

PAPER

A survey on feedlot performance of purebred and crossbred European young bulls and heifers managed under intensive conditions in Veneto, northeast Italy

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Abstract

This study, based on a nearly 10-year collection of performance data of young bulls and beef heifers, aimed to benchmark production traits of specialized fattening herds of northern Italy and to compare the performance of stock calves belonging to several European genetic types (GT). Data originated from 2806 batches (a group of stock calves homogeneous for GT, origin, finishing herd, fattening period, and diets), and concerned 188,891 animals of 10 GT herded in 44 farms of the Veneto region. For each batch, average body weight (BW) at arrival and at sale, duration of the fattening period, losses due to injury or death, purchase and sell price were collected, and average daily gain (ADG) and net sale gain (NSG) per head, per day of fattening, and per kg of BW gain were computed. Charolais and Limousine young bulls accounted for nearly 50% and 20%, respectively, of all animals, and over 90% of calves originated from France. Average BW at arrival and at slaughter approximated 370 and 650 kg, respectively, and ADG approached 1.30 kg/d, but variation due to GT was large ($P < 0.01$). Charolais young bulls were the heaviest at slaughter and showed the greatest ADG, whereas Irish crosses produced the highest NSG per head and per day of fattening. Year affected all traits ($P < 0.01$), but his magnitude was limited for BW at purchase or sale and for ADG, and slightly larger for NSG, even if this last trait did not evidence any long period congruent trend.

Introduction

The European Union is the second consumer and the third producer of beef at world

level (European Commission, 2012). Within the EU, specialist beef producers are represented by breeders, who rear suckler cows and produce calves (48%), by breeders and fatteners, who fatten the calves born on their farm and in some cases calves that have been purchased (40%), and by fatteners (12%), who purchase and fatten calves from specialist breeders and/or from dairy farmers (European Commission, 2011). Beef production systems differ widely among EU countries, ranging from extensive systems in Ireland and Sweden to very intensive systems in Italy. In this country, about two thirds of the young bulls are reared by specialized fatteners located mainly in the northern plains of the country (Veneto and Po' Valley). They use stock calves of local beef breeds, mainly Piemontese in the northwest of Italy (Albera *et al.*, 2001), or young bulls or beef heifers imported from other European countries, especially in the northeast of the country (Cozzi, 2007). Even though Italy accounts for less than 15% of EU specialist fatteners, nearly one third of beef fattened in EU by this category of farms are produced in Italy (European Commission, 2011).

The fattening of imported young bulls or heifers is highly predominant in the Veneto region (northeast Italy), that shares ongoing relationships with several EU countries for the provision of stock calves of several genetic types. Veneto region fattens more than half million heads, and it accounts for nearly 70% of beef bulls produced yearly in Italy by fatteners, 24% of those produced by this category of herds in the whole EU, and more than those produced by every member country, Italy excluded (European Commission, 2011). The stocking density is commonly high and exceeds on average 5 livestock units (LU)/ha, compared with the EU-27 average of 1.8 LU/ha, and average number of head sold per farm is nearly five-fold when compared to that of EU-27 (European Commission, 2011). However, recent and prospected changes in Common Agriculture Policy are reducing measures in favor of specialist beef fatteners (Boatto and Trestini, 2013), thus increasing the uncertainty of farm income and the risk of financial loss.

Although beef production in north Italy can be considered distinguishing within European beef production scenario, benchmarks about typical performance traits, useful for comparisons with other production systems, are still scarcely known. Moreover, the standard management procedures adopted allow to gain reliable comparison of performance traits of several European beef genetic types reared under intensive conditions.

Based on a survey of a nearly 10-years time

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period, this study aimed to characterize the specialized Veneto fattener system and to compare the productive and economic performance of stock calves belonging to different purebred and crossbred genetic types.

