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CICLO XXV°

PRODUCTION AND ECONOMIC TRAITS OF PUREBREED AND CROSSBRED ANIMALS IN DAIRY HERDS OF MOUNTAIN AREAS

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RIASSUNTO

La produzione di carne da parte degli allevamenti di vacche da latte rappresenta un'interessante opportunità per gli allevatori come strategia per l'incremento della redditività aziendale. L'impiego del toro da carne per la fecondazione di bovine da latte non destinate a produrre la rimonta aziendale permette di ottenere un indubbio guadagno dalla vendita dei vitelli meticci se paragonata alla vendita dei vitelli puri. Purtroppo, tale pratica è quasi scomparsa nelle stalle specializzate ad alta produttività di pianura a causa di un'elevata quota di rimonta dovuta principalmente a problemi di fertilità e longevità delle bovine da latte.

Nelle aree di montagna, caratterizzate da una dimensione aziendale medio-piccola, la pratica dell'uso del toro da carne sulle vacche da latte rappresenta ancor oggi la normalità poiché il livello produttivo medio aziendale associato ad una buona fertilità e longevità delle razze bovine allevate permette di mantenere una bassa quota di rimonta e quindi di poter destinare tutte le bovine eccedenti la rimonta ad essere fecondate con razze specializzate da carne in modo da massimizzare il profitto ottenibile dalla vendita dei vitelli baliotti.

In provincia di Trento la federazione degli allevatori ritira e vende settimanalmente i vitelli dalle stalle dei soci ad un'età media di circa 24 giorni. I soggetti che presentano le migliori potenzialità per quanto riguarda la produzione della carne sono dapprima ceduti ad aziende specializzate per lo svezzamento e poi trasferiti presso centri specializzati d'ingrasso. Alla fine del ciclo d'ingrasso tali soggetti sono macellati e la carne è venduta all'interno di una filiera controllata distribuita capillarmente a livello provinciale per cui l'animale nasce, è allevato e macellato nella stessa area di produzione; il tutto garantito da marchio di certificazione.

Oltre a seguire vitelli e ingrasso degli stessi la Federazione allevatori di Trento ritira settimanalmente dagli allevamenti da latte dei soci e vende ad un unico macello, a cui è associata, tutte le bovine a fine carriera.

Gli obiettivi della presente tesi di dottorato sono stati quelli di valutare dal punto di vista produttivo ed economico l'intera filiera di produzione della carne in ambiente montano. Il primo contributo ha studiato le fonti di variazione che influenzano l'età, il peso, il prezzo e il valore commerciale di vacche a fine carriera in fase di macellazione. Nel secondo contributo sono state analizzate le fonti di variazione che influenzano età, peso vivo, e valore dei vitelli raccolti a circa 24 giorni di vita dalla Federazione allevatori di Trento e nel terzo contributo è stata valutata l'influenza della destinazione del vitello (carne bianca o vitellone) e della razza sui caratteri produttivi ed economici degli animali. Infine, nel quarto contributo, sono stati analizzati i caratteri legati al peso e al valore finale di vitelloni e manze da carne in fase di macellazione.

I risultati del primo contributo hanno evidenziato l'importanza economica delle vacche da riforma e hanno mostrato significative differenze fra le razze analizzate. Le vacche di razza Frisona Italiana hanno mostrato delle performance in termini di peso e valore alla macellazione peggiori della Bruna Italiana, mentre le razze a duplice attitudine (Pezzata Rossa) hanno mostrato una maggiore redditività alla vendita.

I risultati derivanti dall'analisi delle performance produttive ed economiche dei vitelli raccolti settimanalmente dalla Federazione Allevatori di Trento hanno evidenziato maggiori pesi alla vendita e valori commerciali per i vitelli provenienti da razze a duplice attitudine rispetto alle razze specializzate da latte. I vitelli ottenuti dall'incrocio fra toro da carne (Blue Belga) e vacche a duplice attitudine (Pezzata Rossa) sono risultati i migliori sia in termini di peso vivo che di prezzo e valore alla vendita. La maggior parte dei vitelli maschi derivanti da razze specializzate da latte sono destinati alla produzione del vitello a carne bianca mentre i vitelli derivanti dall'incrocio con il toro da carne sono maggiormente destinati alla produzione del vitellone da carne.

I risultati del contributo finale hanno permesso di caratterizzare i pesi e i valori commerciali di vitelloni e manze da carne ingrassati all'interno della Provincia di Trento. I vitelloni e le manze derivanti dall'incrocio fra toro Blue Belga e vacca Pezzata Rossa hanno evidenziato le migliori performance produttive (peso della carcassa e accrescimento medio giornaliero) ed economiche alla macellazione. Tuttavia i migliori risultati economici sono stati evidenziati dai vitelloni e manze da carne derivanti dalla combinazione fra Blue Belga e Frisona Italiana e dai vitelloni derivanti dalla Pezzata Rossa; questo risultato è legato alla ridotta valutazione economica dei vitelli che derivano dall'incrocio con la razza Frisona Italiana.

I risultati saranno utili per gli allevatori come linea guida per massimizzare il reddito proveniente dalla vendita di vitelli, dell'ingrasso degli stessi e dalla vendita delle vacche a fine carriera come fonte di integrazione del reddito aziendale.

SUMMARY

Beef production from dairy herds represents an alternative source to improve the farm profitability. The use of beef semen to mate cattle not destined to breed replacement represent an interesting source of income for dairy farmers particularly due to the greater price and value of crossbreed calves respect purebred calves at sale. Unfortunately this practice has been decreasing in the last years in the more specialized herds of the Po valley mainly due to fertility and longevity problems of the high productivity dairy cattle. However, on the mountain area, were farms are characterized by less productivity but high longevity and fertility of their cattle, the low replacement rate permitted each year the use of beef sire to mate a considerable number of cattle not destined to breed replacement.

In the Trentino area (North of Italy) every week the breeding federation collected calves from associated dairy herds and the best of these for beef traits, following weaning at specialized farms, were fattened at local associated fattening farms. After fattening, young bulls and heifers are slaughtered at the same abattoir and the meat are sold at the central butchers and to the entire cooperative wire markets of the Province. This meat is sold with a certified mark that guarantee birth, fattening and slaughtering of the animals in the same area. Moreover, weekly, the breeding Federation of Trento province collected cull cows from associated dairy herds too and these cattle are sold to an associated abattoir.

The aim of the present thesis were to study production and economic traits from the whole beef output from dairy herds in mountain area; the first contribute of the thesis analyzed production and economic traits of slaughtered cull cows while the second and the third contributes analyzed production and selling traits of calves at sale (average 24 days of age). Finally the last contribute studied production and economic traits of young bulls and heifers at slaughter respect the purchase beginning value of calf.

Results of first contribute evidenced that the value of cull cows at slaughter represents a significant source of income for the dairy farm and the large differences among different breeds for cull cow value suggests its possible inclusion in the selection objectives of these breeds. Holstein-Friesian cows were younger at slaughter, yielded lighter carcasses and received a lower price and total value than Brown Swiss cows while dual purpose breeds were older, heavier and received a greater price and value at slaughter than both dairy breeds.

Results from the study that analyzed calves traits had evidenced that the dual-purpose purebred calves received, on average, greater price and value at sale than purebred dairy calves. Furthermore, among crossbreed calves, the progeny from Belgian Blue sire and Simmental dam evidenced the greatest live weight and selling values. Moreover, results evidenced that the majority

of purebred calves from dairy dams were most likely destined for veal production while many dual-purpose calves were most likely destined for beef production as well as the vast majority of beef crossbreed calves.

Results from the final contribute evidenced that crossbred young bulls and beef heifers from Belgian Blue sires and Simmental dam achieved the highest carcass weight and the best daily gain and carcass value. The best economic revenue was achieved by Simmental bulls among purebred animals, and by Belgian Blue sire x Holstein Friesian dams, among crossbreed animals. This is mainly related to less purchase value of calves at the beginning of the fattening period.

Results might be useful for the farmers as guideline to quantify an alternative source of income and to improve the farm profitability obtained from beef production in dairy herds.

GENERAL INTRODUCTION

Beef production in the world, Europe and Italy

Meat production in the world has continuously increased from 70 million of tons in 1960 to 300 millions tons in 2010 (Bologna, 2012). This phenomenon was mainly due to an increase of beef consumption over the years. In 2010 the world beef industry accounted for a total production of 64.089.470 tons of beef (11.027.928 tons from the EU). The world stocks of cattle in the year 2010 accounted for a total of 1.430.101.597 heads and accounted for 124.520.461 heads in the EU (FAO, 2010). The United States, Brazil, and the UE raised the majority of cattle in the world, and among EU countries France raised the majority of cattle (close to 20 millions of heads) followed by Germany (close to 13 millions of heads) and United Kingdom (close to 10 millions of heads). In the East-Europe, more than 5 millions of heads are raised by Poland (Bologna, 2012).

The beef consumption per capita varied among European countries and ranged from less than 2 kg for Romania to more than 25 kg for France. Italy represents the second country for beef consumption per capita with about 23 kg. However, the average value of beef consumption per capita in the EU27 is 15 of kg (Bologna, 2012).

Italy has a tradition in beef cattle production and represents the third main contributor to the total cattle meat produced in Europe after France and Germany. However, the main relevant problem of the Italian meat industry is the strong dependence on imported live animals from foreign countries. The production of bovine meat in Italy is composed of two different typologies: veal and beef (Cozzi, 2007). [1] Veal production system originated mainly from purebred males calves from the two most widespread dairy breeds raised in Italy (Brown Swiss and Holstein Friesian) collected from dairy farms at an average age of 20-25 d. The production of veal in Italy is concentrated in big units (500-600 heads) in the Veneto and Lombardia regions (north Italy); animals are never weaned but fed mainly a milk replacer and small amount of roughage only to provide a minimum rumination. Veal calves are slaughtered at an average age of 180 d and an average live-weight of 230-250 kg. [2] Beef production system originated from three different breed types of animals: specialized cosmopolitan beef breeds, mainly imported from abroad at an average live-weight of 300-400 kg and subsequently fattened and slaughtered at 16-17 mo of age and 650 kg of live-weight (Myers et al., 1999; Cozzi and Ragno, 2003b); dual-purpose purebred calves (particularly male calves because almost all females are reared in the farm of birth as future replacements) originated from dairy farms and sold at approximately 15-20 d of age and subsequently weaned and fattened in specialized farms; and beef crossbreed calves originated from dairy and dual-purpose dams mated with specialized beef bulls. Young beef bulls and heifers are slaughtered at a different age: heifers are slaughtered early at approximately 500 kg of live-weight and 14-16 mo of age while bulls are slaughtered later at approximately 16-18 mo of age and 650 kg of live-weight. Specialized beef farms in Italy are located mainly in Veneto and Lombardia regions. The fattened diet is based on maize-silage and concentrates to promote the maximum individual gain, and it is usually provided as total mixed ration. Less production of beef in Italy originated from Italian specialized beef breeds, particularly in Piemonte region and in the central part of Italy.

Livestock production in Trento province

In mountainous regions, livestock farming has traditionally been of great importance for the vitality of the rural economics (Baldock et al., 1996), where mutually dependent social, economic, technical and cultural changes are leading to the abandonment of agriculture in marginal areas and to the intensification of farming in the most favourable valleys (Mac Donald et al., 2000; Strijker, 2005). Traditional, low-input farms, which played a fundamental role in landscape and ecosystem modeling, are facing abandonment or conversion into more profitable intensive holdings. Both abandonment and intensification lead to a loss of open areas and forest re-growth (Cocca et al., 2012), a loss of biodiversity (Giupponi et al., 2006; Marini et al., 2011), and radical socio-economic changes (Bernues et al., 2005).

In mountainous areas, traditional dairy farms provide multifunctional services. In the Italian Alps, several Protected Designation of Origin (PDO) cheeses are produced (Bovolenta et al., 2011) with an added-value chain that helps to maintain a satisfactory income for farmers. These farms use local forages and highland pastures, preserving the landscape from reforestation and contributing to the maintenance of biodiversity (Giupponi et al., 2006; Cocca et al., 2012). Such a services increase the touristic vocation of mountainous areas, contributing to the economic and social development of rural communities (Scarpa et al., 2010), and thus the maintenance of profitable farms that have adapted to the environmental constraints and are able to guarantee the conservation of traditional land uses is one of the key issues for rural development in mountainous areas (Bernues at al., 2011). The Province of Trento (northern Italy; Figure 1) covers an area of 6,200 km^2 and has been classified as mountainous for the national statistical database (ISTAT, 2010). Utilized agricultural area is predominantly characterized by meadows and pastures (81%), followed by orchards and vineyards (17%). Arable crops represent only 2% of land (ISTAT, 2010). Different breeding typologies are summarized in Table 1.

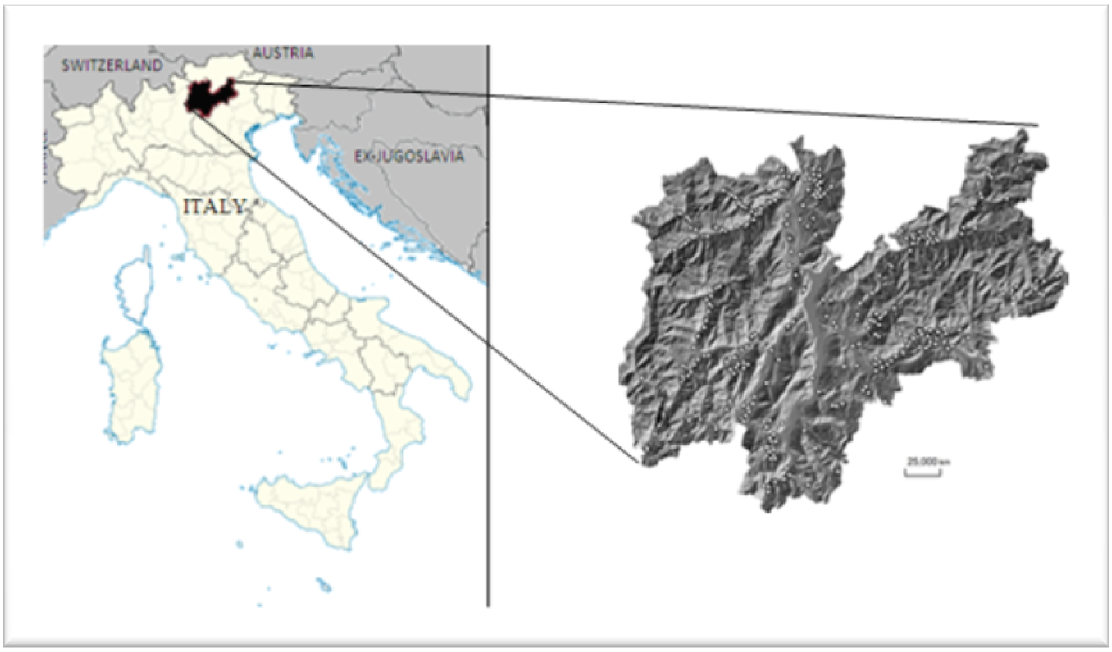
Table 1. Number of heads and farms for each breeding typology in Trento province.

	Heads (N)	Farms (N)
Dairy cattle	38,700	1,111
Sheep	27,653	330
Goats	9,300	420
Beef cattle	8,250	350
Horses	3,700	1,130
Swine	3,938	25

*source: Veterinary database

The breeding of dairy cattle is the predominant agricultural activity. The mean number of heads for farm is 34.3 of which 22.5 are older dairy cattle producing milk and 11.8 are younger animals reared as replacement. Single-breed farms (i.e., farms with more than 90% of cows belonging to only one breed) represented only 31% of the total herd of the area.

Figure 1. The Trento province of Italy.

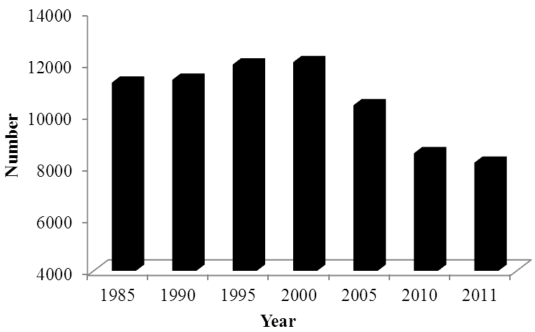


The vast majority of farms are associated with the Consortium of Dairy Cooperatives of the Trento Province (CONCAST) which mainly produces ripened cheeses according to traditional techniques. The pattern of number of dairy cattle reared under official milk recording for each breed from 1985 to 2011 is summarized in Figure 2.

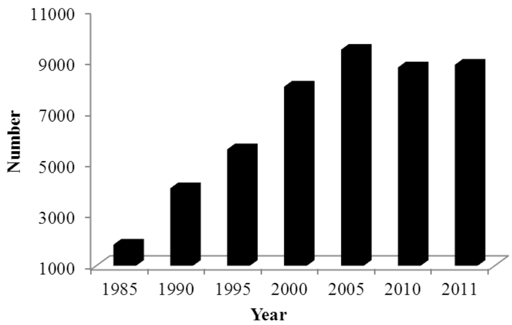
In 1985, the main breed reared in the province was Brown Swiss, an Alpine breed that accounted for 80% of recorded heads (AIA, 1985). At that time, this breed was genetically close to the original dual-purpose Braunvieh cattle native to Switzerland, but a massive importation of bulls and semen from the USA contributed to almost completely replacing the original Alpine breed with the heavily selected dairy strain from America. Therefore, the Brown Swiss cows farmed now are much more specialized for milk production than those farmed a few decades ago (Sturaro et al., 2012). The other 20% of cows farmed in 1980 were mainly from the autochthonous, medium-framed, dual-purpose Alpine Grey and Rendena breeds. Dual-purpose Simmental and Holstein Friesian cows were less present and only in a few farms.

Figure 2. Number of dairy cattle officially recorded for each breed from 1985 to 2011 in Trento province (a = Brown Swiss; b = Holstein Friesian; c = Simmental; d = Alpine Grey; e = Rendena).

a



b



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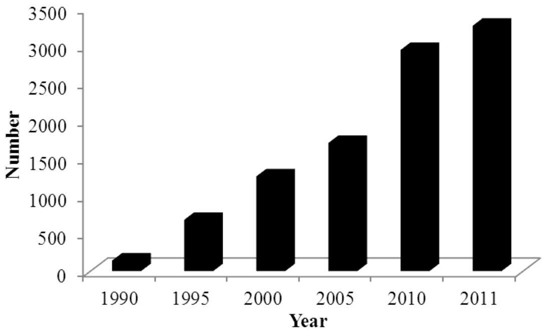

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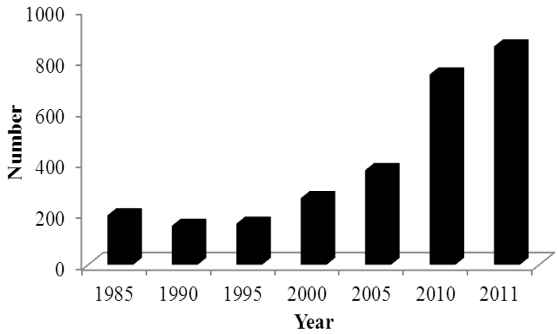
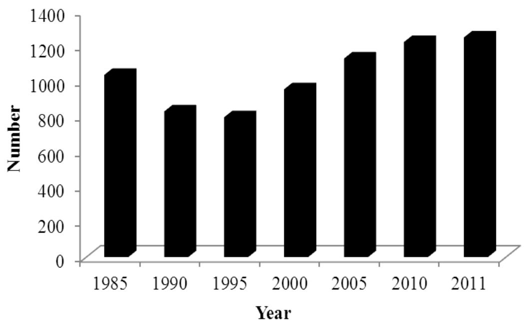


e



*source: Breeders Federation of Trento province

Nowadays the situation is totally changed; particularly Holstein Friesian has become the most numerous breed in the Trento Province and the dual-purpose Italian Simmental (mainly improved by German and Austrian Fleckvieh) has gained importance (Sturaro et al., 2012). The substitution of the original dual-purpose strain with the dairy specialized one did not preserve the Brown Swiss breed from paying a heavy tribute to the tendency toward more intensive dairy systems (the incidence of this breed was halved in 30 years). Nevertheless, Brown Swiss still represents the most important breed in the traditional dairy systems with the majority of lactating cows moved to Alpine high pastures during the summer (Sturaro et al., 2012). The recent evolution of the breed and of its role in the different Alpine dairy systems suggests that the future of the Brown Swiss (and also of large part of mountainous territories) will depend more on its selection for fertility and longevity (Dal Zotto et al., 2005 and 2007a; Rossoni et al., 2007; Tiezzi et al., 2011), milkability (Santus and Bagnato, 1998; Povinelli et al., 2003), milk quality (De Marchi et al., 2009 and 2011; Cipolat-Gotet et al., 2012), and harsh environment adaptation (Bovolenta et al., 2009), than on further improvements in productivity.

