Small Ruminant Research xxx (2009) xxx–xxx

Contents lists available at ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

Auction price of Texel, Suffolk and German white-headed mutton rams: A genetic-statistical study

J. Maxa[a,*], N. Borchers[b], H. Thomsen[c], H. Simianer[a], M. Gauly[a], A.R. Sharifi[a]

[a] Institute of Animal Breeding and Genetics, University of Göttingen, Albrecht-Thaer-Weg 3, 37075 Göttingen, Germany
[b] Chamber of Agriculture Schleswig-Holstein, Section of Animal Husbandry and Breeding, Futterkamp, 24327 Blekendorf, Germany
[c] Department of Genetics and Biotechnology, University of Aarhus, Research Centre Foulum, P.O. Box 50, 8830 Tjele, Denmark

ARTICLE INFO

Article history:
Received 16 April 2009
Received in revised form 24 July 2009
Accepted 27 July 2009
Available online xxx

Keywords:
Auction price
Genetic parameters
Performance traits
Sheep

ABSTRACT

In this study, the impact of various traits and effects on auction price of Texel, Suffolk and German white-headed mutton rams was determined. Furthermore, (co)variance components between auction price and performance traits recorded at licensing were estimated. Data from 1988 to 2007 were extracted from the recording database of the Sheep Breeding Organisation in Schleswig-Holstein, Germany. Auction prices of 1133 Texel, 373 Suffolk and 341 German white-headed mutton rams from the year 2003 to 2007 were analysed. General Linear Models and Multiple Regression Analysis were used to identify the impact of traits and effects on the auction price. Estimation of (co)variance components was carried out using multivariate animal model. From the traits recorded at licensing, live weight, followed by type traits of conformation and muscle mass, had the highest impact on the auction price. Also the effects of breed, PrP (Prion Protein) genotype, and owner of the ram influenced the auction price of rams significantly. A moderate genetic contribution of auction price, with favourable genetic correlations to all collected performance traits (average daily gain from birth until licensing, muscle depth, fat depth, conformation, muscle mass and wool quality), was estimated. Genetic correlations were 0.42, 0.34, 0.17, 0.49, 0.39 and 0.23, respectively. The results showed a high influence of live weight of animal on auction price of the rams contrary to very low influence of carcass quality traits measured with ultrasound technology.

1. Introduction

Specialised meat sheep breeds account for a major part of the herd book sheep population in the German federal country Schleswig-Holstein. Texel, Suffolk and German white-headed mutton sheep are, among others, the most common breeds. Nowadays, the major income from the sheep farming is meat production and economically sustainable production, especially in case of meat breeds, depends on ability to produce high quality carcasses. Ultrasound measurements on live animals are therefore used in Schleswig-Holstein, as well as in other countries, as relatively low cost method of prediction of carcass traits. Ultrasound measurements of muscle (*M. longissimus*) and fat depth are provided in Schleswig-Holstein in a specific period at licensing, 6 weeks before auction. Together with ultrasound measurements the data on weight, average daily gain and three type traits (conformation, muscle mass and wool quality) are recorded and presented on the day of auction. Furthermore, breeding values for average daily gain, muscle mass and ultrasound-measured traits are estimated.

Selling surplus rams at auction yields an important additional income for many sheep breeders. Therefore, the knowledge on important factors affecting selling price of rams at auction as well as the relation to the traits

* Corresponding author. Tel.: +49 551 39 59 29; fax: +49 551 39 55 87.
E-mail address: jmaxa@gwdg.de (J. Maxa).

0921-4488/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.smallrumres.2009.07.011

recorded at licensing are needed for a better understanding of price characteristics. Until now most of the studies analysing auction price focused on beef (Krogmeier et al., 2006; Barham and Troxel, 2007; Troxel and Barham, 2007) or dairy cattle (Ruff et al., 1983; Schierenbeck et al., 2009). In sheep, only studies of Terrill (1953) and more recently Fuerst-Waltl and Baumung (2006) determined the relation of sale price to records of merit of different traits. At latest, the genetic parameters for the trait 'auction price' were estimated in Holstein cattle (Schierenbeck et al., 2009), but there is no study yet with such a focus in sheep.

