Short Term Scientific Mission (STSM) through the **COST Action FA1308** *'DairyCare'*

Implementation report for the research protocol:

'Effects of Genetic Selection for Increased Milk Yield on Sheep Welfare'

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BACKGROUND:

Flock health and fitness outputs constrain decidedly dairy sheep productivity and welfare (Matheson *et al.*, 2012; Gowane *et al.*, 2014). With genetic selection in sheep for resistance to disease being often overlooked and regarded as time-consuming due to the low additive genetic variances and heritabilities of such traits (h^2 ranging from 0.01 to 0.08) (Notter, 2012; Zishiri *et al.*, 2013). In order to formulate proper animal health management and effective disease control measures, accurate estimates of the extent and prevalence of the main technopaties are required (Cross *et al.*, 2010; Willeberg, 2012). However, the literature on dairy ewes fitness characteristics is limited. Furthermore, knowledge of the occurrence rates of various health disorders is important for both veterinarians and researchers, in order to set-out ‚alarm' thresholds, which will then help sheep breeders to monitor more effectively their flocks health and also during the decision making process.

The Tsigai sheep is an ancient breed group, with a history of over 3.000 years, originating from the Dobrogea area (nowadays Eastern Romania). The first archaeological proofs of the breeds existence are dating from over 2.000 years, Tsigai sheep being presented on the Trajan's Column in Rome and the Adamclisi monument from Dorbogea (Padeanu, 2010). From the Danube Delta region, the Tsigai were spread throughout its nowadays rearing areal (around 14 countries) by nomadic Vlach sheep breeders. Tsigai is a traditional triple-purpose sheep group (meat-milk and wool), widely distributed across regions of Central, Eastern and Southern Europe (Cinkulov *et al*., 2008). Production levels vary greatly among countries and regions which rear Tsigai sheep. Out of the native breed groups from Eastern Europe, the Tsigai could be regarded as having the highest milk-ability when managed under proper semi-intensive production systems. The Tsigai group has several recognized emergent-breeds and sub-populations. Phenoypically, the Tsigai are also very diverse most frequent color varieties being white, black, speckled and rusty.

Tsigai sheep are medium-sized animals, and some ecotypes/populations due to upgrading with other specialized breeds have a large body frame. With adults ewes body weights ranging from 35 kg in the mountain unimproved ecotypes to 80 kg in Sombor Tsigai from Serbia. Weight of adult rams is between 50 kg to 140 kg. Given its place of origin, and the typical semi-fine wool (30-35 μm), this breed group is well adapted to the lowland rearing conditions (Kusza *et al.*, 2008). Milk production varies greatly in the Tsigai sheep, from 60-70 kg in unselected flocks to 200 kg in the Sombor Tsigai, in 150 days (Padeanu, 2010; Cinkulov *et al.*, 2008; Kukovics & Kristaq, 2005).

To the best of our knowledge, no other comparative study concerning the fitness and health traits of different Tsigai genotypes exists up to this moment.

Objective of the current study was to evaluate the health and fitness indicators in three Tsigai sheep populations, divergently selected for milk (Sombor), meat (Cokan) and unimproved (Covasna mountain type).

MATERIALS AND METHODS

Location and flock management

The study was carried out in three sites (one experimental farm and two commercial sheep enterprises), *i)* at the Experimental Farm of the University of Debrecen, Cokan Tsigai purebred ewes (HU, managed intensively), *ii)* the first commercial sheep farm was rearing Sombor Tsigai (RO, originating from Serbia, managed semi-intensively) and *iii)* the second commercial farm was rearing Covasna Tsigai (RO, mountain-, unimproved flock, reared extensively).

Ewes were between 1.5 and 8 years old, with age and parity balanced across genotypes and representing a diverse sampling of genetic lines within each flock. The study herds consisted of 175 Cokan, 203 Sombor and 210 Covasna Tsigai breeding ewes (Table 1).

Table 1.

Number of ewes in the study-herds and data on the general rearing conditions

Genotype	Sombor Tsigai	Cokan Tsigai	Covasna Tsigai
Number of ewes/flock	203	175	210
Location	46°3′N/20°40′E (RO)	47°33'N/21°42'E (HU)	46°31′N/25°45′E (RO)
Indoor housing	90 days	Year around	120 days
Mean annual temp.	10.8°C	9.85°C	5.4 °C
Altitude of the site	85 m	121 m	725 m
Annual precipitation	536.3 mm	566 mm	633 mm
Rearing system	Semi-intensive	Intensive	Extensive
Milking	Yes, manual	No	Yes, manual

The research activities were performed in accordance with the European Union's Directive for animal experimentation (Directive 2010/63/EU).

