Appraisal of the Breeding Plan for Scrapie resistance in the Sarda dairy sheep breed.

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Introduction

The Sarda is the largest Italian dairy sheep breed (51% of the national stock) with approximately 2.5 million heads, most bred in Sardinia on 11,000 farms

Selection scheme of Sarda dairy sheep breed

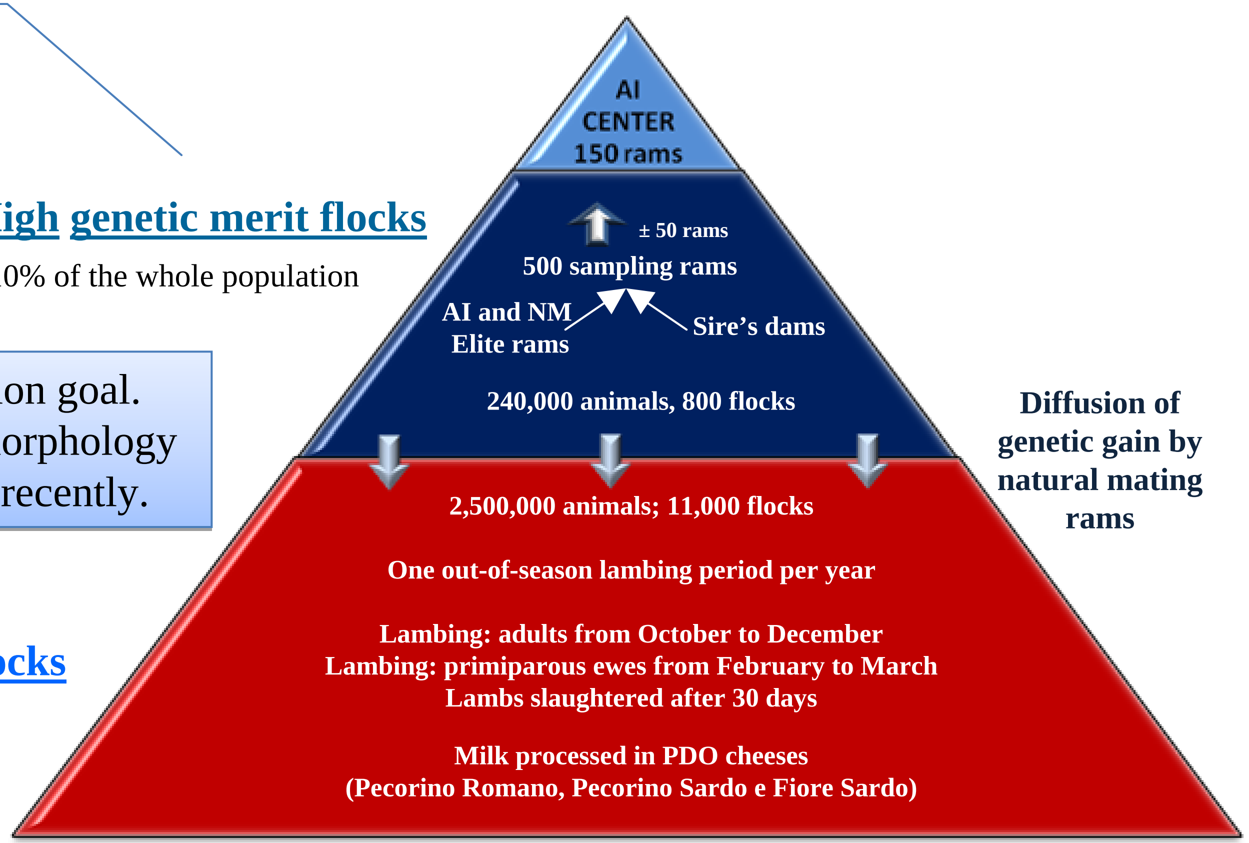
- Official recording
- Artificial Insemination (AI)
- Controlled Natural Mating
- PrP Genotyping

High genetic merit flocks

10% of the whole population

Milk yield is the main selection goal. Scrapie resistance and udder morphology have only been implemented recently.

