ameter probably exceeds 300 light years, since two of the variables are more than 170 light years distant from the center of the cluster.

It is of interest to recall that the study of the brightest stars in N. G. C. 7006 has shown no effect of selective scattering of light in space. It also appears, from the agreement of the parallax based on angular diameter with the values based on magnitude methods, that the general non-selective absorption of light is inappreciable in the direction of N. G. C. 7006, even when the distance involved is, as in this case, 225,000 light-years.

[1] *Mt. Wilson Contr.*, No. 152. p. 13, 1917; *Astroph. J. Chic.*, **48**, 1918 (166).
[2] *Mt. Wilson Contr.*, No. 152, p. 14, *n*-1, 1917; *Ibid.*, **48**, 1918 (167).
[3] *Mt. Wilson Contr.*, No. 156, pp. 1–6, 1918; *Ibid.*, **49**, 1919 (249–54).
[4] *Mt. Wilson Contr.*, No. 161, pp. 16–18, 1918; *Ibid.*, **50**, 1919 (122–4).

THE SKIN TEMPERATURE OF PACHYDERMS

BY FRANCIS G. BENEDICT, EDWARD L. FOX, AND MARION L. BAKER

NUTRITION LABORATORY, CARNEGIE INSTITUTION OF WASHINGTON, BOSTON, MASS., AND NEW YORK ZOÖLOGICAL PARK, NEW YORK CITY

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A knowledge of the temperature of the skin is of great assistance in interpreting the laws governing the loss of heat from the animal organism, but with warm-blooded animals, such as birds and many mammals, the skin temperature is determined only with difficulty, because of the covering of hair or fur. With humans, also, the protective clothing interferes with the accurate determination of skin temperature, for numerous observations have shown that even under ordinary clothing the skin temperature of man is by no means constant and, due to the protective covering, is undoubtedly much higher than it would otherwise be. It seemed, therefore, that records of the skin temperature of certain hairless animals would be of value, since the factor of covering would thus be eliminated. Accordingly, we took advantage of the excellent material at the New York Zoological Park and of the friendly coöperation of Mr. Raymond L. Ditmars to make such observations, and as a result are able to report the surface temperatures of two elephants, one rhinoceros, and a hippopotamus, all presenting large hairless surface areas.

The method employed was that described in an earlier communication.[1] The apparatus consists of two copper-constantan thermo-junctions, with special means of application to the skin to secure the true skin temperature rather than the resultant of skin and environmental temperature. One junction is kept in a thermos bottle with a carefully calibrated thermometer, which is read practically every minute or two, and the other junction applied to the skin. The difference in temperature between the two junctions is noted on a galvanometer, whose "constant" is likewise checked every few minutes.

The natural inquisitiveness and restlessness of the elephants made the task of recording the skin temperature somewhat trying, although in no sense hazardous. The rhinoceros presented an unexpectedly favorable opportunity for measurement, while the uncertain temperament of the hippopotamus interfered greatly with the securing of records of his temperature. An especially advantageous feature of this series of observations is the fact that the temperature of the environmental air in the elephant house at the New York Zoölogical Park remains relatively constant at about 19.5° Centigrade, night and day.

Excluding records obtained at partially protected points, such as the back of the ear, the groin, and axilla, we found with a female Indian elephant a range in skin temperature from a minimum of 20.8° C. at a position on the forehead, midway between the two eyes, to a maximum of 29.6° C. on the shoulder. With a male African elephant the range was from 21.4° to 28.3° C. The relation between surface temperature and the distribution of the blood was strikingly evident in the temperature records on the ear, on the back side of which the veins are very readily observable. Near the veins the skin temperature was high. Owing to the cracks and crevices in the thick elephant skin, difficulty was at times encountered in securing records of surface temperature, especially on the sides of the body, since the tendency was for the warm air to rise, with a distinct circulation of air through the cracks in the skin. Every attempt was made to use as smooth a piece of skin as possible for the temperature measurements. The elephant, therefore, exposed to an environmental temperature of approximately 19.5° C., had a skin temperature which averaged not far from 25.5° C. While there were rather large differences at times between the two elephants, the general picture showed a reasonably uniform bilateral temperature distribution.

The rectal temperature of elephants has not been frequently reported. Dr. W. R. Blair of the New York Zoölogical Society found in his measurements that the rectal temperature of the elephant ranged from 97.2° F. (36.2° C.) to 98° F. (36.7° C.). Using a clinical thermometer, we secured the rectal temperature of the male elephant and found it to be 35.9° C. On two occasions the thermometer was thrust quickly into freshly passed feces, and temperature records secured of 36.2° and 36.7° C., respectively, the large mass of feces losing heat slowly. Thus the elephant apparently has a rectal temperature slightly lower than the average commonly assumed for man.

The skin of the rhinoceros is much smoother than that of the elephant, making possible much more satisfactory measurements. This animal was studied almost exclusively on one side of the body and gave temperature measurements ranging from 24.1° to 27.9° C. In general the temperatures were somewhat warmer in the lower part of the body. An approximate average of 26.2° C. can be taken as the general skin temperature of

the rhinoceros (living in an environmental temperature of 19.5° C.), a value but slightly higher than that found with the two elephants. According to Dr. Blair the rectal temperature of the rhinoceros ranges from 99.7° F. (37.6° C.) to 100° F. (37.8° C.). Our single observation of the rectal temperature of this animal showed a value of 37.4° C.

Although considerable difficulty was experienced in securing the skin temperature of the hippopotamus, sufficient measurements were obtained to give a fairly clear picture of the probable temperature distribution. The temperatures ranged from 20.8° C. on the back to as high as 30.9° C. on the belly. An average figure for the temperature of the whole skin is probably not far from 25° C. In general the lower part of the body was found to be much warmer than the back, the temperature differences being greater with the hippopotamus than with the other three animals. This may be partly due to the fact that there was considerable vaporization of water from the skin, for the skin of the hippopotamus was much moister than that of the other two animals, although he had been out of water for several hours in an environmental temperature of approximately 19.5° C. prior to the actual temperature measurements. As a matter of fact, the temperatures of the dry and wet bulbs near the animal were 19.6° and 11.9° C., respectively. We have been unable to find any records of the rectal temperature of the hippopotamus.

To sum up, then, it can be seen that this group of animals, with a rectal temperature essentially that of man, lives in captivity in a temperature environment of about 19.5° C. with a continuous surface temperature, on the average, but 6 to 7 degrees above the environmental temperature. Man, independent of external temperature as a result of the use of clothing, has adjusted himself to a very much higher skin temperature, although this is still a greatly variable factor, averaging under clothing not far from 33° C. The direct measurement of the heat loss of these huge animals presents engineering problems rather difficult to solve. It is to be hoped that the indirect method of calorimetry (through the measurement of the oxygen consumption and the carbon-dioxide production) under these conditions of internal, environmental, and skin temperatures, may be employed to contribute further to our knowledge of the fundamental laws governing heat loss in the warm-blooded animal unprotected by a fur coating. It must be recognized, however, that with the elephant, rhinoceros, and hippopotamus, as the name of this group of animals implies, extraordinarily thick skins have been developed and thus in a way these animals carry around, instead of fur, an extra heavy plating of epidermis which, without doubt, measurably retards heat loss.

The details of this study are to be found published in the *American Journal of Physiology* for July, 1921.

[1] Benedict, Miles, and Johnson, these PROCEEDINGS, 5, 1919 (218).