

## THE EFFECT OF A STRICT BREEDING STRATEGY ON OVERALL GROWTH AND THE PREVALENCE OF INHERITED DISORDERS IN THE DOUBLE-MUSCLED BELGIAN BLUE BEEF BREED

*De invloed van een precies omschreven fokstrategie op de groei en de prevalentie van erfelijke aandoeningen in het Belgisch Witblauw vleesveeras*

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### ABSTRACT

**Muscular conformation is the main breeding goal in the double-muscled (DM) Belgian Blue beef breed (BBB). In recent years the muscularity has improved enormously, though at the same time the growth rate has decreased and the prevalence of a number of inherited disorders has increased. Professionals working in the cattle breeding industry are encouraging the development of breeding strategies that will increase overall growth and decrease the amount of inherited disorders. One such breeding strategy that was tested in the field neither reduced the prevalence of inherited disorders nor improved overall growth. It can be concluded that breeding strategies should be based more on the relevant genetic values than on the phenotypic values of the parental generation.**

### SAMENVATTING

In het Belgisch Witblauw vleesveeras is er vooral selectie naar steeds meer bespiering. De laatste jaren is de bespiering enorm toegenomen, maar tegelijkertijd is de groei verminderd en is de prevalentie van een aantal erfelijke aandoeningen toegenomen. Mensen die professioneel werkzaam zijn in de rundveesector, moedigen de beleidsverantwoordelijken aan om hun fokstrategie aan te passen aan de noden van de sector. Eén fokstrategie slaagde er niet in om de prevalentie van erfelijke aandoeningen te verlagen. Ook de groeieresultaten waren niet verbeterd. De resultaten van dit onderzoek tonen aan dat de fokstrategie te veel is uitgegaan van de fenotypische waarden van de ouderdieren en te weinig gebruik heeft gemaakt van relevante genetische waarden.

### INTRODUCTION

The double-muscled Belgian Blue Beef breed (DM-BBB) is a relatively young breed. In 1973, the dual-purpose breeding objective was changed and muscular conformation became the major breeding goal (Coopman *et al.*, 2001).

Since then, muscularity has indeed increased intensively (Hanset *et al.*, 1994; Hanset *et al.*, 2001), but the prevalence of inherited disorders has also increased (Charlier *et al.*, 1996; Coopman *et al.*, 2000a; 2000b; Hanset and Michaux, 1978; Hanset *et al.*,

1993; Herd-book, 1995; 1996; Lekeux and Van De Weerd, 1996; Van Huffel, 1991), while at the same time the growth rate has decreased (Hanset *et al.*, 1994; Hanset *et al.*, 2001). Because of these problems, a heterogeneous group of Belgian scientists, administrators and other professionals working in the beef cattle industry (Groupe de réflexion, 1997) recommended that the selection programs should be improved and that the inherited disorders should be eradicated or at least lowered in prevalence.

In response to the recommendations of the reflection group (1997), a group of professional veterinarians working fulltime in DM-BBB breeding set up a project in East Flanders (province in the Northern part of Belgium). The overall goal of this project was to teach cattle breeders different management tools to improve their financial income and to demonstrate that selection of the parental generation could be done based on the phenotypic linear classification (Hanset *et al.*, 1990) of both dam and sire and the breeding values of the sires. More specifically, the aim was to improve overall growth and to reduce inherited disorders such as White Heifer Disease (WHD; Charlier *et al.*, 1996).

This paper reports on the results of this project and, more specifically, on the effects that the chosen selection procedure had on the improvement of overall growth and the reduction of inherited disorders.

## MATERIALS AND METHODS

### Animals

All animals considered in the project belonged to the double muscled Belgian Blue Beef breed (DM-BBB).

### Set-up of the project and data collection

In designing the project, it was decided to use the multiple ovulations/embryo transplantation (MOET) technique, using the best DM-BBB sires, and not the artificial insemination (AI) technique. This was done

to increase the numbers of offspring per selected parents and to visualize already in the first generation the effects of the selection procedure.

First, the parental generation was selected. Sires and dams needed a full pedigree of at least two generations. They were phenotypically free of the inherited disorders known in DM-BBB (Coopman *et al.*, 2000a; 2000b). Both parents had at least the linear scores of bull mother and bull father (Table 1). For the subgroups, withers height (WH) and sound feet and legs (FL), minimum scores of 90 (WH and FL; sires) and 85 (WH; females) or 92 (FL; females) were required because the project designers wanted to promote growth (WH) and sound feet and legs (FL). The sires also needed a positive economical index (Ec-In; live weight \* price per kg live weight; Leroy and Michaux, 1999). Finally, 13 sires and 27 dams passed the selection procedure. All the selected sires were from the Haliba artificial insemination (AI) (Ath, Belgium). Farmers owned the dams.