Materials and methods

Origin of data and data editing

Data for this survey originated from 44 specialized fattening herds located in the Veneto region (northeast Italy). They were associated to a large cooperative of beef producers (AZoVe, Associazione Zootecnica Veneta, Ospedaletto Euganeo, Italy) and included both private and cooperative herds. The reference unit for data collection was the batch, defined as a group of stock calves, males or females, homogeneous for genetic type, origin, finishing herd, fattening period, and characteristics of the diet. For each batch, the following data were acquired: number of calves, average body weight (BW) at arrival and at sale (kg), fattening length (d), losses due to injury or death (% of animals within batch), purchase and sell price per kg of live weight (€/kg) and per head

(€/head). These data were used to compute the following traits: average daily gain (ADG) (kg/d), calculated as (BW at sale - BW at arrival)/fattening length; net sale gain (NSG), calculated as value at sale - value at purchase, and expressed per head (€/head), per day of fattening (€/d), and per kg of BW gain (€/kg). As arrival and final BW was recorded at farm gate, ADG is not affected by BW losses from the native country to the farm and from the farm to the slaughterhouse. Moreover, as the real value paid or received per head was used in computations, the prices per kg, referred to the BW measured at farm, have not to be discounted for BW losses due to transport.

Initial data consisted on 3260 batches recorded from 1998 to 2011. The following restrictions were made to data set during editing procedures:

- year was retained in the data set when at least 100 batches were available. This leads to the removal from final data set of data concerning 1998, 1999, 2003, 2004, and 2011 years;
- genetic type was retained in the data set when at least 20 batches per genetic type were available. This leads to the removal from the final data set of data concerning Charolais×Limousine, Charolais×Salers female, Irish crosses female, and Limousine female genotypes;
- removal of outliers (values lower or greater than the average ± 3 standard deviations within genetic type) for BW at arrival and at sale, and purchase and sell price;
- removal of herds having less than 10 batches collected in the time period considered.

After editing, final data set included the following genetic types: Charolais (CH), Limousine (LI), Salers (SA), Charolais×Salers (CHSA), Charolais×Aubrac (CHAU), French crosses (FRCR), Irish crosses (IRCR), Eastern Simmental (SI), Polish Friesian (FR), and Charolais heifers (CHF). Number of herds, batches, and animals per genetic type is given in Table 1.

Statistical analysis

Prior to statistical analysis, the size of batches was classified into 5 categories, according to the number of animals per batch (1, <30 animals; 2, from 31 to 60 animals; 3, from 61 to 90 animals; 4, from 91 to 120 animals; 5, >121 animals). Data were analyzed using GLM procedure of SAS (SAS Inst. Inc., Cary, NC, USA) according to the following linear model:

$$y_{ijklmn} = \mu + \text{herd}_i + \text{genotype}_j + \text{year}_k + \text{month}_l + \text{batchsize}_m + e_{ijklmn}$$

where y_{ijklm} is the observed trait; μ is the over-

all intercept of the model; herd_i is the fixed effect of the i^{th} fattening herd ($i=1, \dots, 44$); genotype_j is the fixed effect of the j^{th} genotype ($j=\text{CH, LI, SA, CHSA, CHAU, FRCR, IRCR, SI, FR, CHF}$); year_k is the fixed effect of the k^{th} year of arrival ($k=2000, 2001, 2002, 2005, 2006, 2007, 2008, 2009, \text{ and } 2010$); month_l is the fixed effect of the l^{th} month of arrival ($l=1, \dots, \text{ to } 12$); batch size_m is the fixed effect of the m^{th} class of number of animals per batch ($m=1, \dots, \text{ to } 5$) and e_{ijklmn} is the residual random error term $\sim N(0, \sigma^2_e)$. Mixed model including herd as a random variable was not used as the final model because a preliminary analysis showed almost identical Least Squares means (LSM) and significance level when the model with herd as a fixed effect was run, due to the large number of data used, and because the availability of the herds LSM allowed a better evaluation and description of the herd effect.

