CARDIAC REACTIONS IN THE BEHAVIOUR OF YOUNG MOOSE[1]

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ABSTRACT: Using a method of telemetrical electrocardiography 40 young domesticated moose were studied in conditions approximating the natural environment at the experimental moose farm in the Pechora-Ilych Nature Reserve. An environmental physiological estimation of the ontogeny of the behavioural and emotional reactions of moose calves was done. The cardiac rhythm stabilization at value characteristic for adult animals occurred at the age of approximately 3 months. Young moose motions such as walking or pasture increased heart rate by 30-50%. Emotional positive and negative reactions are attended by cardiac chronotropic effect. The most pronounced heart rate increment (up to 250 beats per minute) was found at nursing.

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The experimental moose domestication program conducted in the Pechora-Ilych Nature Reserve since 1949 (Kozhukhov 1973, Knorre 1974) provides unique conditions for field investigations of moose ecology and physiology (Chermnykh 1987). Contemporary telemetrical techniques facilitate investigations into the physiological mechanisms underlying moose behaviour.

Currently, a great deal of information on peculiarities of moose physiology is available. It is known that the myocardium of ungulates exhibits unique electro-physiological properties. There is a "flash" pattern of the ventricular activation (Roshchevsky 1978), which results in accelerated myocardial excitation. Heart rate changes are involved in the emotional reactions and responses to high and low temperatures (Roshchevsky 1967; Roshchevsky *et al.* 1976, 1978; Konovalov 1975, 1981; Chermnykh *et al.* 1980; Chermnykh and Mochalov 1986; Chermnykh *et al.* 1990).

There are data suggesting that the age development in wild ungulates, particularly moose, is highly accelerated compared with cattle (Chermnykh 1992). It has been shown that moose calves have an enhanced body weight increase during the first 2 months after birth. The growth rate differences between moose and bovine calves are maintained up to 18-months of age. This accelerated body weight increase in moose calves makes enhanced demands on the circulatory system. Thus, it is of considerable importance to examine the moose cardiovascular system and heart rate in the period of early ontogeny.

Cardiac rhythm reactions are involved in conditioning development of the circulatory system as it responds to altered environmental parameters. Heart rate changes are induced by the outer factor-induced activation of the sympathetic or parasympathetic partition of the autonomic nervous system. Domestication causes some additional peculiarities in moose behaviour. Under domestication young moose

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behavior is determined by the feeding regime (Knorre 1974). Mother-infant relations are excluded (Stringham 1974) while new social relations between the animals within a group as well as between animals and humans are developed. The objective of the study is to examine the correlation between the young moose heart rate and 3 factors: age, physical activity level, and emotional reactions.

METHODS

The studies were conducted at the moose farm in the Pechora-Ilych Nature Reserve, the Komi Republic, Russia. Data on 40 domesticated young of the year were obtained from 1971 to 1996. The observations were conducted from May to August on calves ranging from 1 week to 3 months. The animals were maintained in an enclosure under environmental conditions close to natural ones with minimal man-made restrictions which might impact their behavior. In order to investigate heart rate variability, long-term continuous electrocardiogram (ECG) registration was applied using a telemetric recording system created in our laboratory. One of the needle subcutaneous electrodes was located on the withers and another one in the area of the *processus xyphoideus*. There were no immobilization or pharmacological interventions applied. The electrodes were placed in a manner preventing anxiety of the animals, as well as minimizing inflammation at the site of electrode attachment, all of which will minimize the occurrence of artifacts in ECG's. Only findings relative to heart rate dynamics obtained from ECG's are presented.

Various behavior states such as bedding, standing, walking, pasture, and nursing (bottle fed by human nursemaid) were analyzed. The term "pasture" refers to eating fresh leaves from the cut branches distributed within the enclosure and fixed in a way convenient for the animals. Also the effects of the various emotional states, either induced or natural, such as nursing, isolation from a group, or the effects of experimental preparations, were estimated. Environmental temperature influences on respiration rate were estimated by counting excursions of the thorax. The observations were done several times daily, but some of the animals were studied at 1 hour intervals over 24 hours. Heart rate age evolution in the range from birth to 3 months was studied.

