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A STUDY OF THE BODY TEMPERATURE, RESPIRATION AND PULSE RATES OF MALAYSIAN SWAMP BUFFALOES EXPOSED TO THE SUN

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RINGKASAN

Kertas kerja ini melaporkan satu kajian mengenai ciri-ciri fisiologi asas ternakan kerbau di Malaysia. Kesan-kesan jantina, umur dan waktu harian semasa kajian terhadap ciri-ciri ke atas ada dibincangkan.

Purata suhu rektal, 'Rhoad's Heat Tolerance Coefficient', kadar pernafasan, Indeks Penyesuaian Benezra and kadar denyutan jantung adalah masing-masing 38.37°C, 89.53, 48.76, 3.14 and 48.32. Ciri-ciri ini tidak dipengaruhi oleh jantina. Walau bagaimanapun, umur memberikan kesan yang tinggi ($P<0.01$) di mana kerbau-kerbau yang berumur 2-4 tahun adalah lebih baik di dalam penyesuaian terhadap alam keliling berbanding dengan kerbau-kerbau yang berumur 1-2 tahun. Kesan waktu harian terhadap perubahan ciri-ciri di atas adalah nyata sekali ($P<0.01$) di mana waktu-waktu yang paling panas mengakibatkan tekanan terhadap ternakan-ternakan ini.

Nilai fisiologi yang diperolehi dari kajian ini telah dibandingkan dengan hasil-hasil kajian yang dijalankan ke atas kerbau-kerbau di Mesir, India dan Filipina di dalam keadaan yang sama. Kerbau sawah di Malaysia ternyata kurang tahan terhadap iklim panas jika dibandingkan dengan kerbau-kerbau di negara-negara tersebut.

Satu cadangan mengenai bentuk penyelidikan yang perlu dijalankan bagi memajukan pengeluaran ternakan di Malaysia melalui peningkatan penyesuaian terhadap alam keliling telah dibincangkan.

INTRODUCTION

In Malaysia, the swamp buffalo has been primarily used as a draught animal in the paddy planting areas of Kedah, Kelantan and Trengganu. On reaching old-age, it is used quite extensively as a source of beef (ISHAK, 1973 and MAHENDRANATHAN, 1973). Sometimes it is used for milk production (DEVENDRA and MAHINDER SINGH, 1974), for home consumption.

With the present government policy of increasing both meat and milk production from ruminants, the need to investigate the productive abilities of the Malaysian swamp buffalo has been emphasised. Amongst the most significant problems of the swamp buffalo in a hot, humid, tropical environment is its inability to withstand high environmental temperatures and humidity. This, coupled with its inefficient sweating and thick skin (MASON, 1974), has resulted in the swamp buffalo being questioned as to its significance as a contributor to either beef or milk in Malaysia. This doubt exists, inspite of the fact that by wallowing, the animal overcomes, to a large extent, this adaptational inability, because the animal wallows and destroys planted pastures and grasslands, incurring heavy developmental losses, and creating a lot of managemental problems.

It was with a view towards eventually solving this adaptational inability, and

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managemental problem due to wallowing, that this study was conducted. This was done to establish some basic physiological characteristics of the Malaysian swamp buffalo, so that future managemental and breeding programmes could be initiated for improvement purposes, with a view towards utilising the Malaysian swamp buffalo on a more intensive and productive level than is presently practiced.

The only other previously reported work on the Malaysian swamp buffalo, with respect to rectal temperature and respiratory rate, was that of KASSIM, *et. al.*, (1977). That report, however, did not investigate the physiological responses throughout the day, nor did it study the sex and age effects. The present study reports the response of Malaysian swamp buffaloes exposed to the sun throughout the day, as affected by both sex and age.

MATERIALS AND METHODS

1. Animals and Treatments

A total of 23 Malaysian swamp buffaloes, 12 female and 11 male, were used in this study. Six females between 1—2 years and 6 between 2—4 years of age, and six males between 1—2 years and 5 between 2—4 years of age were used in this study. All the animals used were normal, healthy animals, with no disease problems and were selected at random. The mature females used were non-pregnant and non-lactating.

