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Contribution of non-genetic factors to the reproductive performance of Mirandesa cows

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Additional keywords

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SUMMARY

Characterization of reproductive traits in Mirandesa beef cattle is important for breed improvement and conservation, mainly due to its little genetic diversity. Reduced individual and maternal performance is often associated with inbreeding depression, which could be further aggravate the environmental effects. In this study, 7386 herd records for Mirandesa were used to characterize the main reproductive traits, like age at first calving (AFC), pregnancy length (PL), calving interval (CI), yearly calving distribution (CD) and productive lifespan (PLf). The non-genetic effects were tested using non-parametric methods, as the target variables were not normally distributed. The median for AFC in Mirandesa was close to 32 months; AFC was affected by the production system, farm and by the year and season of birth. The mean for PL was 287±8.9 days, being affected by parity and calf gender. The median CI, of 378 days, was only affected by the breeding program, parity, season and year. Calving season was unevenly distributed over the year, showing different patterns after the production system. The mean productive lifespan of Mirandesa was 6.45 years, though 20% of the cows presented a PLf longer than ten years. The main non-genetic effects suggested that farmer´s decision and nutrition may constrain the expression of the reproductive traits in Mirandesa breed. This aspect needs to be addressed when designing any breeding programs which should prioritise for the increase in the number of calves per year along with a careful selection of reproducers to decrease reported inbreeding.

Contribuição de fatores não-genéticos para o desempenho reprodutivo de vacas Mirandesa

RESUMO

Conhecer as características reprodutivas da raça bovina Mirandesa é fundamental para o melhoramento e conservação desta raça de carne, sobretudo pela sua baixa diversidade genética. A depressão por consanguinidade acompanha-se frequentemente de desempenhos individuais e maternais mais fracos, que podem agravar os efeitos ambientais. Neste trabalho utilizaram-se 7386 registos do Livro Genealógico para caracterizar alguns indicadores reprodutivos: a idade ao primeiro parto (AFC), a duração da gestação (PL), o intervalo entre partos (CI), a distribuição partos no ano (CD) e a longevidade produtiva (PLf). Testaram-se ainda efeitos não genéticos na sua expressão, através de métodos não-paramétricos, por não estarem cumpridos os pressupostos de normalidade. A mediana para a AFC aproximou-se dos 32 meses, variando com o sistema de produção, a exploração, e o ano e estação de nascimento. A média de PL (287±8.9 dias) foi afetada pela paridade e sexo da cria. A mediana do CI foi de 378 dias, e variou apenas com o programa de reprodução, paridade, ano e estação. Os partos, irregularmente distribuídos ao longo do ano, mostraram padrões distintos segundo o sistema de produção. A longevidade produtiva desta raça foi de 6,45 anos, e 20% da população apresentou uma PLf superior a dez anos. Este trabalho sugere serem a estratégia do agricultor e a nutrição os principais efeitos não genéticos limitando o desempenho reprodutivo nesta raça, a considerar para aumentar o número de vitelos produzidos anualmente em paralelo com uma cuidada seleção de reprodutores para reduzir o inbreeding da raça.

Palavras chave adicionais

Efeitos ambientais.
Fertilidade da vaca.
Produção sustentável de carne.
Sistemas de produção bovina de baixo input
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INTRODUCTION

In most peripheral European countries, indigenous livestock has reduced their number, in the last decades, in response to the pressure exerted by industrial beef production, with subsequent loss of genetic diversity (Beja-Pereira et al. 2003, Soini et al. 2012). Many represent native breeds of limited geographic distribution (Soini et al. 2012), often used in non-specialized, low-intensity cattle systems (Bignal, 1998, Ligios et al.

2005), and often reared under traditional extensive systems that seldom compete with genetically improved breeds in industrial systems. Even though, they play a relevant role in economic-productive terms, for its organic-like quality, its contribution to a sustainable use of natural resources and its maintenance of rural landscaping (Casasús et al. 2012).

Current trends denote the sustainable production concept as a tool to maintain livestock biodiversity, making the local breeds the ideal candidates to the socioeconomic development of agricultural communities in rural areas of limited income. Portugal possesses a large proportion of marginal agricultural zones in Europe (Wright, 1997; Rodrigues et al. 1998). These areas support critical national animal derived food industries and exports, mostly add-valued products under a label of protected designation of origin (PDO) or traditional specialty guaranteed (TSG) and meat of superior taste.

Mirandesa is a Portuguese indigenous beef cattle, well-adapted to the local climate and natural forage. In 2013, a total of 5826 animals were registered in the herdbook, and the number of calving had stabilized between 4000 and 4250 births/year (ACBRM, 2013). Even though, between 2013 and 2015, this number fell away in 25% due to a reduction in the number of breeding cows (ACBRM, personal communication).

