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Phenotypic relationships between longevity, type traits, and production in Chianina beef cattle¹

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ABSTRACT: Longevity is an increasingly important trait in beef cattle. Increased longevity decreases costs for the farmer and increases revenue. The objective of this research was to investigate the phenotypic relationship between type traits and longevity in Chianina beef cattle, and the relationship between production and longevity, to analyze the effect of voluntary culling. Data included records on reproductive, productive, and type traits provided by the National Association of Italian Beef Cattle Breeders from 6,395 Chianina cows. The average length of productive life was 1,829 d. The herd-year had a strong effect on the risk of culling. The effects of 22 type traits were analyzed. All the muscularity traits analyzed were highly significant ($P < 0.01$) and as a group had the largest effect on longevity,

followed by dimension, refinement, and leg traits. Cows that calved before 35 mo of age had a lower probability of being culled than cows calving after 35 mo of age. Variation in herd size had a strong effect on risk ratio, with lower risk for intermediate classes. Cows with approximately one calf per year remained in the herd longer than did cows with fewer calves. Straight-legged animals had a 59% greater probability of being replaced than cows with a moderate angle to the hock, whereas sickle-legged animals had only a 3% higher probability of being culled than average cows. Udder conformation had no effect on longevity. In summary, results of this study indicate that herd-year effects and muscularity traits were the most important factors for longevity for Chianina cows among the factors studied.

Key Words: Beef Cattle, Chianina, Longevity, Survival

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Introduction

In the European Union, where a quota system is applied for surplus meat production, the simplest way for a beef producer to increase income is to reduce costs. One way to do this is to increase length of productive life of cows. Increased longevity reduces the direct costs of raising or purchasing replacement females.

Longevity itself is an easy trait to record. One common way to measure it is as length of productive life, measured as the time from first calving to culling. One problem with recording longevity is that it requires a long time for the information to become available, decreasing the reliability of information for young ani-

mals. The use of indirect measures for longevity increases the reliability of proofs (EBV) for young bulls, and thus stimulates the use of younger bulls, decreasing generation intervals. One way to estimate longevity indirectly is to use information for type traits that are correlated with longevity.

In dairy cattle, type traits are used as an early predictor of longevity (Vollema, 1998; Larroque and Ducrocq, 2001) and as indirect selection criteria for herd life (Gutierrez and Goyache, 2002; Vukasinovic et al., 2002). Various studies have been conducted to quantify the importance and the impact of type traits on longevity in dairy cattle (Boldman et al., 1992; Pasman and Reinhardt, 1999; Larroque and Ducrocq, 2001). Research indicates that dairy cows of moderate size, with functional udders and correct feet and legs are more likely to remain in the herd than cows that lack these characteristics. In beef cattle, little is known of the relationship between type traits and longevity and we have found no recent publications on this topic.

The aim of this study was to investigate the phenotypic relationships between type traits and longevity

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Table 1. Number of herds per artificial insemination and natural service (NS) sire

Herds	AI sires		NS sires	
	No.	Mean	No.	Mean
1	0	0.0	577	1.0
2 to 3	10	2.5	168	2.3
4 to 5	2	4.0	20	4.3
6 to 7	6	6.2	7	6.4
8 to 9	2	8.5	2	8.0
10 to 19	8	14.5	0	0.0
20 to 39	5	32.6	0	0.0
40 to 59	3	51.6	0	0.0
60 to 79	4	67.3	0	0.0
100 to 149	3	129.0	0	0.0
Total	43	27.4	774	1.5

in Chianina beef cattle, and the relationship between production traits and longevity to analyze the effect of voluntary culling for production.

Materials and Methods

General

Data were provided by ANABIC (National Association of Italian Beef Cattle Breeders, Perugia) and consisted of 6,395 Chianina cows with records on reproductive, productive, and type traits. Cows were born between January 1, 1981 and December 31, 1997. All cows had production data for at least the first parity and were scored for type traits. All parities up to the 12th were analyzed. Records from cows with more than 12 parities (0.07%) were truncated at the 12th parity. Longevity was measured as length of productive life (**LPL**) defined as days from first calving to the culling date. Data from 689 herds with one or more uncensored cows per herd were included in the analysis. Herds with only censored cows were deleted. Records from animals without information, such as birth date, parity dates, and production data, were not used. For cows changing herds during their productive life, only the part of the records corresponding to the original herd was included and records were censored at the date the cow moved to the second herd. If a culling date was not available (20%), cows with a final calving date greater than 18 mo prior to the end of the study were considered culled, and culling date was declared to be 180 d from the initiation of the last parity, because 6 mo is the normal time needed to wean a calf in the Chianina breed. Cows were sired by 817 bulls (Table 1). Approximately 5.3% of the sires were used for artificial insemination (AI) and mated with 35.2% of the cows in the data set. The AI sires had an average of 46 daughters distributed in an average of 27 herds, whereas the natural service (NS) sires had an average of five daughters distributed in 1.5 herds. The data show a small average herd size and relatively high use of NS sires.

