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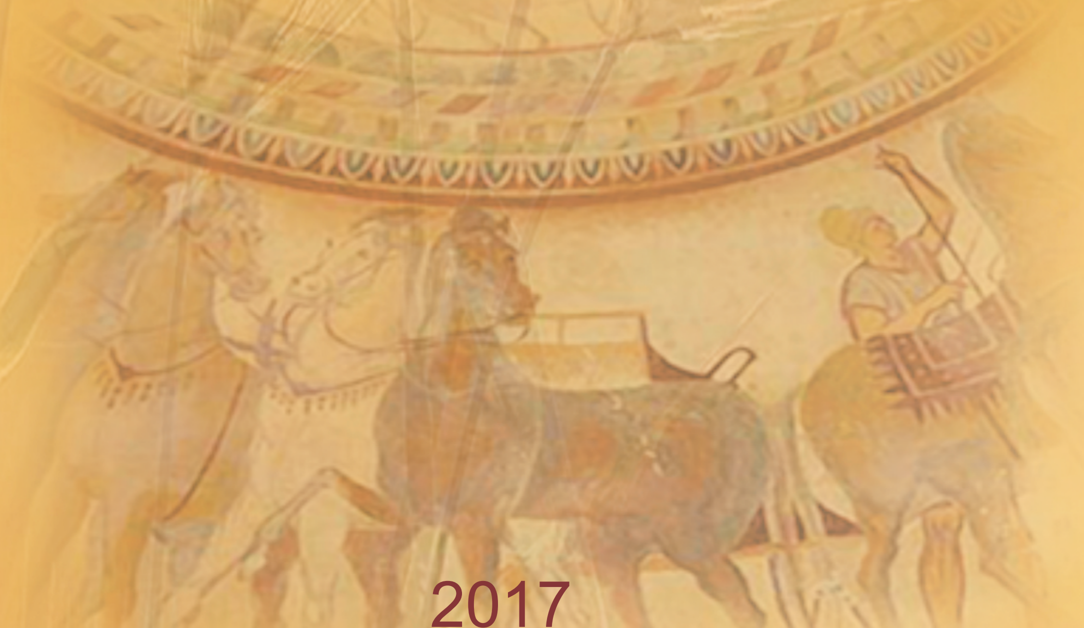

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Study on the loss of accuracy of AC-method for milk yield control in sheep

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Abstract. *The aim of this study was to investigate the loss of accuracy of AC-method for milk yield control in sheep under the conditions of threefold milking per day. Test day milk yield records of 113 ewes raised on sheep farm of the Agricultural University in Plovdiv collected according to official A4 method were used. Two breeds were raised at the university experimental farm: White Maritza (49 ewes) and Patch Faced Maritza (64 ewes). Predicted milk yield data on test day were simulated using different prediction coefficients (calculated at morning, noon or evening milk recording). Database includes 2577 predicted milk yield records on test day. The loss of accuracy using AC method is accumulated in two ways: by milk yield prediction coefficients on test day and milk yield calculations during milking period. Loss of accuracy (LA_1) in prediction of test day milk yield by prediction coefficients varies from 10.02% to 12.74% according to type of milk recording (morning, noon or evening). Three factors such as level of test day milk yield, type of milk recording and animal have larger influence on LA_1, 27.70%, 21.99% and 19.32%, respectively, of total variation. Loss of accuracy (LA_2) in the calculated total milked milk per milking period on the basis of predicted test day milk yield according to the morning, noon and evening milk recordings compared with A4 method are 7.04%, 8.03% and 6.05%, respectively. Depending on the type of milk recording on the test day (morning, noon and evening), 46.88% to 56.15 % of the observations of LA_2 fall within the scope of ±5%. Rank correlations in the ranking of ewes in all years and different designs of AC method have high values from 0.891 to 1.000.*

Keywords: loss of accuracy, milk yield, recording, AC-method, sheep breeding

Introduction

In many European countries where dairy sheep breeding is well developed milking is twice a day. Machine milking in sheep nowadays is common practice in many countries in the world, especially in intensive dairy sheep production systems. Therefore, milk recording in these systems is routine. Nevertheless, in many extensive sheep production systems in Europe milking is still by hand for numerous reasons. Lots of sheep farmers in the Balkan countries are still practicing milking by hand sometimes threefold a day. Some of the farmers who raise dairy or dual sheep breeds are practising threefold hand milking a day have also been included in the milk recording schemes.