Commercial flocks



Scrapie

Transmissible Spongiform Encephalopathy (TSE) of sheep and goats

Susceptibility in sheep is genetically determined due to a polymorphism of three codons of the PrP gene

Resistance pattern (5 alleles)

ARR	++
AHQ	- (in Italian breeds: Acutis et al., 2003)
ARH	-
ARQ	-
VRQ	--

Breeding for scrapie resistance in Sardinia

- **started since 2000**

At the early stage, only AI rams were genotyped at the PrP locus.

- **in 2003**

allelic frequency in HGMF and CF were estimated in the framework of projects funded by the national and regional governments.

Based on these surveys, the starting frequency of the ARR allele was:

- 42% in High Genetic Merit Flock
- 40% in Commercial Flock.

Sarda breed was considered as a medium resistant breed to scrapie deserving a breeding plan for the control of the disease.

- **in 2005**

Start of the official regional plan

aim of the study

Presenting results and prospects of

the official breeding plan for Scrapie resistance

implemented on the Sarda sheep breed in Sardinia.

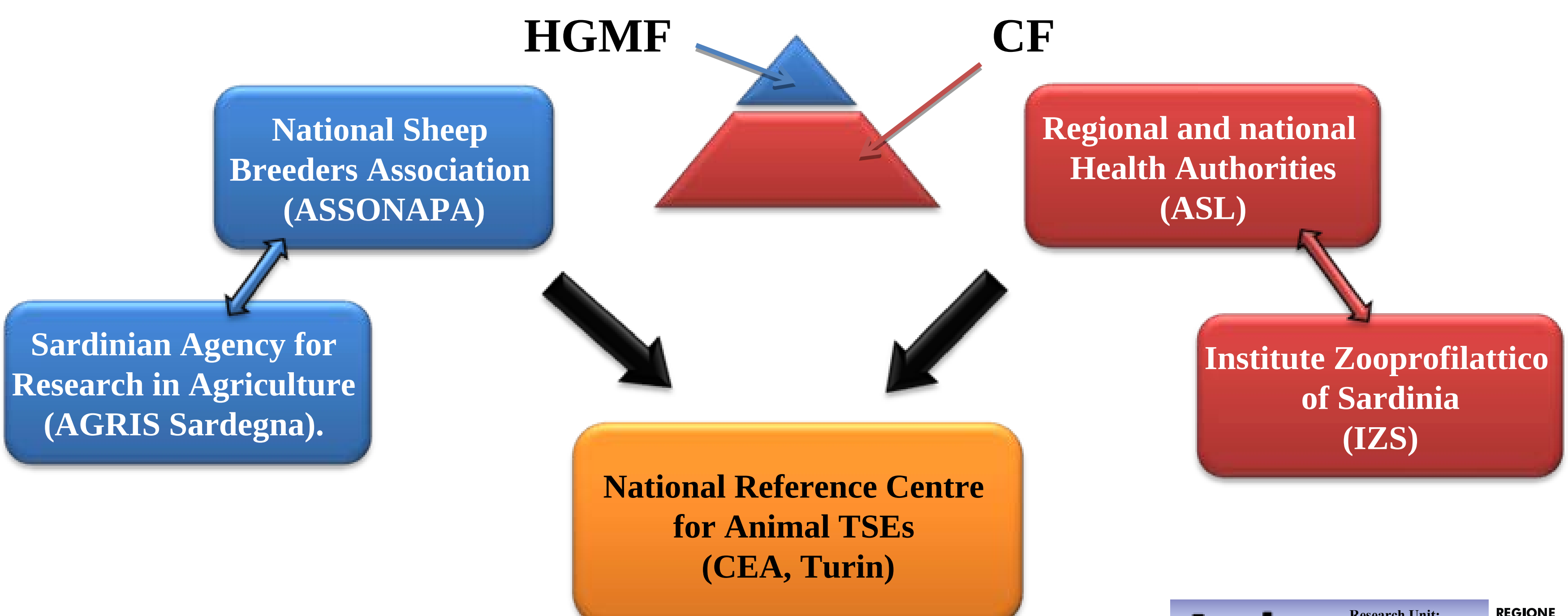
we show how breeding for resistance to Scrapie has been implemented without impairing the genetic progress for production traits of the Sarda breed.

Material and methods

The Plan aims at reducing the risk of Scrapie in sheep flocks by **increasing the frequency of the ARR allele**

An **advisory group** including experts of all the involved institutions was established to **manage the plan and provide scientific and technical support**.

