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ZOOGENIC INFLUENCE ON THE AMOUNT OF SOIL NITROGEN IN AZOV-SYVASH NATIONAL NATURE PARK

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The article deals with the influence of big ungulates on the quantitative changes in the amount of soil nitrogen. The experiment on collection and computation of solid excretions of two main ungulate populations in two dominant parcels on the investigated territory was held. Sampling and analyses of soil (under the ungulates` influence and without it) were held every half-year (in spring and autumn). The dynamics of soil nitrogen concentration during 3-year-influence of deer and fallow-deer is shown. Statistic computations and analyses of the data were made.

Keywords: nitrogen, excretions, ungulates, zoogenic influence, parcels.

The effect of mammals on the biosphere in general and on the biogeocoenosis in particular had been studied for more than half a century. Numerous articles and monographs demonstrate the diversity and complexity of the problem. In our opinion, there is a need for more in-depth study of specific issues on the aspects of the problems that were not disclosed to the end and lit from all sides.

The most vivid form of mammals` participation in the transformation of matter is direct movement through the trophic levels of ecosystems – the so-called trofodynamics [5]. These researchers believed, that mammals transform a very small part of substance and energy into higher trophic levels in zoocenoses of restricted areas. Activity of mammals is especially effective in arid landscapes, including the semi-arid areas and dry steppes [1]. Here a number of natural processes and overall ecosystem functioning is closely linked to the life of mammals, and especially their largest group – herbivorous animals.

Investigations of regulating the ratio of different forms of participation in the mammalian biological cycle is of great interest. It can really help in the management capacity of the biosphere [5]. Understanding the process of recycling the phytomass by consumers and further highlighting it as a secondary metabolite in the form of excrements was one of the key points [2]. Actions of herbivorous can cause a variety of ecological processes, such as with a small increase or decrease in consumption with a strong grazing of primary production, decreasing plant biomass, increasing of species diversity and the emergence of more complex ecosystems [10].

As a result of utilization and allocation of the phytomass, solid excrements of consumers on the ground are a return of partially recycled phytomass, which is a secondary metabolite [3]. Though B. D. Abaturov, N. Y. Kulakova believe that this metabolite is depleted in the course of passage through the gastrointestinal tract and the influence of intestinal microflora is not able to bring in a sufficient amount of mineral elements-organogenes. This, in its turn, minimizes the impact of biotic factors on decomposition and leaching organogenes metabolite in soil [11].

According to A.E. Rodin and N.I. Bazilevich, the biological cycle of steppe ecosystems doesn`t keep organic material so long as in the forests. Furthermore, steppe herbaceous plants are most notably characterized by the accumulation of chemical elements in all organs compared with wild plants [11].

A.V. Miheev and O. E. Pahomov showed that a significant amount of nitrogen, phosphorus and potassium is discharged when herbivores secretions are destructed [9]. They believe the habitat-forming effect of excretory activities as one of the most important manifestations of living organisms, lies in a fertilizer edafotop organic matter, nitrogen and complex mineral elements and the associated change in the chemical properties of the soil [9].

B. D. Abaturov believes that communities of herbivore animals have the greatest importance for the functioning of ecosystems. In his opinion, these animals on the steppe pastures consume the bulk of aboveground phytomass, process it in the digestive system and fully return to the environment [4].

The aim of the article is to clarify the role of solid excrements of ungulates as secondary metabolites in soil formation processes over three years in the Azov-Syvash National Nature Park (ASNNP) located on the Fedotova spit. One of the challenges was figuring out the amount of organogenes which ungulates bring into the soil, which probably allows phytocenoses to recover quickly at extremely high density of ungulates [6]. The effects of excrement influence of Red deer (*Cervus elaphus* Linnaeus, 1758) and European fallow deer (*Cervus dama* Linnaeus, 1758) were studied.

Material and methods

Research was conducted during the autumn-spring period 2009–2011 biennium in the Azov-Syvash National Nature Park (ASNNP) located on the Fedotova spit, Kherson region. The total area of the park is 7,200 hectares, 6,500 hectares of which are available for ungulate grazing. The territory of ASNNP has well defined meso-and micro-relief. This amplitude of heights is a characteristic form of mesorelief, which does not exceed 2–3 m in height, and 50 cm for microrelief forms. Because of the numerous hills and weakly developed hydrological network, the moisture is going to decrease closed stagnant relief - depressions. Their area is 1–2 or more acres [12].