Like many other Mediterranean livestock species, Mirandesa is traditionally reared on extensive or semi-extensive systems based on natural pastures, largely dependent of the seasonality of forage resources (Casasús et al. 2012). Originated from the northeast of Portugal (home-region), Mirandesa dispersed into the south. The larger number of animals is still located in the home-region, which comprises nowadays 79.2% of the total population (4617 animals in the herdbook), compared to the 20.8% (1209 animals) recorded in the dispersal region (ACBRM, 2013).

The two regions differ in respect to the management system and the herd´s size. The home-region uses a semi-extensive system, mostly based on small, family-type herds, usually ranging from small (3-5 cows) to mid-sized herds (18-45 cows) (Fragata & Sousa, 1997). A communitarian bull is maintained separated from the females, and mating occurs upon heat detection, following the owner decision, which takes into account the age of the calf. Contrasting, the dispersal region uses a strictly extensive system similar to the *montado* (Belo-Moreira & Coelho, 1997), and animals are reared in larger stocks of around 50-80 females; the bull is kept with the cows year-round, without fixed breeding seasons (Sousa & Sanchez Garcia, 2009). In either region, the farmers maintain the traditional low-input rearing systems, where animals are fed available forages and other feedstuff produced in the farm, with a low level of intensification and limited technical or economic management (Rodrigues et al. 1998; Lígios et al. 2005; Araújo et al. 2014).

Even though the development of certified meat products revitalized, in recent decades, the local meat production making the Mirandesa the largest commercial PDO Portuguese veal, it failed to introduce technical improvements in the production system. Due to its financial volume of affairs and socio-cultural importance, Mirandesa meat is a recognized national asset. Mirandesa supplies the national meat market and also exports meat associated with a PDO label (Pestana et al. 2012), thus raising the interest in promoting the breed among stakeholders. The breeders association - Associação de Criadores de Bovinos de Raça Mirandesa (ACBRM) - now faces an important concern: to improve the system efficiency to escalate the yearly production of meat to meet the market demands.

In general, farmers put little technical innovation into the system and no truly pressure was yet applied in Mirandesa breed selection, which remained mostly based on the aesthetic appearance of animals. Mirandesa has been identified as the European cattle breed with higher loss of diversity (Cañón et al. 2001). Therefore, the increased endogamy within the breed might be reflected in less favorable fertility parameters. Evaluation of the phenotypic reproductive traits provides helpful information for breeding decisions aimed to improve animal performance and meat production and to support the development of sustainable breeding plans.

The aims of this study were to characterize the main reproductive traits for Mirandesa cows, such as age at first calving, pregnancy length, calving interval, calving distribution through the year and productive lifespan, using data gathered from the official records for the breed; and to determine the main non-genetic factors affecting reproduction in Mirandesa cows. Detailed knowledge of these factors is vital to develop suitable reproductive strategies to Mirandesa and to improve reproductive efficiency.

MATERIAL AND METHODS

Animals and herd management

The analysis covered the main phenotypic reproductive traits collected from records of 7386 Mirandesa purebred cows representing 1801 farms. The records were extracted from the official Mirandesa herdbook, held by ACBRM, the national entity responsible for the Book registries. It included records from 6632 cows reared in the home-region, plus 754 cows located in the dispersal region. Within each region, feeding and keeping conditions were identical among farmers; no feed supplementation was used in cows in either region. However, the management system, as well as the weaning and breeding practices, differ between home and dispersal regions (Sousa & Sanchez Garcia, 2009). The main differences among rearing regions are summarized in **Table I**.

Record analyses

The dataset allowed evaluating the following traits:

The age at first calving - defined as the interval (in days) from birth to first calving - was determined over 3649 records corresponding to females born from January 1995 to December 2006, from identified direct ascendants, with a record for the date and place at the first calving. For this trait, the tested factors were the production system (traditional semi-extensive *vs.*

Table 1. Main differences between the home-region and the dispersal regions concerning the Mirandesa management (Principais diferenças no maneio da raça Mirandesa encontradas entre o solar de raça e a área de dispersão).

Parameter	Home-region	Dispersal region
Total population (%)	79.2	20.8
Geographical region	Northeastern	Southern
Main purposes	Meat production, animal labour and manure	Meat production
General management	Semi-extensive system; animals are housed at night and when land work raise	Strict extensive system
Nutritional management	Natural meadow pastures; supplemented with farm by-products (corn, barley or oat-derivates and hay)	Natural and semi-natural pastures from low fertility soils; sporadically supplemented with hay
Breeding management	Natural hand-mating or artificial insemination upon estrus detection; The bull is in a service centre	Natural service; the bull is maintained in the herd year-round; no breeding seasons
Cow-calf management	Calf suckling restricted to twice a day at 3 months	Calf under the cow until 7 to 9 months

Compiled from: Fragata & Sousa, 1997; Sousa & Sanchez Garcia, 2009; Viegas et al. 2011.

extensive, which overlap with the home and dispersal regions, respectively), the farm at calving (i.e., the same or different from the one at birth) and the year and season of birth.

