# The Cause and the Effect of Lithophagial Instinct

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***Abstract :*** *Long-term researches of lithophagy phenomenon amongst herbivorous animals (most of them took place in the Sikhote-Alin mountains, the Russian Far East) and also analysis of the material devoted to studying medical and biological properties of natural minerals which are consumed by animals allow us to make a conclusion that lithophagy phenomenon in all its diversity could be explained as instinctive wish of the organism to correct the material constitution and functions of its systems with the help of natural minerals which can be violated under the influence of different unfavorable environmental stress-factors. The possibility of this correction can be explained by similar properties which a lot of hypergene minerals have, concerning regulation of biological, physiological and energetic processes in living organisms. Ecological consequences coming from the concept of lithophagial instinct are shown on the example of the Sikhote-Alin mountain taiga landscape.*

***Keywords :*** *lithophagy, geophagy, solonetz, kudyur, kudyurites, adaptation*

## INTRODUCTION

The main question which arises among those who faced with lithophagy phenomenon is what makes animals consume rocks as food addition? On the first stage of studying this phenomenon the researchers such as A. Nasimovich [1] or L. Kaplanov [2] based on the abstract conception about mineral famine which sometimes herbivorous animals feel in several landscapes. The shortage of mineral nutrients supposedly makes them look for scarce chemical elements in minerals. This hypothesis of "mineral famine" was partly confirmed by our early researches of chemical elements balance in the compound of mineral nutrients eaten by the animals and those nutrients gone through digestive tract [3]. Also there is indirect evidence of feed chemical compound and the territory habitation of wild herbivorous animals. In particular, on the example of herbivorous hoofed animals living on the territory of National park Serengeti in Tanzania it is discovered that the quantity distribution of magnesium, sodium, phosphorus in the feed influences their habitation greatly [4].

Widely known ruminants' passion for sodium salt and instrumentally registered in a number of regions low content of sodium in fodder were the basis of other hypothesis concerning the reason of lithofhagy – "sodium". Approximately from the middle part of the last century, beginning from the classical work of D.S. Stockstad et al. [5] and till present time sodium hypothesis was supported by the most part of foreign scientists (anyway for hoofed animals).

After it became apparent that it is impossible to explain the phenomenon in all its diversity on the basis of suggested hypothesizes new proposals appeared. Recently trying to explain lithophagy in some animals, in particular, in elephants living in the National park Udavalov in Sri-Lanka [6], and also in some monkeys in Japan [7] and Africa [8], in herbivorous bats in Amazonian forests [5], and even in some herbivorous birds, for instance, parrots in the South America [9], "detoxic-antidiarrheal" hypothesis or hypothesis of digestive system normalization through using clay minerals such as smectit, illit, kaolin is becoming more and more popular. This hypothesis became dominating while explaining the reasons of lithophagy in human [10, 11]. Appeared interest to sorptive and detoxic properties of consumed clay minerals, of course, is connected with the success of using similar minerals in medicine, at first as a remedy for toxicosis of different aetiology, functional dyspepsia, also with syndrome of diarrhea. The medicine "Smecta", for instance, is widely spread clay mineral smectit which was appreciated by millions of people on all the continents during 10-15 years since it appeared in drug-stores.

We must point out "antidiarrheal" hypothesis as an explanation of consuming clays by wild animals appeared in the fifties of last century. It was suggested by F.D. Shaposhnikov after researching marals (Siberian deer) in the mountains of Altai. Much earlier people noticed the fact clays can have favorable effect on the digestion physiology that is proved by many years' experience of their consuming by indigenous peoples all over the world. It is described in some ethnographic works and also in special publications devoted to the

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problem of lithophagy in human. These works were mentioned in previous publications [3, 12].

It is necessary to add one more hypothesis to those given above which can be called "probiotic". It appeared as an explanation of the reasons the apes ate mineral nutrients of termitary in several African areas. Some researchers [4] paid attention to special microbiological compounds of consuming mineral nutrients by the apes; their detailed studying allowed to make a conclusion that mineral nutrients of termitary can influence the germs in the intestines of humans exposed to lithophagy.

Taking into account the fact that every offered hypothesis is partly confirmed and in this case has a right to exist a new question arises: can we finally determine the reasons of lithophagy combining all these hypotheses – "mineral famine", "sodium", "detoxic-antidiarrheal", "probiotic"?

