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Diurnal variation in the physiological responses of yaks

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In the mammals circadian rhythms are expressed as oscillations in physiological processes, which are responsive either to internal or external stimuli (Giuseppe and Giovanni 2002). The information on diurnal variations in the primary physiological responses of yaks (*Poephagus grunniens* L.) is scantly. Hence, the present study was planned to assess the diurnal variations in the primary physiological responses of yak during winter and at summer at high altitude.

The present study was carried out at yak farm of National Research on Yak, which is located at above 2750 m above mean sea level on 91°4' East longitudes and 27° North latitudes in Nyukmadung area of west Kameng district of Arunachal Pradesh, India. Healthy yaks (30) were divided into 3 groups, viz. calves (age: 8–12 months, average body weight of 67.94±5.09 kg), adult bulls (age: 5–7 years, average body weight of 265±10 kg), with 10 animals in each group. They were maintained under semi range system of management. The primary physiological responses were recorded throughout the day at 4h intervals during alternate months of winter and summer in all the 3 groups of yak. The physiological responses, viz. rectal temperature (°F), respiration rate (breaths/min) and pulse rate (beats/min) were recorded according to Sarkar *et al.* (2000). The ambient temperature and relative humidity of the farm were collected continuously using weather station. The minimum and maximum ambient temperature during winter was 1.54°C and 8.70°C, respectively, along with the relative humidity of 36.0 – 96.00% . During summer, the minimum and maximum ambient temperature was 11.47°C and 15.86°C along with relative humidity of 57.00% and 97.00% respectively. Statistical analysis was done according to Snedecor and Cochran (1967) using one-way ANOVA and non-paired test.

The diurnal variations in body temperature, respiration rate and pulse rate are presented in Table 1. The body temperature was minimum during early morning and maximum during late afternoon in all the 3 groups of yak both during winter and summer. During winter 3 was no significant difference in body temperature among three groups during morning and evening on the other hand the body temperature of calves was significantly higher ($P<0.05$) than adult bulls and lactating yaks at late afternoon. The body temperature of calves was significantly higher ($P<0.05$) than adult bulls and lactating yaks at around 10.00 AM and 6.00 PM during summer. However, the body temperature significantly varied ($P<0.05$) among 3 group at 2.00 PM. The present results are in agreement with the finding of Giuseppe and Giovanni (2002) and Beatty *et al.* (2006). The body temperature shows a distinct cyclic variation throughout the day. The daily oscillation in core body temperature of yaks were 0.5–2.75°F. The variations in the body temperature could be due to the influence of ambient temperature, relative humidity, solar radiation and other factors of environment (Giuseppe and Giovanni 2002, Beatty *et al.* 2006). Homeotherms maintain relatively constant core body temperature within a narrow range of variation in spite of changes in environmental conditions.

The respiration rate was minimum during early morning and maximum during late after noon in all the 3 groups of yak during winter and summer. There was no significant difference among three groups during morning and evening but in calves the respiration rate was significantly higher ($P<0.05$) than adults bulls and lactating yaks at 10.00 AM and 6.00 PM during summer and significant variations ($P<0.05$) were found among all the groups around 2.00 PM. These results are in agreement with the finding of Giuseppe and Giovanni (2002) and Beauty *et al.* (2006). The average respiration rate increased as the temperature of the natural environment increased from cool to moderate to warm. There was a linear increase in mean respiration rate when the ambient temperature increased (Beauty *et al.* 2006). The changes in respiration rate could be due to exposure to greater intensity of solar radiation. The yaks alter their respiration rate not only in response to a changing need for oxygen at high altitude but also to regulate body temperature.