The *pregnancy* length was estimated as the interval (in days) between the last mating/AI recorded and calving, based on 1224 records from 787 cows in the period 1995-1997 (the period with a more regular information on breeding and calving), for what the animal identification and information on the order of pregnancy (thereafter named as parity) and the sex of the calf existed. The dataset was limited to animals presenting a valid breeding record, with known sire and identification of the breeding date, whether it was achieved by natural mating or artificial insemination; the majority of cases were limited to farms with excellent record keeping and mainly represent the home-region.

The calving interval, defined as the number of days between two consecutive calving events, was estimated from a total of 27479 records from 7198 cows over the period 1996-2007. Calving intervals over two years (or 730 days) or below 280 days were censored as corresponding to cases of crossbred calves not registered in the herdbook, or to a calving interval below the mean overall calving length. The following factors of influence were tested: the year and season of calving, parity, the breeding program (AI *vs.* natural mating) and the production system.

The *calving distribution* through the year was studied in 28901 calving records from 7386 cows over a period between 1996 and 2007. It was analyzed monthly and by season.

The *productive* lifespan was estimated subtracting the AFC from the age of the cow at her last calving. PLf was determined from the records of 1355 females selected by the fidelity of the information from 1983-2008.

In this study, parity was categorized as 1, 2, 3 and ≥4, and the months of the year were grouped in four seasons, as follows: winter (January to March), spring (April to June), summer (July to September) and fall (October to December).

Statistical analysis

The statistical analysis was performed using SPSS® (version 22.0. 0 for Mac OS X). The traits analysed were AFC, PL and CI under the effects of the year and season of birth or calving (accordingly) and the production system. The analysis included the general descriptive statistics and the frequency distribution. These traits were further categorized by quartiles. The Kolmogorov-Smirnov and Shapiro-Wilks tests rejected the null hypothesis that dependent variables were normally distributed for each category of independent variables. Non-parametric methods were used to test the medians, Mann-Whitney U for single and Kruskal-Wallis for multiple comparisons, at a 0.01 significance level.

The PLf was analysed using a multiple linear regression having as covariables the CI and number of cows on the farm. The bootstrap method was applied to avoid the normal distribution restriction. The P-values were obtained via Monte Carlo. The bivariate Spearman's rank-order correlations among continuous variables were also calculated. For the analysis of CD throughout the year, it was used the Pearson´s chi-square test (χ^2).

RESULTS

Descriptive statistics of Mirandesa reproductive traits

In Mirandesa breed, the AFC occurred at an average of 954.8±183.5 days, where the median (δ) was 923 days, and data ranged from 576 to 1460 days **(Figure 1A)**. Although more than 77% of the females had their first calving before three years of age, the age at first calving more frequently recorded (764 days) positively skew the frequency distribution curve for AFC **(Figure 1A)**.

The PL in Mirandesa ranged from 260 to 310 days (δ=288 days, for an average of 287±8.9 days). The mean CI in Mirandesa cattle was 405±84.9 days, but the median for CI was 378 days (Figure 1.B). A 365 days CI was found in only 40.2% of the females, while 65% of