Reproduction and Production Traits

All reproductive information (such as age at first calving, birth date, and number of calves) was collected by technicians from ANABIC. Calf weight was the weight of the calf at birth and was defined by six classes, ranging from 1 (low weight) to 6 (high weight). Each class had a range of 5 kg, or 1 phenotypic standard deviation. Calf weight was measured or estimated by a technician in collaboration with the breeder. Data from births with only single calves were considered; twins were excluded from the analyses. In addition to calf weight, another production trait, number of calves born alive per year of reproductive life from first calving to culling, was considered (Table 2).

Type Traits

Beef cattle in Italy are evaluated for 26 traits, of which 22 are scored on a linear scale. The linear traits are described in Table 2. They consist of eight traits for muscle development, seven traits for body size, two traits for structure, two traits for refinement, and one udder trait, each evaluated on a linear scale from 1 (very bad) to 5 (very good). Six traits with intermediate optima describing leg conformation are scored from 1 (very bad) to 3 (optimum), and again with 5 as very bad. Scoring is performed by breed experts who score all first- and second-parity animals present in each herd. In this analysis, an average of 9.2 cows per herd were evaluated. For this study, only cows with complete type information were included. When cows were scored more than once, only the first conformation score was used.

Model

Survival analysis was performed using the Survival Kit, version 3.0, by Ducrocq and Sölkner (1998). A Weibull model was used because of the simplicity of the Weibull survival function $S(t) = \exp(-(\lambda t)^\rho)$ combined with flexibility. Length of productive life was the dependent variable. The following model was used:

$$\lambda(t) = \lambda_0(t) \exp[h_Y(t') + hv(t') + es + l_0 + tt + p_a(t') + w_e(t')]$$

where

$\lambda(t)$ is the hazard function of an individual depending on time t (days from first calving to culling)

$\lambda_0(t)$ is the baseline hazard function (related to the aging process), which is assumed to follow a Weibull distribution with scale parameter λ and shape parameter ρ

$h_Y(t')$ is the fixed time-dependent class effect of herd-year (calendar years)

$hv(t')$ is the fixed time-dependent class effect of variation in annual herd size (five classes: >+60%, +60

Table 2. Summary statistics and description of production and type traits for 6,395 Chianina cows

Traits	Mean	SD	CV, %	Optimum class	Description	
					Class 1	Class 5
Production						
Weight of the calves (w_e), kg	46.75	5.40	11.5			
Number of calves born per year of the cow's reproductive life (p_a)	0.97	0.30	30.0			
Muscle development						
Withers width (MWW)	2.65	0.72	27.2	5	Narrow	Wide
Shoulders convexity (MSC)	2.76	0.72	26.3	5	Flat	Convex
Back width (MBW)	2.73	0.75	27.6	5	Narrow	Wide
Loins width (MLW)	3.21	0.70	21.9	5	Thin	Convex
Rump convexity (MRC)	2.93	0.67	22.7	5	Meager	Convex
Thighs width (MTW)	2.99	0.73	24.5	5	Narrow	Wide
Buttocks convexity (MBC)	2.93	0.68	23.1	5	Concave	Convex
Buttocks length (MBL)	3.07	0.70	22.8	5	Short	Long
Body size						
Height at withers (BsHW)	3.22	0.84	26.0	5	Short	Tall
Trunk length (BsTL)	3.50	0.78	22.3	5	Short	Long
Chest height (BsCH)	3.41	0.70	20.6	5	Shallow	Deep
Chest width (BsCW)	2.98	0.71	23.9	5	Narrow	Wide
Hip width (BsHw)	3.14	0.67	19.7	5	Narrow	Wide
Ischia (Pins) width (BsIW)	2.88	0.71	24.6	5	Narrow	Wide
Rump length (BsRL)	3.40	0.70	20.7	5	Narrow	Wide
Structure and legs						
Rump angle (RA)	2.82	0.45	16.0	3	Inclined	Counter-inclined
Top line (TL)	2.83	0.40	14.3	3	Concave	Convex
Fore legs—front view (FLFW)	3.12	0.40	12.8	3	Twisted inward	Twisted outward
Fore legs—side view (FLSW)	2.99	0.16	5.2	3	Recurved	Arched
Hind legs—side view (HLSW)	2.66	0.56	20.9	3	Sickle-legged	Straight-legged
Refinement						
Skeleton (Ske)	2.84	0.65	22.7	3	Slender	Heavy
Skin (Skin)	2.84	0.56	19.7	3	Thin	Thick

through +15%, +15 through -15%, -15% through -60%, and <-60%), assumed to be piecewise constant, changing every year

