

Original Research Article

Effect of Changes in Behaviour on the Heart Rate and its Diurnal Variation in a Male and a Female Eland (*Taurotragus oryx*)

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Abstract

Heart rate (HR) is related to the physiological state of most of vertebrates, e.g. the level of metabolism, motion or stress. In previous reports, the HR of eland was measured during sedation and general anaesthesia. Therefore, we wanted to evaluate HR in alert eland with emphasis on variations by different behaviours and time of the day. We measured HR by Polar S610 device in an adult male and an adult female. Behaviour during recumbent and rumination, standing and rumination, standing, standing and eating, movement, excitement during feeding, stressful event, handling in restraint box and sleep were recorded and synchronised with data from HR device. In the male, HR was lowest during recumbency and rumination. In the female, HR was lowest during sleep. The highest HR was measured during handling in a restraint box. The HR was higher during the night for most of the behaviours. Further research should focus on explaining the diurnal variation in HR as it relates to specific behaviour.

Keywords: eland; heart rate; remote monitoring; welfare.

INTRODUCTION

Captive animals are exposed to various breeding conditions, which may positively or negatively influence animal welfare. To measure neural and physiological response of negative or positive stimuli on animals, several invasive and noninvasive methods are available. One of the least invasive approaches is a remote measurement of the heart rate (HR). The HR increased during transportation of red deer (*Cervus elaphus*, Grigor et al., 1998), capture and handling of vicuña (*Vicugna vicugna*, Arzamendia et al., 2010), social stress during separation or weaning of cattle (*Bos taurus*, Hopster and Blokhuis, 1994; Hopster et al., 1995; Stěhulová et al., 2008) or as response to higher or lower ambient temperatures in Kirk's dik-dik (*Madoqua kirkii*, Kamau and Maloiy, 1982). Thus, the HR and HR variability combined with specific behaviour were used to monitor welfare of captive animals (von Borell et al., 2007). Moreover, the HR corresponds to the level of metabolism and can be used for monitoring energy expenditure (Arnold et al., 2004) during rest or physical activity.

Circadian rhythmicity in HR was previously found in laboratory rabbits (*Oryctolagus cuniculus*, Lim et al., 2012), reindeer (*Rangifer tarandus*, Eloranta et al., 2002) or red deer (Arnold et al., 2004), but the relation to specific behaviour was not incorporated into statistical models. The HR of eland (*Taurotragus oryx*) was measured only during

sedation or general anesthesia (Cole et al., 2006; Wirtu et al., 2005), thus in this study we wanted to determine if the type of behaviour in eland affects HR and if there is a diurnal variation in HR.

MATERIALS AND METHODS

Location

This study was performed on farm Březová which is located 8 km south-east from Kutná Hora (49° 08' N, 15° 04' E), Czech Republic. Common elands were housed in a barn measuring 9.5 m × 23 m, originally built for cattle and later adapted for elands. The concrete floor was covered by straw bedding and cleaned once a week. Animals had access to 2.2 ha pasture area enclosed by a fence that ranged from 2.5 to 2.8 m in height. The elands were fed twice a day with barley groats and mangel. Meadow hay and water were available *ad libitum*.

Study animals

The study group consisted of two captive born, tame individual elands, 11 years old male (named Ninja, live weight 660 kg) and 8 years old female (named Prima, live weight 350 kg). Total number of animals in the herd was

eight; one adult male, four adult females and three calves (age from six month to one year). The male (Ninja) was penned separately and the female (Prima) was penned with other animals. Ninja and Prima had visual but not physical contact in the barn. The pen area for the male and female was 16 m² and 12 m², respectively.

The two animals were deliberately chosen for the experiment because they reacted relatively calmly to the handling and they allowed the physical contact with humans. The study animals were trained to access the restraint box every 14 days during one year and we also made about 20 attempts to accustom them to the belt with HR recorder.

