Bulgarian Journal of Agricultural Science, 26 (No 6) 2020, 1286–1291

Innovative methods in study of animal's conformation

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Abstract

Batanov, S. D., Baranova, I. & Starostina, O. (2020). Innovative methods in study of animal's conformation. *Bulg. J. Agric. Sci., 26 (6)*, 1986–1291

The analysis of milk productivity, examination of conformation traits and measuring the exterior parameters of the cattle play a significant role in the improvement of genetic potential of animal's productive qualities and creation of high-yielding herds. The article dwells on the objective assessment values of cow conformation obtained by the contact method and presents a method for animals' conformation study using digital technologies. The correlation between the conformation parameters and cattle productivity was revealed. A new approach to conformation assessment was introduced and non-contact methods for measuring main body constitution parameters were analyzed. The values of conformation parameters were obtained by processing the photo image of an animal and through the use of the depth sensor. Basic body measurements (height at withers, height at rump, chest depth, chest width, rump width, rump length, body length, metacarpus girth) were taken in the production environment. They were determined with the accuracy up to 1 mm and an error of about 2%. The experimental findings demonstrate that these techniques may be considered as an innovative method of non-contact measuring of cattle conformation traits. A positive correlation between the conformation body built index and measurements characterizing the degree of body development of the animal (body length, chest width, chest depth, rump length, and rump width) was revealed to vary within the range 0.13–0.52. The correlation between the milk yield, quality indicators of milk and conformation traits was weak or absent (r = from -0.34 to +0.25). A weak (0.19) positive correlation between the conformation body built index and productivity index was observed.

Keywords: contact and non-contact methods; constitution index of cows; exterior; selection and genetic parameters; milk productivity of cows

Introduction

An intensive technology of milk production places high demands not only on the level of cow productivity but also on their physical and physiological conformity to industrial technologies. In dairy farming much attention is given to the assessment of animal conformation as the external appearance and inner properties are closely related to productive and reproductive qualities of the constitution (Abugaliev et al., 2017; Konstandoglo et al., 2017; Lepekhina et al., 2018; Basonov et al., 2018; Batanov et al., 2019).

Studying of the constitution and exterior is important for an animal technician to understand the basis on which biological make-up and production efficiency are developing, as well as advantages and disadvantages, to notice the signs of body composition weakening, and to identify the breeding value of the animal (Brade, 2017; Conte et al., 2017; Basonov et al., 2018; Batanov et al., 2018).

Body exterior examination is based on three main principles:

- animal productivity and its level are reflected into the constitutional peculiarities;

- exterior traits correlate between each other and the development of internal parts of the body;
- peculiarities of exterior traits depend on breed characteristics of the animal (Batanov et al., 2018; 2019).

Therefore, a conformation type as an external manifestation of animal constitution should be considered in all complexity of its interrelation with productive qualities from the position of the body integrity. The type of animals is related to their health status and productivity (Zubriyanov et al., 2001; Babylova & Berezina, 2014; Basonov et al., 2018).

Nowadays an increased attention is being given to the issues of constitution examination and assessment in the countries with developed dairy farming. In the early 1980s a whole new scoring system of dairy cow conformation assessment was introduced in the USA, Canada and West European countries. This system put into practice new principles of subjective visual appraisal of animal constitution, defined the model type of a dairy cow, reduced the influence of appraiser's subjective assessment, created the basis for servicing bull assessment by the conformation traits of their daughters, and standardized assessment by the conformation traits at the country level (Prozherin et al., 2008; Kharitonov et al., 2011).

The assessment of livestock conformation is performed using the following methods of subjective and objective methods:

- methods of visual assessment include free visual assessment, diagram assessment (scoring) and linear assessment of the conformation type;
- objective assessment methods include animal measuring and statistical processing of obtained values (indices of body constitution, outline diagram) and photographing.

In zootechnical practice a greater importance is being attached to photographic images of animals. Herewith, the photos of animals are often used for advertising purposes (Holloway, 2005; Kharitonov et al., 2011; Furaeve & Vorobyeva, 2014).

With the use of the scientific approach and digital technologies, the photo can provide a precise reflection of the reality.

Every year over 500 million heads of cattle is appraised for their breeding value, conformation traits, health and prospects of their use. Herewith, the majority of measurements and the conformation assessment itself is a labor-consuming and subjective process (Valitov & Karamaev, 2012; Mishkhozhev et al., 2017; Basonov et al., 2018; Batanov et al., 2018).