Local Rendena and Alpine Grey breeds maintain constant numbers over the years due to subsidies devoted to endangered breeds and to the high value of purebred and crossbred calves when used for beef production (Dal Zotto et al., 2007b and 2009). The maintenance of local breeds in mountainous areas is particularly important for several reasons: conservation of livestock biodiversity, non-productive services such as the maintenance of marginal open areas and ecosystems with high natural values (Hoffman, 2011), and cultural value (Gandini and Villa, 2003). Beef production favors the maintenance of these breeds in mountainous areas. Despite the fact that the value of Brown Swiss calves destined for veal production is similar to that of Holstein Friesian calves (Dal Zotto et al., 2009), the price paid for these calves is characterized by a moderate genetic variability (Penasa et al., 2012). Moreover, the longevity of this breed in a mountainous environment favors the practice of mating any cows in excess of replacement needs with beef bulls, mainly double muscled Belgian Blue bulls. The total value of Belgian Blue crossbred calves compared with Brown Swiss purebreds is high and greater than the value of other dairy and dual-purpose breeds reared in the region (Dal Zotto et al., 2009).

The production of beef crossbreed calves from dairy farms in Italy is important (i) to reduce the strong dependence on foreign countries for young bulls and beef heifers as intact replacements of specialized beef farms; every year, about one million of heads are imported from abroad (mainly from France) to specialized beef farms (ISMEA, 2006) (ii) beef crossbreeding practice represents also a valuable source of income for the farmers because crossbreed calves are much more valuable than purebred calves as recently confirmed by several Italian (Dal Zotto et al., 2009) and European (Mc Hugh et al., 2010) studies.

Nowadays, the practice of beef crossbreeding has been decreasing in the more specialized dairy farms of the Po valley due to fertility and longevity problems, but this practice could increase again with the increasing use of sexed semen (Hohenboken, 1999; Cerchiaro et al., 2007). However, in the alpine area, characterized by a big number of small dairy farms, the better fertility and longevity of the cattle permit to mate each year more than 30% of cows with beef bulls (Dal Zotto et al., 2009) and the income obtained from the sale of crossbreed calves can counterbalance the less production of milk.

The best economic revenue from the sale of crossbreed calves (average age of 24 d) compared with purebred calves (particularly dairy calves) has been recently confirmed by Dal Zotto et al. (2009). Best production and economic traits of crossbreed bulls and heifers compared with purebred animals has been already investigated by several studies in the past (Cundiff, 1970; Nelson et al., 1982; Cundiff, 2001). Recently, the highest carcass value of beef x dairy crosses has been confirmed (Wolfovà et al., 2007). Furthermore, crossbreed cattle showed better dressing percentage than purebreds (Güngör et al., 2003), and the meat from crossbreed animals showed better eating characteristics than that from dairy animals (Davies et al., 1992).

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AIMS

The sale of animals destined to meat production (cull cows and calves) from dairy herds represent a valuable strategy to improve the farm profitability. The general aim of the present thesis was to investigate production and economic traits related to meat production originated from dairy herds in mountain areas. The thesis consists of four chapters which aimed to:

[1] investigate factors associated with age at slaughter, carcass weight, price, and value in culled dairy and dual-purpose cows sold weekly from mountain dairy farms to a commercial abattoir;

[2] quantify the animal-level factors associated with calf price and live-weight of calves collected weekly from dairy herds and sold by the Breeders Federation of Trento Province (Italy);

[3] to quantify the effect of the inclusion of the production destination system effect in explaining the variation for age, live-weight, price and value of calves at sale using the same data of the previous chapters;

[4] compare production and economic traits of dual-purpose purebred young bulls and crossbreed young bulls and beef heifers from Belgian Blue sires and dairy or dual-purpose dam breeds.

CHAPTER 1

Factor associated with carcass weight, value and price in dairy cull cows

ABSTRACT

The sale of cull cows contributes to the overall profit of dairy herds. The objective of this study was to quantify the factors associated with slaughter age (months), cow carcass weight (kg), price (€/kg carcass weight) and value (€/head) of dairy cull cows. Data included 20,995 slaughter records between the years 2003 to 2011, from 5 different breeds: 2 dairy [Holstein Friesian (HF) and Brown Swiss (BS)] and 3 dual-purpose [Simmental (Si), Alpine Grey (AG) and Rendena (Re)]. The association between herd, breed, year, month of slaughter and age (not for slaughter age) with slaughter age, carcass weight, price and value were quantified using fixed effects models. The seasonal trends of cow price and value traits were inversely related to the number of cows slaughtered, while annual variation reflected the effect of external factors affecting market conditions. Holstein-Friesian cows were younger at slaughter (74.6 vs 81.2 months), yielded slightly lighter carcasses (240 vs 245 kg) and received a slightly lower price (1.69 vs 1.73 €/kg) and total value (384 vs 416 €/head) than BS cows. Dual purpose breeds were older, heavier and received a much greater price and total value at slaughter (518, 522, and 557 €/head, respectively for Si, Re, and AG) than both dairy breeds. Of the dual purpose cows, Si carcasses were heavier (270 kg) while carcasses of local breeds received a higher price (2.03 and 2.17 €/kg for Re and AG, respectively). Alpine Grey cows were the oldest at slaughter (91.9 mo) reflecting greater longevity. The price per kg of cull cow carcass was greatest for very young cows, below 3 years of age and the differential in price and value between younger and older cows was greater in dual purpose than dairy breeds.

Large differences in cull cow carcass value among the dairy breeds suggests such traits could be considered in the selection objectives of the breeds. Results suggested that, regarding the effect of increasing weight of carcass, the increase in total value of carcass was much higher than the gain in weight and so it depended more on enhancement in unitary price paid. Therefore, the quantification of the combined effect of weight and price on the increase of the value of carcass highlight the possible economic advantage of fattening culled cow prior to slaughter.

Key words: cull cow, carcass price, carcass value, age at culling

INTRODUCTION

The sale of cull cows represents a revenue for the dairy farms. Beef originating from culled dairy cows accounts for approximately 13% of domestically produced beef in USA (USDA, 2005). Similarly, a considerable proportion of meat in European countries originates from dairy cull cows (Liboriussen, 1980; Van Arendonk et al., 1984; Seegers et al., 1998; Cabaraux et al., 2005; Vestergaard et al., 2007).

Factors influencing the decision to cull dairy cows include reproductive failure, mastitis and udder problems, low milk production, and old age. Several studies (Gravert., 1980; Fetrow, 1988; Milian-Suazo et al., 1988; Beaudeau et al., 1993; Esslemont et al., 1997; Bascom and Young, 1998; Ruegg et al., 1998) have documented reproductive failure as the primary reason for culling, accounting for approximately 23 % of culling events (Allaire et al., 1976). Mastitis and udder problems were identified as the second most important reasons for culling (Fetrow, 1988; Bascom and Young, 1998; Smith et al., 2000; Cesarini et al., 2003) accounting for approximately 16% of culling.

Breed of cow has been reported to influence culling rate (Heikkilä et al., 2012), but has also been documented to influence carcass weight and the value of cull cows (De Boer et al., 1980; Wiemer et al., 1982) as well as meat quality characteristics in beef cows (Dransfield et al., 2003). Several studies analyzed the effect of plane of feeding on slaughter and meat traits, particularly in beef cull cows. Vestergaard et al. (2007) and Schnell et al. (1997) both reported clear differences in carcass characteristics of cull cows fed different diets. Increasing the nutritional plane of cull cows through supplementation prior to slaughter improved carcass characteristics (Swingle et al., 1979; Matulis et al., 1987; Brown and Johnson, 1991; Cranwell et al., 1996; Minchin et al., 2010) as well as conformation and carcass fat level (Apple, 1999) and tenderness of meat (Miller et al., 1987).

Furthermore, several studies have also documented an effect of age at slaughter on carcass traits of dairy and beef cull cows (Van Arendonk et al., 1984; Seegers et al., 1998; McHugh et al., 2010) and also on BCS and carcass conformation (Vestergaard et al., 2007).

The aim of this study was to investigate the association between cow breed, year and month of slaughtering, with age at slaughter, carcass weight, price, and value in culled dairy and dual-purpose cows.

MATERIALS AND METHODS

Animal Care and use committee approval was not obtained for the present study because all the data originated from a pre-existing database from the Breeders Federation of the Trento (Trento, Italy).

Data

Slaughter records on 20,995 cull cows of 5 different breeds [2 dairy: Holstein Friesian (HF) and Brown Swiss (BS), and 3 dual purpose: Simmental (Si), Rendena (Re) and Alpine Grey (AG)] originating from 486 dairy herds, between the years 2003 and 2011, were provided by the Breeders Federation of Trento (Trento, Italy), located in Northern Italy. Crossbred cows were not included in the analysis due to a paucity of data. Cull cows were collected from dairy farms each Wednesday by the Breeders Federation and, on Thursday, the cows were transported to a commercial slaughterhouse (Italcarni, Pegognaga, Italy). Information available on each animal included herd, breed, birth date, slaughter date, carcass weight (kg), and carcass value (€). Age at slaughter (months) and carcass price (€/kg) were computed.

Only purebred dairy and dual purpose cows between 24 and 200 months of age at slaughter, with a carcass weight between 170 and 400 kg and a carcass value between € 200 and € 1,200 were retained. Furthermore, only animals from herds that supplied at least 10 culled cows across the whole study period were retained. Following these edits, 8,927 HF, 9,555 BS, 1117 Si, 917 Re, and

479 AG culled cows remained for inclusion in the analysis. In 25.5 % of the herds only one breed of cow was represented, while in 39.3 % of the herds and 28.0 % of the herds two and three breeds were represented, respectively.

Statistical Analysis

Factor associated with age at slaughter (months), carcass weight (kg), carcass price (€/kg), and carcass value (€) of cull cows were quantified using the following fixed effect linear model (SAS, 2008):

$$y_{ijklm} = \mu + herd_i + breed_j + year_k + month_l + age_m + b \times CW + e_{ijklmn},$$

where y_{ijklm} is the observed trait; μ is the overall intercept of the model; $herd_i$ is the fixed effect of the i^{th} herd (i = 1 to 486); $breed_j$ = fixed effect of the j^{th} breed (j = HF, BS, Si, Re, AG); $year_k$ is the fixed effect of the k^{th} year of slaughter (k = 2003 to 2011); $month_l$ is the fixed effect of the l^{th} month of slaughter (l = 1 to 12); age_m = is the fixed effect of the m^{th} class of age of cull cow (< 3 years of age, between 3 and 4 years, between 4 and 5 years, between 5 and 6 years, between 6 and 7 years, > 7 years); b×CW is the linear regression on carcass weight, and e_{ijklmn} is the residual random error term ~ N (0, σ^2_e).

Also, two way interactions between breed and year, breed and month, year and month, and between breed and age were tested for significance in the model. Age was not included in the analysis as an independent variable when age at slaughter was the dependent variable and b×CW was only included in the analysis of carcass price. Moreover carcass value was also analyzed with a second model including a within-breed linear regression on carcass weight to generate an estimate of the marginal effect of increasing carcass weight for different breeds. Orthogonal contrasts for different combination of breeds were also undertaken.

RESULTS

The frequency distribution of age at slaughter, carcass weight, carcass price and carcass value is in Figure 1. Cows were, on average, slaughtered at 74 months of age (i.e., over 6 years of age) with an average carcass weight, price, and value of 257 kg, 1.71 €/kg and 455 €/head, respectively. All the distributions were skewed and, in the case of price and value of the carcass, were also bimodal.

Results from the analysis of variance of the slaughter traits are summarized in Table 1. The coefficient of determination of the model was 0.19, 0.25, 0.82, and 0.26 when the dependent variable was slaughter age, carcass weight, price, and value, respectively. All the main effects included in the model were associated ($P<0.001$) with each dependent variable with the exception of year and month of slaughter which were not associated with age at slaughter and year of slaughter and breed × months which were not associated with carcass weight.

Spearman rank correlations between traits identified a strong positive correlation between carcass weight and price (0.77; $P<0.001$) and, as expected, between carcass value and its constituent traits carcass weight (0.91; $P<0.001$) and price (0.96; $P<0.001$). Near zero correlations existed between slaughter age and both carcass price (0.06; $P<0.001$) and value (0.02; $P<0.01$) (data not shown).

Year and month of slaughter

Carcass weight, price, and value varied across the months of the year (Figure 2). However, carcass weight varied to a lesser extent across the months of the year than either carcass price or value. The lowest carcass weight, price, and value occurred in September (245 kg, 1.77 €/kg; and 449 €/head; respectively), while the highest carcass weight occurred in January (258 kg), the highest carcass price in June (1.89 €/kg), and the highest carcass value in May (500 €/head).

The annual pattern in both carcass price and value was similar to each other, increasing from 2003 to 2011 by 42.5% (from 1.46 to 2.08 €/kg) and 47.3 % (from 372 to 548 €/head), respectively (Figure 3). However, the association between month of slaughter and carcass weight, value, and price differed by year of slaughter (Table 1).

Breed of cow

The majority (i.e., 88 %) of the data in the present study originated from cows of the two dairy breeds (HF and BS); the remaining cows were dual-purpose breeds (Si, Re, and AG). Breed was the most strongly associated ($P<0.001$) factor for all of analyzed traits.

The dairy breeds were significantly younger at slaughter, had lighter carcasses, and received the lowest price (at a constant carcass weight) and value than dual purpose breeds (Table 2). Within the dairy breeds, the HF was inferior to the BS for all traits considered (i.e. HF cows, on average, were younger, lighter, and received lower carcass price and value than BS cows).

Among the dual purpose breeds, Italian Simmental cows, on average, yielded heavier carcasses, while the cows of the local breeds were characterized by older age at slaughter and by a higher price per kg of carcass. There was no difference in carcass weight and price among the dual-purpose breeds (Table 2). Among the local dual purpose breeds, the AG were oldest at culling and received the greatest carcass price.

The association between breed with the slaughter traits however differed by year of slaughter (data not shown). A decrease of age at slaughter from 2003 to 2011 was observed and it was very marked for dairy breed (6.2 and 7.4 months younger for HF and BS, respectively) while it was quite limited for the dual-purpose breeds (1.9, 0.4 and 1.3 months younger for Si, Re, and AG, respectively).

Carcass weight showed very limited variation across years ranging from 250 kg to 253 kg in 2003 and 2011, respectively. Carcass weight of BS, HF, GA and Re showed limited variation across years (from 1 to 4 kg) while the carcass weight of Si decreased by approximately 1 kg per year from the year 2003 to 2011.

Carcass price increased for all breeds across time (from 2003 to 2011) but increased more for Si and less for Re cull cows (0.74 and 0.49 €/kg, respectively; data not shown) while the carcass price of both dairy breeds and AG local breed increased at a similar rate across time (0.64, 0.65 and 0.63 €/kg for HF, BS, and AG, respectively; data not shown). The increase in carcass value across years (from 2003 to 2011) was very similar for the two dairy breeds and for Alpine Grey (166, 167 and 179 €/head for HF, BS and AG, respectively), while it was greater for Si and less for Re (239 and 130 €/head, respectively) (data not shown).

Age at slaughter

Young cull cows (less than 3 years old) had lighter carcasses (236 kg) but received the greatest carcass price (€2.02/kg) and a high value (€501/head) (Table 3). Carcass weight increased with age at slaughter until 5-6 years (Table 3). Carcass price of cows slaughtered after 3 years remained relatively constant, while carcass value tended to increase up to 5-6 years after which it decreased.

DISCUSSION

Dairy farming in the Alps

Different dairy systems exist in the Alps varying from very traditional to the more intensive (Sturaro et al., 2009 and 2012; Cocca et al., 2012). The typical traditional mountain farm is based on a small number of cows from the Alpine breeds, like the Brown breeds, Red and White Simmental derived breeds, and local breeds (Bittante, 2011). From autumn to late spring, cows are kept tied in the barn of the main farm in the valleys, and feeding is based on hay and some concentrate, with limited farm pasture (Sturaro et al., 2009). During the summer, the cows and replacement heifers are transported to the summer Alpine highland pastures. The traditional dairy systems of the Alps are based on seasonality, with calving concentrated in the autumn and mating during the winter, so that the majority of cows are in late lactation when moved to the highlands.

Traditional dairy farms in the Alpine regions are characterized by lower average milk yield than more intensive farming systems and by higher labor input per unit milk (Sturaro et al., 2012). The traditional dairy farms partly compensate economically for this lower output by also having lower costs of production (Tiezzi et al., 2011 and 2012), and especially, capital costs, and external (feed) input costs. Moreover, in some areas, like Trento Province, traditional farms receive a milk price premium (20% to 40% greater; Sturaro et al, 2012) because of the superior technological properties of the milk produced (De Marchi et al, 2007; Bittante et al., 2012; Cipolat et al., 2012) and the absence of silage and genetically modified organisms in the diet that qualify their milk for high priced cheeses labeled with the protected designation of origin (PDO) by the European Union (De Marchi et al., 2008; Bittante et al., 2011a, b and 2012).

One option to partly compensate for the lower milk output in the traditional farming systems is to increase income from meat production, both as surplus calves and culled cows. Traditional mountainous dairy farms sell a higher proportion of newborn calves, owing to the superior fertility and longevity of their dairy cows, and therefore a reduced requirement for replacement females. These surplus calves therefore belong to breeds characterized by, on average, higher selling price and weight. Moreover a higher proportion of cows from these herds are mated to beef bulls, often Belgian Blue sires, for the production of high priced crossbred calves (Dal Zotto et al., 2007 and 2009). The value of cull cows is also an important revenue source and the effect of different breeds on cull cow price is, to-date, not well documented.

Age at slaughter of culled cows

The average age of cull cows in the Trento Province at culling (74 mo, Figure 1) was higher than the average age at culling from more intensive dairy areas of Italy (Ahlman et al., 2011;

Hultgren et al., 2011; Romer, 2011; Zavadilová et al., 2011; Sasaki et al., 2012). Age at culling, however, had a high coefficient of variability (41%, Figure 1) and the sources of variation included in the model explained only 19% of the phenotypic variability (Table 1). The most important sources of variation were herd and breed of the cow, followed by the interaction between breed and year of slaughter.

Even if the average age at slaughter of culled cows in the Trento Province was greater than the longevity of the cows enrolled in the national herdbooks, the differences among the dairy and dual purpose breeds of the Alpine province reflect the differences in longevity also documented at national level. Differences in longevity of cows are influenced by both genetic and environmental factors. Milk yield is genetically and phenotypically unfavorably correlated with fertility and longevity, but, for several years now, the breeding goals of dairy breeds include longevity and/or correlated type traits (Miglior et al., 2005). Comparing the longevity of HF, BS and Jersey cows in different regions of the United States, Garcia-Peniche et al. (2006) obtained different results when the breeds were compared using data from single breed herds or mixed breed herds. Moreover, Garcia-Peniche et al. (2006) documented similar overall longevity of the HF and BS cows, but they found also a highly significant interaction between the breed and the region, concluding that an important component of the differences among breeds are differences among dairy systems and environments. Vukasinovic et al. (2001), studying BS, Si and HF cows in Switzerland, found that the risk of culling was much lower for cows moved to summer Alpine pastures than those in the lowland barns year round. Also in Irish pasture conditions, dual purpose breeds had superior longevity than Holsteins (Evans et al., 2004).