Data and statistical analysis

Data was collected from the veterinarian records and the farms own records for a period of 12 months (December 2014 - November 2015). All three flock were included in the official performance recording schemes. Occurrence rates of the following health disorders were recorded: mastitis, lameness, pneumonia and abortion. Annual attrition rates were determined by identifying ewes in the herd at the start of the production year not present in the herd at the end of the production year. Death and culling because of all reasons were included when evaluating attrition rates. Data on the reproductive performance of ewes (conception rate, litter size and survival rates of un-weaned lambs) were recorded for all three populations.

In order to assess the effect of the genotype on the above-mentioned health disorders, as well as on the reproduction performance of the ewes, the STATISTICA software was used (Hill and Lewicki, 2007). The Main Effect ANOVA analysis of variance was applied. Given that data was recorded in three farms with different production systems, the model included this as correction factor. The model used for statistical analysis is presented below:

$$y_{ijk} = \mu + pc_i + g_j + e_{ijk}$$

where y_{ijk} is the studied reproduction or health trait; μ is the overall mean; pc_i represents the fix effect of production system with three levels: intensive, semi-intensive and extensive; g_j represents the random effect of the genotype with three levels: Cokan, Sombor and Covasna Tsigai; and e_{ijk} is the residual effect. When significant effects of the genotype were observed, the comparison among populations was tested by performing contrast analysis, using Tukey test.

RESULTS AND DISCUSSION

Taking into account the clinical mastitis occurrence rate, the two specialized Tsigai genotypes (Sombor and Cokan) were more affected ($p \leq 0.01$ and $p \leq 0.001$, respectively) compared to Covasna Tsigai ewes (Table 2). Results for the two improved populations are consistent with estimates of Giadinis et al. (2011), which report occurrence rates for mastitis of over 10% for commercial sheep flocks. Furthermore, occurrence rates of over 30% in European dairy flocks are being frequently mentioned in the literature (Bergonier *et al.*, 2003; Bishop *et al.*, 2010).

Table 2. Means (±SE) for occurrence rates of mastitis, lameness, pneumonia and abortions in Sombor, Cokan and Covasna Tsigai ewes

Genotype	Mastitis (%)	Lameness (%)	Pneumonia (%)	Abortion (%)
Sombor Tsigai	10.8±0.21	6.4±1.72	5.4±1.59	3.4±1.28
Cokan Tsigai	15.4±0.27	4.5±1.58	4.0±1.49	2.8±1.26
Covasna Tsigai	3.8±0.13	9.7±1.98	2.8±1.15	2.8±1.15
Sombor *vs.* Cokan	*NS*	*NS*	*NS*	*NS*
Sombor *vs.* Covasna	**	*NS*	*	*NS*
Cokan *vs.* Covasna	***	*	*NS*	*NS*

^{NS} p>0.05; * p≤0.05; ** p≤0.01; ***p≤0.001

Mastitis has a negative impact on ewe stayability, milk yield, lambs growth and survival, veterinary costs and representing a major concern for welfare. Importance of clinical mastitis in the Europe was highlighted by Ligda *et al.* (2003), which found mastitis to be the main cause for culling in the Greek sheep industry, accounting for 46% of the attrition cases.

Current study highlights the low resistance to clinical mastitis of the Sombor and Cokan Tsigai populations. As a result, measures such as including the genetic resistance to mastitis as a trait into the breeds selection indexes should be taken. An rough estimation of the costs to the EU main sheep rearing countries per year due to mastitis was of €37 million in sheep alone (3SR project, 2013). The incidence of clinical mastitis in small ruminants is generally lower than 5% (Arranz & Gutierrez, 2012), whereas the prevalence of subclinical mastitis ranges from 10 to 50% (Sechi *et al.*, 2009).

Recently, Somatic Cell Count (SCC) has been found to be a reliable selection trait (Barillet, 2007), which can be used as an indicator to enable selection for increased resistance to subclinical mastitis in the French Lacaune breed (Rupp *et al.*, 2003). For SCC in dairy sheep, heritability estimates reported range between 0.06 and 0.24 (Barillet *et al.*, 2001; Bishop *et al.*, 2010). If treated, ewes with sub-clinical mastitis were found to produce less milk with 15-20%, and in the case of an re-infection, the milk yield to drop with 30% (Petrovic *et al.*, 2005).

Moreover, several candidate genes to be used in genomic selection for the genetic resistance to mastitis were found in the last years (QTL OAR 6, OAR18 and OAR20) and are currently used experimentally in the French Lacaune, Greek Chios and Italian Sarda dairy breeds (Bishop *et al.*, 2010).

Figure 1. Sombor Tsigai replacement ewes (Beba Veche, Romania)

Lameness occurrence rate was 6.4, 4.5 and 9.7 % in Sombor, Cokan and Covasna Tsigai ewes, respectively. This is in accordance with estimates of FAWC (2011) for the English flocks, which range from 8 to 10 %. Significant differences ($p \leq 0.05$) were observed between Cokan and Covasna Tsigai populations. In the current study, the Covasna ewes were reared under pasture-based mountain system, thus the increased rate of lameness in the flock could be explained.