A traditional approach to animal assessment is based on the visual examination, manual assessment, and, as a rule, contact measuring. So, today expert scores are formed by professionals (appraisers) with due account of available linear measurements. The accuracy of such appraisals is determined by subjective reasons (Prozherin et al., 2008; Halachmi et al., 2008; Kharitonov et al., 2011; Huang et al., 2018; Sun et al., 2019; Shi et al., 2019).

Therefore, the development of the comprehensive assessment system for animal conformation with the use of depth sensor is relevant and of scientific and practical significance.

In view of this, the purpose of our study was to analyze the findings of the objective assessment of cow conformation obtained by the contact method and develop the method to study the animal conformation using digital technologies, as well as to reveal the interrelation between conformation traits and productivity of animals.

Material and Methods

The two-phase experimental research (2018–2019) was held on Kholmogory breed cows at the stud farm Put'Ilicha JSC, Zavyalovo District, Udmurt Republic. The size of animal selection was 159 cows.

Phase I. In the period from the 90th to 150th lactation days the animals were assessed through the measurements and calculation of the body built index. We selected the following measurements: height at withers, chest depth, chest width, rump width, rump length, body length, and metacarpus girth. The specified measurements provide the most accurate characteristics of the animal dimensions (carcass). For a more complete assessment of the animal's conformation type, the body built index was calculated according to the formula developed by S. D. Batanov and I. A. Baranova:

$$\mathrm{BBI} = \frac{\sqrt[4]{V_{\text{animal's body}} \cdot MG}}{HW}, \tag{1}$$

where the volume of animal body is calculated according to the formula of truncated pyramid:

$$V_{\text{animal's body}} = \frac{1}{3} \cdot BL \cdot \Big((RW \cdot RL) + \sqrt{CD \cdot CW \cdot RW \cdot RL} + (CW \cdot CD) \Big),$$

where *BBI* – body built index; *BL* – body length, *RW* – rump width, *RL* – rump length, *CD* – chest depth, *CW* – chest width, *MG* – metacarpus girth, *HW* – height at withers, cm.

Three methods were used to obtain conformation parameters. The first method was contract measuring. In this case measurements were taken with measuring tools (measuring tape, measuring stick and compasses).

The second method involves measuring of cows' points using their images (photos).

Determination of body measurements of the cows by their photo image was made with the use of the perspectometer with known dimensions in the photo. We used the measuring stick as the perspectometer. The photo image was taken with a tripod-mounted high-resolution camera Canon EOS 6D (20 mp) using the focusing screen grid. The specified function allows leveling the taken image against the screen. This way the animal image in three views (side view, front view and back view) was obtained. For the side view the cow was placed parallel to the camera, for two other views – perpendicular.

The obtained images were processed in the graphic editor in the following manner. We identified the limits of the perspectometer and studied parameters and drew lines between them (Figure 1).

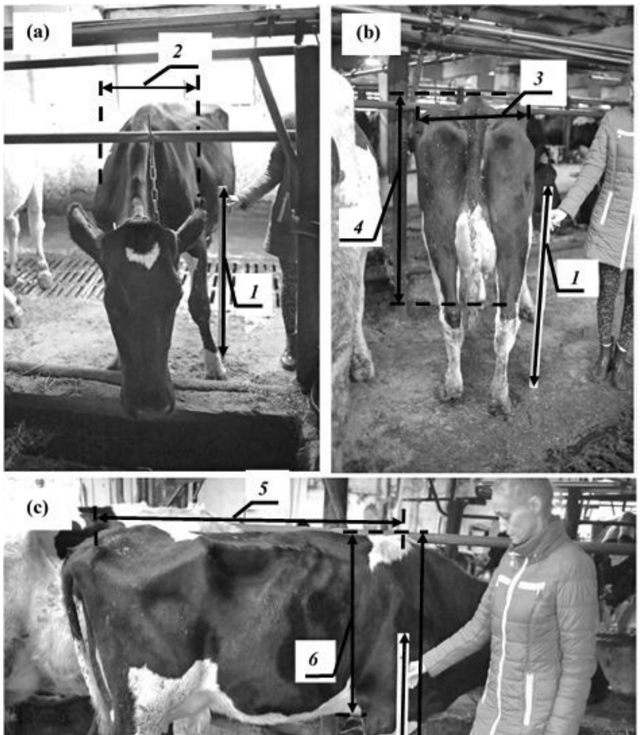

Fig. 1. Diagram of measurements taken from photos: a) front view; b) back view; c) side view; where: 1) perspectometer; 2) chest width; 3) rump width; 4) rump length; 5) body length; 6) chest depth; 7) height at withers; 8) metacarpus girth

This way we obtained the required measurements in pixels. The actual dimensions of conformation parameters were calculated according to the formula:

$$L = \frac{s_2 \cdot l}{s_1}, \qquad (2),$$

where l – perspectometer length, cm; s_1– perspectometer size in pixelss_2–object size in pixels. The line length in pixels was calculated as the hypotenuse of the right-angled triangle, legs of which make the length and width of the distinguished area when identifying the measurement from the photo.

