Level of natremia as an index of the condition of the organism of animals under stress

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In the diagnosis of stressful conditions in humans and other animals, ionic indicators remain practically unused. In this work, we studied the changes in the concentrations of sodium ions in the blood plasma of freshwater fish under stress caused by stressors of different quality and quantity. Most of the experiments were carried out on adult bream (Abramis brama L.) from the Rybinsk Reservoir. Separate experiments were duplicated on adult individuals of roach (Rutilus rutilus L.), lake bream (Abramis balzeri L.), and blue bream (Abramis fulvescens L.). The concentration of cations in the blood plasma was determined using a Funno-4 flame photometer. The data varied, sometimes by 10% or more in chronic lethal stress. During strong acute reversible stress, hyponatremia could reach 30%. Analysis of the material on mammals allowed us to conclude that the adaptation mechanisms in fish and higher vertebrates are similar. In this work, for the first time, the state of the system of electrolyte balance of animals under stress was analyzed from the standpoint of the leading role of ion concentration gradients on the cell membrane (mainly sodium) in the energetics (level of disequilibrium) of the organism. We propose a concept that in normal and extreme conditions fish use two different defense reactions (or adaptation strategies): active and passive, consisting, respectively, in increasing or decreasing the level of disequilibrium (energy) in the organism. The hyponatremia recorded by numerous authors, which accompanies diseases in humans, is evidently a nonspecific reaction of the organism and serves as an indicator of reduced energy of the organism. It is suggested that the sodium level in the internal environment of the organism be used for diagnosing the stress state of animals.

Keywords: fishes; mammalians; energy of the organism; ion concentration gradients; active and passive defense reaction; eustress; distress.

Introduction

The problem of stress among people is especially relevant due to deterioration of the ecological conditions, loss of stability and growing tension in the community, eruption of local wars, terrorism, and the coronavirus. Furthermore, a large portion of the population lives under pressure in everyday life due to high social, psycho-emotional loads, intoxications, diseases, etc.

To determine stress condition in people, ion parameters are not used. Most often, for this purpose, cortisol level in blood is analyzed, but also the diagnostics uses parameters of total protein, astrocyte-specific protein S100β, glucose, activity of aminotransaminase and end-products of metabolism. Diagnostics of fish according to electrolyte balance is extremely rarely conducted: even if studies report the level of natremia, it is considered in a set with other parameters, without consideration of its significance for the organism (Selik, 2004; Akbar, 2014; Martemyanov, 2014). The most intensive research on the influence of stressors on the ion parameters of fish were performed in 1970–1980s. The data varied, sometimes being contradictory and insufficient: most of the data concerning this issue are based on the results of research of response reactions of fish to strong and short term stressors. No generalizing research has been conducted, which would examine a broad range of stress conditions of fish, while the ion criteria of the ill-being of a stressed organism, proposed in some studies, were not broadly used and finally were abandoned completely. Furthermore, the level of natremia was hardly considered at all. Despite the fact that physiological-biochemical processes in fish undergoing stress are being actively studied nowadays (Faught et al., 2016; Rodnick & Planas, 2016; Takei & Hwang, 2016), ion parameters of serum (plasma) of blood of fish are not used to identify stress. No data on this issue are available for other vertebrates (including the higher vertebrates).

For a long time, in medicine, the norm was considered to be a broad range of changes in the concentration of sodium in the internal environment of the organism (130–150 mmol/L). Thus, the norm was understood not in terms of the thresholds of the physiological fluctuations of this parameter in healthy patients, but in terms of the thresholds of the parameters in the conditions compatible with life. The situation began to change only in the recent 5–10 years: the norm is now identified as a narrower range of natremia (135–145 mmol/L). At the same time, hyponatremia (<135 mmol/L) in people (Lee et al., 2014; Henry, 2015; Ball & Iqbal, 2016) occurs more often than hypernatremia (>145 mmol/L) (Reynolds et al., 2006; Muhsin, & Mount, 2016).

This study on fresh-water fish focused on changes in concentrations of cations of sodium in the internal environment in different stress conditions. Moreover, we discussed the data on mammals, which we found in the literature, indicating patterns of changes in ion content of the internal environment in the conditions of influence of unfavourable factors, which are similar to fish.