The main objectives of this study were to determine the impact of performance traits, with special focus on type traits, recorded at licensing on the auction price for further application in deriving of economic weights. Furthermore, factors that affect auction price of Texel, Suffolk and German white-headed mutton rams in Schleswig-Holstein were determined. Along with previous aims, the genetic parameters for the mentioned performance traits as well as for the auction price were estimated.

2. Materials and methods

2.1. Data

Performance test data on purebred Texel, Suffolk and German white-headed mutton rams were collected from the beginning of 1988 to the end of 2007 by the Sheep Breeding Organisation in Schleswig-Holstein, Germany. Pedigrees were traced back to 1970. The performance traits included in the analyses were weight at licensing (W), average daily gain from birth until licensing (ADG), muscle depth (MD), fat depth (FD), conformation (CT), muscle mass (MM) and wool quality (WQ), recorded at earliest 6 weeks before the auction date. The measurements of MD and FD were recorded by ultrasound technology and taken on the right side of the ram lateral to the third lumbar vertebra at the age between 130 and 250 days. Type traits of CT, MM and WQ with scores in the range from 1 (unsatisfactory) to 9 (excellent), where the score 5 represented average, were recorded by representatives of the Sheep Breeding Organisation. Conformation score concerned type, form and feet and legs traits. Type characterized the expression, head and ears of the ram. Form reflected overall impression, shoulder, top line and testes. Locomotion, foot angle, rear leg set as well as bow-legs, knock-knees and claws were taken into account. Muscle mass classification focused on muscling of shoulder, top line and rump. Wool quality score was determined by fineness, length and colour of wool. For the estimation of genetic parameters also the data on ADG, MD, FD, CT, MM and WQ of licensed rams, without information on auction price, were included. In total, auction prices of 1133 Texel, 373 Suffolk and 341 German white-headed mutton rams between 170 and 270 days of age were analysed and collected from 2003 to 2007 at auction sale in Husum in Schleswig-Holstein. The raw dataset also included information on auction price of rams sold at second year of age and older as well as ewes which were not considered in the analysis. The rams with auction price higher than 1000€ were excluded from the analysis using the influence diagnostics presented by Belsley et al. (1980) and incorporated in the PROC REG procedure by using the INFLUENCE option in the MODEL statement. The Studentized residual was then used for analysing the influence of each auction price record. The auction sale took place in August or September at separate days for each breed. The auction prices in the range from 150 to 1000€ were included and further divided into 10 groups of auction price (AP) in order to obtain a normal distribution of the new trait. Auction price was thereafter analysed as a continuous trait. Description of data used for analyses as well as detailed description of data within each AP is presented in Tables 1 and 2, respectively.

Table 1
Description of data used in analyses with SD in parenthesis.

Animals in pedigree	33,504
Sires with offspring	2072
Average no. of offspring per sire	9.2
Average age at auction (SD) in days	216.0 (18.8)
Average weight at auction (SD) in kg	74.8 (16.3)
Auction price	
No. of animals in data	1847
Means (SD) in €	315.9 (133.7)
Auction price group	
No. of animals in data	1,847
Means (SD)	5.5 (2.1)
Average daily gain	
No. of animals in data	19,055
Means (SD) in g	357.1 (69.5)
Muscle depth	
No. of animals in data	8950
Means (SD) in mm	33.6 (4.0)
Fat depth	
No. of animals in data	8950
Means (SD) in mm	8.1 (2.7)
Conformation	
No. of animals in data	18,928
Means (SD) in scores	6.3 (0.8)
Muscle mass	
No. of animals in data	18,934
Means (SD) in scores	6.9 (0.7)
Wool quality	
No. of animals in data	18,934
Means (SD) in scores	6.9 (0.6)

2.2. Statistical analyses

In a first step, the analysis of fixed effects for AP was performed with a GLM procedure (SAS, 1999), including fixed effects of breed, Prion Protein (PrP) genotype, owner (breeder) of the ram and year of auction. Weight at licensing, ADG, MD, FD and three type traits (CT, MM and WQ) were considered in the analysis as covariates. Significance levels of the fixed effects were determined using the *F*-test statistics. A Multiple Regression (SAS, 1999) was used in order to analyse the importance of impact of traits recorded at licensing on AP for each breed separately as well as over all breeds.

