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The Role of the Conformation of Holstein Cows in the Sustainability of Milk Production

Zsolt J. Kőrösi*,[a], László Bognár[a], Szabolcs Bene[b], Ferenc Szabó[c]

[a]National Association of Hungarian Holstein Friesian Breeders, 1134 Budapest, Hungary
[b]Hungarian University of Agriculture and Life Sciences, Deák Ferenc str. 16, 8360 Keszthely, Hungary
[c]Széchenyi István University, Egyetem tér 1, 9026 Győr, Hungary
korosi@holstein.hu

The conformation of dairy cows, referring to their physical form and the arrangement of body parts, plays a critical role not only physiologically but also economically. It is intricately linked to key sustainability traits such as milk production, reproduction, and longevity. Research has revealed genetic correlations between body conformation traits and first lactation milk yield ranging from 0.48 to 0.54, and correlations between fertility and type traits vary from zero to 0.79. The relationships between productive life or herd life and type traits range from –0.06 to 0.16, with negative correlations observed for characteristics such as rump angle, rear leg set, udder depth, and teat length. Larger cows with slightly positive conformation traits are associated with longer herd life. Specifically, cows with well-attached fore udders, high rear udder attachment, strong central ligaments, close front teat placement, and moderately long teats are linked to the longest functional, productive lives.
The heritability estimates for conformation traits are moderate, ranging from 0.20 ± 0.047 to 0.38 ± 0.04. These correlations and heritability values highlight the need for breeders to reassess and prioritise conformation traits within Holstein dairy cow breeding programs. By revising the traits scored and incorporating new ones during selection, breeders can indirectly improve milk production, reproduction, and longevity, enhancing the sustainability of milk production. This review paper aims to summarise current official type evaluation systems for Holstein cows, underscore the significance of various conformation traits in sustainable milk production, and propose potential enhancements to the scoring system.

1. Introduction

Conformation is the physical form of an animal, its shape, and arrangements of body parts. Because the conformation is related to various important production and reproduction traits in the Holstein breed, breeders look for the ideal type. Some descriptive terms describing the ideal Holstein type are stature, angularity, rump, long and lean neck, good udder attachment and teat placement, and strong feet and legs (Taylor and Field, 2001). The Type Classification Service provides an independent assessment of animal conformation, identifying individual animal and whole herd strengths and weaknesses.
By classifying, conformational issues can be recorded and reduced in the next generation via corrective breeding. This has the potential to improve longevity, health, welfare, and production in the long term, benefiting the farm economically. Gains in profitability are experienced by herds with a consistent commitment to assessing conformation over generations of breeding, with continual improvements in functional conformation and productivity. Classification is a comprehensive type of conformation evaluation of the animal's physical structure, identifying strengths and weaknesses whilst highlighting the opportunities for improvement, which can lead directly to accelerated genetic progress, profitability, and longevity.
Herd owners are provided with detailed visual reports for individual animals, plus helpful herd summary and trend reports for benchmarking and goal setting. The material is presented in a way that helps herd owners make better management decisions, leading to improved profit. When a herd starts to classify, several methods of herd improvement are initiated. By utilising the information to make more informed and profitable decisions, herd owners can appreciate the value of the service.

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The role of classification is to identify those animals that will have trouble-free and productive lives. Classifiers score twenty or more individual 'linear' traits on a 1 to 9 or 1-50 scale and combine this information in four or five 'composites' and an overall classification score in the world. Breeders use classification information to help select and develop the best bloodlines in their own herds, as well as when sourcing animals from other herds. Animals that classify well command a premium at sale time. Classification information is a key component in the calculation of the bull proofs and in calibrating genomic evaluations for type traits. The applied linear scale must cover the expected biological extremes of the population in the country of assessment. The precise measurements in the scale given may be used as a guide and should not be treated as an exact recommendation. The head-classifiers of the Holstein breeder countries all around the world have taken part since 1986 in regular World Holstein Friesian Federation (WHFF) workshops to harmonise international classification. (WHFF Cremona, 2024). In the Holstein breeding program in Hungary (HFTE, 2019), as in other countries, in addition to milk production and some functional traits such as somatic cell count, longevity, calving ease, and among conformation traits, the udder and leg structure are as a selection criteria. Other conformation traits, such as stature, chest width, body depth, and rump width, are not included in the selection index.
Several authors point out the need to revise the conformation traits of cows taken into account in the selection process, to delete certain traits, and to include new ones in the selection index. This is topical because, with increased production yield and the modernisation of technology (e.g. robot-milking), the relationship of certain conformation traits to production, health, longevity, efficiency and sustainability may change (Alphonsus et al., 2010, Zink et al., 2014, Martins et al.,2020, Alcantara, et al, 2022, Xue et al., 2022). The present paper aims to draw attention to the need to review and modernise the current system for confirmation judging of Holstein cows.

