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Non-contact methods of cattle conformation assessment using mobile measuring systems

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Abstract. Examination of body conformation traits and measuring of cattle exterior parameters play a significant role in improvement of animal's breeding abilities and enhancement of selection efficiency. Non-contact remote measuring through the use of digital technologies means considerable progress towards mitigation of animal's critical reaction to stress and substantial time reduction in contrast to manual measurements in contact with animals. This article presents a new approach to exterior assessment and provides an analysis of non-contact methods of measuring basic parameters of animals' body conformation. The values of conformation parameters have been obtained by photo image processing of animals and with 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 about 2 %. Experimental findings show that these techniques may be considered as an innovative method of non-contact measuring of cattle conformation traits.

1. Introduction

In dairy farming much attention is given to the assessment of animal's conformation as the appearance and inner properties are closely related to productive and reproductive qualities of the body [1, 2].

An animal technician should study the body composition and conformation traits to understand the basis on which biological make-up and production efficiency develop, as well as advantages and disadvantages, to notice the signs of body composition weakening, and to identify the breeding value of the animal [3, 4, 5].

Body conformation examination is based on three main principles:

- animal's productivity and its level are transferred into the body habitus;
- exterior traits correlate between each other and the development of internal parts of the body; and
- peculiarities of conformation traits depend on breed characteristics of the animal [1, 4].

Today, in countries with developed dairy farming the issues of conformation examination and assessment are gaining increased attention. 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 conformation, defined the model type of a dairy cow, reduced the influence of appraiser's subjective assessment, created the basis for servicing

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bull assessment by the conformation traits of their daughters, and standardized assessment by the conformation traits at the country level [6, 7].

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 built, outline diagram) and photographing.

In zootechnical practice greater importance is being attached to photographic images of animals. However, animals' photos are often used for advertising purposes [6, 8, 9].

With the use of the scientific approach and digital technologies, the animal's photo can provide us with a precise reflection of 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 [4, 10].

A traditional approach to animal assessment is based on visual examination, manual assessment, and, as a rule, contact measuring. So, today expert appraisals are prepared by professionals (appraisers) with due account of available linear measurements. The accuracy of such appraisals is determined by subjective reasons [6, 7, 11, 12, 13, 14].

Therefore, development of the system of comprehensive assessment of animal conformation with the use of depth sensor is relevant and has scientific and practical significance. In view of this, our study aimed at the analysis of the data obtained through objective assessment of cows' conformation using the contact method and the development of animal conformation examination with the use of digital technologies.

2. Material and Methods

Experimental research was carried out in 2018–2019 on the Russian Black Pied and Kholmogory breed cows at breeding farms in the Udmurt Republic. The sampled population consisted of 75 cows. The animals were assessed in the period from the 90^{th} to 150^{th} lactation days. We selected the following measurements: height at withers, height at rump, chest depth, chest width, rump width, rump length, body length, and metacarpus girth. The specified measurements provide the most accurate characteristics of the animal's dimensions (carcass).

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).

Measuring of points using photos 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 using the focusing screen grid. The specified function allows leveling the taken image against the screen. The image in three views: side view, front view and back view was obtained. For the side view the cow was placed parallel with 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 study parameters and drew lines between them (figure 1).

This way we obtained the measurements we need in pixels. Actual dimensions of conformation parameters were calculated according to the formula:

$$L = \frac{s_2 \cdot l}{s_1} \quad (1)$$

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.

