Concentration of Essential Elements (Cu, Fe, Zn, Mn) in Organs and Tissues of Caspian Seal Phoca Caspica Gmelin, 1788

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Abstract. The environment of the Caspian Sea is considered internationally important because the Caspian Sea takes part in maintaining the global biodiversity. Monitoring the concentration of essential chemical elements in the organs and tissues of Caspian seal is an important task of protecting seal population, which makes the research topicality. Determining the metals was carried out by the method of atomic absorption spectroscopy using an MGA-915 MD atomic absorption spectrometer with electrothermal atomization. According to the research results, the chemical elements have been found unevenly distributed in the body of Caspian seal depending to the properties of metals and the functional characteristics of organs. Great concentrations of metals were recorded mainly in organs with active metabolic processes, and, on the other hand, in organs that actively participate in maintaining homeostasis, such as the liver, the kidneys, and the spleen.

Introduction

The environment of the Caspian Sea is considered internationally important because the Caspian Sea takes part in maintaining the global biodiversity. The biodiversity of the Caspian Sea is characterized by a high level of endemism due to its historical isolation. About 40% of the species in the Caspian Sea are endemic, so that any dangerous situation can cause the potentially high losses of globally significant biodiversity. Caspian seal, or Caspian phoca (Phoca caspica, Gmelin, 1788), is one of the endemic species.

Caspian seal (Phoca caspica, Gmelin, 1788) is the only mammal all over the Caspian Sea [2, 5, 8]. It can be met in the different parts of the Caspian Sea, therefore, the microelement composition of the seal organs and tissues not only reflects its physiology, but also characterizes its habitat, as the seal is the highest trophic link of the Caspian Sea [1, 2, 3]. Monitoring the concentration of essential chemical elements in the organs and tissues of Caspian seal is an important task of protecting seal population, which makes the research topicality.

Source Material and Methods of Research

Caspian seal (Phoca caspica, Gmelin, 1788) was taken as the object of research. Samples of Caspian seal organs were obtained from the dead animals in the area around Maly Zhemchuzhny Island during the expeditions during 2011-2018.

The Department of Hydrobiology and General Ecology of ASTU, as well as the Department of Ecology of DGU determined the chemical elements in organs and tissues of dead seals by using the atomic absorption spectroscopy method.

Determining the metals was carried out by the method of atomic absorption spectroscopy using an MGA-915 MD atomic absorption spectrometer with electrothermal atomization. The concentration of essential elements in the organs and tissues of Caspian seal was expressed in mg/kg of the dry weight. The results obtained were subjected to statistical processing.

Results and Discussion

The research results show that Caspian seal accumulates copper mainly in the stomach (36.82 mg/kg of the dry matter) (Table 1).
It is known that swallowing plankton feeders and benthophages together with other aquatic organisms results on its level in the water. Caspian seal is characterized by the high zinc concentration in all organs and tissues. Zinc probably enters the animal body with food and water [4, 6]. This fact is related to the main processes of copper absorption in the stomach and the small intestine, the mucous membrane of which contains metallothionein which forms complex compounds with copper [1]. In the acidic environment copper is liberated from the natural organic complexes and stays in a dissociated state in the form of cations. In the middle part of the intestine copper concentration is 5 times lower (7.04 mg/kg of the dry matter).

Copper ingested with food is imported into enterocytes. After being absorbed, copper enters the bloodstream and is carried to the organs and tissues [2, 8]. The liver is the main organ where copper is deposited and where the homeostasis is regulated. Hepatocytes play a key role in copper exchange. That is why the liver also accumulates a significant amount of copper (31.78 mg/kg of the dry matter). The minimum copper concentration was found in the adipose tissue of mammals and made 0.63 mg/kg of the dry matter.

Relative to copper accumulation the organs and tissues of Caspian seal are lined up in descending order: stomach> liver> heart> kidneys> intestines> lungs> muscle tissue> spleen> adipose tissue.

According to iron accumulation, the organs and tissues of Caspian seal are arranged in descending order: stomach> liver> heart> kidneys> intestines> lungs> muscle tissue> spleen> adipose tissue.

Iron is accumulated in the body of Caspian seal in concentrations higher than other essential elements. The greatest amount of iron is accumulated in the spleen (1598.5 mg/kg of the dry matter). This can be explained by the fact that the process of destroying the old and damaged erythrocytes to hemoglobin occurs in the spleen and through this destroying the spleen participates in iron metabolism.

In addition, the spleen is one of the blood depots [8, 11]. The liver is the second organ that accumulates iron. Compared with the spleen, the concentration of metal in the female liver is 3 times lower, which can be explained by the fact that iron is transported to the liver from the spleen because of destroying erythrocytes. In the liver iron is deposited in the form of ferritin which serves as a buffer stock [6]. In other organs of Caspian seal iron concentration ranges from 118.94 mg/kg (intestines) to 367.02 mg/kg (adipose tissue) of the dry matter. Iron concentrates in fat, because a dense network of blood vessels passes through the adipose tissues, which ensures the heat circulation throughout the animal's body.

