Analysis of the quality of the wool of Shetland Sheep Bred in the Czech Republic

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I. Introduction

Sheep were the first animals to be domesticated. This domestic animals are favourite because the universals benefits (wool, meat, milk), easy for breeding, the low dietary requirement and high resistance to weather conditions. Sheep was very important animals for cultural and religious ceremonies in the past. They were used as religious symbols and sacrificial animals (Heanlen, 2007; Kenner, 2007). Shetland sheep, Romanov, Finnsheep, Moorland, Gotland, Icelandic sheep are classified as a primitives breeds that originated territory is from Russia to Island,Greenland and several islands of Scotland. We classified them between the short tailed sheep *(Brachycerae)*, because they have got less than 13 caudal vertebrae (Ryder, 1983; Thomas, 2010).

Shetland sheep are very resistant animals with dual-coated wool. This breed has small body frame with good reproduction and milk quality (Friggens*et al.*, 1997; Doane, 2015). They can be all year round outside on pasture with small shelter. It´s benefit for breeder, because they have smaller financial costs. These breeds have important function in keeping and using pastures, and grazing to heavily reach areas. Meat is the main product in breeding of short tailed sheep and their crossbreeding in Europe. Wool and milk are still considered like byproducts (Dýrmundsson *et* Niżnikowski, 2010).

Shetland sheep belong to the breeds with long wool with a wide range of colour patterns and quality of fleece. Their classification by the fineness of wool isn't clear. The range of wool is dependent on climatic conditions, sex, age, health conditions act. Some authors and breeders indicate the Shetland sheepas semi-coarse wool breed (Horáket Treznerová, 2010), other says, that it is fine wool (Fair Isle Shetland Sheep, 2015). Shetland wool has 11 main whole colours and 30 recognised markings(The Shetland Sheep Society, 2015).

Thomas (2010) confirm in his paper that is not many studies about quality of wool of short tailed sheep occurring in North America. A last study was about the growth of the wool of lambs and ewes of Shetland sheep, percentage of inactive follicles in the fleece, length and average of fibres. And the difference colour of fibres behind winter and summer. The results of this study the secondary follicles become inactive in both sexes in September, but their new growing is faster. New grow starts from January to March, maximum growth was observed from April to October. The greatest growth was in lambs in July and in ewes in August. Pigmentation was reducing by decreasing the density of pigment granulesin the fibrein winter (Ryder, 1971).

Shetland sheep are kept in small herds especially in interest and small farms. It is the cause for the deficiency of scientific paper. As noted, the breeding Shetland sheep is popular for their unique look and unique fleece. The interest is constantly growing from consumers in the word.

Shetland wool is suitable for both dry and wet felting technique. It is also desirable for farm processing of final products (Anderson, 2001; Thomas, 2010). Tendency is to renew and strengthen the economy in breeding Shetland sheep in England. For example, the production of quality carpets from 100% Shetland wool (Liddle, 2007). Shetland wool has become popular for the unique features like insulation material in the construction industry. Wool industry was threatened by reduction in the quality of the wool due to crossing of Shetland sheep with meat breeds (Thomas, 2010). However Shetland sheep are good for crossing with Australian Merino. This soft wool breed is the recently often breed in England (Saul *et al*., 1992). In 1927, was founded,, Shetland Flock Book Society´´ to protect to this breed and it was prepared description of the breed

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standards. It was selected native endangered breeds of sheep. Measures were designed for their protection as genetic reserves. Hall (2004) said in his work that the Irish and Shetland sheep are among the highest priority for protection bred in England.

Shetland sheep is very popular breed also in America. Four rams and 28 ewes were brought to Canada in 1980. This native breed was brought to USA in 1986 (Doane, 2015). Shetland sheep are used breed for obtain a unique fleece. And demand for this fleece grows constantly (Thomas 2010). Number of Shetland sheep grows around the world. It is especially in England, North America andNetherlands. Also in Czech Republic increased the number Shetland sheep in recent years. It is especially in hobby and small farms (Bucek *et al.*, 2013).