All 23 animals were held in open yards with earthern floor, and exposed to the full sun and atmosphere from 0700 hours on the morning of the first day to 1700 hours on the evening of the third day, after the final recordings were taken. During the period of the study, all the animals were given *ad. lib.* water for drinking and cut Napier (*Pennisetum purpureum*) grass as fodder. They also had access to mineral salt licks at all times. The only times that the animals were removed from this yard was when the recordings were taken 5 times a day.

2. Recordings

The recordings for rectal temperature (RT), respiration rate (RR) and pulse rate (PR) were taken at 0800, 1100, 1430, 1630 and 2000 hours for three successive days, and the method of recording was as described by PATHMASINGHAM, *et. al.*, (1980).

Environmental records of air temperature, relative humidity and wind velocity were recorded at the same time.

Using these recordings, RHOAD's (1944) Heat Tolerance Coefficient (RHTC), and BENEZRA's (1950) Index of Adaptability (BIA), were calculated to assess the adaptability of these animals.

3. Statistical Analyses

An analysis of variance, followed by 'F' tests were carried out on the data recorded. Least Significant Difference (LSD) tests were conducted to both 0.05 and 0.01 percent levels to determine significant levels for the comparisons of sexes, ages and times on the physiological measurements and calculations recorded.

Finally, a correlation analysis followed by a linear regression analysis was carried out for age of the buffaloes with the different measurements taken.

RESULTS

The mean of the environmental records taken over the three days at different times is shown in *Table 1.*

TABLE 1. THE MEANS OF ENVIRONMENTAL RECORDS TAKEN DURING THE STUDY

Recording \ Time	0800 hrs	1100 hrs	1430 hrs	1630 hrs	2000 hrs
Atmospheric temperature °C	35.25	36.43	29.37	34.75	33.50
Relative humidity	66.50	56.50	84.67	83.17	100.00
Wind velocity m^{-s}	1.54	2.80	3.76	1.95	0.00

Since the analysis of variance and subsequent 'F' test conducted showed no significant differences between sexes in the two age groups studied, the results are presented grouping the two sexes together, under age groups.

In *Table 2,* the physiological measurements recorded on 1−2 and 2−4 year-old swamp buffaloes, respectively, are shown. The table also presents the calculations for Rhoad's Heat Tolerance Coefficient (RHTC) and Benezra's Index of Adaptability (BIA). The means for rectal temperature (RT), RHTC, respiration rate (RR), BIA and pulse rate (PR) for 1−2 and 2−4 year-olds were 39.03°C, 86.93, 51.57, 3.26 and 50.72, and 38.73°C, 91.92, 46.19, 3.02 and 46.11, respectively.

Table 3 presents the data on the effect of time of day of all the buffaloes on the measurements taken and calculations made.

TABLE 2. THE RECTAL TEMPERATURE, RESPIRATION AND PULSE RATES, AT DIFFERENT TIMES OF THE DAY, OF 1-2 AND 2-4 YEAR-OLD SWAMP BUFFALOES

	Rectal temperature °C	Rhoad's Heat Tolerance Coefficient	Respiration rate No. per minute	Benezra's Index of Adaptability	Pulse rate No. per minute
Group 1 1−2 yrs.					
T1 0800 hrs	38.39	98.36	51.18	3.23	43.64
T2 1100 hrs	39.17	84.41	64.12	3.81	58.58
T3 1430 hrs	39.30	82.05	55.70	3.45	53.45
T4 1630 hrs	39.20	83.75	48.85	3.15	54.30
T5 2000 hrs	39.07	86.09	38.00	2.67	41.40
Mean	39.03	86.93	51.57	3.26	50.72
Group 2 2−4 yrs.					
T1 0800 hrs	38.11	101.96	42.92	2.86	42.50
T2 1100 hrs	39.01	87.24	57.72	3.53	50.00
T3 1430 hrs	38.95	88.35	52.58	3.30	50.89
T4 1630 hrs	38.78	91.30	42.22	2.85	48.17
T5 2000 hrs	38.81	90.85	35.50	2.56	39.00
Mean	38.73	91.92	46.19	3.02	46.11