Materials and methods

The main object of the studies was mature and close to-maturity bream (Abramis brama L.) of the Rybinsk Reservoir. Separate experiments were performed on adult individuals of pike (Esoc lucius L.), roach (Rutilus rutilus L.) and zope (Abramis balzeri L.) from the same water body.
Experiments were performed in summer, when water temperature equaled 17–20 °C in the conditions of acute, subacute and chronic stress with lethal outcome, and also acute reversible stress of different degree of strength and duration. Low stress (Fig. 1) was caused by putting acclimatized fish into limited water volume (ratio of body weight to water was 1:20) with continuous aeration. Strong reversible acute stress was caused by short-term capture of fish in the natural environment (no longer than 15 min) and their transportation to the laboratory for 1.5–2.0 hours in a limited volume of water (Fig. 2a, 3a) and rapid change in the temperature by 18 °C (Fig. 3a). Acute lethal stress lasting 5 to 12 h was caused by complex action of several strong factors: capture, transportation in a limited volume of water with decreasing oxygen content (to 2.5 mg/L) and increasing temperature (to 25 °C, Fig. 2b, 3b) and imitation of all these factors on acclimated fish (Fig. 3b). Subacute stress with lethal outcome lasting 5–18 days was caused by quite strong stressors, which fish could not adapt to: post-traumatic effects of long traveling and hard transportation conditions (Fig. 2c, 3c) and retention of fish in containers (Fig. 3c). Chronic lethal stress lasting 1–3 months was caused by retention of fish in the laboratory conditions against the background of increased light and noise irritators (Fig. 2d, 3d) and in non-favourable conditions of ponds of the experimental base (Fig. 3d). Each experimental point for bream was represented by 11–24 fish, and by 5–9 individuals of other species.

Concentration of cations in blood plasma was analyzed using Flapho-4 flame photometer manufactured by Carl Zeiss (Jena, Germany). The study presents the mean values of concentrations of ions and standard error (x ± SE). The normal distribution for the selections was tested using the Shapiro-Wilk criterion. We determined that all the selections had normal distribution. Significance of the differences was assessed using the t-test.

Results

In the conditions of influence of weak and short-term stressors (Fig. 1), the content of blood sodium of fresh-water fish may increase 10% on average. Approximately to the same extent, the sodium concentration may decrease during chronic stress with lethal outcome (Fig. 2d, 3d). During subacute stress with lethal outcome, caused by powerful stressors, to which fish was not capable to adapt, hyponatremia reached 20% (Fig. 2c, 3c). During severe acute stress, loss of sodium from the internal environment reached nearly 50%, thus resulting in the quick death of the animals (Fig. 2b, 3b). Maximal possible hyponatremia, in which fish survive, observed during acute reversible stress, may equal 30% (Fig. 2a, 3a). There is a direct dependence between the level of hyponatremia and the strength of stressors.

Fig. 2. Dynamics of sodium concentration in blood plasma of bream in distress (pathological stress, mmol/L): a – acute reversible stress (duration of 1.5–2.0 h); b, c, d – respectively acute, subacute, chronic lethal stress up to the point of death of fish (dark circles indicate the condition before death). * P < 0.05, ** P < 0.01, *** P < 0.001 compared with the norm

Discussion

General mechanisms of adaptation were found in the system of electrolyte balance in fresh-water fish, related to the amount (strength and duration) of the stressor. The stressors were classified according to quality. However, the pattern of their action, as demonstrated in this and the earlier articles (Zaprudnova, 2012, 2017), depended on the intensity of the action: during short-term weak actions, there were seen changes toward increase in concentration gradients on the cell membranes (hypermagnesemia, eu-stress), while in the conditions of strong or prolonged actions – toward decrease (hypoparatremia, distress). At the same time, hyponatremia was seen in all unfavourable conditions.

As demonstrated earlier (Zaprudnova, 2012, 2017), changes the concentrations of other main cations in the internal environment (potassium, calcium, magnesium) during acute stress reaction to short-term weak stressors are oriented toward increase in concentration gradients on the cell membranes (hypokalemia, hypercalcemia, hypomagnesemia), during strong or long-term actions – toward decrease (hyperkalemia, hypocalcemia, hypermagnesemia). Under subacute and chronic stress, before fish died, the concentrations of these ions in blood plasma (serum) were close to the norm. Thus, hyponatremia may be considered the most expressed and reliable ion indicator of malfunctioning of the organism. Many other biochemical parameters also changed noticeably following acute stress loads, while weakly reacting or not responding to subacute and chronic stress at all (for example, glucose, catecholamine etc.).
Changes in the concentrations of ions in blood plasma occurred under short-term weak stressors during spawning, and under long-lasting stressors after spawning (Zaprudnova & Martemyanov, 1988).

