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Genetic Trends For Growth Litter Traits in the Chinese-European Tai Zumu line

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ABSTRACT: Litter weight characteristics are essential components for piglet survival in a context of animal welfare. This study explores consequences of selection for prolificacy and production traits on litter weight characteristics in the Tai Zumu population from 2008 to 2013. Breeding values were estimated with the best linear unbiased predictor. A high selection pressure performed on litter size slowed down the genetic gain on piglets mean weight within litter (MW, -1g at birth from 2012 to 2013) that was previously sustain by selection for reduced age at 100kg (r_g=-0.53 at birth and -0.56 at 3 weeks). The genetic trend for standard deviation of weight within the litter (SDW) slowed down but was still increasing (+1.4 g at birth from 2012 to 2013). Selection against SDW may be performed to improved homogeneity but must take MW into account due to an unfavorable genetic correlation.
Keywords: Genetic trends; Breeding values; Homogeneity of weights

Introduction

Selection on pig maternal lines aims at improving litter size at weaning. In many breeding goals, weight characteristics of the litter are neglected, but data are recorded and an increasing number of genetic studies explore the impact of selection for litter size on litter weight characteristics (e.g., Kapell et al. (2011) and Bouquet et al. (2006)). Indeed, including litter weight traits in breeding goals is becoming important in a context where animal welfare is an essential social component, since these traits are genetically correlated with survival during lactation (Knol et al. (2002)). This study investigates the impact of selection for litter size on piglet weight and homogeneity of weights within the litter in the Chinese-European line Tai Zumu.

Material and Methods

The Breeding Goal in the Tai Zumu line. The Tai Zumu line was created in 1995 by a cross between Meishan sows and hyper prolific French Large White boars. The breeding program applied in this line aims at increasing the number of piglets born alive (NBA), the number of functional teats (NFT), and loin depth (LD), while reducing backfat thickness (BFT) and age at 100kg (AGE). The NBA accounts for 41% of the objective of selection, LD for 23%, AGE for 19%, NFT for 10% and BFT for 9%. More details on the creation of the line and selection steps can be found in Sourdioux et al. (2010).

Animals and data recording. Tai Zumu sows were raised in 3 nucleus herds. These sows are used for selective breeding (1/3 of sows) and as grand maternal sows (2/3 of sows). Since 2009, piglets of purebred litters are weighed individually both at birth (in the 24h) and at 3 weeks of age to keep an eye on the impact of selection for prolificacy on the mean piglet weight within the litter (MW0 at birth and MW3 at 3 weeks of age respectively). Piglet weights were used to calculate the standard deviation of weights within the litter at birth and 3 weeks of age (SDW0 and SDW3 respectively). Weights of litters with less than 4 piglets were regarded as missing data. Three-week weight of piglets previously removed and adopted by another sow was assigned to the nurse sow.

NBA was recorded both on the purebred litter and on the crossbred litter. The AGE, BFT, NFT and LD were measured at approximately 100 kg.

Statistical analyses. The analyses were performed in two steps: a) estimation of genetic parameters (Data set 1), b) estimation of breeding values (EBV - Data set 2). Data set 1 was used to obtain genetic parameters on a contemporary population, while Data set 2 was used for EBV and take in account all performances of a sow since the start of recording. Genetic parameters were estimated using the DMU software (Madsen and Jensen (2008)), with the restricted maximum likelihood methodology applied to a multitrait animal model. Breeding values were estimated with the PEST software (Groenveld and Kovac (1990)). The estimation of genetic parameters and breeding values were conducted with the same models. For maternal traits, parity (6 levels), herd-year-season, boar breed (for NBA, Landrace or Tai Zumu), and the covariable of age of the litter at 3 weeks (for MW3 and SDW3, $\bar{x}$ =20.51±1.37) were considered as fixed effects. The permanent environmental effect of the sow and the additive genetic effect of the sow were added as random effects. For NFT and production traits, the growing batch and the sex of the animal were added as fixed effects, and the effect of the birth litter and the additive genetic effect were considered as random effects. Pedigree information was traced back five generations for the estimation of genetic parameters and ten generations for the estimation of breeding values.

Results and Discussion

Genetic correlations. Estimates of genetic correlations for traits included in the breeding goal (AGE, BFT, LD, NFT and NBA) and for litter weight traits (MW0,

Table 1. Estimates for heritability (on diagonal) and genetic correlations (above diagonal) for production traits and litter traits the Tai Zumu line.