Fixed time-independent effects are as follows:

e is the expert who scored the cows
 l_0 is the age at first calving (26 classes)
 t are the 22 type traits as described in Table 2
 $p_a(t)$ is the fixed time-dependent class effect of the average number of calves born per year of reproductive life, assumed to be piecewise constant, changing every parity; 10 classes were created, ranging from class 0.4 to 1.3 calves born per year of the cow's reproductive life. In the present study, only results for $p_a \leq 1$ are presented, which excludes the cases of cows culled soon after first calving
 $w_e(t)$ is the fixed time-dependent class effect of the weight class of the calf as described in the data section, changing every parity.

The traits included in this analysis were selected in the following manner. Initially, all type and production (p_a and w_e) traits were analyzed simultaneously, and then nonsignificant traits were removed in a stepwise manner. Pastern angle, rear view of hind feet and legs,

and udder were excluded from further analyses because they were not significant. Effects of all remaining traits were highly significant. This process resulted in the set of significant traits presented in Table 2 and used in further analysis.

The risk ratios of each type trait were then estimated one trait at a time without including production traits (p_a and w_e) in the model. Likewise, the risk ratios of each production trait (p_a and w_e) were estimated one trait at a time without including type traits in the model. Hence, estimated risk ratios refer to the effect of a trait on longevity, not corrected for the effects of other traits.

Results

In Chianina cows, the average length of productive life was 1,829 d, which corresponds to an average of approximately 5 yr after first calving (see also Forabosco et al., 2002). In the data, 45% of the records were censored and are related to the fact that the collecting of type data began only in 1993.

Among the original 26 type traits, 22 had significant effects on longevity in the first analysis and were thus retained for subsequent analyses.

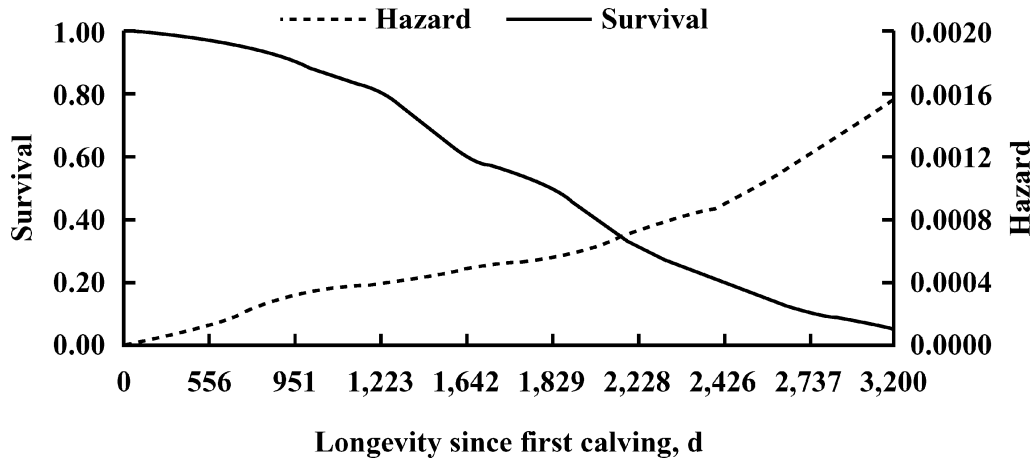


Figure 1. Baseline survival and baseline hazard function.

The estimated Weibull parameter ρ , considering production and all type traits simultaneously, was equal to 2.0 and the intercept $\rho \log(\lambda)$, was equal to -11.3 . In subsequent analyses, the parameter ρ was fixed at 2.0 to reduce the computing time. These two parameters (ρ and intercept) fully describe the baseline hazard function and the baseline survival function $S(t) = \exp(-(\lambda t)^\rho)$. A positive ρ (with $\rho > 1.0$) indicates a baseline hazard function for which risk of culling increases over time. The estimated baseline survival function $S(t)$ and the baseline hazard function $\lambda_0(t)$ are shown in Figure 1. The baseline survival function $S(t)$ corresponds to the fraction of cows that are expected to be alive t days after calving. The baseline hazard function $\lambda_0(t)$ shows the risk of a given cow being culled at a time t , given that she is still alive at time $t - 1$. As indicated by the fact that $\rho > 1$, Figure 1 shows that the average risk of being culled increased as the age of the cow increased.