Estimation of (co)variance components was carried out over all breeds with multivariate animal model using REML and the ASREML package (Gilmour et al., 1998). Heritabilities for performance traits, genetic contribution of AP as well as genetic and phenotypic correlations were calculated based on these estimates. The term 'genetic contribution' is used for AP rather than heritability, because it reflects better to a non-biological sense of auction price. The ASREML package (Gilmour et al., 1998) was also used for calculation of standard errors of estimated genetic parameters. Effects included in the model differed for the traits, and they were as follows:

$$\mathrm{AP}_{ijklp} = B_i + F_j + G_k + \mathrm{AY}_l + \mathrm{adir}_p + e_{ijklp}$$
$$Y_{ijmnop} = B_i + F_j + \mathrm{LS}_m + P_n + \mathrm{LY}_o + b(AL_p) + \mathrm{adir}_p + e_{ijmnop}$$

where AP_{ijklp} = auction price of animal p, Y_{ijmnop} = performance traits ADG, MD, FD, CT, MM and WQ of animal p, B_i = fixed effect of breed, F_j = fixed effect of flock, G_k = fixed effect of PrP genotype, AY_l = fixed effect of year of auction, LS_m = fixed effect of litter size, P_n = fixed effect of parity, LY_o = fixed effect of year of licensing, AL_p = age at licensing of animal p, b = regression coefficient of ADG, MD, FD, CT, MM and WQ on AL of animal p, adir_p = random direct additive genetic effect of animal p, e_{ijklp} and e_{ijmnop} = random residual.

Weight at licensing was not included as covariate in the multivariate model because of confounding effect with ADG. Furthermore, the effect of age at auction was not included in the model for AP because the trait ADG was considered in multivariate analysis and is highly correlated with age at auction. The fixed effect of PrP genotype consisted of two classes where the first genotype class included animals with prion protein allele combination ARR/ARR (natural scrapie disease resistant) and the second genotype class included animals with prion protein allele combinations ARR/AHQ, ARR/ARH and ARR/ARQ (low risk of natural scrapie disease). The animals with other Prion Protein allele combinations were very rare or did

Please cite this article in press as: Maxa, J., et al., Auction price of Texel, Suffolk and German white-headed mutton rams: A genetic-statistical study. Small Ruminant Res. (2009), doi:10.1016/j.smallrumres.2009.07.011

Table 2
Description of data with no. of animals, price range, averages of price, weight at licensing (W), average daily gain until licensing (ADG), muscle depth (MD), fat depth (FD), conformation (CT), muscle mass (MM) and wool quality (WQ), within each group of auction price (AP).

AP	No. of animals	Price range (€)	Price (€)	W (kg)	ADG (g)	MD (mm)	FD (mm)	CT (scores)	MM (scores)	WQ (scores)
1	73	150–180	177.7	58.4	340.8	29.9	6.8	6.2	6.8	6.9
2	105	181–199	190.0	62.0	348.6	30.5	6.9	6.3	6.9	6.9
3	170	200–219	200.1	72.9	384.0	32.9	8.6	6.3	7.0	7.1
4	245	220–245	225.6	68.5	372.6	31.9	7.9	6.4	7.0	7.0
5	287	246–275	251.4	72.2	381.5	33.1	8.4	6.7	7.2	7.1
6	352	276–340	297.9	72.6	392.2	33.2	8.5	6.8	7.3	7.2
7	321	341–410	372.1	75.3	402.7	33.8	8.7	6.9	7.4	7.2
8	169	411–500	470.1	76.8	408.2	34.8	8.6	7.0	7.5	7.2
9	88	501–700	595.3	79.4	427.2	35.4	9.5	7.3	7.7	7.5
10	39	701–1000	860.3	82.2	432.2	36.6	9.6	7.7	7.8	7.6

not occur at the auction. The effect of judges at auction was not considered in this study because the same judge was present throughout the years 2003–2007. There was one auction per year for Suffolk and German white-headed mutton sheep and two auctions (at subsequent days) per year for Texel, always on a separate day for each breed. Singletons, twins and triplets were considered in the analysis, with most lambs born as twins (77.3%). The effects of first and repeated lambing were included in two classes of the fixed effect of parity. Sales class, determined from traits collected at licensing and therefore with these traits highly correlated, was not included in the analysis.