The cost of milk recording in sheep, expressed in units of outcome per animal is about 2 or 3 times higher than dairy cattle milk recording (Sanna and Casu, 1999). This was the reason to seek new ways and methods in dairy sheep breeding to simplify the standard A4 method and to reduce the cost of milk recording in sheep. AT and AC methods of milk recording in sheep are approved simplified methods by International Committee of Animal Recording (Barillet et al., 1992). Astruc and Barrillet (2000) reported that till 2000 the standard A4 method for milk recording in sheep was replaced by AC and AT methods. These are simplified methods in which measuring of milk yield is performed only at one of the two milkings on the test day (TD). The interval of 30±3 days has been accepted as standard interval between successive TDs in the milking period when AC and AT methods are applied (Barillet et al., 1992). The milk yield in TD is calculated by doubled volume of milk yield during the morning or evening milking (AT method) or using prediction coefficient (AC method).

The ICAR regulations are not giving clear guidelines as to at which milking milk recording in sheep has to be made when the situation is threefold milking a day. Then the logical question arises in which milk recording on the TD (morning, noon or evening) loss of accuracy is less?

Simplified AT and AC methods have been tested for accuracy by many authors under the conditions of double milking per day (Sanna and Casu, 1999; Ghita et al., 2007; Ivanova 2013; Pachinovski et al., 2015) and others under the conditions of threefold milking per day (Gievski et al., 2006, Pacinovski et al., 2017). The AC method decreases by 50 % the necessary work to measure milk yield and that's the reason why most countries in Europe switched to using the AC method (Ghita et al., 2007). Sanna and Casu (1999) have checked accuracy and precision of simplified AT and AC methods by comparing the average difference between estimated (predicted) and reference daily milk yields. Under the conditions of double milking per day the authors find that the AC method exhibits rank correlations close to 0.99 with reference yield, revealing loss of accuracy slightly greater than the recorded for the AT method. The AC method had a slightly lower accuracy and precision than the AT, but it can give a considerable flexibility to milk recording in sheep.

The loss of accuracy (LA) of the AC method depends of how much exactly the prediction coefficients predict test day milk yields (TDMYs) and how the loss of accuracy in prediction of TDMYs reflects on the accuracy of calculations for total milked milk (TMM) during the milking period.

Analysing averaged differences between predicted and actual individual TDMYs in sheep under the conditions of threefold milking per day, Gievski et al. (2006) found out that practically three predicting coefficients (morning, noon and evening) gave very small differences between the averaged predicted and actual yields, but when considered minimum and maximum deviations for a particular ewe the results showed extreme differences from –67.1% to +81.3% compared to actual daily yield. The distribution of relative deviations

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of predicted and the actual test day yields in this study illustrated that small part of the loss of accuracy observations were within the scope of ±5% (from 26.2% to 33.8% depending of milk recording type). Pacinovski et al. (2017) assume that differences between the predicted and actual measured daily milk yield in the scope of 7–10% can be taken as good accuracy for prediction.

The aims of this study were to investigate loss of accuracy in prediction of test day milk yields in sheep by different prediction coefficients calculated at morning, noon or evening milk recording during the test days (threefold milking per day) and to estimate loss of accuracy in calculated total milked milk per milking period in sheep.