Only matings which resulted in low inbreeding were done (no identical animals in the first three generations of the calf). No mating between two white animals was allowed, in order to prevent the incidence of WHD.

Using both the selected sires and the selected dams, the MOET procedure was started up, taking into account the mating restrictions. All embryos collected were frozen. Between 10/09/1998 and 01/06/2000, 250 embryos were transplanted into 230 receptors that were synchronised using different tools such as ear implants, prostaglandin injections or an intra-

**Table 1. The minimum selection criteria of the linear scores for the parental generation of the experimental group, the selection criteria for bull father and bull mother as prescribed by the DM-BBB Herd book and the average linear scores of cows in the north and the south of Belgium (pers. com. DM-BBB Herd book).**

Trait	Sire	Bull Father	Dam	Bull Mother	North (N = 7630)	South (N = 34449)
WH	≥ 90	> 75	≥ 85	> 75	80.6	77.3
MC	> 86	> 86	> 84	> 84	84.2	82.9
MT	> 81	> 81	> 79	> 79	79.8	79.8
FL	≥ 90	> 85	≥ 92	> 85	90.8	91.9
OA	> 75	> 75	> 70	> 70	71.7	67.8
TS	> 85	> 85	> 85	> 85	83.9	82.8

WH = withers height; MC = muscular conformation; MT = meat type; FL = feet and legs; OA = overall appearance; TS = total score; North = Flanders (Belgium); South = Wallonia (Belgium); N = number of observations.

vaginal device, and into 20 receptors 6 to 7 days after natural heat. The receptors were maiden heifers (84.0 %) or cows (15.9 %). Most receptors were of dairy breeds such as the Holstein Friesian (Red and Black) or double purpose breeds such as the Red and White of East Flanders. Three months after implantation, pregnancy was controlled manually by rectal examination. All pregnancies were followed and information was collected until the calves were born.

Once the calves were born, being the result of the MOET procedure and being the experimental group, a control group was created. This control group consisted of DM-BBB calves that were born at the same time and place as the calves of the experimental group and that were alive at the moment the first weighing and/or measurement of a calf of the experimental group was done. These calves were at least 24 hours of age at the moment they were selected. The calves of this control group were a reflection of the normal breeding policy on the farms; their fathers usually having been natural service bulls for whom no linear scores of the parents were available.

Starting at birth, measurements using a measuring rod or a measuring tape were collected of withers height (WH), shoulder width (SW; distance between broadest points of the shoulder), width of the hindquarters (BcW; distance between the broadest points of the hind quarters), and heart girth (HG; measuring half of the heart girth following the muscles on the thorax and then multiplying by two). Live weights were collected for animals younger than 10 days using a small weight balance. The older animals were weighed on the farm, if a balance was available, and the slaughter animals were weighed on a balance at the abattoir (live weight and/or carcass weight). All the animals were closely followed during their lifetime and as long as the project continued (June 1999 - December 2002). During farm visits, the apparent disorders and mortality in both groups were written down.

### Statistics

The software SPSS 11 for windows was used to explore and analyze all of the data, to design growth curves for live weights and for the four body measurements using the lowest curve fitting procedure that draws the most likely longitudinal curve along the different data points, and to perform independent-sample T-tests on birth traits, slaughter weights (live weight and carcass weight) and traits of adult females to see whether significant mean differences exist between the experimental and the control groups. Be-

cause the mean ages did not differ significantly ( $p < 0.05$ ) between the experimental and the control groups for all traits considered, no age correction was needed. The software program was also used to see whether the amount of inherited disorders and the amount of dropout after the age of 24 hours between the two groups was significantly different or not ( $X^2$ -test). To see whether significant differences for LW, WH, SW, BcW and HG during early (birth to one year) and juvenile (one to two years) growth exist between the experimental and the control group, and whether sex, birth season and herd influence the traits, a linear mixed effect model over age, with the animal as random effect and an autoregressive correlation structure of the first order, was used.

