
REMAINING QUESTIONS ABOUT THE INHERITANCE OF ROAN COAT COLOR IN HORSES

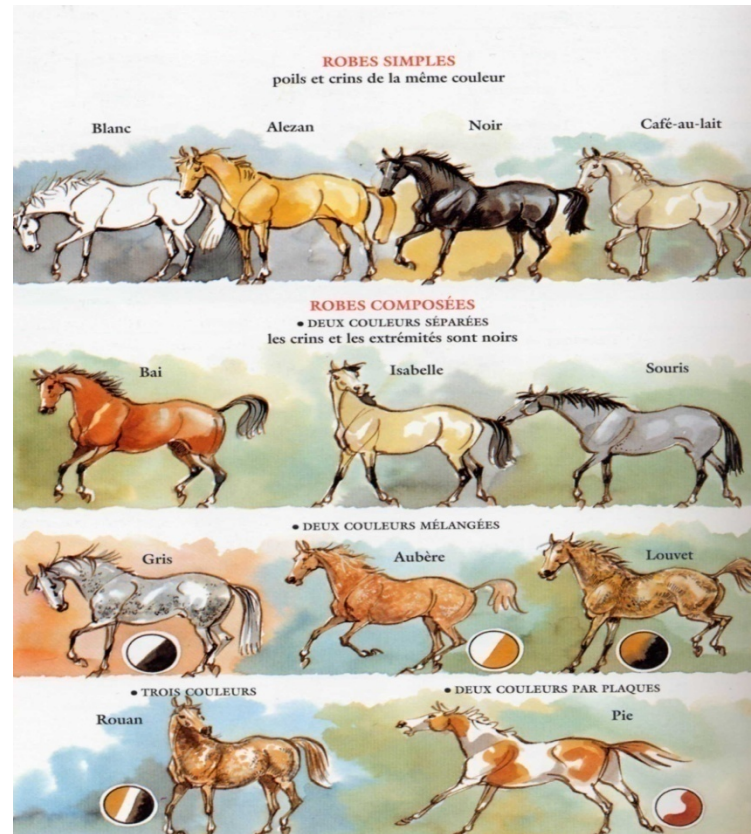
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Some definitions

- The tradition can be traced back to Sanson (1886)



A FIRST STEP FOR A BETTER DESCRIPTION OF THE HORSE COAT COLOR

- Another concept coming from the USA,

Basic coat color and different kinds of modifications:

- Intermixing of White hairs (grey, roan)
- Dilution (Dun characterized by the mule stripe among the mouse grey)
- Paint color which is a mix of white areas with any other coat color (different kinds of pie and skewbald Including tobiano, overo appaloosa, sabino...)

- Modifications restricted to mane and tail (Silver Dapple)

A SECOND STEP NOT STILL REALIZED

- Lauvergne et al. (1991) refined the definition of the basic coat color by introducing the notion of pigmental pattern (distribution of Phaeo- and Eu- mélanic areas) and of the black or brown nature of the eumelanin
 - This refinement is still not assimilated by the practice which is just beginning to apply the concept of modifications of the basic coat color
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THE MAIN BASIC COAT COLORS

Black



Chestnut and sorrel



Bai



THE ROANS STEMMING
FROM THE MAIN BASIC
COLORS

Blue roan



Strawberry roan



Red roan



ROAN'S PARTICULARITIES

- Head, mane and tail, points not affected by the intermixing of white hairs (this is not the case for grey)
- After a wound, hair growth colored again on the scar
- The distal parts of limbs, not affected by the intermixing, draw a sharp end in the front of the leg over the knee
- The head can have some lighter areas around the mouth and the eyes, but remains mainly colored (dark head)

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THE FALSE FRIENDS

- The Grey
 - The varnish roan
 - The Rubicano
 - The Sabino
 - The Dun
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- **Grey** evolves with age to white



- The **varnish roan** is a variety
- of appaloosa
- supposed constellated
- of « speckled with freckles »



- **The rubicano**



- Splashed White and Sabino



- Dun and mouse grey



SEGREGATION STUDY

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- The data are those collected in France for the three following draft breeds: Ardennais (ARD) Trait Du Nord (TDN) and Auxois (AUX)
 - corresponding to the mating seasons from 1994 to 2007 recorded by the SIRE system
 - The two names used in France to qualify roan horses are Aubère (strawberry roan) and Rouan (Red roan).
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- Gris Fer and Gris foncé are used for blue roan which is confusing with greying with age. However this latter gene is supposed to be absent from the breeds studied
 - Five other coat color codes defining intermixing or dark heads were considered with grey as miscellaneous
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- All the data are summarized in the following table
 - The number of matings is in black
 - The number of birth declarations is in blue
 - The number of affected foals is in red
 - An affected foal belongs to the coat color codes translated in English as: strawberry roan, red roan, blue roan and miscellaneous
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mare sire	Straw berry Roan	Red Roan	Blue Roan + Miscellan.	Solid color	Total
Straw berry Roan	4 1 0	51 21 24	0 0 0	106 47 10	161 69 34
Red Roan	401 195 126	3693 1741 266	515 248 147	7904 3715 490	12513 5899 1029
Blue Roan + Miscellan.	17 6 4	130 48 40	155 57 45	125 74 22	427 185 111
Solid color	912 426 170	6933 3415 1466	671 301 89	20084 9096 "56"	28600 13238 1781
Total	1334 628 300	10807 5225 1796	1341 606 281	28219 12932 578	41701 19391 2955