The total length of Fedotova Spit is about 45 km. The ground is mainly quartz sand, sometimes composed of sediment containing pebbles, and the edge of a growing number of limestone [7]. The island is 98% surrounded by the waters of the Sea of Azov and Utlyuks'kyi estuary. It has a small jumper to the mainland, with a width of less than 100 m.

Grass cover throughout ASNNP creates colorful mosaic of steppe, meadow and coastal water parcels that are indigenous, alternating with each other and generally occupy more than 90% of the territory. According to the materials of V. P. Kolomiychuk and O. Bezkorovayniy, on sandy plains dedicated to the highest parts of the spit Biruchiy island, the most common is dominant *Carex colchica* J.Gay, *Cynodon dactylon* (L.) Pers., *Euphorbia seguieran* [8]. On sand and shell spit soils also dominate *Festuca beckeri* (Hack.) Trautv. and *Marrubium peregrinum* L. In some communities *Tortula ruralis* (Hedw.) Gaertn., Meyer et Scherb., *Cladonia rangiformis* Hoffm., *Xanthoparmelia convoluta* (Krempelh.) Hale form 10–20% of the vegetation cover. Stable components of Biruchiy island meadows are *Limonium caspium* (Willd.) Gams, *Cynanchum acutum* L., *Artemisia santonica* L. [8].

Further research from the outset determined the average weight of the pile of excretion (n=100) in raw and absolutely dry weight for each of the investigated species of ungulates. Weight of an average pile of deer excrement was: 110 g wet weight, dry – 36.5 g, and 47 g and 17.3 g for fallow deer. Further, the piles of each species of ungulates were set out in the steppe and meadow parcels of 90 piles each. Feces were laid on the ground in groups with the above average masses in line, the distance between the piles was 1.5 m. Places were marked with special labels. Soil samples were taken directly under excretion every 6 months.

Sampling was carried out in layers, starting with the litter and then in increments of 5 cm to a depth of 20 cm for a similar scheme conducted selection control soil samples. All withdrawals of samples were carried out in 3 times the repetition. Preparation of samples (n=492), bringing to air dry weight and grinding was carried out in the laboratory. Grinding was performed by sieving through a sieve of 0.5 mm mesh size. Chemical analysis of nitrogen by method of E. Arynushkina [13] was conducted in Dnipropetrovsk National University in the complex chemistry laboratory of soil and water. A total of 492 soil analyses were done. Statistical analysis was performed using SPSS version 13.0. All calculations were carried out at the level of confidence of 95%. The analysis of variance of samples by Fisher test was made using ANOVA. Thus we established significant differences (p=0.001) between the average soil nitrogen content in 2009–2010. The above data gives us the right to consider an experiment to be credible. Since 2005 to the present time, every year group of students took part in the recording of ungulates.

Results and Discussion

The number of deer during the study period ranged from 908 to 1320 with a density of 139.7 – 203.1 individuals /1000 ha. The number of fallow deer varied within 1800 – 2450 individuals, with the density of 276.9 – 376.9 individuals / 1000 ha. The feces of ungulates were set out in October 2008 in 2 main parcels, with an average daily temperature of the month + 12C. In the spring of 2009, after six months, first soil samples were obtained.

Six months after the computation of excrement, in the spring of 2009 the concentration of nitrogen under the feces of deer in the steppe was 6.22±0.022 (SD 6.09–6.34), in the meadows 5.55±0.037 mg-eq/100 g of soil, SD (5.37–5.78), with the difference between the parcels to 10.7% (Fig. 1).

Under the fallout deer feces in the steppe its concentration was 6.22±0.02 mg-eq/100 g of soil, SD – (6.6–6.81), in the meadows 5.86±0.046 mg-eq/100 g of soil, SD – (5.71–6.3), difference between the parcels made 12%. Control tests showed the following contents of nitrogen: steppe – 1.44±0.071 mg-eq/100 g of soil, SD – (1.2–2.5), meadow – 1.48±0.054 mg-eq/100 g of soil, SD – (1.24–1.85) (Fig.1). We note that the concentration of nitrogen under the influence of deer feces, as compared with control, increased by 6 months in the steppe – 76.8%, in the meadows – 73.3%. Under the influence of deer in the steppe growth was 38.6%, on the meadows 48.1%.