In medicine, the important (leading) role of sodium concentration in blood serum (plasma) is first of all emphasized for the support of osmolality of the internal environment, single-cell environment, and ultimately, volume-regulation of each cell. This study has for the first time analyzed the conditions of the system of electrolyte balance of animals under stress from the perspective of the leading role of ion-concentrating gradients in the energetics of the organism. It would be more correct to talk about electrochemical gradient on the cellular membrane, but we only have concentration of sodium in the internal environment. Sodium ions take part in energization of the external membrane of animal cells: work of the sodium pump results in the functioning of most of the transport functions of cells (from epithelial to cartilage and brain cells), which are implemented not due to the consumption of energy of ATP particularly, but rather the energy of ion gradients or membrane potential (Ugolev, 1985; Naotchin, 2002; Skulachev et al., 2010). Therefore, we may assume that support of constant ion composition of the internal environment of the organism (mainly sodium) is, to a larger degree, the support of the energetics of the organism, i.e. one of the most important, and perhaps priority role belongs to electrolytic manganese during influence of short-term weak stressors as one of the molecular mechanisms of reduction of oxygen uptake, and therefore, strengthening of anabolism, and thus increase in growth and development of animals (Zaprudnova, 2019). The presented provisions on the two strategies of adaptation in fish in normal and extreme conditions correlate with the provisions of Selye’s theory of eustress and distress, or Arakovsky’s theory of physiological and pathological stress (Dhabhar, 2008; Schreck, 2010; Schreck & Tort, 2016).

Based on the proposed concept of two protective reactions in normal and extreme conditions or adaptation strategies – active and passive, comprising respectively increase or decrease in the level of imbalance (in energetics) of the organism, one may formulate the main principles of diagnostics of fish in natural and artificial environments according to the condition of electrolyte balance. The deviations toward decrease in ion concentration gradients across the membrane of cells and the tissues may be considered as indicators of one or the other extreme of ill-being (pathology), whereas changes in opposite direction: toward increase in concentration gradients as a sign of pathology that may develop in the conditions of continuing stress. The first sign of ill-being is malfunctioning of fluctuation (in eustress) in the studied parameters (the finest level of biological organization). Transition through the phase of hypercompensation (stimulation) to the phase of reduction (depression) is a general pattern in response reaction of biological systems of different organization level to increasing stimulus or its incessant action at the same intensity. The condition of anactivity occupies an intermediate position between the phases of hypercompensation and reduction. At the same time, as mentioned above, the level of normateria is the most reliable indicator of the condition of the organism out of the 4 major cations. The most characteristic signs of active protection reaction (physiological stress, or eustress) include hypernatremia, and passive (pathological stress or distress) includes hyponatremia. Assessment of the level of normateria should take into account not only amplitude, but also the time factor as well. It is important to determine the extent of stability in time of hypernatremia in the diagnostics of pathology itself (actual) in order to exclude short-term (reverse) hyponatremia during acute stress. The advantage of this parameter is low variability and some latency (retardation of changes) in the organism. For example, concentration of potassium in blood plasma changes in fish almost immediately after any action, particularly a longer period of capturing than needed (Zaprudnova, 2018).

Analysis of information in the literature about the condition of the system of electrolyte balance in mammals (chiefly humans) in stress conditions and diseases, and also the extent of the pressure an experimental object of research experiences, suggests a conclusion about the similarity of mechanisms of adaptation to stress in fish and higher vertebrates: during short-term weak loading, deviations occurring in the system of electrolyte balance are oriented toward increase in concentration gradients across the cell membrane, and toward decrease during strong or long-term loading. The most revealing work concerning this aspect was performed by Indian scientists on rats in the conditions of high hypoxia. The authors determined that raising the animals to 2-5 km above sea level led to hypernatremia, then at the height of 7.5 km, absence of reaction to the impact was observed, and further elevation to the height of 10.5 km led to hyponatremia and death of the animals (Purshottam & Ghosh, 1971). As the main cause of changes in the content of ions in the tissues, the authors mention acute hypoxia. In this and other similar earlier studies, no attempts were made to determine general mechanisms of adaptation. The authors of the mentioned study (Purshottam & Ghosh, 1971) also presented literature information about the results of studies of influence of high altitude hypoxia on content of sodium and potassium ions in the tissues of rats, dogs and human volunteers, conducted by Soviet and foreign researchers in the 1930–1960s. The analysis of these literature data allows us to conclude that they are coherent with our concept of two strategies of adaptation of animals in normal and extreme conditions: i.e. de-
pending on strength of stressors (amount of hypoxia or height above sea
level, and also time of exposure), the pattern of response reaction can take
its course according to the type of hypercompensation or reduction, and
also no changes may occur at all (condition of areactivity), as a result of
restoration of the functions during multi-hour observations among other
reasons.