Two-step plan

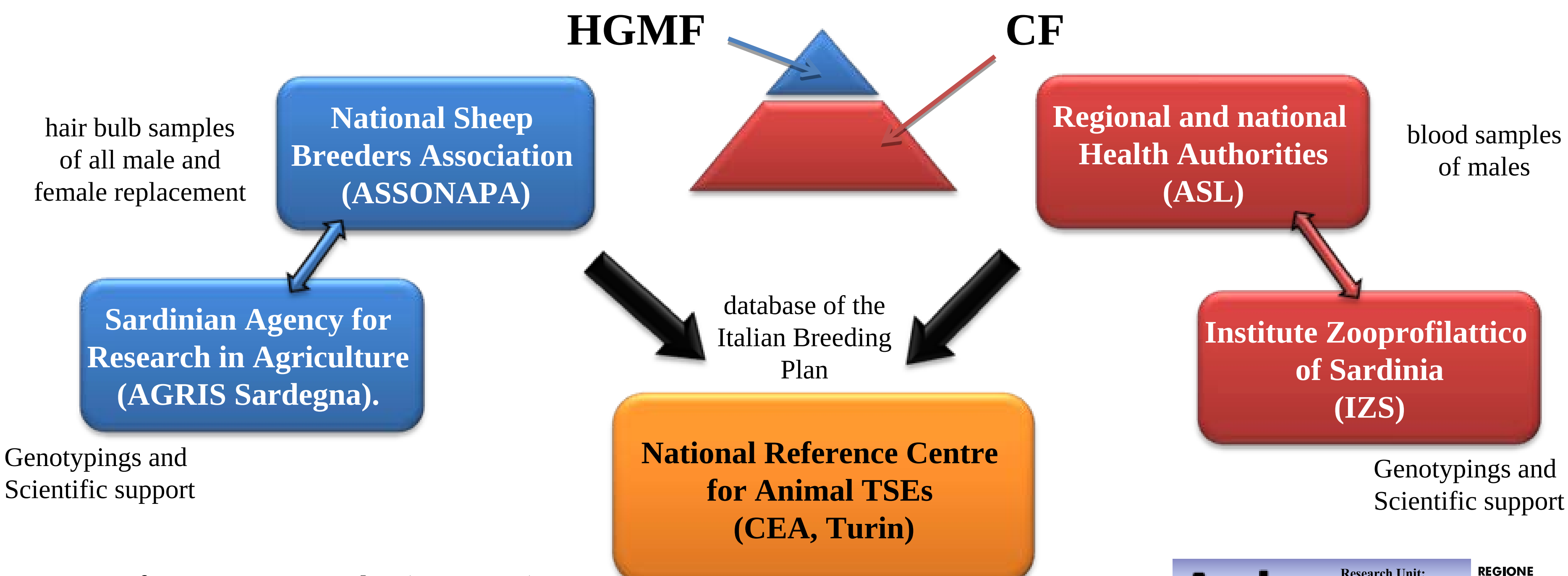


First-step (up to 2009)

genotyping and selection of animals was applied mainly in HGMF in order to exploit the pre-existing breeding structure involved in the selection for production traits.

The main purpose was to **increase the availability of ARR carrier rams** while preserving the genetic merit for production traits.

All **breeding males and the young ewes** with high pedigree genetic merit for milk yield, and therefore candidate to become dams of ram, had to be genotyped.



First-step (up to 2009)

To preserve production traits,

➢in the **early stages** of the plan even **homozygous susceptible rams** **with high genetic merit for production traits** were used for breeding.

These rams were preferably mated to ARR homozygous ewes.

No distinction was made between homozygous and heterozygous ARR carriers and both were selected according to the genetic merit for production traits.

➢**ARR homozygous young rams** **without progeny test for production traits were licensed as *“sire of ram”*** when their pedigree index was beyond a specific threshold to increase the availability of ARR carrier rams in HGMF.

➢Use of susceptible rams in HGMF was permitted only within the birth flock up to 4 years from the beginning of the Regional Plan.