3. Results and discussion

3.1. Impact of fixed effects and covariates on auction price

General Linear Model was used for determination of fixed effects. Analysed fixed effects and covariates with *F*-values and levels of significance are shown in Table 3. A major part of the effects had a highly significant ($P < 0.0001$) influence on AP, apart from ADG, MD and WQ with a lower level of significance ($P < 0.05$) and FD which had no significant influence on AP.

According to the results presented in Table 3, the most important factor influencing AP was the weight at licensing, followed by type trait CT which, simply described, characterises overall impression of the ram on classifier. Impact of other traits such as ADG, MD, MM and WQ was lower compared to the effect of PrP genotype or breed. Detailed, separate analysis of the impact of the traits recorded at licensing, determined using Multiple Regression is discussed in Section 3.2.

Table 3
F-values with level of significance for different fixed effects on auction price (AP).

	F-value	*P*-value
Weight at licensing	215.43	<0.0001
Average daily gain until licensing	5.61	0.0180
Muscle depth	4.69	0.0305
Fat depth	0.21	0.6448
Conformation	153.73	<0.0001
Muscle mass	22.38	<0.0001
Wool quality	6.34	0.0119
Breed	45.77	<0.0001
PrP genotype	69.25	<0.0001
Owner of the ram	3.07	<0.0001
Year of auction	21.00	<0.0001

As expected, customers favoured rams with higher scores of all recorded type traits. Auction price therefore increased with increasing score of these traits and vice versa. Least Squares Means of AP for different score classes of type traits are presented in Table 4. In order to obtain these results, a separate General Linear Model analysis was provided. Traits such as type, frame, form and wool score were also included in the analysis of auction price of ewes and rams in the study of Fuerst-Waltl and Baumung (2006). As in our study, auction price of the rams increased with increasing score of the mentioned traits. Contrary to the results of analysed rams, Fuerst-Waltl and Baumung (2006) presented lower auction price of ewes with score class 6 for frame, form and wool, compared to auction price of ewes with score class 5 and lower. According to Terrill (1953), higher prices were paid for the rams having better mutton conformation and rams in a stronger condition. Selling price was positively affected by increasing scores of muscle and frame mass in other species like cattle as well (Barham and Troxel, 2007).

There was a significant effect of breed on AP, but somewhat surprising a lower AP (3.41) was paid by customers for Suffolk compared to German white-headed mutton sheep (4.55). On the other hand, the rank in AP between Suffolk and German white-headed mutton sheep was dependent on the number of effects included in the model. Nevertheless, Texel was the breed with highest AP (6.10) in any case. The importance of breed on the selling price at auction corresponds to the results presented for beef cattle by Barham and Troxel (2007).

The rams with the first PrP genotype class (natural scrapie disease resistant) had a significantly higher ($P < 0.001$) AP (5.02) compared to rams included in the second PrP genotype class (4.36). The proportion of rams sold

Table 4
Least Squares Means of auction price (AP; 1–10), with SE in parenthesis and significance levels in superscript, for type traits: conformation (CT), muscle mass (MM) and wool quality (WQ) over all breeds.

	Score class		
	≤6	7	≥8
CT	3.89 (0.09)[a]	4.93 (0.09)[b]	5.24 (0.14)[c]
MM	4.37 (0.16)[a]	4.64 (0.08)[a]	5.05 (0.09)[b]
WQ	4.49 (0.13)[a]	4.69 (0.09)[a]	4.89 (0.10)[b]

Least Squares Means within variable with different superscripts differ significantly ($P \leq 0.05$).

