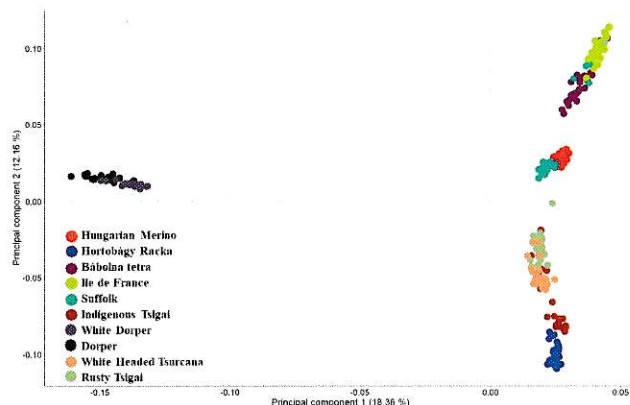
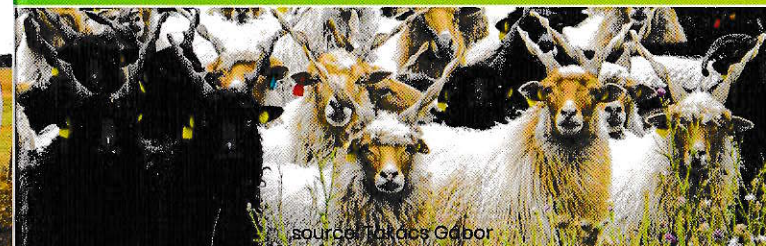
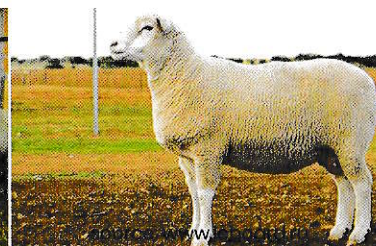


Combined analysis of all varieties yielded the result we expected, namely that Dorper and White Dorper, the two varieties established under tropical climate conditions and introduced only recently to Hungary are completely separate from the other varieties on PCA2. On the other hand, the varieties that have long been present in the Carpathian Basin (indigenous Tsigai, Hortobágy Racka, Rusty Tsigai and Tsurcana) form another group separate from the other varieties studied but not indigenous to our region, i.e. Île de France, Hungarian Merino, Suffolk and Bábolna Tetra.



In the course of our work we also verified the origin of the varieties as well as their interrelationships. Within the framework of the SMARTER project we determined the current diversity levels; however, these need to be continuously monitored and repeatedly determined every few years in order to be able to assess the efficiency of breeding.

The SMARTER project offered a great opportunity for the improvement of sheep breeding in Hungary, because the results presented supplied fundamental gap-filling information for the breeding programs of indigenous sheep varieties. Furthermore, the international framework provided by the project for the cooperation of scientists and farmers, their networking and the extension of their collaboration proved to be highly inspiring. We trust we will have further opportunities in the future to continue building what has been started here within the framework of similar projects. This would serve the interests of all participants.



Smarter
SMAII RuminanTs breeding for Efficiency and Resilience



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SMARTER PROJECT RESULTS OBTAINED IN HUNGARY

It has become a cliché that the climate change of our Earth has extremely serious meteorological, biological, and thereby societal effects. Moreover, the emergence of many new diseases as well as the problems of food safety for the ever increasing human population also involve unforeseeable risks and challenges. The conservation of biological diversity and a better understanding of wild and domesticated plant and animal species successfully adapting to a changing environment are research tasks that serve the long-term future of humanity and, at the same time, promise to provide results that can also be utilized in everyday animal husbandry. It follows, then, that the preservation of the genetic diversity of livestock is one of the key concerns of both the present and the future.

Central and Southern Europe, and in particular the Carpathian Basin constitute a highly valuable geographical unit. These regions have maintained and are cultivating intensive economical, commercial and, occasionally, political relations with each other, and have therefore mutually and considerably affected the spread and diversification of domesticated animal species in each other's territories.

So far, however, only a minuscule fraction of this rich heritage has been subjected to genetic diversity studies.

Within the framework of the SMARTER project we have had the opportunity to study the genetic diversity of Hungarian and related sheep varieties (the latter living in present-day Romania) using 50K ovine SNP chips. The majority of these varieties have not been researched with the use of such tools or for such purposes, thus the project may benefit both the scientific community and sheep breeders.