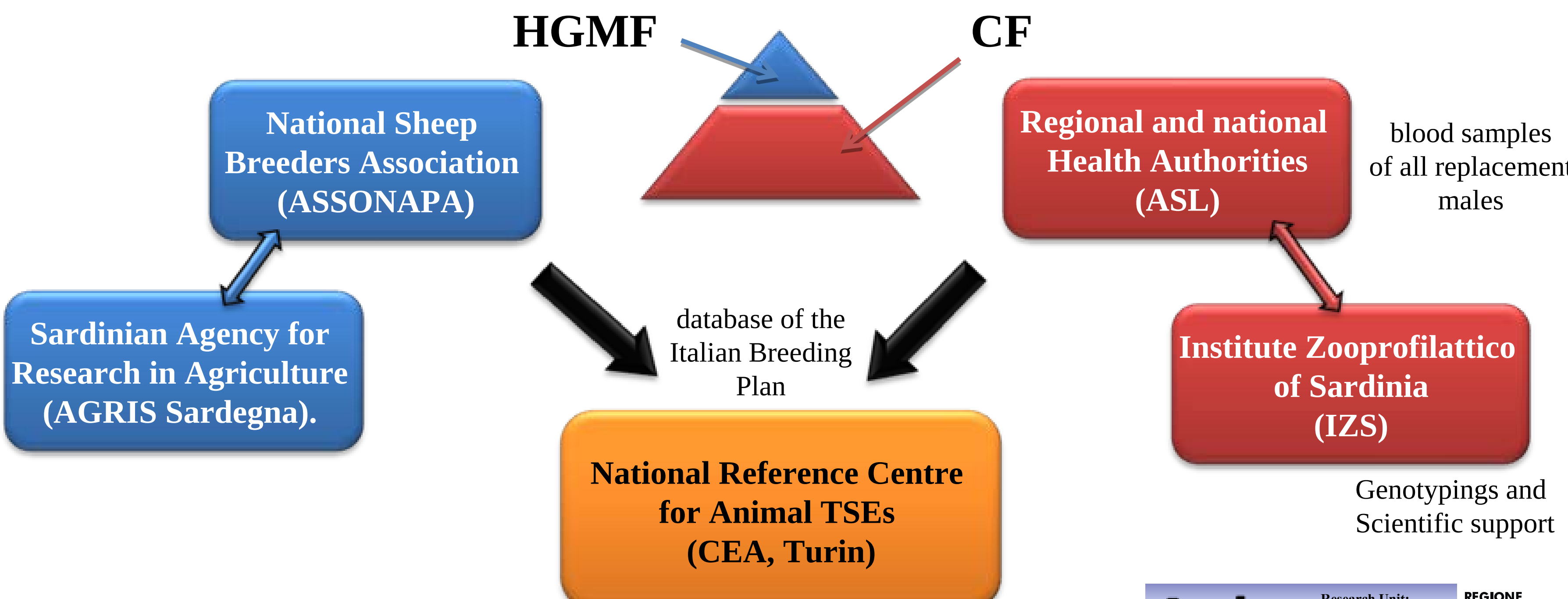
Second-step (since 2009)

the **expected genotypic frequencies** of the next cohort of males was estimated basing on the genotypic frequencies of breeding males and females.

to **calculate the amount of rams** both homozygous resistant and with good genetic merit for production traits that HGMF was able to produce.

to **schedule the second step** of the breeding plan (the exclusion of homozygous susceptible rams from reproduction in CF).

Objective: **accelerating the dissemination of rams from HGMF to CF by exploiting the large availability of ARR carrier rams previously generated in HGMF.**



Results and discussion

HGMF

Number of hair bulbs samples and genotypings per sex and year

		hair bulb samples		genotypings	
Year	flocks	ewes	rams	ewes	rams
2005	753	40,633	8,574	5,616	8,418
2006	548	24,907	3,268	4,125	3,040
2007	531	21,071	3,258	5,520	3,449
2008	581	28,562	3,918	2,322	3,567
2009	588	25,939	3,951	2,656	3,893
2010	662	33,577	5,022	5,822	5,242
2011	645	30,106	4,278	8,188	4,364
2012	623	28,356	3,549	1,980	3,539
2013	562	22,891	3,531	2,882	3,616
Total		**256,042**	**39,349**	**39,111**	**39,128**

Samples collection from males and the whole female replacement at one year of age.

This strategy allowed the punctual genotyping of elite ewes (20% of the whole female population), avoiding a further visit in the flocks for sampling.

Genotypings of ewes allowed farmers to select for ARR allele also on the "dam of sire" pathway.