As our long experience of investigating this problem shows [3, 12] all suggested hypotheses neither together nor alone are able to discover the reasons of lithophagy because of different causes for consuming minerals by animals and humans. During almost 30 years we conducted our field study of lithophagy phenomenon in animals (most part of it was on the Sikhote-Alin area), and the analysis of published material devoted to the study of medical and biological properties of natural minerals consumed by animals and humans allow us to make a conclusion that lithophagy phenomenon in its diversity can be explained as instinctive wish of the organisms with the help of widely spread natural minerals to correct nutrients and functions of their different systems which can be violated under the influence of different unfavorable environmental stress-factors.

Per se, we say about the appeared problems of the organisms adaptation with the development of stress under the influence of geological, geophysical, cosmophysical factors and evolutionally existing instinctively common way of correction such shortage consuming natural minerals. Stress among animals caused by environmental factors, can be aggravated by pregnancy, moulting, injuring and other diseased conditions. If we say about the reasons not in common, but in definite cases, they can be rather different. These differences can be divided into the main reasons based on the stress-factors (the peculiarities of geochemistry and biogeochemistry in a given area, climate features, the proportion of toxic plants in fodder etc.) or reasons of secondary importance based on some deflection in the organism.

The possibility to correct organism throughout lithophagy itself is caused by similar properties which a lot of hypergene minerals (formed in the zone of rocks erosion) have in regulating physiological, informational and energetic processes of living organisms.

Smectits, minerals from kaolin group, peaches, hydromica, vermiculite, several types of zeolites, and several forms of silicon oxide can be considered as minerals which have marked regulating and stabilizing properties concerning living systems. Their favorable activity to the mammal organisms is confirmed and experimentally proved as we wrote [2, 3, 12, 13]. At present the quantity of published works devoted to the problems of medico-biological aspects of zeolites, smectits and kaolins influence is great. We can notice all natural minerals without exception have biological activity, however, not all of them have the goal to stabilize the structure and the functions of mammal organism systems (do not confuse "profit" or "harm" resulting from dose).

Among discovered properties of mentioned above minerals which can be used as compensation of different deflections in the mammal organism we can mention the following: ability to correct alkaline and alkali-soil compound elements in the organism; to be provider of biophile microelements, and also bioactive forms of silicon oxide; to influence metabolism in the organism owing to energization and prolongation of enzyme systems activity; to have favorable effect on symbiont microflora and water balance in digestive tract, immune status, the processes of tissue regeneration. All mentioned above minerals are able to carry out detoxication of the organism.

Without doubt, natural minerals have other properties in regulating the processes of different organism systems which are to be discovered. One of little known bioregulating mineral property can be its ability to grade negative effects of heat regulation deflection. Recently the data about zeolites ability to grade most part of negative effects both hypothermia [14] and overheating of organism [15] appeared. It is known either hypothermia or overheating destroy almost all the processes of life support in the organism. From the point of view of cell pathology negative effect of both low and high temperatures provides in the cells decreasing activity of redox enzymes and increasing activity of hydrolytic enzymes, tissue hypxia development, energetic resources decreasing, violation of regulating intracellular mechanisms. In general we can logically assume that consuming some minerals can have vital importance to enlarge the adaptive possibilities for organism to survive in both too low and too high temperatures.

Existence of bioactive properties in hypergene minerals is, of course, nonrandom. There is something behind it. These properties could appear only to make appropriate order; they have close connection of residual soil minerals and biological systems from the time of life origin on the Earth and improved during long co-evolution of mineral-crystalline and biological worlds.

Thus, the reasons of lithophagy, if we characterize them in common, are always the state of stress during organism disadaptation, which animals instinctively try to get rid of by consuming widely spread minerals of different rocks erosion zone. In this case the notion "stress" should be understood in its classical definition according to G. Selye as nonspecific complex of functional and morphological changes in the organism appeared under the influence of any environmental impacts or stressors [16]. The notion "adaptation-disadaptation" should be specially determined because authors have their own vision of it. The state of definite organism adaptation is understood as harmonious interaction of organism (its internal sphere with its time structure) with the substance and other organisms of its permanent space, and also with the flow of time existing in this space. Disadaptation appears when this harmony is destroyed.