We focused on objective evaluation of fineness, length and the amount of Shetland sheep wool in Czech Republic, due to deficiency of scientific paper. These measured values were evaluated depending on the age of the selected animals and their sex.

II. Materials and Methods

a) Animals

Animals were selected for this experiment from the biggest farm of Shetland sheep in Czech Republic. This farm was founded in Mělník in 2005. Shetland sheep were imported from Netherlands in 2008. Since then, the farm name is Shetland Farm Mělník. They behave here 12 ewes, 2 rams, 4 castrate rams and 15 lambs (9 rams, 6 ewes) in this time. This farm is classified in monitoring performance. Altogether 22 Shetland sheep was included in our experiment (rams from 1-6 years, ewes from 1-9 years, castrate rams 1 and 3 years old).

b) Sample processing

Measurement of body size (height at withers and body length) and quantity indicators wool (length and quantity shorn wool) was performed during staple. Samples of wool were taken from various parts of the body - shoulder, side andrump. Samples were washed in petroleum ether, and then were colored with picric acid. Measurement of wool was photometrical at fourfold magnification microscope with a Nikon camera that is connected to the computer. Samples were evaluated after shooting PC software NIS-Elements AR, version 3.2. Each sample of wool was measured hundreds of times.

c) Statistical evaluation

The results were statistically evaluated by monitoring the program SAS 9.1 (SAS Institute Inc., 2003), multiple analysis of variance with the interaction of gender and year of birth.

$$Y_{ijk} = \mu + d_i + s_j + (ds)_{ij} + e_{ijk},$$

Where: y_{ijk} = value of the trait; μ = overall mean; d_i = effect of age; s_j = effect of sex; $(ds)_{ij}$ =sex and age interaction; e_{ijk} = residual error.

Significance levels $P < 0.05$ and $P < 0.01$ were used to evaluate the differences between groups.

III. Results

From the results shown in table 1 can be compared with the average values of the measured variables and their statistical significance in relation to sex, age and the interaction of these two indicators.

Quantity of wool is highest at the rams in the second year of life. The average value of wool is in annual males 0.78 kg and in two-year 1.48 kg. The average value of wool for four-year, five-and six-year rams is 1.20 kg. In castrate rams is a difference in the amount of wool depending on age, like as in rams. The average value of wool from one year rams is 0.95 kg and from three years rams increased to 1.75 kg. The measurement was performedon wool of females in selected between one and nine-yearpieces. The average value of a quantity of wool ewes range from 0.72 kg to 1.36 kg.

Wool of two years rams is the longest, it is 9.50 cm. Four years rams have the wool length shorter, only 6 cm. Difference was measured in the wool length of one-year and three-year castrated rams. Wool length of annual castrated rams was 7.32 cm and 9 cm at three years. The average wool length in ewes was in ranges from 5 to 12 cm. Withers height and body length increases with age to four year in rams. Ewes were measured at different values. The measured height at the withers ewes ranged from 50.66 - 60 cm. All of these values are statistically highly significant.

Other monitored characteristics of wool were the fineness of wool on selected body parts. The fineness of wool was monitored on shoulder, side and the rump. The average value of the fineness of wool on the shoulder rams are in the range from 22.97 to 31.15 μm, in castrated rams from 21.15 to 25.06 μm and ewes values were from 21.46 to 27 μm. The fineness of wool on the sideof the rams ranged from 20.35 to 27.92 μm, with rams 22 – 24.78 μm and ewes from 21.20 to 27.64 μm. The average value of the fineness of wool measured on the side of rams range from 25.99 to 36.54 μm. The average value of the fineness of wool measured on the side of castrated rams range from 24.13 – 24.78 μm and ewes 24.24 – 31.25 μm.

In our results, the fineness of wool statistically significant on the shoulder and side depending on age, sex and the interaction of these two factors. The fineness of the wool is not statistically significant on the side depending on the sex of the animals. But the age and the interaction of age and sex was demonstrated statistical significance.

