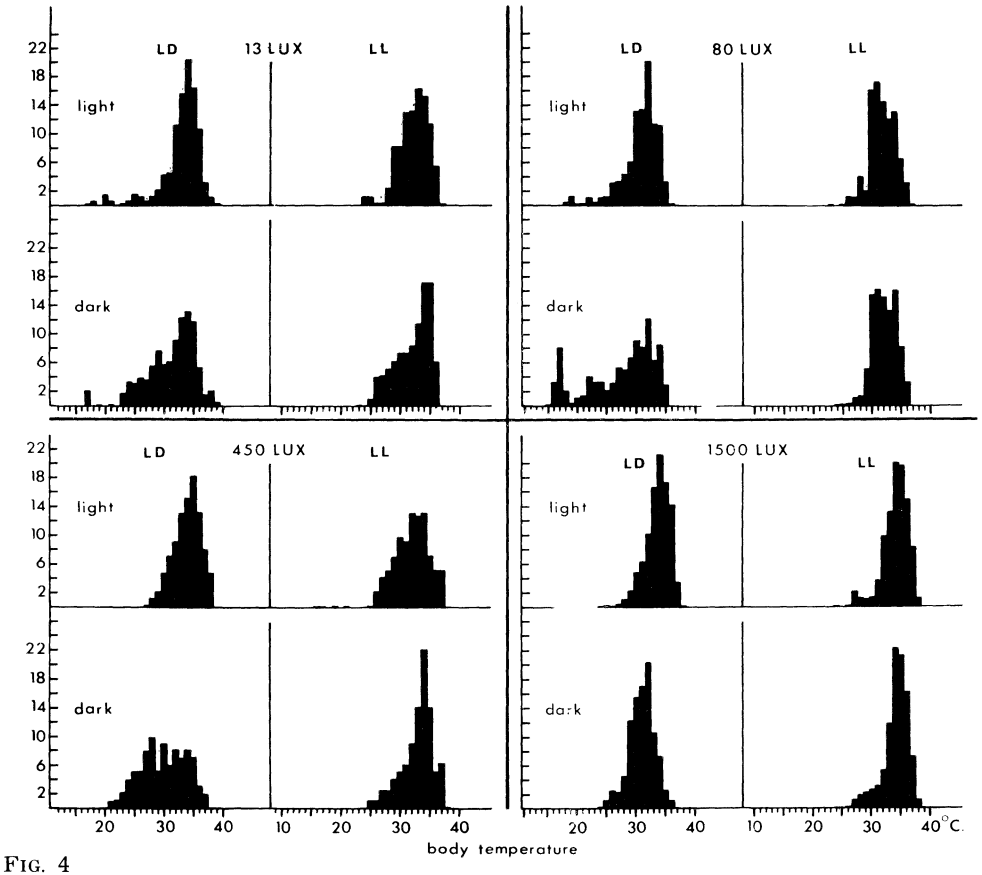

FIG. 4

Changes in the level of metabolic heat production and/or integument conductance, synchronised with the LD cycle is a factor which requires further investigation. It is however only in larger reptiles, with a small surface area in proportion to their mass, that metabolic heat production greatly alters the body temperature, and even in these large animals it is due to the large mass which has a slow loss of heat. In the lizards examined here (13-28 gms) there may be a slight change in metabolic heat production synchronised with the LD cycle but it is unlikely that this could contribute greatly to the present results.