Material and methods

In this study 859 TDMY data recorded by A4 method on the experimental farm of Agricultural University in Plovdiv collected during five years (1997, 1998, 1999, 2000 and 2003) were used. The two sheep breeds were kept in two small flocks: White Maritza (49 ewes) and Patch Faced Maritza (64 ewes). In order to estimate the loss of accuracy (LA) of AC method two approaches were used: loss of accuracy (LA_1) in predicted test day milk yield (PTDMY) and loss of accuracy (LA_2) in calculated TMM during milking period. Actual test day milk yield (ATDMY) data were used to simulate PTDMY data by different prediction coefficients calculated at morning, noon or evening milk recording on the TD. The prediction coefficient on the TD sometimes called flock coefficient is the ratio of total milk yield of the flock on TD to total milk yield of the flock in the milk recording milking that may be morning, noon or evening milking. Common database includes 2577 PTDMY records of 113 ewes under the conditions of threefold hand milking per day. Test day milk yields recorded in late milking period, when ewes were milked twice or once a day, were discarded. The interval between successive test days in the course of the milking period in this study was 15 days. The LA_1 was calculated as relative difference between PTDMY and ATDMY of particular ewe depending on morning, noon or evening prediction coefficients.

$$LA_1 = [(PTDMY - ATDMY) / ATDMY]. 100$$

where: LA_1 – individual loss of accuracy in PTDMY, %; PTDMY – predicted test day milk yield using morning, noon or evening prediction coefficients, mL; ATDMY – actual test day milk yield, mL.

The effects of farming year, month of lambing, litter size, flock test day, ewe test day, type of milk recording, level of milk yield, breed and animal on the LA_1 have been included in fixed linear model. In order to take into account some environmental effects on the LA_1 for data processing general linear models were used as follows:

$$Y_{in} = \mu + x_i + e_{ij}$$

where: Y_{ij} – variable; μ – LS – mean, x_i – fixed effects of animal (113), farming year (5), flock test day (10), ewe test day (10), level of test day milk yield (5), type of test day milk recording (3), month of lambing (7) and litter size (3) e_{ij} – residual error.

The factor level of test day milk yield was divided into 5 levels: up to 500mL, 501 - 1000 mL, 1001 - 1500 mL, 1501 - 2000 mL and over 2001 mL. The environmental effects were successively analysed. To solve the equations of fixed linear model SSPS 13.0 were used.

The second aim in this study was to estimate individual loss of accuracy of calculation of TMM on the basis of PTDMYs. The centered method for lactation calculations was used to calculate TMM. The approach in formula for LA_1 was also applied to TMM per milking period (La_2).

$$LA_2 = [(TMM - ATMM) / ATMM]. 100$$

where LA_2 – loss of accuracy in calculated TMM, %; TMM – total milked milk per milking period calculated by morning, noon or evening type of milk recording, L; ATMM – actual total milked milk per milking period, calculated by actual test day milk yield, L.

Relative differences in the formulas above were taken for data processing at their absolute values. This approach was preferred for data processing as this measure discovers more clearly the size of loss of accuracy in PTDMY and calculated TMM in sheep. In order to check changes in ranking of the ewes by TMM, when AC method is used instead of A4, Spearman's rank correlation was calculated.

Results and discussion

Threefold hand milking per day is still a common practice on many sheep farms in lowland regions in Bulgaria and other Balkan countries in particularly small and medium sheep farms. The possibility and right of sheep breeders practising threefold milking per day to take part in milk recording schemes set the question what type of milk recording is to be used. Gievski et al. (2006) suggested that in prediction of TDMY the most considerable is the importance of morning prediction coefficients followed by the evening and midday ones. The situation in different sheep farms is quite different. In practice, it is not so easy to decide which milking has to be used for milk recording in the TD in situation of threefold milking. A proper prediction of TDMY is important, but implementation of a milk recording scheme as long term practice is also very important.