Effect of Longevity Adjusted for Productivity; The Contribution to the Likelihood

The contribution of individual traits to the likelihood was studied using the model where all traits were included simultaneously. The contribution to the likelihood ($-2 \log$ likelihood) of each trait is shown in Figure 2. The contribution for the herd-year as a time-dependent effect was equal to 4,260, which was the highest among all factors in the model. Contributions from the variation in annual herd size and the expert who scored the cows were lower than the contribution of the herd-year but higher than the contribution from age at first calving and type traits.

All muscularity traits analyzed were highly significant, with a contribution to the likelihood ranging from 745 for muscularity at withers (**MWW**) to 389 for muscularity at buttocks length (**MBL**). Body size traits had smaller, but still significant contributions to the likelihood. Front and side view of fore legs (**FLFW** and

FLSW), rear legs side view (**HLSW**), body refinement for skin (**Skin**) and skeleton (**Ske**) had moderate contributions to the likelihood.

Effect of Age at First Calving and Variation in Herd Size

To interpret fixed effects for each effect included in the model, the class containing the largest number of animals was used as a reference point, and the risk ratio for this class was set to 1. The effects from other classes were then expressed relative to this class. The effect of age at first calving of 25 mo (Class 25) was used as a reference point (Figure 3). The risk ratio (**RR**) for age at first calving and herd variation were estimated without including production and the type traits information in the model. In this analysis, the 26 classes for age at first calving, ranging from 25 to 50 mo of age, were also considered to account for some differences in the management systems. This is because cows that were raised indoors usually calve earlier in life relative to cows raised outdoors with a seasonal calving.

Age at first calving had a small effect on the RR. For a high age at first calving, the RR was higher but the SE was large. After 38 mo, RR must be interpreted carefully due to a high SE, caused by a reduction in the number of older cows calving.

For variation in herd size, five classes were considered and the RR are shown in Figure 4. Animals in Class 2, corresponding to a small increase in herd size, had a lower risk of being culled (8% less) than the animals in Class 3 (stable herd size). Not surprisingly, decreasing herd size was associated with more risk of culling, as cows in Class 4 had an 11% higher probability of being culled than animals in Class 3, and for cows in shrinking herds (Class 5) the probability of being culled was 73% higher than in a stable herd (Class 3). Risk of culling in herds with large increases in size

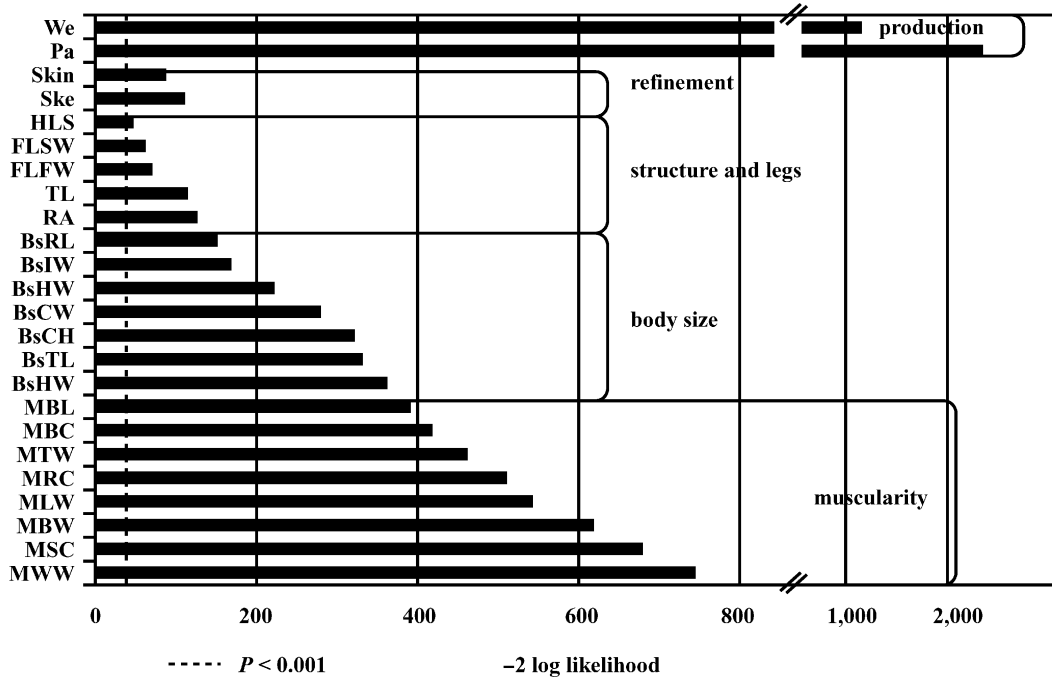


Figure 2. Contributions of individual traits to the likelihood for longevity for Chianina cows. See Table 1 for definition of abbreviations.

