RADIOTELEMETRY AS A MEANS OF ASSESSING ADAPTATION TO ENVIRONMENTAL CONDITIONS

*A. M. HARTHOORN, †J. KANWISHER and *N. TOMKINS

**Dept. of Physiology & Biochemistry, University College, Nairobi, Kenya*
†Woods Hole Oceanographic Institution, U.S.A.

INTRODUCTION

To survive in the hot and often arid areas of the African continent, many animals must have developed specialised physiological and behavioural mechanisms. The latter are fairly well documented and play an essential role particularly in the survival of the very small animals. The medium-sized and larger animals are somewhat less susceptible to the adverse effect of heat as they have a relatively smaller body surface, although in the elephant this has probably caused a problem of the opposite order.

Many of the African ungulates live in an almost shadeless environment, in which water is scarce. The solar radiation in high altitude, tropical latitudes is intense. When the ground is dry and vegetation sparse, the heat gained from reflected radiation is great. It would seem that animals living under these conditions—such as the plains antelope—have a considerable problem in coping with the radiation load, quite apart from the ambient temperature.

The measurement of the physiological parameters of wild animals poses a considerable problem, as even the sight and smell of man induces reaction. This reaction is manifested by changes of heart rate and even fluctuations in body temperature. Attempts made to measure the physiological parameters of wild animals (Allbrook *et al* 1958; Harthoorn and Luck 1962) suffered from disadvantages caused by the proximity of the operator or the use of restraining compounds.

The use of radiotelemetric senders to monitor the body processes such as deep body temperature (Bligh and Harthoorn 1964, 1965) offer a great advantage. With this apparatus it has proved possible to make continuous day and night measurements of deep body temperature. The more recent elaboration of equipment that will also transmit heart and respiration rates, enables a more composite picture to be acquired of the normal animals both at rest and in response to changes in the environmental conditions.

An immediate use for these tools is to compare the responses of various wild African ungulates with those of cattle. It has been suggested that marginal habitats may best be used for wildlife production, which would induce stabilisation. Not all wild animals are equally suitable for a given area and it must be decided whether the utilisation of wild or domestic stock constitutes the best economic, sociological or ecological activity. In this context (Riney 1965) writes: "There is the problem of matching the most suitable combination of animals with the most suitable environment."

The immediate problem is to find animals ecologically suitable for various brittle environments, which will increase productivity, and at the same time halt land deterioration resulting from unsuitable pastoral practices. One of the criteria of suitability for marginal areas is the

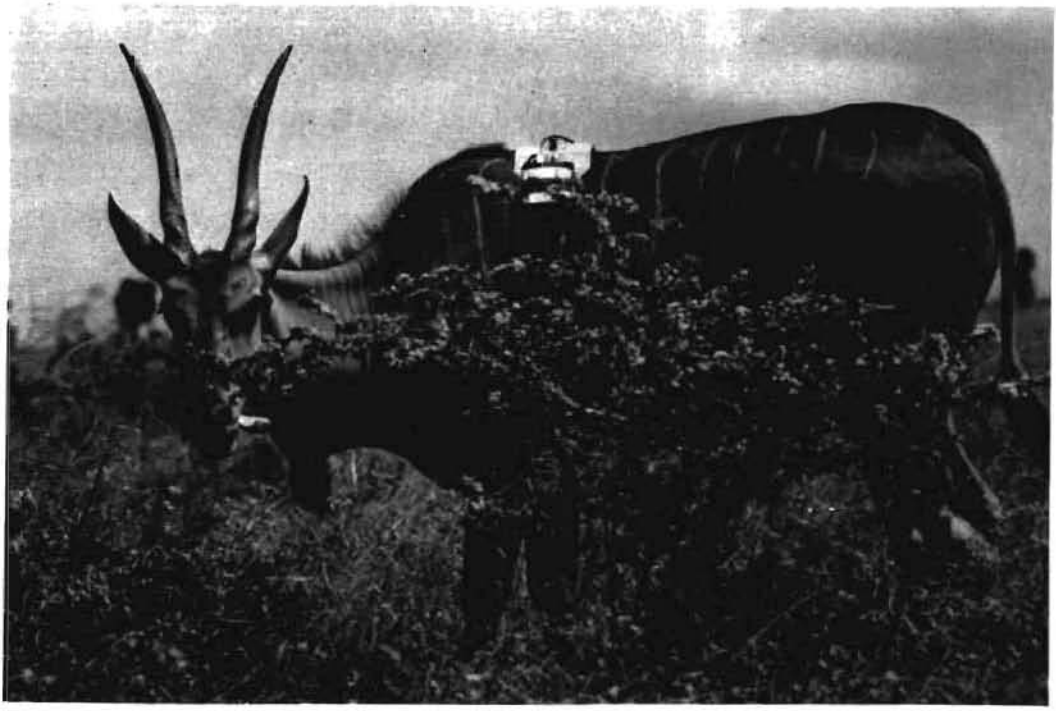

FIGURE 1
Eland on free range, showing telemetric apparatus.