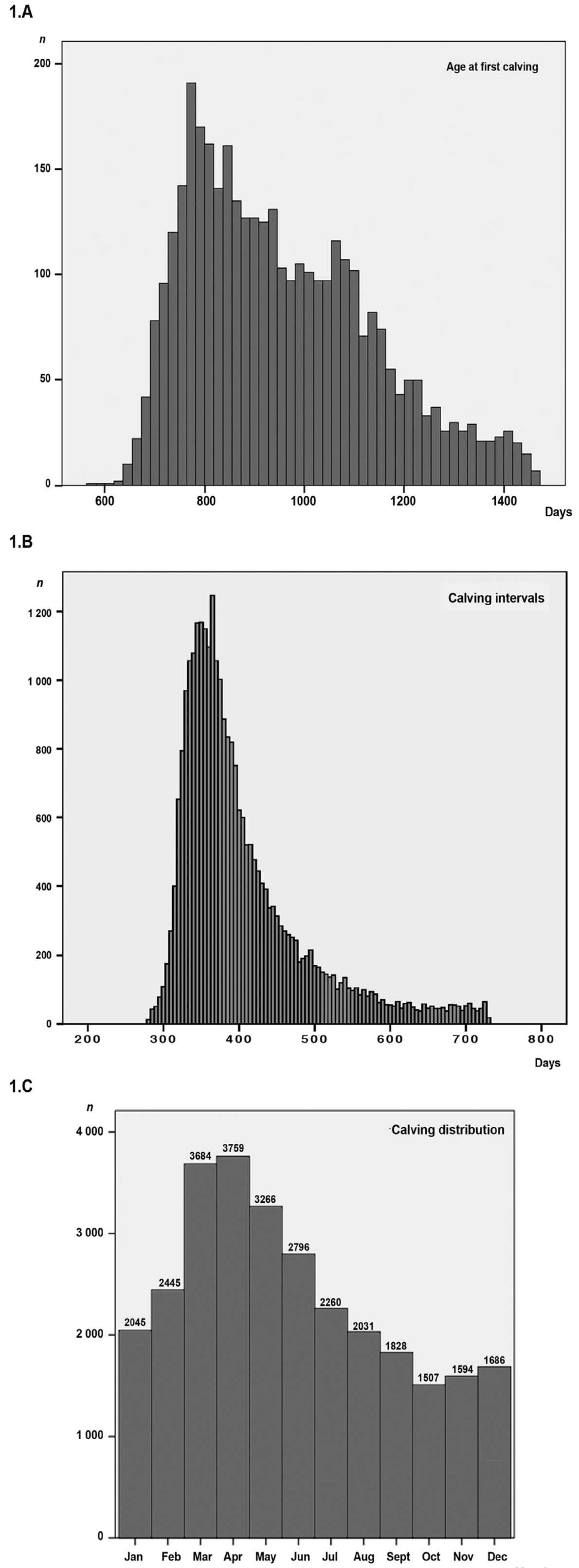

Figure 1. Main reproductive traits in Mirandesa beef breed. A. Frequency distribution for the age at first calving in heifers (n=3649 records). B. Frequency distribution of the calving intervals (n=27479 records). C. Monthly distribution of calving (n= 28901 records) (Principais características reprodutivas da raça Mirandesa, de aptidão cárnica. A. Distribuição da idade ao primeiro parto (n=3649 registos). B. Distribuição do intervalo entre partos (n=27479 registos). C. Distribuição de partos ao longo dos meses (n= 28901 registos).

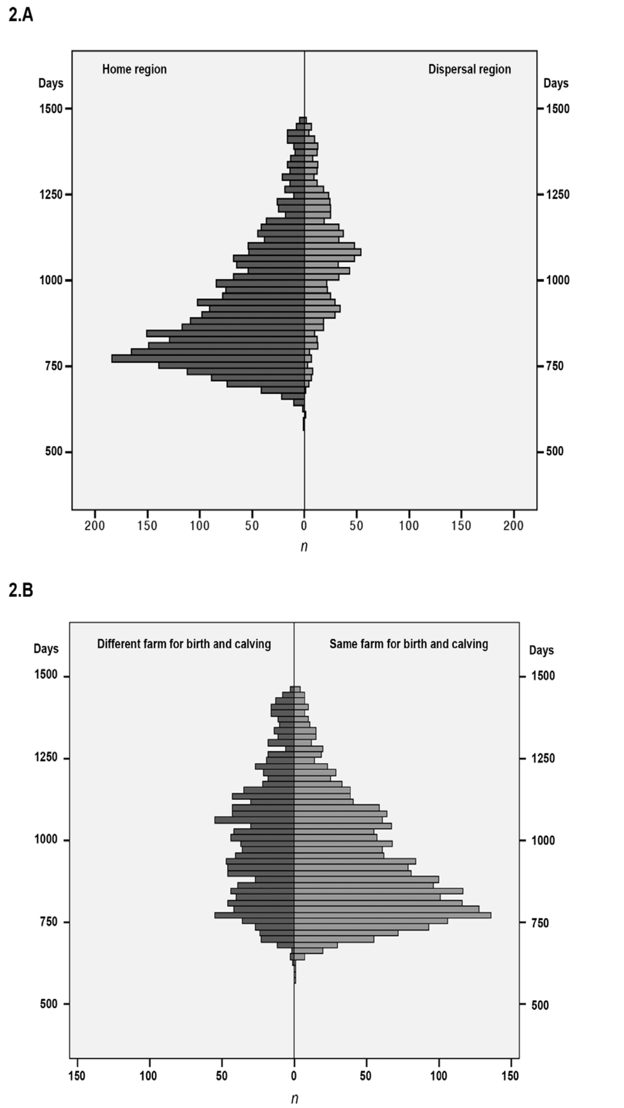

Figure 2. Non-genetic factors affecting the age at first calving (AFC) in Mirandesa heifers. A. Frequency distribution of AFC according to the production system (semi-extensive/home region vs. extensive/dispersal region). B. Frequency distribution according to the farm of first calving (birth and 1st calving occurred at the same vs. different farms) (Fatores não-genéticos com influência sobre a idade ao primeiro parto (AFC) em vitelas Mirandesas. A. Distribuição do AFC segundo o sistema de produção (semi-extensivo/solar de raça vs. extensivo/área de dispersão). B. Distribuição segundo a exploração onde ocorre o primeiro parto (parto ocorre na exploração de nascimento ou noutra exploração).

cows showed CI of 405 days. For each 100 cows, 90 was the annual expectation of calving events.

In this breed, calving was not evenly distributed through the year (χ^2 = 2893.74; P<0.001; n= 28901) **(Figure 1C)**. It occurred more frequently from March to May, in contrast to other months (e.g., from October to December **(Figure 1C)**.