The more rapid decrease in age at slaughter from the years 2003 to 2011 in HF and BS cows but not the dual-purpose breeds (interaction between breed and year effects) can be explained more by environmental rather than genetic reasons (because of the inclusion of longevity in the selection indices of both dairy breeds). In fact, the tendency toward the abandonment of the traditional farming system and the increase of modern intensive farms affected, in particular, the two specialized dairy breeds (Giupponi et al., 2006; Sturaro et al. 2012).

Carcass weight of culled cows

Carcass weight of cull cows was heaviest during winter and was lightest during autumn (Figure 2), concomitant with the return from summer pastures and the end of lactation in the more traditional farming systems. Culling rate in September and October was almost double that of June, July and August (the months of the summer pasture). Mc Hugh et al. (2010) observed that in Ireland the number of cows sold at marts exhibited a bimodal distribution with greater numbers sold in spring (postpartum period) and autumn (end of lactation). It should be noted that, in this case, only a proportion of the cows sold at marts were slaughtered within a few days and that data referred to both dairy and beef cows. Considering only slaughtered animals in Ireland, Maher et al. (2008) found that the greatest number of cows were culled in October and November, one month later than in the present study, although the grazing season is expected to be longer in Ireland than in the Alpine highland regions.

Average carcass weight of the HF cull cows in the present study was heavier than that documented, for the same breed, by Yan et al. (2009) on lactating cows. However the average carcass weight of the HF cull cows was similar to that reported by Vestergaard et al. (2007) and by Minchin et al. (2010) on dry cows slaughtered without a fattening period. The average carcass weight of the HF cull cows in the present study was, however, lighter than that documented by Seegers et al. (1998), Jurie et al. (2007), Allen et al. (2009), and Węglarz (2011) although the cows in these studies were generally subjected to an extra-feeding period. Heavier live-weight and carcass weight of cull cows is expected when subjected to a finishing period as confirmed by several studies (Vestergaard et al., 2007; Allen et al., 2009; Franco et al., 2009; Lee et al. 2009;

Minchin et al., 2009 and 2010). No detailed information is available on the feeding regime of culled cows by farmers in the Trento Province, but, with the exception of cows slaughtered with urgency (calving problems, severe mastitis, accidents, lameness, etc), the cows are normally slaughtered towards the end of lactation when the marginal profit of milk production per day become negative.

Compared with the number of studies on HF cull cows, there is little information on cull cows from other dairy breeds. Often when comparisons do exist, the different dairy breeds are simply grouped as "dairy cows" while data on dual purpose breeds generally originate from beef herds. Whether the slightly heavier carcass weight for BS cows compared to HF in the present study was due to a greater live weight or a superior dressing percentage is not known. It worth noting that the least squares means in Table 2 were obtained from a model that included the age at slaughter; considering the younger age at culling of HF cows, and the increase of carcass weight with age, larger true differences between breeds are expected.

The dual purpose Alpine breeds had heavier carcasses than cows from specialized dairy breeds, and especially Si cows yielded the heaviest average carcass weight; this was consistent with results documented by Habermann et al. (2000) on Simmental cows slaughtered after drying off without any finishing period. Habermann et al. (2000) found that, after 98 days finishing, average live weight increased 147 kg and carcass weight 104 kg, confirming the high growth rate that characterize the Simmental breed.

The Re and AG local breeds are known as medium framed dual purpose breeds with lighter average liveweight than HF and BS cows. The heavier carcasses of the local breeds in the present study are therefore most likely due to a greater dressing percentage. Greater dressing percentage is also the result of a selection scheme that included, as in the case of Re, a combining index of growth capacity, in vivo estimated dressing percentage, and carcass muscularity (Bittante et al., 2007). Comparisons carried out on fattening young bulls of the three dual purpose breeds, confirmed the superiority of Si breed in terms of body size and weight gain, but also the good dressing percentage and meat quality of both local Alpine breeds (Bonsembiante et al., 1988; Cozzi et al., 2009).

Carcass price and value of culled cows

Few studies have quantified the factors associated with cull cow market value. Differences in price per kg of HF and Si cow carcasses was studied by Kaufmann et al. (1996) on the basis of the yield and value of individual retail cuts. The carcass of Si females was 21.9% more valuable than HF cows as young cows but reduced to 8.5 % in older cows while in the present study the difference in carcass values was of 33.1% and 24.2% in young and older cows, respectively. In our study, the association between cow breed and both carcass price and value also differed by age of cow at slaughter confirming that the superiority of the dual purpose cows was greatest when they were younger.

More recently, Mc Hugh et al. (2010), analyzing the value of cows sold at auctions in Ireland, found that Si were received a 20.3 % greater price than HF without correcting for liveweight; this reduced to 15.2 % after adjustment for differences in live-weight. In the study of McHugh et al. (2010), however, the data were obtained on live animals, only some of which were slaughtered within a few days from purchase. Moreover, Si cows in Ireland generally reside in beef herds as suckler cows and are generally not used for milk production, thus influencing the results. McHugh et al. (2010) also reported that the dual purpose breeds of Montbeliarde and Normande were worth 9.9 % and 16.6 % more, respectively than the Holstein; when live-weight was included in the model, the respective values were 14.1 % and 16.8 %. Dal Zotto et al. (2009), analyzing the auction price of Italian calves produced by four of the five breeds considered in the present study in the same environment, reported greater prices for Si calves, followed by AG and subsequently by the two dairy breeds (HF and BS).

Beyond the differences among different breeds, Mc Hugh et al. (2011) found also that the value of beef and dairy cows sold at auction is heritable, even if the heritability of price was about half than that of live-weight and much lower than heritability estimates for price of calves, weanling and post-weanlings. Also Penasa et al. (2012) found, on BS calves sold at auction and produced in the same environment as in the present study, that the value of animal is heritable, like its body weight. Moreover, some research (Otto et al., 1991; Schnell et al., 1997; Gregory et al., 1998; Vestergaard et al., 2007; Minchin et al. 2009; Yan et al., 2009) outlined the positive effect of cow body condition on quantity and quality traits of the cull cow at slaughter, and other research found that body condition score of the dairy cows is heritable and is positively correlated with fertility (Berry et al., 2003; Boettcher, 2005; Dal Zotto et al., 2007). Selection for body condition score can represent an indirect selection for increased value of culled cows.

It is interesting to note that the increase of carcass value, within breed, per unit increase in carcass weight was much higher (2-2.5 times) than the average price of the carcass. In fact, results evidenced an increase in total value of carcass of 3.84, 3.92, 4.37, 5.18 and 5.55 €/kg, for HF, BS, Si, Re and AG, respectively (data not show) which were much greater than the gain in weight. This implies a greater emphasis by the purchaser on quality and quantity (i.e., carcass weight). Several studies demonstrated that fattening of cull cows increased not only live-weight, but also the dressing percentage, the muscularity and fatness of carcasses, the quantity of superior retail gut yield, and also the quality traits (Habermann et al., 2000; Vestergaard et al., 2007; Allen et al., 2009; Franco et al., 2009). None of these studies attempted to quantify the increase in price and value due to fattening of cull cows.

CONCLUSIONS

The value of cull cows at slaughter represents a significant source of income for the dairy farm. However considerable variation in cull cow value exists. The main sources of variation are breed, herd, age and weight of carcass, as well as year and season of slaughtering. Holstein-Friesian cows were younger at slaughter, yielded lighter carcasses and received a lower price and total value than Brown Swiss cows. Dual purpose breeds were older, heavier and received a greater price and value at slaughter than both dairy breeds. Of the dual purpose cows, the Simmental cows were heavier while cows of local breeds Rendena and Alpine Grey received the greater price, resulting in no difference in carcass value among the dual purpose breeds. Alpine Grey cows were also characterized by the highest longevity.

The large differences among different breeds in cull cow value highlight the importance of cull cow characteristics and suggests its possible inclusion in the selection objectives of these breeds. Moreover, the quantification of the combined effect of weight and price on the increase of the value of carcass highlight the possible economic advantage of fattening culled cow before slaughtering.

Table 1. Results from ANOVA for slaughter age (months), carcass weight (kg), carcass price (€/kg), and carcass value (€/head) of 20,995 culled cows.

Effect	df	Slaughter age		Carcass weight		Carcass price		Carcass Value	
		F-value	*P*-value	*F*-value	*P*-value	*F*-value	*P*-value	*F*-value	*P*-value
Herd	485	6.15	<0.0001	10.05	<0.0001	3.35	<0.0001	9.12	<0.0001
Breed (B)	4	34.62	<0.0001	62.07	<0.0001	194.46	<0.0001	92.51	<0.0001
Age of cow (A)	5	-	-	13.52	<0.0001	76.97	<0.0001	7.16	<0.0001
Year of slaughter (YS)	8	1.69	0.09	1.03	0.4096	429.59	<0.0001	42.12	<0.0001
Month of slaughter (MS)	11	1.36	0.19	4.72	<0.0001	13.27	<0.0001	4.13	<0.0001
Carcass weight (CW[1])	1	-	-	-	-	53,684.90	<0.0001	-	-
B × A	20	-	-	1.98	0.006	7.50	<0.0001	3.11	<0.0001
B × YS	32	2.16	0.0001	1.75	0.005	8.84	<0.0001	3.18	<0.0001
B × MS	44	1.45	0.03	1.00	0.47	2.69	<0.0001	1.61	0.007
YS × MS	88	1.26	0.05	2.14	<0.0001	24.84	<0.0001	3.61	<0.0001
R^2	-	0.19		0.25		0.82		0.26	
RMSE[2]	-	27.54		40.40		0.20		170	

[1] The regression coefficient of carcass price on CW is +0.00797±0.00003 €×kg^{-1}

[2] RMSE = Root mean square error

Table 2. Least square means (LS-means), standard error (SE), and contrasts of breed effect for slaughter age (months), carcass weight (kg), carcass price (€/kg), and carcass value (€/head) of culled cows.

		Slaughter age		Carcass weight		Carcass price		Carcass value	
Breed	N	LS-mean	SE	LS-mean	SE	LS-mean	SE	LS-mean	SE
Holstein-Friesian (HF)	8,927	74.6	0.53	240	0.8	1.69	0.004	384	3.8
Brown Swiss (BS)	9,555	81.2	0.39	245	0.6	1.73	0.003	416	2.7
Simmental (Si)	1,117	79.4	1.09	270	1.8	1.74	0.009	518	7.4
Rendena (Re)	917	82.5	2.04	251	3.2	2.03	0.016	522	13.6
Alpine Grey (AG)	479	91.9	2.44	251	4.8	2.17	0.023	557	20.0

Contrast	*P*-value	*P*-value	*P*-value	*P*-value
[1](HF+BS) *vs*. (Si+Re+AG)	***	***	***	***
[2]HF *vs*. BS	***	***	***	***
[3]Si *vs*. (Re+AG)	***	***	***	NS
[4] Re *vs*. AG	**	NS	***	NS

NS = not significant; *P<0.05; **P<0.01; ***P<0.001

[1](HF+BS) *vs*. (Si+Re+AG) = contrast between dairy and dual-purpose breeds.

[2]HF *vs*. BS = contrast between the dairy breeds.

[3]Si *vs*. (Re+AG) = contrast between Simmental and the local dual-purpose breeds.

[4]Re *vs*. AG = contrast between the local dual-purpose breeds.

Table 3. Least square means (LS-mean) and standard error (SE) of carcass weight (kg), carcass price (€/kg), carcass value (€/head) of cull cows at different age at slaughter.

Slaughter age (years)	N	Carcass weight		Carcass price		Carcass value	
		LS-mean	SE	LS-mean	SE	LS-mean	SE
< 3	1,363	236	4.37	2.18	0.02	501	18.39
3 - 4	2,871	245	2.13	1.85	0.01	446	8.97
4 - 5	3,639	253	1.95	1.81	0.01	470	8.20
5 - 6	3,465	261	1.76	1.82	0.01	504	7.39
6 - 7	2,857	257	1.68	1.81	0.01	482	7.08
> 7	6,800	257	1.16	1.77	0.01	474	4.89

Figure 1. Frequency distribution, mean, standard deviation (SD), skewness and kurtosis for slaughter age (months), carcass weight (kg), carcass price (€/kg), and carcass value (€/head) of culled cows.

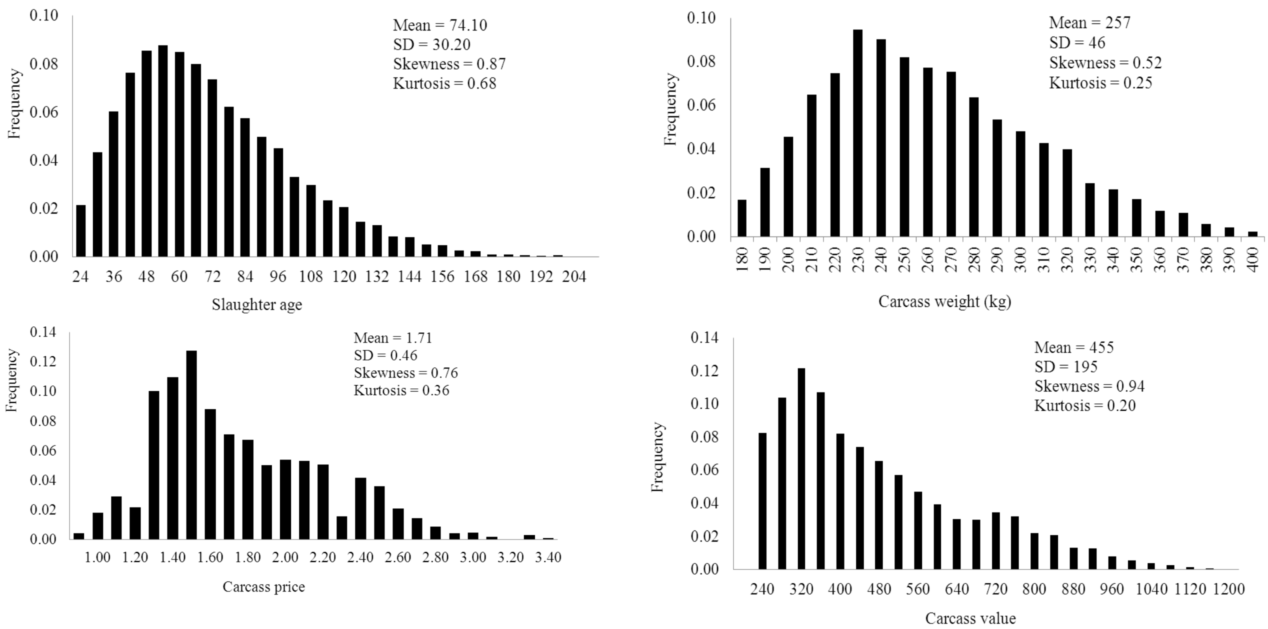


Figure 2. Monthly least squares means (one standard error represented each side of the mean as an error bar) for carcass value (€/head), carcass price (€/kg), carcass weight (kg), and number of culled cows.

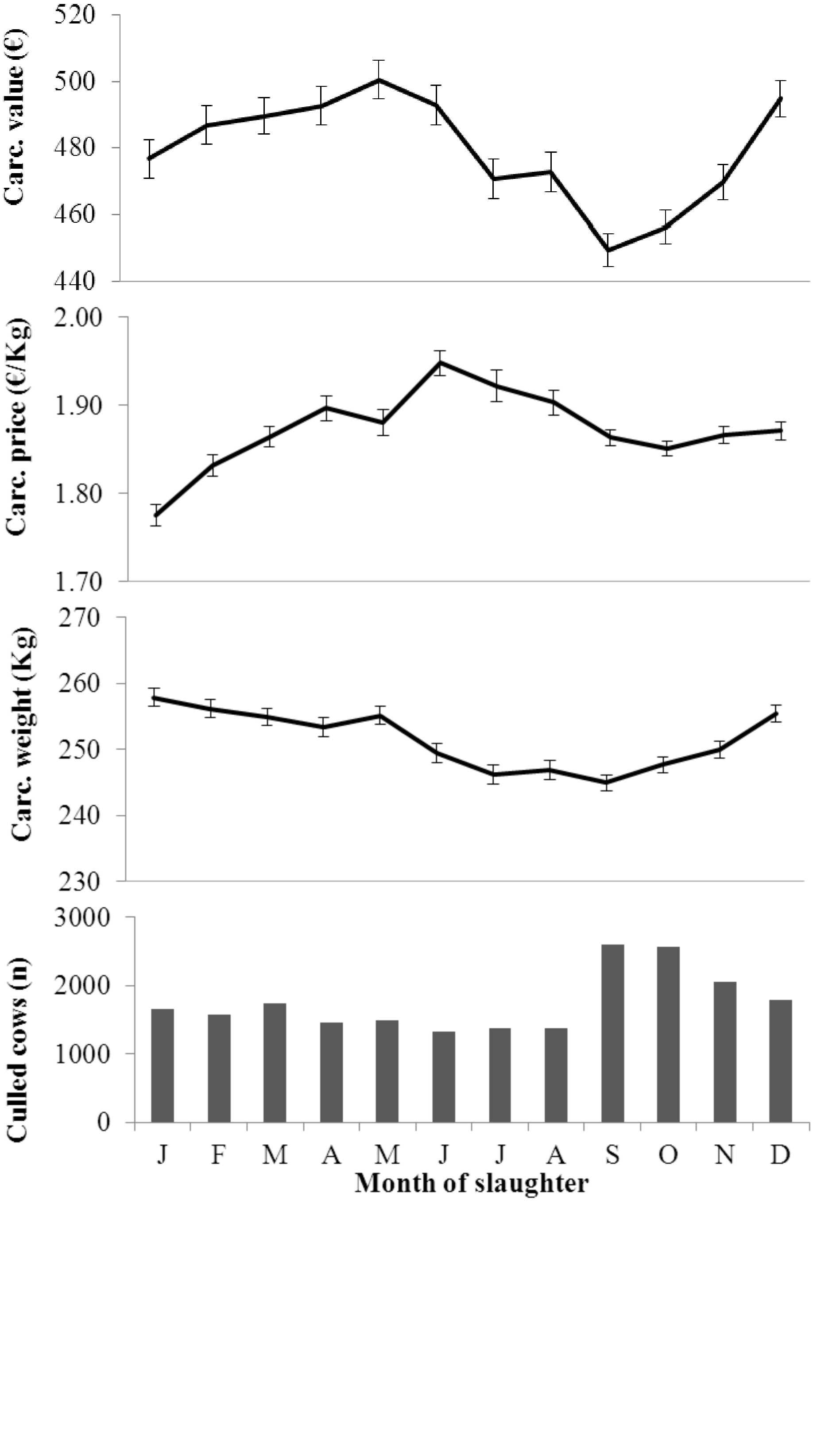
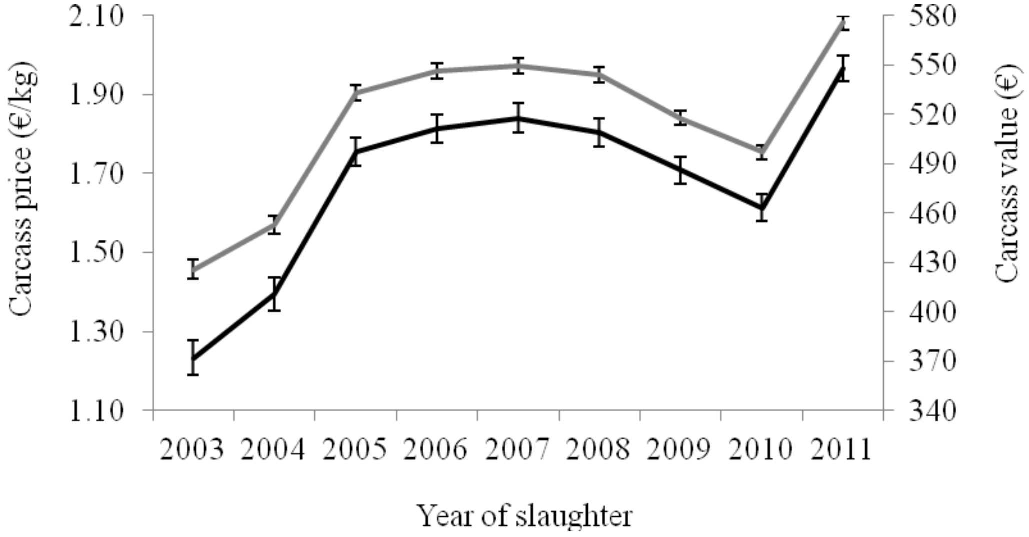


Figure 3. Annual least square means (one standard error represented each side of the mean as an error bar) of carcass price (€/kg; grey line) and carcass value (€; black line) of culled cows.



