Scientific Papers. Series D. Animal Science. Vol. LXVII, No. 2, 2024
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

ESTIMATION THE GENETIC PARAMETERS FOR GROWTH TRAITS IN ABERDEEN ANGUS BREED

Mircea Catalin ROTAR, Rodica Stefania PELMUS, Mihail Alexandru GRAS, Cristina VAN

National Research-Development Institute for Animal Biology and Nutrition,
1 Calea Bucuresti, 077015, Balotesti, Romania

Corresponding author email: catalin.rotar@ibna.ro

Abstract

The objective of this study was to estimate the breeding values and genetic parameters for birth weight and weaning weight in Aberdeen Angus cattle breed with maternal animal model. Data consisted of records of 1206 calves of Aberdeen Angus breed from Aberdeen Angus Association Romania. The direct breeding values for birth weight were in the population between -12.8 and 21.93 and for weaning weight from -82.68 to 155.10. The direct breeding values for calves with records for birth weight were from -8.87 to 16.077 and for weaning weight from -71.51 to 150.26. The maternal breeding value for birth weight ranged between -2.772 and 3.388 and for weaning weight from -38.273 and 49.693 in the population. The maternal breeding values for calves with records for birth weight ranged between -2.206 and 1.668 and for weaning weight were from -25.824 and 27.906. The direct heritability for birth weight was 0.266 and for weaning weight was 0.217. The maternal heritability was 0.048 for birth weight and 0.081 for weaning weight. The total heritability was 0.24 for birth weight and 0.20 for weaning weight.

Key words*: breeding value, genetic parameters, maternal animal model.*

INTRODUCTION

The birth weight and the weaning weight are important traits in beef cattle. Aberdeen Angus is a breed from Scotland used for beef production. The breeding program of Aberdeen Angus breed in Romania have the objective the improvement of the traits for meat production and the reproduction and functional traits. Aberdeen Angus cows breed is resistant to environment conditions, adaptable, mature extremely early and the cows have a high carcass yield with marbled meat. This breed has a good meat quality. The females of Aberdeen Angus breed calve easily and have good ability to rear the calves. The maternal animal model was used for genetic evaluation of beef cattle. The maternal animal model was used in studies by different authors. The aim of this study was to estimate the breeding values and genetic parameters for birth weight and weight at 6 months in Aberdeen Angus breed using a maternal animal model for the selection of the cows. The growth traits in beef cattle are still the base information in genetic evaluation (Otto et al., 2021). Even if in the world wide the Angus breed is well studied and BLUP methodology is applied to different animal models (Boddhireddy et al., 2014), in Romania, Angus breed is just at the beginning of breeding programs and genetic evaluations (Madescu et al., 2022; Gociman et al., 2019). Because in our study we discuss of a population of Angus cattle of the Romanian territory, it is mandatory to have local estimation of genetic parameters that will be particularly to our studied population.

MATERIALS AND METHODS

The data were from 1206 Aberdeen Angus calves. The pedigree consisted in 2563 animals: 1206 calves with performances, 1203 dams and 154 sires. The calves were born in 2021 and 2022 years, even in the data set were two years of calving, it was no difference between years and it was not used as a fixed effect in the biometrical model. The data were from Aberdeen Angus Association Romania. The cows' data were from 169 farms and herd was used in the model as an fixed effect.

The weaning weights were corrected for standardized age.

The usual method for calculating standard age weight is based on determining average daily gain between two weight recordings; then,

assuming growth to be linear between the recordings, estimate live weight increase from the day of first recording and reference day and add it to weight on first recording. It is preferable that the age to which weight is being adjusted occurs between two successive recordings. If this is not possible, an extrapolation is possible if age at last recording falls within a specific time interval from the standard age. The time interval has to be determined by each recording organization based on recording frequencies (ICAR, Section 3-Beef cattle).
Where with the exception of birth weight, there is only one weight record available after birth:
- let AR be reference age;
- let WR be weight at reference age;
- let DB be birth date let;
- Dt be recording date t;
- let WB be birth weight;
- let Wt be recorded weight at date t;
- let At be age of animal at recording date (= Dt - DB).
If AR < At
then
WR = [(Wt - WB)/ At]*AR + WB
If AR > At
then WR = {[(Wt - WB)/ At]*(AR - At)]} – Wt