2. Methods

Linear-type traits are measured in most international breeding programs and are predominantly related to dimension. They are thus less likely to be as highly correlated to fertility as the effects of body tissue mobilisation. Nevertheless, some of these traits may provide additional information (Pryce et al., 2000). Subjective visual assessment of animals by classifiers is undertaken for several different purposes in livestock. For example, linear type classification in dairy cattle is routinely performed in many countries, and records are used, for example, for the prediction of longevity (Brotherstone and Hill, 1991), and genetic correlations between conformation and longevity traits differed between years of birth (Vollema and Groen 1997), Body weight (Veerkamp et al., 2002), udder health, feet and leg problems, and calving ease.
Canadian scientists have studied the connection between long-lasting, productive life and confirmation. Most phenotypic correlations (r_p) between lifetime production and type were in the range of 0.15 to 0.20, except for capacity, rump, and feet and legs, which were around 0.07. Genetic correlations were strong between lifetime production and angularity (r_g= 0.44 to 0.55) and dairy character (r_g= 0.53 to 0.56). Genetic correlations were low to moderate between lifetime production and stature (r_g= 0.14 to 0.25), size (r_g= 0.07 to 0.18), texture (r_g= 0.19 to 0.26), style (r_g= 0.11 to 0.27), head (r_g= 0.15 to 0.23), pin setting (r_g= 0.10 to 0.16), rear udder (r_g= 0.19 to 0.25), and rear attachment (r_g= 0.10 to 0.22). The only notable negative genetic correlations were lifetime production with a rear heel (r_g= –0.16 to –0.27), thru width (r_g= –0.18 to –0.24), and foreudder (r_g= –0.05 to –0.11) (Klassen et al., 1992).
Most phenotypic correlations (r_p) between conformation and economically important production and other traits are from 0.15 to 0.20 except for capacity, rump, and feet and legs, which were around (r_p= 0.07). The highest genetic correlations were between the lifetime production and rear udder (r_g= 0.19 and r_g= 0.25) and lifetime production with dairy character (r_g= 0.53 and r_g= 0.56). Genetic correlations between lifetime production and capacity, rump, feet and legs, and mammary system were close to 0 (r_g= -0.06 to 0.07). Genetic correlations between lifetime production and final class, final score, and general appearance were small and favourable (r_g= 0.04 to 0.18), and genetic correlations between lifetime production and fore-udder were small and unfavourable (r_g= -0.05 to -0.1) (Klassen et al., 1992). Udder depth and teats rear view were significantly correlated with survival to 84 months in grade cattle. Udder depth accounted for as much variation in stayability as yield. Udder depth and teat rear view were the traits most related to survival in both grade and registered cows. Body traits were favourably correlated with survival only in registered cows. Models were explored to determine the best predictor models when more than one type of trait was included.
Generally, the highest determination coefficient (R^2) was found in a combination of the best single traits. The R^2 value in multiple type traits was significant in some models (Rogers et al., 1998). Results from a US study indicate that the genetic correlations between most types of traits and diseases other than mastitis are small. Traits that are exceptions to this general result include dairy form and rump angle. More slope from hooks to pins was genetically associated with less frequent foot and leg diseases. Likely, more importantly, the genetic correlations between dairy form and diseases were unfavourable. Selection for higher dairy production based on conformation scores may substantially increase diseases other than mastitis and may compound the

undesirable response in diseases other than mastitis that accompanies selection for increased yield (Rogers et al., 1999). The phenotypic and genetic relationships of 3 locomotion traits with profit, production, longevity, and fertility traits were studied to determine the importance of locomotion traits for dairy producers.