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CHAPTER 2

Factors associated with selling price and live weight of Italian calves

ABSTRACT

The aim of this study was to quantify the factors associated with live-weight (kg), price (€/kg) and value (€) of purebred and beef crossbreed calves sold in Italy. Every week the Breeders Federation of Trento province (northern Italy) collected surplus calves (average age 24 d) from several dairy herds. Following editing, information on live-weight, price, value and destination production system of 38,151 calves from 391 dairy herds was available. Factors associated with age, live-weight, price and value were herd, year and month of sale, and interactions between breed type and gender, and between breed and age of calf (not for age at sale). Five pure breeds [(2 dairy; Brown Swiss (BS) and Holstein Friesian (HF); and 3 dual-purpose; Simmental (Si), Rendena (Re) and Alpine Grey (AG)], five breed crosses from Belgian Blue (BB) sires and two breed crosses from Piemontese (Pi) and Limousin (Li) sires mated to BS dams were involved in the study. Male calves were 4 kg heavier than females, and their value was 40 € greater than that of females. Results showed large differences among breeds and breed types for live-weight, price and value; Si male purebred calves were the heaviest (69.6 kg) while BS purebred females were the lightest (59.4 kg). On average, calves destined to beef production were heavier (69 kg) and received a greater price and value at sale (4.6 €/kg and €291, respectively) than calves destined to veal production (62 kg of live-weight, 3.9 €/kg of price and €253 of value). Dual-purpose purebred calves, especially SI calves, received greater price and value at sale than purebred dairy calves. Calves from BB x Si showed the greatest live weight and value. Mating BS cows with BB sires resulted in better live weight and value compared with Pi and Li sire breeds.

Keywords: crossbreeding, live-weight, selling price, dairy breeds, Belgian Blue

INTRODUCTION

The sale of surplus calves from dairy herds represents a valuable source of income for Italian dairy herds, particularly on the alps where the low replacement rate of the less specialized farms allowed the mating of more than 30% of cows with specialized beef sires to obtain a considerable source of income from the sale of crossbreed calves. Nowadays, the use of sexed semen in dairy farms is increasing (Hohenboken, 1999; Cerchiaro et al., 2007) and this practice increase the number of cows to be mated with beef bulls. However, only two Italian studies (Dal Zotto et al., 2009; Penasa et al., 2009) and an Irish study (McHugh et al., 2010) have investigated the association between animal-level factors and calf price in Europe.

In particular, Dal Zotto et al. (2009) analyzed a dataset of 96,458 purebred and crossbred calves sold during public auctions in Bolzano province using a statistical model that included herd of origin of the calf, year and season of selling, sex, age and breed; the authors reported $0.89/kg greater price for males than females. Using the previous data and selecting only the calves from Belgian Blue sires x Brown Swiss dams (n = 11,300), Penasa et al. (2009) reported €82 higher value for males than females. McHugh et al. (2010), using Irish data from livestock auctions (n = 58,838), reported large breed differences in calf price; no data were available in that study on animal live-weight. The authors reported that the price increased linearly with age, the males received 0.21 euro more than females for each day of age, and crossbreed calves progeny of Belgian Blue and Charolais sires received the best selling values.

Breed differences in calf price have also been documented in the United States (Faminow and Gum, 1986; Schroeder et al., 1988; Troxel and Barham, 2007) confirming the clear association between animal factors such as age and gender, and calf price. Crossbreed calves progeny of Hereford sires and Charolais dams received the best price whereas Longhorn purebred calves received the worst.

The objective of this study was to quantify the animal-level factors associated with calf price and live-weight in Italian calves.

MATERIAL AND METHODS

Data

Data were available from the Breeders Federation of Trento province (northeast Italy) on 38,151 calves sold from 468 farms between June 2002 and May 2011. Every Monday, surplus calves were collected from dairy farms at approximately 3 weeks of age. All calves were weighed at collection using weighing scale. Subsequently, they were transported to a central location where a technician attributed the individual price and an overall value (price x live-weight). On the subsequent morning all calves were transported to different specialized producers outside the province.

The information recorded on each animal was calf price (€/kg of live-weight), live-weight (kg), calf value (€ per calf), date of birth, and date of sale. Data were also available for sire and dam breeds. Purebred calves were Brown Swiss (BS), Holstein Friesian (HF), Simmental (Si), Alpine Grey (AG), and Rendena (Re), and crossbreeds between previous pure dam breeds and Belgian Blue (BB) sires. Besides the aforementioned breeds and breed type, crossbreed calves from Limousin (Li) and Piemontese (Pi) sires and BS dams were analyzed.

Only calves with known dam and sire breeds, from herds with at least 10 calves, and sold between 7 and 60 d of age and 30 and 120 kg of live-weight were retained in the dataset.

Statistical analysis

Factor associated with live-weight (kg), price (€/kg), value (€), and age (d) of calves at sale were analyzed using the following linear model (SAS, 2008):

$$y_{ijklmno} = \mu + herd_i + breed_j + age_k + gender_l + year_m + month_n + (breed \times age)_{jk} + (breed \times gender)_{jl} + e_{ijklmno},$$

where $y_{ijklmno}$ is the observation $_{ijklmno}$ for live-weight, price, value or age of calves at sale; μ is the overall mean; herd is the fixed effect of the *j*th herd of origin of the calf (*i* = 1 to 391); breed is the fixed effect of the *j*th breed (*j* = BS, HF, Si, Re, AG, BBxBS, BBxHF, BBxSi, BBxRe, BBxAG, LixBS, and PixBS); age is the fixed effect of the *k*th day of age (*k* = 7 to 60); gender is the fixed effect of the *l*th gender of the calf (*l* = female and intact male); year is the fixed effect of the *m*th year of sale of the calf (*m* = 2002 to 2011); month is the fixed effect of the *n*th month of sale (*n* = 1 to 12); and $e_{ijklmno}$ is the residual random error term N ~ (0, σ^2_e). Furthermore, first order interactions between breed and age and between breed and gender were included in the models. For the analysis of age of calf the effects of age and the interactions between breed and age were excluded from the model.

RESULTS

General statistics

More than 80% of the calves were males, 53.2% were sold between 14 and 26 d of age (mean of 24 d and SD of 9 d), and 65.5% were sold between 55 and 75 kg of live-weight (Figure 1). Table 1 summarizes the number of calves sold from different sire and dam breed combinations; the vast majority of the crossbreed calves were progeny of BB sires. Moreover, crossbreed calves from Pi and Li sire breeds were progeny of only BS dams. Sixty-seven percent of the total data were represented by purebred and dual-purpose calves while the remaining 33% were crossbreed calves from beef sire breeds.

The number of calves sired by beef bulls varied across different dam breeds (Table 1) ranging from 18.3% for HF dams to 46.4 and 51.7% for BS and Si breeds, respectively; this pattern reflects the practical use of crossbreeding by the farmers across different breeds of cows in Trento province.

Analysis of variance

The phenotypic correlations between calf weight (kg) and price (€/kg) at sale was 0.47 ($P<0.001$) and between calf weight (kg) and calf market value (€) was 0.64 ($P<0.001$) (data not shown). Furthermore, the correlation between calf value (€) and price (€/kg) was the highest (0.96; $P<0.001$), because calf value was obtained by multiplying price by live-weight. Moreover, the correlation between live-weight and age of calf at sale was 0.28 ($P<0.001$).

Results of analysis of variance and contrast estimates for analyzed traits are in Table 2. All effects were highly significant in explaining the variation of studied traits ($P<0.01$). The coefficients of determination were 0.29, 0.56, 0.93 and 0.91 for age, live-weight, price and value of calf at sale, respectively.

Breed types largely differed for calf price and value ($P<0.001$). Significant differences were also detected between purebred and crossbreed calves for all the analyzed traits ($P<0.001$). Furthermore, significant differences in calf weight were found between dairy and dual purpose calves, between Si and local dual-purpose calves (AG and Re; $P<0.001$), between BB x BS and BB x HF crossbred calves ($P<0.01$), and between BB x Si and local dual-purpose breeds (AG and Re; $P<0.05$). Finally, highly statistical difference in age of calf at sale was found among dairy calves and among BB sired breed calves from the two dairy dam breeds.

Breed and gender effect

Figures 2, 3, 4 and 5 show least squares means of calf weight, price, value and age at sale of calves of different breeds and breed crosses by gender. Males showed greater live weight (+4 kg) than females. Moreover, male calves were younger (-3 d) than females and received +0.71 €/kg and +65 €/calf, respectively, than females.

Generally, the practice of crossbreeding increased live-weight of both genders of calves (Figure 2), particularly in the case of the 2 dairy breeds. On average, the live weight, price and value of crossbreed calves were greater than those of purebred calves (+6.3 kg, +€ 2.80/kg and + € 208/calf). Among purebred calves, the Si were the heaviest (64.9 and 69.4 kg for males and females, respectively), while the HF calves were the lightest (62.2 and 57.1 kg for males and females, respectively; Figure 2). No significant difference for live weight were found between purebred and crossbreed HF and BS calves.

Among crossbreed calves the BB x Si and BB x Re male calves were the heaviest (71.4 and 71.5 kg, respectively), and the BB sire breed showed greater potential to increase calves live weight respect to Li and Pi sire breeds; in fact, live weight of BB x BS male and female calves was 67.9 and 71.3 kg, which is greater than live weight of Pi x BS and Li x BS calves (66.2 and 70 kg, and 64.8 and 67.9 kg, respectively).

Crossbreeding practice increased price and value of both genders of calves (Figures 3 and 4). Among purebred calves the BS and Si showed the lowest and highest price and value, respectively. The Re and AG breeds showed intermediate price and value respect to the other pure breeds. Among crossbreed calves the Li x BS calves showed the lowest price and value (€ 3.47/kg and € 234/calf, respectively), whereas the BB x Si showed the highest price and value (€ 6.96/kg and € 492/calf, respectively). Regarding the combination of BS dams breeds, the best results for price and value were evidenced in the case of BB x BS (€ 6.18/Kg and € 431/calf) followed by PiXBS (€ 5.22/Kg and € 357/ calf). Furthermore, the latter combination evidenced greater values respect to LiXBS and BBXBS. Finally the difference between purebred Si calves and BB x Si calves were lower than those between purebred (BS, HF, Re and AG) and crossbred (BB x BS, BB x HF, BB x Re and BB x AG) calves, because of great price and values of purebred Si calves.

Concerning the age at sale, purebred calves were older than crossbreed calves (P<0.001). On average, dairy and dual-purpose purebred calves had the same age at sale, and BS purebred calves were older than HF purebred calves (28 and 25 d, respectively; Figure 5).

Year and month of sale effect

Least squares means of age (d), live-weight (kg), price (€/kg) and value (€) of calves across months and years of sale are depicted in Figures 6 and 7, respectively. On average, the age and live-weight of calves varied less than price and value across months. The highest and lowest live-weight values of calves were in May (67.4 kg) and November-December (65 kg), respectively. The worst price (€ 4.19/kg) and value (€ 286) of calves were found in December, whereas the best price (€ 4.76/kg) and value (€ 327) were found in June. The calf price and value increased from May to July according to the increase of calves supply, while they decreased in autumn and winter. Furthermore, the minimum age at sale of calves occurred in October (23 d) and the maximum in January (26 d).
Age, live-weight, price and value of calves at sale varied across years of sale (P<0.001; Figure 7). The variation of calf price and value across years was similar and the best price and value was in 2006 (€4.97/kg and € 337, respectively) and the worst in 2008 (€4.03/kg and € 281, respectively) and 2011 (€3.99/kg and € 285, respectively).

The increase of live weight across years was positive and varied from 63.2 kg in 2002 to 68.6 kg in 2011 (Figure 7). Also, the age of calves increased from 2002 to 2011 (23 to 26 d, respectively).

DISCUSSION

Knowledge of the factors associated with animal live-weight and price or value are useful to provide advice to producers on the cost:benefit of alternative breeding and management strategies and to quantify the different income for dairy herds obtainable from different strategies.

This study showed that purebred dairy calves were lighter and received less price and value at sale than purebred calves from dual purpose dams. Beef crossbred calves received higher price and value than dual-purpose and dairy calves, respectively, and the best were received from progeny of BB sires and dual purpose dams.

The lighter live-weight of female calves respect to males was widely investigated (Pell and Thayne, 1978; Leighton et al., 1982; Holland and Oddle, 1992). The greater live weight of the Si calves respect to purebred calves confirmed results reported by Dal Zotto et al. (2009) on 96,458 calves. According to Dal Zotto et al. (2009), the dairy calves were the lightest, the local dual purpose calves showed similar live-weight, and Si purebred and BB x Si calves showed the greatest live-weight. The better conformation and greater live-weight of dual-purpose calves respect to purebred dairy calves were reported also by Bittante et al. (2005).

Crossbreeding with beef bulls increased live-weight of calves at sale respect to purebred calves, and reduced the difference of live-weight between purebred calves from different breeds of dam; this was confirmed also by Dal Zotto et al. (2009).

Different supply and demand of calves is the likely reason for the change in price by month of sale. During autumn and winter the majority of calves are sold due to the seasonal production system of calving. The greater price received for male calves observed in the present study corroborate other international studies (Troxel et al., 2002; Barham and Troxel, 2007). In the present study, no information was available on factors such as calf health, muscle thickness, frame score, fill, color, horn status and body condition that have already been shown to be associated with calf, steer heifer and bull price; several studies estimated a close relationship between these traits and calf price and value (Schroeder et al., 1988; Barham and Troxel., 2007; Troxel and Barham, 2007). Beef crossbreed calves showed greater muscularity score (McGee et al., 2007; Clarke et al., 2009; Campion et al. 2009) and better feed efficiency (Pfuhl et al., 2007; Clarke et al., 2009) than purebred calves.

Bittante et al. (2005) and Dal Zotto et al. (2009) reported greater price at selling of dual-purpose calves compared to dairy calves, which agrees with findings from our work. The use of double muscling sire breeds, especially BB, is increasing in Europe because double-muscling is responsible for yielding well conformed carcasses with reduced fat content (Hanset et al., 1987; Uytterhaegen et al., 1994). Brown Swiss purebred calves increased the selling price more than Re, AG, Si, and HF breeds when mated with BB bulls, and this was confirmed by Dal Zotto et al. (2009).

Breed effect on selling price of cattle was studied by several authors. Brown and Morgan (1998) reported that Angus cattle sold at livestock auctions during 1996 in Georgia, received $3 premium selling price over the overall mean respect to other breeds. Also, Smith et al. (1999) compared selling prices of different breeds of cattle sold in east Oklahoma (USA) during the years 1997 and 1999, and they highlighted better performance for crossbreed calves. More recently, Barham and Troxel (2007) reported that breed effect was the main source of variation to explain the selling price of cattle at Arkansas livestock auctions.

In our study the variation of calf value followed the variation of calf price and consisted with data reported by Dal Zotto et al. (2009) in Italian field condition.

Simmental calves received greater value than purebred dairy calves as demonstrated by other authors (Alberti et al., 2008; Dal Zotto et al., 2009), and BB sires gave the best combination with BS breed respect to Li and Pi sire breeds. Recently, Mc Hugh et al. (2010) reported an increment in calf value, which was associated to the increased percentage of BB blood in Ireland. Progeny of Li sires tended to have calves with less calving difficulty and greater survival rates than other breed combinations (Comerford et al., 1987) but the value was lower respect to the progeny of BB and Pi sires because they were lighter at birth and consequently at sale. Moreover, Wolfovà et al. (2007) confirmed that carcasses from beef x dairy crosses were much more valuable than carcasses from purebred dairy animals; crossbreeds showed better eating characteristics of the meat (Davies et al., 1992) and greater dressing percentage (Gϋngor et al., 2003).

CONCLUSION

The sale of calves represent a valuable source of income for the farmer of the alpine region characterized by less productivity but higher longevity and fertility than the more specialized dairy farms. Nowadays the use of sexed semen in dairy farms is increasing and this would lead to more dairy cows available for mating with beef sires to increase the income from the sale of crossbreed calves. Dual-purpose purebred calves, especially Si, received greater price and value at sale than purebred dairy calves. Crossbreed calves from BB x Si showed the greatest live weight and value. Mating BS cows with BB sires produces calves that perform better in terms of live-weight and value than Pi x BS and Li x BS calves.

TABLES AND FIGURES

Table 1. Number of calves of different breeds[1] and breed crosses[2]

	Dam Breed					
Sire breed	HF	BS	Si	AG	Re	TOTAL
Purebred	11,947	9,134	1,217	467	2,512	25,277
Beef bulls:						
Pi		197				197
Li		281				281
BB	2,680	7,419	1,304	193	800	12,396
TOTAL	14,627	17,031	2,521	660	3,312	38,151
Incidence %	18.32	46.37	51.72	29.24	24.15	33.36

[1]HF = Holstein Friesian; BS = Brown Swiss; Si = Simmental; AG = Alpine Grey; Re = Rendena;

[2]Pi = Piemontese; Li = Limousin; BB = Belgian Blue.

Table 2. Analysis of variance and contrast estimates for breed effect for age, live-weight, price and value of calf.

Effect	df	Age of calf (d)		Calf weight (kg)		Calf price (€/kg)		Calf Value (€)	
		F-value	*P*-value	*F*-value	*P*-value	*F*-value	*P*-value	*F*-value	*P*-value
Herd	466	32.99	<0.0001	38.01	<0.0001	10.61	<0.0001	23.29	<0.0001
Breed (B)	11	20.39	<0.0001	71.47	<0.0001	3,194	<0.0001	1,951	<0.0001
Age of calf (A)	1	–	–	497.74	<0.0001	6.91	<0.008	305.24	<0.0001
Gender (G)	1	144.25	<0.0001	425.77	<0.0001	2,151	<0.0001	2,226	<0.0001
Year of sale (YS)	9	43.83	<0.0001	179.11	<0.0001	1,640	<0.0001	563.50	<0.0001
Month of sale (MS)	11	50.46	<0.0001	44.05	<0.0001	411.64	<0.0001	308.57	<0.0001
B × A	11	–	–	7.36	<0.0001	9.74	<0.0001	41.37	<0.0001
B × G	11	14.75	0.0001	13.04	<0.0001	28.89	<0.0001	19.55	<0.0001
Contrast Breed effect						P-value			
Purebred vs. Crossbreed			***		***		***		***
[(BS+HF) vs. (Si+AG+Re)][2]			NS		***		***		***
(BS vs. HF)[3]			***		NS		***		***
[Si vs. (AG+Re)][4]			NS		***		***		***
[(BBxBS+BBxHF) vs. (BBxSi+BBxAG+BBxRe)][5]			NS		NS		***		***
(BBxBS vs. BBxHF)[6]			***		**		***		***
[BBxSi vs. (BBxAG+BBxRe)][7]			NS		*		***		***
R^2		0.29		0.56		0.93		0.91	
RMSE[1]		7.78		6.78		0.50		43.65	

HF = Holstein Friesian; BS = Brown Swiss; Si = Simmental; AG = Alpine Grey; Re = Rendena; BB = Belgian Blue sire.
[1]RMSE = Root mean square error;
NS = not significant; *P<0.05; **P<0.01; ***P<0.001.
[2]Contrast between dairy and dual-purpose purebred calves.
[3]Contrast between purebred calves from the two dairy dams.
[4]Contrast between Simmental and local dual-purpose purebred calves.
[5]Contrast between crossbreed calves from dairy and dual-purpose dam breeds.
[6]Contrast between crossbreed calves from the two dairy dam breeds.
[7]Contrast between crossbreed calves from Simmental and local dual-purpose dam breeds.

