International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-9 Issue-1, October, 2019

Application of Innovative Aerospace Technologies for Pastoral Farming of Sheeps

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Abstract*: *Development of an innovative system of livestock husbandry based on the use of digital aerospace technologies and telemetry is a new modern direction in the development of the livestock industry, designed to solve the many problems of restoring fertility of soil and pasture for animals. To develop a methodology for remote assessment of pasture fertility, we used the technological capabilities of using unmanned aerial vehicles and satellite service, which allows us to study the dynamics of the NDVI (Normalized Difference Vegetation Index) of various pasture plots in the Stavropol Territory of the Russian Federation. The analysis of literary sources shows that the main problems associated with the complex automation of forecasting processes for complex objects are not technical, but methodological in nature and are caused by the lack of a theoretical base that should form the basis for creating the corresponding model and algorithmic support. A comparison of the results of a prognostic assessment of the nutritional value of fodder plants obtained from unmanned aerial vehicle (UAV) images, space services with actual nutritional values obtained from studies of the zoochemical composition of feeds showed a high degree of correlation. The UAV capabilities were recognized as promising for assessing the ethological characteristics of the Manych merino sheep, which allows to optimize the acquisition of groups of animals consolidated by forage activity. The article considers the issues of assessing the nutritional value of pasture feed and the vegetation index when raising sheep of the Jalgin merino breed in the conditions of the steppe regions of the Stavropol Territory. The introduction of remote assessment methods in pastoral livestock can optimize the cultivation of various sex and age groups of sheep and reduce the time to achieve production parameters by 5-8%.

Keywords* : *pasture feed, remote monitoring, vegetation index, pasture, productivity, sheep of the Jalgin merino breed.

I. INTRODUCTION

The study of agricultural territories at the present stage involves the widespread use of aerospace monitoring. The use of satellite photographs and images from the technological equipment of unmanned aerial vehicles includes the tasks of quickly obtaining information about the composition and condition of crops, potential yields, diseases and damage to crops by pests, and the tasks of inventorying land resources, estimating biomass, studying the dynamics of agricultural land use [10].

Among the main areas of using unmanned aerial photography for agricultural purposes, the most promising are the following areas: building digital elevation models, analyzing heterogeneity of land fertility by spectral characteristics, monitoring the operation of drainage systems, assessing variability of crops by vegetative indices, and revealing damage to vegetation from external influences [9].

An important advantage of distance materials obtained during aerospace surveys is, first of all, the scale, uniformity and comparability of data obtained for vast territories, great visibility, modernity and permanency, which are decisive factors for the fulfillment of the above tasks. The development of an innovative system of livestock husbandry based on the use of digital aerospace technologies and telemetry is a new modern direction in the development of the livestock industry of the countries of the Eurasian Economic Union (EAEU), designed to solve the many problems of restoration of soil and pasture fertility for animals.

To characterize the vegetation cover, various vegetation indices (VI, NDVI, EVI) are used, which are obtained based on the analysis of spectral brightness in the red and near infrared zones [3-7]. The main assumption on the use of vegetation indices is that some mathematical operations with different remote sensing channels can provide useful information about vegetation. This is supported by a wealth of empirical evidence. The second assumption is the idea that the open soil in the image will form a straight line (soil line) in the spectral space. Almost all common vegetative indices use only the ratio of red - near infrared channels, suggesting that in the near infrared region lies the line of open soil. It is understood that this line means zero amount of vegetation. The first reflection-based vegetation index was the index of reflection coefficients (Ratio VI, RVI), later this index was improved and named as the difference normalized vegetation vegetation index - NDVI. A number of researchers studied the question of which spectral channels are most suitable for characterizing individual biophysical parameters of agricultural crops. Spectral measurements were made of the reflectivity of cotton, potatoes, soybeans, corn and sunflower. The characteristics considered included biomass, leaf index, plant height [8].

Revised Manuscript Received on October 30, 2019.
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It was established that the strongest relationship with the characteristics of crops was observed in the narrow ranges of red (650-700 nm), green (500-550 nm) and near infrared (900-940 nm). The center of sensitivity to humidity is located at 982 nm.