Higher scores for feet and legs (FL), foot angle (FA), and rear legs set (RLS) were positively related to production and functional traits, whereas fertility was not significantly affected. The cows that scored the highest for FL were 213 $/y more profitable, produced 575 kg/y more milk and remained in the herd for 307 more functional days than the cows scoring the lowest. Feet and legs were the traits most genetically correlated to profit, although a low value (r= 0.10) was obtained, whereas RLS was the trait most correlated to milk production (r=0.12). Genetic correlations among FL, FA, RLS, and longevity traits (r_g= −0.10 to 0.05) were low. Quadratic curves were the best fit for both profit and functional herd life for EBV of each of the 3 locomotion traits (Pérez-Cabal et al., 2006). When a herd starts to classify, several methods of herd improvement are initiated. By utilising the information to make more informed and profitable decisions, herd owners can appreciate the value of the service.

- Early culling tool that identifies problem cows;
- Insight into possible management changes
- Consultation with an objective/unbiased expert who sees thousands of cows
- Benchmarking your herd against others
- Mating & Selection Tool: (a) Select the best cows in the herd to keep for the next lactation and to be the dams of your next generation of cows; (b) Select the optimal sire to mate to each cow or group of cows

Low-cost investment with a high return means that cows with better functional conformation last longer and generate more income over their lifetime. The classification system has many linear traits and defective characteristics that are combined to calculate points in four scorecard sections: Mammary System, Feet & Legs, Dairy Strength, and Bodyscore. An overall confirmation score is calculated based on the importance of each of the scorecard sections. Research has revealed genetic correlations between body conformation traits and first lactation milk yield ranging from (rg= 0.48 to 0.54), and correlations between fertility and type traits vary from zero to 0.79 (Tapki and Güzey, 2013). Heritabilities (h2) of disease R2 traits were low, ranging from 0 to 0.05. Exceptions were lameness (h2= 0.16) and ketosis (h2= 0.39) (Van Dorp et al., 1998). Correlations phenotypic of disease traits with 305-day milk yield and of selected type traits with retained placenta, displaced abomasum, mastitis, and lameness were estimated.

Phenotypic correlations did not substantially differ from 0 except for the correlation between lameness and rear leg set (0.37) (Van Dorp et al., 1998). Genetic correlations between disease traits and milk yield were mostly positive (rg= 0.02 to 0.44) (Van Dorp et al., 1998). Only retained placenta had a negative genetic correlation with milk yield (rg= –0.28). Genetic correlations ranged from 0 to 0.37 between udder conformation traits and mastitis, from –0.38 to 0.09 between leg conformation traits and lameness, and from –0.11 to 0.38 between rump conformation and retained placenta (Van Dorp et al., 1998).

Table 1. Heritability values of different traits of Holstein Friesian dairy breed

Trait	Heritability (h^2)	Trait	Heritability (h^2)
Milk (kg)	0.23	Fore teat placement	0.36
Fat (kg)	0.26	Teat length	0.41
Protein (kg)	0.21	Body condition	0.29
Stature	0.53	Locomotion	0.08
Chest width	0.29	Rear teat placement	0.33
Body depth	0.37	Body score	0.40
Angularity	0.27	Overall feet and legs	0.15
Rump angle	0.38	General appearance	0.16
Rump width	0.35	Dairy character	0.31
Rear leg set side view	0.19	Body capacity	0.46
Rear leg rear view	0.13	Overall udder	0.23
Foot angle	0.12	Dairy strength	0.28
Fore udder attachment	0.25	Final score	0.27
Rear udder high	0.23		
Udder support	0.22		
Udder depth	0.42		

The results suggest that selection based solely on yield may increase the incidence of disease. Selection on conformation traits can help reduce the incidence of disease, although genetic correlations are low. The relationships between productive life or herd life and type traits range from –0.06 to 0.16, with negative correlations observed for characteristics such as rump angle, rear leg set, udder depth, and teat length (Wasana et al., 2015). Generally, larger cows with slightly positive conformation traits are associated with longer herd life (Vollema and Groen, 1997). Specifically, cows with well-attached fore udders, high rear udder attachment, strong central ligaments, close front teat placement, and moderately long teats are linked to the longest functional, productive lives (Vollema and Groen, 1997). The heritability estimates for conformation traits are moderate, ranging from h2= 0.20 ± 0.047 to 0.38 ± 0.04 (Toghiani Pozveh et al., 2009). The conformation scoring systems are uniform in the different Holstein breeding countries, so the results of countries can be compared, and one country can take into account the results obtained in another country. These correlations and heritability values highlight the need for breeders to reassess and prioritise conformation traits within Holstein dairy cow breeding programs. Table 1. summarises the average heritability values obtained in several studies and used in INTERBULL International organisation.