RESULTS

In moose calves the highest heart rate was found in newborns (171±17 beats per minute [bpm]). There was a significant decrease in the heart rate of 1 month old calves (97±8 bmp) compared to newborns. When heart rate was plotted against age the value approached asymptotically the value characteristic for adult animals (Fig.1). The adult cardiac rhythm in young moose was established at the age of approximately 3 months.

High summer temperatures (25-29°C) induced significant heart rate increase which was associated with thermoregulatory polypnea (up to 120 excursions per minute). An increase in the ambient temperature from 16 to 27°C caused the heart rate to accelerate from 120 to 136-150 bpm in calf No. 10 at the age of 12 days and from 103-111 to 125-136 bpm in calf No. 17 at the age of 60 days. When temperatures in the shade were 25°C and the respiration rate in calf No. 2 (age 80 days) was 108 excursions per minute, the heart rate was 116 bpm, compared to the baseline value of 97 bpm.

The heart rate was dependent upon the behavioural activity (Figs 2-3). In the course of 24 hours, we observed the overall range of behavior reactions and cardiac rhythm changes. The minimal heart rate level in young moose of all ages was registered in

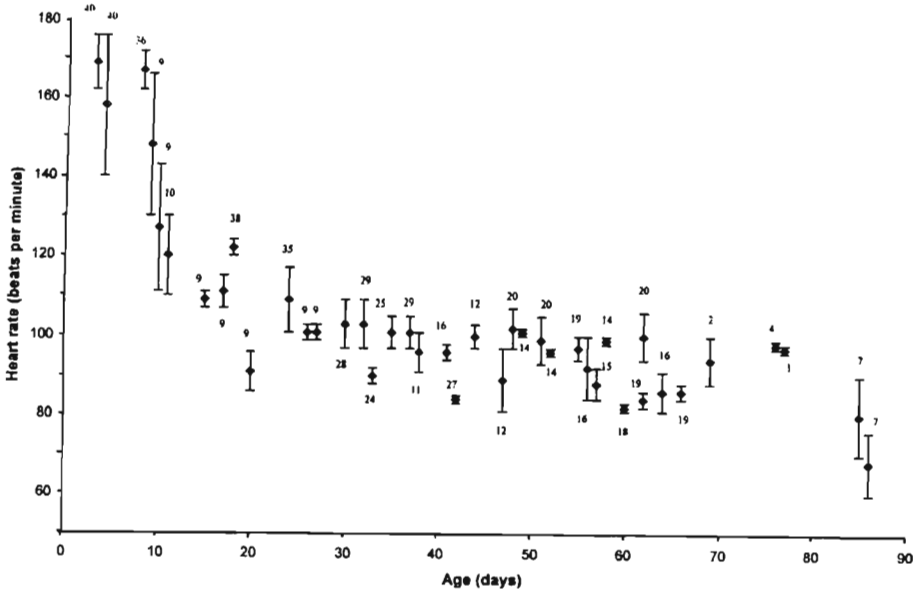

Fig. 1. Age evolution of heart rate in young moose at rest (bedding). The numbers indicate individual animals. Each point corresponds to the median and the variation limits.