Descriptive statistics of ATDMYs of two sheep breeds are presented in Table 1. The levels of test day milk yield of White Maritza sheep (741.58 mL) and Patch faced Maritza sheep (693.00 mL) kept on the experimental farm of Agricultural university of Plovdiv are the typical levels of dual purpose sheep breeds. There is no significant difference between the average test day milk yields of the two sheep breeds which is the reason to combine the data in a common database in order to analyse the other environmental

Table 1. Descriptive statistics data of actual test day milk yield (ATDMY) of White Maritza and Patch faced Maritza sheep breeds kept on the experimental farm of Agricultural University in Plovdiv.

Breeds	n	$\overline{x} \pm S_{\overline{x}}$	CV, %	Significance differences
White Maritza	339	741.58 ± 17.99	55.25	ns
Patch Faced Maritza	520	693.00 ± 17.60	46.78	ns
Total	859	722.63 ± 7.46	52.40	

*CV - coefficient of variation; ns - no significant difference

Table 2. Loss of accuracy (LA_1) in PTDMY predicted by different predicting coefficients depending on morning, evening or noon milk recording on test day.

Type of milk recording	n	$\overline{x} \pm S_{\overline{x}}$	Min - Max
AC_n	859	12.74 ± 0.37^{ns}	0.00 - 75.60
AC_e	859	10.02 ± 0.29^{ns}	0.00 - 67.20
AC_m	859	10.49 ± 0.33^{ns}	0.00 - 56.67

Key: LA1 - loss of accuracy; n, e, m – subscripts denote type of milk recording on the test day (noon, evening, morning); PTDMY – predicted test day milk yield; $\overline{x}$ - mean; $S_{\overline{x}}$- error of mean; ns - no significant difference between averages.

effects on loss of accuracy in PTDMY.

High coefficients of variations of ATDMYs are close to our previous studies for these breeds (Dimov, 1998, 2011). Normally, the usage of prediction coefficients to predict TDMY to a certain extent lead to loss of accuracy. It is very important to know how much is this loss of accuracy and whether it is acceptable. In this study LA_1 varies from 10.02% to 12.74% (Table 2) according to type of milk recording (morning, noon or evening milk recording). Pachinovski et al. (2017) assume that it can be taken as good accuracy for prediction of TDMY if deviations from actual test daily milk yield are 7–10%. The results in calculating LA_1 presented in Table 2 are slightly larger than this assumption and therefore we have analyzed influence of various factors that may have effect on LA_1.

Table 2 gives the corresponding analyses of sources of variation on LA_1 and shows that animal, farming year, flock test day, level of TDMY and type of test day milk recording have significant effects (P<0.001). The effects of month of lambing and litter size are with lower degree of probability. The effects of breed and ewe test day are not significant.

Having in mind all significant and non-significant effects we have estimated proportion of the influence of difference factors (Table 3). Three factors such as level of test day milk yield, type of milk recording and animal have larger influence on LA_1, 27.70%, 21.99% and 19.32%, respectively, of the total variation. Farming year, month of lambing, litter size, flock test day and ewe test day comprised small part of total variation– 4.27%, 3.58%, 3.78%, 2.76% and 0.74%, respectively.

PTDMY is taken into account in the formula for lactation calculations about TMM. According to type of milk recordings (morning, noon or evening milking) different values of TMM have been calculated (Table 4).

Analysing different averaged values about TMM it can be pointed out that differences caused by applying different types of milk recording (AC_n, AC_e, or AC_m) in comparison with A4 method are not so big: from +2.23 L to -1.73 L for noon, evening and morning milkings. Prima facie, the lack of significant differences in comparing averaged values of TMM measured by different designs of AC method has calming effect about all applications of the AC-method. However, comparisons between these groups means hiding real loss of accuracy depending on type of milk recording (AC_n, AC_e, and AC_m). When loss of accuracy is considered and calculated in absolutely individual deviations, it was found out in particular ewes that averaged values of LA_2 at morning, noon and evening milk recordings are 7.04%, 8.03% and 6.05%, respectively (Table 5).