The third method of conformation parameter measuring includes the processing of depth images obtained with Structure Sensor 3D (Occipital Structure Sensor 3D-scanner). The depth sensor is a camera that is attached to the tablet and allows capturing 3D-image of objects. Besides the camera the device comprises the infrared laser, sensor and special backlight. The infrared laser projects a dotted pattern (invisible for a human eye) on objects within the distance of 3.5 meters, and the infrared sensor concurrently record the pattern distortion. Thus, a depth map for the scene and objects on it is created. The pattern is supplemented with the photo image from the camera, which provides 3D models of the objects and the surrounding space. The sensor software allows obtaining the information on the distance between objects, distance from the camera to the object and determining any linear dimension of the object on a real-time basis. The main significant advantage of the depth sensor is that it allows determining dimensions of the object without the use of the perspectometer; it may be made with the involvement of the minimum number of people and reduces the stress level in animals. The obtained model provided all necessary conformation parameters.

Phase II. Milk productivity was assessed by such indicators as milk yield over 305 days of the last completed lactation (MY), mass fraction of fat and mass fraction of protein. The productivity index was calculated using these indicators according to formula (3):

$$PI = \frac{MY \cdot (MFFa + MFPa)}{MFFb + MFPa}, \qquad (3)$$

where *MFFa* – actual mass fraction of fat, %; *MFPa* – actual mass fraction of protein, %; *MFFb* – basis mass fraction of milk fat (3.4%); *MFPb* – basis mass fraction of milk protein (3.0%).

The initial data were used to calculate the selection and genetic parameters of cow's conformation and productivity within the studied population. The correlation factor was calculated to determine the relation between all conformation assessment parameters, body built type and milk productivity of the animals.

Results

The parameters obtained in the study of conformation traits in the cow population by the above-mentioned methods are given in Table 1.

When assessing the exterior of animals, it should be generally noted that the cows have a strong core muscles, good parameters of the height, properly positioned fore and hind limbs. The animals are noted for high adaptation to the production process. The conformation development in the studied cow population is rather balanced and the variability of the study parameter is within the range 3.56–8.87%. However, it should be noted that there are no significant differences in the values of conformation assessment parameters obtained by different methods except for the metacarpus girth measurement, the deviation in which is 4.41% ($P < 0.01$) and 3.43% ($P < 0.05$) (Tables 1 and 2). The measurement "metacarpus girth" characterizes the degree of carcass development and may be considered as one of the most difficult to measure, so the obtained results have a relatively high margin of error (4.41% and 3.43%). As for other tested conformation parameters, the error in the value of obtained measurements between methods 1 and 2 vary from 1.04% to 2.51%, and between methods 1 and 3: 0.97% to 3.62%, respectively (Table 2). The analysis of Table 2 demonstrates that the measurement error between the contact method and method of photo image processing, as well as between the contact method and method of measurements obtained with the depth sensor does not exceed 5%.