Figure 1. Frequency distribution, mean and standard deviation (SD) for age (days), weight (kg), price (€/kg) and value (€/calf) of calves at sale (N = 38,151)

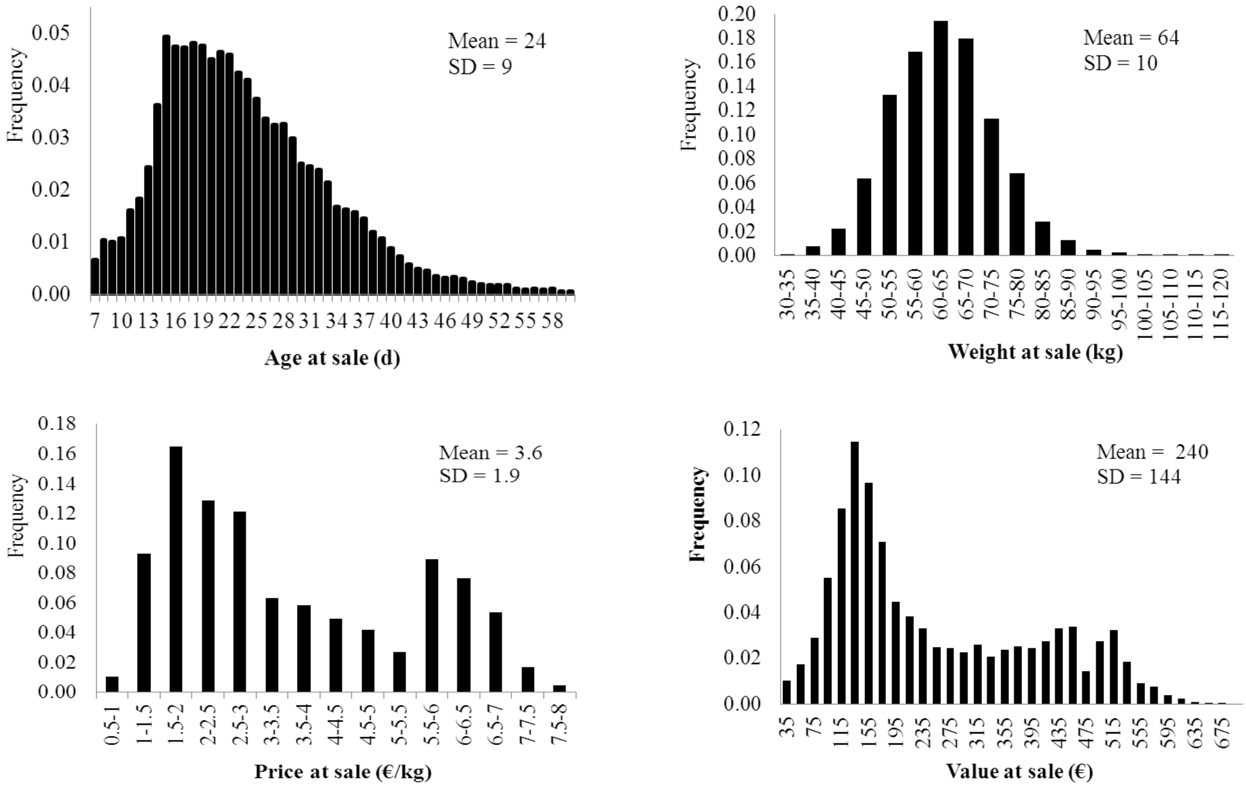
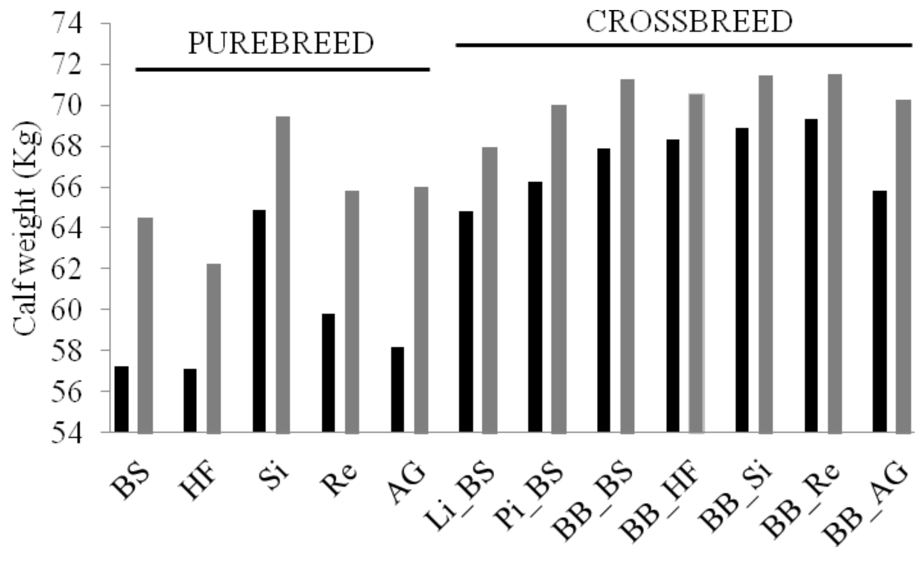
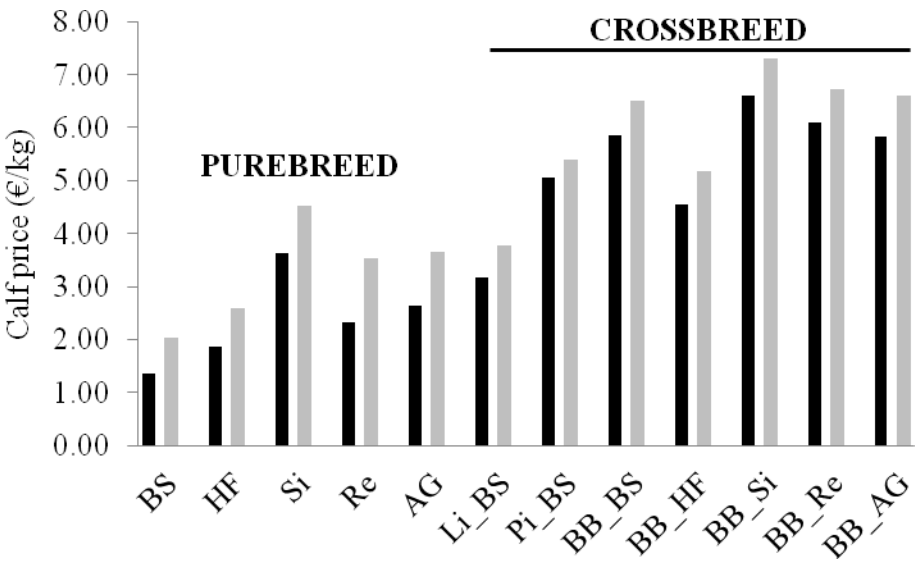


Figure 2. Least squares means of calf weight at sale of calves of different breed[1] and breed crosses[2] by gender (female=black bars; male=grey bars).



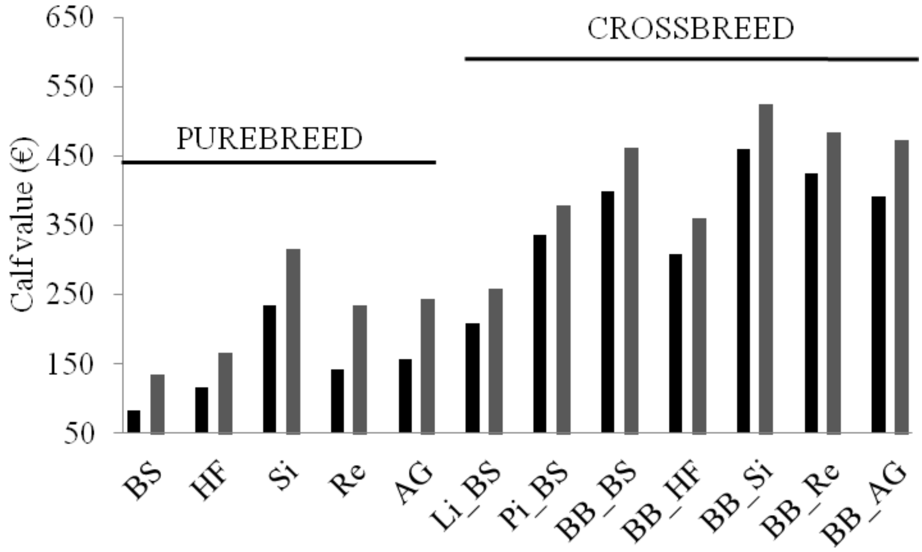
[1]HF = Holstein Friesian; BS = Brown Swiss; Si = Simmental; AG = Alpine Grey; Re = Rendena; [2]Pi = Piemontese sire; Li = Limousin sire; BB = Belgian Blue sire.

Figure 3. Least squares means of calf price at sale of calves of different breed[1] and breed crosses[2] by gender (female=black bars; male=grey bars).



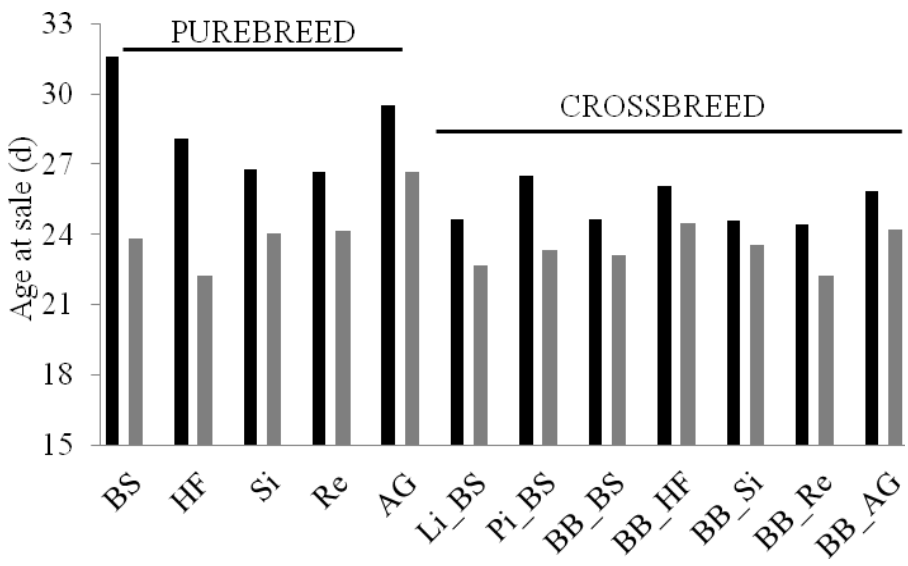
[1]HF = Holstein Friesian; BS = Brown Swiss; Si = Simmental; AG = Alpine Grey; Re = Rendena; [2]Pi = Piemontese sire; Li = Limousin sire; BB = Belgian Blue sire.

Figure 4. Least squares means of calf value at sale of calves of different breed[1] and breed crosses[2] by gender (female=black bars; male=grey bars).



[1]HF = Holstein Friesian; BS = Brown Swiss; Si = Simmental; AG = Alpine Grey; Re = Rendena; [2]Pi = Piemontese sire; Li = Limousin sire; BB = Belgian Blue sire.

Figure 5. Least squares means of age at sale of calves of different breed[1] and breed crosses[2] by gender (female=black bars; male=grey bars).



[1]HF = Holstein Friesian; BS = Brown Swiss; Si = Simmental; AG = Alpine Grey; Re = Rendena; [2]Pi = Piemontese sire; Li = Limousin sire; BB = Belgian Blue sire.

Figure 6. Least squares means of age (d), weight (Kg), price (€/Kg) and value (€) of calves across month of sale.

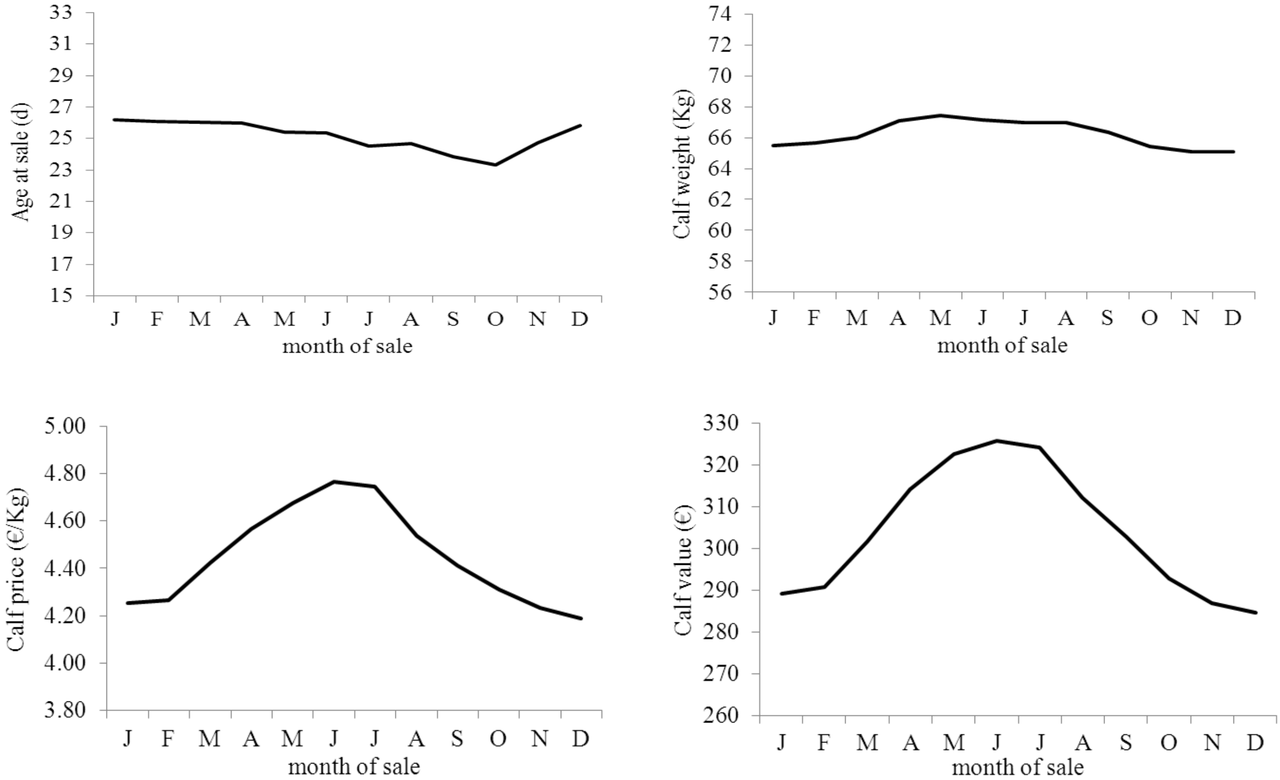
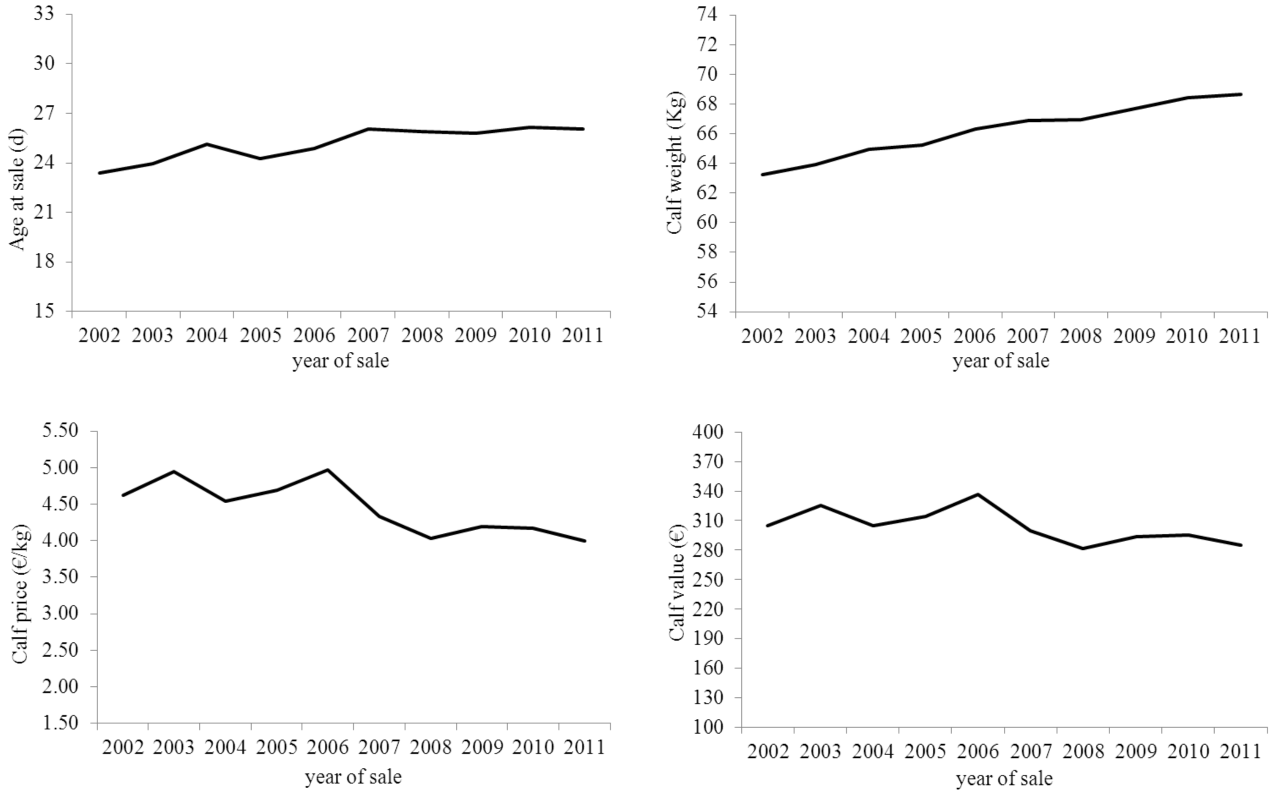


Figure 7. Least squares means of age (d), weight (Kg), price (€/Kg) and value (€) of calves across year of sale.



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CHAPTER 3.

Effect of destination (beef vs. veal) and breed on economic value of calves

ABSTRACT

The aims of this study were to compare four different statistical models for analyzing sources of variation of live-weight, price, value and age of calves at sale and to define predicted probabilities of a calf being sold for beef instead of veal production. Data were available for 38,587 calves collected from 467 dairy herds from June 2002 to May 2011. Four statistical models were developed: the first accounted for the effects of herd, year, month of selling, gender and age (not for age of calf); the second included all previous effects, the effect of destination of the calf, and the interaction of the latter factor with gender and age; the third included all the effects of the first model, the effect of breed, and the interaction of the latter factor with gender and age; finally, the fourth included both destination and breed effects, and the interactions with gender and age. Five pure breeds (Brown Swiss, Holstein Friesian, Simmental, Rendena and Alpine Grey) and five breed crosses from Belgian Blue sires, and two breed crosses from Piemontese and Limousin sires mated to Brown Swiss dams were available. The best statistical model in explaining the variability of calf traits was the model that included breed effect.

Logistic regression was used to identify the factors associated with calf destination (veal vs. beef production); purebred dairy calves had greater likelihood of being destined for veal production whereas crossbred calves from Belgian Blue sires had greater likelihood of being destined for beef production.