(Class 1) was actually greater than in herds with small increases or stable size, but these differences were not significant.

Effect of Number of Calves and Weight

Longevity adjusted for production considered cow productivity as the number of calves born per year of the cow’s reproductive life and the weight of the calves. No type traits were included in the model, and one effect at a time (either p_a or w_e) was analyzed.

The RR of the class which corresponded to a single calf per year was set equal to 1.0 (Figure 5). Cows that calved only once every 2 yr (Class 0.5) had four times higher probability of being culled than cows in Class 1.0. For cows belonging to classes below 0.7, the risk of being replaced increased drastically, probably due to health problems or voluntary culling associated with low fertility.

Results for the effects of weight of calves (w_e) are presented in Figure 6. Six classes were considered from 1 (low weight) to 6 (high weight) and only single parity

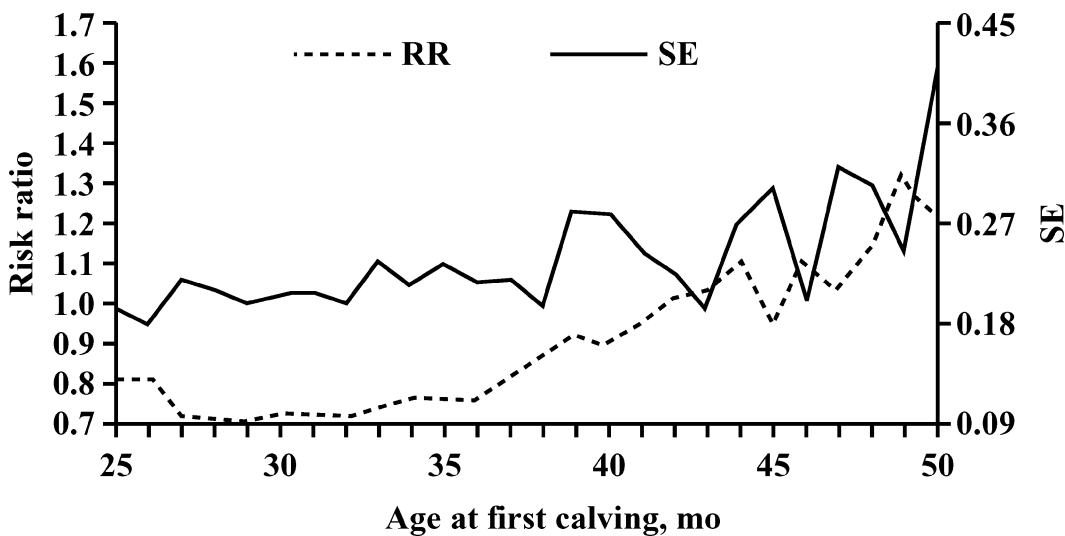


Figure 3. Risk ratio (RR) and SE for age at first calving for Chianina cows.

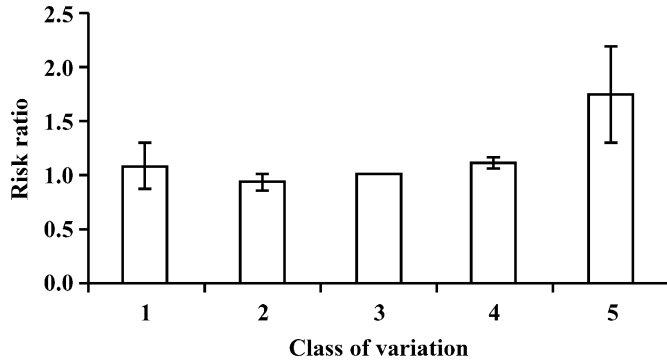


Figure 4. Risk ratios (RR) for variation in herd size for Chianina cows. Classes are defined as 1) an increase of 60% or more in herd size; 2) an increase between 60 and 15%; 3) a change between 15 and -15%; 4) a reduction between -15 and -60%; and 5) a reduction of more than 60%.

was considered in this analysis. Cows with their calves belonging to Class 2 and 4 had, respectively, 0.85 and 0.79 probability of being culled. The weight of the calf had a smaller effect on longevity than the number of calves (Figure 6 vs. 5).

Effect of Type Traits

Risk ratios for muscularity traits are in Table 3. Looking at the muscularity traits as a whole, one can see a clear trend in the RR between Class 1 and Class 5. In all cases, the RR in Class 5 was less than in Class 1, meaning that cows with high muscle development were more likely to remain in the herd. In some combinations of traits and classes, standard errors were large, but for all muscularity traits the trend for increased longevity for cows with more muscle development was consistent.

Risk ratios for body size traits are in Table 4. Results in Table 4 show that taller (Class 4) Chianina cows

with a long body and a deep and wide chest had a higher probability of survival. Results in Table 5 show that structure and leg traits were less informative for longevity than were muscularity and body size traits.