TABLE 3. THE EFFECT OF TIME OF DAY ON THE PHYSIOLOGICAL MEASUREMENTS AND CALCULATIONS RECORDED

	Rectal temperature °C	Rhoad's Heat Tolerance Coefficient	Respiration rate No. per minute	Benezra's Index of Adaptability	Pulse rate No. per minute
T1 0800 hrs	38.25	100.24	46.87	3.04	43.04
T2 1100 hrs	39.08	85.88	60.78	3.66	54.10
T3 1430 hrs	39.12	85.29	54.07	3.37	52.11
T4 1630 hrs	38.98	87.69	45.39	2.99	51.10
T5 2000 hrs	38.93	88.57	36.70	2.61	41.22
Overall mean	38.87	89.53	48.76	3.14	48.32

The effect of age and sex on the overall physiological recordings taken is presented in *Table 4.* The table gives the age and sex means for the two age groups and sexes, and mean of both ages and sexes, for all recordings. It also summarises the overall means with RT, RHTC, RR, BIA and PR being 38.87°C, 89.53, 48.76, 3.14 and 48.32, respectively, throughout the day.

Tables 5, 6 and *7* present the differences between time means for RT, RHTC, RR, BIA and PR, respectively.

In *Table 8,* the correlations and regression equations for significant correlations, between age and the different recordings are given. Pulse rate was not significantly correlated with age and any of the times of recording. The other measurements were correlated with age at one time or another of the day, significantly.

No correlations of physiological measurements recorded with atmospheric measurements were made because the atmospheric records made were insufficient.

TABLE 4. THE EFFECT OF AGE AND SEX ON THE OVERALL MEANS OF THE PHYSIOLOGICAL MEASUREMENTS AND CALCULATIONS RECORDED

	Rectal temperature °C	Rhoad's Heat Tolerance Coefficient	Respiration rate No. per minute	Benezra's Index of Adaptability	Pulse rate No. per minute
Group 1	39.03	86.93	51.57	3.26	50.72
Group 2	38.73	91.92	46.19	3.02	46.11
Males	38.83	90.49	49.82	3.18	47.04
Females	38.92	88.66	47.79	3.10	49.48
Overall mean	38.87	89.53	48.76	3.14	48.32

TABLE 5. THE DIFFERENCES BETWEEN TIME MEANS FOR RECTAL TEMPERATURES AND RHOAD'S HEAT TOLERANCE COEFFICIENT

		T2		T3		T4		T5	
		RT	RHTC	RT	RHTC	RT	RHTC	RT	RHTC
T1	RT	0.83**		0.87**		0.73**		0.68**	
	RHTC		14.36**		14.95**		12.55**		11.67**
T2	RT	—		0.04^{ns}		0.10^{ns}		0.15^{ns}	
	RHTC		—		0.59^{ns}		1.81^{ns}		2.69^{ns}
T3	RT			—		0.14^{ns}		0.19*	
	RHTC				—		2.40^{ns}		3.28**
T4	RT					—		0.05^{ns}	
	RHTC						—		0.88^{ns}

** P/0.01
* P/0.05
ns Not significant

TABLE 6. THE DIFFERENCES BETWEEN TIME MEANS FOR RESPIRATION RATE AND BENEZRA'S INDEX OF ADAPTABILITY

		T2		T3		T4		T5	
		RR	BIA	RR	BIA	RR	BIA	RR	BIA
T1	RR	13.91**		7.20**		1.48^{ns}		10.17**	
	BIA		0.62**		0.33**		0.05^{ns}		0.43**
T2	RR	—		6.71**		15.39**		24.08**	
	BIA		—		0.29**		0.67**		1.65**
T3	RR			—		8.68**		7.37**	
	BIA				—		0.38**		0.76**
T4	RR					—		8.69**	
	BIA							—	0.38**