Table 1.Values of exterior parameters obtained through three different methods

Indicator	$\bar{x} + \Delta\bar{x}$, cm	Lim min-max, cm	Cv, %
Contact method (Measurements)			
Height at withers	138.70±0.66	(131.00-148.00)	3.60
Body length	147.40±0.93	(132.00-172.00)	4.70
Chest depth	84.30±0.62	(75.00-94.00)	5.54
Chest width	52.40±0.31	(46.00-57.00)	4.60
Rump width	67.60±0.59	(60.00-79.00)	6.74
Rump length	113.20±0.61	(99.00-119.00)	4.23
Metacarpus girth	20.40±0.11	(19.00-22.00)	3.90
Photo image processing			
Height at withers	141.80±0.69	(130.50-151.00)	3.69
Body length	145.86±0.91	(127.10-160.00)	4.69
Chest depth	82.18±0.59	(72.40-92.30)	5.47
Chest width	51.20±0.47	(44.40-59.00)	6.86
Rump width	65.90±0.74	(54.50-79.00)	8.42
Rump length	111.40±0.92	(96.40-129.30)	6.23
Metacarpus girth	21.30±0.16**	(16.70-24.20)	5.80
Processing of depth images from depth sensor			
Height at withers	141.10±0.67	(130.20-148.50)	3.56
Body length	145.72±0.87	(135.30-162.00)	4.50
Chest depth	81.60±0.77	(71.20-89.60)	7.19
Chest width	50.50±0.50	(44.00-57.00)	7.58
Rump width	66.00±0.81	(55.80-77.00)	8.87
Rump length	112.10±0.60	(107-120.00)	3.99
Metacarpus girth	21.10±0.23*	(17.90-24.00)	8.27

* $P < 0.05$; ** $P < 0.01$

Table 2. Relative error in measurements of exterior parameters obtained by contact method, method of photo image processing and with depth sensor

Parameter	Relative error of exterior parameters obtained by a contact method and image processing method, %	Relative error of exterior parameters obtained by a contact method and depth sensor, %
Height at withers	2.24	1.73
Body length	1.04	1.14
Chest depth	2.51	3.20
Chest width	2.29	3.62
Rump width	2.51	2.37
Rump length	1.59	0.97
Metacarpus girth	4.41	3.43

Therefore, the analysis of the obtained results suggests the feasibility of digital technologies implementation and new methods for measuring conformation parameters in the production environment. Non-contact methods allow for the high accuracy of linear measurements (up to mm); they are less time-consuming and less stressful for animals.

The primary criterion for the assessment of biological make-up of dairy cattle is the level of milk productivity and quality indicators of milk. Selection and genetic parameters of milk productivity and cow's body constitution indicators are presented in Table 3.

The study of milk productivity in the cumulative sample demonstrated that in the Kholmogory breed population the milk yield for 305 lactation days is rather high (7242.73 kg) with the fat and protein content in milk amounted to 3.85% and 3.08% respectively. The productivity index was 7847.82 kg.

The variability of exterior characteristics was assessed by individual evaluation of animals, which cumulatively characterized the level of cattle population development according to the studied indicators. The most objective indicator of the sign variability is the variability coefficient, as due to the fact that it is expressed as a percentage, it is universal for any parameter.

The data analysis demonstrates that the parameters of dairy

Table 3. Selection and genetic parameters of milk productivity and cows' body constitution indicators

Indicator		Lim min-max	Cv, %
Milk yield for 305 lactation days, kg	7249.73±97.95	(4513–11600)	17.04
Mass fraction of fat, %	3.85±0.02	(3.4-5.07)	5.04
Mass fraction of protein, %	3.08±0.01	(2.92-3.45)	2.66
Productivity index, kg	7847.82±106.09	(5232.51–12270.63)	17.05
Body built index	0.457±0.002	(0.417±0.482)	2.87

Table 4. Correlation between exterior parameters and milk productivity of cows

	1	2	3	4	5	6	7	8	9	10	11	12
1*	1.00	-0.22	-0.01	0.96	0.03	0.06	0.22	0.09	0.03	0.25	0.14	0.24
2	-0.22	1.00	0.45	0.06	-0.03	0.03	-0.12	-0.02	-0.01	-0.27	-0.10	-0.16
3	-0.01	0.45	1.00	0.20	-0.09	-0.06	-0.06	-0.16	-0.03	-0.34	0.01	-0.13
4	0.96	0.06	0.20	1.00	0.02	0.06	0.19	0.08	0.02	0.16	0.12	0.19
5	0.03	-0.03	-0.09	0.02	1.00	0.60	0.56	0.15	0.58	0.31	0.35	-0.28
6	0.06	0.03	-0.06	0.06	0.60	1.00	0.43	0.23	0.43	0.51	0.17	0.30
7	0.22	-0.12	-0.06	0.19	0.56	0.43	1.00	0.08	0.35	0.33	0.29	0.14
8	0.09	-0.02	-0.16	0.08	0.15	0.23	0.08	1.00	0.05	0.11	-0.06	0.19
9	0.03	-0.01	-0.03	0.02	0.58	0.43	0.35	0.05	1.00	0.33	0.21	0.13
10	0.25	-0.27	-0.34	0.16	0.31	0.51	0.33	0.11	0.33	1.00	0.11	0.52
11	0.14	-0.10	0.01	0.12	0.35	0.17	0.29	-0.06	0.21	0.11	1.00	0.38
12	0.24	-0.16	-0.13	0.19	-0.28	0.30	0.14	0.19	0.13	0.52	0.38	1.00