PRELIMINARY COMMENTS a)

- Only **15%** of the foals are affected by the character but **32%** of the producing stallions and **31%** of the mated mares are affected.
 - **Selection in favor of roan coat colors seems to occur in these breeds**
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PRELIMINARY COMMENTS b)

- Some assortative matings can also be ascertained:
- 11.2% of observed coverings are affected males by affected females **greater** than 10.1% expected at random
- 67.7% non affected males by non affected females **greater** than 46.2% expected
- 20.4% non affected males by affected females **lower** than 22.2% expected
- 19.5% affected males by non affected females **lower** than 21.3% expected

TRANSMISSION OF THE ROANING CHARACTER (R+)

Sire	Dam	Nb birth	% of R+ obs.	%of R+ exp.
R+	R+	2317	28,1	33,3
R-	R+	4142	41,6	50,0
R+	R-	3836	13,6	50,0
R-	R-	9096	0,6	0,0

PRELIMINARY COMMENTS c)

- According to the accepted mechanism of Roan coat color, a dominant allele, lethal in the homozygous state, **we should admit a deleterious effect even in heterozygous state** to explain the deficit of R+ in the observed data
 - Deficit of expression can not be retained because mating R- together gives a too low percentage of R+. $0.6\% \ll 3.8\%$ which is the proportion of bai out of two chestnut in the file which gives an estimation of the confidence of the data
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PRELIMINARY COMMENTS d)

- Therefore the **Dominant nature of the allele, can be admitted**
 - However, one can observe the very dissymmetric male and female path of transmission of the character
 - 13.6% male transmission #41.6% female transmission
 - **Mares transmit R+ character better than stallions**
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EFFECT OF MATING
ACCORDING TO THE
COAT COLOR ON
FERTILITY

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- Under the hypothesis of a lethal allele a lower fertility is expected from the crossing
 - $R^+ \times R^+$
 - Compared to
 - $R^+ \times R^-$ and $R^- \times R^-$
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BIRTH RATE RESULTS

sire	Dam	Nb covering	Nb birth	Birth rate
R+	R+	4966	2317	0,466
R-	R+	8516	4142	0,486
R+	R-	8135	3836	0,472
R-	R-	20084	9096	0,453

COMMENTS

- In general the birth rate declaration for draft breeds is low 45.3% here for the mating of solid color together.
 - Mating for color seems to benefit from better care
 - R+ x R+ appear however the less fertile (46.6%), followed by R+ x R- (47.2%) and R-x R+(48.6%)
 - Should the R+ Mother protect her heterozygous embryo better from death ?
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SEGREGATION ANALYSIS

- Observed segregation data could be biased by the very skew reproduction structure of horse populations, the family size having a very high variance
 - Therefore a segregation study taking the pedigree information in account was conducted
 - The study was restricted to the families where the character was segregating (i.e where affected and non affected = probant animals were observed)
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RESULTS FROM THE R+ sire by R+ dam CROSSING

- The maximum likelihood estimate of the segregation ratio was:
 - **0.33** with 95% confidence interval (0.31-0.35)
 - Exactly what was expected from a 2/1 segregation corresponding to a dominant gene lethal in the homozygous condition.
 - All R+ can therefore be assumed to be heterozygous and a proportion of homozygous can be excluded
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RESULTS FROM THE R- sire by R+ dam CROSSING

- The maximum likelihood estimate of the segregation ratio was:
 - **0.62** with 95% confidence interval (0.60-0.64)
 - This is a clear deficit in affected foals expected around 50%
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RESULTS FROM THE R+ sire by R-dam CROSSING

- The maximum likelihood estimate of the segregation ratio was:
 - **0.71** with 95% confidence interval (0.70-0.73)
 - Confirming a clear deficit in affected foals and the dissymmetry of the two paths
 - R+ dams seem to better protect their heterozygous embryo from death than do the R-
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CONCLUSION a)

- At the end of this study The determinism of Roan coat color in horses by a dominant allele lethal in the homozygous state is confirmed by the segregation study of Roan by roan and non Roan by non Roan matings.
 - But the dissymetry of Roan sire and non Roan dam versus non Roan sire Roan dam and the deficit in roan foals observed is not in agreement with the current theory.
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CONCLUSION b)

- May we suggest to conciliate these discordant results:
 - Some lethality of the heterozygous embryos
 - This lethality being lower in roan mares that still overcome the difficulty of wearing the deleterious allele, than in non roan mares
 - Do the roan mares benefit from a genetic protection factor or do they develop a kind of epigenetic protection still active in their ovum ?...
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