During the autumn of 2009, after the 12 month period, concentration of nitrogen in the soil under the influence of a deer in the steppe amounted 8.62±0.13 mg-eq/100 g of soil, SD – (7.8–9.89), on the meadows 8.68±0.17 mg-eq/100 g of soil, SD – (7.15–9.98). Under fallow deer feces: in the steppe – 8.85±0.088, while SD – (8.1–9.45) meadows – 8.74±0.1 mg-eq/100 g of soil, SD – (8.1–9.67) (Fig. 1). Compared to the previous season, the amount of nitrogen under the influence of deer excretion increased for 27.8% in the steppe and for 36% on the meadows. Feces of fallow deer increased concentration of nitrogen for 29.7% in the steppe and for 32.95% on the meadow. The control showed the nitrogen concentration in the steppe – 4.06 mg-eq/100 g of soil, SD – (4.0–4.11), that is 64.5% more than the spring concentration. In the meadows this number was 3.64 mg-eq/100 g of soil, SD – (3.3–3.9) (Fig. 1), that is 59.3% more than the spring concentration. It was assumed that in the first year of exposition of ungulate excrements there was found very positive influence on the ground, in particular the concentration of nitrogen increased, which is a factor for intensifying the growth of herbaceous vegetation. In their absence common stock of vegetation is not major for this type of soil.