Data collection

The experiment was done in March during the winter housing of animals and period of equinox. The temperature inside the barn was relatively constant during 24 hours of observation and ranged between 2- 11 °C during whole observational period. To monitor the levels of HR in eland, we observed behaviours described below by 24-hours focal sub group sampling (Altmann, 1974) in the pen barn. We identified the behaviours that could affect HR as the following: standing and ruminating; recumbent and ruminating; standing; standing and eating; movement; sleep; excitement during feeding by keeper; stressful events (entrance of unfamiliar person, noise from outside of barn) and handling in restraint box.

The monitored behaviour was categorised as 'movement'- associated with the walking or movement of an animal thorough the pen barn. 'Sleep' was defined as the position at which the animal was lying with its eyes closed and its neck flexed and head rested backward on the flank (Kiley-Worthington, 1978). Sleep was reported and evaluated only for female due to problematic visual recognition of a sleep in male based on pen position. Those unclear and timely sporadic observations were not included in the analysis. Situations when animals were disturbed, startled or during handling, were considered as potentially 'stressful events'. 'Excitement during feeding' was recorded during morning and evening, when a keeper was delivering feed to the elands. Elands were fed in a group, with the exception of the male who was separated during the period of winter housing. 'Handling' in restraint box was specified as the interval between when the animal entered the restraint box and was subject to handling to attach HR monitoring device to when the procedure was completed and animal was released the box.

Two observers alternated every six hours. The onset and termination of each type of behaviour for each animal was recorded by observation and written down on a tabulated data format. The animals were observed in their home barn to keep the environmental conditions constant (ambient

temperature), equal light and night regime for 12 hours and avoid the disturbance by external noise, strangers etc. During the night, the light was dimmed to simulate intensity of moonlight.

Heart rate monitoring

We used the least invasive method to monitor the HR. The most common type of sensor used in previous studies for HR monitoring was Polar ® Sport Tester (PST). It has been successfully used in horses (*Equus caballus*, van Oldruitenborgh-Oosterbaan, et al. 1988), cattle (Hopster and Blokhuis, 1994), pigs (*Sus scrofa*, Marchant et al., 1995), reindeer (Mesteig et al., 2000), red deer (Price et al., 1993) and alpaca (*Vicugna pacos*, Pollard and Littlejohn, 1995). Previous studies of the precision and accuracy of the PST showed that it provides sufficient and valid data on HR.

We used the device Polar S610 with accuracy ± 1 beats per minute (bpm). It consisted of two steel electrodes size of 17.5×10^{-4} m², which were connected to a signal carrier. A data recorder about the size of digital watch was attached 20 cm away from the signal carrier and all components were attached by tape to an elastic belt (see Fig. 1). Electrodes were placed on left side of the trunk in the chest area behind shoulder with a minimum distance between electrodes of 30 cm. The recorder was attached in the dorsal part at the withers. The selected recording rate of heart rate was every 15 seconds as a mean value of bpm as a minimum storing interval to not exhaust capacity of the recorder's memory for 24 hours of continuous recording.

Statistical analyses

Data were analyzed using the SAS System V 9.2 (SAS Inst. Inc., Cary, NC). The associations between



Fig. 1. A female eland with the heart rate device attached using an elastic belt.