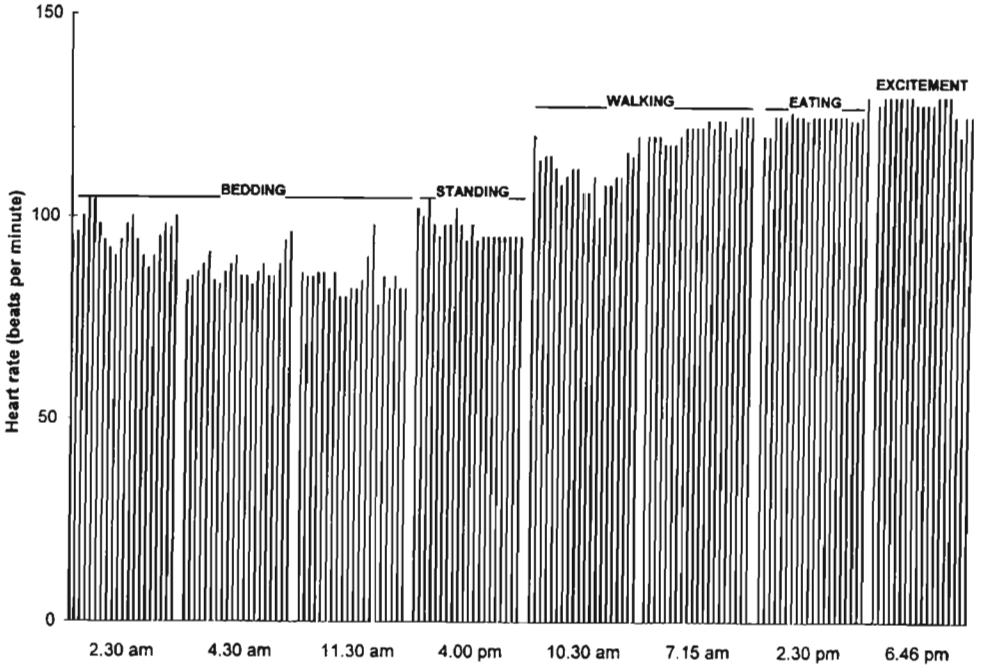

Fig. 2. Heart rate in moose calf No. 6 (age 64-65 days) under various behaviour states. Note that at bedding there is marked respiratory heart rate variability.

bedding animals and during sleep (Table 1). The greatest heart rate increase over the minimum (30-50%) was observed during walking within the enclosure and pasture. In calf No. 2 (age 69-70 days) the pulse rate was 82 bpm during sleep, 92 bpm during bedding but awake, 92-116 bpm while rising, and 119-126 during walking (Fig. 3). Similar changes were revealed in calf No. 6 (Fig. 2). In this animal there was also a

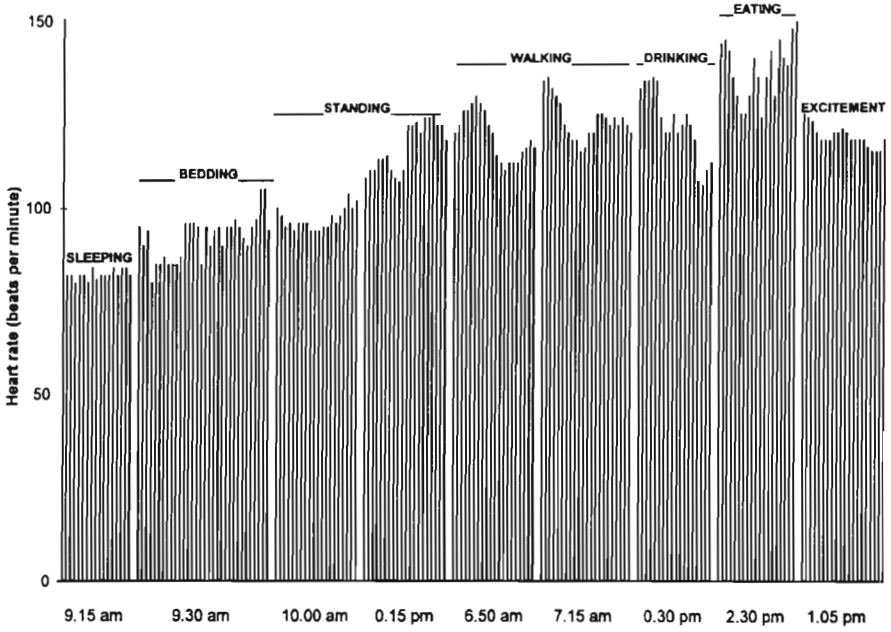

Fig.3. Heart rate in moose calf No. 2 (age 69-70 days) under various behaviour states.

marked respiratory heart rate variability during bedding state.