The low iron content in the organs of the gastrointestinal tract of Caspian seal can be explained by the fact that ferritin in the form of apoferritin, together with the iron-binding protein – transferritin, transport iron absorbed by the intestine to the depositing organs, in particular to the liver, to maintain and ensure erythropoiesis [9].

According to iron accumulation, the organs and tissues of Caspian seal are arranged in descending order: spleen > liver > adipose tissue > lungs > muscle tissue > kidneys > heart > stomach > intestines.

Zinc probably enters the animal body with food and water [10, 11], which can explain the high concentration of this chemical element in the organs of the digestive system (liver, intestines). The main zinc depot is the liver (109.39 mg/kg of the dry weight). The portion of zinc in the kidneys is comparable to that in the intestines. The minimum amount of zinc was found in adipose tissue (42.51 mg/kg of the dry weight, respectively).

The organs and tissues of Caspian seal can be arranged in descending order, according to zinc concentration: liver> intestines ≥ kidneys > muscle tissue > lungs > stomach > heart > spleen > adipose tissue.

It is difficult to identify the regularity of bioaccumulation in the elements with high biophilic property. The organisms have a strong need for zinc [4, 11], although the accumulation rate of zinc in the body depends on its level in the water. Caspian seal is characterized by the high zinc concentration in all organs and tissues. It is known that swallowing plankton feeders and benthophages together with other aquatic organisms results in a higher concentration of zinc in the seal body [4, 8].

| Bodies     | Cu      | Fe       | Zn      | Mn       |
|------------|---------|----------|---------|----------|
| kidneys    | 10.8±0.7| 287.2±12.3| 87.3±3.4| 1.9±0.4  |
| stomach    | 36.8±1.4| 147.6±3.4 | 64.7±2.9| 1.4±0.2  |
| intestines | 7.0±0.3 | 118.9±2.8 | 90.6±4.4| 1.6±0.2  |
| liver      | 31.8±1.1| 481.9±15.6| 109.4±3.4| 8.6±0.8  |
| spleen     | 4.2±0.2 | 1598.5±21.3| 44.0±2.3| 1.4±0.2  |
| heart      | 11.8±0.5| 280.8±11.4| 63.6±2.1| 1.3±0.3  |
| muscle tissue| 5.8±0.2| 338.9±14.3| 69.8±3.2| 0.6±0.04 |
| adipose tissue| 0.6±0.04| 367.0±12.9| 42.5±3.3| 0.2±0.01 |
| lungs      | 6.4±0.2 | 351.7±13.4| 67.4±4.3| 0.9±0.04 |
Manganese. Maximum concentration of manganese can be observed in Caspian seal liver, where it reaches 8.58 mg/kg of the dry matter. Manganese is known to enter the body of animals by the alimentary route. 15% of its incoming amount is absorbed in the small intestine and then deposited in the liver [8, 9]. The accumulation of manganese in the heart, stomach, spleen, mid-intestine and kidneys ranges from 1.3 mg/kg (heart) to 1.93 mg/kg (kidney) of the dry matter. The accumulation of manganese by muscle and adipose tissues, as well as by the lungs, was less than 1 mg/kg of the dry matter.

By manganese concentration the organs and tissues of Caspian seal can be arranged in descending order: liver > kidneys > intestines > spleen > stomach > heart > lungs > muscle tissue > adipose tissue.

The high level of the studied chemical elements recorded in the organs and tissues of the animal, once again confirms their vital necessity, iron playing a special role, because its concentration is rather higher than that of other biogenic elements (Fig. 1).

Fig. 1. Distribution of chemical elements in organs and tissues of the Caspian seal

It has been shown that the spleen acts as an accumulator of iron in the seal body, where the proportion of iron is 97% of the other studied chemical elements. Zinc in the spleen makes 2.7%, while copper and manganese are less than 1%. Compared with the organs under study, the liver appears as the main accumulator of essential elements. Thus, the distribution of chemical elements in the liver is presented as follows: the concentration of iron is 76% of all the studied chemical elements, zinc - 17%, copper - 5%, and manganese - 1%.

Conclusion
The obtained data on accumulating the chemical elements by organs and tissues of Caspian seal indicate the specific distribution of metals in the body. Besides, the metals are characterized by uneven distribution and depend on the functional features of the organs, their cumulative activity and the chemical properties of each metal.

The main organ of Caspian seal, where the accumulation of the studied chemical elements occurs, is the liver. In adipose tissue the amount of the studied metals is recorded in the smallest amounts, with the exception of iron. The iron content in fat can be explained by the fact that a dense network of blood vessels passes through the adipose tissue, which ensures heat spreading throughout the animal's body.

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