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Comparative genome analyses of two local cattle breeds reared in the Parmigiano Reggiano region

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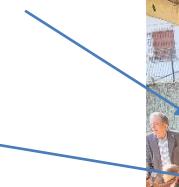
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Hamed Kazemi

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Francesca Bertolini

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- About 40 kg of cured cheese obtained from about 520 liters of milk
- No silage and no preservatives
- 2820 farms with a total of about 265,000 dairy cattle
- About 16% of the milk produced in Italy
- 3.6 M cheese moulds y
- 2.4 billion of euro

Reggiana



Modenese (Bianca Val Padana)



Reggiana



Statistics 2018

4,051 cattle registered to the herd book
2,379 dairy cows in 129 farms



ANABORRE

Modenese (Bianca Val Padana)



1,035 cattle registered to the herd book
451 dairy cows in 46 farms

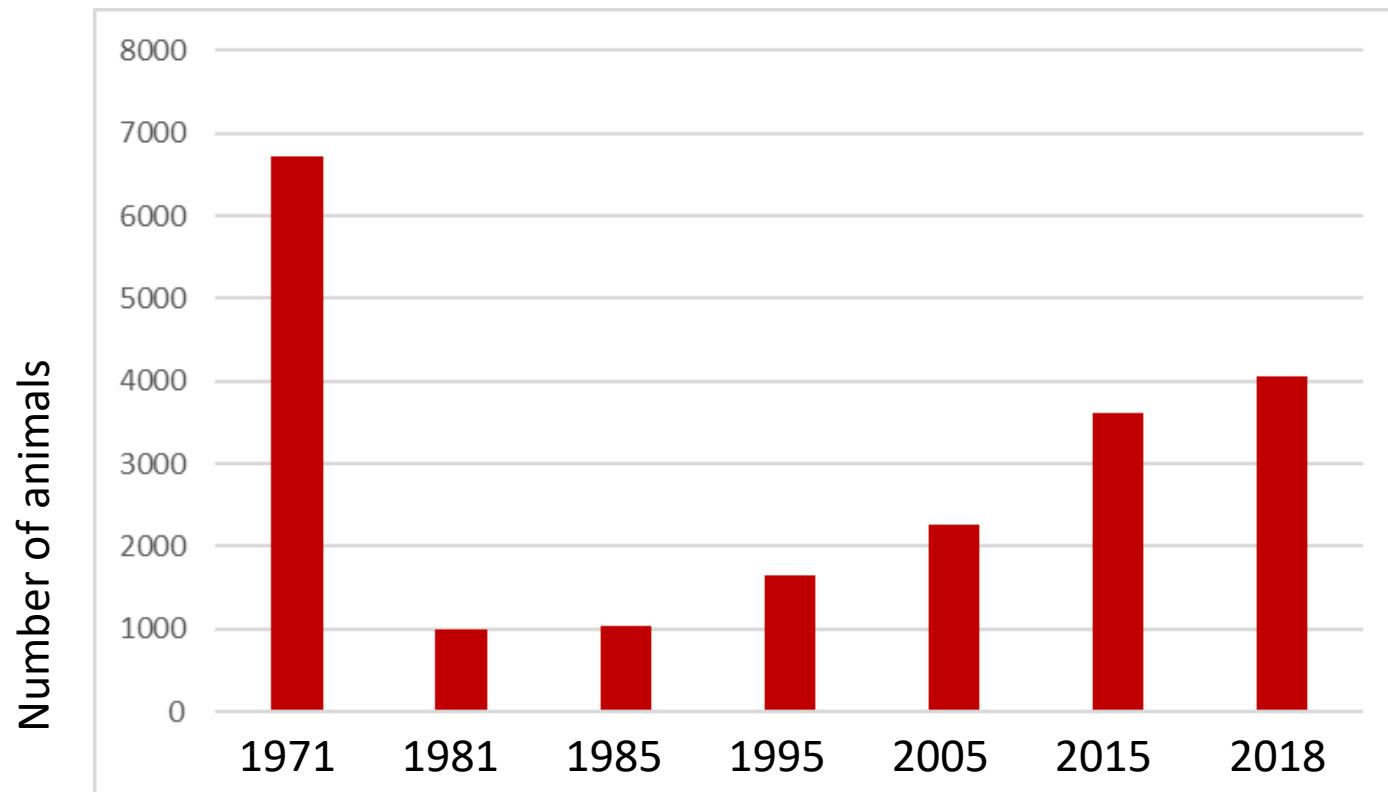
Reggiana



Modenese (Bianca Val Padana)



Reggiana cattle registered to the herd book



Years



1991

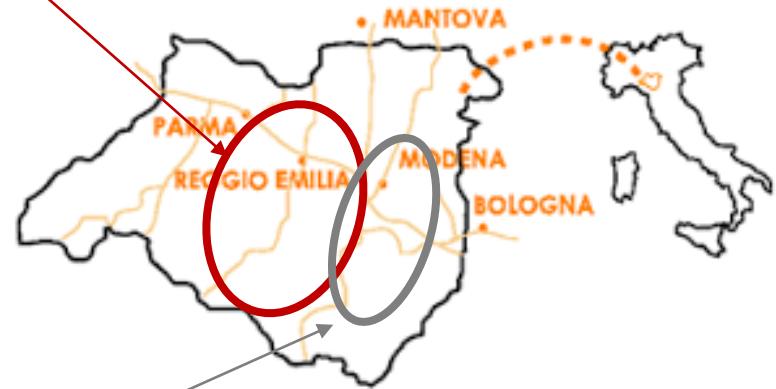


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Reggiana



Modenese (Bianca Val Padana)