Keywords: crossbreeding, Belgian Blue, , veal and beef production, commercial value

INTRODUCTION

The sale of surplus calves not destined to breed replacement in Ialian dairy herds represents an important source of income for the farmers. This is particularly true on the alpine region (Dal Zotto et al., 2009) where there are small dairy farms characterized by less productivity because the limited duration of the vegetative season, orography and slope of the land do not permit the cultivation of maize, which is the main source of energy in high concentrate diets (Salandin and Cozzi, 2008). Fortunately, alpine small dairy herds are also characterized by higher fertility (Tiezzi et al., 2011) and longevity of their cattle compared with specialized bigger farms (Dal Zotto et al., 2007; Boettcher, 2005). The low replacement rate of the alpine dairy herds permits the use of beef sires to mate cows not destined to breed replacement and to obtain more income from the sale of both genders of beef crossbreed calves; this practice has been already studied by several authors in the past (Cundiff, 1970; Nelson et al., 1982) and in recent years (Cundiff et al., 2001) also regarding carcass and meat characteristics (Davies et al., 1992; Güngör et al., 2003). Only few studies in Italy (Dal Zotto et al., 2009; Penasa et al., 2009) have attempted to quantify the association between animal level factors and calf price. Breed difference in determining calf price and value has been reported by several authors in the United States (Farminow and Gum, 1986; Schroeder et al., 1988; Troxel and Barham, 2007) and in Ireland (Mc Hugh et al., 2010).

In Italy two major distinct calf market destinations exist: veal and beef. Calves destined to veal production are feed an artificially milk replacer and a small quantity of roughage, and are slaughtered at approximately 5 to 6 mo of age (Cozzi, 2007), whereas calves destined to beef, after the weaning period, are fed a high concentrate diet to promote the maximum daily gain and are slaughtered at approximately 17 to 20 months of age (Myers et al., 1999; Cozzi and Ragno, 2003b). The objective of the present study was to compare four different models for the analysis of calf weight, price and value, and to define the logit of the probability of a calf to be destined to beef as opposite to veal production.

MATERIAL AND METHODS

Data

Data were collected by the Breeders Federation of Trento province on 38,587 calves sold from 467 associated farms between June 2002 and May 2011. Every Monday, surplus calves were collected from dairy farms of the Trento Province at approximately 3 wk of age. All calves were weighed at collection using a weighing scale. Subsequently all calves were transported to a central location where a technician attributed a price and an overall value (i.e. price times live-weight) to each calf. On the subsequent morning (i.e., Tuesday) all the calves were transported to different specialized producers outside the Trento province. The veal calves were sold to 8 specialized farms in the Po valley of Italy and fed milk replacer and a small quantity of roughage until slaughter at approximately 6 months of age. The calves destined to beef production, after weaning at approximately 5 months of age and 250 kg of live-weight, were transported to 6 beef specialized farms in the Trento province. The animals were fattened on high concentrate maize-silage based diets. Bulls were slaughtered at approximately 20 months of age and 650 kg of live-weight, whereas heifers were slaughtered at approximately 14 months of age and 500 kg of live-weight.

Information on calf price (€/kg live-weight), live-weight (kg), calf value (€ per calf), date of birth, date of sale and veal or beef destination were recorded. Data were also available on the sire and dam breed of each animal. Purebreds calves in this study belonged to Brown Swiss (BS), Holstein Friesian (HF), Simmental (Si), Alpine Grey (AG), and Rendena (Re) breeds, and crossbred animals were obtained from the mating of each of the previous purebred dams with Belgian Blue (BB) sires. Crossbreed calves from Limousine (Li) and Piemontese (Pi) sires and BS dams were also analyzed. Only calves with known breed of dam and sire, sold between 7 and 60 d of age and weighing between 30 and 120 kg were retained. Furthermore, only animals from herd with at least 10 calves collected were retained.

Statistical analysis

Data recorded on each animal (age of calf (d), calf weight (kg), calf price (€/kg) and calf value (€)) at sale were analyzed with four separate models (A, B, C, D) using the GLM procedure of SAS (SAS, 2009). Fixed effects in model A were herd of calf birth, gender of calf, month and year of sale and age (not for age). Fixed effects in model B were those included in model A plus the effect of the calf destination and its interactions with gender and age. Fixed effects considered in model C were those included in model A plus the inclusion of the breed effect and its interactions with gender and age. Fixed effects in model D were those included in model A plus the inclusion of both destination and breed effects and their interactions with gender and age.

Logistic regression with PROC LOGISTIC (SAS, 2009) was used to determine the factors associated with destination production system (i.e., veal production or beef production). The logit of the probability of an animal being sold for veal production (as opposed to being sold for beef production) was modeled accounting for the binomial distribution of the data. Fixed effects considered in the model were breed, gender and month of sale. The logit of the probability of an animal being sold for veal production was predicted from the model solutions as:

$$P(X) = [1 + e^{-(\alpha+\beta x)}]^{-1}$$

Where $\hat{\alpha}$ is the predicted intercept of the model, and $\hat{\beta}$ is the predicted regression coefficient for the independent variables (X). Odds ratios were calculated as the exponent of the model solutions. An odds ratio compares opposing probabilities to determine which is the more likely result for a given outcome; in this study the outcome was the probability of a calf going for veal production system. In the present study, if the odds ratio is 1.5, then the animal had a 50% greater likelihood of being destined for veal production. An odds ratio of 2 reflects double the likelihood of the animals being destined for veal production.

RESULTS

Table 1 summarizes means and standard deviations of the data for live-weight (kg), price (€/kg), value (€) and age (d) of calves at sale by destination (veal and beef production). Approximately one third of the calves sold were destined to beef and two third to veal production.

Calves destined to veal were younger and lighter at sale (23 d; 59 kg) while calves destined to beef production were heavier and older (25 d; 71 kg). Furthermore, calves destined to veal received less than half price and value (€ 2.57/kg; €154) respect to those destined to beef (€ 5.54/kg; € 395).

Figure 1 reports the least squares means of the gender effect from the four models for age (a), live-weight (b), price (c) and value (d). Age of calf at sale did not show large differences between males and females across the four models. However, significant differences were found across the different models for calf weight, price and value.

Models that did not include destination and breed evidenced the same values of calf weight for males and females; while the inclusion of breed and destination (Model D) showed heavier live weight for males respect to females (68.8 vs. 64.4 kg).

Furthermore, in both models without breed effect females received greater prices and values respect to males; while the inclusion of breed effect evidenced opposite pattern with greater prices and values of males (€ 4.81/kg and € 337) than females (€ 4.08/kg and € 273) underlining huge difference in prices and values between genders.

Figure 2 shows the least squares means of destination x gender effect from the model with only the destination and the final model with both destination and breed effects for age (a), live-weight (b), price (c) and value (d). The inclusion of the breed effect increased the age at sale of females destined to beef production. However, not differences were found between the two models for calf weight. Moreover, significant differences were estimated in calf price and value; in particular, the inclusion of the breed effect reduced the difference between males and females destined to veal and to beef, and underlined the highest prices and values of males respect to females for both production destination systems.

Purebreed dairy calves were most likely destined to veal (particularly, HF calves; 0.99) (Figure 3). Approximately 0.50 was the predicted probability of dual-purpose calves going for beef production system. However, crossbreed beef calves were most likely destined to beef respect to purebreed dairy or dual-purpose calves except those from Li sire x BS dam (0.25). Beef crossbred calves from BB sires x dual-purpose dams (>0.91) or BB x BS (0.88) were most likely destined to beef compared with those from HF (0.64) dams. Crossbred calves from Pi sires x BS dams were most likely destined to beef (0.77) but less respect to those from BB x BS. The predicted probabilities of a calf going for veal production destination (opposite as those for beef production destination) varied across different months of sale for each breed or breed combination (Figure 4); in particular is described the predicted probability (across monts) to have a calf male, from Si breed, sold at 24 d of age and at 65 kg of live. Even after adjusting for breed, age and live weight, calves were most likely destined to veal production in December. Figure 4 reports also the odds ratio (grey line); 95% confidence interval of odds ratios are represented as vertical error bars.

DISCUSSION

Age, price and value

The importance of the breed effect in determining calf price of cattle has been reported by several studies (Farminow and Gum, 1986; Schroeder et al., 1988; Troxel and Barham, 2007).

Recently, Dal Zotto et al. (2009) underlined the importance of breed effect in determining calf price and value of more than 50,000 calves sold at public auctions in Bolzano Province. Those authors did not study the effect of production destination (veal/beef); nevertheless, they reported a clear difference in calf price and value between pure and crossbreed calves that are usually destined to beef production.

In agreement to our findings, also Dal Zotto et al. (2009) reported greater price and values of males respect to females from the model whit breed effect, and these results consisted with those reported by Mc Hugh et al. (2010) who analyzed more than 53,000 calves sold in Ireland at livestock marts between 2000 and 2008. Greater price and value of females of the model without breed was due to the fact that the majority of females in the data were crossbreed calves and they received greater price and value respect to males; the purebred females, that were not included in the analyzed data, remain in the birth farm to produce milk

The production destination effect seemed to be not very informative in determining calf age, weight, price and value, and the best model was that whit the inclusion of the breed and without the production destination system effect. For this reason the inclusion of both breed and destination effects did not change least square means of the studied traits.

Production System Destination

Beef crossbred calves showed higher dressing percentage at slaughtering (Gϋngor et al., 2003) and carcasses were more appreciated than dairy animals (Wolfovà et al., 2007). Several studies reported greater live weight gain (Keane 2003; Alberti et al., 2008;), better feed efficiency (Pfuhl et al., 2007; Clarke et al., 2009) and greater live animal muscularity (McGee et al. 2007; Clarke et al., 2009) for beef breeds than contemporary dairy breeds. Furthermore, beef breeds showed higher carcass daily gain respect to dairy breeds (More O'Ferrall and Keane, 1990; Keane and More O'Ferrall, 1992; Cummins et al., 2007; Keane and Drennan, 2008; Clarke et al., 2009). In a recent study, Clarke et al. (2009) reported the progeny from LI sires as those that showed the lower carcass gain for day of age respect to progeny from BB, Charolais and Si. The double muscling characteristics of the BB breed were responsible for yielding well conformed carcasses with reduced fat content; this has been already confirmed in the past (Hanset et al., 1987;

Uytterhaegen et al., 1994) and more recently by Dal Zotto et al. (2009) who reported better price and value of the progeny from BB respect other breeds and breed types.

A lot of small dairy herds of the alpine region operate in a seasonal production system and majority of cattle calve in autumn and winter months when are reared in barn. Nowadays, less specialized bigger farms on the alpine region rear cows in barn all the year and calves are available in each month. However, cattle calving majority of purebred calves during autumn and winter seasons. In December, when calves were lighter and receive less price and value at sale as a consequence of the greater number of calves sold, the predicted probability to veal production destination was higher. However, in April, when less calves are sold, price and value were higher, the predicted probability to veal destination were lower.

Relevant differences in predicted probability to beef production destination system (opposite as those to veal) between dairy, dual-purpose and crossbreed calves found in the present study have been already confirmed by a recent study (Dal Zotto et al., 2009) on calves reared in a similar farming system.

CONCLUSION

The best statistical model in explaining the variation for calf traits was the model that included the breed effect. The inclusion of the production destination system effect along with the breed seem to be not very informative in determining calf traits. Majority of purebred calves from dairy dams were most likely destined for veal production while many dual-purpose calves were most likely destined for beef production. Finally, the vast majority of beef crossbreed calves (particularly those from BB sires and BS and dual-purpose dams) were most likely destined for beef production.

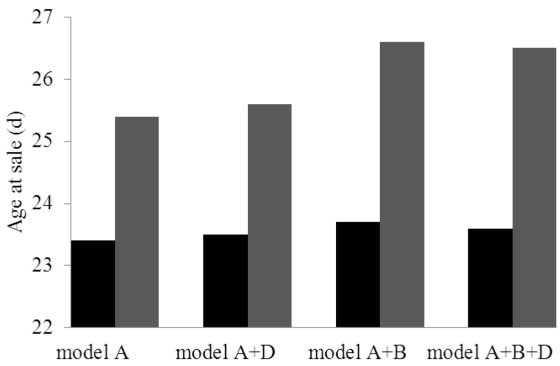
TABLES AND FIGURES

Table 1. Mean and standard deviation (SD) of the data included in the analysis by veal and beef production destination.

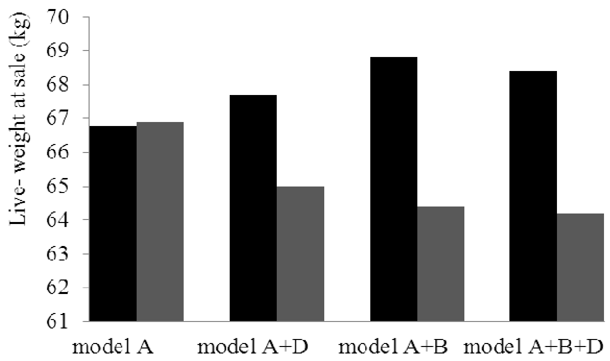
	Production destination			
	Veal (N = 24,804)		Beef (N = 13,783)	
	Mean	SD	Mean	SD
Live-weight at sale (kg)	59	9	71	8
Price at sale (€/kg)	2.57	1.10	5.54	1.38
Calf value (€)	154	71	395	110
Age (d)	23	9	25	9

Figure 1. Least squares means of male (black bars) and female (grey bars) calves from four different models involved for age (a), live-weight (b), price (c) and value (d).

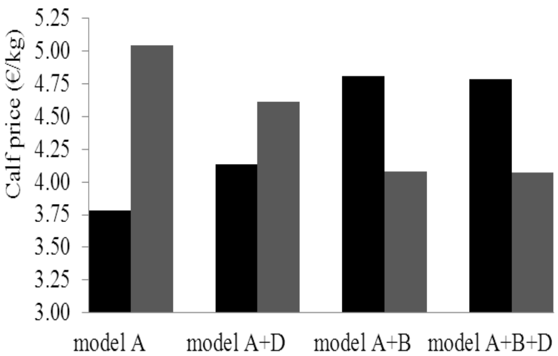
a



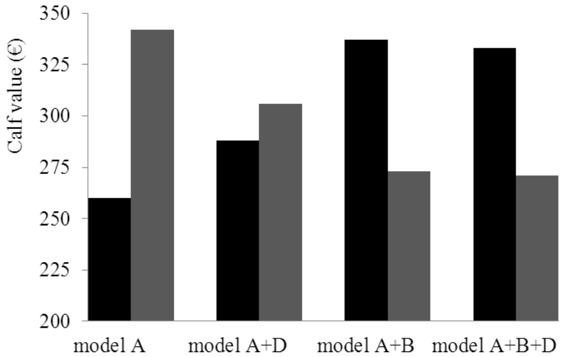
b



c



d



Model A includes the effects of herd, year, month, gender and, for live-weight, price and value, of age at sale.

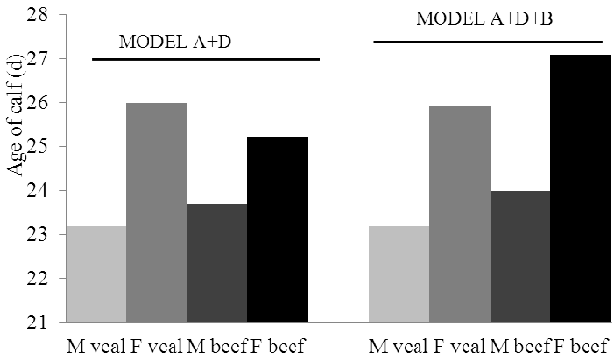
Model B was model A plus the effects of destination of calves and its interactions with gender and age at sale.

Model C was model A plus the effects of breed of calves and its interactions with gender and age at sale.

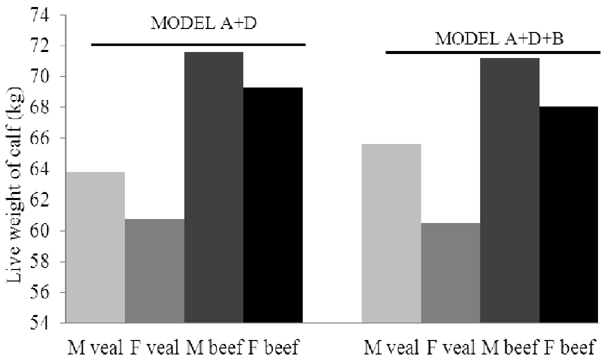
Model D was model A plus the effects of destination of calves and breed, and their interactions with gender and age at sale.

Figure 2. Least squares means of male and female calves by veal and beef destination production system from the model whit only the destination and the final model with both destination and breed effects for age (a), live-weight (b), price (c) and value (d).

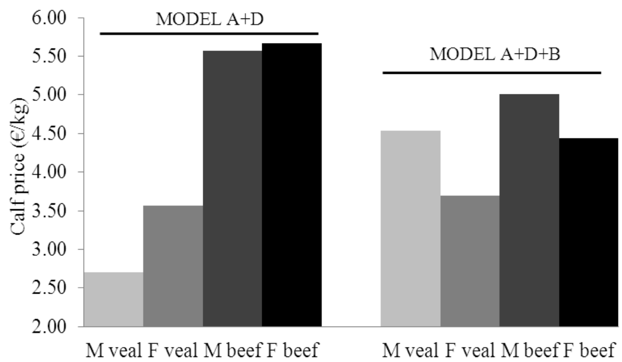
a



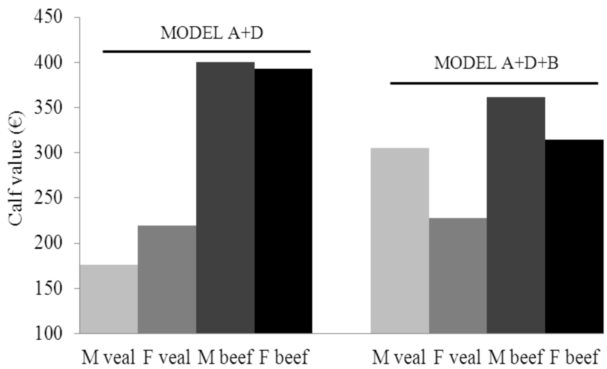
b



c



d

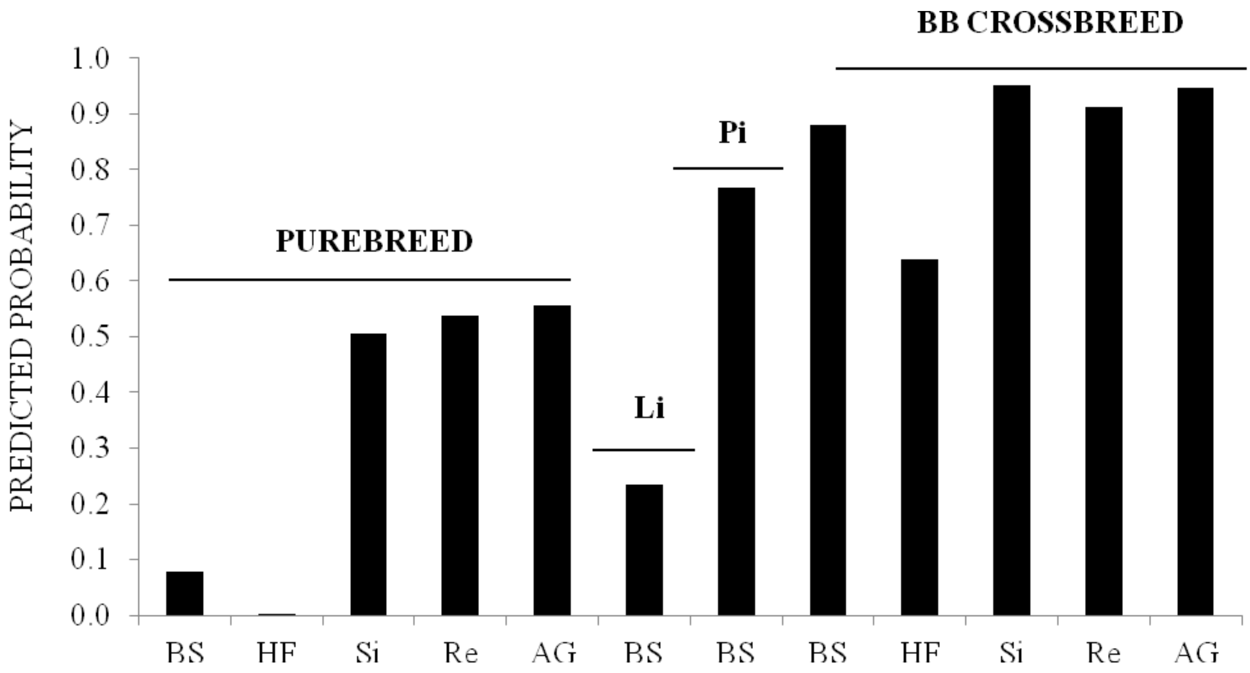


Model A+D includes the effects of herd, year, month, gender and, for live-weight, price and value, of age at sale plus the effect of destination and its interaction with gender and age at sale.