Please cite this article in press as: Maxa, J., et al., Auction price of Texel, Suffolk and German white-headed mutton rams: A genetic-statistical study. Small Ruminant Res. (2009), doi:10.1016/j.smallrumres.2009.07.011

Table 5
Impact of weight at licensing (W), average daily gain until licensing (ADG), muscle depth (MD), fat depth (FD), conformation (CT), muscle mass (MM) and wool quality (WQ) on auction price (AP; in % of explained variability) over all breeds and separately for Texel, Suffolk and German white-headed mutton sheep.

	Over all breeds	Texel	Suffolk	German white-headed mutton sheep
W	56.29	74.29	63.59	75.59
CT	27.50	17.18	23.79	20.41
MM	8.73	5.38	2.45	1.61
ADG	3.35	1.93	8.48	0.02^{ns}
MD	2.48	0.95	0.02^{ns}	1.85
FD	1.49	0.18^{ns}	0.00^{ns}	0.00^{ns}
WQ	0.16^{ns}	0.03^{ns}	1.67	0.52^{ns}

ns = not significant ($P \leq 0.05$).

at auction with PrP genotype class two decreased from 48.76% in the year 2003 to 24.57% in the year 2007. The similar tendency is expected in the future so that the influence of this effect on AP will drop to minimum.

The owner (in most cases also the breeder) of the ram was an important criterion for the customer, as shown by its highly significant effect ($P < 0.001$) on AP. Personal preferences as well as owners' reputation were probably of importance for customers and therefore highlighted the impact of the owner on the final price. Terrill (1953) also mentioned personalities and friendships of the trading partners, being among many factors that cannot be measured, influencing the price of the ram at auction sale.

Even though the year of auction had a significant effect on AP of the rams in the sense that there were differences in prices among years 2003–2007, we could not see any clear trend (progressive or regressive) between AP and different auction years in our study (data not shown).

3.2. Impact of performance traits recorded at licensing on auction price

The impact of performance traits recorded at licensing on AP analysed with Multiple Regression over all breeds as well as for each breed separately, is presented in Table 5. In the analysis over all breeds, all the traits, with exception of WQ had a highly significant influence on AP. Nowadays, wool is hardly even marketable for sheep farmers and therefore WQ plays an unimportant role in relation to AP. On the other hand, wool quality should not decrease when meat quality is the main breeding goal. In the study of Fuerst-Waltl and Baumung (2006) wool score had a significant effects on AP in ewes while, as in this study, no significant effect was observed in rams. Weight at licensing was estimated as the most important factor among the traits recorded at licensing, influencing AP, with 56.29% of explained variability. Conformation explained 27.50% of the total variability, followed by MM with 8.73% of explained variability of AP. Average daily gain from birth until licensing had very low influence on AP. This was probably due to high correlation with W, which absorbed part of variability remained from ADG. On the other hand, the measurements of both of these traits were available to customers (printed in the auction catalogue) and therefore were included in the evaluation model. Both ultrasound measurements had very low impact on final AP of the rams. These results showed a negative trend, which is increasing over the last years. Traits predicting carcass quality such as ultrasound measurements are not enough considered by the customers in evaluation at auction. Thus, there is a very high impact of live weight of the animal on AP with almost no consideration of the carcass quality traits at the same time. The results from the study of Terrill (1953), analysing sale price of Columbia, Targhee and Rambouillet rams indicated that customers attached real importance to production traits body weight, fleece weight and mutton conformation.

Breed separate analysis of impact of traits recorded at licensing on AP is presented in Table 5 and as in the analysis over all breeds W had the highest influence on AP, with explaining variability in the range from 63.59% to 75.59%. Explained variability from CT ranged from 17.18% for Texel to 23.79% for Suffolk. There were differences in significance of influence of other traits on AP. This could also be partly explained by different number of observations per breed, with the highest number for Texel (1133) compared to Suffolk (373) and German white-headed mutton sheep (341). For all three breeds it is shown that WQ, MD and FD had no or very low influence on AP.