That was the reason to search for a new approach to discover the detailed picture about LA_2 about calculated TMM when different types of milk recordings (AC_n, AC_e, and AC_m) are used. The variation of LA_2 was divided in three different ranges: ±5%, > -5% and > +5% as it was done in the study by Gievski et al. (2006). Table 6 gives the distributions of different values of LA_2 according to selected ranges.

The analyses of distributions of observations across to selected three ranges show a new picture of the loss of accuracy of calculated TMM. Usually, in the common practice milk recording is performed at morning milking. Sanna and Casu (1999) find out that morning milking had greater contribution to daily yields and provided better estimates revealing lower difference between predicted and actual TDMY. The distributions of LA_2 in Table 6 show that at the morning milk recording 51.54% of the observations of LA_2 fall within the scope of ±5%. From this point of view when the AC method is implemented in the scheme of evening milk recording, it gives approximately the

Table 3. Analysis of sources of variation of LA1 and proportion of influence in PTDMY

Sources of variation	df	SS	F	P	Proportion,%
Animal	112	34855.086	2.640	***	19.32
Breed	1	4009.318	0.714	ns	0.02
FY	4	7786.544	20.681	***	4.27
ML	6	1528.158	2.636	**	3.57
LS	2	557.092	2.876	*	3.77
FTD	9	5099.535	5.942	***	2.76
ETD	9	715.689	0.819	ns	0.74
Level of TDMY	4	5107.589	13.417	***	27.70
Type of TDMR	2	3628.930	18.966	***	21.99
Residual	2428	186595.05			15.86
Total	2577	249882.991			100

Key: FY – farming year; ML – month of lambing; LS – litter size; FTD – flock test day; ETD – ewe test day; Level of TDMY – level of test day milk yield; Type of TDMY – type of test day milk recording; F – Fischer criterion; P – degree of probability * - p<0.05; **- p<0.01; ***-p<0.001; ns - non significant.

Table 4. Accuracy of total milked milk recorded by different types of AC milk recording method

Method of milk recording	n	Total milked milk, L	
		$\bar{x} \pm S_{\bar{x}}$	D
A4	113	97.64±3.52	0
AC_n	113	99.87±3.66	$+2.23^{ns}$
AC_e	113	95.91±3.50	-1.73^{ns}
AC_m	113	95.97±3.61	-1.67^{ns}

Key: TMM - total milked milk; $\bar{x}$ - mean; $S_{\bar{x}}$- error of mean; A4 – official standard method of milk recording in sheep; AC – simplified milk recording method in sheep, n, e, m – subscripts denote type of milk recording on test day (noon, evening or morning milk recording); D - difference between mean values of TMM measured by different AC methods with standard A4 method; a - superscripts denote significance p<0.05.

Table 5. Loss of accuracy (LA_2) in calculated TMM by different designs of AC methods depending of morning, evening or noon milk recording on the test days

Designs of AC method of milk recording	n	$\bar{x} \pm S_{\bar{x}}$
AC_n	113	8.03 ± 0.58
AC_e	113	6.05 ± 0.46
AC_m	113	7.04 ± 0.47

Key: AC – simplified milk recording method in sheep; n, e, m – subscripts denote type of milk recording on the test day (noon, evening, morning).

Table 6. Distribution of relative differences of TMM in different classes of range depending on type of AC milk recording (n=113)

Method	Classes of relative differences, %		
	> –5%	±5%	> +5%
AC_n	17.19	46.88	35.94
AC_e	27.69	56.15	23.85
AC_m	30.78	51.54	18.46

same precision, because 56.15% of the observations fall within the scope of ±5%. Although noon milk recording is more comfortable from organisational point of view in comparison with other types of milk recordings (morning and evening), less LA_2 observations fall within the acceptable scope of ±5%. The analysis of Table 6 shows that in the morning and evening milk recordings the MY is underestimated at 30.78% and 27.69% of the observations, respectively. Table 6 gives discover approximate estimations that not a small number of observations have a great loss of accuracy (LA_2).