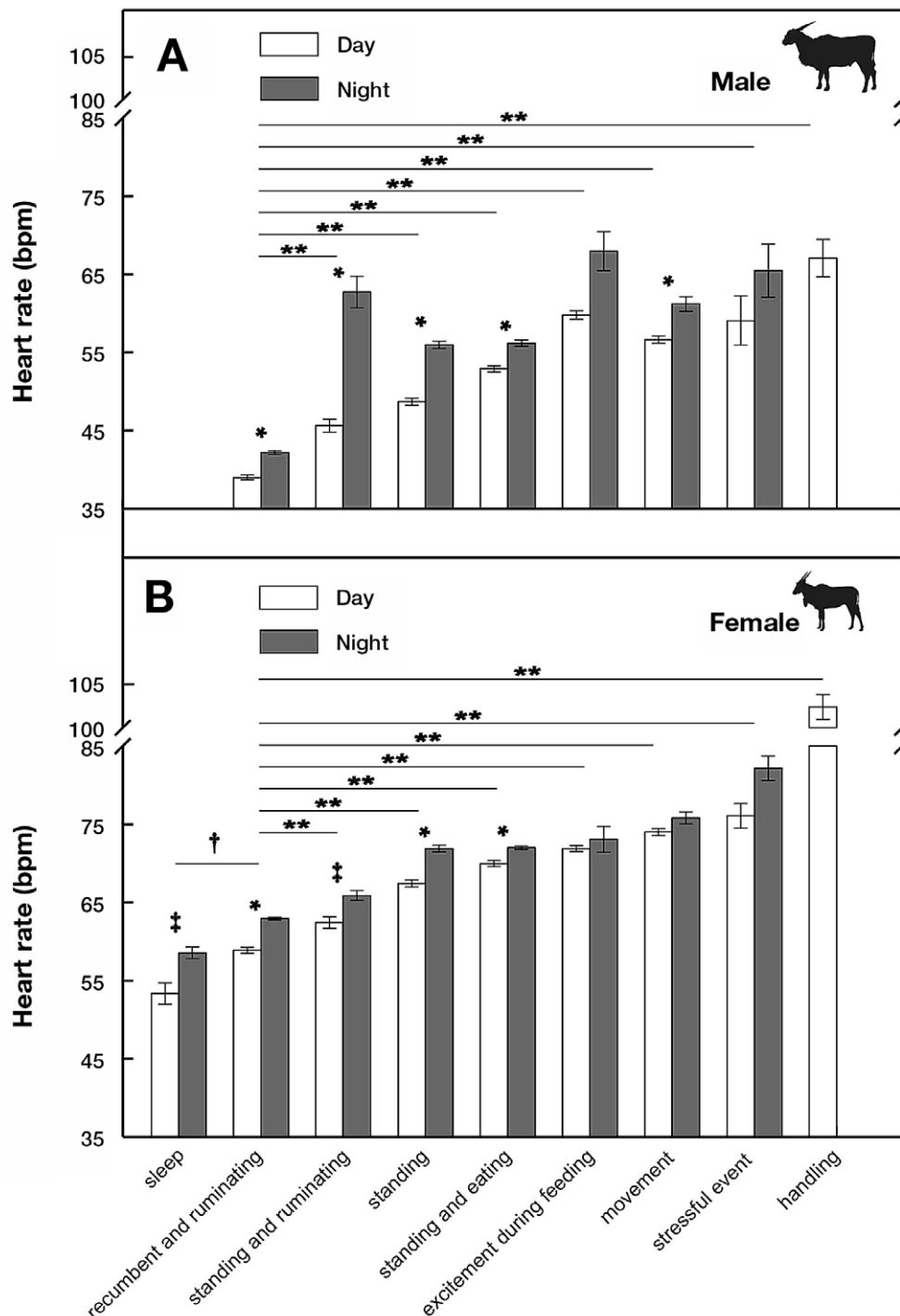


Fig. 2. Differences between mean heart rate (HR) during different types of behaviour in male (A) and female (B) eland. Asterisk ‘*’ above two bars indicates significant difference ($p < 0.001$) between mean HR of different types of behaviour during a day and night and double dagger ‘‡’ above indicates significant difference ($p < 0.05$). Differences between mean resting HR during ‘recumbent and rumination’ and other types of behaviour are indicated by double asterisk ‘**’ ($p < 0.001$) and dagger ‘†’ ($p < 0.01$) above horizontal lines connecting couple of bars representing mean HR during ‘recumbent and rumination’ with couple of bars representing mean HR of different behaviour in male (A) and female (B).

the percentage of time spent by specific behaviour and the fixed effects were tested using a Generalized Linear Mixed Model (GLMM). The HR was included as a

dependent variable. The independent fixed effects were the class variables of different types of behaviour namely ‘recumbent and rumination’, ‘standing and rumination’,

‘standing’, ‘standing and eating’, ‘movement’, ‘excitement during feeding’, ‘stressful event’ and ‘handling in restraint box’. An additional behaviour, ‘sleep’, was tested in the female. Another fixed effect was ‘Day/Night’ phase distinguish the day light hours and dark night hours. We run tests for male and female independently using PROC MIXED. The significance of each fixed factor in the GLMM was assessed using the F-test. The least-squares-means (LSMEANS) were used to find differences between the classes tested. For multiple comparisons we used the Tukey-Kramer adjustment.