3.3. Heritabilities

Heritabilities, genetic contribution with genetic and phenotypic correlations for AP and the performance traits are presented in Table 6. From the previous parts of this study it is clear that AP is determined by a wide range of the traits which are collected at the day of licensing before the auction. A possible consideration of the AP as an indicator trait for the improvement of type traits requires knowledge on genetic contribution of AP and the genetic correlations between AP and mentioned traits. Estimation of genetic

Table 6
Heritabilities and genetic contribution (both in bold on the diagonal), genetic correlations (below the diagonal) and phenotypic correlations (above the diagonal), with standard errors in parenthesis, for auction price (AP), average daily gain until licensing (ADG), muscle depth (MD), fat depth (FD), conformation (CT), muscle mass (MM) and wool quality (WQ), over all breeds.

	AP	ADG	MD	FD	CT	MM	WQ
AP	**0.27 (0.06)**	0.49 (0.02)	0.28 (0.02)	0.16 (0.02)	0.47 (0.02)	0.42 (0.02)	0.18 (0.02)
ADG	0.42 (0.10)	**0.38 (0.02)**	0.38 (0.01)	0.32 (0.01)	0.25 (0.01)	0.33 (0.01)	0.18 (0.01)
MD	0.34 (0.12)	0.34 (0.05)	**0.32 (0.03)**	0.08 (0.01)	0.14 (0.01)	0.22 (0.01)	0.10 (0.01)
FD	0.17 (0.12)	0.26 (0.05)	0.07 (0.06)	**0.38 (0.03)**	0.12 (0.01)	0.16 (0.01)	0.11 (0.01)
CT	0.49 (0.13)	0.17 (0.06)	0.19 (0.08)	0.06 (0.08)	**0.10 (0.01)**	0.41 (0.01)	0.17 (0.01)
MM	0.39 (0.12)	0.21 (0.04)	0.36 (0.06)	0.23 (0.06)	0.49 (0.06)	**0.21 (0.02)**	0.21 (0.01)
WQ	0.23 (0.12)	0.11 (0.04)	0.04 (0.07)	0.11 (0.06)	0.03 (0.07)	0.22 (0.05)	**0.24 (0.02)**

Please cite this article in press as: Maxa, J., et al., Auction price of Texel, Suffolk and German white-headed mutton rams: A genetic-statistical study. Small Ruminant Res. (2009), doi:10.1016/j.smallrumres.2009.07.011

parameters for AP and such traits was therefore one of the aims of this study.

A moderate genetic contribution of AP (0.27) was estimated in our study which cannot be compared to other results on sheep, because no such estimates were provided. Only in the study of Schierenbeck et al. (2009), auction price was also determined by a multitude of traits and moreover considered as an overall breeding goal for Holstein cows with an identical but not comparable estimate to ours.

The estimates of heritability for ADG (0.38) and FD (0.38) were identical with the estimates of the same traits from a study of Savas et al. (2001). In the mentioned study, (co)variance components were estimated for Texel, Suffolk, German white- and German black-headed mutton sheep in Schleswig-Holstein, based on the subset data from the year 1995 to 1999. Similar estimates of heritability for FD were also obtained for Texel in the studies of Jones et al. (2004) and Maxa et al. (2007), with values of 0.38 and 0.39, respectively. The heritability estimate for MD was somewhat higher in this study (0.32), compared to what was presented for Texel (0.29) by Maxa et al. (2007). Compared to our study, Fernandes et al. (2004) estimated a higher heritability for MD when adjusted to a constant age (0.38). Even higher heritability of MD (0.46), including age as covariate in the model, was presented by Olesen and Husabø (1994). Low heritability for MD (0.09) was estimated for Suffolk by Maniatis and Pollott (2002), which also used age as covariate in the model. The estimates of heritability for CT (0.10) and MM (0.21) were lower in our study compared to the study of Savas et al. (2001). Wool quality had the highest heritability (0.24) estimated among the three type traits.

3.4. Genetic and phenotypic correlations

The genetic correlations between AP and the performance traits were all positive and favourable (Table 6). The highest estimate of genetic correlations was found between AP and CT, followed by ADG, MM and MD. Favourable, but lower were the genetic correlations between AP and WQ and AP and FD. Thus, selection for increasing performance traits will affect AP in a positive direction and vice versa. Based on moderate heritability of auction price and favourable genetic correlations Schierenbeck et al. (2009) recommended using auction price of Holstein cows as an indicator trait for the improvement of the udder and the feet and leg composite.