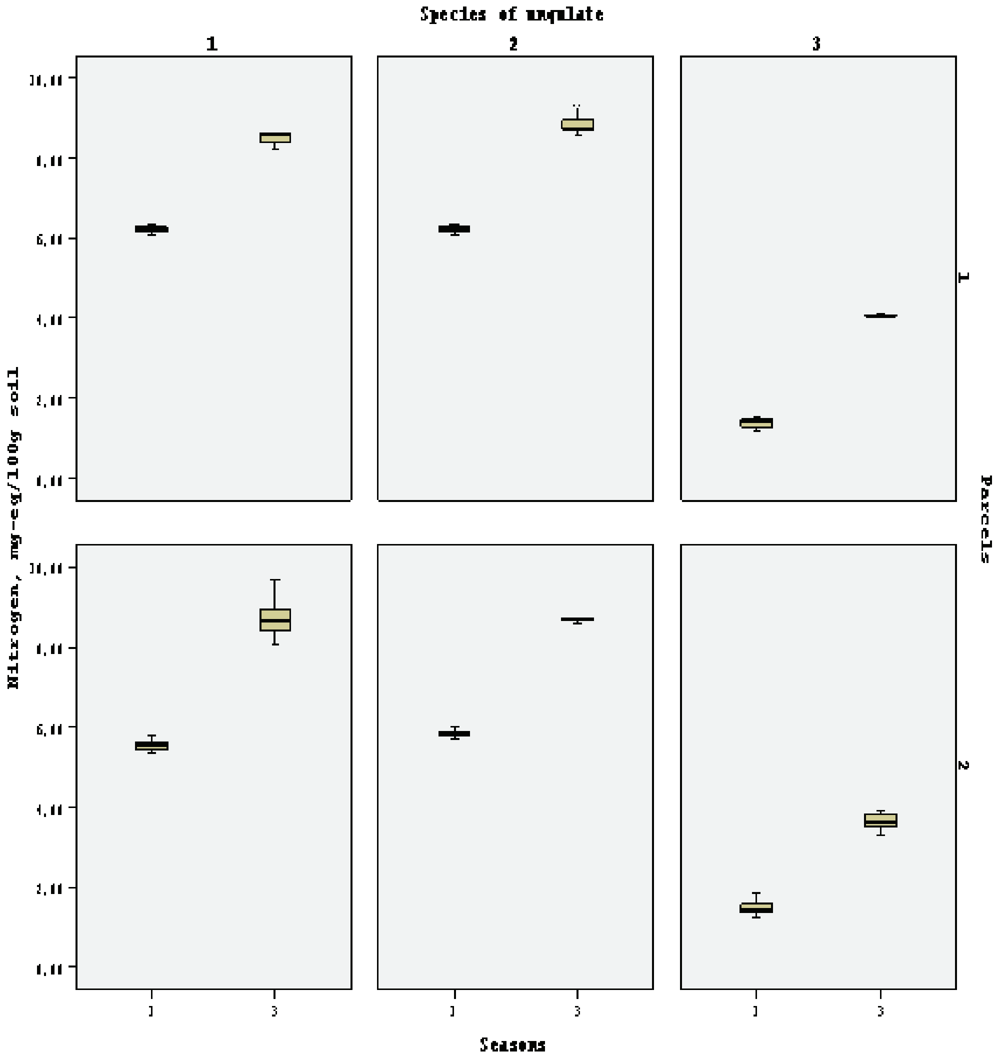

Fig. 1. Dynamics of average nitrogen content under deer feces (1) and fallow deer feces (2) compared with controls (3) in different seasons of 2009 in meadow and steppe parcels of ASNNP. Species of ungulates: deer – 1; fallow deer – 2; control – 3. Parcels: steppe – 1; meadow – 2. Seasons: Spring – 1; Fall – 3.

In the spring of 2010, under the influence of deer excretions in the steppes the concentration of nitrogen was 14.94±0.05 mg-eq/100 g of soil, SD (14.5–14.9), in the meadows – 14.11±0.23 mg-eq/100 g of soil, SD (12.89–14.11). Under the fallow deer feces amount of soil nitrogen in the steppes was equal 14.6±0.13 mg-eq/100 g of soil, SD (13.5–14.59), in the meadows – 15.71±0.24 mg-eq/100 g of soil, SD – (13.7–15.71). In the steppe the stock of nitrogen in the control was 6.71±0.02 mg-eq/100 g of soil, SD (6.61–6.71), on the meadows – 5.72±0.04 mg-eq/100 g of soil, SD – (5.46–5.72), with the difference between the parcels equal 14.7% (Fig. 2) Compared with control over experimental platforms, we see that the nitrogen content under the