Recently, accurate remote positioning systems have become more and more firmly part of the system of grazing, helping to optimize production processes and terms of pasture use, which can significantly affect the efficiency of restoration of pasture fertility for grazing large volumes of farm animals and the application of aerospace monitoring data in the livestock industry [9].

Thus, modern approaches to the development of an innovative system of livestock husbandry should include monitoring the nutritional value and amino acid composition of feed in combination with the use of digital aerospace technologies and telemetry.

II. MATERIALS AND METHODS

Studies were conducted in centers of collective use:

Collective Use Center "Educational Scientific Testing Laboratory (ESTL)",

The collective use center “STC Feed and Metabolism” and using the unique scientific installation “Laboratory of Breeding Quality Control of Milk” on the basis of FSBEI HE “Stavropol State Agrarian University”.

Object of foreign infrastructure: Testing center of LLP "Kazakh Research Institute of Livestock and Feed Production"

Unique scientific setting:

UNU Integrated geophysical information-measuring system of the Kabardino-Balkarian State University. H.M. BERBEKOVA (UNU: KGFIIS KBSU)

The question of the use of remote assessment of the nutritional value of pasture feeds and the vegetation index when raising sheep of the Jalgin merino breed remains poorly studied, since these animals are characterized by outstanding meat qualities and are adapted for growing conditions in the arid zone of the Stavropol Territory.

Pasture forages for research were selected during the period of the main vegetation of plants (June-July) and studied by standard generally accepted methods. The chemical composition of the feed (crude protein, crude fiber, crude fat, crude ash, calcium, phosphorus, amino acid composition) and moisture were determined using equipment from INGOS (Czech Republic), FIBRETHERM (Germany), VELP SCIENTIFICA (Italy) in the STC “Feed and metabolism ”(accreditation certificate No.ROSS RU.0001.21PU12 dated 10.28.2014).

Crude feed protein was determined by ashing the organic matter of the analyzed sample with sulfuric acid in the presence of a catalyst, alkalizing the reaction product, distilling and titrating the ammonia released, calculating the mass fraction of nitrogen and calculating the mass fraction of crude protein by multiplying the result by the conversion factor for the mass fraction of nitrogen by the mass fraction of crude a protein of 6.25 (Kjeldahl) [10].

Crude fiber was determined (according to Genneberg and Shtoman) by a method based on sequential processing of a sample of a test sample with acid and alkali solutions, ashing and quantitative determination of the organic residue by a gravimetric method. Crude fiber content is expressed as mass fraction in% or in grams per 1 kg of dry matter. Crude fat in the feed was determined by extraction of crude fat from a sample with diethyl or petroleum ether in a Soxhlet apparatus. removing the solvent and weighing the fat-free residue. Crude ash in the feed was determined by determining the mass of the residue after burning and subsequent calcination of the sample. Calcium in feed was determined by the method of ashing the organics of the analyzed sample, treating the resulting ash with a solution of hydrochloric acid, precipitating calcium in the form of calcium oxalate, followed by dissolving the precipitate with a solution of sulfuric acid to form oxalic acid, which is titrated with potassium permanganate. Phosphorus in feeds was determined by dry ashing of a sample with calcium carbonate and heating the residue with hydrochloric and nitric acids (for organic feed) or in wet ashing of a sample with a mixture of sulfuric and nitric acids (for mineral compounds and liquid feed). An aliquot of the hydrolyzate is mixed with molybdovanadate reagent and the optical density of the resulting yellow solution is measured at a wavelength of 430 nm.

Groups of animals for research were formed on the basis of analogue pairs from young animals of the Jalgin merino sheep fattening group. The number of young fattening sheep in each group was 100 animals; the animals were 6 months old. The control period for growing experimental animals was 60 days.

In our studies, groups of sheep grazed on pastures, the botanical composition of which consisted of leguminous-cereal plants (25: 75%): onobrychis, medicago, festucapratensis, loliumperenne. Determination of live weight of experimental young animals was carried out by standard zootechnical method by weighing. The study of pasture ecosystems was carried out using an AS-32-10 unmanned aerial vehicle and a DJI 900 hexacopter, a Canon M10 camera and vegetation index calculation software (NDVI).