Figure 2. Cokan Tsigai breeding ewes (Debrecen, Hungary)

Given the low winter temperatures reached in the mountains, pneumonia incidence in Covasna Tsigai flocks is of concern to both scientists and breeders, being a lowland semi-fine wool breed. However, breed differences for pneumonia were not significant ($p>0.05$) between the two improved populations, differences ($p\leq0.05$) being registered between the Sombor and Covasna populations. Higher pneumonia incidence in the Sombor population could be attributed to the upgrading of the breed with Italian Mediterranean Bergamasca breed, which is not adapted to the lower climate during winter found in Central and Eastern Europe .No available data for comparison on pneumonia occurrence in European countries was found, except for information on flocks infected with Maedi-Visna (Benavides *et al.,* 2013).

Occurrence rate of the abortions was not influenced by genotype ($p>0.05$). According to previous reports, in healthy flocks abortion accounts for less than 2%, with 5% occurrence rate being considered as an alarm threshold (Menzies, 2011). Out of the four health disorders studied, abortion has to have the most significant economical and welfare implications, given that abortion will most likely result in culling or death of the ewe.

Sombor, Cokan and Covasna Tsigai populations expressed similar ($p>0.05$) conception rates (Table 3). Results suggest that the selection for milk and meat of the two Tsigai specialized genotypes has not resulted in lower conception rates in the two studied populations. Conception rates for the Tsigai ewes are consistent with those estimated by Krupova *et al.* (2009) for the breed.

Figure 3. Covasna Tsigai breeding ewes (Ineu-Harghita, Romania)

Compared to Covasna population, the Sombor and Cokan ewes produced significantly higher litters ($p \leq 0.001$). Considerable lower values for litter size in Tsigai are reported by Krupova *et al.* (2009) and Padeanu *et al.* (2012). Higher litter size in Cokan Tsigai ewes during current trial might be attributed to the good feeding and management conditions. In addition, during previous studies, ewes were reared for both meat and milk productions, while in the current reference flock, ewes were lactating for only a short period of time (80-90 days), until the lambs were weaned. This might have lead to a better body condition of ewes during mating season and thus to higher ovulation rates. For the Covasna population, the litter size is similar to reports of Ilisiu *et al.*, 2010.

Table 3. Means (±SE) for reproductive performance and attrition rates in Sombor, Cokan and Covasna Tsigai ewes

Genotype	Conception rate (%)	Litter size (lambs)	Lambs weaning rate (%)	Attrition rate (%)
Sombor Tsigai	96.0±0.13	145.1±4.06	95.5±1.20	21.1±0.28
Cokan Tsigai	97.1±0.12	142.3±4.07	95.1±1.38	22.8±0.31
Covasna Tsigai	95.2±0.14	121.0±2.93	91.6±1.74	17.6±0.26
Sombor *vs.* Cokan	NS	NS	NS	NS
Sombor *vs.* Covasna	NS	***	*	NS
Cokan *vs.* Covasna	NS	***	NS	NS

Lambs weaning rates were not influenced by genotype ($p>0.05$), except for the mountain Covasna Tsigai lambs, which had lower ($p\leq0.05$) survival rates til weaning compared to Sombor Tsigai. This finding are consistent with reports of Padeanu *et al.* (2012) for Tsigai lambs, under European temperate conditions. Although Covasna Tsigai ewes were less prolific, the lower milk ability, extensive production system and higher altitude might had lead to the lower survival rates of lambs in the population.

Under commercial sheep production systems, the importance of fitness relates to the attrition of breeding ewes (Borg, 2007). Differences in attrition rates between Tsigai genotypes were not significant ($p>0.05$). The slight genotype disparities in attrition rates could be explained by the considerable lower selection pressure applied for the Covasna Tsigai flock, and as a result, decisions on voluntary culling of ewes were made only in extreme cases for the genotype. In Sombor and Cokan Tsigai populations the voluntary culling of ewes occurred especially based on traits such as milk yield, fertility, weaning ability, age, body condition and health disorders. Data on attrition rates for the three Tsigai populations are consistent with estimates reported by Mekkawy *et al.* (2009) for commercial sheep flocks.

CONCLUSIONS

» Comparison of the three Tsigai populations for their reproductive performance and organic resistance under European temperate conditions were considered necessary knowledge for the sheep industry as sheep breeds adaptation and welfare tend to be matters of concern for the breeders.

» This comparative study was the first attempt to provide information on the reproductive efficiency and health traits in Sombor, Cokan and Covasna Tsigai breeds under temperate climate conditions found in Europe.

» For the selected specialized Tsigai populations (Sombor and Cokan) it would be advisable as to include fitness traits into the breeding selection schemes of the genotipes (with special focus on mastitis genetic resistance and ewe stayability) in order to improve animal welfare and overall productivity.

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