3. The current scoring systems

Each Holstein-Friesian breeding country, following the World Holstein Friesian Federation (WHFF) recommendations, applies and integrates the 18 linear evaluation traits into its own assessment system. Every breeding organisation has its own breeding program, which is formulated in consultation with their breeders. Following European and global trends, each country includes additional traits in its conformation assessment traits to achieve the goals outlined in their breeding programs. In the overall conformation practice, every breeding community seeks functional conformation traits that support long productive lifespans, which in turn supports economical milk production. This is complemented by traits that aim at health, welfare, cost-effective, and environmentally friendly long-term economical milk production (Gutierez et al., 2023).

Nowadays, there is increased emphasis on traits that aim to improve fertility indicators and traits related to ease of calving, and milk ability is also of similar importance. The construction and use of farms employing robotic technology are currently experiencing a renaissance, and efforts are being made to serve these farms through the selection of cows suitable for robotic milking (Zagidulin et al., 2023). Temperament, learning ability, intelligence, and udder conformation suitable for robotic milking all play important roles in thorough preparation for the specific milking technology (Broucek and Tongel, 2017). The current scoring system uses twenty-one linear traits in Hungary as followed by the World Holstein Friesian Federation recommendation of eighty-teen and additional three extra traits:

1. Stature
2. Chest Width
3. Body Depth
4. Rib Structure
5. Rump Angle
6. Rump Width
7. Rear Legs Rear View
8. Rear Legs Set
9. Foot Angle
10. Locomotion
11. Fore Udder Attachment
12. Front Teat Position
13. Teat Length
14. Udder Depth
15. Rear Udder Height
16. Central Ligament
17. Rear Teat Position
18. Body Condition
19. Rear udder width
20. Bone quality
21. Udder texture

Table 2. Genetic correlations between countries for 21 traits analysed by INTERBULL, WHFF Meeting for head classifiers of the world (WHFF Cremona, 2024)

Trait	Average correlation (r_g)	Trait	Average correlation (r_g)
Stature	0.91	Udder support	0.74
Chest width	0.78	Udder depth	0.92
Body depth	0.81	Fore teat placement	0.91
Angularity	0.72	Teat length	0.93
Rump angle	0.82	Rear teat placement	0.92
Rump width	0.85	Locomotion	0.64
Rear leg set side view	0.82	Body condition	0.86
Rear leg rear view	0.70	Overall conformation	0.68
Foot angle	0.74	Overall udder	0.79
Fore udder attachment	0.78	Overall feet and legs	0.66
Rear udder high	0.80		

The classification system has four main characteristic scores, including some parts of the cows. Body score, Dairy strength, Feet and legs, and Mammary system. These scores give the final score of the animal, following the percentage of each trait. Body score 20 %, Dairy strength 15 %, Feet and legs 25 %, and the Mammary system 40 %. Table 2. presents the average values of the genetic correlation values based on the last research results of the world classifiers meeting in Cremona (WHFF Cremona 2024) between the countries, according to Gerben De Jong. Based on the mentioned publication, there are very highly correlated conformation traits, and some of them need more improvement in the future.

4. Conclusions

The different Holstein breeding countries are using different number of linear traits and main characteristic scores and different weight for final scores. In Germany the Body score has 20 %, Dairy character 10 %, Feet and legs 30 % and the Mammary system 40 %. They are giving 5 % more importance for Feet and legs, and 5% less for dayriness of the cow. UK classifiers are giving scores by the next roles: Mammary system 40 %, Feet and legs 30 % but they are scoring the Rump separately 10 %, and two different ways for dairyness Dairy Capacity 10 %, Dairy character 10 %.

In Canada, the classifiers of the Holstein Canada follow the next scoring system: Mammary System 40 %, Dairy Strength 20 %, Feet & Legs 28 %, and Rump 12 %. In a dairy farm using Automatic Milking System (AMS), the main selection objectives concerning the udder conformation traits are related to the increase of udder depth, to obtain cows with stronger suspensory apparatus of the udder and, with greater longevity.