### RESULTS

In total, 124 receptors were pregnant at three months, being 49.6 percent. One hundred and nine calves were born alive. After birth and over time, many of the calves of the experimental group that were born alive still died. Because of these losses and because some farmers did not allow their calves to be measured or weighed, only 88 calves were finally present in the experimental group. They were born on 35 different farms. In the control group there were 55 calves, which were born on 26 different farms. After the age of 24 hours, one calf of the control group died because of cardio-respiratory problems. The mortality after 24 hours in the experimental group was significantly ( $p < 0.001$ ) higher than the mortality seen in the control group after this age. In Table 2, the reasons why embryos and calves of the experimental and control group were lost are described chronologically. Because the calves of the control group had to be alive at 24 hours to be taken into account, no information is available before this age. There were 48.8 % males and 51.1 % females in the experimental group and 47.2 % males and 52.7 % females in the control group. Both sexes are therefore almost equally distributed in the two groups considered.

Twelve disorders in nine (= 10.2 %) of the calves in the experimental group were observed at birth or during life. These disorders were spastic paresis (N = 4; SP; Hanset *et al.*, 1993), congenital articular rigidity (N = 4; CAR; Van Huffel, 1991), hypotony of the muscles of the front legs (N = 2; De Kesel *et al.*, 1981) and *Brachygnathia inferior* (N = 2), also called parrot jaw (Hanset and Michaux, 1978). Seven of these calves had only one disorder. Two out of these nine

**Table 2. Reasons for fetus/calf mortality starting three months after confirmation of pregnancy (experimental group) and starting at 24 hours of age after birth (control group).**

Reason	Experimental group	Control group	
<b>Between 3 and 8 months of pregnancy</b>	Abortion because of ...	6	NA
<b>Between 8 and 9 months of pregnancy</b>	Oversized	1	NA
	Premature birth	6	NA
<b>At birth</b>	Oversized	1	NA
	Umbilical cord problem	1	NA
	Too late with calving assistance	2	NA
	Traction	1	NA
<b>Between birth and 24 hr of age</b>	Cardio-respiratory problems	1	NA
<b>After 24 hours of age</b>	Respiratory problem	2	1
	Too late with calving assistance	1	0
	Sudden death	2	0
	Fire	1	0
	Suckling problem	1	0
	<i>Escherichia Coli</i> Diarrhoea	1	0
	Fading away	2	0
	Unknown	3	0

calves showed multiple disorders. One had CAR and SP, and the other had CAR, SP and a parrot jaw. Two cases of SP were seen in full sibs. One sire had three disabled calves, another had two, and four others had just one each. Two dams had two disabled calves each, while five others had one. In the control group, one disorder on one calf (= 1.8%; CAR at all legs) was seen. The chi-square test shows that the numbers of calves affected and the numbers of CAR, SP, hypotony and parrot jaw cases in the experimental group significantly ( $p < 0.001$ ) differ from the numbers of affected calves in total, as well as from the numbers of specific disorders in the control group. No problems with WHD were mentioned either in the embryo or in the control group.

The average values for the different subclasses of the linear classification of both the selected sires and the selected dams are presented in Table 3. No values for their offspring or for the calves outside of the control group could be calculated, because only a few of

**Table 3. Average values of the subscores of the linear classification system of the parental generation.**

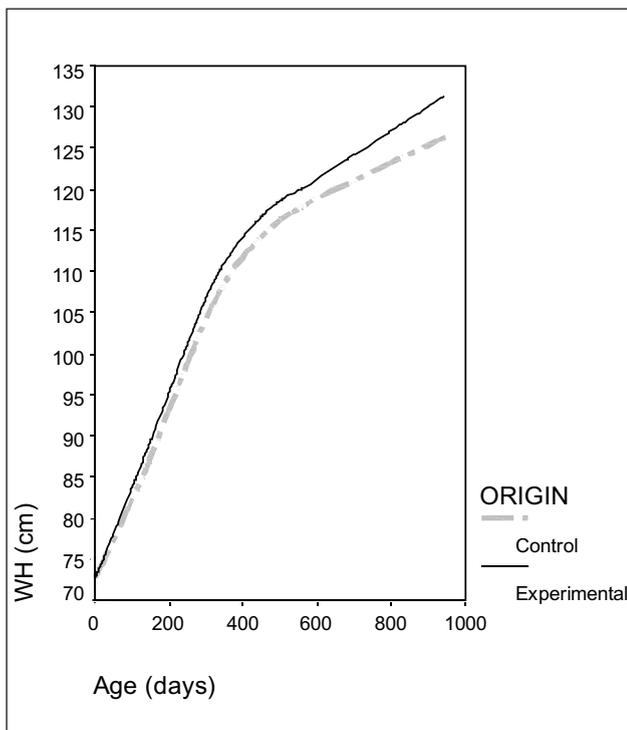
Trait	Sire Average	Dam Average
<b>WH</b>	92.7	90.1
<b>MC</b>	89.6	88.1
<b>MT</b>	84.7	82.9
<b>FL</b>	92.2	95.0
<b>OA</b>	82.7	81.0
<b>TS</b>	89.7	88.1

WH = withers height; MC = muscular conformation; MT = meat type; FL = feet and legs; OA = overall appearance; TS = total score.

