Method for Studies of Behavior and Physiology of Sea Mammals

V. B. Voinov, S. A. Siniutin, E. S. Siniutin, N. N. Kavtsevich, and A. S. Zotov

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The potentialities of an original programmed complex for long-term monitoring of oxygen supply and behavior of sea mammals under conditions of free behavior were evaluated. Results of pilot studies of behavioral activity and body systems of seals are presented.

Key Words: *sea mammals; programmed device; electrocardiogram; behavior*

Despite the interest of scientists of many countries to biology and physiology of sea mammals, we cannot yet speak about profound understanding of blood supply mechanisms of diving animals [2-5]. The development of methods for description and evaluation of body systems of whales and pinnipeds acquires special significance due to the development of technologies for creation of biotechnological systems for various purposes.

We evaluated advantages of a new complex of programmed devices for long-term monitoring of behavior and physiology of sea mammals under conditions of free behavior.

The Polygraph hardware-software complex is fixed to animal body for recording and accumulation of data on sea mammal behavior and physiology under conditions approximating the natural ones. It was created in collaboration with specialists from Taganrog Radiotechnological University in 2004-2006 at Southern Research Center [1]. Polygraph is a device created on the basis of MSP430 microcontroller (Texas Instruments). It records and analyzes ECG in two leads from two electrode pairs (one ground wire), pneumogram (chest perimetry; parameter of external respiration), acceleration developed by the animal during moving (calculated from accelerometry in two orthogonal planes — frontal and saggittal). The device was fixed to animal body with elastic textile strips with stickers or with a special strap. Surface electrodes (round, stainless steel, 15 mm in diameter, with special electrode paste) and needle electrodes were fixed to the surface layers of animal skin (standard acupuncture needles from inert alloy, about 0.3 mm in diameter). The sites for electrode fixation were determined on the basis of the data on projection of electrical axis of the heart on the body surface [5]. The electrodes were controlled by two pickup pairs (E1-E2, K1-K2) fixed crosswise on the dorsal side of the chest; the ground wire was placed arbitrarily (Fig. 1). The chest perimetry pickup was fixed in the diaphragm zone with an elastic strip. Resident software realizes scanning of signals in the oscillograph, monitoring, deletion, and input modes. The potentialities of the software permit low- and high-frequency digital filtration, which provides more correct analysis of electrograms.

Pilot studies of the pinnipeds behavior and physiology were carried out at testing grounds of Murmansk Institute of Marine Biology, Kola Research Center of Russian Academy of Sciences (the Barents Sea coast), and at the Utrish Sea Station of Institute of Problems of Ecology and Evolution, Russian Academy of Sciences (M. Utrish settle-

Southern Research Center, Russian Academy of Sciences, Rostov-on-Don. ***Address for correspondence:*** voinov@mmbi.krinc.ru. V. B. Voinov

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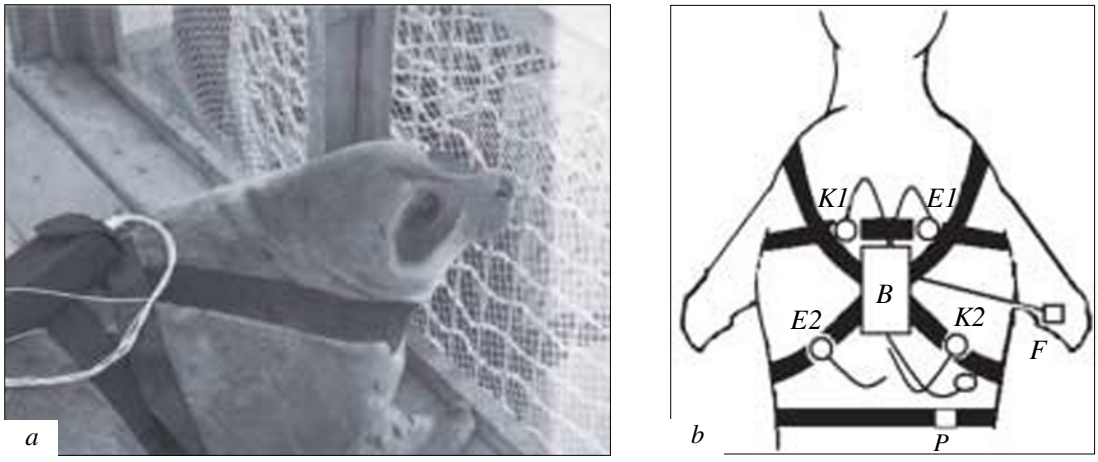

Fig. 1. Mounting of Polygraph mobile complex for physiological studies. *a*) general appearance; *b*) scheme. *B*) main block; *K1*, *K2*, *E1*, *E2*: two pairs of ECG electrodes; *P*: ground wire, strap, and perimetry pickup; *F*: photoplethysmograms.

ment, Black Sea coast, Krasnodar Territory). The following animals were studied: Greenland seals (*Pagophilus groenlandica*; three seals aged about 5 years and two aged 1 year), gray seal (*Halichoerus grypus* aged about 5 years), walrus (*Odobenus rosmarus* aged about 5 years), *Tursiops truncatus ponticus* (aged about 11 years), and fur seal (*Callorhinus ursinus* aged about 8 months). Total duration of physiological parameters registration varied from 15 min to 4 h. The quality of the record (a fragment of at least 25-30 sec) was satisfactory without side effects caused by animal movements.