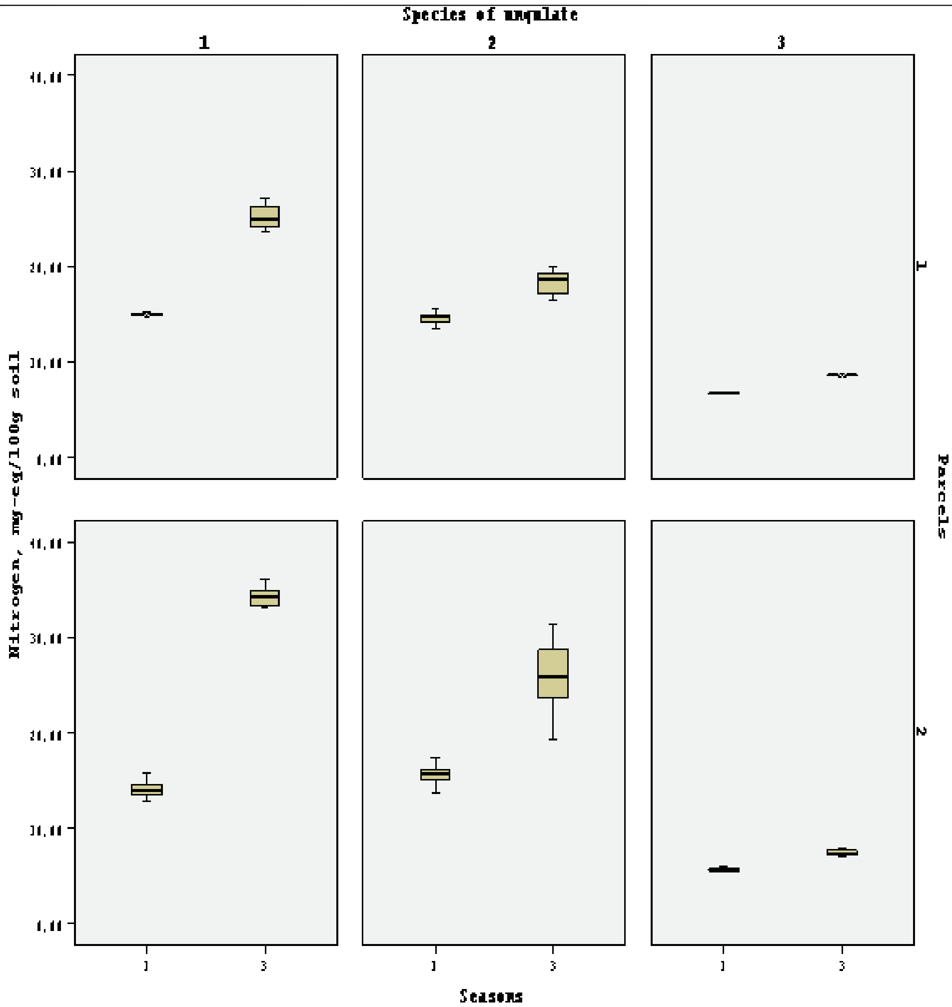

Fig. 2. Dynamics of average nitrogen content under deer feces (1) and fallow deer feces (2) compared with controls (3) in different seasons of 2010 in meadow and steppe parcels of ASNNP. Species of ungulates: deer – 1; fallow deer – 2; control – 3. Parcels: steppe – 1; meadow – 2. Seasons: Spring – 1; Fall – 3.

deer feces increased by 55% in the steppes and in the meadows to 59.4%, while under the influence of fallow deer these figures showed 54% and 63.6%, respectively.

In 2 years from the beginning of the experiment, in autumn 2010, the amount of soil nitrogen continued to change. Under the influence of deer excretions in the steppe its` quantity was equal 25.21±0,29 mg-eq/100 g of soil, SD (23.65–27.11), which was 25% lower than the amount in the meadows, where its concentration was 33.73±0.537 mg-eq/100 g of soil, SD – (28.55–36.11). The excretions of fallow deer in the steppe changed the concentration of soil nitrogen to 18.19 mg-eq/100 g of soil, SD – (16.41–19.91) (Fict. 2), which was 30% lower than in the meadows, where the concentration was equal 25.83±1.05 mg-eq/100 g of soil, SD – (19.31–31.40). Control tests in the steppe have shown the soil nitrogen content 8.6±0.037 mg-eq/100 g of soil, SD – (8.46–8.92). In the meadows concentration was 7.41±0.083 mg-eq/100 g of soil, SD – (7.1–7.87), the difference between control parcels was 13.8%.

Summarizing the changes in the concentration of soil nitrogen in spring and autumn 2010 we note that its stock in pilot sites has increased within 52.7–71.3% compared with the control. It`s necessary to point out that the benchmarks of the fall content also increased by 21.97% in the steppe and 22.8% in the meadow. Particularly interesting is the fact that the autumn revealed clear differences in the nitrogen concentration between the types of parcels. The overall picture shows a clear and significant increase in soil nitrogen stocks to autumn by more than 2 times as compared with the spring, due, in our opinion, to the demise of a large number of phytomass and the beginning of the wet season, and this leads to intense leaching of nitrogen from fallen plants and feces into the soil.