*1– Milk yield per lactation, kg, 2– Fat content in milk, %, 3 – Protein content in milk, %, 4 – Productivity index, 5 – Height at withers, 6 – Body length, 7 – Chest depth, 8 – Chest width, 9 – Rump length, 10 – Rump width, 11– Metacarpus girth, 12 – Body built index

cows body constitution are not highly variable. It has been found that the least variable parameters are the animal height (3.56%), body length (4.50%), rump length (3.99%) and complex body built index (2.87%). The parameters of maximum variability are the chest depth (7.19%), chest width (7.58%), rump width (8.87%) and metacarpus girth (8.27%). Among the indicators characterizing the milk productivity, the milk yield for 305 lactation days (17.04%) and productivity index (17.05%) is the indicator of the highest variability. These parameters ensure more efficient selection than parameters with low variability coefficient.

The conformation and productivity parameters of daily cattle are characterized by certain relation between each other (Table 4). Many parameters are in positive or negative interrelations. Herewith, the relation between parameters may be strong or weak.

The analysis and assessment of the correlation coefficient between parameters allow predicting so called indirect selection, when making a selection by one parameter we indirectly change the other interrelated parameter. The analysis of the correlation coefficient value between various body constitution parameters of the study population demonstrates that the basic measurements characteristic of conformation peculiarities of animals reveals positive (moderate, average) relation in the following indicators: "height at withers–body length" - 0.60; "height at withers–chest depth" - 0.56; "height at withers–rump length" - 0.58; "height at withers–metacarpus girth" - 0.35; "body length–chest depth" - 0.43; "body length–rump length" - 0.43; "body length–rump width" - 0.51; "rump length–chest depth" - 0.35; "height at withers–rump width" - (0.31); "rump width–rump length" - (0.33). Herewith, the analysis reveals weak relation between the height at withers and chest width (0.15), body length and chest width (0.23), chest width and rump width (0.11), body length and metacarpus girth (0.17), rump length and metacarpus girth (0.21), rump width and metacarpus girth (0.11) (Table 4).

The study of correlation between the conformation index and measurements forming the body constitution type is of certain interest. The study reveals a positive correlation between the body constitution index and measurements characterizing the level of the animal's body development (body length, chest width, chest depth, rump length, and rump width), which varied within the range 0.13–0.52. A negative correlation (r= -0.28) between the conformation index of body built and height of the animal seems logical.

Table 4 also provides the value reflecting the following correlations: milk yield–mass fraction of fat, milk yield– mass fraction of protein, fat content and protein content in milk, as well as milk yield–productivity index and milk yield–conformation index of body constitution. It is found that the correlation between milk yield and qualitative milk content was generally negative in the studied population. The fat–protein content correlation was positive. The productivity index is under a strong positive influence (r = 0.96) of milk yield with a weak correlation between the mass fraction of fact and mass fraction of protein in milk.

The correlation between the milk yield, qualitative characteristics of milk and exterior parameters was weak or absent (r = -0.34–+0.25). At the same time, it is necessary to note a weak (r = +0.19) positive correlation between conformation index of body constitution and productivity index.

Conclusion

Therefore, rapidly changing technologies in the area of dairy farming and formation of genetic diversity of parameters encourage the specialists choose advanced methods for enhancement and acceleration of the selection process. The use of digital technologies and new methods in the assessment of biological specificity of animals allows to characterize more precisely the body constitution at the production and to reveal an interaction between conformation and productive parameters of the dairy cattle. Herewith, proper application of assessment results will contribute to increased milk yield and productive longevity of cows, as well as qualitative characteristics of milk.

Acknowledgments

The reported study was funded by RFBR according to the research project No. 19-016-00192.

References

Abugaliev, S. K. (2017). Productive and exterior indicators of hplstein cows breeding in TOO "SP Pervomaysky". *Journal Zootechniya*, *10,* 2-5 (Ru).

Babaylova, G. P. & Berezina, T. I. (2014). Milk productivity and life time milk yield of different body types cows of Black-and-White breed. *Journal Zootechniya*, *2,* 15-17 (Ru).

Basonov, O. A., Klipova, A. V. & Shkilev, N. P. (2018). Exterior and constitutional features of cows of Black-and-White breed of different genotypes. *Journal Zootechniya*, *11,* 5-8 (Ru).