** P/0.01
* P/0.05
ns Not significant

TABLE 7. THE DIFFERENCE BETWEEN TIME MEANS FOR PULSE RATE

	T2	T3	T4	T5
T1	11.06**	9.07**	8.06**	1.82^{ns}
T2	—	1.99^{ns}	2.00^{ns}	12.88**
T3		—	1.01^{ns}	10.89**
T4			—	9.88**

** P/0.01
* P/0.05
ns Not significant

However, the ranges obtained for atmospheric records were temperature, 27.5°-37.0°C, humidity, 51.0-100.0% and wind velocity 0.00-6.11 m/sex for the three days at the different times of recording.

DISCUSSION

From *Table 1,* it can be seen that the atmospheric temperature dropped suddenly at 1430 hours to 29.37°C from 36.43°C, at 1100 hours. This was not a normal situation, and was only caused by a sudden heavy overhead cloud on one of the days during the study. This, however, has not significantly affected the physiological field records taken on the animals.

The study showed that the mean RT of all animals for all times was 38.87°C, which compared with the 39.0°C reported by KASSIM *et. al.,* (1977) for 1330 hours. The mean for males and females was 38.82 and 38.92°C, respectively. This difference was insignificant and is similar to the report of TANEJA and BHATNAGAR (1958) in India, and MENSALVAS and RIVERA (1951) in the Philippines. The means for 1-2 year (Group 1) and 2-4 year (Group 2)-olds, which were 39.03 and 38.73°C, showed a highly significant (P 0.01) difference. This is similar to reports by PAL (1952) in India, and BADRELDIN *et. al.* (1951) in Egypt. The mean reported by BADRELDIN *et. al.* (1951) of 38.3°C for 2 year-olds and 38.2°C for 3 year-

TABLE 8. CORRELATIONS AND REGRESSIONS BETWEEN AGE AND THE DIFFERENT PHYSIOLOGICAL MEASUREMENTS RECORDED

		Rectal temperature °C	Rhoad's Heat Tolerance Coefficient	Respiration rate No. per minute	Benezra's Index of Adaptability	Pulse rate No. per minute
(a)	**Correlations:**					
T1	0800 hrs	−0.48*	0.46*	−0.42*	−0.43*	-0.21^{ns}
T2	1100 hrs	-0.30^{ns}	0.29^{ns}	-0.24^{ns}	-0.21^{ns}	-0.37^{ns}
T3	1430 hrs	−0.46*	0.46*	-0.12^{ns}	-0.13^{ns}	-0.14^{ns}
T4	1630 hrs	−0.53*	0.53*	-0.39^{ns}	-0.39^{ns}	-0.36^{ns}
T5	2000 hrs	-0.33^{ns}	0.33^{ns}	-0.14^{ns}	-0.15^{ns}	-0.15^{ns}
(b)	**Regressions:**					
T1	0800 hrs	Y=38.6691 −0.0175X	Y=93.5250 +0.2732X	Y=58.2643 −0.4722X	Y=3.5499 −0.0212X	− ns −
T2	1100 hrs	− ns −	− ns −	− ns −	− ns −	− ns −
T3	1430 hrs	Y=39.6069 0.0203X	Y=76.4648 +0.3656X	− ns −	− ns −	− ns −
T4	1630 hrs	Y=39.5462 0.0233X	Y=77.5549 +0.4199X	− ns −	− ns −	− ns −
T5	2000 hrs	− ns −	− ns −	− ns −	− ns −	− ns −

* P<0.05
ns Not significant

olds is lower than what was obtained in this present study. The possible explanation for this difference is that the Malaysian swamp buffalo is less well equipped, compared to the Egyptian counterpart, for efficient thermoregulation, since both air temperature and humidity in Egypt were similar to that recorded here.