Adequate udder balance, front teat distance, and rear teat distance will allow the proper identification of all teats during milk. Udder depth has a negative and unfavourable correlation with front teat distance and rear teat distance, indicating that cows with teats farther apart have the udder closer to the floor. This could be either a result of ligamentous sagging or larger udders tending to be closer to the floor and having the teats farther apart. However, as the genetic correlation values are moderate or low, selection can be simultaneously carried out to increase udder depth without causing a sharp approximation of the teats. In this context, it is possible to find cows with udders far from the floor and well-separated teats, which will result in these cows having longer productive lives and being easier to milk.

The average values of genetic correlation between udder balance and the front teat distance and rear teat distance traits were negative and low, indicating that selection for increased front teat distance and rear teat distance will result in progenies with lower udder balance values, which is undesirable. Selection for more balanced udders should be prioritised rather than focusing efforts on selecting only for the distance between the teats since udder balance exerts a greater influence on milk production and longevity than the latter traits.

Besides, the correlation between udder balance and distance fore and rear quarters is positive, favourable, and low. Thus, genetic selection for cows with greater distance between the front and rear seats, that is, with greater udder length, will tend to generate animals with udders that are more firmly attached to the abdominal wall. Subjective visual assessment of animals by classifiers is undertaken for several different purposes in livestock. For example, linear type classification in dairy cattle is routinely performed in many countries, and records are used, for example, for the prediction of longevity (Brotherstone and Hill, 1991).

The success of harmonised linear evaluation should be considered one of the greatest accomplishments of the Federation. Progress in harmonised type evaluation might seem slow to some, but in the 32 y since the first workshop for classifiers in Cremona, giant strides have been made. The precise description of each trait is well-defined, and it is essential to use the full range of linear scores to identify the intermediate and extremes of each trait within its population. It is very important to develop the number of traits, use the exact definitions, and a consequent scoring system to collect the confirmation dates for the breeding value estimation. We believe that it is important to systematically examine the association between different conformation traits and the production, functional and reproduction traits. Improve the scoring systems in a direction that combines the ideal type and the long-term sustainability of large-scale dairy production.

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References

Alcantara L.M., Baes C.F., Gerson A.O.J., Schenkel F.S., 2022, Conformation traits of Holstein cows and their association with a Canadian economic selection index. Can. J. Anim. Sci., 102, 490-500, DOI: 10.1139/cjas-2022-0013.

Alphonsus C., Akpa, G.N., Oni O.O., Rekwot P.I., Barje P.P., Yashim S.M., 2010, Relationship of linear conformation traits with bodyweight, body condition score and milk yield in Friesian× Bunaji cows. J. Appl. Anim. Res., 38, 97-100, DOI: 10.1080/09712119.2010.9707164.

Brotherstone S., Hill W.G., 1991, Dairy herd life in relation to linear type traits and production 1. Phenotypic and genetic analyses in pedigree type classified herds. Animal Science, 53, 279-287, DOI:10.1017/S0003356100020274.

Broucek J., Tongel P., 2017, Robotic Milking and Dairy Cows Behaviour. 2017 International Conference on Control, Artificial Intelligence, Robotics & Optimization, 33-38, DOI:10.1109/ICCAIRO.2017.16.

Gutiérrez-Reinoso M.A., Aponte P.M., Garcia-Herreros M., 2023, Genomic and Phenotypic Udder Evaluation for Dairy Cattle Selection: A Review. Animals, 13(10), 1588, DOI: 10.3390/ani13101588.

HFTE, 2019. Breeding program of Hungarian Holstein-Friesian breed, National Association of Hungarian Holstein Friesian Breeders, Budapest. <https://holstein.hu/egyesulet/tenypro_2019.pdf>, accessed 08.11.2024. (in Hungarian)

Klassen D.J., Monardes H.G., Jairath L., Cue R., Hayes J.F., 1992, Correlations Between Lifetime Production and Linearized Type in Canadian Holsteins. Journal of Dairy Science, 75(8), 2272-2282, DOI:10.3168/jds.S0022-0302(92)77988-0.

Martins B.M., Mendes A.L.C., Silva L.F., Moreira T.R., Costa J.H.C., Rotta P.P., Chizzotti M.L., Marcondes M.I., 2020, Estimating body weight, body condition score, and type traits in dairy cows using three dimensional cameras and manual body measurements. Livestock Sci., 236, 104054, DOI: 10.1016/j.livsci.2020.104054.