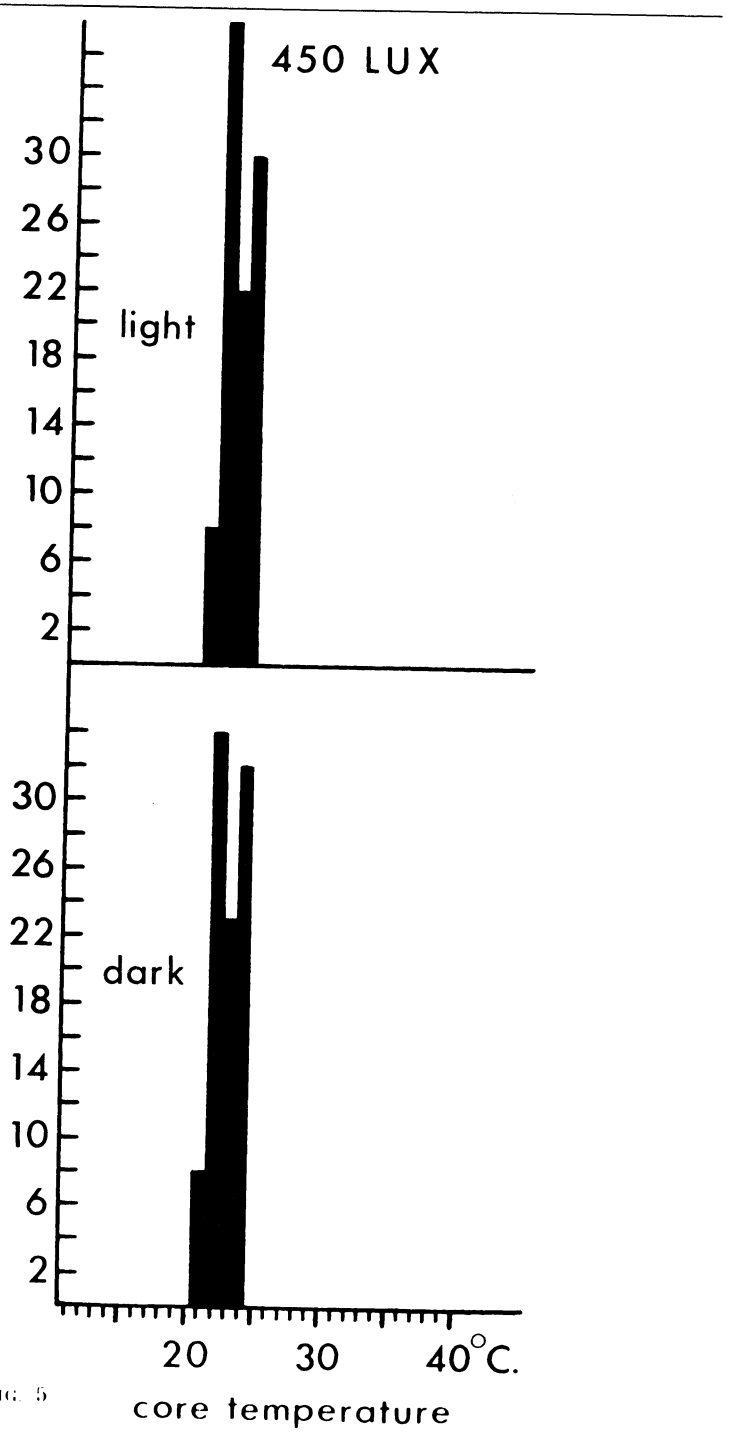

FIG. 5

The difference in body temperature levels could simply reflect a difference in activity. That is during the light phase the lizards are active and will therefore be more likely to move over warmer areas of the chamber more often than during the dark phase when less activity would be expected. The mean half hour temperatures (Fig. 1, 2) do not indicate this, and the small standard deviations in the light phase suggest that the lizards do in fact select out higher temperatures at that time.

It seems plausible that these two species do select lower body temperatures at night. Possibly the termination of light may be a signal for submergence and under natural conditions it is assumed that submergence in these species diminishes chances of predation and exposure to sub-Critical Minimum temperatures. Under natural conditions the lizards submerge during the late afternoon when light intensity has decreased although substrate surface temperatures might still provide sufficient heat energy for the maintenance of voluntary temperatures. It seems therefore that onset of dark acts as a signal to submerge which is coupled with a decrease in body temperature. That is submergence and a decrease in body temperature are synonymous to the animal. In the thermal gradient chamber, the lizard reacts to the onset of the dark phase not by submergence but by a selection of a lower body temperature. In other words in this artificial situation the lizard can not submerge but a lowering of the body temperature is equated with submergence and signals protection from predation and possibly lethal ground surface temperatures.