Reggiana



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Reggiana



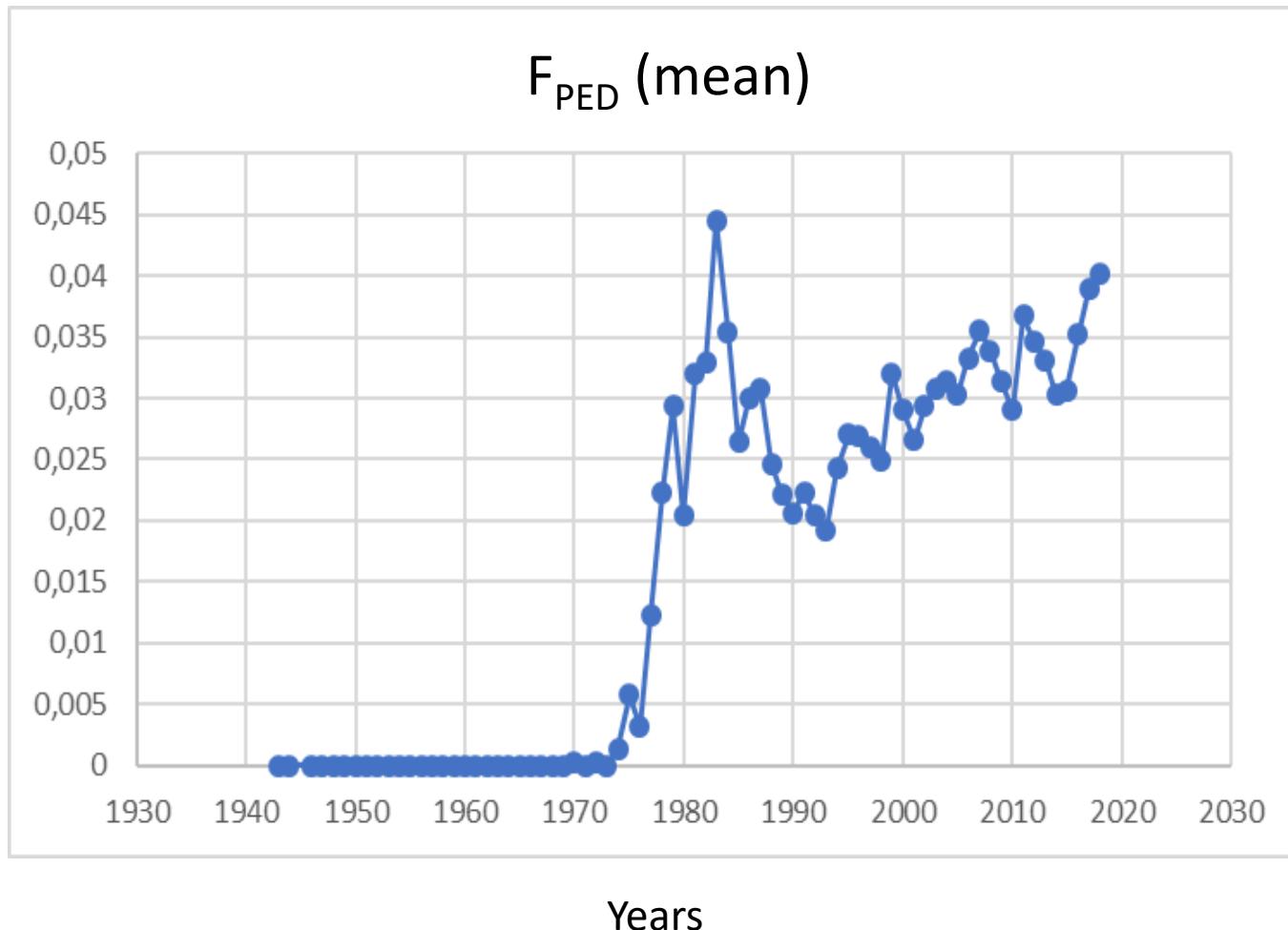
Modenese (Bianca Val Padana)



Conservation genetics

- Small populations
- Inbreeding
- Pedigree records (poor)
- Mating plans
- Breed-specific traits
- Sustainable productions
- Frauds
- Cheese-making properties of the milk
- Unknown genetic defects/deleteriour alleles
- ...

Reggiana



Genomic analyses



Reggiana



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Reggiana



658 cattle genotyped with:

- the GeneSeek Genomic Profiler Bovine 150K (GGP-HD)
- several gene markers

Modenese (Bianca Val Padana)



110 cattle genotyped with:

- the GeneSeek Genomic Profiler Bovine 150K (GGP-HD)
- several gene markers

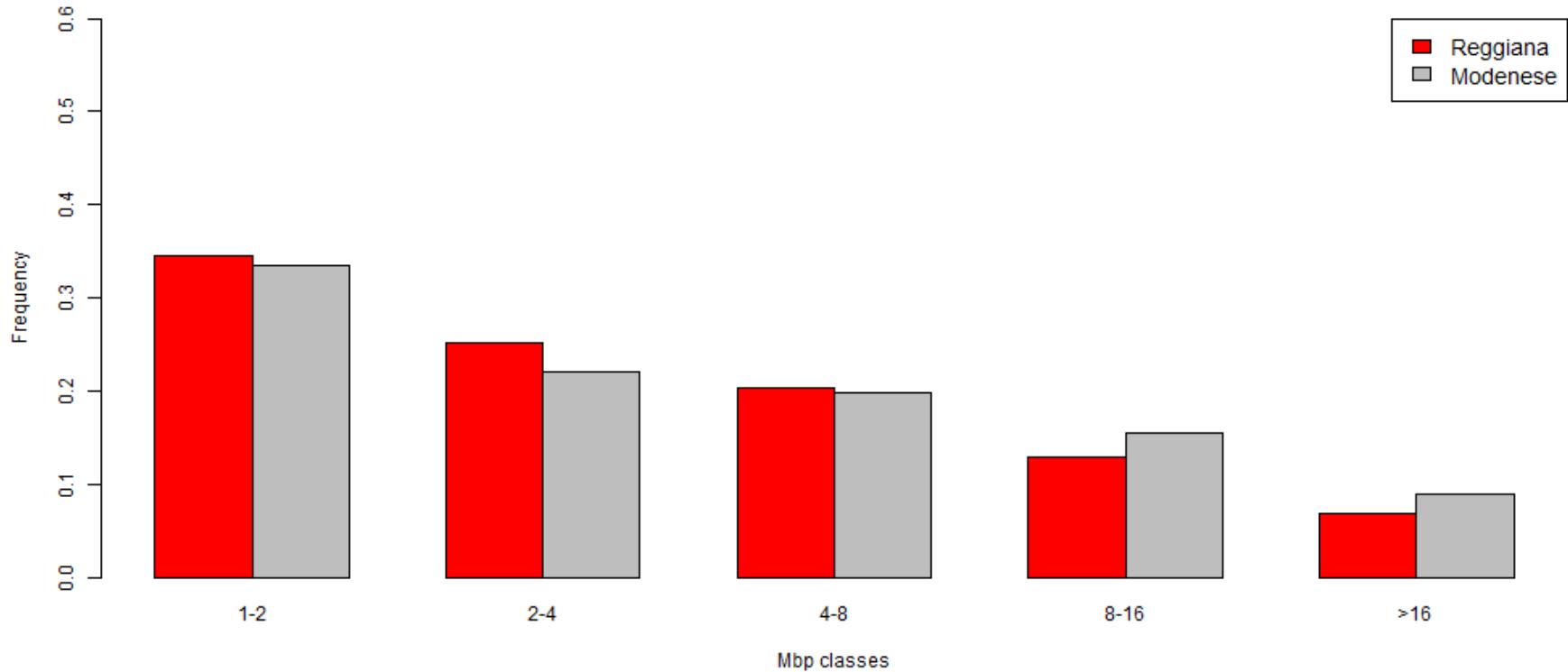


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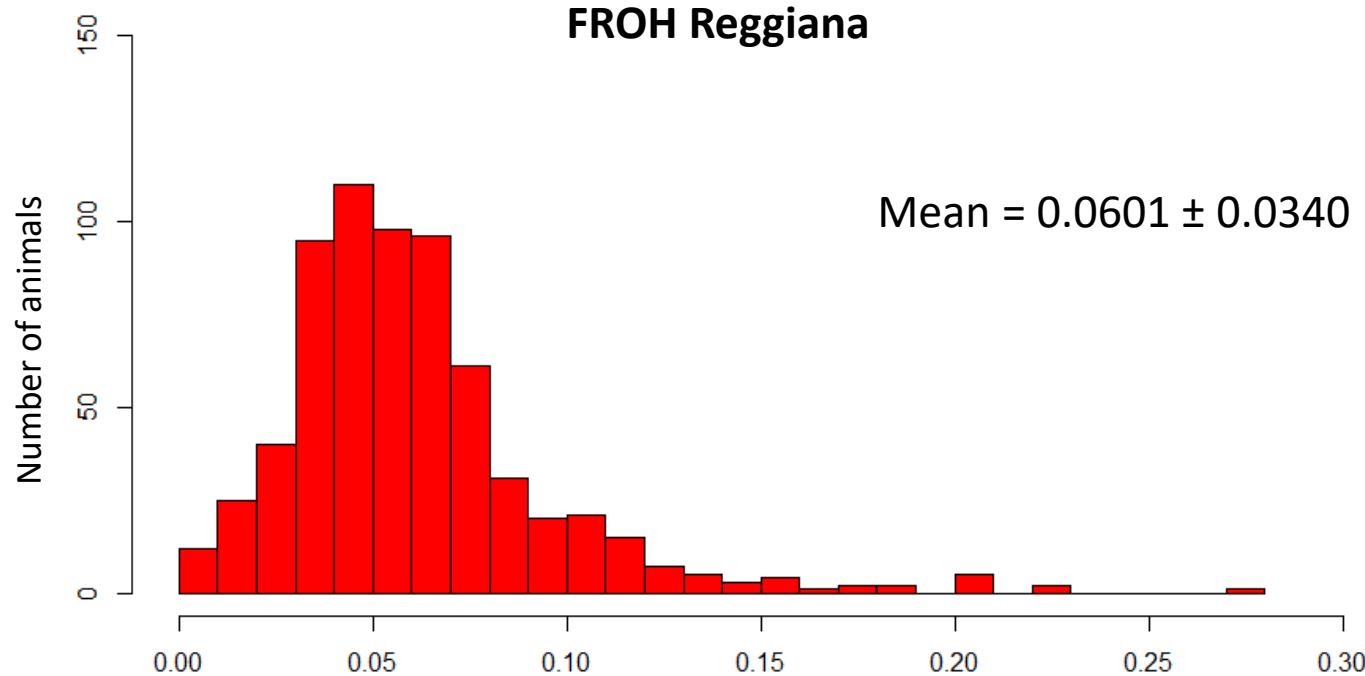
Runs of Homozygosity (ROH)

- Minimum number of consecutive SNPs: 15
Minimum homozygous density: 100
Heterozygous allowed: 0
Missing SNP allowed: 5
Minimum length of the segment: 1000 kb
- Different length classes (1-2, 2-4, 4-8, 8-16, >16 Mbp)
- FROH (the proportion of the autosomal genome covered by ROH)