Discussion

The highest contribution to the likelihood was due to the herd-year effect followed by production traits, herd variation, age at first calving, and type traits. Among the type traits, muscularity made the highest contribution to the likelihood, followed by dimension, refinement, and leg traits. Muscularity is logically the most important morphological trait for the breeder. Cows with good muscularity are thus more likely to avoid voluntary culling by the breeder than cows with poor muscularity. Among the dimension traits, stature (**BsHW**) was the strongest indicator trait for longevity. Bünge and Hermann (1999) reached similar conclusions for dairy cows, but this result differed from that of Larroque and Ducrocq (2001), who found a nonsignificant contribution of the stature to longevity for the nonregistered Holstein population in France and a moderate contribution for the registered population. Wide hips and wide pins increase the probability of a cow remaining longer in the herd. The same results were found by Schneider et al. (1999), where dairy cows with wide pins had a 74% higher probability of avoiding culling than did cows with narrow pins. In this work, it was found that animals in Class 2 for pins (**BsIW**) had a 38% higher probability of being replaced than cows with wide pins (Class 4). Rump length was a trait with an RR around 1.0 for all five classes. Similar results were found by Larroque and Ducrocq (2001) in dairy cattle.

No general trends were observed for the traits associated with structure and leg. When ignoring Classes 1 and 5 due to their large SE, an intermediate optimum seemed to exist for FLFW and FLSW. For HLSW, the situation was slightly different. Considering the HLSW

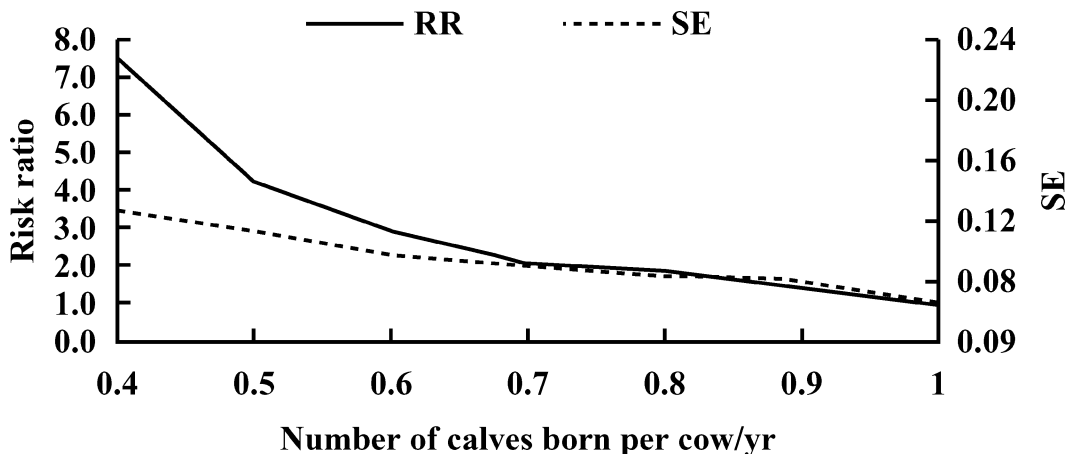


Figure 5. Risk ratio (RR) for number of calves born per cow per year of reproductive life for Chianina cows.

