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Genetics of lifetime reproductive performance in Italian Heavy Draught Horse mares

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Background

Reproductive success

- Implication on the economic efficiency in animal production
- Reproductive traits not easy to measure and used for selection, particularly in females
- Lifetime reproductive performances and reproductive traits pertaining to individual breeding season
- Lifetime fertility traits of easier use for breeders
- Limited number of studies on horses at population level
- Retrospective studies on reproduction layouts (Hemberg et al., 2004) or on factors affecting horse births (Langlois & Blouin, 2004)

Aim of the study

Analyze lifetime reproductive performance in Italian Heavy Draught Horse (IHDH) mares, and particularly:

1. To identify a phenotypic variable useful to define a mares' lifetime fertility trait
2. To analyze the genetic component for the proposed trait

Lifetime reproductive performance variable

Lifetime foaling rate (LFR)

- Number of foal produced by a mare divided by the number of opportunities to do so (Meyer et al., 1990)
- Known limits:
  1. Longer lifetime increases opportunities of foaling but also the chance of failure, and older mare could express lower values than younger animals
  2. Possible asymmetrical distribution due to the proportion variable

Exploit the possible expression of LFR at a given endpoint to overcome limit no. 1, and to investigate a transformation of the variable for limit no. 2

STEP 1 - Training dataset

- Reproductive events from the studbook database for 1,487 mares born after 1990
- Mares had at least 6 subsequent registered reproductive seasons, belonged to environmental units with at least 2 observations (group of studs in the same geographical area and common rearing system by year of birth), and had both parents known
- Dataset for producing a set of predictive coefficients or equations to estimate the no. of foals produced at the 6th reproductive season depending on:
  1. previous no. of foals after 3, 4 or 5 reproductive seasons
  2. the age at first foaling (3 or 4 years)

Analysis of biases to compare the predictive ability of coefficients or equations

STEP 2 – Validation dataset

- 3,033 mares' reproductive events (at least 3 registered reproductive seasons) and edited as before
- Individual lifetime foaling rate at the 6th reproductive season, i.e., foals produced at 6th reproductive season/opportunities (i.e., 6) using both coefficients or equations methods
- Dataset contained actual (n=1,950) and estimated (n=1,443) LFR (from at least 3 reproductive seasons)

The transformation of the data in arcsin (i.e., as suggested for proportions; Fernandez, 1992) was investigated

Heritability values were estimated for normal or transformed LFR (Coeff. or Equat.) under animal model accounting 6,803 animals in pedigree

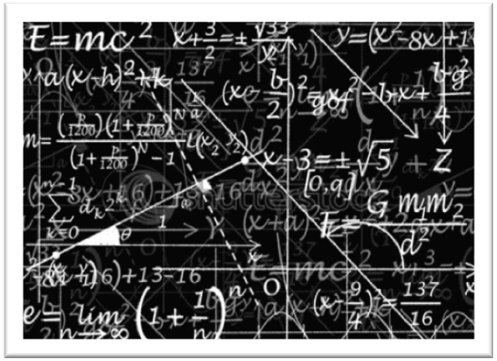
Predictive ability of coefficients or equations

Item	Method	
	Coefficients	Equations
Estimate from 3, 4 or 5 events		
- Percentage Squared Bias[1]	1.214%	1.188%
- Mean Absolute Deviation[2]	0.450	0.450
- Residues' standard deviation[3]	0.545	0.538