RESULTS AND DISCUSSION

The resting HR during recumbency and rumination in both animals differed from HR during all other behaviours, specifically in the male (Fig. 2, $F_{(7,3925)} = 448.85, p < 0.0001$) and in female (Fig. 2, $F_{(8,2942)} = 397.8, p < 0.0001$).

The lowest value of HR was recorded during recumbency and rumination in the male and sleep in female. The latter was the lowest value measured for the female. These values correspond to the lowest values monitored in deer during the same behaviour (Nilssen et al., 1984). HR in all other behaviours significantly increased in the male and female. Other behaviours, except standing and standing and rumination, are associated with some physical activity. During standing and standing and rumination only muscles supporting animal to stand are involved.

The highest values of HR were recorded during handling, stressful event and excitement during feeding by keeper, where the movement was combined with stressful stimuli. The highest values of HR were also monitored during feeding in rabbits (Lim et al., 2012) and pigs (Marchant et al., 1997). Increases in HR were also reported during the process of capture and enclosure of deer in restraint box when HR increased from 55.3 bpm to 111 bpm (Carragher et al., 1997). Baldock and Sibly (1990) reported similar findings in sheep with an increase in HR of 20 bpm during isolation. Similarly, Price et al. (1993), reported an increase in HR of 27 bpm in deer during the social isolation.

The HR during specific behaviour was lower during the day, than at night in the male (Fig. 2, $F_{(14,3919)} = 23277.85, p < 0.0001$) and female (Fig. 2, $F_{(16,2935)} = 202.61, p < 0.0001$). In contrast to our findings in eland, other studies reported a decrease of HR during the night in laboratory rabbits (Lim et al., 2012), reindeer (Eloranta et al., 2002) or red deer (Arnold et al., 2004). Those studies also described lower activity of animals during the night, but diurnal variation of HR was not evaluated according to specific behaviour. Therefore, it is unclear why eland have nocturnally higher HR during all monitored behaviour in constant climate inside the barn.

Thus, further research is warranted to explain the diurnal variation in HR and its association with specific behaviour.

The present study provides baseline information and first account of remote monitoring of the HR of eland without the use of anaesthetic and sedative agents. Additionally, we document diurnal variation in specific behaviour and HR in the eland antelope.

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REFERENCES

- Arnold W., Ruf T., Reimoser S., Tataruch F., Ondersheka K., Schober F. (2004): Nocturnal hypometabolism as an overwintering strategy of red deer (*Cervus elaphus*). American Journal of Physiology-Regulatory Integrative and Comparative Physiology 286(1): 174-181.
- Altmann J. (1974): Observational study of behaviour: sampling methods. Behaviour 49: 227-267.
- Arzamendia Y., Bonacic C., Vila B. (2010): Behavioural and physiological consequences of capture for shearing of vicunas in Argentina. Applied Animal Behaviour Science 125(3-4): 163-170.
- Baldock N.M., Sibly R.M. (1990): Effects of handling and transportation on the heart rate and behaviour of sheep. Applied Animal Behaviour Science 28: 15-39.
- Carrager J.F., Ingram J.R., Matthews L.R. (1997): Effects of yarding and handling procedures on stress responses of red deer stags (*Cervus elaphus*). Applied Animal Behaviour Science 51: 143-158.
- Cole A., Mutlow A., Isaza R., Carpenter J.W., Koch D.E., Hunter R.P., Dresser B.L. (2006): Pharmacokinetics and pharmacodynamics of carfentanil and naltrexone in female common eland (*Taurotragus oryx*). Journal of Zoo and Wildlife Medicine 37(3): 318-326.
- Eloranta E., Norberg H., Nilsson A., Pudas T., Sakkinen H. (2002): Individually coded telemetry: a tool for studying heart rate and behaviour in reindeer calves. Acta Veterinaria Scandinavica 43(3): 135-144.
- Grigor P.N., Goddard P.J., Littlewood C.A. (1998): The behavioural and physiological reactions of farmed red deer to transport: effects of sex, group size, space allowance and vehicular motion. Applied Animal Behaviour Science 56(2-4): 281-295.