The most numerous studies of ion-regulation performed on people in extreme
situations were carried out by domestic and American authors on cosmonauts (and astronauts) during flights. At the same time, the resear-
chers considered weightlessness as the main (disturbing) factor and drew
no conclusions on general mechanisms of adaptation (Gazenko et al.,
1996; Natochin, 2000). In short, the patterns of changes in the human system of electrolyte balance during space flights, determined
by the authors, are coherent with the dependence of the pattern and extent of response reaction in fish on the amount (strength) of stressor
and initial functioning condition of the organism, which we determined.
Most often, after long flights, the cosmonauts were observed to have
hypokalemia and hypercalcemia. In a number of cases, hyponatremia
and increase in osmolality of blood were also observed. That means, all of
those are “symptoms” of physiological stress. Hypermantemia and hyper
calcemia were usually observed only during the very first days after re-
turn to Earth. However, hypoclocaemia increased a week later, reaching
50%. For us it is obvious that in the conditions of hyperpolarized inhibi-
tion, there occurred powerful restorative (anabolic) processes in cosmo-
auts who had lost weight during the flights (particularly, decrease in the
volume of thighs was recorded). However, right after the take off (during
transition to weightlessness), hyponatremia was observed (i.e. shifts ac-
cording to the type of pathological stress). Low hyponatremia (1.5%) was
seen after landing after short flights. We may assume that decrease in con-
centration of sodium in blood plasma would have been more notable if
before landing the cosmonauts had not received food rich in sodium chlo-
ride. Moreover, during flights and as a result of the flights, the individual
variability of the surveyed parameters increased. For example, after lan-
ding, the coefficient of sodium variability in blood plasma doubled. Indi-
vidual differences in reactions to extreme conditions of flights were so
high that in a number of cases, members of one crew were observed to have
differences not only in the amount, but also in the orientation of re-
response reaction.

That means that in some individuals, the shifts in the system of elect-
rolyte regime of balance occurred as a type of physiological stress, while
in others, a clear tendency was seen in the change in a number of parame-
ters toward pathologization. Mass media reports of approximately twenty-
years ago inform us that one of the cosmonauts suffered myocardial in-
farction during the flight. Selye classified it to idiopathic or plucausal
diseases, i.e. caused by non-specific (stress) irritators. To those categories,
he also identified cancer, arthrosis, osteochondrosis, stroke and other.
In other words such diseases are called adaptation diseases. Under very
strong loads (space flights), it was possible to classify people based on the
magnitude and orientation of ion changes according to the extent of stress-
resistance (health condition). During the flights and after landing, the cos-
monauts were observed to have high level of aldosterone in blood and
large losses of potassium in the organism, i.e. distinctive signs of stress.
This shows general reaction to strong stressor related to intensive cata-
bolism of muscle proteins. The long-duration flights led to bleeding of
potassium from the bones, loss of manganese, phosphorus and number of
other ions, i.e. the same negative balance of ions that takes place under
strong stressors and diseases, earlier indicated by Selye.