Rogers G.W., McDaniel B.T., Dentine M.R., 1998, Relationships Among Survival Rates, Predicted Differences for Yield, and Linear Type Traits 1. Journal of Dairy Science, 71(1), 214-222, DOI:10.3168/jds.S0022-0302(88)79544-2.

Rogers G.W., Banos G., Sander-Nielsen U.,1999, Genetic Correlations Among Protein Yield, Productive Life, and Type Traits from the United States and Diseases Other than Mastitis from Denmark and Sweden. Journal of Dairy Science, 82(6), 1331–1338, DOI:10.3168/jds.S0022-0302(99)75357-9.

Pérez-Cabal M.A., García C., González-Recio O., Alenda R., 2006, Genetic and Phenotypic Relationships Among Locomotion Type Traits, Profit, Production, Longevity, and Fertility in Spanish Dairy Cows. Journal of Dairy Science, 89, 1776–1783, DOI: 10.3168/jds.S0022-0302(06)72246-9.

Pryce J.E., Coffey M.P., Brotherstone S., 2000. The Genetic Relationship between Calving Interval, Body Condition Score and Linear Type and Management Traits in Registered Holsteins. Journal of Dairy Science 83(11), 2664–2671, DOI: 10.3168/jds.S0022-0302(00)75160-5.

Taylor R.E., Field T.G., 2001, Scientific farm animal production. 7th ed.Prentice-Hal, Inc, Upper Saddle River, New Jersey 07458, United States.

Tapki I., Güzey Y., 2013, Genetic and Phenotypic Correlations between Linear Type Traits and Milk Production Yields of Turkish Holstein Dairy Cows. Greener Journal of Agricultural Sciences. 3. 755-761. DOI:10.15580/GJAS.2013.11.072913763.

Toghiani Pozveh S., Shadparvar A.A., Moradi Shahrbabak M., Taromsari M.D., 2009. Genetic analysis of reproduction traits and their relationship with conformation traits in Holstein cows. Livestock Science 125, 84–87. https://doi.org/10.1016/j.livsci.2009.02.015

Van Dorp T.E., Dekkers J.C., Martin S.W., Noordhuizen J.P., 1998, Genetic parameters of health disorders, and relationships with 305-day milk yield and conformation traits of registered Holstein cows. J. Dairy Sci., 81(8), 2264-2270, DOI: 10.3168/jds.S0022-0302(98)75806-0. PMID: 9749393.

Veerkamp R.F., Gerritsen C.L.M., Koenen E.P.C., Hamoen A., De Jong G., 2002, Evaluation of Classifiers that Score Linear Type Traits and Body Condition Score Using Common Sires. Journal of Dairy Science, 85(4), 976-983, DOI: 10.3168/jds.S0022-0302(02)74157-X.

Vollema A.R., Groen A.F., 1997, Genetic correlations between longevity and conformation traits in an upgrading dairy cattle population. J Dairy Sci., 80(11), 3006-3014, DOI: 10.3168/jds.S0022-0302(97)76267-2.

Wasana N., Cho G., Park S., Kim S., Choi J., Park B., Park C., Do C., 2015, Genetic Relationship of Productive Life, Production and Type Traits of Korean Holsteins at Early Lactations. Asian-Australas J Anim Sci., 28(9), 1259-1265, DOI: 10.5713/ajas.15.0034.

WHFF Cremona, 2024, Workshops to harmonize international classification. World Holstein Friesian Federation (WHFF) Cremona, Italy, 16-19 April 2024.

Xue X., Hu H., Zhang J., Ma Y., Han L., Hao F., Jiang Y., Ma Y., 2022, Estimation of genetic parameters for conformation traits and milk production traits in Chinese Holsteins. Animals, 13(1), 100, DOI: 10.3390/ani13010100.

Zagidullin L.R., Khisamov R.R., Kayumov R.R., Shaidullin R.R., Zinnatov F.F., Sadykov N.F., 2023, Dairy robotic milking system. BIO Web of Conferences, 71, DOI: 10.1051/bioconf/20237101004.

Zink V., Zavadilová L., Lassen J., Stipkova M., Vacek M., Stolc L., 2014, Analyses of genetic relationships between linear type traits, fat-to-protein ratio, milk production traits, and somatic cell count in first-parity Czech Holstein cows. Czech J. Anim. Sci., 59, 539-547, DOI: 10.17221/7793-CJAS.