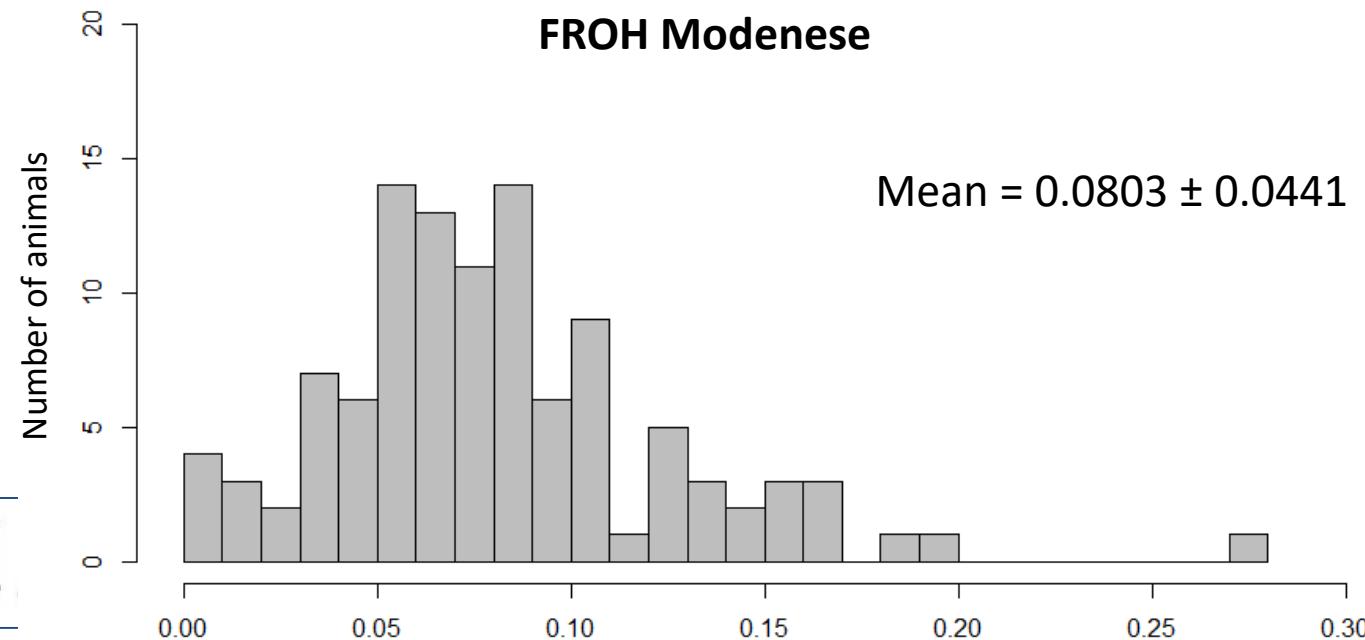
Runs of Homozygosity (ROH)