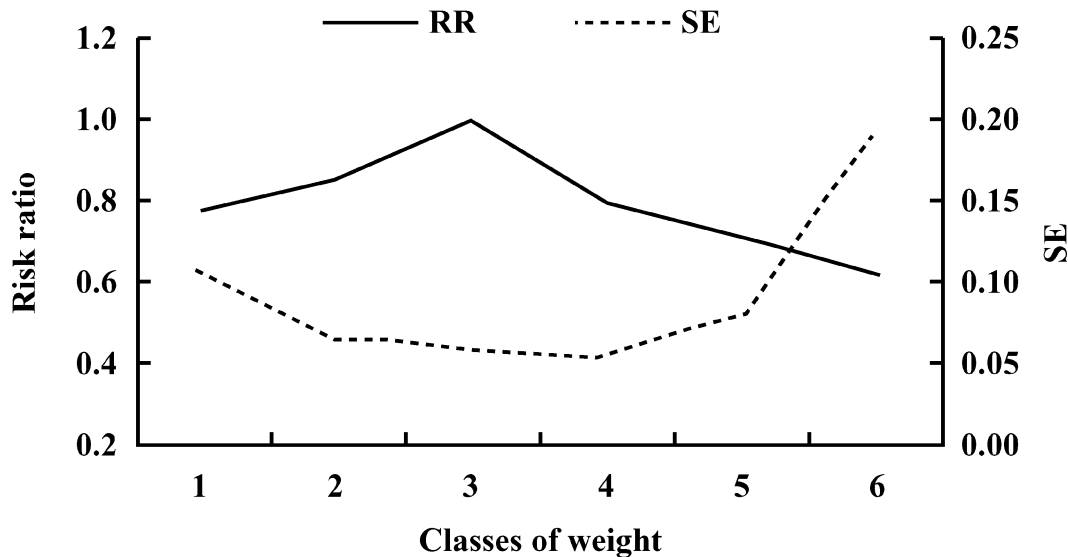


Figure 6. Risk ratio (RR) for weight of calf for Chianina cows. Six classes are considered from 1 (low weight) to 6 (high weight). Each class is 1 standard deviation (5 kg), with an average of 47 kg per calf.

(and excluding Classes 1 and 5 that included few animals), animals in Class 4 (straight-legged) had a 59% greater probability of being replaced than did animals in Class 3. The RR for cows in Class 2 (sickle-legged) was only 3% higher than the RR for Class 3. In contrast, dairy cows with sickle-shaped legs have a much higher relative probability of being replaced than straight-legged cows (Burke and Funk, 1993; Schneider et al., 1999). This difference is likely due to differences in management and housing conditions. Whereas most dairy cattle spend major proportions of their lives confined in barns, beef animals are raised mainly in pastures and straight-legged cows may have more problems walking in an open field.

Traits that show a moderate effect on longevity, such as the legs and refinement traits, suggest that beef producers do not consider these traits as very important for their culling policy. Cows that have one calf per year are more profitable for the breeder, so they remain in the herd longer than do cows that produce fewer calves. The majority of voluntary culling occurs between first and second calving and cows with even small problems at that period are often preferentially culled by the

breeder who prefers to retain the older cows that have already proven themselves. When interest is in longevity itself (e.g., when estimating breeding values for functional longevity), the use of p_a as a productivity trait may be inappropriate for cows that give birth for the first time and die soon afterward. Such cows have a high p_a due to their short LPL. Hence, the use of p_a to account for voluntary culling may cause a bias in the correct estimation of breeding values for longevity. For the purpose of breeding value estimation, it may be better to use a binary time-dependent fixed effect, which indicates whether or not the cow produced a calf. In the present study, where interest was in the effect of the number of calves on longevity, only results for $p_a \leq 1$ are presented (Figure 5), which excludes the cases of cows culled soon after first calving.

It is not easy to understand why cows that have calves with high weight (Classes 4, 5, and 6) had a higher probability of surviving than animals in the average class. Large calves are generally associated with increased rates of calving problems. One of the reasons may be related to the fact that a significant proportion of Chianina cattle are raised outdoors and these cows

Table 3. Risk ratio for muscularity traits for Chianina cows

Class	Muscularity traits ^{a,b}															
	MWW	SE	MSC	SE	MBW	SE	MLW	SE	MRC	SE	MTW	SE	MBC	SE	MBL	SE
1	1.62	0.12	1.92	0.15	1.39	0.12	1.20	0.29	1.43	0.25	1.80	0.21	1.44	0.21	2.01	0.18
2	1.15	0.05	1.06	0.05	1.11	0.05	1.12	0.06	1.27	0.05	1.34	0.05	1.15	0.05	1.08	0.06
3	1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00	
4	0.95	0.08	0.87	0.07	0.88	0.07	0.91	0.05	0.83	0.06	1.00	0.06	0.99	0.06	0.88	0.06
5	0.62	0.41	0.23	0.30	0.64	0.30	0.47	0.22	0.31	0.35	0.37	0.25	0.72	0.25	0.56	0.23

^aSee Table 2 for class descriptions.

^bMWW = withers width, MSC = shoulder convexity, MBW = back width, MLW = loin width, MRC = rump convexity, MTW = thigh width, MBC = buttocks convexity, MBL = buttocks length.

Table 4. Risk ratio for body size for Chianina cows

Class	Body size ^{a,b}													
	BsHW	SE	BsTL	SE	BsCH	SE	BsCW	SE	BsHw	SE	BsIW	SE	BsRL	SE
1	1.49	0.16	1.15	0.34	1.09	0.41	1.66	0.19	1.14	0.39	2.57	0.20	1.03	0.58
2	1.04	0.06	1.26	0.08	1.09	0.08	1.16	0.05	1.18	0.09	1.15	0.05	1.24	0.08
3	1.00		1.00		1.00		1.00		1.00		1.00		1.00	
4	0.89	0.05	0.97	0.05	0.88	0.05	0.83	0.06	0.93	0.05	0.83	0.07	0.95	0.05
5	1.00	0.09	0.83	0.09	0.40	0.14	0.67	0.20	0.69	0.12	0.52	0.20	0.99	0.11

^aSee Table 2 for class descriptions.