HGMF

Artificial Insemination Program: doses per year and PrP genotype

(R = resistant allele; S = susceptible allele).

2005: Starting year of Regional Plan

Year		PrP Genotypes		
		RR	RS	SS
2000		3,267 (16%)	10,314 (50%)	6,938 (34%)
2001		2,607 (14%)	8,335 (44%)	7,793 (42%)
2002		2,795 (14%)	9,611 (49%)	7,212 (37%)
2003		4,184 (23%)	8,135 (44%)	6,275 (34%)
2004		3,841 (21%)	9,157 (50%)	5,288 (29%)
2005	**ARR 49%**	3,947 (26%)	6,980 (46%)	4,202 (28%)
2006		3,300 (26%)	5,796 (45%)	3,682 (29%)
2007		5,011 (37%)	7,973 (59%)	552 (4%)
2008		4,192 (40%)	6,372 (60%)	0 (0%)
2009		6,187 (59%)	4,383 (41%)	0 (0%)
2010		7,245 (70%)	3,040 (30%)	0 (0%)
2011		6,635 (88%)	902 (12%)	0 (0%)
2012		4,792 (95%)	246 (5%)	0 (0%)
2013	**ARR 100%**	6,308 (100%)	0 (0%)	0 (0%)

HGMF

ARR allele frequency and number of genotyped animals according to sex and year of birth

Birth year	rams N	rams ARR frequency	ewes N	ewes ARR frequency
2003	4,725	44.8%	11,932	42.1%
2004	3,064	47.9%	3,646	44.7%
2005	3,697	45.5%	4,880	47.2%
2006	2,910	51.4%	3,649	47.1%
2007	3,397	55.3%	2,342	51.9%
2008	3,581	57.6%	4,687	54.1%
2009	3,635	60.8%	5,444	58.4%
2010	4,650	63.5%	4,826	60.7%
2011	4,253	68.3%	3,108	65.8%
2012	3,473	70.7%	1,245	72.9%
2013	3,337	74.0%		

94% of ARR carriers

HGMF

Number and proportion of mating group per PrP genotype and mating year

(R: resistant allele; S: susceptible allele)

Mating year	Genotype					
	RR		RS		SS	
2004	260	24.0%	529	48.8%	295	27.2%
2005	264	26.0%	487	48.0%	264	26.0%
2006	304	31.6%	486	50.5%	172	17.9%
2007	355	36.5%	471	48.5%	146	15.0%
2008	397	41.3%	462	48.0%	103	10.7%
2009	470	50.8%	406	43.9%	49	5.3%
2010	514	58.4%	366	41.6%		0.0%
2011	559	69.5%	245	30.5%		0.0%

ARR/ARR rams actually used for reproduction increased of 43,5% from 2005 to 2011

Use of susceptible rams in HGMF was allowed by 2009.

ARR/ARR rams with good genetic merit for production traits that **HGMF** was able to produce.

commercial flocks (2009)

- 40,000 males mated every year
- sex ratio of 1/50
- ram reproduction career 3 mating years
- replacement rate 0.33
- yearly requirement 13,200 new rams.

High genetic merit flocks

- 240,000 ewes
- 0.37 ARR/ARR frequency of progeny
- 0.50 sex ratio at birth

240,000 x 0,50 x 0,37 = 44,000
New ARR/ARR rams in HGMF.

Genotype frequencies of all possible matings

Genotype and frequency of female parents		*Genotype and frequency of male parent* RR	RS	SS
		51.9	43.3	4.8
RR	23.6	12.2	10.2	1.1
RS	53.4	27.7	23.1	2.6
SS	23.0	11.9	10.0	1.1

Mating *Type*	*Frequency*	*Genotype and frequency of progeny* RR	RS	SS
RR x RR	12.2	12.2	-	-
RR x RS	27.7 + 10.2	19.0	19.0	-
RR x SS	11.9 + 1.1	-	13.1	-
RS x RS	23.1	5.8	11.6	5.8
RS x SS	10.0 + 2.6	-	6.3	6.3
SS x SS	1.1	-	-	1.1
	Sum =	37.0	49.9	13.1

Selection of the best 30% for production traits to satisfy CF needs of new rams.