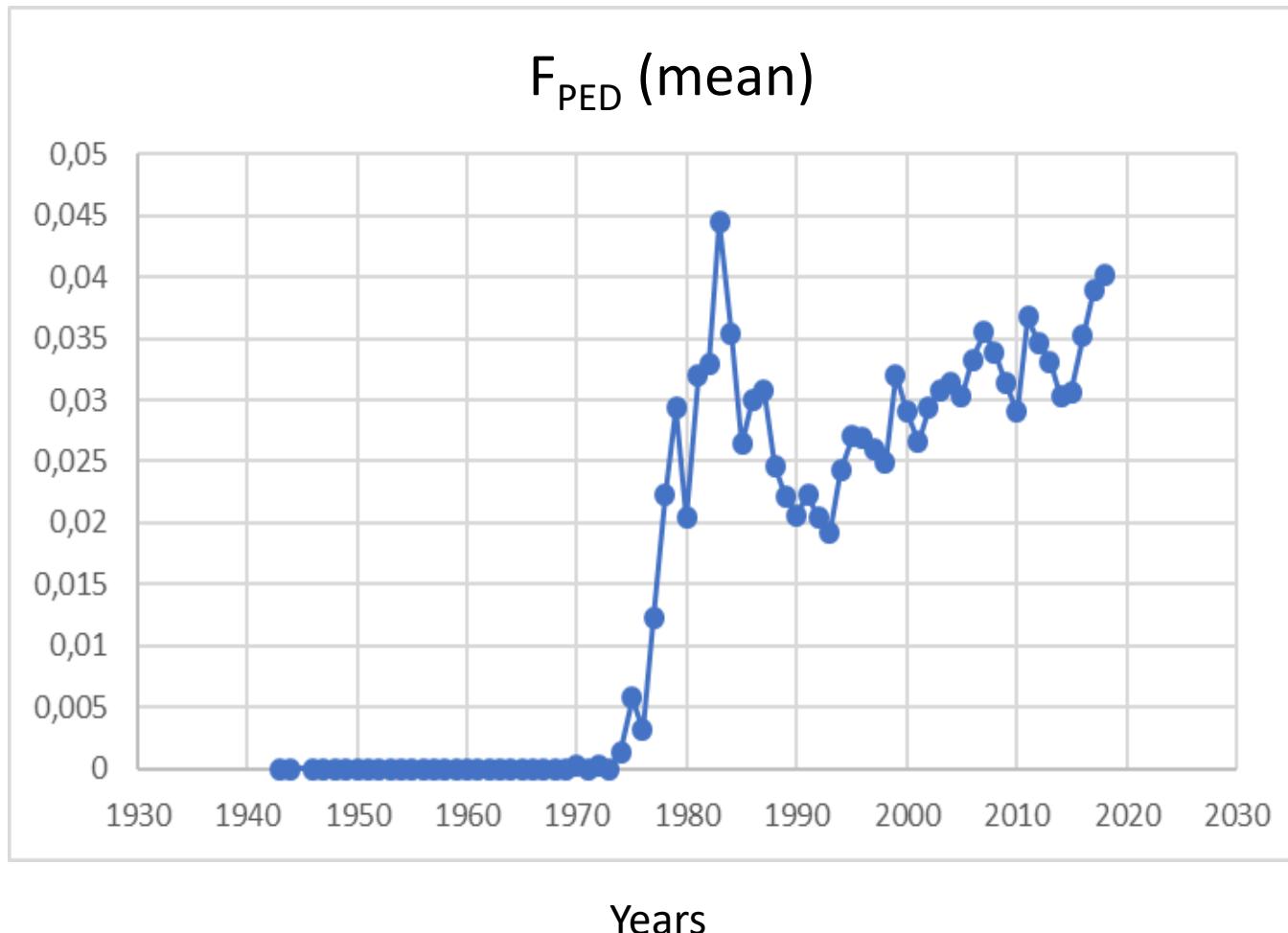
FROH Reggiana



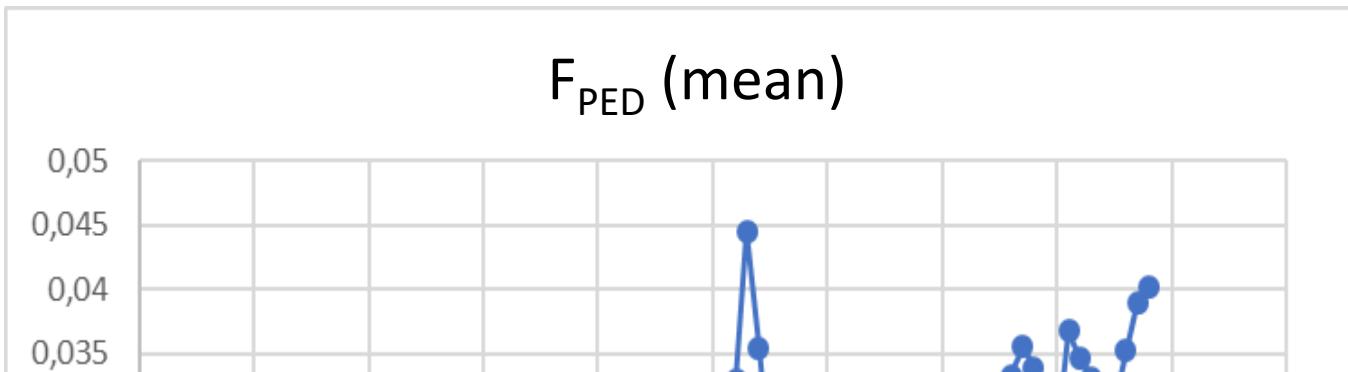
FROH Modenese



Reggiana



Reggiana



Spearman correlation between FPED and FROH = 0.020



Reggiana



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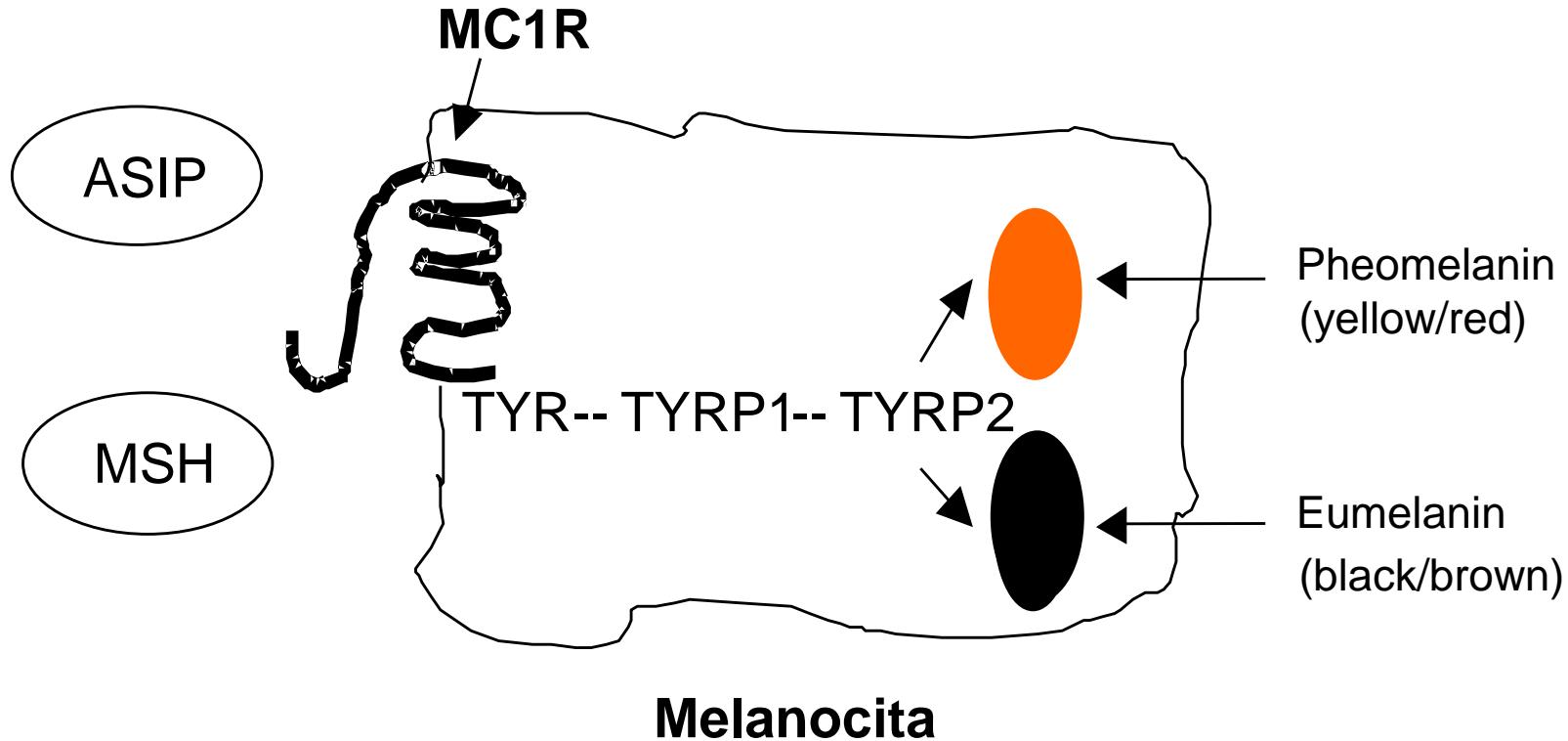
Reggiana