Finally, the Mirandesa PLf was 6.45 years. About 14.2% of the cows had a PLf shorter than two years, while 20% of the cows showed a productive lifespan longer than ten years.

Table II. Descriptive statistics for age at first calving (days) in Mirandesa heifers (Estatística descritiva para a Idade ao primeiro parto (em dias) em vitelas de raça Mirandesa).

Factor	Level	n	$\bar{X}$	δ	Q_1	Q_3
Management system	Traditional	2785	917	874	784	1018
	Extensive	864	1076	1075	955	1182
Farm at birth and calving	Same	2359	930	890	790	1048
	Different	1290	1000	987	842	1130
Season of birth	Spring	1253	940	898	779	1091
	Summer	883	927	874	803	1028
	Fall	548	980	945	863	1067
	Winter	965	985	981	831	1086
Year of birth	1995	245	913	857	782	1015
	1996	215	969	923	815	1086
	1997	273	951	917	812	1054
	1998	302	926	874	792	1040
	1999	313	941	892	802	1054
	2000	305	933	897	791	1034
	2001	263	965	945	820	1081
	2002	363	959	933	806	1077
	2003	374	962	942	806	1086
	2004	572	1019	1029	849	1161
	2005	298	963	963	830	1090
	2006	126	809	788	746	867

n:number of cases; $\bar{X}$ mean; δ: median.

Non-genetic influences over the Mirandesa reproductive traits

The AFC in Mirandesa heifers was affected by the production system/region, farm at calving and season of birth. The mean AFC differed almost five months between animals reared under the semi-extensive system/home-region and in extensive system/dispersal region (P<0.0001; **Table II; Figure 2A)**. Similarly, a delay of more than six months (P<0.0001) was also found in the AFC median in extensive systems compared to the semi-extensive´s **(Table II)**. For most heifers (64,6%), birth and calving occurred in the same farm, although a representative percentage of animals (35.4%) calved on a different one, which elongated the AFC median (P<0.0001) in 97 days **(Table II; Figure 2B)**.

An uneven distribution amongst season (P<0.0001) was observed for AFC. Non-significant differences were observed for births occurring from April to September or from October to March, but these two periods differed significantly **(Table II)**, the largest variations found between summer and fall (P<0.0001). Although the year of birth did not show any evolutionary

Table III. Descriptive statistics for pregnancy length (days) in Mirandesa cattle (Estatística descritiva para a duração da gestação (em dias) na raça Mirandesa).

Factor	Level	n	$\bar{X}$	δ	Q_1	Q_3
Calf gender	Male	603	288	288	283	293
	Female	621	286	287	281	292
Parity	1^{st}	185	285	286	279	291
	2^{nd}	321	287	288	281	292
	3^{rd}	229	286	287	281	292
	≥4	489	288	288	283	293
Season	Spring	394	286	286	281	292
	Summer	363	286	288	281	292
	Fall	238	287	288	282	293
	Winter	229	288	290	284	294

n:number of cases; $\bar{X}$ mean; δ: median.

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tendency **(Table II)**, its effects on the AFC presented different distributions (P<0.0001). The lowest mean value for AFC was recorded on 2006, which significantly differed from all the other years (P<0.0001**; Table II)**. In contrast, animals born in 2004 recorded the highest age at first calving, significantly different from those born in 1995, and in the periods between 1997 and 2000 or 1996, 2002 and 2003 (P<0.0001**; Table II)**.

Results on Mirandesa PL indicated a significantly effect of calf gender (P<0.0001), parity (P=0.004) and season (P≤ 0.001). Male pregnancies were slightly longer than the female´s **(Table III)**. In line with previous results, PL increased with parity in 0.386 days per calving. However, only the first pregnancy was statistically different from the others (P<0.0001 between the 1st and 4th pregnancies; P= 0.026 between the 1st and 2nd pregnancies; and P=0.0074 between the 1st and 3rd pregnancies). Season significantly influenced PL (P=0.001) showing a shorter timespan in spring and longer in winter **(Table III).** Only pregnancies occurring in winter were however significantly different from those occurring in spring (P<0.0001), fall (P=0.011) or summer (P=0.001) (**Table III**).

Parity (P<0.0001), the breeding program (natural breeding *vs*. artificial insemination; P<0.0001), and season (P<0.0001) significantly affected the CI of Mirandesa (**Table IV**), which was unaffected by the production system/region (semi-extensive *vs*. extensive; P=0.146) or calf gender (P=0.109). Only the first and the second CI were significantly different from the others (P<0.0001 and P= 0.002, respectively) (**Table IV**). The use of artificial insemination elongated the CI in 12 days compared to natural mating **(Table IV)**. The median for CI was shorter in winter and spring, compared to summer and fall **(Table IV)**. The influences of the year of calving on CI failed to show any evolutionary tendency. Nevertheless, the year of 2003 presented significantly shorter CI than all other years (P<0.0001) except for 2005 **(Table IV)**, despite the nearness of values with the CI in the years of 2002 (P=0.003) and 2001 (P=0.012).

