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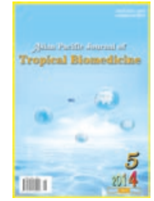

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Geophagy (rock eating), experimental stress and cognitive idiosyncrasy

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PEER REVIEW

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Comments

This scientific work is interesting and directs on the solution of an actual fundamental problem–to broaden understanding of the complex biogeological phenomenon–geophagy. During 5 d experiment based on an author's method of research, the optimizing effect of geophagy on cognitive and motivational and power spheres of SA at laboratory rats is shown. It is shown that the experimental geophagy promoted reliable improvement of parameters of these behavioural spheres that is coordinated with anti–stressful influence of used natural components.
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ABSTRACT

Objective: To discuss the impact of geophagy on behavior and conditioned–reflex activity of Wistar rats subjected to instrumental stress under experimental conditions.
Methods: Experimental geophagy was simulated by adding zeolite–containing tuff (clinoptilolite) to animal feed, the amount relating to 2% of body mass. Tuff was obtained from areas where animals usually eat subsurface rock. Search activity of animals and peculiarities of information and emotional stress were studied through the use of a universal problem chamber.
Results: The results of this experimental study showed the negative impact of instrumental stress on laboratory animals, manifested in behavioral dysfunction, in the form of changes in qualitative and quantitative characteristics of search activity. Experimental geophagy contributed to significant improvement in behavioral parameters, confirming the anti–stress effects of the use of natural ingredients.
Conclusions: These results suggest that, in natural environmental conditions, "edible" rocks serve as an adaptive tool for recovery from various types of environmental stresses, and are examples of self–medication.

KEYWORDS
Geophagy, Cognition, Search activity, Zeolite, Stress

1. Introduction

The needs of food and drink are crucial for self–preservation and for ensuring the successful interaction of human and animal organisms with the environment. Searching for food and water is a fundamental principle to ensure the survival of species in their natural habitat.

The phenomenon of geophagy (in Russian science literature–*Lithophagy*), which has been studied for many years in all its different contexts, can be explained as an instinctive desire of an organism to correct material and as functional deficiencies by using natural minerals[1,2]. This can be incompatible with some adverse environmental

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conditions and transient physiological states, such as pregnancy, lactation, rutting, *etc*[3,4].

One thing is clear that geophagy, as a complex biogeological phenomenon, has several causes and effects. That is why it is possible to list the main theories that seek to explain geophagy. These are partially supported by facts, but to date none of them is prevalent and unambiguous, such as hypothesis of "mineral or microelement hunger"[4,5], antitoxic and "antidiarrheal" hypothesis[6-9], "Probiotic" hypothesis[10].

It is known that animals in their natural habitat suffer from periodic stress. The problem of stress (temperature, psychoemotional state, *etc*.) is currently highly relevant. As the increasing impact of stressors on biological objects, it becomes a pathogenetic basis for vital activity and disturbance for different organisms.

In order to assess the effects of geophagy, a search activity (SA) was used in our experiment to provide a stress load and an indicator of higher nervous activity. The concept in this SA was created by V.V. Rotenberg and V.V. Arshavskii[11,12]. It is the most integrated of all modern psycho-physiological concepts. One of the basic ideas in this concept is that SA aims at changing a situation or changing attitudes towards it. The very process of SA, regardless of the result, increases the organism's resistance and stress tolerance.

The aim of the current work is to study SA characteristics among laboratory animals in the context of experimental geophagy and defensive motivation, under artificial, experimental conditions.

2. Material and methods

All procedures with experimental animals were carried out with due regard to the requirements of the Declaration of Helsinki and "Regulations for working with experimental animals" (1977, Russian Federation).

The experiment was performed on 46 male Wistar rats weighing (280±12) g. Animals were divided into two groups: control and experimental, containing 23 individuals for each. Training of animals was carried out individually.