Batanov, S. D., Baranova, I. A. and Starostina, O. S. (2018). Selection-genetic parameters of exterior and complex evaluation of the milk cattle construction type. *Trends in the Development of Science and Education, 43(6),* 13-19 (Ru).

Batanov, S. D., Baranova, I. A. & Starostina, O. S. (2019). Prediction model for milk production of cows by their exterior features. *Bulletin of the Bashkir State Agrarian University*, *1(49),* 55-62 (Ru).

Brade, W. (2017). Body size of Holstein cows – A critical analysis from the point of view of breeding and animal welfare. *Berichteuber Landwirtschaft*, *95 (3).* doi: 10.12767/buel.v95i3.143.g372. http://buel.bmel.de/index.php/buel/article/view/143/pdf.

Conte, A. F., Kharitonov, S. N., Sermyagin, A. A., Ermilov, A. N., Yanchukov, I. N. & Zinovieva, N. A. (2017). Variability of genetic parameters for linear type traits in Russian black-and-white cattle population. *Journal of Dairy and Beef Cattle Breeding, 8,* 3-9.

Furaeva, N. S. & Vorobyeva, S. S. (2014). Application of linear and exterior estimation method in Yaroslavl cattle breeding. *Agrarian Bulletin of the Upper Volga, 4,* 98-102 (Ru).

Halachmi, I., Polak, P., Roberts, D. J. & Klopcic, M. (2008). Cow body shape and automation of condition scoring. *Journal of Dairy Science*, *91(11),* 4444-4451.

Holloway, L. (2005). Aesthetics. Genetics and evaluating animal bodies: Locating and displacing cattle on show and in figures. *Environment and Planning D: Society and Space*, *23(6),* 883-902.

Huang, L. W., Li, S. Q., Zhu, A. Q., Fan, X. Y., Zhang, C. Y. & Wang, H. Y. (2018). Non-contact body measurement for Qinchuan Cattle with LiDAR Sensor. *Sensors*, *18(9).* doi: 10.3390/s18093014

Kharitonov, S. N., Yanchukov, I. N. & Ermilov, A. N. (2011). Improving the system of evaluation of dairy cattle for a complex of exterior indicators. *Bulletin of the Thimiryazevskaya Agricultural Academy, 4*, 103-13 (Ru).

Konstandoglo, A., Foksha, V., Stratan, G. & Stratan, D. (2017). Evaluation of the exterior of Holsteinand Simmental primiparous cows. *Scientific Papers. Series D. Animal Science, 60*, 35-39.

Lepekhina, T. V., Bakai, A. V. & **Bakai, F. R.** (2018). Variability and repeatability of signs of milk productivity cows of Black-and-White breed. *Journal Zootechniya*, *12,* 10-11 (Ru).

Mishkhozhev, A. A., Aisanov, Z. M., Tarchokov, T. T. & Tleinsheva, M. G. (2017). Dairy efficiency of Holstein cows of different lines. *Journal Zootechniya, 9,* 2-5 (Ru).

Prozherin, V. P., Zavertyaev, B. P., Yaluga, V. L. & Mohnatkina, Yu.M. (2008). Linear evaluation of the exterior of cows of Kholmogory breed. *Journal Zootechniya*, *12,* 3-4 (Ru).

Shi, C., Zhang, J. L. & Teng, G. H. (2019). Mobile measuring system based on LabVIEW for pig body components estimation in a large-scale farm. *Computers and Electronics in Agriculture, 156*, 399-405.

Sun, Z. J., Zhang, C., Qin, X. F., Zhang, Y. A., Song, R. D. & Sakamoto, M. (2019). Two-dimensional image based body size measurement and body weight estimation for yaks. In: *Proceedings of the 2019 International Conference on Artificial Life and Robotics (ICAROB).* Alife Robotics Co, Oita, JP, 241-245.

Valitov, Kh. Z. & Karamaev, S. V. (2012). Productive longevity of cows in conditions of intensive milk production technology. Samara State Agricultural Academy Press, Samara (Ru).

Zubriyanov, V. F., Lyashenko, V. V. & Morozov, I. M. (2001). Body conformation and productivity of Black-and-White Povoizhsky cattle. *Journal Zootechniya*, *4*, 4-6 (Ru).

Received: August, 28, 2019; *Accepted:* September, 25, 2019; *Published:* December, 31, 2020