The production system significantly influenced CD through the year (χ^2 = 209.612; p≤0.001; n= 28901). In the semi-extensive system/home-region, calving from March to June predominated over the other months, while a decrease occurred in October. In contrast, in the extensive system/dispersal region, a marked reduction in calving was found in June and July.

The Mirandesa´ PLf increased with the number of animals in the farm and the CI (P=0.001), as shown by the bootstrap analysis. Nevertheless, these two variables were negatively correlated (P<0.0001), i.e. CI decreases as the female number on the farm increases. In addition, a weak positive association with AFC was observed [r_s (1353) = 0.130; P<0.0005].

DISCUSSION

This study extracted data from the official herdbook records to characterize the main phenotypic traits in Mirandesa beef cattle and to estimate the main non-genetic effects that impact its reproductive efficiency. Consequently, it happens that some descriptors (such as nutrition) are unavailable, even if these limitations were partly overcome by testing the "year effect" and the "system" or "farm" effects on the target traits. Thus the information gathered herein reflects the genotype and environment interaction.

In Mirandesa cattle, the mean AFC (31.5 months) was within acceptable values (Bourdon & Brinks, 1983; Diskin & Kenny, 2014), although above the 24-30 months targeted in most beef production systems (Short & Adams, 1988). It was similar to that reported for other breeds originating from the same ancestral trunk (Cañon et al. 2001), such as Asturiana de los Valles (Goyache & Gutierrez, 2001) or even lower than in other national breeds with similar body frame (cow weight close to 600kg) reared in strictly extensive systems, like Alentejana or Mertolenga (37 months; Carolino, 2006; Carolino & Gama, 2008). However, comparing the mode and median for AFC (ca. 24 and 26 months, respectively) suggests that it is possible to introduce heifers into reproduction earlier than it is currently practiced, fostering a longer productive lifespan. It might need to encompass, in the dispersal regions, the introduction of new practices, namely im-

Table IV. Descriptive statistics for the factors affecting the calving interval (days) in Mirandesa cattle (Estatística descritiva para os fatores que afetam o intervalo entre partos na raça Mirandesa).

Factor	Level	n	$\bar{X}$	δ	Q_1	Q_2
Parity	1st	5242	421	392	355	461
	2nd	4963	406	379	347	436
	3rd	4333	401	375	345	427
	≥ 4th	12941	399	375	346	425
Breeding program	NBr	22027	403	376	346	431
	AI	5452	413	388	356	445
Season	Spring	9345	399	376	348	420
	Summer	5796	409	388	351	449
	Fall	4501	420	393	350	467
	Winter	7837	400	371	344	421
Year of birth	1996	1217	403	379	349	436
	1997	1546	408	384	353	438
	1998	1931	408	381	349	441
	1999	2127	408	382	351	437
	2000	2306	406	380	348	434
	2001	2433	401	376	346	431
	2002	2544	402	378	347	433
	2003	2490	397	372	344	422
	2004	2462	407	380	348	435
	2005	2668	403	375	344	428
	2006	2795	408	380	348	437
	2007	2960	407	379	347	442

n: number of cases; $\bar{X}$: mean; δ: median; NBr: natural breeding; AI:Artificial insemination

proved grazing or demarcated breeding seasons for heifers, harmonising grazing with the availability of nutritionally richer forages.

The AFC is a trait with low heritability. In a variable degree, differences in AFC may reflect the influences of managerial decisions and environmental factors than the genetic merit of an animal (Bourdon & Brinks, 1982). This study showed that both the production system and the season or the year of birth, which are often associated with the nutritional level in extensive systems, affected AFC of the breed. Heifers reared in the strict extensive system/dispersal region first calve later than those reared in semi-extensive system/home-region. The differences may relate to considerable reduction of the availability and nutritional quality of natural pastures, observed between August and October in the extensive system of the south region. As shown before, in southern Europe the natural grasslands present strong seasonality in forage availability and nutritional quality, contrasting with the regular and abundant pastures found in central and northern Europe (Revilla, 1993; Ligios et al. 2005; Casasús et al. 2012), and forage nutritional quality is an important non-genetic factor with impact in cattle fertility traits (Patterson et al. 1992; Lemenager et al. 1980; De Rensis & Scaramuzzi, 2003). This impact is mitigated in the semi-extensive/home-region system, where young animals are often strategically supplemented with farm by-products (e.g. young grass plants, grains, and cereals) (Rodrigues et al. 1998), allowing a better control of an adequate energy intake during the year and sustaining growth.