Mono-breed Parmigiano
Reggiano cheese

Frauds are an urgent
problem for the Reggiana
production chain

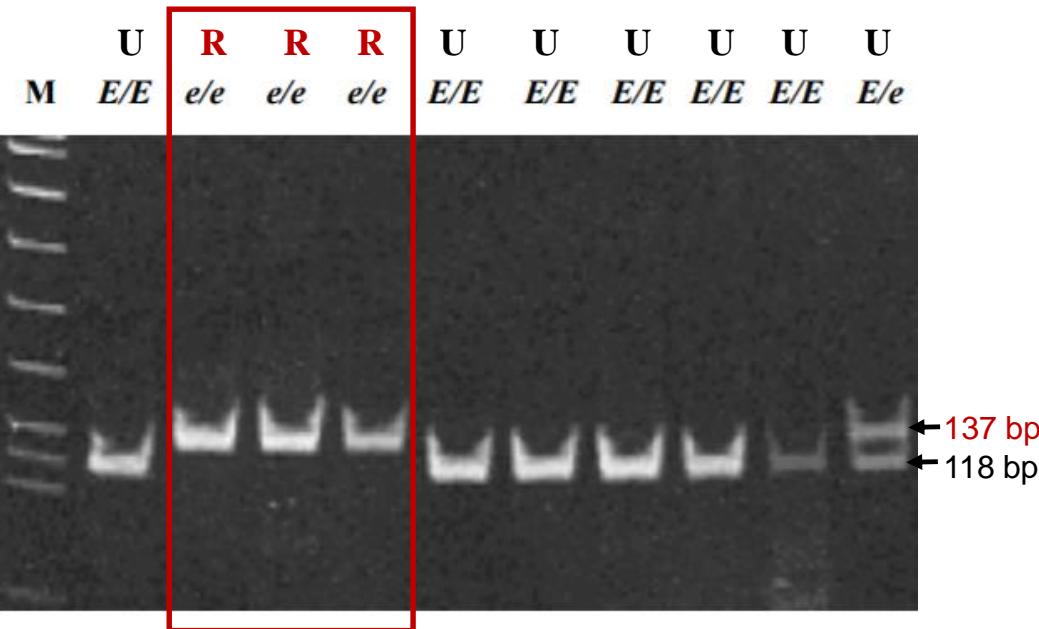
Breed-specific traits: Coat colour



Reggiana



MC1R alleles detected from cheese DNA



R = Parmigiano-Reggiano from only Reggiana milk
U = Parmigiano-Reggiano from unknown cattle

Analysis of melanocortin 1 receptor (*MC1R*) gene polymorphisms in some cattle breeds: their usefulness and application for breed traceability and authentication of Parmigiano Reggiano cheese

Vincenzo Russo, Luca Fontanesi, Emilio Scotti, Marco Tazzoli, Stefania Dall'Olio, Roberta Davoli

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ABSTRACT

In cattle, the *MC1R* gene has been the subject of several studies with the aim to elucidate the biology of coat colour. Thus, polymorphisms of this gene have been proposed as tools for breed identification and tracing. In this study, we investigated the usefulness of *MC1R* polymorphisms for the traceability of mixed-breed dairy cattle products we investigated, using PCR-RFLP and PCR-APLP procedures. The *MC1R* gene contains 11 exons and 10 introns spanning approximately 10 kb of DNA and is composed of 1263 amino acids. For each of seven breeds (Dekker Holstein, Italian Brown, Belgian Simmental, Rendena, Jersey, Friesian and Holstein Friesian) we determined the presence of the *MC1R* gene and the presence of the *MC1R* polymorphisms. The *MC1R* gene was found in all the cattle breeds investigated. The *MC1R* polymorphisms were found in all the cattle breeds except in Italian Brown, Rendena, Grigia Apula, Piedmontese, Swedish Red and White and Danish Red. The recessive allele 'e' was found in all the cattle breeds except in Jersey, Friesian and Holstein Friesian. The dominant allele 'R' was found in all the cattle breeds except in Italian Brown, Rendena, Grigia Apula, Piedmontese, Swedish Red and White and Danish Red. The *MC1R* gene was found in all the cheese samples. The *MC1R* polymorphisms were found in all the cheese samples, which is a result for about 2/3. The *MC1R* locus is highly informative with respect to breeds that carry other polymorphisms. This study demonstrates the usefulness of the *MC1R* gene and its polymorphisms to identify the presence of milk from some other breeds in Parmigiano Reggiano cheese labelled as exclusively made from Reggiana cattle. This study also demonstrates the usefulness of the *MC1R* gene and its polymorphisms to analyse polymorphisms of the *MC1R* locus in several dairy products, including Pecorino Romano cheese, and to verify the authenticity of these products. The *MC1R* gene and its polymorphisms can be used as a tool for the authentication of cheese products. © 2007 Blackwell Publishing Ltd, *J. Appl. Microbiol.* 102: 287–293