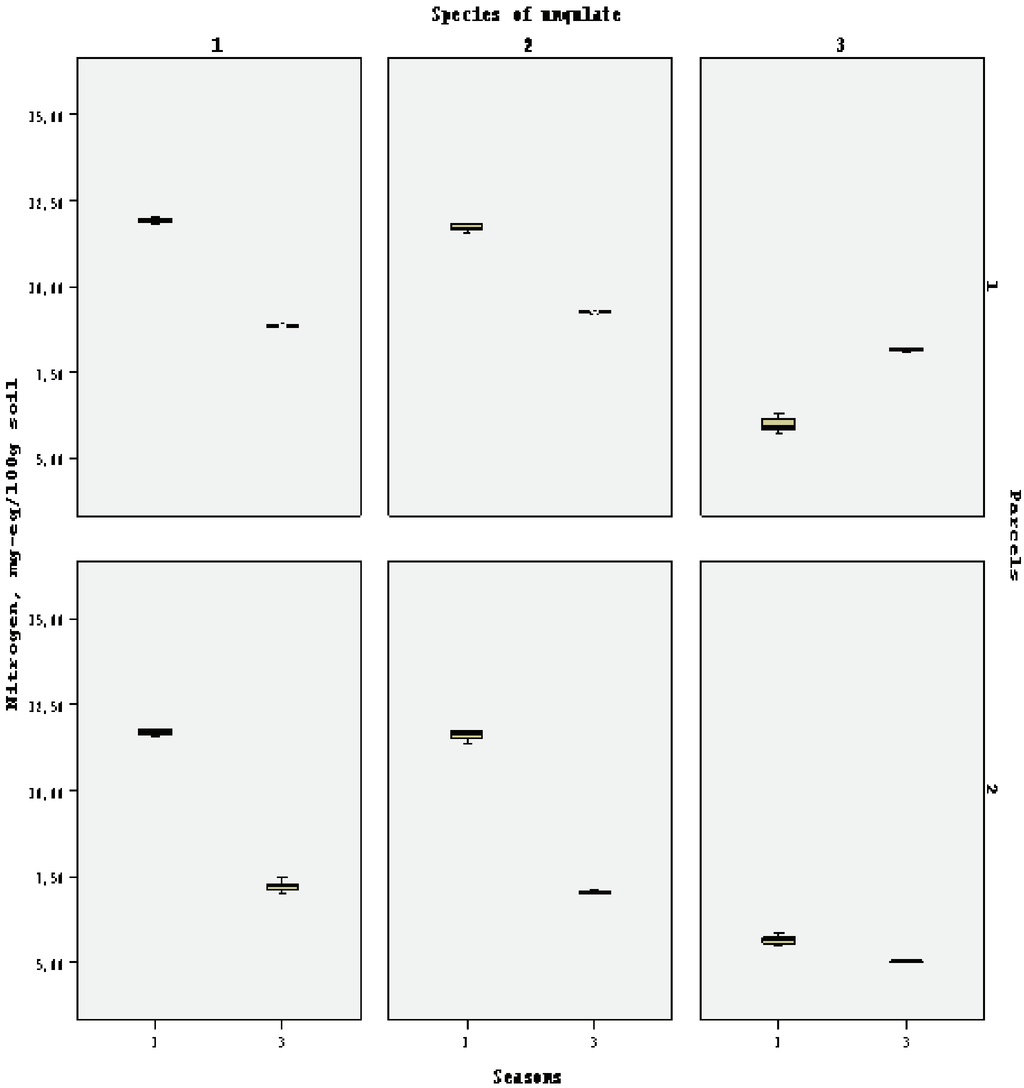

Fig. 3. Dynamics of average nitrogen content under deer feces (1) and fallow deer feces (2) compared with controls (3) in different seasons of 2011 in meadow and steppe parcels of ASNNP. Species of ungulates: deer – 1; fallow deer – 2; control – 3. Parcels: steppe – 1; meadow – 2. Seasons: Spring – 1; Fall – 3.

Spring 2011 showed the following changes in the amount of nitrogen in the soil. The impact of deer feces in the steppe changed the amount of nitrogen to 12.57±0.358 mg-eq/100 g of soil, SD – (11.8–15.31) in a meadow 12.4±0.38 mg-eq/100 g of soil, SD – (11.58–15.28). The amount of nitrogen in the meadow is only 0.17 mg-eq/100 g less and is not significant. Under the influence of fallow deer feces in the steppe the nitrogen concentration was 12.47±0.38 mg-eq/100 g of soil, SD – (11.74–14.86) and meadow concentration was equal 12.22±1.339 mg-eq/100 g of soil, SD – (11.36–14.81) (Fig. 3). The difference between the parcels was only 2%. We consider it necessary to note that after 2.5 years after the start of the experiment difference in nitrogen content under different ungulate feces is almost negligible.

Control samples contained the amount of nitrogen equal 5.97±0.06 in the steppe at SD – (5.71–6.31) and 5.66±0.03 mg-eq/100 g of soil, in the meadow, SD – (5.5–5.86) respectively (Fig. 3). The difference between controls of meadow and steppe parcels comprised 5.2% or 0.31 mg. Test samples indicate that under the influence of deer excreta nitrogen stock has increased by 54.9% in the steppe and by 54.3% in the meadows. Under the influence of fallow deer these figures were respectively 51.8% and 53.69%. So the species difference in the amount of introduced nitrogen is not substantial. In the spring of 2011, after 2.5 years after the start of the experiment, the first decreasing in the concentration of nitrogen at excrement from the previous season was registered. In the steppe, under the influence of deer excreta the amount of nitrogen was 50.1% and 63.23% in the meadows. Under the influence of fallow deer excreta in the steppe concentration of nitrogen from the previous season was 31.8%, 52.7% in the meadows respectively. These figures are significant and indicate, in our view, the impact of partial suspension of solid feces on the ground, due to the total or partial destruction of them.