For estimate the genetic parameters was used the maternal animal model. For analyze the data was used the R software, the script was realized by Grosu (Grosu & Oltenacu, 2005).
The model was (Mrode & Thompson, 2005):

y = Xb+Za+Wm+Spe+e
where:
y = the vector of performances;
b = the vector of the fixed effects, in our study was the sex of calves and the herd;
a = the vector of the random animal effects;
m= the vector of the random maternal genetic effects;
pe = the vector of the permanent environmental effects and
e = the vector of the random residual effects.
X, Z, W and *S* are the incidence matrices referring to animal performance, to the fixed effects, to the direct effects, to the maternal effects and to the permanent environmental effects.
It is assumed that:

$$\text{var}\begin{bmatrix} a \\ m \\ pe \\ e \end{bmatrix} = \begin{bmatrix} \sigma_a^2 A & \sigma_{am} A & 0 & 0 \\ \sigma_{am} A & \sigma_m^2 A & 0 & 0 \\ 0 & 0 & I\sigma_{pe}^2 & 0 \\ 0 & 0 & 0 & I\sigma_e^2 \end{bmatrix}$$

where:
A is the kinship matrix between animals;
I is the identity matrix;
σ^2_a is the additive genetic variance for the direct effects;
σ^2_m, the additive genetic variance for the maternal effects;
σ_{am}, the additive genetic covariance between the direct and maternal effects;
σ^2_{pe}, is the variance due the permanent environmental effects;
σ^2_e, is the variance of the residual error.

The genetic parameters were estimated based on the next formulas:

- the direct heritability:

$h_a^2 = \sigma^2_a / \sigma_p^2$

where σ^2_a and σ_p^2 is the genetic and phenotypic variance;

- the maternal heritability:

$h_m^2 = \sigma^2_m / \sigma_p^2$

where σ_{am} direct is maternal additive genetic covariance;

- the total heritability (Wilham et al., 1972):

$$h_T^2 = \frac{\sigma_a^2 + 0.5\sigma_m^2 + 1.5\sigma_{am}}{\sigma_p^2}$$

- the genetic correlation between the direct and maternal effects:

$$r_{am} = \frac{\sigma_{am}}{\sqrt{\sigma_a^2 \cdot \sigma_m^2}}$$

The error of heritability (Hoj-Edwards, 2017):

$$s.e.(h^2) = \sqrt{[\left(\frac{\partial h^2}{\partial \sigma_g^2}\right)^2 (se_g)^2 + \left(\frac{\partial h^2}{\partial \sigma_e^2}\right)^2 (se_e)^2 + 2\left(\frac{\partial h^2}{\partial \sigma_g^2}\right)\left(\frac{\partial h^2}{\partial \sigma_e^2}\right)\rho_{g,e} se_g se_e]}$$

where:
$\frac{\partial h^2}{\partial \sigma_g^2} = \frac{\sigma_e^2}{(\sigma_g^2+\sigma_e^2)^2}$; $\frac{\partial h^2}{\partial \sigma_e^2} = \frac{-\sigma_g^2}{(\sigma_g^2+\sigma_e^2)^2}$; $\rho_{g,e} se_g se_e = cov(\hat{\sigma}_g^2, \hat{\sigma}_e^2)$

RESULTS AND DISCUSSIONS

The average performances for growth traits for Aberdeen Angus cattle are presented in Table 1.

Table 1. The average performances for growth traits

No.	Birth weight	Weaning weight
Mean	29.954	219.007
Standard error	0.142	1.272
Median	29	215.5
Mode	30	225
Standard deviation	4.952	44.179
Sample variance	24.524	1951.863
Kurtosis	1.432	2.512
Skewness	0.848	0.808
Range	31	380.45
Minimum	19	78.12
Maximum	50	458.57
Sum	36125	264123.49
Count	1206	1206
Confidence level	0.279	2.495
Coefficient of variation (%)	16.53	20.17

The mean of birth weight in our study was lower than the mean reported by Nikolov and Karamfilov (2020) in Aberdeen Angus breed 31.6 kg and higher that the mean reported by Jakubec et al. (2003) 29.22 kg in Aberdeen Angus from Czech Republic and Kolisnyk et al. (2018) in Ukraine, 26.5 kg for the females and 29.4 kg for the males. The weaning weight (at 200 days) in our study was higher than the weaning weight at 210 days, 204 kg in Aberdeen Angus from organic farm from Bulgaria.