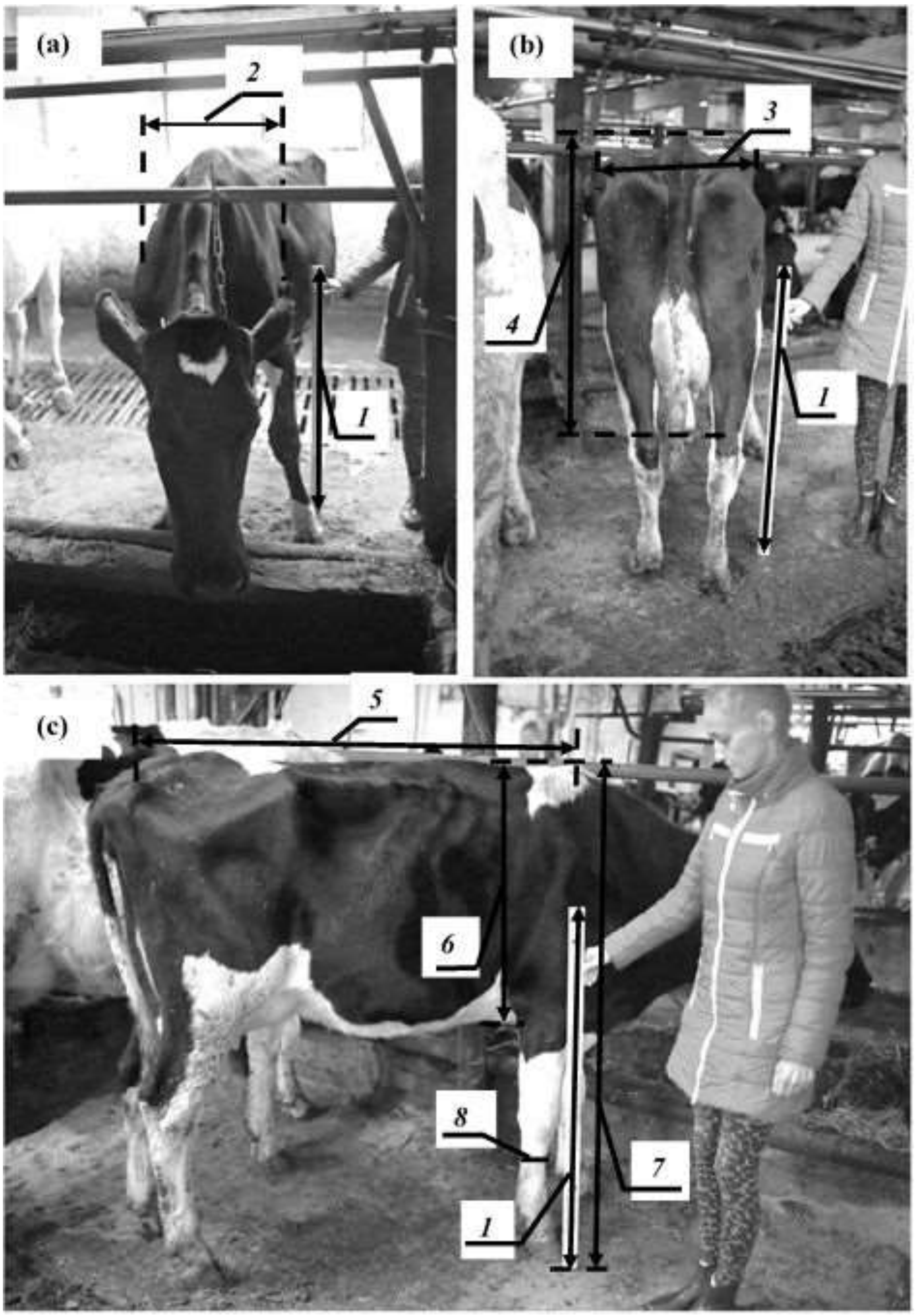

Figure1. Diagram of measurements taken from photos; where:1) perspectometer, 2) chest width, 3) rump width, 4) rump length, 5) body length, 6) chest depth, 7) height at withers, 8) metacarpus girth.

The third method of conformation parameter measuring is processing of depth images obtained with Structure Sensor 3D. 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 perspectometer; may be made with involvement of the minimum number of people; and reduces the animal's stress. The obtained model provided all necessary conformation parameters.

3. Results

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

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

Indicator	$\bar{x} \pm \Delta\bar{x}$	Lim min-max	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

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

Assessing the conformation traits of animals, it should be generally noted that the cows have a strong deep body, 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 study 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 4.4 % ($P < 0.01$) and 3.4% ($P < 0.05$) (table 1). The measurement "metacarpus girth" characterizes the degree of carcass development and may be considered one of the most difficult one to measure, so the obtained results have a relatively high margin of error (4.41 % and 3.43 %). As for other study 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 2. Relative error in measurements of conformation parameters obtained by contact method, method of photo image processing and with depth sensor (75 cows).

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

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

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