The genetic correlations among the performance traits were all positive, whereas some of the estimates such as between MD and FD, MD and WQ, FD and CT and CT and WQ were not significantly different from zero. In agreement with this study, most of the results from the literature reported positive genetic correlations between growth traits and MD and FD (Gilmour et al., 1994; Conington et al., 1995; Larsgard and Olesen, 1998). Genetic correlations between ultrasound measurements of MD and FD vary considerably in the literature, from being negative (Conington et al., 1995; Fernandes et al., 2004) to positive (Roden et al., 2003; Jones et al., 2004). Some differences were found in the estimates of genetic correlations between ADG and type traits CT and MM as well as between ultrasound measurements MD and FD and type traits CT and MM in comparison with Savas et al. (2001). However, it should be pointed out that the genetic correlation estimates were positive in both studies. There is a possible influence of age at which the performance traits, especially MD and FD, were measured as well as live weight of the animal at the time of measurement, on the direction of genetic correlations among these traits. Genetic correlations between type traits CT and MM were high (0.49). Wool quality was positively correlated with all the performance traits, but most of the estimated genetic correlations were low or very close to zero. The results are in agreement with Dzakuma et al. (1978) who reported positive genetic correlations between the wool and conformation traits in Hampshire. Moderate and favourable genetic correlations between average daily gain and wool traits of fleece weight and staple length were presented by Bromley et al. (2000). In the same study of Bromley et al. (2000), the genetic correlations between average daily gain and fleece grade were small and negative.

Positive phenotypic correlations were estimated between AP and all the performance traits. More than twice higher as for FD (0.16) and WQ (0.18) were the phenotypic correlations between AP and ADG (0.49), AP and CT (0.47) and AP and MM (0.42). Auction price and MD were moderately correlated (0.28).

The phenotypic correlations among the performance traits, estimated in this study, generally agree with literature estimates from Dzakuma et al. (1978), Savas et al. (2001), Roden et al. (2003) and Jones et al. (2004).

4. Conclusions

The analysis of impact of the performance traits recorded at licensing of Texel, Suffolk and German white-headed mutton rams indicated live weight of the rams as the trait with major influence on the auction price. Conformation, followed by muscle mass had an important effect on the auction price as well. Furthermore, the results indicated that ultrasound measurements of muscle and fat depth had a minimum impact on the final auction price of the rams. As the traits give more accurate knowledge on carcass quality, the information on ultrasound measurements should not be omitted at auctions by customers. Besides the traits recorded at licensing, also the effect of breed, PrP genotype, and owner of the ram attached the importance of customers and affected the auction price. In addition to previous effects the results showed a moderate genetic contribution of auction price and favourable genetic correlations between auction price and the performance traits.

Acknowledgement

The authors are grateful to Landesverband Schleswig-Holsteinischer Schafzüchter e.V., Kiel (Sheep Breeding Organisation in Schleswig-Holstein, Germany) for providing the data.

Please cite this article in press as: Maxa, J., et al., Auction price of Texel, Suffolk and German white-headed mutton rams: A genetic-statistical study. Small Ruminant Res. (2009), doi:10.1016/j.smallrumres.2009.07.011

References

Barham, B.L., Troxel, T.R., 2007. Factors affecting the selling price of feeder cattle sold at Arkansas livestock auctions in 2005. J. Anim. Sci. 85, 3434–3441.

Belsley, D.A., Kuh, E., Welsch, R.E., 1980. Regression Diagnostics: Identifying Influential Data and Sources of Collinearity. Wiley, New York, NY.

Bromley, C.M., Snowder, G.D., Van Vleck, L.D., 2000. Genetic parameters among weight, prolificacy, and wool traits of Columbia, Polypay, Rambouillet, and Targhee sheep. J. Anim. Sci. 78, 846–858.

Conington, J., Bishop, S.C., Waterhouse, A., Simm, G., 1995. A genetic analysis of early growth and ultrasonic measurements in hill sheep. Anim. Sci. 61, 85–93.