Accordingly, the influences associated with pastures cycles may be aggravated in particular years, due to extreme climatic conditions and the impact of climate change. This could account for the effects of the year of birth on Mirandesa´ AFC, which are similar to those recorded in other grazing beef breeds in the Mediterranean area (Casasús et al. 2002; Carolino et al. 2009). Mirandesa heifers born in 2004 were the oldest at first calving. In that year, a severe drought prolonged into the winter (Santos et al. 2007) and aggravated the poor quality of the natural pastures and also herds productivity in Portugal, negatively affecting the growth rate and fertility of animals (De Rensis & Scaramuzzi, 2003). The effects of season on the onset of puberty have been recognized for long (Schillo et al. 1992; Patterson et al. 1992). Overall, Mirandesa heifers born in spring and summer were younger at first calving than those born in fall and winter, contrasting with the described for Rubia Gallega (Cantalapiedra, 2003), but agreeing with the currently accepted positive influences of environmental factors on puberty onset (Schillo et al. 1992; Patterson et al. 1992). The lowest values found in heifers that born and first calve in the same farm, compared to those that born and first calve in different farms, suggests that managerial influences also strongly affect AFC in Mirandesa. Heifers selected for replacement and kept on the farm of birth are either reared under a closer surveillance of farmers or precociously selected, and thereby may be given a different treatment compared to the ones to be put on the market (Fragata & Sousa, 1997). Females that first calve in a different farm would need to adapt to a different location before breeding, and thus affected by acknowledged modulatory influences of the herd on the reproductive efficiency of cattle, including the herd size, management or environment (Pérez et al. 1997; Sanchez & Martinez, 2010).

In the case of PL, numerical values were close to that of Rubia Gallega (Vallejo et al. 1989) and agreed with other Iberian breeds such as Frieiresa, Vianesa, and Caldelana, and the Asturiana de los Valles (Goyache & Gutierrez, 2001; Goyache et al. 2002). Despite the existent breed-related variations, PL is a relatively constant parameter in cattle (Norman et al. 2009). Mirandesa PL was unaffected by the production system/region. It was also unaffected by the calving season, contrasting to the reported to Asturiana (Goyache et al. 2002) and Rubia Gallega (Becerra et al. 2006). As it is commonly reported in cattle (Vallejo et al. 1989; Hagger & Hofer, 1990; Goyache et al. 2002), calf gender influenced Mirandesa PL. Parity has also been pointed as a major non-genetic modulator of cattle PL (Bourdon & Brinks, 1982; Becerra et al. 2006; Norman et al. 2009; Yagüe et al. 2009) while the interactions of the cow´s age are controversial (Anderson & Plum, 1965; Reynolds et al. 1980), suggesting that in some production systems age and parity are more closely associated than in others. In Mirandesa breed, PL was affected by parity but not by age. Parity elongates Mirandesa PL in 0.39 days per calving (almost 4 days over 10 occurrences), a higher value than the reported by Silva et al. (1992) in dairy breeds. The most important difference existed for the first pregnancy, as recognized in the literature (Silva et al. 1992; Norman et al. 2009). Season interactions in PL were observed mainly in winter, but not towards other seasons, as described in the Asturiana de los Valles (Goyache et al. 2002). It was shown that the environmental temperature influences PL, which is longer in winter and shorter in summer (Andersen & Plum, 1965; Norman et al. 2009). However, as suggested by Norman et al. (2009), climatic influences over PL might have different impacts depending on genetics, or because it may impose variable constrictions related to farm facilities.

The median length of Mirandesa CI approaches the yearly interval reported for Maronesa (Payan-Carreira et al. 2006), with a production system similar to the semi-extensive used in Mirandesa home-region (Araújo et al. 2014), or for Asturiana de los Valles (Goyache & Gutierrez, 2001). Even though, the mean CI was almost one month longer. The CI in Mirandesa is slightly lower compared to other indigenous breeds, such as the Mertolenga, Barrosã or Alentejana breeds (CI ranging from 14.5 to 15 months; Carolino, 2006; Carolino et al. 2009), which are explored in similar extensive conditions in the dispersal region. However, the production system/region did not significantly impact the Mirandesa CI, which may be a consequence of the deferral at the moment for the first postpartum breeding practiced in the breed home-region as part of the farmer´s strategy to not overburden the cow with a new pregnancy while suckling a young calf. This practice also allows to reduce the production costs and to endorse the sustainability of the system (Viegas et al. 2011). Such practice contributes to bringing closer the CI between the two production systems (and therefore between home and dispersal regions). The adoption of a calf-under-cow system in the dispersal region/extensive production system, without partial weaning (used in the home-region), added to the seasonal fluctuations in the nutritional quality of natural pastures, would favour the inhibitory influences imposed on GnRH pulsatility and a delay in the resumption of regular ovarian activity (Crowe et al. 2014).