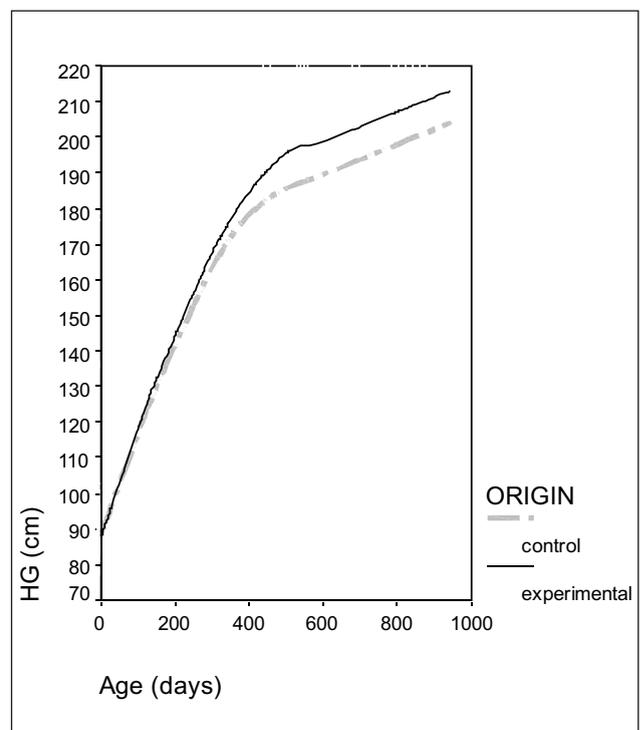
**Table 4. Characteristics of the data structure.**

	Range of BY	BS (%)				Range of Age (days)	LW (kg) N, range	WH (cm) N, range	SW (cm) N, range	BcW (cm) N, range	HG (cm) N, range
		1	2	3	4						
<b>Experimental group</b>	1999-2000	12.5	14.7	38.6	30.0	0-944	111, 39-797	379, 66-143	324, 22-74	324, 23-67	323, 78-244
<b>Control group</b>	1999-2000	12.7	16.3	41.8	29.0	0-946	38, 38-919	181, 62-136	179, 22-76	178, 24-72	178, 82-230

N = number of weightings or measurements; BY = birth year; BS = birth season; 1 = winter; 2 = spring; 3 = summer; 4 = autumn; LW = live weight; SW = shoulder width; BcW = width of the hind quarters; HG = heart girth.



**Fig 1. Growth of the withers height (WH) of the experimental and control groups.**



**Fig 2. Growth of the heart girth (HG) of the experimental and control groups.**

the animals in the experimental group and none of the animals in the control group had been scored.

The number of times the calves are weighed and measured and the ranges for the different traits considered are listed in Table 4, along with some other characteristics of the data set.

At around 400 days, the growth curves for withers height and heart girth started to diverge between the experimental and the control group, as shown in Fig. 1 and Fig. 2.

The characteristics of the traits (live weight and body measurements) for animals = 10 days, slaughter bulls and females = 700 days can be found in Table 5.

The independent sample T-tests show that the withers height ( $p < 0.01$ ) and the heart girth ( $p < 0.05$ ) of the females = 700 days of the experimental group is significantly higher than for the females = 700 days of the control group. The slaughter bulls of the control group weigh more than the slaughter bulls of the experimental group, but not significantly more.