Experimental geophagy was simulated by adding zeolite-containing tuff (clinoptilolite) to animal feed, the amount relating to 2% of body mass. Tuff was obtained from areas where animals usually eat subsurface rock. Animal feed (30 to 32 g) consisted of 25 g of mixed feed (feed-stuff containing proteins, fats, carbohydrates, vitamins, minerals and microelements in rational doses) and 5 to 7 g vegetables. Rats were fed twice a day. Tuff with feed was given to an experimental group twice a day as well (1% of body mass at a time).

Tuffs consisted of zeolites (clinoptilolite, less often-mordenite, from 50% to 70%), clay minerals (predominantly smectite up to 30%), and a small amount of inert matter (quartz, oligoclase, volcanic glass, *etc*.).

The chemical composition derived from the X-ray fluorescence analysis (Thermo OptimX) is shown in Table 1.

Tuff was granulated using a roll-jaw crusher Fritsch Pulverisette 1 (Fritsch, Germany) and a Bandelin Sonopuls 3400 (Bandelin, Italy) ultrasonic homogenizer, according to the methodology described before[13]. The size of mineral particles, based on particle size analysis using Fritsch Analysette 22 Nanotec (Fritsch, Germany) eventually ranged from 50 to 500 microns.

Animals were kept in standard vivarium conditions, with sufficient (without limitation) access to food and water in the natural interchange of diurnal light cycles. They were housed in spacious cages, separate from other species. All training and testing experiments were carried out in the daytime.

Table 1

Chemical composition of tuff derived from X-ray fluorescence spectroscopy.

Element	Contents
K (%)	1.330
Ca (%)	4.260
Ti (%)	0.408
V (mg/kg)	57.00
Cr (mg/kg)	-
Mn (%)	0.100
Fe (%)	3.380
Ni (mg/kg)	24.60
Cu (mg/kg)	40.80
Zn (mg/kg)	117.00
Ga (mg/kg)	21.10
Ge (mg/kg)	1.92
Rb (mg/kg)	50.90
Sr (mg/kg)	5191.00
Y (mg/kg)	39.70
Zr (mg/kg)	205.00

-: Below the limit of detection.

SA of animals and peculiarities of information and emotional stress were studied through the use of a universal problem chamber (UPC) (Figure 1)[14,15].

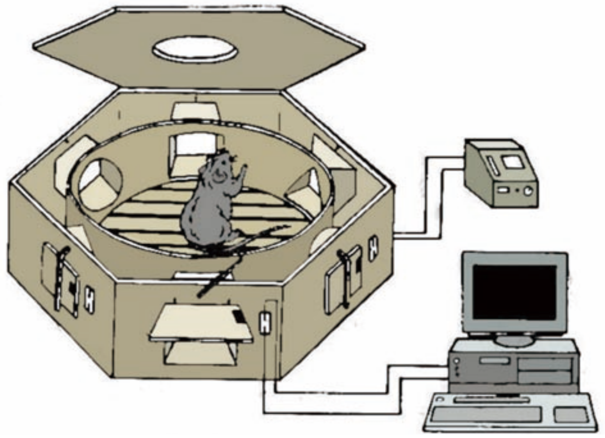

Figure 1. Scheme of a UPC used for search activity and search refusal analyses in the experiment, with recorder.
Interpretation of the device operation can be found in the text below.

A model of problem solving was created where each alternative choice or decision is made by an animal without prompting. This situation forces the animal to find immediate solutions and to make permanent action corrections which directly relate to higher brain functions that relate to receiving and processing information, memory, behavioral control, emotional assessment, and dynamic and regular decision-making. SA testing in the context of defensive behavior was carried out after the initial establishment of a unilateral escape reflex. The next stage was to focus on the instrumental reflex of active avoidance by using paw electrodermal irritation with an impulse current up to 5 mA and a stimulation duration of 1 second, with a 10 seconds frequency, immediately after placing the animal into the chamber.