degree of adaptation of various animals to the conditions of drought and heat that may prevail there. For this reason the temporal variations of physiological parameters such as body temperature, respiratory rate and heart rate are being determined for a number of domestic and wild animals.

MATERIALS AND METHODS

The transmitter is based on a thin metal plate contoured to fit behind the withers, and bearing a plastic box on each side to hold the apparatus and batteries. The weight is under 1 kilogram, and the apparatus is held in place by two perforated rubber straps (Fig. 1).

The temperature transmitter is based on a pulse frequency modulation generated by a uni-junction transistor and varied by a thermistor as the temperature device. The E.K.G. signal is amplified to one volt which switches the current in the transmitter. The respiration transmitter uses a thermistor as a sensor, and produces a continuous varying note.

The power supply is from four Mallory H 135R batteries in parallel, producing a nominal voltage of 6.75 for E.K.G. and respiration. Two T.R. 135 7 volt batteries are used for the temperature. The thermistor probe for respiration and the E.K.G. circuit have a separate input supply comprising 6.75 volt H 135R Mallory batteries. Transmission is over a distance

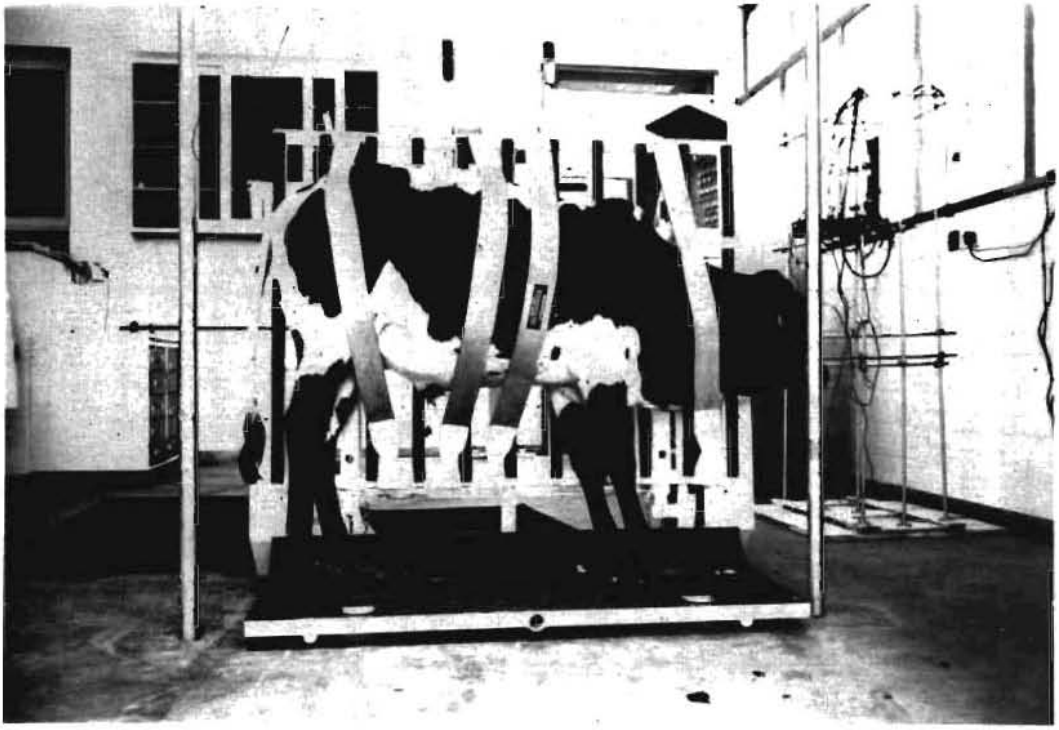

FIGURE 2
Operating turntable—trailer in use under laboratory conditions.

of two hundred metres. This range makes it possible to keep the experimental animals in a paddock area of near 400 by 400 metres and containing a variety of vegetation. More recently the temperature has been transmitted over longer distances approaching one mile.