A comparison of the Malaysian swamp buffaloes' RT with Kedah-Kelantan and Brahman cattle (PATHMASINGHAM and DEVENDRA, 1974), though not studied at the same time, but under similar conditions, indicates that the former is even less well adapted to an exposed hot environment than these cattle. This situation is also reflected in the reports of ASKER *et. al.* (1953), BADRELDIN and GHANY (1952) and MULLICK (1960).

The time effect on RT (*Table 5*) showed highly significant ($P < 0.01$) differences between T1 (0800 hours) and T2 (1100 hours), T3 (1430 hours), T4 (1630 hours) and T5 (2000 hours). The only other significant ($P < 0.05$) difference was between T3 and T5. These differences confirm the reports of ALIM and AHMED (1959), ALIM and FATTAH (1966), BHATNAGAR and CHAUDHARY (1960) and MISRA *et. al.* (1963), that RT is closely correlated with air temperature, and hence follows it closely.

All the animals in the study, because of obvious heat stress were observed to show discomfort, and were salivating heavily, panting, mucating from the nostrils, and were all trying to get into some shade. Also, the animals were observed to try and make wallows in the ground, to cool themselves. This, however, was prevented, as the purpose of the study was to test them under heat stress, without shade, water sprinkling or wallowing.

In terms of RHTC, the trend followed indentically with that of RT; the males and females had 90.49 and 88.66, respectively, and showed no significant differences; the difference between age groups was highly significant ($P<0.01$), with group 1 having 86.93 and group 2, 91.92. The time effect trend was similar to that for RT (*Table 5*). The overall mean RHTC obtained for all animals for all times was 89.53, which is superior to that reported for Egyptian buffaloes, of 76, by ASKER *et. al.* (1952), and 61 for Indian buffaloes, reported by MULLICK (1960), but inferior to BADRELDIN *et. al.'s* (1951) values. The comparison of the RHTC values with the local Kedah-Kelantan and Brahman cattle which had 95.67 and 94.63, (PATHMASINGHAM and DEVENDRA, 1974), showed that the buffaloes had a lower ability to withstand heat, and were less adaptable than these *Bos indicus* cattle. However, when compared with imported Hereford cattle, which had an overall mean RHTC of 58.52 (PATHMASINGHAM *et. al.*, 1980), the buffaloes were far superior.

This rather comparatively poor heat tolerance of these buffaloes could be explained to a certain extent by the absence of a protective and reflective hair coat, the presence of a dark skin, which is conducive to absorptivity of infrared radiation, the extra thick *stratum corneum,* and the comparatively (with cattle) lower density of sweat glands (MASON, 1974).

The overal mean RR recorded in this study was 48.76, with the males and females having 49.82 and 47.79, respectively. The difference was not significant, which is contrary to that reported by MENSALVAS and RIVERA (1951) for Philippine carabaos. The carabao males had 24.6 whilst the females had 27.1 RR. The age group comparison was highly significantly ($P < 0.01$) different with group 1 and group 2 having a RR of 51.57 and 46.19, respectively. Here, as with the case of RT and RHTC, the older buffaloes were able to respond better to the hot environment that the younger ones (BADRELDIN *et. al.*, 1951). These results when compared to that reported in Egypt (BADRELDIN *et. al.*, 1951) and India (MULLICK and KEHAR, 1951), show vast differences. The Egyptian buffaloes had a RR of 26 for 2 year-olds and 25 for 3 year-olds, whilst the Indian buffaloes had an overall mean RR of only 21. This comparison again raises the possibility that the Malaysian swamp buffalo is less well adapted to an exposed hot environment than the Egyptian, Indian or Philippine buffaloes. This is a point of detail that needs to be investigated further, in view of the significant importance of the physiological comfort of an animal if it were to perform optimally regularly.

The RR between the various times differed significantly ($P<0.01$) mostly (*Table 6*) and again tended to follow air temperatures fairly closely (BADRELDIN *et. al.*, 1951 ALIM and AHMED, 1957, MISRA *et. al.*, 1963 and BHATNAGAR and CHAUDHARY, 1960).

