GENETIC PARAMETERS OF BEHAVIOURAL TRAITS IN THE BOVINE (*Bos taurus*)

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INTRODUCTION

It has becoming increasingly accepted that genetic variation makes an important contribution to individual differences in the normal range of behaviour, including general ability traits (Plomin, 1999) and to population differences (Plusquellec and Bouissou, 2001). Important variability between populations, *e.g.* breeds, within species is commonly accepted and the recognition of a genetic background for these traits is implicit (Sandnabba, 1995, Schneider-Stock, 1995). Knowledge of the relative importance of the genetic component for the behaviour traits would allow for the development of strategies to genetically modulate its expression within a breeding population.

Although this objective may be important above all for species such as dogs and cattle, the lack of information about genetic parameters of animal behavioural traits is considerable. Some exceptions are the estimates of the heritability for fear and excitability in dogs (Goddard and Beilharz, 1982) and dominance (Wieckert, 1971) or docility in cattle (Le Neindre *et al.,* 1995). Estimation of genetic parameters such as heritabilities and genetic correlation requires objective phenotypic and pedigree information among recorded animals. While morphological and (many) productive traits can be measured easily and accurately, behavioural traits are more complex and most often determined in a subjective manner which can lead to errors in the process of assigning animals to classes or categories. These resulting errors increase the residuals thereby reducing heritability estimates.

Bullfighting cattle have been empirically selected for their behavioural traits, especially those related to aggressiveness, during the past five centuries and are famous for their tendency to fight someone provoking them with some kind of lure. Traditional practices of a bullfighting production system include registration of the correct pedigree information and recording of each animal's scores on an important set of behavioural traits. The objective of this paper is to analyse the main genetic parameters for Aggressiveness, Ferocity, Mobility, and other eleven behaviour traits using two pieces of available information : the *a priori*, *i.e.*, pedigree, information and the phenotypic records.

MATERIAL AND METHODS

Performance recording system. Males were scored at three to four years of age during an actual bullfight held in a bullfighting arena called a plaza (bull ring), whereas cows were scored at two years of age at the ranch in a field called a tienta which simulates the plaza environment and conditions. It should be noted that the animals were scored only once as they are capable of remembering what is involved in the test thus making subsequent bullfights dangerous.

Traits recorded were: Aggressiveness (Agg) : Fighting ability, wildness; the more the animal faces the bullfighter rather than trying to escape, the higher the score ; Ferocity (Fe) : Strength, feeling of danger ; the ability to attack with strength using the whole body ; Fixedness (Fx): The animal is absorbed in the fight and in his opponent and pays attention to nothing and no-one else ; Involvement (In) : Accepts the deceit of the pass under the cape but continues with the hope of catching the 'adversary' without loosing interest ; charging or returning to the cape with gusto following each pass ; Mobility *(*Mo *)*: Movement; the animal is in continuous movement pacing from one place to another especially when provoked by a person waving a lure ; Enters in a gallop (Ga) : The animals gallops into the attack, the opposite is walking or trotting ; Falling (Fa) : The action of bending the legs or hooves, or even collapsing during the charge, accidental falls or slips are not taken into account ; Homing instinct (Hi) : The preference to flee toward any point or points of the bullring other than the fight, looking for refuge or escape; spot to which the bull tends to return ; Development (De) : Refers to the animal's spirit throughout the fight which can increase, decrease or remain stable ; Distanc***e*** (Di) : Refers to the distance travelled beyond the cape and from which the animal begins its run-up to return to the fray ; Hiding of the face (Hf) : The head is bent toward the chest during the run up to the cape ; Straightforwardness (St) : going straight for the cape with no turning aside ; Rhythm (Rh) : Running into the cape with uniform speed throughout the entire pass ; Nobility (No) : Opposite to ill-tempered, a noble animal presents no odd or unexpected types of behaviour which might make the task of the bullfighter more dangerous or onerous.

Most of these behavioural traits mainly include their reaction to fear in different situations, *e.g*., when separated from their group and novelty and surprise inducing fear are presented.

Table 1. Data and pedigree structure.

Data Structure		Pedigree Structure	
Number of records	5,313	Number of base animals	249
Number of animals	8,038	Number of animals with records	5,313
		Number of sires with progeny records	230
Environmental effects:		Number of dams with progeny records	1,510
Year of birth	36-40	Number of grand-sires with progeny records	269
Sex of the animal	2	Number of grand-dams with progeny records	1,072

Pedigree information has been available since the beginning of this century and phenotypic data became available in 1959. Data collected up to 2001 was used ; however, animals included in the analysis were those born before 1999.

Genetic model. Genetic parameters were estimated using a multivariate REML procedure applied to a mixed linear model and which included the year of birth and sex of the animal as fixed effects for all traits. The model also included the animal additive genetic effect (u) which was considered as a random variable ($u \sim N(0, A\sigma^2_u)$) with A representing the additive relationship matrix. Analysis were carried out using DFREML (Meyer, 1988) and ASREML (Gilmour *et al.*, 1998). A model including maternal effect was also considered, though eventually rejected, since its likelihood was no different from the model without the maternal effect.