According the results of table 2, the values of the correlation coefficient are below 0.3. It indicates a weak dependence. Correlation coefficient determines the degree of dependence of two variables. The correlation coefficient of fineness of wool is 0.149 in samples collected on the shoulder and side. It is 0.148 on the shoulder and rump, and 0.229 on the shoulder and rump. And on the side and rump it is 0.147.

Consequently, the fineness of the wool measured at the shoulder, side and the rump of the selected animals are dependent on each other very weakly. This means, that the diversity of the wool is minimal on the body of the Shetland sheep. For a comprehensive assessment of the fineness of wool, it is appropriate to take samples from different parts of the body.

Relationship of the average value of fineness was scored in depending on the sex of the animals, it is in table 3. All age groups were included in the monitoring. According to the results, ewes have the fineness wool 20.81 μm, then rams 20.47 μm and castrated rams 20.86 μm. These results are statistically highly significant (at the surface evidential <0.0001).

The average fineness of wool is registered in table 4, regardless of sex or age of the animals. The fineness wool is in side (24.5 μm), shoulder (25.05 μm) and the highest in the rump (27.59 μm). These results are statistically significant.

The average values of the fineness of wool taken from the shoulder, side and rump selected animals depending on their age. The finest wool animals have one year to the side (20.99 μm) and the roughest wool was measured at seven years old animals on the rump (32.35 μm). Furthermore, it is evident from these results that the coarsest wool was measured at all ages except eight year animal on the rump. These results are statistically highly significant.

IV. Discusion

There are no scientific papers about quantity and quality indicators Shetland wool in depending on sex and age. Some scientists studied ideal composition of the diet of sheep (Iason *et al*., 1994, 1995) or a growth and development of their sceletons (Friggens *et al*., 1997) or the occurrence of various diseases such as scrapie (Vilas *et al*., 2006). Ryder (1971) was studied Shetland wool. In his research, he studied cyclical follicular growth in Shetland wool. This research was focused mainly on quantity of inactive hair follicles and their pigmentation. It was measured at rams and ewes for three years, depending on the season. Anderson (2001) in his studies has focused on difficulty of processing method of Shetland sheep fleece. Some authors classify Shetland wool as semi-rough-wooled (Horak et Treznerová, 2010). The others authors describe it as a very fine (Fair Isle Shetland Sheep,

2015). The fineness Shetland wool ranges from 18 to 30 microns (The Shetland Sheep Society, 2015). Wool of this breed has a wide range of fiber fineness and fiber colors. According to our results, we can classify Shetland Sheep reared on Shetland farm Mělník in Czech Republic between fine-wolled to semi-fine-wooled sheep. This sheep have an average length of wool 5 to 12 cm. The wool length of Shetland Sheep bred in England is from 8 to 18 cm (The Shetland Sheep Society, 2015).

The demand for wool of Shetland sheep began to show increasing especially in small and hobby farms, despite the worldwide lack of interest. These results are unique benefit and provide important information for Czech breeders of Shetland sheep. According to our results, we can include Shetland sheep reared in the Czech Republic between fine-wolled to semi-fine-wooled sheep with length of wool 12 cm. The wool measured at various body parts of animals have different fineness. Fineness of wool in one animal is not uniform. It is necessary to analyse the wool of three parts (shoulder, side, rump) for the determination.

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Tab. 1 : There is the averagevaluesof the measuredvariables andtheirstatistical significancein relation to sex, age andthe interaction of thesetwoparameters