As it is known lithophagy have two varieties: gastrolithic – ingestion of small pebbles and kudyuritic – soil eating. The first variety is typical for herbivorous birds and other herbivorous cloacal animals and, at first, reptiles (in past gastrolithic lithophagy was typical for herbivorous dinosaurs). The second variety (kudyuritic) is typical for herbivorous placental mammals and, as it was recently discovered, for some herbivorous birds, in particular, for several parrots' species as it was mentioned above. As gastrolithic lithophagy in contrast to kudyuritic does not have seasonal character (there are practically always gastrolithes in the stomach) it follows that gastrolithes are always included in the system of homeostasis, but kudyurits eaten by herbivorous animals are used periodically when the organism (its systems) discovers the unstable state. It is necessary to notice that till the present time the main function of gastrolithes in stomachs of herbivorous birds and dinosaurs was the function of "millstones" which provided grinding of solid fodder components in gizzards and masticatory stomachs. Recently the set of these functions was extended. For instance, in the Vings thesis [17] devoted to studying dinosaurs' gastrolithes and comparing them with the gastrolithes of African ostriches a number of hypotheses concerning the functions of gastrolithes are offered. Among them along with the function of grinding the food the following are suggested: the source of mineral nutrients; the substance for digestive juices; the ballast (hydrostatic function for aquatic reptiles).

Nevertheless, real progress in understanding gastrolithe functions was made by V.I. Bgatov et al. [18] during the experimental study on hens. With the help of unusual technology using contemporary methods of chemical analysis the gastrolithes were shown to have considerable influence both on mineral and common metabolism in the hens' organisms (probably it is typical for all cloacal animals). At the same time it was proved gastrolithes influence the interchange of the chemical compounds set. The mechanism of this influence is clear; these are mechanical and chemical reactions taking place in digestive tract with the work of silicon gels which actively remove different positively charged ions from the organism. Here we can point out the evident disparity of traditional "millstone" hypothesis with a number of evident facts. For example, the most massive existence of gastrolithes in the stomachs of wild geese and ducks is observed in spring at the time when in their ration they have juicy green grass [3].

Some herbivorous mammals, especially ruminants, because of their passion for sodium (as it is known a great amount of sodium at this group of animals is involved in digestive cycle) have two incentives to lithophagy [19]. Along with instinctive wish to eat minerals which have broad adaptogenic activity, there can be directed reflective wish to any sodium contained compounds, at first to freshwater and marine plants, and also to different solid and liquid mineral and organic mineral substances (spring and marine waters, kudyurites, soils). As Australian scientists discovered [20], during the search for sodium special and almost studied reflexive mechanisms work. A man (either an animal) has the feeling similar to that as if he is thirsty.

Sodium is known to be the most important biophile element determining the effectiveness of passing membranous processes in cells. Also steady supplying of the organism with sodium is known to increase substantially its adaptive possibilities. However, hard shortage of sodium in the environment, as Australian researchers showed [20], is not absolutely limited factor for inhabiting landscapes having sodium deficit. On such landscapes animals have specific physiological mechanisms and behavioral strategies for surviving. It is not necessary to have sodium salt in the menu of people living on the area with low consumption of this element, for example the experience of the Lykovs, the eremitic family lived in the mountains of Altai. (We can notice the territory where the Lykovs lived more than 40 years without salt has absolute marks approximately 1000 m, and it is characterized by extremely low sodium content in soils, rocks and plants).

As it comes from our research [3] sodium is always present in kudyurite compounds in the form of absorbed ions in spore space of mineral sorbents ion-exchange reactor. When penetrating in digest tract, exchanged sodium from minerals is easily displaced by extra ions of potassium and ammonium in cicatricial and intestinal electrolyte, after that the deficit element is assimilated by the organism. At the same time the quantity of sodium in kudyurites can vary greatly. Maximum quantity of exchangeable sodium is contained in zeolite kudyurites spread mostly in young-aged volcanic rocks; minimal content (often very tiny) is typical for kaolin-peach-

hydromica compounds which are spread much wider than zeolites and are typical for ancient fold mountains on all the continents.

For a long time scientists were misled about real reasons of lithophagy by well-known fact about ruminants crave for sodium which is sometimes deficit in the environment and instrumentally established fact of some kudyurites enriched with this element. Only after collecting critical sum of facts it was managed to differentiate widely spread situations of deficit element direct reflective search by animals (that is more typical for ruminants) from instinctive search of "minerals-adaptogens" (that is typical for phytophages, some omnivores and even for some predators, for instance bears).

One of such typical facts was noticed while investigating the elks on kudyurs on the territory of Kempendian zeolite deposits in Yakutia [3]. The elks eat actively clay-zeolite rocks on the territory where a lot of outcrops of rock salt – halite with the springs of salty waters are situated but they are not interesting for animals. The elks prefer clay rocks in the habitat where there is plethora of sodium but rather strict biogeochemical and climate stressors.