Traits[1]	AGE	BFT	LD	NFT	NBA	MW0	SDW0	MW3	SDW3
AGE	**0.45[2]**	0.42[3]	0.46	0.09	0.10	-0.53	-0.37	-0.56	-0.41
BFT		**w0.65**	0.22	0	0.10	-0.46	-0.33	-0.38	-0.36
LD			**0.42**	0.06	-0.04	-0.09	-0.19	-0.08	-0.19
NFT				**0.52**	-0.09	0.08	0.11	-0.03	-0.16
NBA					**0.18**	-0.53	0.10	-0.52	0.09
MW0						**0.49**	0.34	0.67	0.18
SDW0							**0.20**	0.24	0.53
MW3								**0.27**	0.32
SDW3									**0.15**

[1]AGE=age at 100kg; BFT=Backfat Thickness at 100kg; Loin Depth at 100kg; NFT=Number of Functional Teats; NBA= Number of Born Alive per litter; MW0 and MW3=piglets Mean Weight within the litter at birth and at 3 weeks of age respectively; SDW0 and SDW3= Standard Deviation of Weight within the litter at birth and at 3 weeks of age respectively.
[2]Standard errors of estimation for heritability values ranged between 0.02 and 0.05.
[3]Standard errors of estimation for genetic correlations ranged between 0.03 and 0.20.

MW3, SDW0 and SDW3) are shown in Table 1. The EBVs were derived from these estimates. We found an unfavorable genetic correlation between AGE and homogeneity of weights within the litter (SDW0 and SDW3). The genetic merit for growth and low fat content seemed to negatively impact the sow capacity to produce homogeneous litters in weight. Bergsma et al. (2008) showed that the milk production is genetically dependent of fat resources. Conversely, selecting animals for growth during the fattening period seems to impact positively on mean piglet weight, both at birth and at 3 weeks of age.

The number of piglets born alive was negatively correlated with the mean piglet weight. This result is in agreement with Kapell et al. (2011) and Bouquet et al. (2006). The genetic potential of Meishan sows to produce numerous piglets with little consequence on the homogeneity of weights in the litter (Bidanel et al. (1989)) was identified in the Tai Zumu line (genetic correlations of 0.1 and 0.09 between NBA and SDW0/SDW3). However, there was an unfavorable genetic correlation between MW and SDW (r_g>0.18).

Genetic trends. The genetic trend for the number of born alive is shown in Figure 1. We can identify two periods for this trait. The first one (until 2010), shows a decrease of the genetic level for this population (-0.18 piglets from 2008 to 2010). This decrease was due to a change in the breeding goal in 2007. The number of piglets weaned by the sow was included as selection criterion and accounted for 16% in the breeding goal, whereas the weight on NBA was reduced to 17%). But after four years of selection, results showed that the numerical productivity slowed down and finally decreased. That's the reason why since 2011, the breeding program focused on the number of piglets born alive. Since then, the genetic capacity of sows for prolificacy has been increasing on average (+0.49 piglets born alive from 2010 to 2013). But this change has indirectly impacted the weight characteristics of the litter. Because litter size is unfavorably correlated with mean piglet weight, the genetic improvement of the Tai Zumu for MW0 and MW3 slowed downed and then decreased for MW0 (+76 g from 2008 to 2012 and -1 g between 2012 and 2013, Figures 2a and 2b). Since 2010, the genetic trends for SDW0 and SDW3 slow downed but are still positive: +1.4 g (+2% of genetic standard deviation) and +3 g (+1% of genetic standard deviation) from 2012 to 2013 for SDW0 and SDW3, respectively. The last trend is not as important as expected, based on the unfavorable genetic correlations between SDW0 or SDW3 and AGE or BF. This result can be explained by the favourable correlated responses to selection for loin depth and the number of functional teats on SDW.