[1] $\left(\sum(y-\hat{y})^2/\sum y^2\right)\times 100$

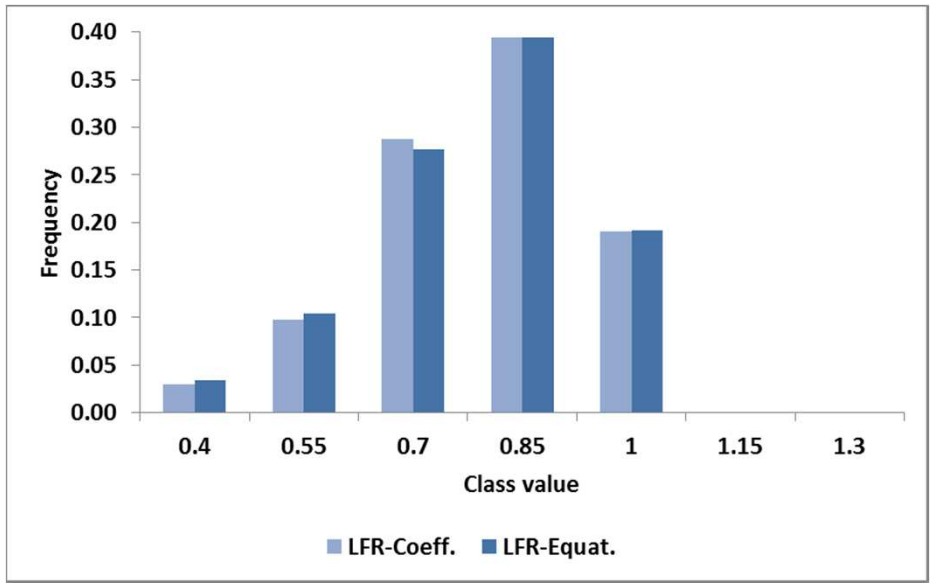
[2] $\sum|y-\hat{y}|/n$

[3] s. d. of $(y-\hat{y})$

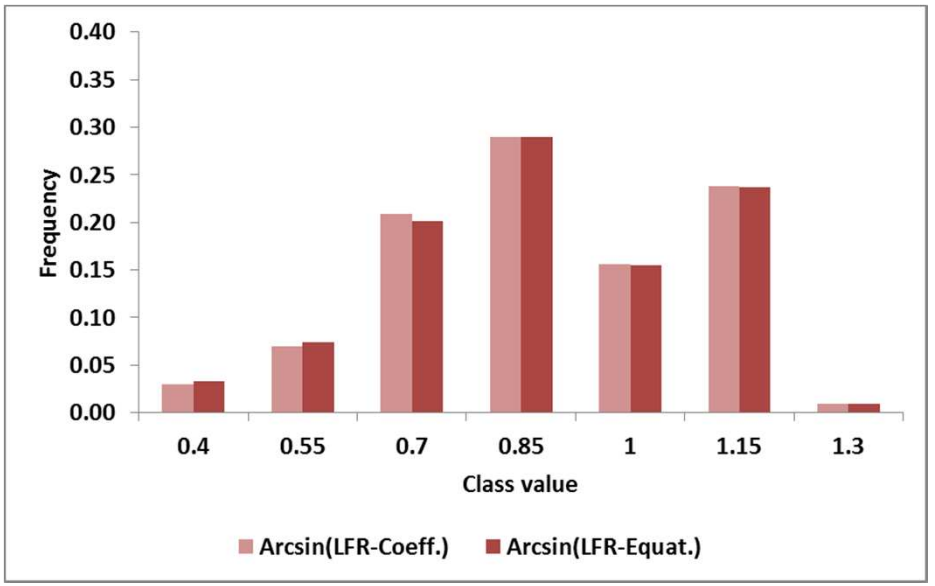


Normal vs. Transformed Lifetime Foaling Rate

Normal LFR



Transformed LFR



Item	LFR-Coeff.	LFR-Equat.
Kolmogorov-Smirnov D	0.16 (P<0.01)	0.14 (P<0.01)
Anderson-Darling A-Sq	82.9 (P<0.01)	78.7 (P<0.01)
Skewness	-0.88	0.14

Item	Arcsin(Coeff.)	Arcsin(Equat.)
Kolmogorov-Smirnov D	0.15 (P<0.01)	0.11 (P<0.01)
Anderson-Darling A-Sq	67.2 (P<0.01)	60.1 (P<0.01)
Skewness	-0.51	0.19

ANOVA on validation dataset

Item	Factor		RSD
	Environm. Unit x BY	Age 1st Foaling	
d.f.	124	1	2907
LFR-Coeff.	0.029***	0.963***	0.019
LFR-Equat.	0.029***	1.134***	0.020
Arcsin (LFR-Coeff.)	0.053***	1.657***	0.037
Arcsin (LFR-Equat.)	0.053***	2.003***	0.037