Jakubec et al. (2003) obtained the mean for weight at 210 days 241.41 kg and 379.50 at 365 days in Aberdeen Angus cattle from Czech Republic. Meyer (1995) reported the birth weight 34.07 in Aberdeen Angus calves from New Zealand and 33.27 kg for calves from Australia and the weaning weight 216.8 kg, respectively 233.1 and the weight at 365 days 285.8 kg, respectively 337.5. Crawford et al. (2016) reported the birth weight 36.2 kg, the weaning weight 213.5 kg and yearling weight 345.6 kg in Angus breed.

For the fixed factors in the model were ranged from -9.3 to 13.61 for birth weight and from -86.66 to 96.07 for weaning weight when we discuss about the influence of herd as a fixed factor. Regarding the sex factor it was 29.29 in birth weight and 212.23 in weaning weight for females and for males it was 29.97 for birth weight and 224.18 for weaning weight.

The factors which influenced the weight of cattle are: the breed, herd, sex, year, age of cow, season and month of birth. The direct and maternal breeding values for the best animals are presented in the Table 2.

Table 2. The direct and maternal breeding values of the 10 best Aberdeen Angus cattle for birth weight and the weaning weight

No.	The direct breeding values for the birth weight	The direct breeding values for the weaning weight	The maternal breeding values for birth weight	The maternal breeding values for weaning weight
1.	17.8726	89.6712	3.0859	53.9754
2.	13.5882	63.8356	2.7191	38.2261
3.	13.5372	59.8817	2.1664	30.9036
4.	13.5197	56.6923	1.7084	22.8797
5.	13.3831	46.5922	1.6791	22.5334
6.	13.1785	45.8782	1.6075	22.3953
7.	12.8879	45.6202	1.5795	21.0499
8.	12.839	44.7397	1.5617	20.9878
9.	12.2577	42.0329	1.5083	20.7223
10.	12.2359	42.0271	1.4701	19.7131

In Table 3 were the direct and maternal breeding values for calves with records. Duchacek et al. (2011) estimated the breeding values for weaning weight in Aberdeen Angus from Czeck Republic.

Table 3. The direct and maternal breeding values of the 10 best Aberdeen Angus calves with records for birth weight and the weaning weight

No.	The direct breeding values for the birth weight	The direct breeding values for the weaning weight	The maternal breeding values for birth weight	The maternal breeding values for weaning weight
1.	13.5882	63.8356	2.7191	38.2261
2.	13.5372	59.8817	2.1664	30.9036
3.	13.5197	56.6923	1.7084	22.8797
4.	13.3831	46.5922	1.6791	22.5334
5.	13.1785	45.8782	1.6075	22.3953
6.	12.8879	45.6202	1.5795	21.0499
7.	12.839	44.7397	1.5617	20.9878
8.	12.2577	42.0329	1.5083	20.7223
9.	12.2359	42.0271	1.4701	19.7131
10.	11.3321	41.5604	1.4662	19.3915

The mean breeding values for direct effects ranged between 1.76 and 4.73 between the years 1997-2007. Duckacek et al. (2011) constated that the increased number of Aberdeen Angus cattle included in performance recording in the Czech Republic resulted in

increased value of breeding value for direct effect for weight at 210 days of age.

The estimates of (co)variance components, direct heritability, maternal heritability, direct-maternal genetic correlation and fraction of total variance due to maternal permanent environmental effects for growth traits are shown in Table 4.

Table 4. Estimates of (co)variance components and genetic parameters for birth weight, weaning weight for Aberdeen Angus cattle breed

Item	Birth weight	Weaning weight
σ^2_a	6.39±0.260	506.873±20.65
σ^2_m	1.17±0.047	189.529±7.72
σ_{am}	-0.79	-90.712
σ^2_{pe}	14.98±0.610	1360.592±59.43
σ_e^2	0.65±0.026	179.674±7.31
σ_p^2	24,01±0.978	2327.381±94.81
c^2	0.623	0.584
$\sigma_{am}/\ \sigma_p^2$	-0.032	-0.038
h_a^2	0.266±0.106	0.217±0.046
h_m^2	0.048±0.055	0.081±0.053
r_{am}	-0.291	-0.292
h_T^2	0.240±0.108	0.200±0.048

σ^2_a direct additive genetic variance, σ^2_m maternal genetic variance, σ_{am} direct–maternal additive genetic covariance, σ^2_{pe} maternal permanent environmental variance, σ_e^2 residual variance, h_a^2 direct heritability, h_m^2 maternal heritability, $c^2 = \sigma_{pe}^2/\sigma_p^2$ ratio of maternal permanent environmental variance to phenotypic variance, σ_{am} / σ_p^2 covariance between direct and maternal effects as proportion to phenotypic variance, r_{am} genetic correlation between direct and maternal effects, h_T^2 total heritability.