The animals were usually captured by driving into a crush, and injected with acetylpromazine at a rate of 0.1 to 0.2 mgm per kg. After a lapse of 30–60 minutes the animals were again captured and injected with Etorphine hydrochloride (M.99) at about 4 ug. per kg., and led to a mobile operating turntable, situated at a convenient location nearby. As soon as the animal became sufficiently quiet, the belts of the operating table were applied and tightened, the table tipped to a convenient angle and the base-plate removed. Fig. 2 shows the table in use for a steer restrained in laboratory surroundings. For field use the angle is adjusted to about 45°, thereby minimising any risk of regurgitation. The requisite areas were then clipped and sterilised and a local anaesthetic injected.

The temperature probe was inserted through a small stab wound to a depth of 8 cm. in the dorsal neck region. A pathway was previously made by inserting a pair of *Spencer Wells* haemostats. After insertion the thermistor probe was recalibrated against a standard mercury thermometer (and again calibrated on removal).

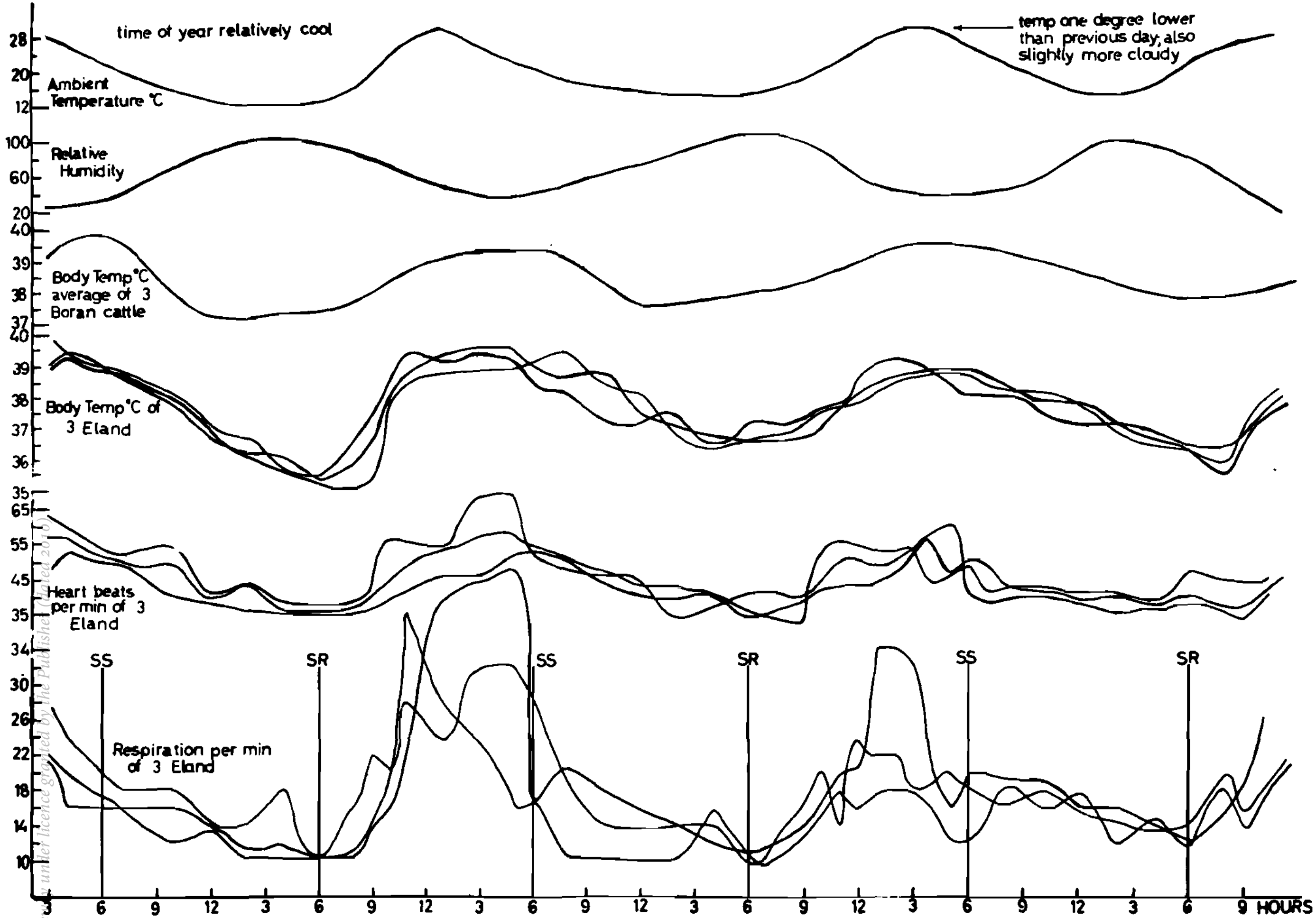

Figure 3

Variations in the body temperature, heart rate and respiration of boran cattle and eland with normal hydration.