Model C was model A plus the effects of breed of calves and its interaction with gender and age at sale.

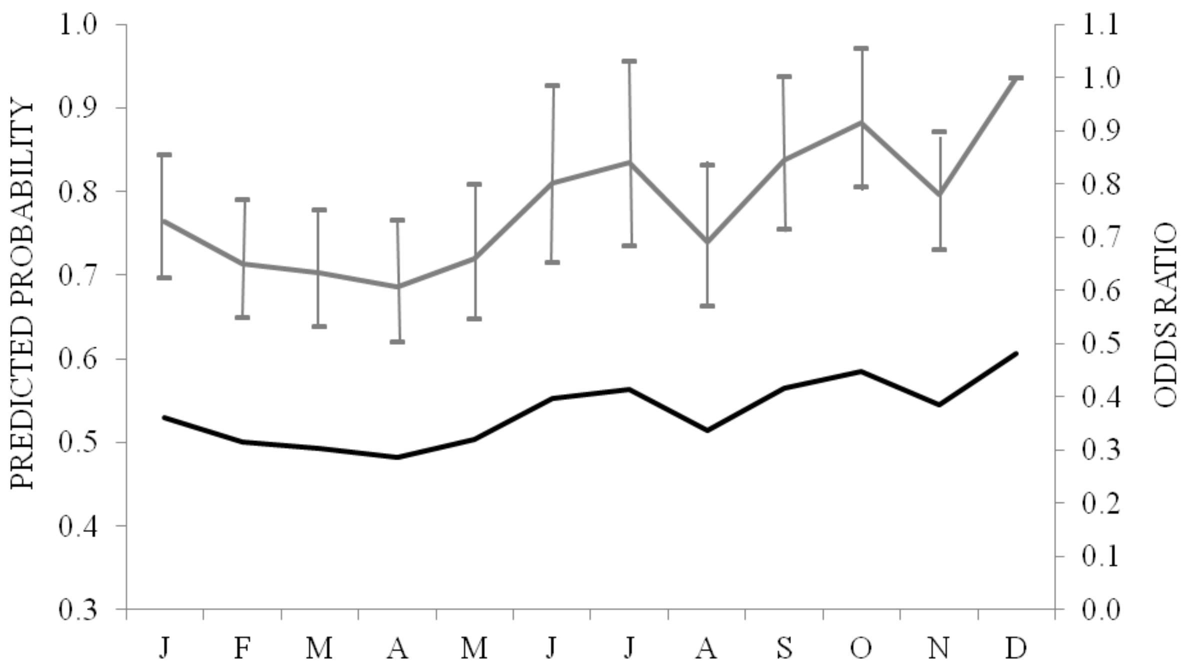
Model A+D+B was model A+D plus the effects of breed of calves and its interaction with gender and age at sale.

Figure 3. Predicted probability of a calf being sold for beef production, during the month of December at an average age of 24 d and live-weight of 65 kg (as opposed to being sold for veal production) for different breeds[1] and breed crosses[2].



[1]BS = Brown Swiss; HF = Holstein Friesian; Si= Simmental; Re= Rendena; AG= Alpine Grey
[2]Li = Limousin; Pi = Piemontese; BB = Belgian Blue.

Figure 4. Predicted probability of a Simmental male calf, at 24 d of age and 65 kg of live-weight, being sold for veal production (as opposed to being sold for beef production) (black line) and odds ratio (grey line) for each month of sale (95% confidence interval of odds ratios are represented as vertical error bars).



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CHAPTER 4.

Use of crossbreeding with Belgian Blue bulls in dairy herds: effect on age at slaughter, carcass traits and selling value

ABSTRACT

The aim of the present study was to analyzed carcass traits and selling values of different breed types of young bulls and beef heifers. Data on age, live weight, price and value of calves, and carcass weight, carcass price, carcass value, date of birth, date of selling, and date of slaughter of 3,701 young beef bulls and 2,327 beef heifers slaughtered from 2005 to 2011 were available for statistical analysis. Animals belonged to purebred Simmental, Rendena and Alpine Grey dual-purpose breeds (only bulls) and 5 crossbreed types obtained from mating the previous dual-purpose dam breeds and 2 dairy dam breeds (Brown Swiss and Holstein Friesian) with Belgian Blue sires. Only animals between 210 and 500 kg of carcass weight, between 1,050 and 2,050 € of carcass value and between 350 and 700 d of age at slaughter were retained. Data recorded from each animal were analyzed with two separate linear models (for bulls and beef heifers) with the inclusion of effects of breed type, year and month of selling, and the fattening farm (only for bulls). The coefficients of determination were 0.55 and 0.52, 0.44 and 0.25, 0.22 and 0.04, 0.67 and 0.77, 0.44 and 0.51, 0.41 and 0.53, 0.41 and 0.45 for slaughter age, carcass weight, carcass daily gain, carcass price, carcass value, added value, daily added value, for young bulls and heifers, respectively. Dual-purpose Simmental young bulls carcasses were heavier (373 kg) and received greater value (€ 1,618/head) compared with Alpine Grey and Rendena young bulls (343 kg; €1,444 and €1,458/head, respectively). Crossbreed young bulls and heifers from Simmental dams showed the best carcass weight (385 and 283 kg) and the best carcass daily gain (0.74 and 0.67 kg/d). Finally, crossbreds from Simmental and Belgian Blue sires and Holstein Friesian dams resulted in the highest added value (€ 1,260; € 1,264 and € 1,159, respectively).

Key words: crossbreeding, Belgian Blue, young bulls, beef heifer, carcass weight, selling value

INTRODUCTION

Beef production from dairy farms in Italy is a common practice, particularly in the Alps where the low replacement rate of dairy herds allow the mating of a substantial number of cows (25-30% each year) with beef sires to obtain greater income from selling crossbred instead of purebred calves as reported studying the literature (Dal Zotto et al., 2009; Mc Hugh et al., 2010). The vast majority of crossbred calves in northern Italy are progeny of Belgian Blue sires. The use sires from double-muscling breeds, in particular the Belgian Blue, is gaining interest in Europe (Dal Zotto et al., 2007b, 2009; Penasa et al., 2009) because they have less bone, less fat, more muscle and greater dressing percentage than dairy purebreds (Shahin and Berg, 1985; Hanset et al., 1987; Uytterhaegen et al., 1994). Crossbreeding between dairy and beef cattle breeds has been investigated in the past (Cundiff, 1970; Nelson et al., 1982) and more recently by Cundiff et al. (2001). Carcasses from beef x dairy cows are more valuable than those from purebred dairy cattle (Wolfovà et al., 2007); in fact, crossbreeding improves the eating characteristics of meat (Davies et al., 1992) and dressing percentage more than purebred animals (Gϋngör et al., 2003). In Italy two major calves market destination exist, namely veal and beef. Almost all calves destined to veal production are represented by purebred calves from specialized dairy breeds (mainly Holstein Friesian and Brown Swiss) whereas the majority of crossbreed calves and purebred calves from dual-purpose dams are destined to beef production and are more rewarded by the market than those destined to veal production. Purebred calves from dual-purpose dam breeds are heavier, performed better and received greater price and value at sale than calves from dairy breeds (Bittante et al., 2005). No studies are currently available that quantified the fattening performance of dual purpose young bulls and crossbred animals from Belgian Blue sires and dairy and dual-purpose dams. Therefore, the objective of the present study was to compare carcass value and weight of dual purpose bulls from Simmental, Rendena and Alpine Grey breeds, and crossbreed young bulls and beef heifers progeny of Belgian Blue sires and 5 dam breeds, namely Holstein Friesian, Brown Swiss, Simmental, Rendena and Alpine Grey.

MATERIAL AND METHODS

Data

The information recorded on each animal included age, live weight, price and value of sold calf, breed or breed type, carcass weight, carcass price, carcass value, date of birth, date of purchase, and date of slaughter of 3,701 young beef bulls and 2,327 heifers from 3 purebred dual-purpose breeds (Simmental, Si; Rendena, Re; and Alpine Grey, AG) (only bulls) and 5 crossbred types obtained from mating the previous 3 dual-purpose dam breeds and 2 dairy dam breeds (Brown Swiss, BS, and Holstein Friesian, HF) with Belgian Blue (BB) sires. Data consisted of animals slaughtered from 2005 to 2011 and originated from 6 different fattening farms for young bulls and only 1 fattening farms for heifers. Young bulls and beef heifers originated from calves born from associated dairy farms of the Trento province (Italy). Animals were collected once a week by the Breeders Federation of Trento province at a mean age of 24 d, and were subsequently destined to beef production system by one qualified technician who also attributed a market value to each calf. Animals were weaned in specialized farms outside the Trentino region and at approximaterly 5 month of age and 250 kg of live weight came back for the fattening period. The animals were fattened on high-concentrate traditional cereal based diets to promote their maximum daily gain, usually provided as total mixed ration to promote a synchronized intake of roughage and concentrates. The heifers were slaughtered at approximately 14 months of age and 500 kg of live weight whereas bulls were slaughtered at approximately 20 months of age and 650 kg of live weight. At slaughtering, carcass weight was recorded on each animal and a technician attributed a value to the carcass (carcass weight x carcass price).

Only animals between 210 and 500 kg of carcass weight and between 1,050 and 2,050 € of carcass value were retained. Moreover, only animals between 350 and 700 d of age at slaughter were analyzed.

Statistical analysis

Data recorded from each animal (age, live weight, price and value of the calf at purchase, slaughter age, carcass weight, carcass daily gain, carcass price, carcass value, added value and daily value increase) were analyzed with two separate models (for young bulls and beef heifers) using the GLM procedure of SAS (SAS, 2009). Fixed effects included in both models were breed or breed type, and year and month of slaughter. Besides these factors, the effect of fattening farm was included only in the model of young bulls.

RESULTS

General statistics

Male and female calves destined to beef production were sold at an average age and live weight of 24 and 25 d, and 74 and 70 kg, respectively, and received an average price and value of 6.08 and 5.91 €/kg, and 446 and 416 €/calf, respectively. Following the same weaning period, the fattening time was quite different; in particular beef heifers were slaughtered earlier than young bulls (430 vs 532 d of age, respectively) and their carcass was lighter than that of young bulls (279 vs 373 kg, respectively). Young bulls and beef heifers were evaluated 4.43 and 5.52 €/kg of carcass weight and of 1,651 and 1,545 €/head of carcass value, respectively. Moreover, young bulls and beef heifers showed on average 0.70 and 0.65 kg/d of carcass daily gain, a mean added value of 1,204 and 1,129 €/head and an average daily added value of 2.38 and 2.78 €/d.

Analysis of variance

Results from analysis of variance for young bulls and beef heifers are summarized in Tables 2 and 3, respectively. The coefficients of determination for calf traits were 0.03 and 0.04, 0.04 and 0.04, 0.89 and 0.78, 0.76 and 0.49, for calf age, calf weight, calf price and calf value, for young bulls and heifers, respectively. Moreover, the coefficients of determination for slaughter traits were 0.55 and 0.52, 0.44 and 0.25, 0.22 and 0.04, 0.67 and 0.77, 0.44 and 0.51, 0.41 and 0.53, 0.41 and 0.45 for slaughter age, carcass weight, carcass daily gain, carcass price, carcass value, added value, and daily added value, for young bulls and heifers, respectively.

All the main effects included in the model for young bulls and beef heifers were significant in explaining the variation of all traits ($P<0.001$) with some exceptions (e.g. breed effect was not significant in explaining the variability of carcass price and carcass daily gain for beef heifers).

Breed effect

Least squares means and contrast estimates for the breed effect for the analyzed traits are in Tables 4 and 5 for young bulls and beef heifers, respectively. The majority of the data were represented by crossbreed animals from BB sires and the two dairy dam breeds (BS and HF). In particular, crossbred animals of BBXBS represented more than 48% and >60% of the total data for beef bulls and heifers, respectively.

Purebred male calves received less price and value at purchase sale than crossbred calves, and less carcass price and carcass value at slaughter. Simmental male calves received greater price and value at sale compared with the other two dual-purpose breeds, and greater carcass price, carcass value and greater added value at slaughter. Furthermore, purebred Si bulls were heavier, younger and also exhibited greater carcass daily gain at slaughter than the other two dual-purpose breeds (Re and AG).

Male calves from the crossbred combination between BB sires and Si dams received the greatest price and value at sale. Male calves from BB sires and HF dams were older and received less price and value than the other crossbred male calves. Furthermore, crossbred bulls from HF and AG dams, were lighter, and received less carcass price and value at slaughter, but they exhibited greater added value and daily added value than the other breeds.

Significant differences were detected between Si bulls and the other 2 local dual-purpose breeds for all the analyzed traits ($P<0.001$) with the exception of age of calf at sale. Furthermore, differences between the local dual purpose breeds were not significant for age and weight of calf at sale and for carcass weight, carcass price, carcass value and added value. Significant differences were detected between crossbred bulls from Si dams and from the two local dual-purpose breeds for calf price, calf value, carcass weight, carcass daily gain, carcass value and daily added value ($P<0.05$). No differences were detected between crossbred bulls from dairy and dual-purpose dam breeds for slaughter traits, with the exception of added value and daily added value ($P<0.001$). No differences between crossbred bulls from the two dairy dams were found for slaughter age and carcass price.

Female calves from BB sires and Si dams received the greatest price and value at sale and the greatest carcass value at slaughter. Furthermore, BB x Si beef heifers exhibited the best carcass daily gain. However, female calves from the crossbred combination between BB sires and HF dams were older and received less price and value at sale, and less carcass price and carcass value at slaughter, but they exhibited the greatest added value and daily added value. Furthermore, females crossbred calves from BB sires and AG dams exhibited the worst carcass daily gain.

No significant differences were detected between crossbreed females from Si dams and the local dual purpose dam breeds (Re and AG) for age and weight of calf at sale, carcass price and added value. No differences were detected between crossbred females from dairy and dual-purpose dam breeds for age of calf at sale, carcass weight, carcass price and carcass value. Significant differences were detected between crossbreed females from the two dairy dam breeds (HF and BS) for all the analyzed traits with the exception of slaughter age. Furthermore, no differences were detected between crossbred females from the two local dual-purpose dam breeds.

Year and month of slaughter

Slaughter age varied across months of slaughter (Figure 1a). Bulls slaughtered in February were younger whereas those slaughtered in July were older (497 and 549 d of age, respectively). However, heifers slaughtered in September and October were younger and those slaughtered in May were older (416 and 439 d of age, respectively).

Carcass weight varied across months of slaughter (Figure 1b). Bulls slaughtered in February were lighter and those slaughtered in August were heavier (354 and 380 kg, respectively). Heifers slaughtered in June were heavier and those slaughtered in October were lighter (282 and 269 kg, respectively).

Carcass price varied across months of slaughter (Figure 1c). Higher carcass price occurred in April for both young bulls and heifers (4.46 and 5.57 €/kg, respectively) whereas lower carcass price occurred in June and July for bulls, and in December for heifers (4.33 and 5.40 €/kg).

Age at slaughter and carcass weight varied across years (Figures 2a and 2b, respectively). Bulls and heifers slaughtered in 2005 were younger (485 and 373 d of age) and lighter (340 and 248 kg) while bulls slaughtered in 2011 and beef heifers in 2010 were older (579 and 471 d of age) and heavier (398 and 299 kg), respectively. Furthermore, carcass price varied across year of slaughter (Figure 2c). The highest carcass price occurred in 2008 for both young bulls and heifers (4.68 and 5.97 €/kg) and the lowest in 2005 (4.01 and 4.89 €/kg).

DISCUSSION

Differences found for age at sale, calf price and calf live weight for gender effect were confirmed by several studies (Troxel et al., 2002; Barham and Troxel, 2007; Dal Zotto et al., 2009; Mc Hugh et al., 2010). Furthermore, Holland and Hoddle (1992) reported a difference of 2.5 kg between male and female calves at birth, and these results consisted with those reported in our study.

As expected, greater carcass weight of young bulls compared with beef heifers were found, in agreement with several studies (Karolyi et al., 2006; Bidner et al., 2008; Węglarz, 2010). Furthermore, Hoving-Bolink et al. (1998) reported greater daily gain for bulls than heifers. The BS was the most represented dam breed of the dataset. This is because the BS breed represents one of the most widespread dairy cattle breed in Trento province (Bittante et al., 2011); BS is reared for better milk quality traits and particularly for greater protein and fat contents (Samorè et al., 2007), better milk coagulation properties (De Marchi et al., 2007, 2009; Cecchinato et al., 2009) and its specialization for PDO cheeses manufacturing (De Marchi et al., 2008). Furthermore, the use of beef sires is more relevant on BS cattle breed than on other dairy or dual-purpose breeds, as reported by Dal Zotto et al. (2009), reflecting the greater fertility and longevity of the BS breed reared on the alpine area (Dal Zotto et al., 2007a).

Superiority of the calf and slaughter traits of Si bulls compared to the local dual-purpose purebred bulls was due to the effective greater size of Si breed (Dal Zotto et al., 2009). Furthermore, Si dams produced better calves and carcass traits of young bulls and beef heifers also when were mated with beef sire (especially with BB sire). The superiority in calf traits of the progeny from BB sire and dual-purpose dams compared with the progeny of local dual-purpose breeds and of crossbreds between BB sires and dairy dam breeds has been already reported by Dal Zotto et al. (2009).

Live weight of calf at sale was associated to the age of calf accordingly to findings from Dal Zotto et al. (2009); however, Bittante et al. (2011) reported a strong and negative genetic correlation between age of calf at sale and live weight, and this is related to farmer decisions (they sell first the fast growing and later the slow growing calves).

During the summer season less animals from both genders were slaughtered because the supply of beef decreased; this caused an increasing in carcass weight and slaughter age of both young bulls and beef heifers. In fact, carcass weight was positively associated with slaughter age for both genders of animals.

Differences in carcass traits across different breed or breed types have been reported by Laborde et al. (2001) who analyzed 136 crossbreed steers progeny of purebred Angus or Simmental bulls mated to dam differing in proportion of Angus, Simmental and various other breeds. Breed differences in age and weight at slaughter has been already confirmed by several authors in the past (Vanderwert et al., 1985; Gregory et al., 1994; Mandell et al., 1998c) according to different precocity of each breed. Recently, Alberti et al. (2008) reported significant breed differences in slaughter weight and daily gain comparing 15 different European breeds of young bulls.

CONCLUSION

Results showed that crossbred young bulls and heifers from BB sires and Si dams achieved the highest carcass weight and the best daily gain and carcass value. However, the best economic revenue was achieved by Si bulls, among purebred animals, and by BB sires x HF dams, among crossbreed animals. This is mainly a consequence of less purchase value of calves at the beginning of the fattening. However, no information were recorded in the present study on feed intake and feed efficiency of each breed or breed combination, and thus the real best economic revenue of the progeny of BB sires and HF dams should be validated by further analyses considering also the different feed intake and efficiency of each breed type.

TABLES AND FIGURES

Table 1. Means and standard deviations (SD) of the data included in the analysis for young bulls and heifers.

Trait	Young bulls (N = 3,701)		Heifers (N = 2,327)	
	Mean	SD	Mean	SD
Age of calf (d)	24	9	25	9
Calf weight (kg)	74	8	70	8
Calf price (€/kg)	6.08	1.11	5.91	0.66
Calf value (€)	446	88	416	60
Slaughter age (d)	532	63	430	31
Carcass weight (kg)	373	48	279	26
Carcass daily gain (kg/d)	0.71	0.07	0.65	0.05
Carcass price (€/kg)	4.43	0.35	5.53	0.44
Carcass value (€)	1,651	231	1,545	200
Added value (€)	1,204	229	1,129	206
Daily added value (€/d)	2.38	0.40	2.78	0.46

Carcass daily gain = carcass weight/slaughtering age.