The genetic parameters ranged in the values obtained in the literature. Meyer (1995) obtained the direct heritability for birth weight in Aberdeen Angus from New Zealand 0.286 and for Aberdeen Angus from Australia 0.379 and for weaning weight the heritability was 0.201 and respectively 0.230. The maternal heritability reported by Meyer (1995) was 0.096 for birth weight and 0.081 for weaning weight in Aberdeen Angus from New Zealand. The maternal heritability for Aberdeen Angus from Australia was 0.066 for birth weight and 0.084 for weaning weight. Crawford et al. (2016) reported the direct heritability for birth weight was 0.42 and maternal heritability was 0.14, for weaning weight, the direct heritability was 0.26 and maternal heritability was 0.23 and the direct heritability at 365 days 0.45 and maternal heritability 0.23. Costa et al. (2011) reported the direct heritability for weaning weight 0.44 and for yearling weight 0.43. The maternal heritability was 0.25 for weaning weight and 0.12 for yearling weight. Williams et al. (2012) obtained the heritability for weaning weight at low altitude 0.28 and 0.26 at high altitude in Angus breed. Boddhireddy et al. (2014) obtained the heritability for birth weight 0.42, for weaning weight 0.20 and for yearling weight 0.20 in Angus breed. Baccino et al. (2020) obtained the heritability for birth weight 0.25 and for weaning weight 0.16. Robinson et al. (1996) reported direct heritability for Australian Angus cattle 0.35 and maternal heritability 0.08 for birth weight, direct heritability for weaning weight 0.20 and maternal heritability 0.09 and for yearling weight direct heritability 0.24 and maternal heritability 0.06.

The covariance and the correlations between the direct and maternal genetic effects for birth weight and weaning weight were negative in our study. The genetic parameters from our study were influenced by the variable environmental factors due the different herds. Robinson et al. (1996) reported also the correlations between direct and maternal effects were large and negative. Gociman et al. (2019) reported that in 2019 were in the Aberdeen Angus Romanian Herdbook 45000 cattle in Romania and the breed was adapted well in the Romanian pedoclimate conditions. Table 2 shows the breeding values for all the cattle analyzed, not just the one with performance, and because of that we can observe that the best animal has an anormal high breeding value. The reason for that is because in real practice, the information from farmers are very different and we cand have a farm with 1 male that has 1 calf and that one it is very possible to be one of the best, and because of that, his sire will have a huge breeding values. On the opposite we can have a sire with multiple calves and his breeding value will be corrected based on much more information and for that reason the breeding value cand be smaller. In that way we can say that a breeding value of +21.93 can be accepted in the analyze but we do not recommend to farmers we promote that animal further to reproduction.

CONCLUSIONS

The direct breeding values of the best cows were between 15.18 and 21.93 kg for birth weight and between 82.49 and 155.10 for the

weaning weight. The direct heritability for birth weight and weaning weight was moderate and the maternal heritability for these traits was low. Genetic parameters for birth weight show that these traits have huge variability, in specially when we look at the maternal heritability. One conclusion that can be obtained is that based on the birth weight breeding values is very difficult to have a valid selection decision and because of that is even more important to use the best biometrical model in the estimation of breeding values. Only in that way we can make objective decision regarding the genetic selection process. The most important conclusion and the aspect that offers the novelty characteristic of this work is the fact that the genetic parameters are, as mentioned in all breeding books, particular and characteristic of each individual population and each individual generation, and their estimation must be done either how many times there are changes in the structure of a cattle population. Moreover, the genetic parameters can be used in the breeding programs carried out on the territory of Romania.

ACKNOWLEDGEMENTS

This work was supported by funds from project ADER 8.1.2 granted by Ministry of Agriculture and Rural Development, the Perform project 8 PFE/2021, funds from Ministry of Research, Innovation and Digitalization and Aberdeen Angus Association Romania.