Parity also influenced CI. As described for other beef breeds (Werth et al. 1996), younger cows need more time to recover from the negative energy balance after calving (Oxenreider & Wagner, 1971; Short et al. 1990; Diskin & Kenny, 2014). However, Mirandesa CI was independent of the calf gender, contrasting to other reports (Bourdon & Brinks, 1983). This may be related to the differences in the calf weaning policies in the two production systems/regions (Sousa & Sanchez Garcia, 2009), or with the deferral in the moment of first postpartum breeding in the home region, as described earlier. So, although CI is often used as a predictor of cow fertility in production systems without fixed breeding season (Roughsedge et al. 2005), in Mirandesa cattle this character might be a poor indicator of the physiology capacity of the breed. However, the establishment of advisory criteria that take into consideration the body condition and sucking strategies should be envisaged to pursuit any new breeding targets in the breed. For this purpose, the surveillance of estrus behavior and the study of progesterone profiles during the early postpartum period would be critical to clarify the breed´s physiologic limitations.

The breeding program also impacts the CI in this breed, although these results mainly represent occurrences recorded for the home-region, as in the dispersal region the bull ranged with the cows year-round and no individual records existed for mating. These results may reflect the influences of the farmer ability in spontaneous heat detection, the male availability in the region or the efficiency of the AI.

The season and the year interacted with CI in Mirandesa cattle. Alike the Alentejano breed, CI were longer in winter calving cows compared to those calving in summer (Horta et al. 1990). Although cows are not seasonal breeders, it is generally accepted that the onset of ovarian activity in the post-partum cow may be directly or indirectly modulated by environmental factors such as nutrition or photoperiod. Hauser (1984) and Peter (1984) showed that postpartum anestrus was longer in winter compared with summer calved beef cows. The photoperiod influences results often from a complex interaction between day length (Hansen & Hauser, 1984) and other environmental factors such as nutrition (Hansen, 1985; Sanz et al. 2004), body condition (Horta et al. 1990; Sanz et al. 2004) or parity (Hansen & Hauser, 1984).

Calving was unevenly distributed during the year in Mirandesa cattle, in a pattern that differed between the two production systems/regions. It might correspond to an increased number of fertilizations occurring in summer and fall, respectively for the home- and dispersal regions. Taking into account the differences between regions in the forage cycle and climate, the calving spreading through the year copes with better fertility following periods of higher availability of native pastures (Lemenager et al. 1980), reflecting the local adaptation of farmers to the natural forage cycle, which may affect the energetic metabolism of cows and fertility (Baumont et al. 2009). Similar findings were reported for Alentejana cows (Horta et al. 1990).

Mirandesa presented a shorter PLf than reported for Simmental and Charolais breed (6.45 years vs. 7.9 and 7.1 years, respectively) (Szabó & Dakay, 2009), or the described for Alentejano and Hereford (10.3 years) or Angus cows (8.1 years) (Carolino & Gama, 2008). The modest PLf found for Mirandesa might reflect the European and national policies leading to a reduction in the national livestock activity. It may also result from the fact that the herdbook exists for a relatively short period. Further, our data showed that about 14% of cows have a productive lifespan of two years, denoting that a large proportion of females are sold before their first calving. This suggests that farmers select their animals both on the basis of the reproductive performance and on conformation, increasing the production costs and the inefficiency of the process. Moreover, it should be emphasized that 20% of the Mirandesa cows have a PLf of more than 10 years. As described by Szabó and Dakay (2009) for beef cattle, Mirandesa PLf was not affected by the factors tested herein, excepting the number of females in the farm and the CI. The lack of reliable predictors for PLf to be applied in the early stages of heifers productive life coupled with its low heritability are the main obstacles to the use of this trait in a selection program. It is commonly believed that cows retained in the farm to higher parities are also more fertile and started their reproductive activity earlier (Lemenager et al. 1980), which is also suggested in the present study by the negative association between CI and PLf in Mirandesa. A limited number of records existed for cows with more than 10 calving, usually in home-region, corresponding to females that proved their fitness for character or land work. This suggests that these cows stay on the farm as long as they maintain their productive efficiency, as it happens in other beef breeds (Gutiérrez & Goyache, 2002).

CONCLUSIONS

The results of this study pointed out the main non-genetic factors affecting the Mirandesa breed reproductive traits, which can be used to devise a suitable breeding plan targeting the demands for a more competitive reproductive performance. Data gathered in this study will support changes in the breeding programmes and the optimization of both the cow and the system productivity, and may also be of interest for other Mediterranean countries, as some aspects can be extrapolated to extensive production systems. Taking into account all the non-genetic influences exerted over the Mirandesa reproductive traits, it is our opinion that new targets in the Mirandesa reproductive traits may be foreseen in any breeding programme to be designed in the future: earlier introduction of the heifers into reproduction, reduction of the calving intervals by farmer education on weaning management and strategies for improved nutritional plans, particularly in the dispersal regions. During the implementation of new breeding targets, advisory actions should be contemplated to improve the production system efficiency, acting close to farmers and taking into account the environmental and cultural aspects underlying non-genetic factors identified herein. Further, inbreeding control and a careful selection of the pairs cow/bull (breeders), should be pivotal for farmers and the ACBRM to combat the genetic bottlenecks reported to exist. These measures together would allow increasing the Mirandesa breed competitiveness in the market of PDO meat.

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