Genetics of Lifetime Foaling Rate

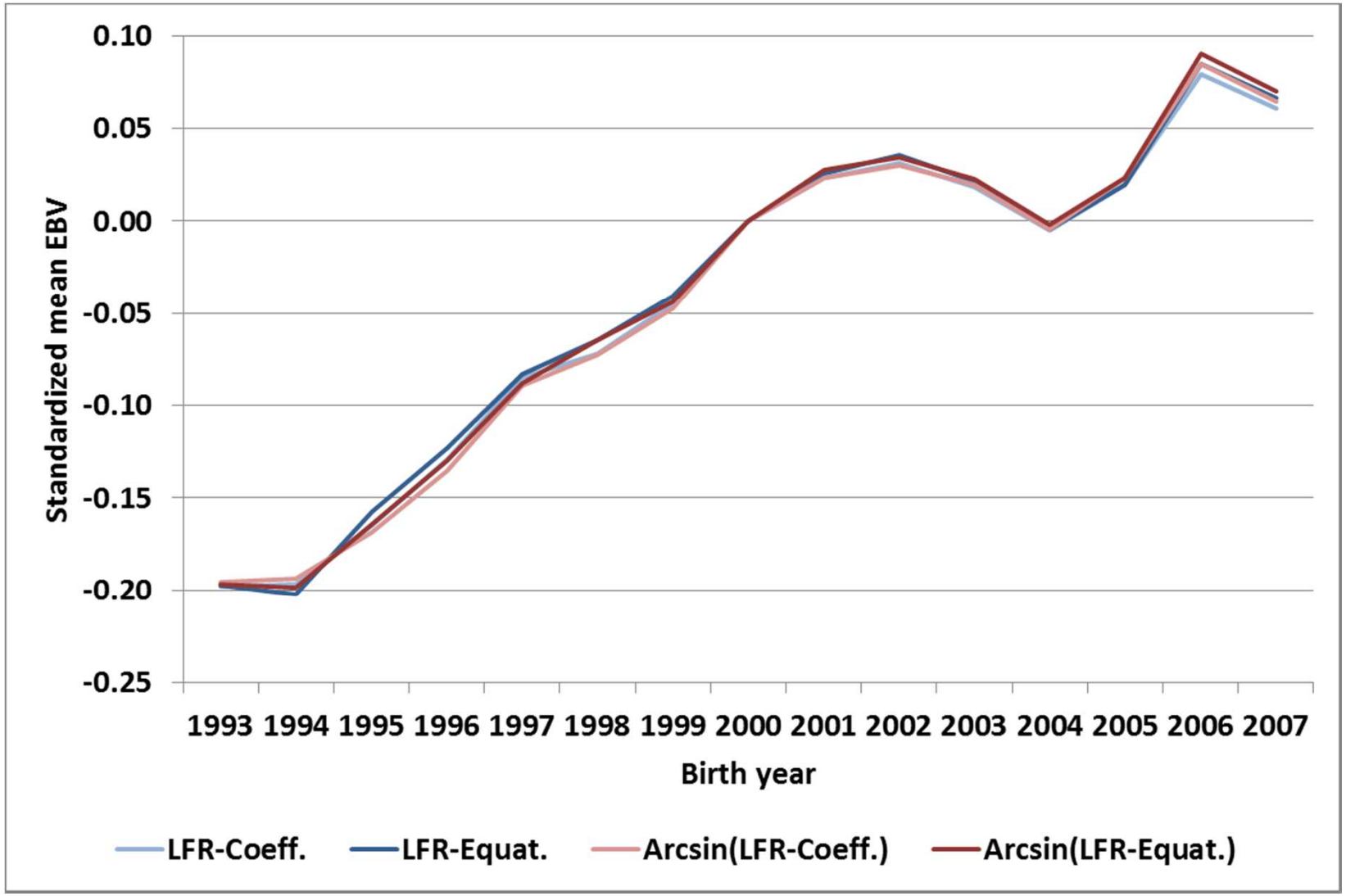
Item	LFR		Arcsin (LFR)	
	Coeff.	Equat.	Coeff.	Equat.
Mean	0.700	0.699	0.794	0.793
SD	0.142	0.144	0.195	0.197
Genetic Variance[1]	4.855	5.016	9.233	9.385
Residual Variance[1]	14.520	14.987	27.765	28.326
Phenotypic Variance[1]	19.375	20.003	36.998	37.711
h^2	**0.251**	**0.251**	**0.250**	**0.249**
SE h^2	**0.030**	**0.030**	**0.029**	**0.029**
-2logL	2776	935	2720	843

[1] Multiplied by 1000

Ranking correlations

Comparison	Females with record (n=3033)	Stallions >3 daughters (n=270)
LFR-Coeff. vs. LFR-Equat.	0.998	0.996
LFR-Coeff. vs. Arcsin(LFR-Coeff.)	0.997	0.996
LFR-Equat. vs. Arcsin(LFR-Equat.)	0.997	0.996
Arcsin(LFR-Coeff.) vs. Arcsin(LFR-Equat.)	0.998	0.996