Key words: breed traceability, dairy cattle products, cheese authentication, *MC1R* polymorphism, Parmigiano Reggiano cheese

J. Appl. Microbiol., 102, 287–293, 2007

287

Holstein



E^d

Brown

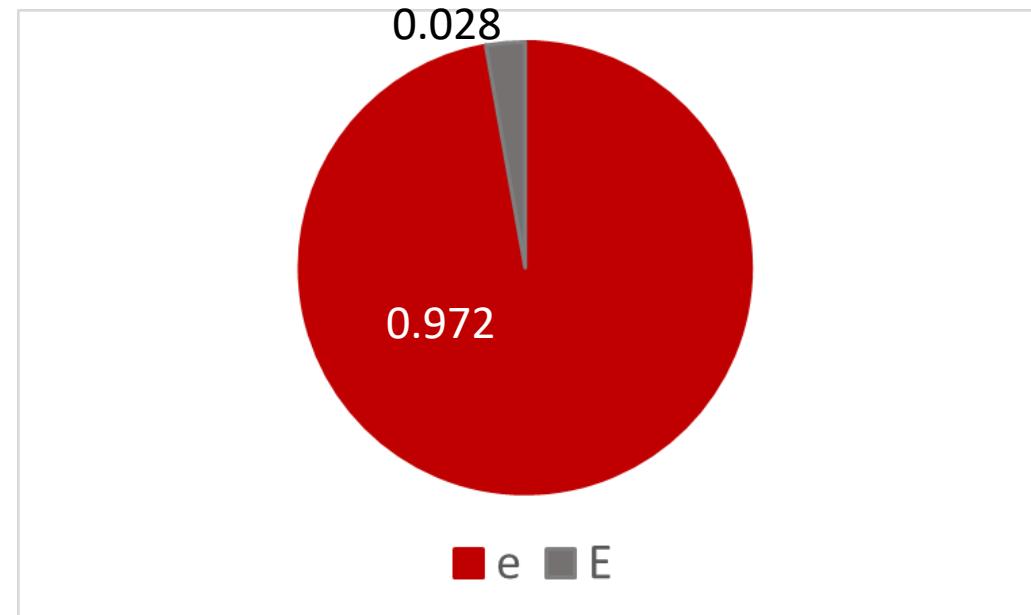


E^+

Reggiana



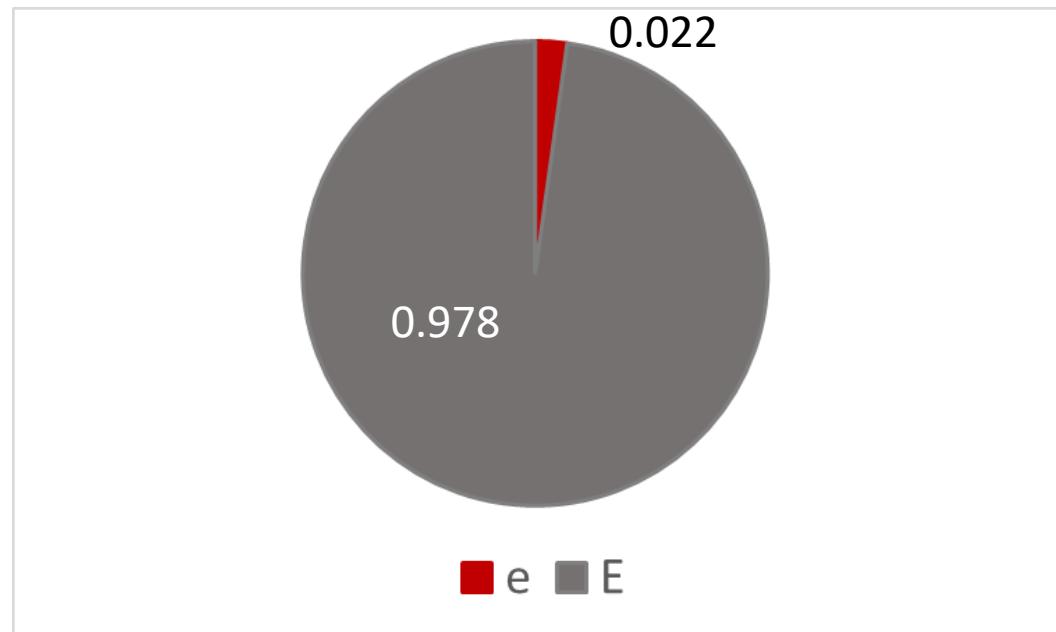
MC1R allele frequencies of the analysed Reggiana cattle



Modenese (Bianca Val Padana)



MC1R allele frequencies of the analysed Modenese cattle



Reggiana



Modenese (Bianca Val Padana)