The situation with clay preferences where there is sodium plethora is similar for domestic animals (sheep, goats, horses, cattle and even pigs). The cases of carving for eating clays or other soil nutrients are widely spread among humans especially among children and pregnant women.

Thus, search for sodium is one of plenty possible reasons of lithophagy which is more typical for sodium deficit landscapes where animals have adaptation problems.

Sodium chloride is known to become an important mineral food addition for a contemporary man that can be explained by a steady habit of the organism appeared on the basis of a lot of stress-factors which man constantly faces with. For a contemporary man the main stressors are known to be not environmental but social, first and foremost intensive neuropsychic interactions between people.

Instinctive search of kudyurites as gastrolithes can have traditional forms of animals' regular visits to the same places during long period of time. For all that, definite landscape complexes clearly distinctive in trace activity of animals – kudyurs can be formed. (This term of Turkic origin was suggested by V.I. Bgatov in order to change the previous inappropriate term "animal solonetz" with the same meaning). Kudyurs are formed mainly by horned plant feeders, while the proportion of birds is insignificant and rather tiny.

Concerning the birds we can notice their search for necessary minerals such as quartz feldspar sand and gravel, the derivatives of different silicon containing rocks, is not connected with any difficulties usually (we say only about gastrolithes). The rocks of such kind are widely spread everywhere. Very seldom the vast territories of marshland or fertile chernozem (black earth) without "pebbles" both in the line of springs or roots of fallen trees can be met. In such situations adaptation problems can appear for settled herbivorous birds, for instance, from Gallinaceae. In this case birds can have anomalous deflection, morphology of organs and space organization of population which is described on capercailies in one of the places of the Eastern Siberia [21]. For such areas traditional places of collecting gastrolithic "pebbles" by birds are typical and they can exist for a long time.

The presence of kudyurs in the landscape is a direct signal, on the one hand, of strong stressors existence which sometimes or always influences the animals, on the other hand, uneven distribution of kudyurites on the territory (i.e. mineral adaptogenes).

The degree of kudyurs trace intensity depends on the quantity and species of animals visiting them, since the degree of their intensity on the landscape and the quantity of one-time consumed minerals is pro rata to the weight of the animal (the weight of one-time consumed minerals usually fluctuates from 0.5 to 5% of animal weight). Thus, deer with its weight of nearly 100 kg can consume to 5 kg of clay material at once (author's observations). The elephant with its weight of one ton can ingest 10 and more kilograms at once [6]. The hen with its weight of 1 kg can ingest nearly 10 g of gastrolithes [18], the ostriches which weight is not more than 100 kg ingest nearly 1 kg of gastrolithes [17]. The richest kudyurs form the most massive species. The elephants, of course, are hors concours.

The areas of kudyurs steady forming are always geologically, geomorphologically, biogeographically determined, so they are constant places of hoofed animals concentration and, of course, connecting with them vermin. Probably some of these areas can be the same during even geological epoch. Ancient herbivorous placental mammals, like their ancestors birds-dinosaurs, certainly had closer connection with geological landscape constituent, it is proved by the findings of kudyurits in the stomachs of mammoths and rhinoceroses found in permafrost [22], and also gastrolithes in the places of skeletal remains of dinosaurs herbivorous representatives [17, 19]. Developing this idea here are a few words about noticed by several researches closeness of paleofauna burying places with typical kudyurite soil and natural sodium salt resources [1]. Today it is widely recognized that mass tombs of animals more often occurred because of the ecological catastrophes in past. The state of stress appeared at animals in such situations made them instinctively concentrate at the places of saving kudyurite outcrops.

For all that, some time animals could live uniting in herds until they die in mass because of anomalous cold, volcanic heat or sharp increasing of poisonous substances in the environment.

As our long investigating experience shows, remarkable influence of environmental stress-factors on hoofed animals in mining forests on the territory of Sikhote-Alin becomes apparent on the altitudes of 600 m and higher. The degree of their manifestation depends on geological and geomorphological conditions, soil variations, flora compound, microclimate and other environmental parameters. In such situations kudyurs have great influence on animals' concentration and the character of their seasonal movements. In the sodium deficit areas animals try to visit either kudyurites or all the other available sources of sodium (algae plantation, the sources of mineralized water and shores, alkali soil, solonetz, artificial salting). Two vivid doubling animals' attempts with close goals connected with compensation of disadaptational stress but with different objects of their aim created and still create difficult puzzle for researchers to solve.