In the autumn of 2011 under the influence of deer excretions the concentration of nitrogen in the steppe has made 8.87±0.01 mg-eq/100 g of soil, SD – (8.76–8.97) and meadows 7.25±0.04 mg-eq/100 g of soil, SD – (7–7.48), with a difference of 1.24% between parcels. Under the fallow deer feces, the amount of soil nitrogen in the steppe amounted to 9.27±0.01 mg-eq/100 g of soil, SD – (9.21–9.38), while the meadows reached 7.05±0.007 mg-eq/100 g of soil, SD – (7.02–7.1), the difference between the parcels was 24%. Control soil samples had the following parameters: steppe – 8.15±0.033 mg-eq/100 g of soil, SD – (8.1–8.19), meadow – 5.04±0.026 mg-eq/100 g of soil, SD – (5–5.08) (Fig. 3). Difference between the parcels of control areas amounted to 38.1%. This season (fall of 2011), the difference between control and experiment is significant. In the steppe the nitrogen concentration exceeds the benchmarks by only 8.1% under the deer feces and 12% under the fallow deer feces. In the meadows, this difference was significant and 30.4% for deer and 28.5% for fallow deer.

In the spring 2011 we noted that on pilot sites the nitrogen supply exceeds autumn one. Spring, in our opinion, exceeds the fall for the following reasons: lack of extremely high solar activity and high temperature and soil moisture levels and normal rainfall, humidity.

Autumn period of 2011 was characterized by the decrease of nitrogen as compared to spring on experimental grounds. Control samples showed an increase nitrogen stocks in soil in the fall. Clearly marked increase happened in the steppe, while in the meadow it was not so noticeable.

The dynamics of nitrogen concentrations in the soil of ASNNP for the 3 year period (2009–2011) had a parabolic increase. Parabola (the concentration of nitrogen) had its roots in the spring of 2009 and was growing up to the fall of 2010, then went into decline until the fall of 2011 (Fig. 4). The total dynamics of soil nitrogen change showed a gradual increase under excreta of ungulates in the course of the first 2 years after computations of the excrements. After that nitrogen stock began to decline sharply, by more than 50% of the maximum recorded in the first 2 years, almost to the end of the experiment (Fig. 4). Control soil samples also had some changes in concentration toward growth, although these changes are not comparable with the experimental sites.

