Short communication

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Study of the spectral reflection of visible light on the surface of cattle of different breeds

Abstract

This work aims to measure the total and spectral reflectance of visible radiation by various coat colors of cattle. It came to the interest of the author to determine also the reflectance by muzzle, a hairless pigmented portion of the integument. Measurement of the total and spectral reflectance of visible radiation, 400-700 nm, by cattle coat and muzzle was conducted using the integrating sphere and spectroradiometer. The total reflectance of visible radiation by black, brown and white coats were 77%, 11.68% and 65.76% respectively. Total reflectance values for muzzle were 11.5%, 34.61% and 22.1 % for black, brown and brown-black muzzle respectively.

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Introduction

The coats of cattle reflect solar radiation both in the visible and in the infra-red region of the spectrum. Differences in the ability of different coat colours to reflect radiation has been established.[1,2,3,4] Darker coats reflect less radiation than lighter coats. Reflectance (hence absorptance) of radiation has been assumed to be a major factor that influences the heat tolerance of cattle. Other factors which affect the heat load of an animal are sweating mechanism[5] coat type i.e., curliness, depth, hair density, skin pigmentation, etc.[6,7,8] and thermal insulation properties of the coat.[9,10]

Materials and methods

Samples:— Experiment was performed on a total of thirty nine samples of coat from six heads of cattle, 3 of which was predominantly black and the rest was brown. These samples were taken from various points of the animal, i.e., head, neck, shoulder, back, belly and rump Figure 1 illustrates these points.

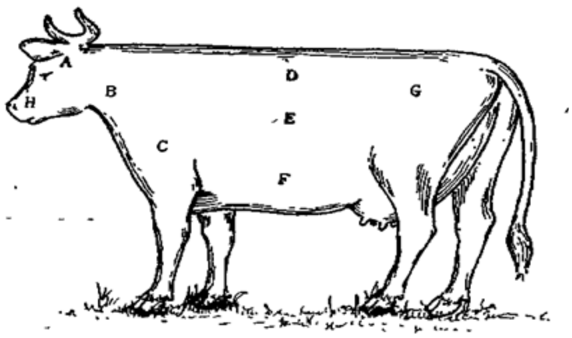

Figure 1 Cattle points where coat samples and muzzle were collected.

A Head, B Neck, C Shoulder, D Back, E Side, F Belly, G Rump, H Muzzle.

Table 1 summarizes the color characteristics of the samples taken from areas of the body surface of each animal.

Table 2 shows the total results of studies of the reflectance of visible radiation in the range from 400 to 700 nanometers of different body surface color (skin and hair) for a group of six cows.

The snout of the animal has also aroused interest for research due to the varying degrees of pigmentation. Five muzzles had different pigmentation, three of which were black, one light brown, and the other black-brown. Table 3 summarizes the total reflectance of visible radiation wavelength 400 to 700 nm by cattle muzzle.

Table 1 Characteristics of coat and muzzle samples

Cattle No.	Predominating Hair Coat	Color Muzzle	Features of flair Coat
I	Black	Black	Long and rough
II	Black	Black	Curly and dense
III	Black	Black	White patches in belly
IV	Brown	Brown	White patches in belly
V	Brown	N.S.*	White patches in belly, fine
VI	Brown	Brown- Black	Brindle - intermixing of and light brown dark

Table 2 The total reflectance of visible radiation (wavelengths 400 to 700 nm) by cattle coats

Reflectance in Per Cent						
Color	Black			Brown		
Cattle No.	I	II	III	IV	V	VI
A. Head	3.84	3.17	4.26	8.45	16.78	7.91
B. Neck	2.67	4.08	3.45	11.12	N.S.	8.72
C. Shoulder	3	2.51	4.1	8.58	12.27	12.69
D. Back	3.64	3.1	4.97	10.77	13.41	15.21
E. Side	3.68	N.S.	4.42	12.46	N.S.	7.02
F. Belly	3.89	3.53	5.18*	14.97*	10.55*	1.05
G. Rump	4.56	3.54	4.33	15.35	11.24	12.11
AVERAGE	3.62	3.32	4.39	11.67	12.85	10.53

N.S. = No Sample

*Reflectance value for the black portions of the coat sample. Reflectance of white coat from the cattle III, IV and V are 85.43%, 67.94% and 44.80% respectively, giving an average total reflectance value of 65.76%.

Table 3 The total reflectance of visible radiation wavelength 400 to 700 nm) by cattle muzzle

Reflectance in Per Cent					
Colour	Black			Brown	Brown-Black
Cattle No.	I	II	III	IV	VI
Total Reflectance	10.23	11.02	13.26	34.16	22.44
	11.5			34.16	22.44

All skin and fur samples of animals were stored in a freezer and then thawed at room temperature before measurement.

Equipment:— To measure the total reflectance to visible radiation, the integrating sphere was used. This instrument was developed primarily to measure the optical properties of plant surfaces. The light source emits light with a spectral composition of visible light. This light, illuminates the sample suspended inside the integrating sphere. All the light - which is reflected or transmitted through the surface is then detected by a thermopile and is 'sensed' by a volt-meter and measurements are then translated in the form of a chart by a recorder.[11] Measurement was made twice for each coat and muzzle sample at 0°, 25° and 50° angle incidence.