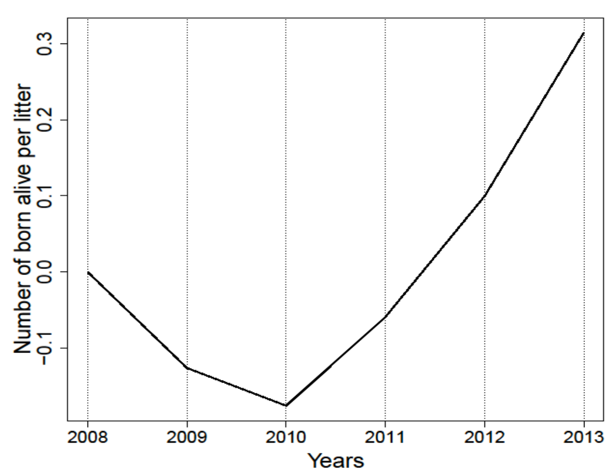

Figure 1. Genetic trends for number of born alive per litter.

Genetic trends for production traits and the number of functional teats NFT are not given here but were also estimated. The genetic level for AGE was reduced by 6.4 days since 2008. The BFT decreased by 1.07 mm and the w

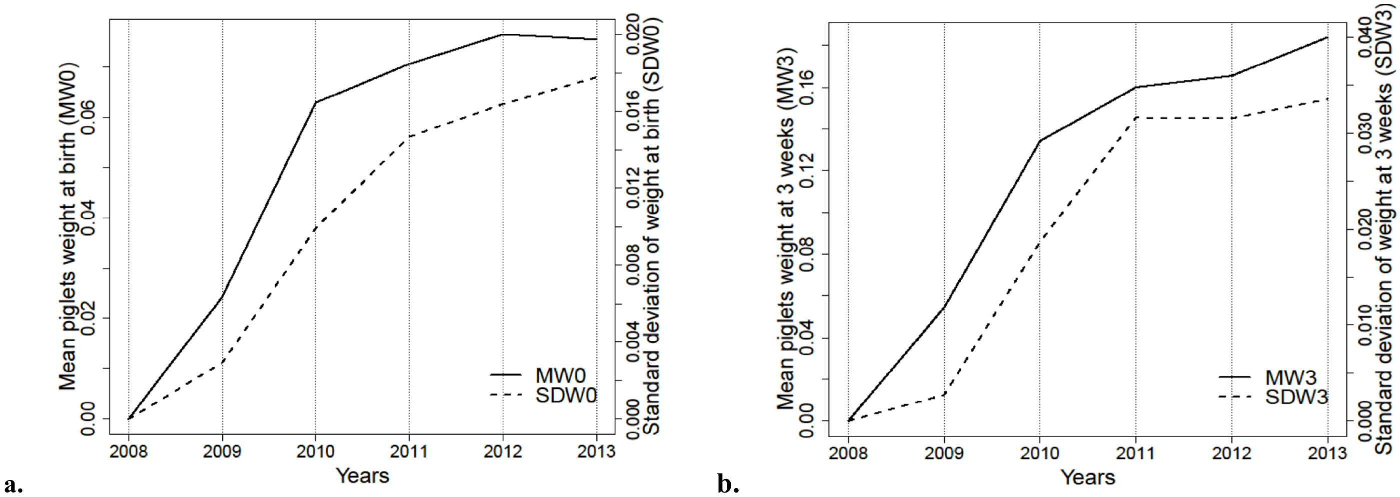

Figure 2. Genetic trends for mean piglet weight and standard deviation of weights within the litter at birth (MW0 and SDW0 respectively, figure a) and at 3 weeks of age (MW3 and SDW3 respectively, figure b) in kilogrammes.

[1,2]MW0 and MW3=piglets Mean Weight within the litter at birth and at 3 weeks of age respectively; SDW0 and SDW3= Standard Deviation of Weight within the litter at birth and at 3 weeks of age respectively

genetic gain for LD was 0.96 mm. NFT, with only 10% weight in the breeding goal, increased by 1.06 teats.

Conclusions

So far, the breeding program applied to the Tai Zumu population has not decreased mean piglet weight. This result can be explained by the selection pressure on age at 100 kg that is favorable for piglet growth. But to improve homogeneity of piglet weights within the litter, it appears necessary to select against the standard deviation of weights within the litter. Including this new criterion in the selection index requires the selection pressure on other traits to be reduced and could damage the genetic capacity of sows for piglet growth. Simulations are planned to predict genetic gain on litter homogeneity and investigate the possibility to improve production and preserve the capacity of Tai Zumu sows to give birth to piglets homogeneous in weight.

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