The deadline to exclude the use of susceptible rams in CF in the second step of the Regional Plan was fixed at end of 2011.

commercial population

Number of rams per genotype and ARR carriers frequency per birth year

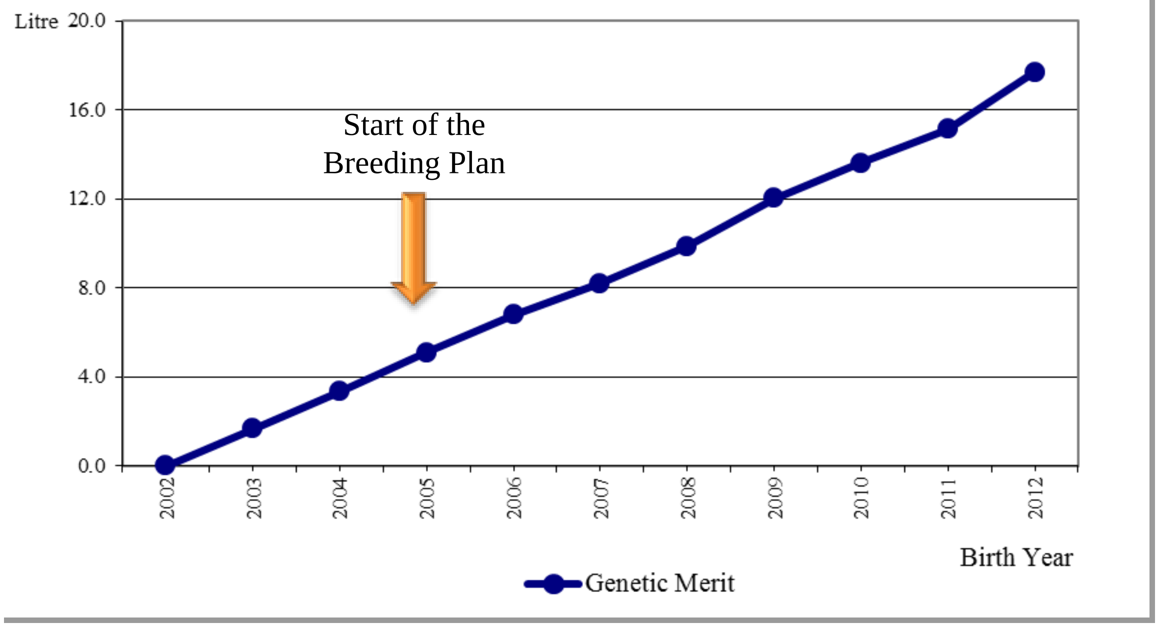
birth year	SS	RS	RR	Total	% ARR carriers
2004	4,280	6,137	2,458	12,875	66.8%
2005	2,174	3,249	1,206	6,629	67.2%
2006	3,042	4,413	1,747	9,202	66.9%
2007	3,283	5,015	2,038	10,336	68.2%
2008	3,451	5,048	2,098	10,597	67.4%
2009	3,324	5,127	2,255	10,706	69.0%
2010	1,866	3,392	1,599	6,857	72.8%
2011	1,554	2,890	1,655	6,099	74.5%
2012	659	1,580	965	3,204	79.4%

This trend was the clear effect of the rules on the rams utilisation included in the last version of the Regional Plan.

Effect of Scrapie selection on the genetic merit for production traits in HGMF

1. Using of SS rams with high genetic merit for production traits for breeding.
2. No distinction between RR and RS rams and their selection according to the genetic merit for production traits.
3. Licensing RR young rams without progeny test for production traits as *“sire of ram”*

the genetic trend of milk yield



Conclusion

- The breeding structure based on a pyramidal management built to select for production traits was efficient also to select for Scrapie resistance.

- A “two step” plan combined with rules for preserving genetic merit for production traits and facilitate the use of ARR/ARR rams has produced good results in high genetic merit flocks.

- These results are now being quickly transferred to the commercial population.

Conclusion

- However, further tools to accelerate the ram flow from high genetic merit flocks to the commercial population should be implemented

- it is crucial to establish the ARR frequency at which the genotyping of all male replacement is still economically profitable. Less genotyping effort is probably adequate at high frequency of ARR allele.

- It would be advantageous to introduce analytical methods at low cost that allow identifying flocks with increased level of risk: a procedure to estimate flock PrP genotype frequencies by bulk milk analysis has been set up in the Sarda breed.

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Thank you for attention

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