In principle, the AC-method of milk recording in sheep is applied in order to obtain objective data on the milk yield in sheep. These data are used for estimations of genetic parameters, breeding values and ranking of ewes in the process of selection. The question arises whether these LA_1 and LA_2 could affect the ranking of ewes for milk yield? The answer to this question was looking for calculation of rank correlations (r_s) depending of the type of milk recording (Table 7). Rank correlations in all years and different designs of the AC method have high values from 0.891 to 1.00, which means that the change of ranking of ewes by TMM calculated on the basis of AC_n AC_e AC_m designs is non-significant.

Obviously, applying the AC method under the conditions of threefold milking per day is associated with loss of accuracy both for PTDMY and TMM. Such data for milk yields in sheep accumulated as database are important for future analyses in test day models and lactation models. That's why the loss of accuracy has to be as small as possible. Significant influence of the factors animal, farming year, flock test day, daily milk level and type of test day milk recording on the loss of accuracy of PTDMY show that additional measures are necessary to decrease the influence of environmental effects on TD.

Table 7. Rank correlations of the ranking ewes by TMM calculated by different types of milk recordings

Year	n	r_s at AC_n	r_s at AC_e	r_s at AC_m
1997	13	0.989	0.973	0.978
1998	5	1.000	0.900	1.000
1999	20	0.968	0.901	0.944
2000	11	0.891	0.945	0.973
2003	64	0.981	0.984	0.983

The literature review shows that many authors who have investigated the loss of accuracy of the AC method are satisfied to compare averages of milk yields in sheep obtained from the simplified AC and A4 standard methods (Sanna and Cassu, 1999, Ghita et al., 2007, Ivanova, 2013). The results of this study show that this approach cannot reveal the true loss of accuracy by using the AC method. In principle, in order to benefit from the simplified AC method, there should be no differences in the average milk yields between AC and A4 methods. The absence of a difference between the average values of the two sets shows that the simplified AC method does not displace the average of the general population, which means that the obtained average corresponds to the theoretically expected. Otherwise, the AC method cannot be used for milk recording in sheep. However, the averaging of milk yield data obtained under the simplified AC method conceals significant individual deviations. In this study we tried to analyse these otherwise unavoidable deviations. The analysis showed that the loss of accuracy is more prominent when it is expressed as an absolute value of the relative deviation of predicted test day milk yield with actual test day milk yield. Averaging of data with absolute values of individual loss-of-accuracy data ignores the meaning of the positive and negative signs, otherwise averaging a line or column of numbers with positive or negative signs reduces the arithmetic mean.

Regardless of the loss of accuracy in PTDMY and TMM caused by different factors when different designs of AC method are applied, this method has so far remained the only suitable method for milk recording in a sheep flock where the milking is threefold a day.

Conclusion

The implementation of AC method in the situations of threefold milking a day in the sheep breeding practice is associated with some loss of accuracy. This loss of accuracy is accumulated in two ways: by the milk yield prediction coefficients on test day and by calculating this loss of accuracy in milk yield calculations during milking period. There is a tendency on test day the loss of accuracy of predicted test day milk yield to be the greatest when milk recording is done at noon milking – 12.74%. Many factors such as animal, farming year, flock test day, test day milk yield and type of milk recording on test day have significant influence on the loss of accuracy of predicted test day milk yield. Three factors such as level of test day milk yield, type of milk recording and animal had larger influence on the loss of accuracy on test day and their proportions in total variation are 27.70%, 21.99% and 19.32%, respectively. Different designs of AC method according to type of milk recording during milking period are associated with acceptable loss of accuracy 6.05%, 7.04% and 8.03%, respectively, at evening, morning and noon milk recording. Ranking of ewes by total milked milk using the AC method is insignificantly changed.