**Table 5. Weight and/or body measurements of calves younger than 10 days (male and female), at slaughter (males only) and older than 699 days (females only). Age between the experimental and the control groups does not differ significantly ( $p < 0.05$ ) in any of the three categories.**

Animal	Trait	Group	N	Mean	s.e.
<b>Calves &lt; 10 days</b>	LW (kg)	Experimental	31	55.41	6.68
		Control	14	54.00	7.39
	WH (cm)	Experimental	41	73.69	3.21
		Control	25	72.65	3.78
	SW (cm)	Experimental	41	28.95	14.45
		Control	25	28.80	15.24
	BcW (cm)	Experimental	41	30.36	14.07
		Control	25	30.60	14.65
HG (cm)	Experimental	41	87.92	10.11	
	Control	25	89.36	5.64	
<b>Slaughter Bulls</b>	LW (kg)	Experimental	14	704.50	66.52
		Control	7	729.57	93.43
	WCW (kg)	Experimental	15	472.00	67.10
		Control	12	493.33	39.62
<b>Females &gt; 699 days</b>	WH (cm)	Experimental	29	128.03	5.77
		Control	16	123.75	2.88
	SW (cm)	Experimental	29	59.27	4.75
		Control	16	60.18	3.50
	BcW (cm)	Experimental	29	60.34	4.38
		Control	16	60.18	3.61
	HG (cm)	Experimental	29	206.41	13.91
		Control	16	193.12	26.05

LW = live weight ; WH = withers height ; SW = shoulder width ; BcW = width of the hind quarters ; HG = heart girth ; WCW = warm carcass weight ; N = number ; s.e. = standard error.

The results of the linear mixed model showed that between birth and one year, significant differences for withers height exist between the experimental group and the control group. Animals born in the autumn have in the first year of their life a significantly ( $p < 0.05$ ) higher withers height than animals of less than one year and that are born in other seasons. Between one and two years, WH, SW, BcW and HG are significantly ( $p < 0.05$ ) higher in males than in females. Ani-

mals born during the winter had significantly ( $p < 0.05$ ) higher values for WH, SW, BcW and HG between one and two years of age compared to animals born in the spring or summer.

## DISCUSSION

This paper reports on the results of a DM-BBB project set up in East Flanders (Belgium) by professio-

nals working fulltime in DM breeding. More specifically, it reports on the effects the chosen selection procedure had on the improvement of overall growth and on the reduction of inherited disorders.

The pregnancy rate of the MOET procedure can be considered acceptable in accordance with the figures given by Smith and Grimmer (2002; 38.2%) and da Costa *et al.* (2001; 46%).

The high mortality, especially at the time of calving, indicates that the calving procedure and the raising of DM-BBB calves is not an easy business. Many farmers had nice explanations as to why calves died at or around birth, but in most cases the calving assistance was either too late or inadequate. DM-BBB breeders must have considerable technical skills and much experience to bring a calving to a successful conclusion. The reason why mortality after 24 hours is significantly higher in the experimental group remains unclear. Both groups were raised in similar conditions and had similar contacts with infectious agents. The most obvious reason could be that the calves of the experimental group are more typical DM-BBB animals and therefore are more susceptible to accidents, infections and metabolic disorders. If this is true, then economic simulation, being the basis of economical breeding strategies, should take into account the higher mortality which occurs when selection focuses on greater muscularity and growth. This can also be an indication that farm management must improve consistently when one is dealing with purebred and highly selected DM-BBB animals.

Looking at the percentages of the inherited disorders seen in the experimental group, it is clear that one of the aims of the selection procedure failed totally. The high proportion of affected calves in the experimental group out of phenotypically apparently normal parents may be an indication of a recessive mode of inheritance or incomplete penetrance for these disorders seen in the experimental group. On the other hand, one should also question whether there is any relationship between the high percentage of affected calves and the MOET procedure (e.g. CAR can be caused by limited intrauterine space (Van Huffel, 1991) in small receptor heifers), and even whether there is any relationship between this high rate of affected calves and the requested minimum values of the linear scores for the parental generation. When selecting sires and dams for a MOET procedure, breeders should take into account the presence or absence of these disorders in their previous progeny, and not only the absence of the disorder in the parental generation itself. Sires with affected offspring should be

used with caution or even eliminated. The dams should not be used as bull mothers anymore. From an economic point of view, the influence of these disorders in this project on financial income has been rather small. Only two bulls were slaughtered at a young age (one at two months and another at six months before normal slaughter age). All the other animals were slaughtered at normal ages and showed no clear differences from the other animals of the experimental group. Considering the WHD, it is hard to conclude from the results of this project that the use of a white and blue animal as one of the parents provides any guarantee of preventing this disorder. Indeed, no such precautions were taken in the control group and this group of animals did not show any WHD either.