III. RESULTS AND DISCUSSION

Currently, there is no mowing process of natural pasture grass on the farms, which affects the reduction of the biological diversity of the grass stand and can lead to its reduction in 10-60 years by 50-60%

In the Stavropol Territory, the area of degraded pastures is more than 190 thousand ha, 290 thousand ha and 50 thousand ha of hayfields are subject to water and wind erosion. Table 1 presents data on the productivity of the grass stand with systemic and unsystematic grazing of animals.

Table –I: Yield of pasture grassland depending on the type of animal grazing

Option	Sheep load, heads / ha		Dry matter yield after grazing, kg / ha
	optimal	actual	
System grazing	1,5-2,0	1,5-2,0	3-3,5
Haphazard grazing	1,5-2,0	12,0-15,0	0,4-0,7

According to the table, it is clear that the systemic grazing of animals allows more efficient use of pasture productivity.

To improve the productivity of pasture lands, it is necessary to carry out their reclamation, including both biological and technical measures. Remote methods for assessing pasture fertility provide systematic and objective data on soil fertility and reduce physical and material costs for land surveys.

In modern conditions, the task is set to intensify pastoral livestock raising in order to ensure at least 70% of the annual animal nutrient requirement due to grazing feed, including the consumption of digestible protein. Due to the unstable dynamics of the climatic conditions of recent years, remote assessment methods for pasture fertility based on the use of aerospace monitoring are of particular importance, which will increase the efficiency of pasture land use in the region and increase the economic attractiveness of the industry.

Figure 1 presents the dynamics of changes in the vegetation index for the period from 02/02/2018 to 02/02/2018. The data were calculated using the regression equation:

y = 1E-13x6 - 9E-11x5 + 3E-08x4 - 3E-06x3 - 6E-05x2 + 0.0174x - 0.002,

where y is NDVI, x - days from the start date (February 2, 2018).

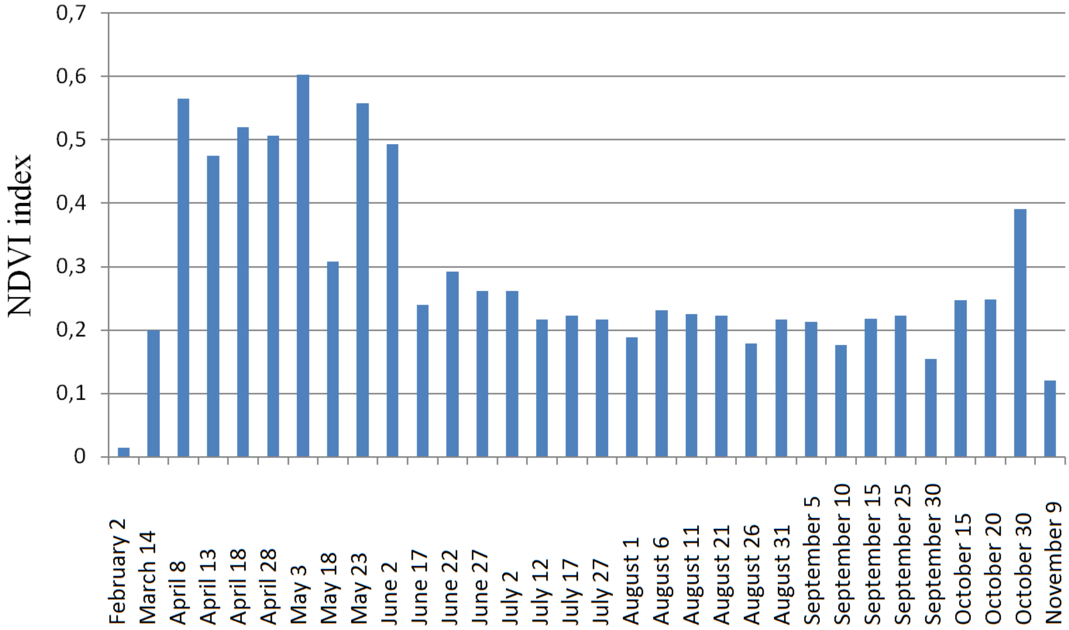

Fig. 1. Averaged NDVI values taking into account areal coefficients

The results of the studies showed that there is a correlative relationship between the values of the vegetation index (NDVI) and the main parameters of feed quality (Table II).