- Hopster H., Blokhuis H.J. (1994): Validation of heart rate monitor for measuring a stress response in dairy cows. *Canadian Journal of Animal Science* 74: 465-474.
- Hopster H., O'Connell J., Blokhuis H.J. (1995): Acute effects of cow-calf separation on heart rate, plasma cortisol and behaviour in multiparous dairy cows. *Applied Animal Behaviour Science* 44: 1-8.
- Kamau J.M.Z., Maloiy G.M.O. (1982): The relationship between rate of oxygen-consumption, heart-rate and thermal conductance of the dik-dik antelope (*Rhynchotragus kirkii*) at various ambient-temperatures. *Comparative Biochemistry and Physiology A-Physiology* 73(1): 21-24.
- Kiley-Worthington M. (1978): The causation, evolution and function of the visual displays of the eland (*Taurotragus oryx*). *Behaviour* 66: 179-222.
- Lim K., Burke S.L., Armitage J.A., Head G.A. (2012): Comparison of blood pressure and sympathetic activity of rabbits in their home cage and the laboratory environment. *Experimental Physiology* 97(12): 1263-1271.
- Marchant J.N., Mendl M.T., Rudd A.R., Broom D.M. (1995): The effect of agonistic interactions on the heart rate of group-housed sows. *Applied Animal Behaviour Science* 46: 49-56.
- Marchant J.N., Rudd A.R., Broom D.M. (1997): The effects of housing on heart rate of gestating sows during specific behaviours. *Applied Animal Behaviour Science* 55: 67-78.
- Nilssen K.J., Johnsen H.K., Rognmo A., Blix A.S. (1984): Heart rate and energy expenditure in resting and running Svalbard and Norwegian reindeer. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology* 246: 963-967.
- Pollard J. C., Littlejohn R. P. (1995): Effects of social isolation and restraint on heart rate and behaviour of alpacas. *Applied Animal Behaviour Science* 45: 165-174.
- Price S., Sibly R., Davies M. H. (1993): Effects of behaviour and handling on heart rate in farmed red deer. *Applied Animal Behaviour Science* 37: 111-123.
- Stěhulová I., Lidfors L., Špinka M. (2008): Response of dairy cows and calves to early separation: Effect of calf age and visual and auditory contact after separation. *Applied Animal Behaviour Science* 110(1-2): 144-165.
- Van Oldruitenborgh-Oosterbaan S., Van Den Hoven R., Breukink H. J. (1988): The accuracy of three different heart rate meters for studies in exercising horse. *Journal of Veterinary Medicine Series A* 35:665-672.
- Von Borell E., Langbein J., Despres G., Hansen S., Leterrier C., Marchant-Forde J., Marchant-Forde R., Minero M., Mohr E., Prunier A., Valance D., Veissier I. (2007): Heart rate variability as a measure of autonomic regulation of cardiac activity for assessing stress and welfare in farm animals - A review. *Physiology & Behavior* 92(3): 293-316.
- Wirtu, G., Cole A., Pope C. E., Short C. R., Godke R. A., Dresser B. L. (2005): Behavioral training and hydraulic chute restraint enables handling of eland antelope (*Taurotragus oryx*) without general anesthesia. *Journal of Zoo and Wildlife Medicine* 36(1): 1-11.

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