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REFERENCES

CLOUDSLEY-THOMPSON, J. L. (1971). *The temperature and water relations of reptiles.* Merrow Technical Library, Watford, 159p.
GEHRMANN, W. H. (1971). Influence of constant illumination on thermal preference in the immature water snake *Natrix erythrogaster transversa*. *Physiol. Zool.* **44**(2), 84-9.
HOFFMANN, K. (1960). Versuche zur analyse der tagesperiodik. 1. Der einfluss der lichtintensität. *Z. vergl. Physiol.* **43**, 544-66.
MARX, C. and KAYSER, C. (1949). Le rythme nycthemeral de l'activité chez le lezard (*L. muralis et L. agilis*) *C.r.Soc. Biol. Paris*, **141**, 1375-7.
REGAL, P. J. (1967). Voluntary hypothermia in reptiles. *Science*. **155** (3769), 1551-3.
ST. GIRONS, H. (1971). Quelques facteurs du rythme circadien d'activité chez les Lepidosaurians (Reptiles). *Bull. Soc. Zool. Fr.* **96**, 317-30.

	LD			LL		
	light intensity (lux)	light phase (°C)	dark phase (°C)	defference	"light phase" (°C)	"dark phase" (°C)	difference
L. agilis							
	1500	31.5	29.0	2.5	31.9	31.9	0.0
	450	33.0	29.3	3.7	31.6	30.8	0.8
	80	31.4	29.8	1.6	32.3	31.6	0.7
	13	31.5	28.3	3.2	31.8	31.6	0.2
L. viridis							
	1500	33.4	30.8	2.6	33.6	33.9	0.3
	450	33.8	30.1	3.7	31.6	32.9	1.3
	80	30.2	27.3	2.9	31.7	31.9	0.2
	13	32.9	31.0	1.9	32.0	31.9	0.1

Table 1. Mean body temperatures in a thermal gradient.

EXPLANATION OF TEXT FIGURES

FIGURE 1.
Lacerta agilis mean body temperatures for each half hour interval in a light dark cycle. Light phase commences at 0600 hours. The horizontal bar is the mean and the vertical line is ± one standard deviation. Data for each light intensity are the combined results from two animals over 9-11 days.

FIGURE 2.
Lacerta viridis and as for Figure 1.

FIGURE 3.
Lacerta agilis percent frequency histograms of body temperature in LD and in LL. Data for the light and dark phase in LD are the same as used in Figure 1. Data for LL are the combined results from two animals over 4-6 days. No 24-hour rhythm was detected in LL and so temperatures for the equivalent "light" phase histogram represents 06.00 hours to 18.00 hours.

FIGURE 4.
Lacerta viridis and as for Figure 3.

FIGURE 5.
Model plasticine lizard percent frequency histogram of temperatures recorded for ten days in LD.

A NOTE ON A TAILLESS EMBRYO OF THE LIZARD, *CALOTES VERSICOLOR*

By

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During our studies of the embryology of *Calotes versicolor* we examined well over 500 embryos at different stages of development. The embryos were obtained from eggs collected from the field or recovered from gravid females. All the eggs were successfully incubated up to hatching at room temperature (22.2° to 31.7°C) on water flooded cotton wool.

A clutch of 16 eggs (usual clutch size 11 to 20) was recovered from a gravid female on 14th August, 1971. Of these eggs 12 were set aside for incubation and the other four were used for biochemical studies. Of the 12 eggs set aside for incubation 8 were opened during the course of incubation and 4 were incubated up to their hatching on 7th October, 1971. Except for a single embryo recovered by opening an egg on 20th September all the other embryos and hatchlings of this clutch were found to be normal.

The abnormal embryo was 16 mm long and was at stage 40 of development (Muthukkaruppan *et al.*, 1970). It showed an abnormality hitherto unreported in any lizard: complete absence of a tail (Fig. 1). The only other morphological deviation in the embryo concerned the location of the cloaca. Normally the cloaca is located a little posterior to the junction of the hind limbs with the body but in this embryo it was located at the level of the junction itself (Fig. 2). A postanal stump, 1 mm x 2 mm, was formed due to the forward shifting of the cloaca. For histological studies the embryo was fixed in 4% buffered formalin (pH 7.2) and sectioned at 4 μm in paraffin wax. The sections were stained with methyl green-pyronin or alcian blue-eosin.