Table –II: Nutritional value of pasture feed, M ± m

Indicator	Value NDVI		
	0,41	0,61	Average
Crude protein,%	2,90±0,03	4,55±0,03	3,72±0,83
Total humidity%	31,49±5,45	42,97±4,92	37,23±5,74
Crude fiber,%	25,78±1,79	18,13±0,91	21,95±3,83
Crude fat,%	1,39±0,03	1,75±0,29	1,57±0,18
Crude ash,%	3,36±0,04	3,84±0,27	3,60±0,24
Calcium%	0,39±0,01	0,41±0,01	0,40±0,01
Phosphorus,%	0,23±0,01	0,20±0,03	0,22±0,01

Evaluation of the effectiveness of growing sheep in experimental groups allowed us to determine the optimal range of dynamics of the NDVI index, which is 0.41-0.61. Repairing young sheep should preferably be grazed on pastures whose vegetation index is not lower than 0.60. Moreover, the vegetative index NDVI adequately reflects the accumulation of nutrients in plants, which coincides with the studies of Prasad S. [9]. In our opinion, the measurement range of the vegetation index 500-550 nm accurately reflects the change in the nutritional value of pasture plants. It is advisable to select the optimal pasture area to reduce labor costs and conduct remote assessment of the condition of pasture feeds using unmanned aerial vehicles, for example, an aircraft type AC-32-10 or a DJI 900 hexacopter, which are equipped with a Canon M10 camera and software for calculating the vegetation index (NDVI).

Thus, carrying out sheep breeding in accordance with the developed production program that excludes unsystematic use of pastures will allow raising animals more efficiently (Table III).

Table III - Productive quality of the repair young stock 4-6 months, M ± m

Indicator	Group	
	I	II
Average live weight at the beginning of the experiment, kg	23,57±0,56	23,81±0,48

Average live weight at the end of the experiment, kg	34,29±1,12	35,27±1,15
Average daily weight gain, g	178,6±4,1	191,0±3,8

The group of young sheep, which was raised on a pasture plot with a vegetation index of 0.61, showed a growth energy of 7.0% higher compared to the control group.

According to the results of studies, it was found that when rearing young Jalgin merino sheep, it is advisable to use remote methods for determining the vegetation index using unmanned aerial vehicles, such as an aircraft type AC-32-10 or a DJI 900 hexacopter, which are equipped with a Canon M10 camera and software to calculate the vegetation index (NDVI). When choosing a pasture site for rearing young sheep, it is advisable to use areas with a vegetation index of NDVI of 0.6, which will allow animals to realize a genetically determined development potential of 187-195 g of average daily gain in live weight.

IV. CONCLUSION

Proper organization of sheep grazing will significantly reduce the costs of sheep husbandry for a given period and increase the productivity of pasture land use, but it is necessary to strictly adhere to certain rules on the use of natural pastures, compliance with which will extend the productivity of the pasture.

The organization of a new direction in grazing livestock based on the use of an innovative remote monitoring methodology using aerospace digital technologies will accelerate the intensification of grazing livestock, increase the growth energy of animals by 12-15%, and will contribute to the production of additional products.

The economic efficiency of using remote aerospace monitoring to improve the biological productivity of pasture territories will allow to achieve pasture productivity at the level of 17-20 kg / ha and additionally receive 3-4 kg of pasture fodder per 1 ha and get an additional 1-1.2 kg of feed units from 1 ha.

ACKNOWLEDGMENT

The work was supported by the Ministry of Education and Science of the Russian Federation; electronic budget agreement number 075-02-208-920; internal agreement number 14.613.21.0081; 14.613.21.0081 and the Russian Ministry of Education dated November 22, 2017; unique work identifier: RFMEFI61317X0081 R&D registration number AAAA- A18-118040390089-9.

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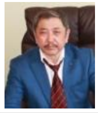

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