The overall mean BIA obtained was 3.14, with the males and females having 3.18 and 3.10, respectively. This was not a significant difference. The age group comparison showed highly significant ($P < 0.01$) differences with group 1 and 2 having values of 3.26 and 3.02, respectively. The time means were again highly significantly ($P < 0.01$) different for all comparisons except for T1 and T4 (*Table 7*). These differences and trends were exactly as for RR; it tended to follow atmospheric temperatures and humidity.

The use of BIA, which incorporates both RT and RR in the equation to try and establish a coefficient for adaptability is probably of more value, and gives a more accurate evaluation of adaptability. However, in this study, the BIA values have only confirmed further the evaluations obtained by using RT, RHTC and RR, as the results follow the same trend.

The PR values also followed air temperatures (BADRELDIN *et. al.*, 1951) and had similar trends with the other physiological measurements. The overall PR recorded was 48.32. The male and female values were

47.04 and 49.48; these were not significantly different. This was similar to Philippine carabaos (MENSALVAS and RIVERA, 1951). The age group values, with 50.72 and 46.11 for groups 1 and 2 were, however, significantly ($P < 0.01$) different. The PR values obtained in this study were lower than those reported for Egyptian buffaloes (BADRELDIN *et. al.*, 1951). The Egyptian buffaloes had PR values of 60 and 59 for 2 and 3 year-olds, respectively, and a mean value of 56, throughout the day. The comparative value reported for Indian buffaloes was 41 (MULLICK and KEHAR, 1951). The difference between time means (*Table 7*) showed a significantly ($P < 0.01$) low PR for 2000 hrs compared to other times. This emphasises the need for the baffalo to have a cool environment away from the sun to be comfortable.

Finally, in a study of correlations of the physiological measurements with age, at different times of the day, the RT, and hence RHTC, were found to be significantly ($P < 0.05$) correlated at 0800, 1430 and 1630 hours (*Table 8*). The corresponding regression equations are presented (*Table 6*). The only RR and BIA that was significantly ($P < 0.05$) correlated was for 0800 hours. These correlations and regressions would be of value in determining the extent to which management would have to be intensified for these buffaloes at different ages, at different times of the day, to provide shade and cooling facilities, for maximising production.

In an overall evaluation, it has been found that the older Malaysian buffaloes are more heat tolerant (MASON, 1974) than the younger ones, and that differences between males and females are slight and insignificant. It has also been observed, by comparing reports, that Malaysian buffaloes are less well adapted to heat stress conditions than their counterparts in Egypt, India and the Philippines. This would probably warrant the use of genetic material from these three countries to upgrade the Malaysian buffalo to be able to withstand heat better, and hence increase its production.

The results of this study open up various avenues of research and study, in the management of especially young buffaloes, which are more prone to heat stress, than older ones. Now that a base has been established, future research should be directed and concentrated along these lines to improve conditions of comfort for these buffaloes, so that better production levels can be achieved.

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SUMMARY

The paper reports a study of the basic physiological characteristics of the Malaysian swamp buffalo. It also discusses the effect of sex, age and times of the day on these characteristics.

The overall means recorded on all the animals in this study, for rectal temperature, Rhoad's Heat Tolerance Coefficient, respiration rate, Benezra's Index of Adaptability and pulse rate was 38.87°C, 89.53, 48.76, 3.14 and 48.32, respectively. The effect of sex on these measurements was insignificant. However, the age effect was highly significant ($P < 0.01$), with the 2-4 year-old buffaloes being superior in adaptability to an exposed environment, as compared to the 1-2 year-olds. Further, the effect of time of day on the different characteristics was variously significant ($P < 0.01$), with the hottest hours of the day producing severe stress on these animals.

The physiological values obtained in this study were compared with those obtained from buffaloes in Egypt, India and the Philippines, under similar conditions. The comparison demonstrated that the Malaysian swamp buffalo is less well adapted to a hot environment than its counter parts in Egypt, India and the Philippines.

A suggestion as to the kind of research that needs to be undertaken to improve the productivity of the Malaysian buffalo, by increasing its adaptability, is discussed.

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