Added value = carcass value - calf value.

Daily added value = added value / (slaughter age – age of calf).

Table 2. Results from ANOVA for analyzed traits of young bulls.

Trait	Breed effect		Herd effect		Month effect		Year effect		R^2	RMSE[1]
	F-value	*P*-value	*F*-value	*P*-value	*F*-value	*P*-value	*F*-value	*P*-value		
Age of calf (d)	7.45	<0.0001	1.84	0.1	1.76	0.05	5.68	<0.0001	0.03	8.48
Calf weight (kg)	5.75	<0.0001	5.97	<0.0001	4.05	<0.0001	3.47	0.002	0.04	8.18
Calf price (€/kg)	3574.96	<0.0001	5.45	<0.0001	1.76	0.05	121.90	<0.0001	0.89	0.37
Calf value (€)	1364.43	<0.0001	2.51	0.03	5.66	<0.0001	28.09	<0.0001	0.76	43.48
Slaughter age (d)	5.14	<0.0001	181.22	<0.0001	56.85	<0.0001	284.93	<0.0001	0.55	42.56
Carcass weight (kg)	46.29	<0.0001	73.28	<0.0001	17.33	<0.0001	163.66	<0.0001	0.44	35.88
Carcass daily gain (kg/d)	76.91	<0.0001	56.81	<0.0001	5.92	<0.0001	20.20	<0.0001	0.22	0.06
Carcass price (€/kg)	61.91	<0.0001	768.81	<0.0001	18.59	<0.0001	544.82	<0.0001	0.67	0.20
Carcass value (€)	88.78	<0.0001	75.82	<0.0001	8.15	<0.0001	316.84	<0.0001	0.44	172.90
Added value (€)	16.42	<0.0001	78.84	<0.0001	7.03	<0.0001	333.56	<0.0001	0.41	175.93
Daily added value (€/d)	30.29	<0.0001	302.06	<0.0001	6.89	<0.0001	127.54	<0.0001	0.41	0.31

[1]RMSE=root mean square error.

Carcass daily gain = carcass weight/slaughtering age.

Added value = carcass value - calf value.

Daily added value = added value / (slaughter age – age of calf).

Table 2. Results from ANOVA for analyzed traits of young bulls.

Trait	Breed effect		Herd effect		Month effect		Year effect		R^2	RMSE[1]
	F-value	*P*-value	*F*-value	*P*-value	*F*-value	*P*-value	*F*-value	*P*-value		
Age of calf (d)	7.45	<0.0001	1.84	0.1	1.76	0.05	5.68	<0.0001	0.03	8.48
Calf weight (kg)	5.75	<0.0001	5.97	<0.0001	4.05	<0.0001	3.47	0.002	0.04	8.18
Calf price (€/kg)	3574.96	<0.0001	5.45	<0.0001	1.76	0.05	121.90	<0.0001	0.89	0.37
Calf value (€)	1364.43	<0.0001	2.51	0.03	5.66	<0.0001	28.09	<0.0001	0.76	43.48
Slaughter age (d)	5.14	<0.0001	181.22	<0.0001	56.85	<0.0001	284.93	<0.0001	0.55	42.56
Carcass weight (kg)	46.29	<0.0001	73.28	<0.0001	17.33	<0.0001	163.66	<0.0001	0.44	35.88
Carcass daily gain (kg/d)	76.91	<0.0001	56.81	<0.0001	5.92	<0.0001	20.20	<0.0001	0.22	0.06
Carcass price (€/kg)	61.91	<0.0001	768.81	<0.0001	18.59	<0.0001	544.82	<0.0001	0.67	0.20
Carcass value (€)	88.78	<0.0001	75.82	<0.0001	8.15	<0.0001	316.84	<0.0001	0.44	172.90
Added value (€)	16.42	<0.0001	78.84	<0.0001	7.03	<0.0001	333.56	<0.0001	0.41	175.93
Daily added value (€/d)	30.29	<0.0001	302.06	<0.0001	6.89	<0.0001	127.54	<0.0001	0.41	0.31

[1]RMSE=root mean square error.

Carcass daily gain = carcass weight/slaughtering age.

Added value = carcass value - calf value.

Daily added value = added value / (slaughter age – age of calf).

Table 3. Results from ANOVA for analyzed traits of heifers.

Trait	Breed effect		Year effect		Month effect		R^2	RMSE
	F-value	*P*-value	*F*-value	*P*-value	*F*-value	*P*-value		
Age of calf (d)	3.30	0.01	3.13	0.004	4.86	<0.0001	0.04	8.73
Calf weight (kg)	9.24	<0.0001	2.41	0.02	4.72	<0.0001	0.04	7.92
Calf price (€/kg)	1840.92	<0.0001	77.82	<0.0001	6.44	<0.0001	0.78	0.31
Calf value (€)	532.25	<0.0001	11.80	<0.0001	3.32	0.0002	0.49	43.13
Slaughter age (d)	5.56	0.0002	276.43	<0.0001	19.43	<0.0001	0.52	21.86
Carcass weight (kg)	8.58	<0.0001	87.85	<0.0001	6.03	<0.0001	0.25	22.26
Carcass daily gain (kg/d)	14.31	<0.0001	3.45	0.002	1.71	0.06	0.04	0.05
Carcass price (€/kg)	2.25	0.06	1255.62	<0.0001	7.75	<0.0001	0.77	0.21
Carcass value (€)	8.70	<0.0001	341.44	<0.0001	5.64	<0.0001	0.51	140.77
Added value (€)	24.09	<0.0001	354.35	<0.0001	5.64	<0.0001	0.53	141.71
Daily added value (€/d)	34.37	<0.0001	264.14	<0.0001	2.97	0.0006	0.45	0.34

[1]RMSE = root mean square error.

Carcass daily gain = carcass weight/slaughtering age.

Added value = carcass value - calf value.

Daily added value = added value / (slaughter age – age of calf).

Table 4. Least squares means and contrasts estimates among breed type for calf and slaughter traits of young bulls.

	Heads No.	Calf traits				Slaughter Traits[1]						
		Age d	Weight kg	Price €/kg	Value €/head	Age d	Carcass kg	CDG Kg/d	Price €/kg	Value €/head	AV €/head	DAV €/d
Purebreds:												
Simmental (Si)	253	25	76	4.73	358	522	373	0.72	4.36	1,618	1,260	2.55
Alpine Grey (AG)	94	27	74	4.07	300	545	343	0.63	4.22	1,444	1,144	2.20
Rendena (Re)	368	26	72	3.93	285	529	343	0.65	4.26	1,458	1,173	2.35
Crossbreds from Belgian Blue sire and:												
Simmental dam (BB×Si)	508	24	74	7.34	543	520	385	0.74	4.50	1,726	1,183	2.39
Alpine Grey dam (BB×AG)	69	24	75	6.85	513	525	372	0.71	4.46	1,657	1,144	2.29
Rendena dam (BB×Re)	227	23	74	6.77	502	523	376	0.72	4.48	1,679	1,177	2.36
Brown Swiss dam (BB×BS)	1,766	24	73	6.50	474	520	379	0.73	4.48	1,692	1,218	2.46
Holstein Friesian dam (BB×HF)	416	26	74	5.29	393	522	372	0.71	4.46	1,657	1,264	2.56
Contrast Breed effect						*P*-value						
[Si *vs.* (AG+Re)][2]		NS	***	***	***	***	***	***	***	***	***	***
(AG *vs.* Re)[3]		NS	NS	**	**	**	NS	**	NS	NS	NS	***
[(Si+AG+Rd) *vs.* (BB×Si+BB×AG+BB×Re)][4]		***	NS	***	***	**	***	***	***	***	*	NS
[BB×Si *vs.* (BB×AG + BB×Re)][5]		NS	NS	***	***	NS	***	***	NS	***	NS	*
[(BB×BS+BB×HF) *vs.* (BB×Si+BB×AG+BB×Re)][6]		***	*	***	***	NS	NS	NS	NS	NS	***	***
(BB×BS *vs.* BB×HF)[7]		***	*	***	***	NS	***	***	NS	***	***	***
(BBxAG *vs.* BBxRE)[8]		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1]CDG = Carcass daily gain; AV = Added Value; [2]DAV =Daily Added Value; NS = not significant; *P<0.05; **P<0.01; ***P<0.001
[2]Contrast between Simmental and local dual-purpose breeds. [3]Contrast between the two local dual-purpose breeds. [4]Contrast between purebred and crossbreed bulls from dual-purpose dams. [5]Contrast between crossbreed bulls from Simmental dams and the two dual-purpose local dam breeds. [6]Contrast between crossbreeds bulls from dairy and dual purpose dam breeds. [7]Contrast between crossbreed bulls from the two dairy dam breeds. [8]Contrast between crossbreed bulls from Alpine Grey and Rendena dams.

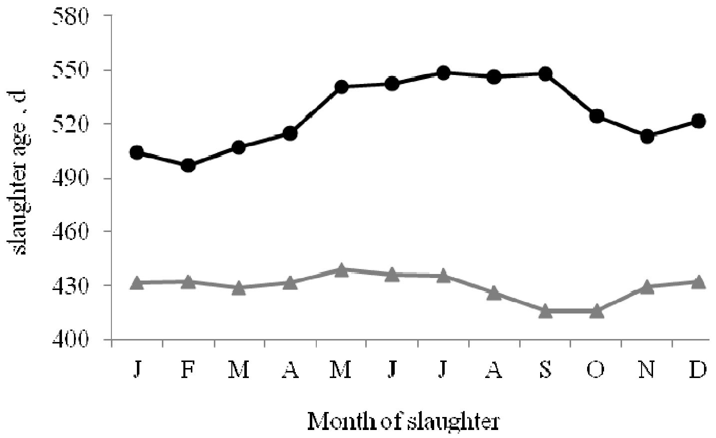
Table 5. Least squares means and contrasts estimates among breed type for calf and slaughter traits of heifers.

Crossbreds from Belgian Blue sire and:	Heads No.	Calf Traits				Slaughter Traits[1]						
		Age d	Weight kg	Price €/kg	Value €/head	Age d	Carcass kg	CDG Kg/d	Price €/kg	Value €/head	AV €/head	DAV €/d
Simmental dam (BB×Si)	402	24	73	6.68	486	425	283	0.67	5.48	1,556	1,070	2.66
Alpine Grey dam (BB×AG)	43	25	73	6.22	450	437	272	0.62	5.45	1,485	1,035	2.50
Rendena dam (BB×Re)	155	23	73	6.13	445	433	276	0.64	5.49	1,518	1,073	2.61
Brown Swiss dam (BB×BS)	1,398	24	71	5.88	415	427	279	0.66	5.47	1,533	1,118	2.77
Holstein Friesian dam (BB×HF)	329	26	72	4.71	340	426	275	0.65	5.44	1,499	1,159	2.89
Contrast breed effect						*P*-value						
[BBxSi *vs.* (BBxAG+BBxRe)][2]		NS	NS	***	***	***	***	***	NS	***	NS	**
[(BBxBS+BBxHF) *vs.* (BBxSi+BBxAG+BBxRe)][3]		NS	**	***	***	***	NS	*	NS	NS	***	***
(BBxBS *vs.* BBxHF)[4]		**	**	***	***	NS	***	**	*	***	***	***
(BBxAG *vs.* BBxRe)[5]		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

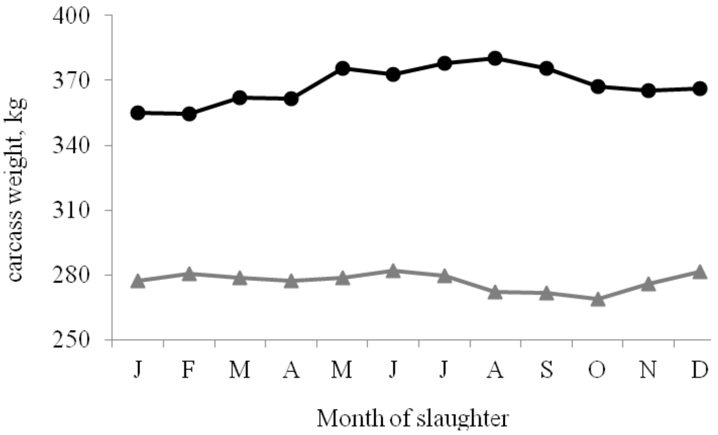
[1]CDG = Carcass daily gain; AV = Added Value; [2]DAV = Daily Added Value. NS = not significant; *P<0.05; **P<0.01; ***P<0.001.
[2]Contrast between crossbreed heifers from two local dual-purpose dam breed and Simmental breeds. [3]Contrast between crossbreed heifers from dairy and dual-purpose dam breeds. [4]Contrast between crossbreed heifers from the two dairy dams breeds. [5]Contrast between crossbreed bulls from Alpine Grey and Rendena dams.

Figure 1. Least square means of slaughter age (a), carcass weight (b), and carcass price (c) of young bulls (black line) and heifers (grey line) for month of slaughter.

a



b



c

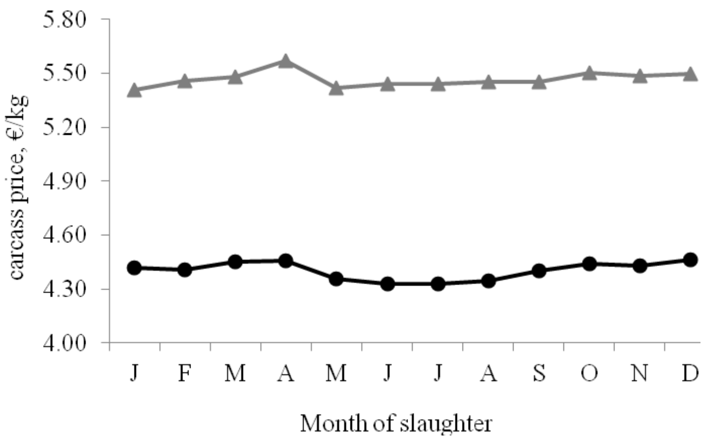
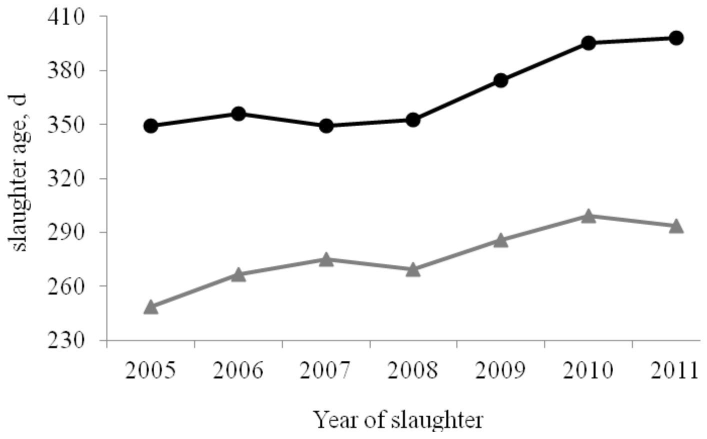
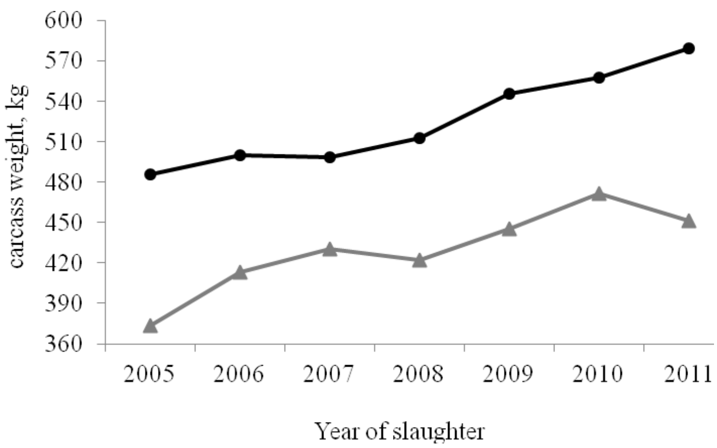


Figure 2. Least square means of slaughter age (a), carcass weight (b), and carcass price (c) of young bulls (black line) and heifers (grey line) for year of slaughter.

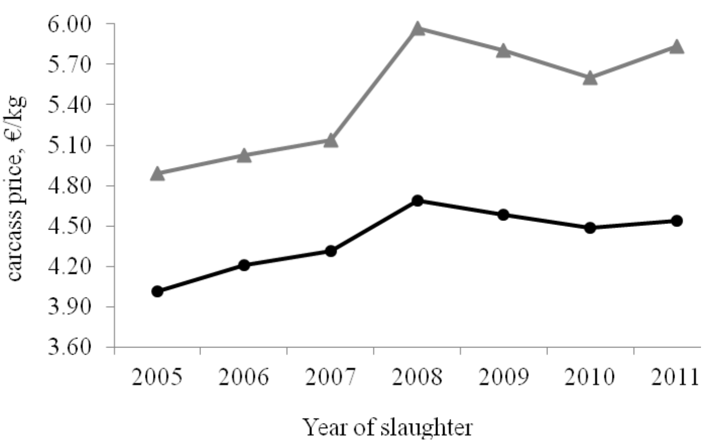
a



b



c



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GENERAL CONCLUSIONS

The sale of animals destined to meat production (cull cows and calves) is a strategy to enhance the profitability of dairy herds.

The value of cull cows at slaughter represents a significant source of income for the farmer as highlighted in this thesis. On average Holstein-Friesian cows were younger at slaughter, yielded lighter carcasses and received lower price and value than Brown Swiss cows. Dual-purpose breeds were older, heavier and received greater price and value at slaughter than Holstein Friesian and Brown Swiss dairy breeds. Among dual-purpose cows, the Simmental was the heaviest and local Rendena and Alpine Grey received the greatest price. The large differences in value among cull cows from different breeds highlighted the importance of cow characteristics.

The sale of calves (average 24 d of age), particularly of beef crossbreed calves, followed by the fattening of animals in specialized farms and the sale of the meat in a local market, represents a good strategy to improve the farm profitability in dairy herds of mountain areas. The best results for calf and fattening traits were obtained with crossbred animals from Belgian Blue sires and Simmental dams. However, the best economic revenue was obtained from the fattening of purebred dual-purpose Simmental young bulls and both crossbreed young bulls and heifers from Belgian Blue sires and dairy dams.

Crossbreed young bulls and beef heifers from Belgian Blue sire and dual-purpose dams (especially Simmental) evidenced the best fattening performance. However, purebred Simmental bulls and both young bulls and heifers progeny from Belgian blue sire and Holstein Friesian dam evidenced the best economic revenue at slaughter.

The use of beef bulls on dairy and dual-purpose cows represents a common practice in the Alps where the farmers seek to maximize the income from the sale of calves. This practice is much less common in specialized dairy farms of the Po Valley due to fertility and longevity problems which impose to mate all the herd with bulls of the same breed to guarantee the replacement of culled animals. In the Alps, the small dairy herds are characterized by less productivity but high fertility and longevity which allow the use of beef sires on a considerable number (approximately 30%) of cows within the dairy farm every year.

The usual practice of beef crossbreeding permitted to maximize the income from the sale of calves for the farmers. Furthermore, the following fattening to the local fattening farms and the slaughter of both crossbreed young bulls and beef heifers with a registered label who guarantee the consumers about the traceability from the birth until the sold of the meat to the associated butcheries can provide an adequate profit also to the few beef farms located at the low- level quota. Each subsequent year the increasing of the number of consumers associated to the improvement of the number of young bulls and heifers slaughtered in the traceability previously cited systems seem to define evidenced the fidelity of the consumers to the traceability system. Moreover, majority of tourists who came on Italian alpine region for their summer or winter holidays prefer to consume high quality guaranteed meat area, also if the cost of certified meat is higher respect the conventional meat. However, in an integrate system this contribute to the remuneration and the continuation of the farming activity associated to the maintenance of the alpine land territory and the environment biodiversity due to the grazing of the cattle and the cutting of the alpine meadows. Finally, this has a positive imaging for the attraction of the touristic activity.

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