High variability of cardiac activity under emotional loads was found in young moose. The mere approaching of an observer caused the heart rate to increase 29-33% above baseline conditions. The positive emotional reaction at nursing from cow or artificial induced the most pronounced alterations. The increased heart rate increment at nursing was approximately double that when sleeping. The greatest variability tended to occur in the youngest animals (Table 1). In moose calf No. 9 at the age of 26 days under these conditions there was sinus tachycardia development up to 250 bpm (Fig. 4). The duration of the chronotropic effect period was about a few seconds.

Negative influences, such as isolation from a group, electrode placement and limitation of free behaviour resulted in an excitement and short-term heart rate acceleration. In young moose the most pronounced emotional stress was related to isolation from a group. In calf No.3 (age 81 days) this uncomfortable state of loneliness caused the heart rate to increase from 106 to 133 bpm.

DISCUSSION

The cardiac rhythm changes described in our study could be related to 3 different circumstances, namely heart rate age evolution, cardiac rhythm alterations due to change of physical activity level, and those caused by emotional reactions of the animals.

On the basis of the ECG analysis, regression equations illustrating heart rate age evolution in various behaviour states have been obtained (Chermnykh and Mochalov 1986, Chermnykh *et al.* 1990). Hyperbolic function of age changes of cardiac work intensity asymptotically runs to the heart rate level characteristic of adult animals. Increased pulse values and variation limits in resting newborns may be considered as an index of the significant energy exchange intensity in growing animals and

Table 1. Heart rates (bpm) in young moose of various age at different behaviour states during summer.

Age (days)	Bedding	Standing	Walking	Pasture	Nursing
1-10					
$\bar{x}$ ± SE	146±16	196±19	242±8		236±18
range	102–169	167–214	225–250		200–250
n	9	10	2		4
11-20					
$\bar{x}$ ± SE	105±11	126±17	173±8	116±10	212±3
range	89–125	99–150	165–181	105–127	208–214
n	12	6	2	4	3
21-30					
$\bar{x}$ ± SE	110±8	120±6	146±7	130±11	185±6
range	88–125	110–131	131–166	113–143	160–218
n	17	4	4	5	9
31-40					
$\bar{x}$ ± SE	97±8	115±8	134	116±10	142
range	78–113	96–126		104–140	
n	32	8	1	5	1
41-50					
$\bar{x}$ ± SE	97±11	106±2	111	120±9	
range	72–112	104–108		108–128	
n	16	2	1	4	
51-60					
$\bar{x}$ ± SE	96±5	117±1	128±6	110±4	
range	82–107	116–118	122–134	106–113	
n	20	3	2	2	
61-70					
$\bar{x}$ ± SE	95±6	110±9	129±4	121±10	195
range	84–109	99–126	125–132	105–140	
n	12	7	2	5	1
71-86					
$\bar{x}$ ± SE	91±13	109±8	114±6	133	
range	79–108	96–127	108–122		
n	7	5	4	1	

of the incompletely formed cardiac regulatory mechanisms. In moose there is more rapid "maturation" of the cardiac rhythm regulatory mechanisms. The heart rate characteristic of adult moose developed as early as 3 months, while the cardiac rhythm in cattle is not established until 4 to 5 months. These data provide evidence in support of an hypothesis (Chermnykh 1992) of accelerated ontogeny of wild ungulates.

The highest energy consumption occurs with walking and pasturing. When muscle work is required, mobilization of the circulation system is essential for optimal oxygen delivery to the working organs. Therefore, when animals pass from bedding to a more