The E.K.G. lead was threaded through an 18 gauge 20 cm. long needle inserted from the anterior aspect of the chest to lie near the medial side of the heart. The reference electrode was placed in the skin of the left shoulder by threading braided wire through a needle previously pushed through a skin fold.

The respiration probe was placed in the trachea through an aspirator needle which was inserted through a small stab wound through the skin and the cartilage, about two thirds of the way from the sternum to the pharynx. An alternative position used lately is in the wing of the nose.

All probes were sutured in place and connected to the transmitter by thin plastic-covered coaxial cable, sufficiently loose to allow for changes in distance between the probes and the transmitter as the animal moved. Recently wires have been placed under the skin several weeks prior to the time of the experiment.

RESULTS AND DISCUSSION

An example of the results obtained is given in Figure 3.

The recordings show fluctuations in body temperature of the species studied that are monophasic in character and can be positively correlated with variations in the ambient temperature. They also reveal a wide variation in the degree of thermostability by the different species. The extent of the variation is, however, different for the various species. The oryx, buffalo, eland and hartebeest show the highest degree of thermolability with a variation approaching five degrees centigrade, similar to that found for the dehydrated camel (Schmidt-Nielsen *et al* 1957).

Respirations tend to peak from 20 to 60 at midday, but return to near their original value soon after this time. This occurs in spite of a continued rise of both the body temperature and the environmental temperature. The pulse-rate rises during panting, but also at other times. In cattle and eland a rise in pulse-rate was often observed after sunset.

The variation in the degree of thermostability may be due to inherent physiological mechanisms in some species, while in others it may be due to behavioural adaptations. The temperature variations in the hippopotamus with access to water is less than 1°C. (Luck and Wright 1959). But hippopotamus that are deprived of water in the heat of the day suffer rapid and fatal temperature rise, particularly if the sweating mechanism is also blocked (unpublished results). It cannot be unconditionally accepted that the variation found in a number of African ungulates is an adaptation common to all tropical mammals. On the contrary, there appears to be a continuous spectrum of thermostability extending from a variation of a little more than 1°C in the more thermostable animals to 3°C in the hartebeest, buffalo and eland. The degree of variation depends upon the ambient temperature and also on the physiological reaction as well as on the behaviour of the animal.

DRUGS USED

Etorphine hydrochloride (M.99) Reckitt & Sons Ltd., Dansom Lane, Hull, England.
Cyprenorphine hydrochloride (M.285) Reckitt & Sons Ltd., Dansom Lane, Hull, England.
Acetylpromazine *Acepromazine*. Boots Pure Drug Co. Ltd., Nottingham, England.

REFERENCES

ALLBROOK, D. B., HARTHOORN, A. M., LUCK, C. P. and WRIGHT, P. G. 1958. Temperature regulation in the white rhinoceros. *J. Physiol.* 143: 51-52.

BLIGH, J. and HARTHOORN, A. M. 1964. Continuous records of the deep body temperature of some tropical animals made under field conditions by radiotelemetry. *Proc. Physiol. Sept.*: 5-6.

BLIGH, J. and HARTHOORN, A. M. 1965. Continuous radiotelemetric records of some unrestrained African Mammals under near-natural conditions. *J. Physiol.* (*Lond.*) 176: 145-162.

HARTHOORN, A. M. and LUCK, C. P. 1962. Aspects of the circulation on the pinna of the African Elephant (*Loxodonta africana*). *Proc. Physiol. Soc.* 163: 52.

LUCK, C. P. and WRIGHT, P. G. 1959. The body temperature of the hippopotamus. *J. Physiol.* (*Lond*). 147: 53-54.

RINEY, T. 1965. The importance of wildlife as a marginal form of land use in developing countries. Paper 65/H. Symp. of large wild and tame herbivores. Aberdeen/Cambridge. Sept.

SCHMIDT-NIELSEN, K., SCHMIDT-NIELSEN, B., JARNUM, S. A. and HOUPT, T. R. 1957. Body temperature of the camel and its relation to water economy. *Amer. J. Physiol.* 188:103-112.