Spectroradiometer was used to measure the spectral reflectance of the coats at various visible wavelengths. Samples from the back of 6 cattle were used in this section of the experiment. The spectral diffuse reflecting power of the coats was measured relative, to the fresh surface of magnesium oxide standard and corrected for the spectral reflectivity of the magnesium oxide. Readings were taken from 425 to 750 nm at an interval of 25 nm.

Results

The total reflectance of visible radiation by black and brown coats using the integrating sphere is 3.77% and 11.68%, respectively. The lightest coat colors (cattle V) has the highest reflectance value of 12.85% while the darkest coat (cattle II) has a minimal value of 3.32 % reflectance. The white portions of the belly coat of cattle III, IV, and V give a high reflectance value of 65.76%. The values obtained are summarized in Table 2. The muzzle has the highest reflectance for the light brown followed by the one with intermixed brown and black pigments, and the black ones have the lowest (34.16%, 20.52% and 11.5%, respectively). Table 3 gives the results for total muzzle reflectance.

Figure 2 shows the spectral reflectance of visible radiation (wavelength 425 to 750 nm) by black, brown and white coats, Spectral reflectance of muzzle is presented in Figure 2. For readings taken, the lowest reflectance value for all colours is at the shorter wavelengths while the highest is at the longer wavelengths of the visible spectrum Table 4.

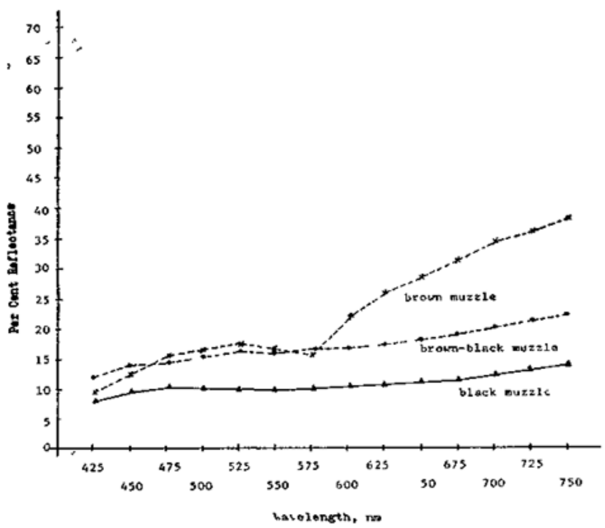

Figure 2 The spectral reflectance of cattle muzzle at wavelengths between 425 and 750 nm.

Table 4 The spectral reflectance of cattle coat and muzzle

	Reflectance in Per Cent					
	Coat			Muzzle		
Wave length nm	Black	Brown	White	Black	Brown	Brown-Black
425	1.6	2.5	24.26	8.06	9.8	12.4
450	1.8	3.29	28.72	9.97	12.73	1429
475	2.16	3.68	32.52	10.34	15.7	14.97
500	2.15	4.15	38.56	10.13	16.74	15.44
525	2.19	4.65	40.94	10.09	17.11	16.33
550	2.33	5.64	43.17	10.04	16.45	16.37
575	2.48	6.91	46.18	10.2	16.24	16.25
600	2.53	8.23	48.25	10.57	22.2	17.08
625	2.77	9.68	51.18	11.11	26.22	17.66
650	2.83	11.31	53.99	11.44	28.6	18.54
675	3.08	13.03	56.96	11.9	31.3	19.31
700	3.43	15.16	60.71	12.65	34.08	20.36
725	3.82	17.12	63.46	13.67	36.02	21.6
750	4.32	19.12	66.3	14.61	38.6	22.9

Discussion

The reflectance value obtained in this experiment agrees with the findings of earlier workers.[1,2] It is shown that colour is an important factor affecting reflection of radiation — black being the colour that reflects the least and the white the most The direction of the hair its curliness and smoothness are of secondary importance with respect to reflection of light.[2] It is a misnomer to state without qualification that a white coated animal will have lesser heat load than a darker coated animal. Factors like penetrance of coat by radiation, evaporative cooling plus the physiological adjustment of the animal contributes to the heat balance of the animal in addition to the attributes due to coat color.

Reflection also depends on the angle of incidence of radiation. The values reported in this experiment are the averages for 0°, 25° and 50° angle of incidence. An attempt to get values at an angle greater than 50° was limited by the capability of the integrating sphere. It is expected that greater reflection would take place as the angle of incidence approaches 90° or grazing angle.[12]

Muzzle is a hairless specialized portion of the integument. Its optical properties are determined by its surface and pigment layer.[13,14]

Conclusion

This experiment shows that it behaves similarly with any colored surface in terms of reflection of light, i.e., the darkest has the lowest reflectance and vice versa for the lightest. The structural significance of the hairless areas of the integument like the eyelids, nostrils, lips vulva and anus is marked when considering the absorption of the ultra

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violet (UV) radiation (wavelengths less than 400 nm). At this visible spectrum, reflection is nil. The pigment layer protects the underlying tissue from the harmful effects of the UV radiation (e.g., skin cancer). It is important to select animals which are not prone to heat stress, especially in tropical areas where the solar radiation flux is maximum.

Acknowledgments

None.

Conflicts of interest

The author declares there is no conflict of interest.

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