^bBsHW = height at withers, BsTL = trunk length, BsCH = chest height, BsCW = chest width, BsHw = hip width, BsIW = ischia (pins) width, BsRL = rump length.

calve without assistance from the respective breeders. Cows with heavy calves have a high probability of dystocia and stillbirth (Williamson and Humes, 1985; Nix et al., 1998), but because of the rearing management of the breed (extensive on pasture) stillborn calves are frequently not recorded and subsequently weighed. Thus, the majority of the heavy calves registered were likely those that were born alive. If this is the case, a bias would be present for the animals in Classes 4, 5, and 6. A solution for this bias might be to model the effect of calf weight within the breeding system in the model. In addition, effect of calving weight might be better modeled by accounting for the age of the dam.

Culling Reasons

In dairy cattle, culling reasons are grouped into two categories: involuntary and voluntary. Involuntary culling is done for health problems and reproduction, whereas voluntary culling is done for productivity. Longevity corrected for voluntary culling is called *functional longevity*, whereas actual observed longevity is called *true longevity* (Ducrocq et al., 1988). The reason for distinguishing between voluntary and involuntary culling is that the selection for true longevity is largely equivalent to selection for productivity (at least in dairy cattle) and does not necessarily lead to genetic improvement in the ability to withstand involuntary culling (Dekkers, 1993).

In this study, we have used the number of calves born per year and the weight of calves as production traits, because the calf is the main source of income for

the farmer. However, the weight of the calf may also be related to involuntary culling because of its relationship with calving difficulty. This distinction between voluntary and involuntary culling is particularly difficult in beef cattle as pointed out by Beaudeau et al. (1999). They noted that, except for emergency culling for acute health disorders (such as severe locomotive disorders, metritis, abortion, dystocia, or even death), all other culling decisions are technically decided and planned by the farmer. This system of culling also occurs in herds with Chianina cattle. In fact, muscularity traits appear to be important in culling decisions and the farmer seems to retain animals with better muscle development, as pointed out by the results in Table 3.

Final Considerations

To allow an interpretation of the RR without being conditioned by all of the other traits, one type trait at a time was considered in the model when calculating RR. However, because these traits are correlated, their effects cannot be simply added. When choosing which traits to include in a breeding program, correlations between traits must be considered.

In this study, longevity was defined as LPL (i.e., from first calving to culling), whereas survival from birth to first calving was not considered. Obviously, survival from birth to first calving is also important, but survival during this period is probably a very different trait genetically than is survival after first calving, due to biological differences and differences in management policies of the farmers. For this reason, a single Weibull

Table 5. Risk ratio for structure and legs for Chianina cows

Class	Structure and legs ^{a,b}													
	RA	SE	TL	SE	FLFW	SE	FLSW	SE	HLSW	SE	SKE	SE	SKI	SE
1	1.05	0.41	0.91	0.35	0.97	0.79	NE	NE	1.32	0.17	1.46	0.23	1.09	0.32
2	0.99	0.06	1.03	0.06	1.27	0.13	1.77	0.19	1.03	0.05	1.21	0.05	1.02	0.05
3	1.00		1.00		1.00		1.00		1.00		1.00		1.00	
4	0.82	0.14	0.95	0.32	1.36	0.06	0.86	0.38	1.59	0.16	0.84	0.06	0.82	0.08
5	0.97	0.30	1.09	1.14	1.08	0.33	1.04	0.86	1.23	0.92	1.01	0.30	1.05	0.69

^aSee Table 2 for class descriptions.

^bRA = rump angle, TL = top line, FLFW = fore legs—front view, FLSW = fore legs—side view, HLSW = hind legs—side view, SKE = skeleton, SKI = skin, NE = not estimable.

survival function may not properly fit a definition of survival that combines both the periods preceding the first calving and LPL after the first calving. In a breeding program, a sensible approach would be useful to treat survival until first calving and LPL as separate but correlated traits that are both included in the breeding goal.

Implications

Results of this study indicate that herd-year effects and muscularity traits were the most important factors for longevity for Chianina cows among the factors studied. Not surprisingly, notable differences were observed in the relationship between conformation and survival for beef cattle compared with previous studies on dairy cows. In beef cattle, traits such as muscularity and longevity must be considered in a future implementation of a beef cattle breeding schema and cannot be simply extrapolated from dairy cattle. For the purpose of genetic evaluation for productive life in beef cattle, a single Weibull function may not properly fit survival from birth to culling. It could be useful to treat survival until first calving and length of productive life as two separate but correlated traits that are both included in the breeding goal.

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