Thus, we can give exact answer to the question: why the influence of environmental stressors in the middle and upper mountains especially in the areas where eruptive rocks are spread is more active than in plains and low mountains. First of all soils (flora respectively) in eruptive rocks always have more contrasting chemical compound (there is more dispersion of macro- and microelements contents) than in terrigenous sediments. It can be easily explained. Magma eruption is a product of the earth's crust or mantle atoms long inside nidus differentiation, while terrigenous sediments are the result of different rocks mixing during their denudation and transit to the places of deposits with chemical compound averaging-out. More over, soils, water and flora of low landscapes are always more saturated by lively forms of the elements and compounds, and, as a rule, they have more favorable balance in respect of living substance. As a remark we can notice that rather contrast rocks regarding their chemical compound, which animals' adaptation problems are often connected with, are different sorts (especially calcium carbonate and magnesium carbonate) of haemmogeneous sediments. The animals living in the areas where these rocks prevail often visit cudures. Such rocks are not endemic for the Sikhote-Alin, but they are typical for other areas in the world.

Among the animals living in mountain landscapes of low hypsometric level in other similar conditions the problems connected with climate are always seen less because the period of low temperatures is shorter, the period of starting flora vegetation is starting earlier, more seldom than in high altitude there is deep snow.

The animals living on the plains have less adaptation problems and they have less distinctive lithophagy form. Nevertheless, lithophagy can be met in some places on the plains. Mainly it is on the north territories where the climate is hard and cold, in the dry areas and the territories where carbonate or saline soil prevails.

In order to understand why passion for minerals, as suppliers of chemical elements, among herbivorous animals is higher than, for example, carnivores have, let us remind that vermin eat balanced in chemical elements food (meat). Chemical variations of meat are rather inconsiderable, while the content of the elements in plants can fluctuate within great limits. Thus, physiological state of herbivorous animals during the change of feed allowance (especially in spring) or those which live in the areas of geochemical anomaly depends very much on chemical content of the food fluctuation.

Lack of interest to kudyurites among hoofed animals in the Sikhote-Alin landscapes with low hypsometric levels is explained by the absence of strong environmental stressors in correlating stations. Especially it is well seen in the situations in a number of territories where there are outcrops of clay zeolites related to zeolitic Neozoic graben-like structures. Such situations, for example, can be seen on the territory of Kraskino cavity on the south-western coast of Primorskiy kray, and also on the territory of Chuguyevka on zeolite deposit in central low mountain part in Primorskiy kray. We did not see here any lithophagy evidence with kudyurs forming. Less presence of negative factors which influence the animals can explain weak trace activity of kudyurs in south-eastern part of Primorye (including the river Vanchin). In mountain taiga landscapes of north-eastern part of Primorye (in latitude North of Terney) kudyurs trace is more active in spite of both comparing areas they have similar structure of kudyurites and form in similar landscapes in the zone of the Sikhote-Alin main range. The only difference is in higher middle level of altitudes and harder climate conditions of animals' habitats. Partly, more active kudyurs trace in northern parts of Primorye can be explained by the elks presence – the animals which are heavier and more inclined to forming passes.

Including the biggest kudyure complexes into nature protected areas (NPAs) is the main constituent in the system of ecological balance preserving measures in the scale of any region where such areas exist. From this point of view the first territory configuration variant of the biggest nature reserve in Sikhote-Alin with the coverage of the Bekin river basin part was optimal. After decreasing the area of the nature reserve in 60-th the attempts of its restoring failed. As a result unique kudyur complexes in the limits of the Bikin latitude zone are still unprotected. Including part of this territory into

Verhnebikinskiy nature reserve will not improve the situation now.

Logging is right up against the unique kudyur complexes in subwatershed of the Bikin and the Maksimovka rivers. Field verification of the situation in 2005 showed that lots of habitats in this area with steady high animals density supported by kudyurs is crippled much that is, first of all, connected with the advent of ways for poachers.

In connection with the discussing theme the question about technologies of crucial improvements of hoofed animals habitats in unfavorable landscapes from the point of view of different stress-factors is quite logically arises. As Caucasian state nature reserve experience shows that creating artificial solonetz in the zone of upper forest boundary allows increasing the animals' density in mountain habitats very efficiently. Maximum effect from such measures can be reached in case of laying sodium in the places of natural or imitated exposing similar to mineral content to kudyurites typical for definite region.