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Preparation of papers

Papers shall be submitted at the editorial office typed on standard typing pages (A4, 30 lines per page, 62 characters per line). The editors recommend up to 15 pages for full research paper (including abstract references, tables, figures and other appendices)

The manuscript should be structured as follows: Title, Names of authors and affiliation address, Abstract, List of keywords, Introduction, Material and methods,Results, Discussion, Conclusion, Acknowledgements (if any), References, Tables, Figures.

The title needs to be as concise and informative about the nature of research. It should be written with small letter /bold, 14/ without any abbreviations.

Names and affiliation of authors The names of the authors should be presented from the initials of first names followed by the family names. The complete address and name of the institution should be stated next. The affiliation of authors are designated by different signs. For the author who is going to be corresponding by the editorial board and readers, an E-mail address and telephone number should be presented as footnote on the first page. Corresponding author is indicated with *.

Abstract should be not more than 350 words. It should be clearly stated what new findings have been made in the course of research. Abbreviations and references to authors are inadmissible in the summary. It should be understandable without having read the paper and should be in one paragraph.

Keywords: Up to maximum of 5 keywords should be selected not repeating the title but giving the essence of study.

The introduction must answer the following questions: What is known and what is new on the studied issue? What necessitated the research problem, described in the paper? What is your hypothesis and goal ?

Material and methods: The objects of research, organization of experiments, chemical analyses, statistical and other methods and conditions applied for the experiments should be described in detail. A criterion of sufficient information is to be possible for others to repeat the experiment in order to verify results.

Results are presented in understandable tables and figures, accompanied by the statistical parameters needed for the evaluation. Data from tables and figures should not be repeated in the text.

Tables should be as simple and as few as possible. Each table should have its own explanatory title and to be typed on a separate page. They should be outside the main body of the text and an indication should be given where it should be inserted.

Figures should be sharp with good contrast and rendition. Graphic materials should be preferred. Photographs to be appropriate for printing. Illustrations are supplied in colour as an exception after special agreement with the editorial board and possible payment of extra costs. The figures are to be each in a single file and their location should be given within the text.

Discussion: The objective of this section is to indicate the scientific significance of the study. By comparing the results and conclusions of other scientists the contribution of the study for expanding or modifying existing knowledge is pointed out clearly and convincingly to the reader.

Conclusion: The most important consequences for the science and practice resulting from the conducted research should be summarized in a few sentences. The conclusions shouldn't be numbered and no new paragraphs be used. Contributions are the core of conclusions.

References:

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Books: Author(s) surname and initials, year. Title. Edition, name of publisher, place of publication. Example:

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Book chapter or conference proceedings: Author(s) surname and initials, year. Title. In: Title of the book or of the proceedings followed by the editor(s), volume, pages. Name of publisher, place of publication. Example:

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Todorov N and Mitev J, 1995. Effect of level of feeding during dry period, and body condition score on reproductive performance in dairy cows, IX^{th} International Conference on Production Diseases in Farm Animals, September 11–14, Berlin, Germany.

Thesis:

Hristova D, 2013. Investigation on genetic diversity in local sheep breeds using DNA markers. Thesis for PhD, Trakia University, Stara Zagora, Bulgaria, (Bg).

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Animal welfare

Studies performed on experimental animals should be carried out according to internationally recognized guidelines for animal welfare. That should be clearly described in the respective section "Material and methods".

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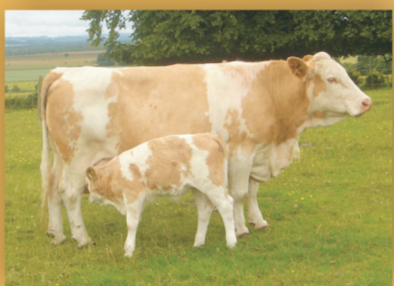

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