Over the recent years, a connection has been found between hyponat-
remia and a number of diseases: heart failure (Bettari et al.,2012, Schcke-
kochkikhin et al., 2013; Ali et al.,2016), cirrhosis (Ginis 
and colleagues, 1998; Gerbes et al., 2003; Ginès & Guevara, 2008), kidney failure (Pérez-García et al., 2016; Zhang et al., 2017), cancer (Bergmanns et al., 2000; Castillo et al., 2016; Workneh et al., 2020), alcoholism (Limias et al., 2000; Stasiukynienė, 2002), and also age (Wannamethee et al., 2016). Hyponat-
remia was observed in patients during the post-surgery period (Leung,
2012; Leise & Findlay, 2017). Thus, in general, hyponatremia was ob-
served to accompany adaptation diseases. Connection of hyponatremia
with adaptation diseases, especially heart failure, cirrhosis and oncoge-
ness, was a subject of many studies (several times more than presented
here), but the present article, due to its limited volume, cannot provide that
many references. Higher mortality and longer duration of hospital treat-
ment was determined with patients with hyponatremia than with normo-
natremia. Kutina and the co-authors (Kutina et al., 2005), in their study,
which contains references to over 450 literature sources, based on their
own and literature data, suggest that the normal levels of natremia in
healthy person equal 141.0 ± 2.3 mmol/L. Despite the fact that the authors
had not concluded that there is a connection between the levels of ions in
the internal environment and stress, the study nonetheless suggests that
frequently occurring hyponatremia in humans is evoked by one or the
other stressor or disease. For example, the authors mention that hyponat-
remia develops more often in children receiving long term hospital treat-
ment, regardless of pathology or age, and it may be an indicator of deve-
lopment of sepsis, and also was observed in patients suffering severe
forms of malaria. Hypermantemia, rarely recorded by the authors, was
caused by the action of a short term stressor on healthy trained people.
Nevertheless, the literature contains suggestions for treating hyponat-
remia during various diseases, mainly heart failure, cardiovascular failure
using receptor blockers in the kidneys of vasopressin hormone (antidiure-
tic hormone) (Greenberg, 2010; Sahay & Sahay, 2014; De Vecchis et al.,
2017). However, as our work suggests, the treatment and especially liq-
duation of the causes (if possible) may be the most effective means of treat-
ing hyponatremia. Likewise, the disease itself may be an endogenous
stressor. On fish, it was shown that in the initial period of the disease, the
changes in concentration of ions in the tissues of fish were aimed at eleva-
tion in concentration gradients across the membrane of cells (hypercom-
pensation), and during the late stages of the disease – decrease (reduction).
This is relevant for both contagious (Laranski, 1984; Zapradnova, 2018)
and non-contagious diseases (Natochin et al., 1995).

Changes in the concentration of ions in patients (the organs) suffering
adaptation diseases also occur according to the type of reduction, i.e. to-
ward decrease in concentration gradients across the membrane of cells and
tissues. Selye observed decrease in concentrations of potassium and in-
crease in sodium in the cardiac muscle in patients suffering myocardial
infarction. Further, such a dynamic in ion content of the heart muscle, as
well as changes according to the type of reduction in the internal environ-
ment, were seen by many researchers. The authors determined direct
dependence of the degree of damage to the heart muscle on the decrease
in the concentration gradients of sodium and potassium across the mem-
branes of cells. With improvement of the clinical condition of patients, ion
composition in the tissues normalized. As known, during oncogenesis, ion
composition of diseased cells changes according to the reduction type
(Malenkov, 1976).

However, during strokes (brain ischemia or brain hemorrhage), also
related to adaptation diseases, both hyponatremia and hypernatremia were
recorded in earlier studies (Vilenkis et al., 1998; Carcel et al., 2016; Mur-
phy, 2016). Perhaps, in this case, we need to consider specific changes in
the system of electrolyte exchange. We may assume that during ischemia
or brain bleed, the nervous structures related with hormone regulation of
electrolyte exchange (hypothalamus, pituitary gland) become damaged, for
example, vasopressin is being generated insufficiently (antidiuretic
hormone) thus weakening the action of the hormone towards the corre-
sponding cell receptors. Hypermantemia may also occur during depression
(Ozderni, 2013). During this disease, the deficit of the influence of antidi-
uretic hormone on renal structures is likely related to excessive influence
of it on the corresponding brain structures.