REFERENCES

Baccino, C.A.G, Laurenco, D.A.L., Miller, S., Cantet, R.J.C., & Vitezica, Z.G. (2020). Estimating dominance genetic variances for growth traits in American Angus males using genomics models. *J. Anim. Sci.*, 9(1), 1-7.

Boddhireddy, P., Kelly, M. J., Northcutt, S., Prayaga, K.C, Rumph, J., & De Nise, S. (2014). Genomic predictions in Angus cattle: Comparisons of sample size, response variables, and clustering methods for cross-validation. *J. Anim. Sci.,* 92, 485-497.

Crawford, N.F., Thomas, M.G., Holt, T.N., Speidel, S.E., & Enns, R.M. (2016). Heritabilities and genetic correlations of pulmonary arterial pressure and performances traits in Angus cattle at high altitude. *J. Anim. Sci*, 94, 4483-4490.

Costa, R. B., Misztal, I., Elzo, M. A., Bertrand, J. K., Silva, L. O. C., & Lukaszewicz, M. (2011). Estimation of genetic parameters for mature weight in Angus cattle. *J. Anim. Sci.*, 89, 2680–2686.

Duchacek, J., Prybyl, J., Stadnik, L., Vostry, L., Beran, J., & Stolc, L. (2011). Stability of Aberdeen Angus breeding values in the Czeck Republic from 1997 to 2007. *Czech J. Animal Science, 56*(11), 509-520.

Gociman, I.T., Mărginean, G.E., Bărăităreanu, S., Nicolae, C.G., & Vidu, L. (2019) Research on the evolution of the evolution of the Aberdeen Angus breed in Romania. *Scientific Papers, Series D, Animal Science, LXII*(2), 145-149.

Grosu, H., & Oltenacu, P.A. (2005). Breeding programs in Animal Husbandry. Bucharest, RO: Ceres Publishing House.

Hoj-Edwards, S. (2017). *Standard errors of heritability estimates.* Web publication/site. Royal (Dick) School of Veterinary Studies. https://www.research.ed.ac.uk/en/publications/standard-errors-of-heritability-estimates.

Jakubec, V., Schlote, W., Rika, J., & Majzlik, J. (2003). Comparison of growth traits of eight beef cattle breeds in the Czech Republic. *Arch. Tierz, 46*(2), 143-153.

Kolisnyk, O. I., Prudnikov, V. G., & Kryvoruch-ko, Y. I., (2018). Monitoring and evaluation of the meat diseases of the Aberdeen-Angus breed in Ukraine. *Bulletin of Poltava State Agrarian Academy*, 3, 127-131.

Mădescu, B.M., Lazăr, R., Davidescu, M.A., Matei, A.C., & Boișteanu, P.C. (2022). Research on morpho-productive indicators observed of Aubrac and Aberdeen Angus cattle breeds. *Scientific Papers. Series D. Animal Science., LXV*(2), 279-283.

Meyer, K. (1995). Estimates of genetic parameters and breeding values for New Zealand and Australian Angus cattle. *Australian Journal of Agricultural Research*, 1-16.

Mrode, R.A., & Thompson, R. (2005). Maternal Trait Models: Animal and Reduced Animals Models. Linear models for the Prediction of Animal Breeding Values. UK: Cabi Publishing House, 121-133.

Nikolov, V., & Karamfilov, S. (2020). Growth of female calves of the Aberdeen Angus cattle breed reared in an organic farm. *Scientific Papers. Series D. Animal Science, LXIII*(1), 60-66.

Otto, P.I., dos Santos, A.L., Perotto, D., de Oliveira, S.N., Granzotto, F., Gobo Rosa, D.O., Zanao de Souza, F.E., & Thomazini, G. (2021). Estimation of genetic parameters for weaning and yearling weights in a composite population used from a Purana breed. *Resita Brasileira de Zootecnia*, 50, 320180224. https://doi.org/10.37496/rbz5020180224

Robinson, D.L. (1996). Estimation and interpretation of direct and maternal genetic parameters for weights of Australian Angus cattle. *Livestock Production Science*, 145, 1-11.

Wilham, R.L. (1972). The role of maternal effects in animal breeding. Biometrical aspects of maternal effects in animals. *J. Anim. Sci.,* 35, 1288-1293.

Williams, J. L., Bertrand, J. K., Misztal, I., & Łukaszewicz, M. (2012) Genotype by environment interaction for growth due to altitude in United States Angus cattle. *J. Anim. Sci.*, 90, 2152–2158.