RESULTS AND DISCUSSION

Heritabilities, genetic and phenotypic correlation estimates are shown in Table 2. Estimates of the amount of the additive genetic component indicate that genes account for about one third of the variance in aggressiveness, ferocity, and mobility. Levels of heritabilities are moderate but can be considered high if the subjective nature of these traits is taken into account, therefore, an acceptable response to selection should be expected. This relatively high additive genetic effect may be due to assortative mating. Positive, though not significant, genetic correlation among Agg and other important traits such as Fe, Mo, Fa or Di has been found which indicates a lack of non-desirable correlated response. Standard errors for heritability estimates were around 0.03 for all traits (average value =0.032).

Table 2. Heritabilities (diagonal) and genetic (above diagonal) and phenotypic (below diagonal) correlation for the fifteen analysed traits (---- means r^2=0)

	Agg	Fe	In	Fx	Mo	Ga	Fa	Hi	De	Di	Hf	St	Rh	No
Agg	**0.35**	0.25	0.46	0.73	0.19	0.35	0.07	-0.76	0.78	0.14	0.22	0.09	0.11	-0.20
Fe	0.18	**0.29**	0.16	0.08	0.20	0.16	-0.51	-0.13	0.19	-----	0.15	-0.34	-0.59	-0.87
In	0.40	0.10	**0.31**	0.77	------	0.49	-0.13	-0.06	0.19	0.73	0.81	0.51	0.71	0.23
Fx	0.54	0.05	0.49	**0.22**	------	0.38	0.14	-0.38	0.45	0.28	0.48	0.40	0.43	0.09
Mo	0.26	0.21	0.11	0.03	**0.27**	-----	-0.39	0.07	0.22	-----	0.16	-0.31	-0.25	-0.24
Ga	0.24	0.04	0.36	0.25	0.03	**0.25**	0.11	-0.11	0.09	0.34	0.16	0.23	0.18	------
Fa	-----	-0.4	-----	0.09	-0.20	0.08	**0.24**	-0.11	-----	-0.27	-0.15	0.29	0.24	0.38
Hi	-0.62	------	-0.09	-0.34	-0.02	-0.06	-0.08	**0.21**	-0.97	0.26	0.09	-0.09	0.24	0.25
De	0.55	0.10	0.13	0.25	0.16	0.04	------	-0.62	**0.14**	-0.20	0.16	------	-0.13	-0.26
Di	0.12	0.03	0.44	0.11	0.15	0.20	-0.11	0.1	-0.03	**0.28**	0.46	0.24	0.62	0.41
Hf	0.16	0.09	0.61	0.26	0.13	0.18	-0.02	0.04	0.03	0.32	**0.32**	0.36	0.44	0.19
St	0.08	-0.07	0.20	0.18	-0.02	0.10	0.05	------	0.03	0.10	0.13	**0.08**	0.34	0.41
Rh	0.14	-0.31	0.46	0.27	-----	0.22	0.11	------	------	0.39	0.33	0.21	**0.22**	0.87
No	-----	-0.53	0.19	0.11	-0.06	0.11	0.16	------	-0.03	0.25	0.11	0.21	0.58	**0.25**

The few estimates found for cattle behaviour traits, with values ranging from 0.20 for docility (Le Neindre *et al.*, 1995) to 0.67 for reaction to restraint (Fordyce *et al.*, 1982), together with those in the present paper seem to guaranty that traits involving aggressiveness have a genetic base and, thus, genetic response can be expected with appropriate selection. Although this evidence exists, Plusquellec and Bouissou (2001) failed to find phenotypic differences in aggressiveness between two cattle breeds (Hérens and Brune des Alpes) diversely selected for intra-specific fighting. Genetic trends graphs of three of the most important traits (Figure 1) show little change occurring in the population until the beginning of performance recording in 1959. This pattern continued for the Agg trait with a slight decrease for Fe until the change in data collection criteria implemented in 1976. Figure 2 also shows a dramatic increase for the first trait (Agg) though little additional change in the Fe and Mo traits after the change in data collection criteria. It can thus be inferred that the selection objective in this population has been to increase **Agg**.

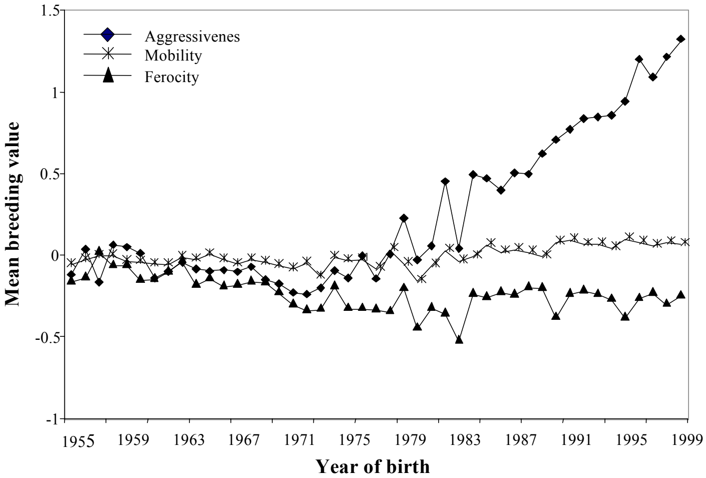

Figure 1. Genetic trends averaging genetic merits for agressiveness, ferocity and mobility by year of birth

CONCLUSION

The main conclusion of this study has been the confirmation of a genetic basis for behavioural traits related to aggressiveness which can then be used to carry out breeding programs in order to get a significant genetic trend following the desire aim.

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