Therefore, a question arises of why dependence of the pattern of respon-
se reaction of the electrolyte balance system on the amount (strength
and duration) of stressor has not been seen in higher vertebrates? There
may be two main reasons for this. First of all, in medicine and other
spheres of biology, on higher vertebrates, i.e. directly or indirectly related
to medicine, the priority is still the study of specific component of respon-
se reaction (i.e. quality to the disadvantage of quantity) and significantly
less attention is paid to the study of general mechanisms of adaptation.
First of all, there are specific reasons of the disease, associated for example
with excess or deficiency of the action of hormones that regulate electro-
yte balance of the organism, and also with disorders in consumption of
water and salt, both arbitrary and not. The second reason is the high level
of homeostasis in mammals, which manifests both in narrower range of
deviations of ion content from the normal values and in the rarely applied strategy according to the reduction type. Increase in homeostasis should be considered as one of the most important signs of progressing evolution of the system of electrolyte balance. In other words, in lower aquatic vertebrates, dependence of the changes in the system of electrolyte balance on the amount of stressor is easier to detect. Deviations according to the reduction type in fish are more common and occur more often than in higher vertebrates. Reversible hyponatremia during action of strong stressors, as demonstrated in the study, may reach 30%. The same amount and longer duration is possible for reversible hyponatremia in dormant fish in low water temperatures (Zaprudnova, 2005). In mammals, even during quite prolonged action of a strong stressor leading to the development of a triad of pathologies (increase in the cortex of the adrenal glands, involution of status thymolympheaticus, ulcer of stomach and intestine), the organism prefers to maintain sodium homeostasis (absorbing or containing high amounts of sodium) while experiencing high loses of potassium. The situations analyzed above, which occurred during excessive loads in the conditions of space flights, are examples of slight deviation of sodium in the internal environment from the norm according to the reduction type. Only specific changes in the system of electrolyte balance during various diseases (for example, syndrome of inadequate secretion of antidiuretic hormone, deficiency of adrenocorticotropic hormone and others) represent greater deviations of sodium concentration in the internal environment (usually up to 15–16%) (Kutina et al., 2005). Hyponatremia in higher vertebrates in acute lethal cases is lower than in fish (Punshottam & Ghosh, 1971). That being said, the broad range of fluctuations of normal values of sodium concentrations in blood plasma in humans (130–150 mmol/L), reported in many books over several decades, is surprising. Possibly, the currently proposed normal range of natremia in humans is also quite wide: 135–145 mmol/L. This is even stranger because we observed fish that belong to lower vertebrates to have a narrow range of the normal values of natremia: in bream, for example, it equalled 130–133 mmol/L in the normal laboratory conditions and ecologically clean districts of the Rybinsk Reservoir (Zaprudnova, 2018). Even slight deterioration in the maintenance conditions of fish in the laboratory caused low (2–4%) hyponatremia (Zaprudnova, 1999), and bream in ecologically unfavourable districts could be observed to have low hypo- and hyponatremia, and normonatremia (condition of areactivity) depending on time and intensity of the action of the stressor (Zaprudnova, 2018). After significant exacerbation of ecological circumstances as a result of large industrial accidents, sodium concentration in the blood plasma of bream could drop down to 80 mmol/L (Martemyanov, 2014). However, we should recognize that in the studies on humans, there already are emerging researches reporting a narrower range of normal values of natremia. Therefore, sodium concentration in blood plasma equaling 136 and 138 mmol/L was considered a marker of mortality and risk of cardio-vascular diseases in elderly men (Wannamethee et al., 2016).

In the times of Selby, the role of retention of sodium and water in the organism during stress, evoked by elevation of aldosterone in blood and accompanied by strengthening of inflammatory processes in the tissues and rise in blood pressure, has been unclear. Later, aldosterone was found to be associated with an increased risk of death from cardio-vascular diseases (Tomaschitz et al., 2010). The adaptive significance of this hormone as a first line defense in the organism’s energetics of ion concentration gradient toward decrease in concentration gradients across the cellular membrane (hyponatremia, distress or pathological stress), during the influence of weak and short-term – toward increase in ion concentration gradients (hypermattremia, eustress or physiological stress). Judging from the literature data, changes in ion composition of the internal environment of higher vertebrates during stress are similar to those of fish. In the present research, for the first time the analysis of the condition of the system of electrolyte balance of animals during stress was made from the perspective of the leading role in the organism’s energetics of ion concentration gradient across the membrane of cells. The study suggests that there are two different strategies of adaptation depending on intensity of the action of stressor: active and passive. Hyponatremia that accompanies many diseases in people (mainly, diseases of adaptation) is supposedly a non-specific reaction of the organism and an indicator of decreased energetics of the organism. Sodium level in the internal environment of the organism is proposed for diagnostics of stress condition of animals.

**Conclusions**

During the influence of strong or long-term stressors of various quality, sodium concentration in the internal environment of fish changed toward decrease in concentration gradients across the cellular membrane (hyponatremia, distress or pathological stress), during the influence of weak and short-term – toward increase in ion concentration gradients (hypermattremia, eustress or physiological stress). Judging from the literature data, changes in ion composition of the internal environment of higher vertebrates during stress are similar to those of fish. In the present research, for the first time the analysis of the condition of the system of electrolyte balance of animals during stress was made from the perspective of the leading role in the organism’s energetics of ion concentration gradient across the membrane of cells. The study suggests that there are two different strategies of adaptation depending on intensity of the action of stressor: active and passive. Hyponatremia that accompanies many diseases in people (mainly, diseases of adaptation) is supposedly a non-specific reaction of the organism and an indicator of decreased energetics of the organism. Sodium level in the internal environment of the organism is proposed for diagnostics of stress condition of animals.

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