While conducting short-term training devoted to active avoidance or escaping from the chamber, with all the doors of the UPC unblocked, 100% of the experimental animals mastered this skill. The testing of the search ability is a standard cognitive tasks with an alternative choice of movement direction from the UPC. Immediately after the animal has escaped from the chamber through a given door, this door is blocked. This makes the exit used a dead-end, so that the need to find a new unblocked exit arise. The animal needs to do this when it is returned by the experimenter to its UPC start point to avoid a repeat of the irritant. This process is repeated cyclically until the rat finds the sixth and last exit from the chamber, and thus completes one search cycle. Movements are recorded as being correct if they are made to an unblocked (*i.e.* previously unused) door. Incorrect or erroneous movements are recorded for each movement directed towards a blocked door.

In the course of its forming the following SA parameters were registered and recorded in the UPC at the initial or single step testing: 1) motivational and energy indicators: time of search (TS) in seconds and the intensity of movements (IM) (*i.e.* the number of purposeful movements of animals from the UPC per minute); 2) cognitive sphere parameter-cognitive indicator (CI). CI reflects cognitive abilities, expressed as a percentage (*i.e.* the number of faultless arrivals at chamber entrances, so if the animal has not made any wrong movements, then CI is 100%).

Test duration was 5 days.

Laboratory rats belonging to the mean behavioral type were selected, according to the methodology used in our early experiments[15]. Statistical processing was carried out using the BioStat program (version 5.1).

3. Results

Indicators of SA were studied in a series of experiments carried out on laboratory rats in a problem chamber, focusing on defensive behavior in the course of experimental geophagy (eating zeolite). SA indicators such as TS, IM, and CIs were compared to the equivalent parameters of the control group.

When comparing the mean values of learning dynamic indicators in the control and experimental groups, we found that the control animals were 1.5 times more likely to develop the instrumental reflex of active avoidance than the group receiving minerals. The difference between the two groups of animals was statistically significant ($P<0.01$). These results indicate that zeolite has an activating effect on conditioned reflex activity.

The following data were obtained from tests conducted using the UPC. TS values in both groups are shown in Figure 2. Number of movements (NMs) values in both groups are shown in Figure 3. CI values in both groups are shown in Figure 4.

Therefore, consideration of qualitative and quantitative components of SA should look beyond the kind of deprivation and the associated behavior structure.

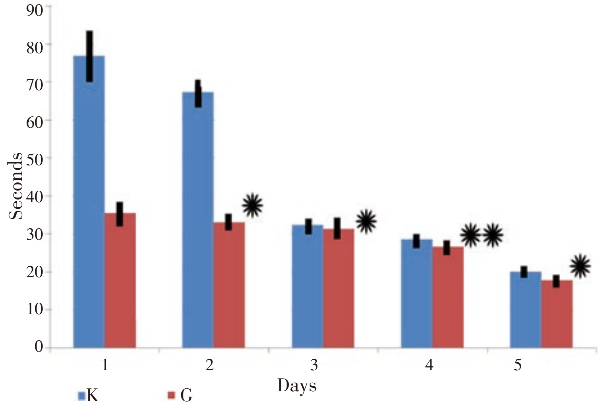

Figure 2. Changes in TS (in seconds) in the control animals (K), and animals fed with tuff (G) during the 5-day experiment.

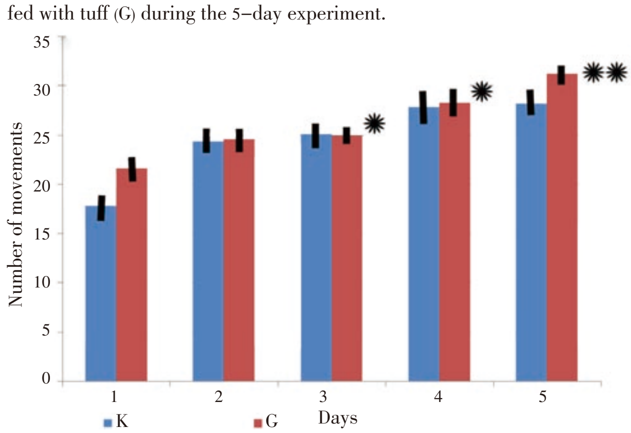

Figure 3. Changes in the NMs in the control animals (K) and animals fed with tuff (G) during the 5-day experiment.