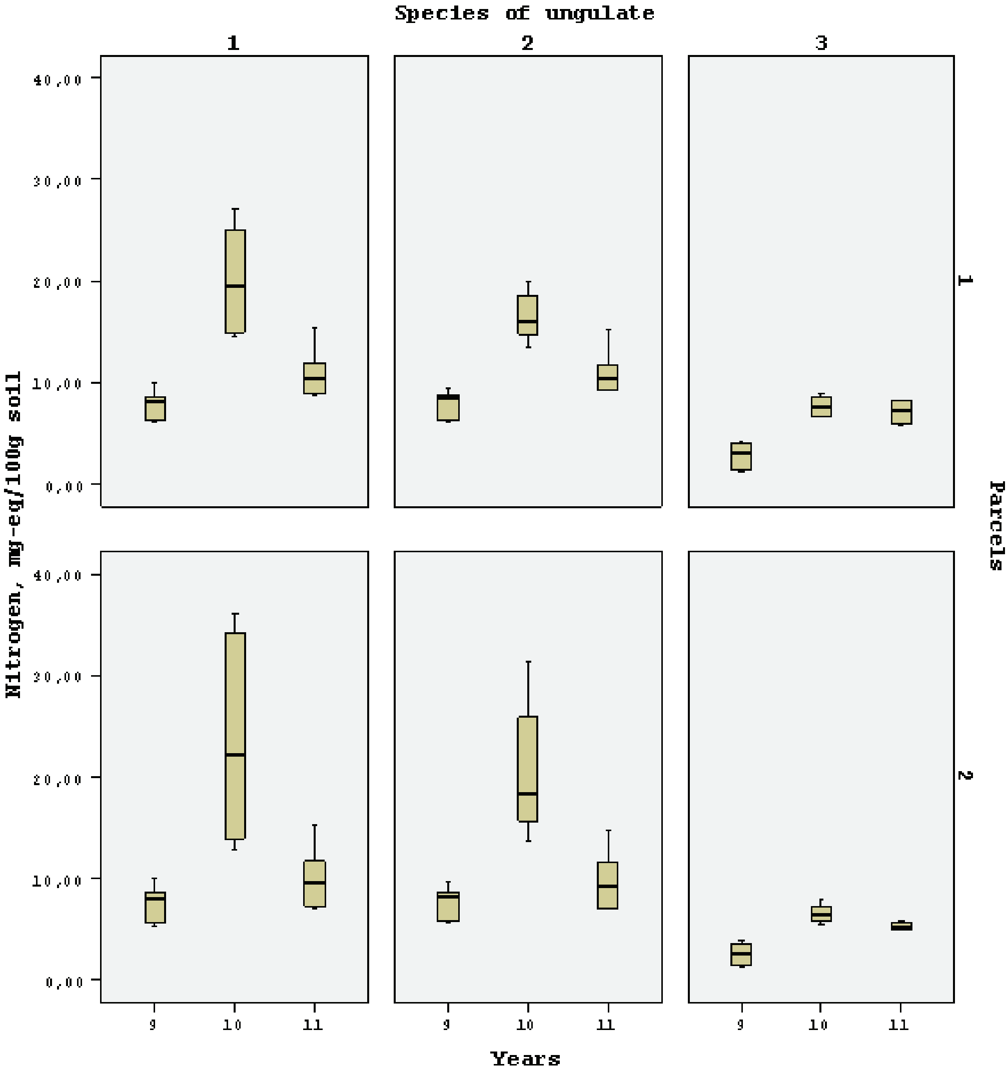

Fig. 4. Dynamics of average nitrogen content under deer feces (1) and fallow deer feces (2) compared with controls (3) during 2009–2011 in meadow and steppe parcels of ASNNP. Species of ungulates: deer – 1; fallow deer – 2; control – 3. Parcels: steppe – 1; meadow – 2. Years: 2009 – 9; 2010 – 10; 2011 – 11.

The destruction of ungulates` solid excreta under the influence of biotic and abiotic factors occurs within 3 years. During this period the soil gets extra nitrogen. Its concentration reaches maximum in the second year.

The average content of soil nitrogen under the European fallow deer and red deer excreta for the entire period of study has significantly (p=0.05) increased more than twice as compared to control.

The quantities of nitrogen in soil under the European fallow deer and red deer excreta are statistically different. The average amount of it is 12.3±0.43 mg-eq/100 g of soil and 13.4±0.61 mg-eq/100 g of soil respectively.

The concentration of nitrogen in the control samples also varied during the period of research. Compared to 2009, the average concentration of nitrogen in soil has increased by 62.6% in 2010, and in 2011 it dropped to 12.6%. The change of nitrogen concentration in control samples is a consequence of a big amount of precipitation, partial flooding by ground waters and the amount of phytomass, which, in our opinion, led to the change.

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ЗООГЕННИЙ ВПЛИВ НА ВМІСТ ҐРУНТОВОГО АЗОТУ В АЗОВО-СИВАСЬКОМУ НАЦІОНАЛЬНОМУ ПРИРОДНОМУ ПАРКУ

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У статті розглядається вплив великих ратичних тварин на кількісні зміни азоту у ґрунті. Проведено експеримент зі збору та викладу твердих екскрецій двох головних популяцій великих ратичних у двох головних парцелах на території досліджень. Надалі кожні півроку (навесні та восени) проводився відбір і аналіз ґрунту під впливом екскрементів та без їх впливу. Показано динаміку концентрації азоту під екскреціями оленя та лані протягом трьох років. Проведено статистичний обрахунок і аналіз отриманих даних.

Ключові слова: азот, екскременти, ратичні, зоогенний вплив, парцели.

ЗООГЕННОЕ ВЛИЯНИЕ НА СОДЕРЖАНИЕ ПОЧВЕННОГО АЗОТА В АЗОВО-СИВАШСКОМ НАЦИОНАЛЬНОМ ПРИРОДНОМ ПАРКЕ

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В статье рассматривается влияние больших копытных животных на количественные изменения азота в почве. Проведен эксперимент по сбору и выкладке твердых экскреций двух основных популяций копытных в двух доминантных парцеллах на территории исследования. Далее каждые полгода (весной и осенью) проводился отбор и анализ земли под влиянием экскрементов и без них. Показана динамика концентрации азота под экскрементами оленя и лани на протяжении трех лет. Проведен статистический обсчет данных и анализ полученного материала.

Ключевые слова: азот, экскременты, копытные, зоогенное влияние, парцеллы.