The averages of the linear sub-scores (Table 3) show that both the dams and the sires are far beyond the values of bull father and bull mother (Table 1). This indicates that they are among the top-breeding animals within the DM-BBB breed. Theoretically, one would expect the progeny to have average linear scores that are comparable with their parents' scores and are above the mean scores of the population. Unfortunately, despite the efforts of the first author to organize the linear scoring of all animals, the relation between the scores of the experimental group and the scores of the parental generation and the scores of the control group could not be estimated because insufficient data were available. This shows that linear classification is not routinely done and that the organization of data collection in this branch of cattle breeding is hard to do. Nevertheless, the routine collection of data on animals using tools such as the linear classification system is the basis of good breeding practice.

The figures roughly show the differences that exist for WH and HG between the experimental and the control group, but apparently only at older ages. More specifically, significant differences for WH and/or HG in some age categories were found between the experimental and the control groups. The significantly higher withers height seen in the experimental group during the first year of life was not observed in the second year of life. The females in the experimental group that were two years or older seemed to be taller and to have a larger heart girth, and should therefore be heavier than the females in the control group. This is because a positive correlation of  $r = 0.89$  ( $p < 0.01$ ) exists between HG and WH with live weight (Coopman *et al.*, 2003). Considering these results and this assumption, it looks like the selection procedure did change both the overall growth rate and the speci-

fic (WH and HG) growth rate in females, and therefore one of the aims of the procedure for this group has been attained. Unfortunately, this difference in weight is not visible in the slaughter bulls. It even seems that the bulls in the control group are on average heavier at slaughter age.

The increasing differences between the two sexes at one year of age can be explained by the fact that, apart from the hormonal and other differences between the sexes, at the age of one year the bulls are housed and fed differently than the females.

One explanation for the seasonal influences (autumn and winter) is provided by the fact that in DM-BBB breeding, most calves are born in late winter and early spring. Because of this fact, many calves are present in late winter and early spring, when a high level of infectious diseases is seen. The calves born in autumn and early winter are not that numerous and do not have to deal with such high infection levels. In addition, autumn and early winter calves have higher chances of being fed better than calves born in late winter and spring. These latter calves are often sent to pasture with their mother. In order to decrease the numbers of infections, an all-in, all-out system, a common practice in pig breeding, could possibly be a management tool to be considered in DM-BBB breeding as well. Giving more adequate feeding to calves grazing with their dams is worthwhile considering as well.

Taking into account the fact that the mean weight of the bulls at slaughter age is not significantly different and the fact that the large numbers of disorders and especially the high mortality rate doubtless have a financial impact on the business, the question arises as to whether, economically speaking, the breeding strategy followed in this project was beneficial.

As a field trial, this study has provided us with a realistic picture of DM-BBB breeding, which leads us to an interesting and fundamental point of discussion concerning the DM-BBB breeding enterprise. In dairy cattle breeding, production control and linear classification are done routinely, but this is not the case with DM-BBB breeding. Only four animals out of the experimental group were classified linearly. In many cases, the farmers did not know the final weights of the slaughter bulls. Only three out of the fifty participating farms (14 had no living calves) had a scale. But even on these farms, the animals were not weighed on a regular basis. Selection of natural service bulls out of the experimental group was done by visual appraisal rather than on the basis of objective parameters such

as weight and/or measurements. Often, a bull selected because the farmer considered him to be the heaviest and to have the best muscularity, turned out to have measurements (WH, HG, SW and BCW) that were lower than the measurements of the other bulls. Therefore, judging on the basis of objective measurements, these bulls could not be the best. To improve DM-BBB breeding, objective data collection is fundamental. Perhaps the first change that needs to be made in DM-BBB breeding is to increase both the quantity and the quality of the data collected on the basis of objective measurements of weight, type traits, etc., so that breeding decisions can be made on the basis of reliable and realistic figures. Breeding strategies should also be based more on the results of genetic parameter estimations (progeny testing,  $h^2$ , genetic correlations, estimated breeding values) of the economically important traits, rather than on the performance test of the parental generation, as was primarily done in this project and is common practice in DM-BBB breeding, despite the available genetic figures (Leroy and Michaux, 1999; Farnir *et al.*, 1999).

## CONCLUSION

The breeding procedure used in the project here presented did not reduce the prevalence of inherited disorders. No explicit effects on overall growth were observed in the first generation. Therefore it must be concluded that other selection procedures must be taken into account for the purpose of reducing the amount of inherited disorders and improving overall growth. Additionally, the organization of the data collection needs to be adapted, it needs to be done more routinely and on a larger scale, and it needs to be carried out in greater compliance with the project designs. At the current time there are no practical indications that DM-BBB breeding is being done in a scientifically acceptable manner.

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