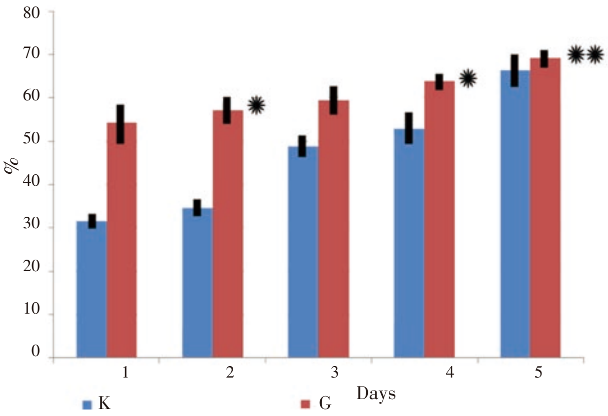

Figure 4. CI change (in percentage) in the control animals (K) and animals fed with tuff (G) during the 5-day experiment.

The needs of food and drinking as well as freedom of movement are basic self-preservation needs which ensure the successful interaction of human and animal organisms with the environment. Failure to meet these needs leads to death of the organism at different time at intervals.

The results of this experimental study show the negative impact of instrumental stress on laboratory animals, manifesting in behavioral dysfunction in the form of changes in qualitative and quantitative characteristics of SA.

Experimental geophagy contributed to significant improvement in behavioral parameters, confirming the anti-stress effects of the use of natural ingredients.

4. Discussion

The main conclusion is that SA indicators (TS, IM and a CI) for laboratory animals, which were kept in a problem chamber in the context of experimental geophagy (intake of zeolite-containing tuff), are optimized faster than those of the control group.

Based on the results obtained we can assume that the "edible" rocks, if they are ingested, can improve SA among animals, *i.e.* their adaptogenic effect extends to the neuropsychic organization of living systems. In other words, there is reason to believe that geophagy is a natural stimulant of SA. Generally speaking, we can assume that geophagy is an example of animal self-medication[16], because of eating subsurface rock, the adaptation abilities of animals improve.

It has been reported elsewhere that the geophagy phenomenon[1,6,7], in its variety of manifestations, can be explained as an instinctive desire of the organism to correct material composition using natural minerals, which can create problems in the presence of various adverse environmental stressors.

The phenomenon of eating subsurface rocks and minerals has been recorded in various stress conditions[17-21]. This provides confirmation of our hypothesis about the adaptational and psychological role of geophagy in nature.

The possibility of such a correction depends on the substances being consumed containing certain minerals, in the case of eating with the aim to regulate biological, physiological, energetic and behavioral processes in living organisms.

Conflict of interest statement

We declare that we have no conflict of interest.

Acknowledgements

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Comments

Background

The problem of geophagy has interdisciplinary character and represents a great interest for various scientists making researches on a joint of geography, geology, medicine and biology. However attempts to study systematically the influence of geophagy on organism practically weren't undertaken and similar researches were based mainly on biochemical indicators. Therefore the presented work devoted to influence of a geophagy on the cognitive sphere, considering a very important aspect of this problem.

Research frontiers

This work is devoted to the study of indicators of cognitive ability at laboratory rats against an experimental geophagy in the conditions of an artificial tool situation as defensive motivation.

Related reports

Application by authors of the chosen technique in this research is represented logically and reasonably.

Innovations and breakthroughs

On the basis of experiments authors assumed that the geophagy was a natural stimulator of SA.

Applications

It is shown that opportunity to regulate cognitive activity of mammals by entering into their diet of powders of a zeolite-contained tuff .

Peer review

This scientific work is interesting and directs on the solution of an actual fundamental problem-to broaden understanding of the complex biogeological phenomenon-geophagy. During 5 d experiment based on an author's method of research, the optimizing effect of geophagy on cognitive, motivational and power spheres of SA at laboratory rats is shown. It presents that the experimental geophagy promoted reliable improvement of parameters in these behavioural spheres which is coordinated with anti-stressful influence of used natural components.

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