Dzakuma, J.M., Nielsen, M.K., Doane, T.H., 1978. Genetic and phenotypic parameter estimates for growth and wool traits in Hampshire sheep. J. Anim. Sci. 47, 1014–1021.

Fernandes, T.L., Wilton, J.W., Tosh, J.J., 2004. Estimates of genetic parameters for ultrasound-measured carcass traits in sheep. Can. J. Anim. Sci. 84, 361–365.

Fuerst-Waltl, B., Baumung, R., 2006. Economic weights for conformation traits in Mountain sheep. Arch. Tierz. Dummersdorf 49, 575–582.

Gilmour, A.R., Gogel, B.J., Cullis, B.R., Thompson, R., 1998. ASREML User Guide. Release 1.0. NSW Agriculture, Orange, Australia.

Gilmour, A.R., Luff, A.F., Fogarty, N.M., Banks, R., 1994. Genetic parameters for ultrasound fat depth and eye muscle measurements in live Poll Dorset sheep. Aust. J. Agric. Res. 45, 1281–1291.

Jones, H.E., Lewis, R.M., Young, M.J., Simm, G., 2004. Genetic parameters for carcass composition and muscularity in sheep measured by X-ray computer tomography, ultrasound and dissection. Livest. Prod. Sci. 90, 167–179.

Krogmeier, D., Luntz, B., Götz, K.U., 2006. Ableitung von Grenzerträgen für Exterieurmerkmale bei Braunvieh und Fleckvieh anhand von Jungkuh-Auktionsdaten. Vortragstagung der DGfZ und GfT, Hannover (in German).

Larsgard, A.G., Olesen, I., 1998. Genetic parameters for direct and maternal effects on weights and ultrasonic muscle and fat depth of lambs. Livest. Prod. Sci. 55, 273–278.

Maniatis, N., Pollott, G.E., 2002. Maternal effects on weight and ultrasonically measured traits of lambs in a small closed Suffolk flock. Small Rumin. Res. 45, 235–246.

Maxa, J., Norberg, E., Berg, P., Pedersen, J., 2007. Genetic parameters for carcass traits and in vivo measured muscle and fat depth in Danish Texel and Shropshire. Acta Agric. Scand. 57, 49–54.

Olesen, I., Husabø, J.O., 1994. Effect of using ultrasonic muscle depth and fat depth on the accuracy of predicted phenotypic and genetic values of carcass traits on live ram lambs. Acta Agric. Scand. 44, 65–72.

Roden, J.A., Merrell, B.G., Murray, W.A., Haresign, W., 2003. Genetic analysis of live weight and ultrasonic fat and muscle traits in a hill sheep flock undergoing breed improvement utilizing an embryo transfer programme. Anim. Sci. 76, 367–373.

Ruff, N.J., Vinson, W.E., Pearson, R.E., White, J.M., Meland, O.M., Edlund, D.P., 1983. Factors affecting price differences within sales of registered Holstein cattle. J. Dairy Sci. 66, 587–594.

Sas Institute Inc., 1999. SAS/STAT User's Guide, Version 9.1. Cary, NC, USA.

Savas, T., Röhe, R., Kalm, E., 2001. Genetisch-statistische Analyse der Mastleistungs- und Schlachtkörperwertmerkmale von Fleischschafrassen aus der Feldprüfung von Schleswig-Holstein. Züchtungskunde 73, 62–73 (in German with English summary).

Schierenbeck, S., König, S., Simianer, H., 2009. Genetic and environmental impact on auction prices for Holstein cows. Livest. Sci. 121, 327–334.

Terrill, C.E., 1953. The relation between sale price and merit in Columbia, Targhee and Rambouillet rams. J. Anim. Sci. 12, 419–430.

Troxel, T.R., Barham, B.L., 2007. Comparing the 2000 and 2005 factors affecting the selling price of feeder cattle sold at Arkansas livestock auctions. J. Anim. Sci. 85, 3425–3433.

Please cite this article in press as: Maxa, J., et al., Auction price of Texel, Suffolk and German white-headed mutton rams: A genetic-statistical study. Small Ruminant Res. (2009), doi:10.1016/j.smallrumres.2009.07.011