We collected whole EDTA-anticoagulated blood samples for our experiments. Blood samples were stored at -20 °C until use. Next, genomic DNA was isolated from the samples and submitted for genotyping to a foreign service provider.

COUNTRY	VARIETY	NUMBER OF INDIVIDUALS
Hungary	Indigenous Tsigai	28
	Hungarian Merino	29
	Dorper	21
	White Dorper	20
	Bábolna Tetra	27
	Île de France	27
	Suffolk	20
Romania	Hortobágy Racka	28
	Rusty Tsigai	30
	White-Headed Tsurcana	30
TOTAL		260

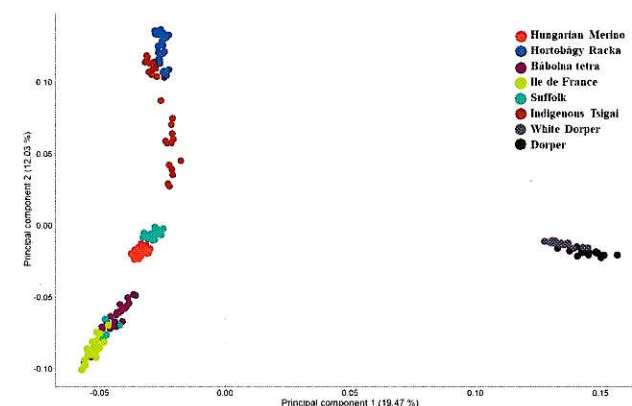
The results showed that both the observed and the expected heterozygosity values were closely similar in the case of all varieties tested. Inbreeding coefficient values indicated that in the case of certain varieties – such as Dorper and White Dorper – inbreeding depression can be a concern ($F > 12.5\%$), whereas the inbreeding levels of the indigenous Tsigai, Suffolk and Hortobágy Racka varieties are moderate ($F > 10\%$).

Variety	Observed heterozygosity		Expected heterozygosity		Inbreeding coefficient
	mean	Std (\pm)	mean	Std (\pm)	
Indigenous Tsigai	0.357	0.152	0.373	0.133	0.112
Hungarian Merino	0.369	0.164	0.374	0.133	0.070
Dorper	0.365	0.180	0.351	0.147	0.173
White Dorper	0.367	0.166	0.363	0.140	0.177
Bábolna Tetra	0.385	0.155	0.380	0.130	0.037
Île de France	0.372	0.157	0.372	0.136	0.074
Suffolk	0.361	0.163	0.371	0.136	0.110
Hortobágy Racka	0.356	0.165	0.367	0.137	0.125
Rusty Tsigai	0.386	0.152	0.386	0.126	0.025
White-Headed Tsurcana	0.383	0.146	0.382	0.126	0.039

The AMOVA test carried out as part of the examination of the genetic structure of the varieties showed that the most of the total genetic variance (90.77%) exists among individuals within breeds, with lesser amounts among breeds (9.23%), which offers a wide range of possibilities for intrapopulation selection. The presence of phylogenetic structure was also supported by the significant value of the fixation index among the varieties studied ($F_{ST}=0.092$; $P=0.000$).

Source of variance	d.f.	Sum of squares	Variance components	Variance (%)
Among breeds	9	513989.359	929.234	9.23
Among individuals within breeds	508	4640990.158	9135.807	90.77
Total	517	5154979.517	10065.041	
Fixation index (FST)			0.092	

Clustering by principal component analysis revealed that the Hortobágy Racka and the indigenous Tsigai form one group, whereas the Suffolk and Hungarian Merino varieties, which are not indigenous to Hungary form another group together with the Île de France and Bábolna Tetra as well as the Dorper and White Dorper varieties, convincingly demonstrating their origins. It was also observed that the principal component PCA2 separated the White Dorper and Dorper varieties from the rest, whereas PCA1 separated the Hortobágy Racka and indigenous Tsigai varieties from the other varieties studied.



The results of the principal component analyses of the two varieties sampled in present-day Romania are illustrated separately. The two principal components separate the two varieties; however, Rusty Tsigai produces a more diffuse pattern along PCA2 than does White-Headed Tsurcana, which forms tighter clusters.