Associazione Nazionale Allevatori
Servizi di Ricerca Reggiana

dualbreeding

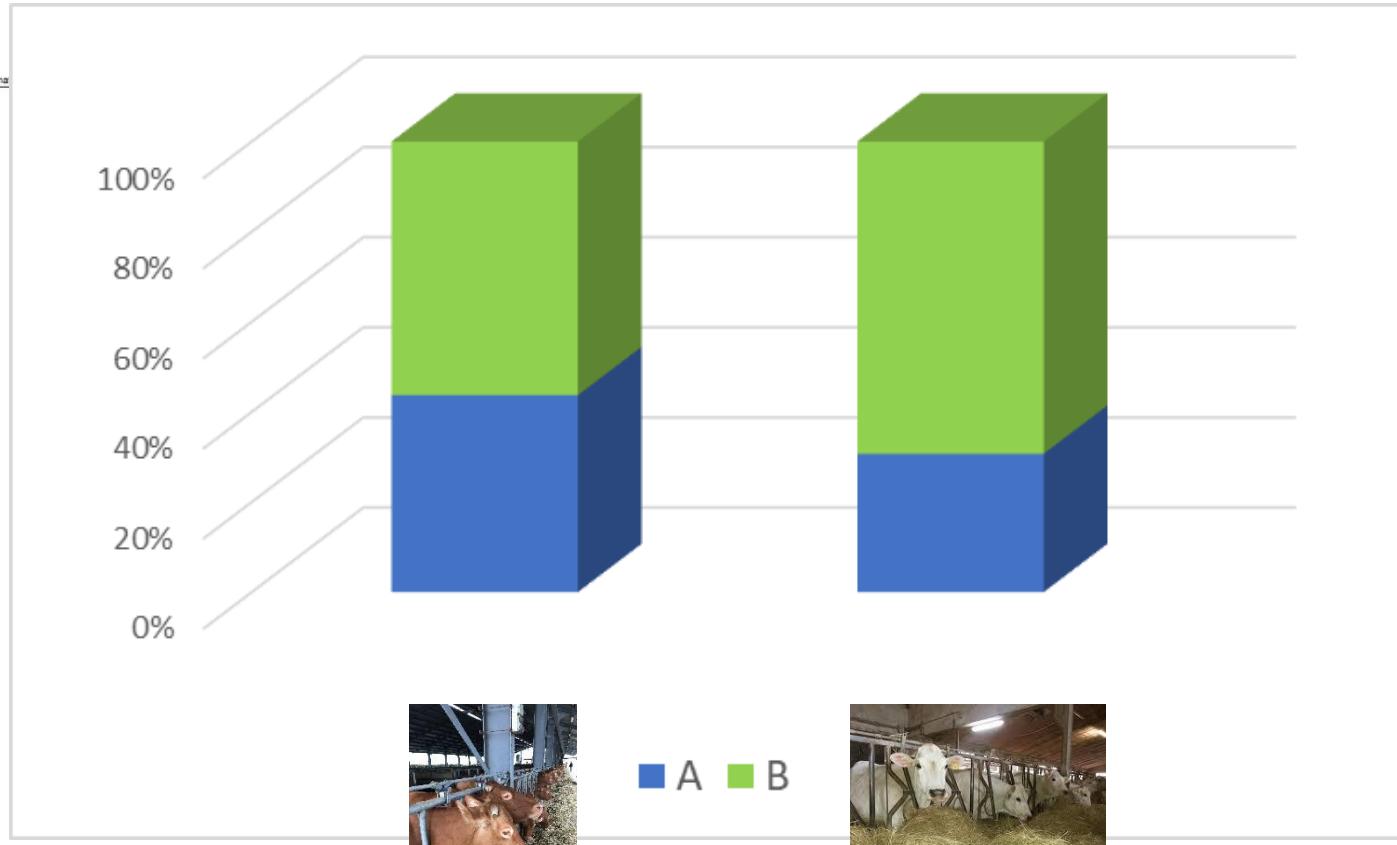
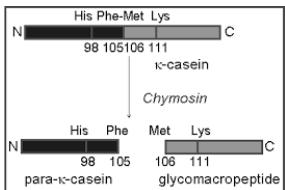
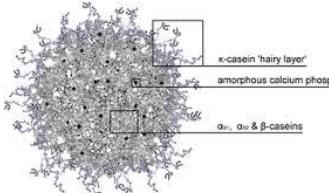
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Cheese-making properties of the milk: k-casein (CSN3) genotypes



Conclusions (1)

Reggiana herd book actions

1. For all animal records:
 - Inclusion of FROH in addition to FPED
 - Inclusion of *MC1R* genotype
 - Inclusion of *CSN3* genotype
2. Carriers of other alleles at the *MC1R* gene will not be registered anymore
3. The mono-breed authentication system based on the DNA analysis is driving the Reggiana production chain



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Conclusions (2)

4. We are working to implement the use of FROH in mating plans in the Reggiana and Modenese breeds
5. We are working to detect deleterious alleles in the two breeds
6. We are moving from a simple description to the use of genomic variability/information for the sustainable conservation of cattle genetic resources

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Massimo Bonacini
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Marco Prandi



Roberto Mantovani



«Fondo europeo agricolo per lo sviluppo rurale: l'Europa investe nelle zone rurali»



Direzione generale dello sviluppo rurale Ministero delle politiche agricole alimentari e forestali



Thank you!



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MC1R genotypes in different cattle breeds

Breeds	N.	Genotypes (n. of animals)								<i>ee</i>
		<i>E^DE^D</i>	<i>E^De</i>	<i>E⁺E⁺</i>	<i>E⁺e</i>	<i>E⁺E1</i>	<i>E1E1</i>	<i>E1e</i>		
Italian Holstein*	253	209	44	-	-	-	-	-	-	-
Italian Brown	247	-	-	75	4	107	31	7	-	-
Italian Simmental	208	-	-	1	10	-	-	-	197	
Reggiana	284	-	-	-	-	-	-	-	284	
Modenese	74	-	-	68	6	-	-	-	-	-
Rendena	84	-	-	43	2	36	3	-	-	-
Jersey	100	-	-	91	9	-	-	-	-	-
Total	1250									(Russo et al. 2007)

*Spotted black

Genotypes

$E^+ E^+$

$E^+ e$

$E1 E1$

$E^+ E1$

$E1 e$



Italian Brown

No: $E^+ e$

Genotypes

$e e$

($E^+ e$)

($E^+ E^+$)

Italian Simmental



Yes

$E^+ E1$

Genotypes

$e e$



Reggiana

No: e

Yes

E^D

Genotipi

$E^D E^D$

$E^D e$

Yes

E^D

Italian Holstein*



Yes

E^D



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