sex	age	QW (kg)	LW (cm)	HW (cm)	LB (cm)	Shoulder (μm)	Side (μm)	Rump (μm)
male	1	0.78	6.85	56.13	56.28	22.97	20.35	25.99
	2	1.48	9.50	63.00	66.00	27.12	27.92	31.45
	4	1.20	6.00	66.00	67.00	26.07	23.92	25.46
	5	1.20	6.00	66.00	67.00	26.29	21.85	30.88
	6	1.20	6.00	66.00	67.00	31.15	27.54	36.54
female	1	1.22	12.00	50.66	51.00	22.27	21.20	25.46
	2	1.34	9.00	56.50	58.50	23.23	24.88	29.34
	3	0.81	6.00	59.00	62.00	21.46	27.28	25.74
	4	1.14	11.52	57.37	64.00	22.39	21.92	24.31
	5	0.91	7.04	59.00	65.02	22.98	23.50	25.70
	6	0.72	5.00	58.50	67.50	24.67	27.64	24.24
	7	1.36	7.00	56.00	61.00	26.46	24.03	31.25
	8	1.25	9.33	59.00	63.33	27.00	25.88	24.96
	9	1.00	7.50	60.00	66.00	21.80	23.15	26.66
castrated male	1	0.95	7.32	56.70	58.31	21.15	22.00	24.13
	3	1.75	9.00	62.00	64.00	25.06	24.78	24.78

Conclus.

	QW	LW	HW	LB	Shoulder	Side	Rump
RMSE	0.187	1.678	1.441	1.963	4.968	4.878	6.875
sex	0.001	0.001	0.001	0.001	0.001	0.854	0.001
age	0.001	0.001	0.001	0.001	0.001	0.001	0.001
sex*age	0.001	0.001	0.001	0.001	0.012	0.0154	0.001

Abbreviated: QW – quantities of wool, LW – length of wool, HW – height at withers, LB – length of body, Shoulder – fineness of wool on shoulder, Side – fineness of wool on side, Rump – fineness of wool on rump.

Tab. 2 : The correlationcoefficientindicating thedegree ofdependence of twovariables (fineness of Shoulder x Side, Shoulder x Rump, Side x Rump)

	Shoulder	Side	Rump
Shoulder		0.148	0.229
		0.0005	< 0.0001
Side	0.148		0.147
	0.0005		0.0005
Rump	0.229	0.147	
	< 0.0001	0.0005	

Abbreviated: Shoulder – fineness of wool on shoulder, Side – fineness of wool on side, Rump – fineness of wool on rump.

Tab. 3 : Average values offinenessof wool, depending on the sex of the animals

sex	the average value ofthe fineness ofwool (μm)	SEM	P-value
1	26.86	0.349	< 0.0001
2	24.81	0.198	< 0.0001
3	25.47	0.522	< 0.0001

Abbreviated: sex – 1 = ram, 2 = ewe, 3 = castrated ram

Tab. 4 : The average value of the fineness of wool taken from the shoulder, side and rump selected animals depending on their age

age	Body parts	Finenessofwool (μm)	SME	P-value
1	Shoulders	21.89	0.433	< 0.0001
	Side	20.99	0.433	< 0.0001
	Rump	24.83	0.433	< 0.0001
2	Shoulders	24.88	0.683	< 0.0001
	Side	26.14	0.683	< 0.0001
	Rump	30.11	0.683	< 0.0001
3	Shoulders	24.08	1.067	< 0.0001
	Side	25.94	1.067	< 0.0001
	Rump	26.26	1.067	< 0.0001
4	Shoulders	23.77	0.921	< 0.0001
	Side	22.31	0.921	< 0.0001
	Rump	25.29	0.921	< 0.0001
5	Shoulders	24.39	0.845	< 0.0001
	Side	23.04	0.845	< 0.0001
	Rump	27.25	0.845	< 0.0001
6	Shoulders	27.18	0.912	< 0.0001
	Side	27.86	0.912	< 0.0001
	Rump	28.41	0.912	< 0.0001
7	Shoulders	27.80	1.545	< 0.0001
	Side	24.31	1.545	< 0.0001
	Rump	32.35	1.545	< 0.0001
8	Shoulders	28.35	0.967	< 0.0001
	Side	26.16	0.967	< 0.0001
	Rump	26.06	0.967	< 0.0001
9	Shoulders	23.14	1.139	< 0.0001
	Side	23.42	1.139	< 0.0001
	Rump	27.76	1.139	< 0.0001

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