## CONCLUSIONS

In conclusion it is necessary to stress the theme of kudyurs and lithophagy in animals, which systematical studying began more than seventy years ago by Adolph Mure and almost simultaneously by Andrey Nasimovich and Lev Kaplan, has not investigated properly yet. It has been formed in all its complex and incredible depth. Here the problem is not only in learning little known patterns of animal interactions with abiotic environmental factors for theoretical and applied ecology, but the main, we can say even cosmic, depth is observed in essential interaction of biological and mineral-crystalline world. More over, the main problem, from our point of view, is the minerals interaction mechanism with living systems now is starting to open the sphere of energy informational interactions. And practical solving of it is not only the animals but in considerable degree this is the way to improve the men's health.

## REFERENCES

[1] Nasimovich, A.A. "To the knowledge of mineral nutrition of wild animals of the reserve of the Caucasus," *Proceedings of the Caucasusian Reserve*, 1, 49-54, 1938.

[2] Kaplanov, L.G. "Tiger. Manchurian deer. Moose," *Bull. MOIP. Otd. zool.*, 14, 18-126, 1949.

[3] Ketch, L.A. et al. "Comparative microbial analysis and clay mineralogy of soils eaten by chimpanzees (Pan troglodytes schweinfurthii) in Tanzania," *Soil Biology and Biochemistry*, 33(2), 199-203, 2001.

[4] Shaposhnikov, F.D. "About «solontsevanii» wild hoofed animals in the mountain taiga of the Altai," *Bull. MOIP. Otd. biol.*, 58, 1, 1953.

[5] Voigt, C.C. et al. "Mineral Lick Attract Neotropical Seed-Dispersing Bats," *Research Letter in Ecology*. Article ID 34212. 4, 2007.

[6] Panichev, A.M. "Litofagy in animals and humans," Author's abstract. diss. doct. biol. science. Vladivostok,. 59, 1998.

[7] Wakibara, J.V. et al. "The Adaptive Significance of Geophagy for Japanese Macaques (Macaca fuscata) at Arashiyama, Japan," *International Journal of Primatology*, 22(3), 495-519, 2001.

[8] Panichev, A.M. "Value litofagy in the life of wild herbivores," *Reports of the USSR Academy of sciences*, 306(4), 1018-1021, 1989.

[9] Selye, H. "Stress without distress." Moscow, Publ. Progress. 250, 1979.

[10] Ochev, V.G. et al. "Gastrolithes of fossil animals," *Priroda*, 10. 46-49, 2004.

[11] Panichev, A.M. et al. "Zeolites in surgery," Publ. FENTU, Vladivostok. 120, 2004.

[12] Klein, N. et al. "Geophagy: soil consumption enhances the bioactivities of plants eaten by chimpan zees," *Naturwissenschaften*, 95, 325-331, 2008.

[13] Mashchenko, E.N. "New data about the peculiarities of biology of the mammoth," *Priroda*, 10, 41-53, 1999.

[14] Bgatov, V.I. et al. "Functions of natural minerals in the metabolic processes of poultry," *Agricultural biology*, 7, 98-102, 1987.

[15] Blair-West, J.R. et al. "Changes in sodium appetite in cattle cluduced by changes in CSF sodium concentration and osmolality," *Physiol. Behav.*, 39: 465-469, 1987.

[16] Mcnaughton, S.J. "Mineral nutrition fnd spatial concentrations of African ungulates," *Nature*, 334, 343-345, 1988.

[17] Vings, O. "Identification, distribution, and function of gasstroliths in dinosaurs and extent birds with emphasis on ostriches (struthio camelus)"

Dissertation, 2004. http//hss. ulb. uni – bonn.de/diss_online electronisch publiziert.

[18] Abrahams, P.W., Parsons, J.A. "Geophagy in the Tropics: a literature review," *Geogr. J.*, 162(1): 63-72, 1996.

[19] Golokhvast, K.S., Tseluyko, S.S. "Immuno modulating properties of zeolites Vangin deposits with inhalation in a general cooling" *Far East Medical Journal*, 3, 92-94, 2006.

[20] Panichev, A.M. "Natural mineral ion exchangers - regulators of ion balance in the animal-litofags," *Reports of USSR Academy of Sciences*, 292(4), 1016-1019, 1987.

[21] Mure, A.J. "The moose of isle Royale," *Misc. Publ. Mus. Zool. Univ. Mich.*, 25, 1-44, 1934.

[22] Aufreiter, S. et al. "Mineralogical and Chemical Interactions of Soils Eaten by Chimpanzeers of the Mahale Mountains and Gombe Stream National Parks, Tanzania," *J. Chemical Ecology*, 27(2): 285-311, 2001.