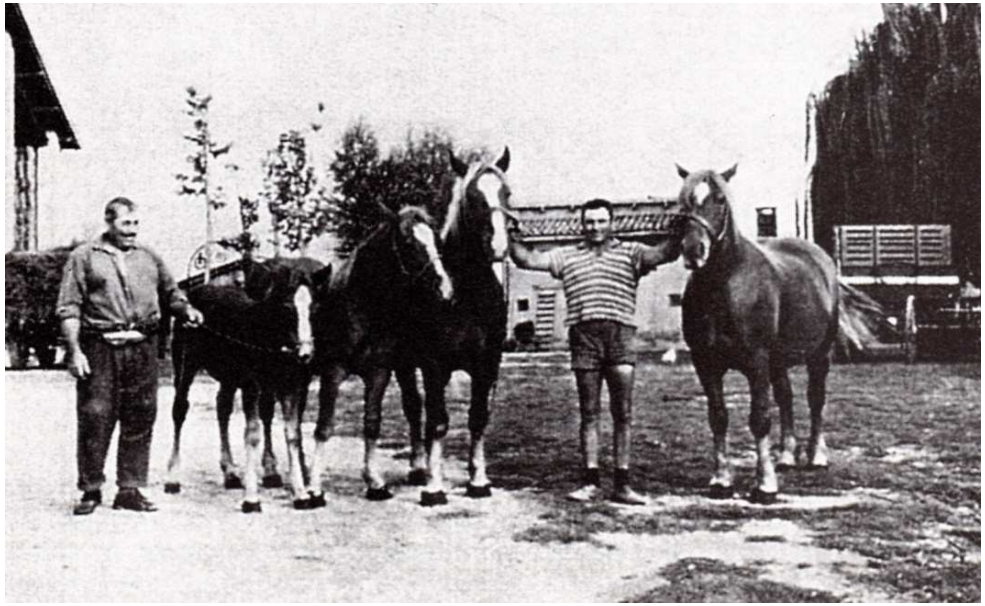
Genetic Trends (females with records)

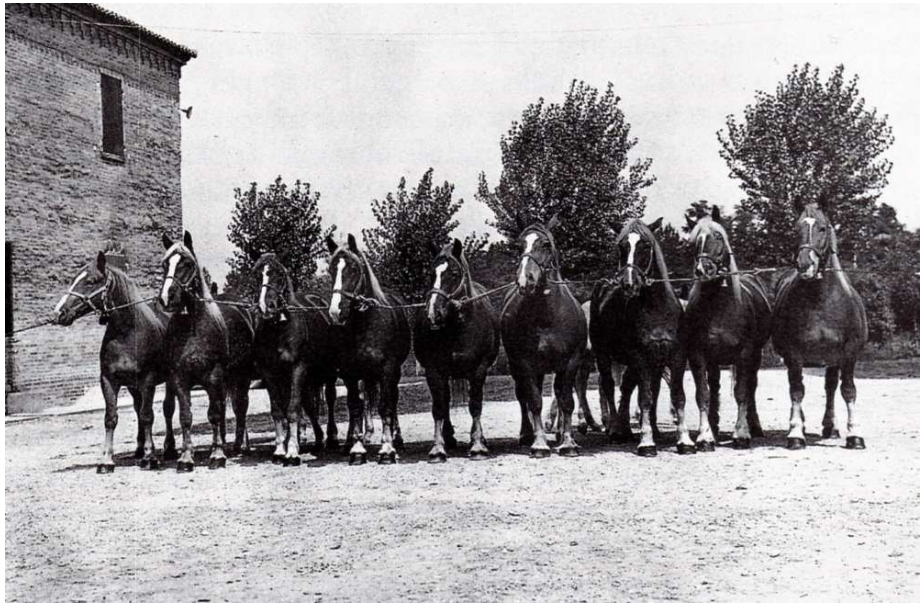


Conclusions

- The **LFR** variable calculate at a specific endpoint using actual and estimated no. of foals seem a **feasible method to express lifetime reproductive success** in IHDH mares
- Estimates of foals at 6th reproductive event **through equations** performed slightly better than coefficients
- **Arcsin transformed LFR** did not improve the analysis
- A **significant genetic variation** was detected for LFR, i.e., medium low heritability value (0.25)
- **Small positive genetic trend** observed, although mares have not been yet selected for LFR

Thank you for your attention





Welcomed questions & comments