The behavior was described from visual observations of animals; the library of behavioral patterns (stable repeated movements) was created. Animal behavior was characterized by free alternation of active and passive states irrespective of the place (basin or dry yard). Active behavior was characterized by searching reactions, abrupt active movements, rapid transposition under water, anxious vocalization, manifest aggressive defense reactions towards research workers, while more calm behavior was characterized by a lower motor activity, quiet lasting submerging under water surface, stereotypical swimming in water thickness, periods of rest on the banks with prolonged respiratory pauses, eating. The ECG and pneumogram of a Greenland seal recorded in the yard clearly shows significant changes in heart rhythm (Fig. 2). The rate of respiratory movements was low at some electrogram sites (apnea about 7 sec), heart rate was about 60 bpm; at other sites, the respiration rate was higher and heart rate reached 160 bpm. Averaged cardiocomplex patterns was described for each state (Fig. 3). All typical components (*P*, *Q*, *R*, *S*, *T*), characteristic of mammalian ECG, were maximally represented in the lead *E* cardiocomplex. The amplitude of *R* wave (lead *E*), recorded by surface application of electrodes to animal back, reached 0.4-0.6 mV. A more active status was characterized by a shorter *PQ* interval, more pronounced *S* and *Q* components, and a lesser *R* amplitude.

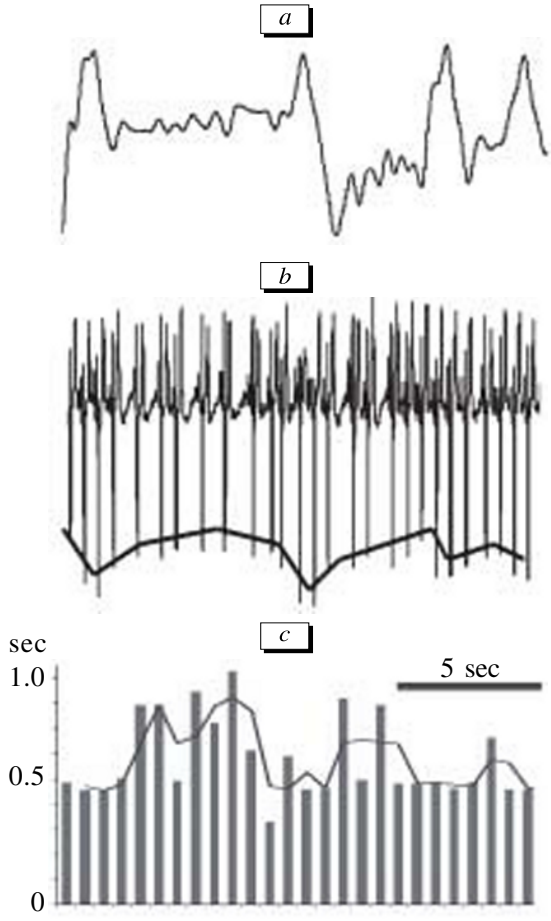

Fig. 2. Manifestations of respiratory rhythm (*a*) in *S* wave amplitude on the ECG (*b*) and in cardiointerval duration (*c*) of a Greenland seal.

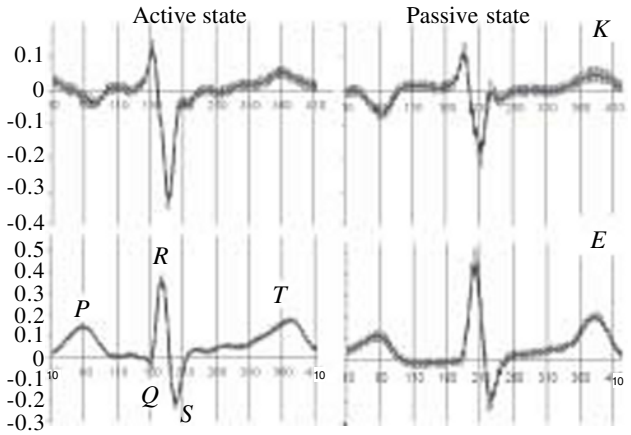

Fig. 3. Cardiocomplexes of a Greenland seal male (aged about 1.7 years), characteristic of the studied ECG leads, recorded in an active and passive state.

Hence, the proposed programmed device allows prolonged monitoring of the parameters of oxygen supply systems of sea mammals under conditions of their free behavior (in corrals). Objective data on the levels of seal activity and status of their body systems, essential for the diagnosis of their functions, were obtained. These data can be used in studies of the voluntary diving reflex, characteristic of pinnipeds and realized not only in water, but also on the ground [5].

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REFERENCES

1. E. S. Siniutin, *Double-Purpose Marine Physiological and Biotechnological Systems* [in Russian], Rostov-on-Don (2005), pp. 72-74.
2. R. D. Andrews, D. P. Costa, B. J. Le Boef, and D. R. Jones, *Respir. Physiol.*, **123**, Nos. 1-2, 71-85 (2000).
3. P. J. Butler, *Respir. Physiol. Neurobiol.*, **141**, No. 3, 297-315 (2004).
4. R. W. Davis, L. A. Fuiman, T. M. Williams, and B. J. Le Boef, *Comp. Biochem. Physiol. A. Mol. Integr. Physiol.*, **129**, No. 4, 759-770 (2001).
5. V. S. de Kleer, *Rapp. Reun. Cons. Int. Explor. Mer.*, **169**, 145-153 (1975).