A circadian rhythm was observed in the pulse rate of yaks with a minimum during early morning and maximum during

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Table 1. Diurnal variation in the physiological responses of calves, adult bulls and lactating yak cows during winter and summer

Physiological responses	Animal	Winter					Summer				
		6.00 AM	10.00 AM	2.00 AM	6.00 AM	10.00 AM	6.00 AM	10.00 AM	2.00 AM	6.00 AM	10.00 AM
Rectal temperature (°F)	Calves	99.88 ±0.02	100.11^{A} ±0.03	100.19^{Aa} ±0.03	100.09A ±0.02	99.99 ±0.03	99.94 ±0.03	101.63^{Ba} ±0.06	102.75^{Ba} ±0.05	100.73^{Ba} ±0.09	100.05 ±0.02
	Adult bulls	99.90 ±0.02	100.19^{A}± ±0.04	100.46^{Ab} ±0.05	100.17^{A} ±0.03	99.98 ±0.01	99.93 ±0.03	101.06^{Bb} ±0.06	102.36^{Bb} ±0.12	100.52^{Bb} ±0.07	100.02 ±0.02
	Lactating yaks cows	99.86 ±0.02	100.18^{A} ±0.03	100.34^{AB} ±0.03	100.15^{A} ±0.02	99.98 ±0.02	99.92 ±0.04	101.44^{Bc} ±0.04	102.60^{Bc} ±0.04	100.54^{Bc} ±0.09	100.02 ±0.02
Respiration rate (Breaths/min)	Calves	19.40 ±0.22	19.70^{A} ±0.25	20.40^{Aa} ±0.29	20.30^{A} ±0.24	20.20 ±0.14	20.15± ±0.31	34.85^{Ba} ^{a}±1.03	43.25^{Ba} ±0.69	27.30^{Ba} ±0.51	20.70 ±0.29
	Adult bulls	20.20 ±0.14	20.40^{A} ±0.42	21.50^{AB} ±0.40	20.70^{A} ±0.23	20.60 ±0.21	20.50 ±0.32	27.85^{Bb} ±0.50	37.70^{Bb} ±0.94	25.80^{Bb} ±0.55	21.15 ±0.33
	Lactating yaks cows	20.00 ±0.25	20.50^{A} ±0.38	21.50^{Ab} ±0.30	20.50^{A} ±0.31	20.40 ±0.23	20.40 ±0..35	32.05^{Bc} ±0.62	41.20^{Bc} ±0.71	26.80^{Bb} ±0.53	20.70 ±0.33
Pulse rate (Beats/min)	Calves	57.70^{A} ±0.30	57.80^{A} ±0.50	58.40^{Aa} ±0.34	58.20^{A} ±0.32	58.20 ±0.29	58.35 ±0.45	73.30 ±0.44	79.30^{Ba} ±0.51	66.50^{Ba} ±0.39	58.50 ±0.32
	Adult bulls	58.20 ±0.38	58.80^{A} ±0.22	61.10^{Ab} ±0.34	59.00^{A} ±0.31	58.80 ±0.37	58.50 ±0.60	71.10^{Bb} ±0.44	76.80^{Bb} ±0.10	63.10^{Bb} ±0.61	59.50 ±0.63
	Lactating yaks cows	57.90 ±0.38	58.20^{A} ±0.38	60.50^{Ab}± ±0.12	58.40^{A} ±0.28	58.20 ±0.43	58.35 ±0.45	72.10^{Bb} ±0.31	77.60^{Bb} ±0.71	64.35^{Bb} ±0.50	58.50 ±0.32

The means bearing different superscripts of small letters are significantly (P<0.05) different in same column; the means bearing different superscripts of capital letters are significantly (P>0.05) different in same row.

late afternoon. The pulse rate followed the same pattern as that of body temperature and respiration rate during both the season. Maximum pulse rate was found during late afternoon and it varied significant (P<0.05) among all the groups. Present results are in line with the finding of Beatty *et al.* (2006) and Collier *et al.* (2006). The significant increase in pulse rate during summer represented the cardiac ability to fulfil the increased demand for gas transport and also served as a heat loss mechanism by increasing blood flow to the peripheral organs and skin thereby taking away the heat from the core body (Collier *et al.* 2006).

SUMMARY

The present study was carried out at National Research Centre on Yak. Healthy yaks (30) were divided into 3 groups, viz. calves, adult bulls and lactating yak cows. They were maintained under semi range system of management. The primary physiological responses were recorded at 4h intervals at alternate months throughout the year in all the 3 groups of yak. The physiological responses were minimum in the early morning and maximum during late afternoon. The physiological responses of calves were significantly (P<0.05) higher than adult bulls and lactating yak cows during late afternoon. In all the three groups of yak the physiological responses were significantly higher (P<0.05) during summer than winter.

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