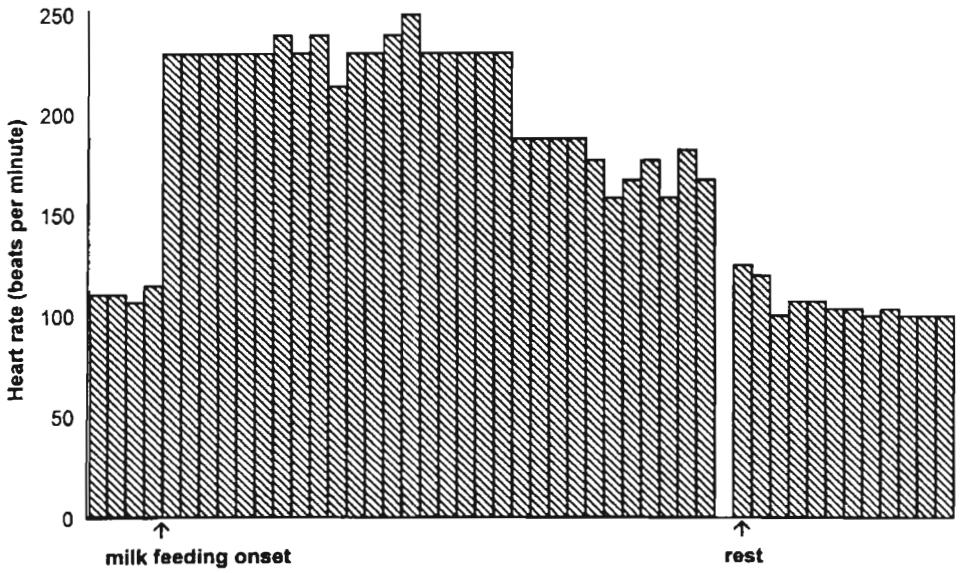

Fig.4. Nursing-induced heart rate reaction in moose calf No. 9 (age 26 days).

active state such as standing, walking, or pasture, cardiac output should be augmented. The possible means of this augmentation is heart rate increase, which has been suggested, if recorded telemetrically, as a measure of energy expenditure of moose in an unaltered natural environment (Renecker *et al.* 1982, Renecker and Hudson 1985, Chermnykh *et al.* 1990). The circulatory system is also involved in reactions to high or low environmental temperatures. Our results show that increased thermal load on moose calves is associated with heart rate acceleration correlated with polypnea, indicating stress of thermoregulation.

One of the major influences on the heart rate in young moose should be emotional reactions. It has been pointed out that at this age the predominant cardiac emotional reactions are the positive ones (Konovalov 1981). One of these positive reactions is a significant heart rate acceleration (up to 250 bpm in our study) at nursing. In 2-month-old calves Konovalov (1981) revealed 4 stages of heart rate development. At the first stage when a person carrying milk was approaching, the heart rate in young moose increased from 93±7 to 112±5 bpm. The next stage was the recovery of the heart rate to the resting level (99±6 bpm) while waiting for feeding. The third was characterized by a significant heart rate augmentation up to 203-209 bpm during nursing. The fourth stage was also recovery to the initial level. Physiological estimation of the newborn moose feeding behaviour was carried out at the Kostroma moose farm (Bogomolova *et al.* 1990, Minaev 1992). The authors observed heart rate increases from 130-160 to 230-260 bpm in artificially reared young moose while nursing. We found the magnitude of this positive emotional effect dependent upon the age of calves. The most pronounced heart rate increase tended to be in the youngest animals. Presumably 2 factors may be involved in formation of this dependence: age-induced pulse rate deceleration and appearance of vegetable forage and diminishing of the milk portion in the ration of older animals. We found that heart rate acceleration, although not as prominent as described above, could be observed during negative influences, such as isolation from a

group, and electrode placement.

CONCLUSIONS

1. In young moose the function of heart rate age evolution approaches asymptotically the value characteristic for adult animals (60±7 bpm) from the high heart rate magnitude (171±17 bpm) found in the neonatal period. The pulse magnitude establishment occurred at the age of approximately 3 months.
2. Heart rate in young moose is highly influenced by the temperature of environment. At high temperatures (25-29°C) sinus tachycardia developed.
3. Behaviour states associated with motions such as walking or pasturing caused a 30-50% increase in heart rate.
4. Positive as well as negative emotional reactions in young moose are attended by cardiac chronotropic effect. The most pronounced heart rate increment (up to 250 bpm) was found at nursing.
5. The study of heart rate changes may be used for estimation of the energy balance level, essential for the field investigations of the environmental physiology of wild animals.

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