Contrasts between genetic types were planned to investigate the difference among: CH, taken as reference breed, *vs* other specialized or dual purpose French, Irish, or east Europe breeds or crossbreds [CH *vs* LI; CH *vs* SA; CH *vs* (CHSA+CHAU+FRCR); CH *vs* IRCR; CH *vs* (SI+FR)]; CH young bulls *vs* CH heifers (CH *vs* CHF); French crossbreds of different origin [(CHSA+CHAU) *vs* FRCR; CHSA *vs* CHAU]; East Europe dual purpose breeds (SI *vs* FR).

and the average size of batch was 67 ± 23 stock calves (Table 1). Nearly half of the batches and calves reared in the herds surveyed were CH. Also LI, the other main French beef breed, was widespread. The purebred French hardy breed SA was rarely imported, whereas its crosses sired by CH were more represented, such as crossbreds obtained from another French hardy breed of the Massif Central, the Aubrac. All together, the French hardy breeds and their CH crosses represented about 10% of young bulls fattened. All the aforementioned categories of stock calves are produced from extensive farms rearing suckler cows kept at pasture with their calves from spring to autumn. Male stock calves imported from France and originated mating beef bulls to dairy and dual purpose cows, the so called French crossbreds, accounted for less than 4% of total beef cattle found in the present survey. Irish crosses, quite variable in terms of breed combinations, represented about 5% of the total. From Eastern European countries, importations were occasional (2.5%) and the most represented breeds were SI (from Croatia, Hungary, Slovakia, Czech Republic) and old dual purpose FR from Poland. The last appreciable category of calves imported from France is represented by heifer-calves, mainly CHF, which accounted for nearly 8% of batches and 5% of animals imported.

Results

Genetic types and gender of stock calves imported by specialized fatteners

The total number of batches and calves recorded in the time interval considered approached 2800 and 189,000, respectively,

Sources of variation of fattening and economic performance of young bulls and heifers

Results from ANOVA for performance and economic traits of young bulls and beef heifers are given in Table 2. With the only exception of losses due to death or injury, effects included in the analysis explained notable proportion of traits variation, and the coefficient of determi-

Table 1. Number of herds, batches, and heads according to genetic type and gender.

Genetic type	Herds, n	Batches		Heads	
		n	%	n	%
Charolais	43	1367	48.72	99,690	52.78
Limousine	30	602	21.5	40,900	21.7
Salers	14	45	1.60	3218	1.70
Charolais×Salers	21	137	4.88	7526	3.98
Charolais×Aubrac	11	119	4.24	6258	3.31
French crosses	24	101	3.60	7210	3.82
Irish crosses	22	135	4.81	9113	4.82
Eastern Simmental	11	32	1.14	2060	1.09
Polish Friesian	16	41	1.46	2761	1.46
Charolais heifers	13	227	8.09	10,155	5.38
Total	44	2806	100.0	188,891	100.0

nation ranged from 0.40 to 0.80 for most traits of concern. Herd, genetic type, year effects, and, to a lesser extent, month of arrival were significant sources of variation of performance and economic traits considered. Conversely, the class of batch size affected variation of final BW and ADG only.

Fattening performance of young bulls and beef heifers according to their genetic type

Least squares means of performance traits of young bulls and beef heifers according to their genetic type are shown in Table 3. Weight of stock calves at arrival approached on average 370 kg, but variation due to genetic type was quite large. Generally, CH male calves were heavier at arrival than all other genetic groups, with the only exception of the crossbred calves imported from France when taken as a whole. Within this complex group, FRCR were lighter than the crosses from the hardy maternal breeds SA and Aubrac (372 vs 391 or 410 kg, respectively, $P < 0.001$). Also the difference between these last two genotypes was significant, as the CHAU stock calves were the heaviest among all the categories compared. The weight at arrival of IRCR stock calves was on average slightly lower than that of the CH male calves, whereas the dual purpose stock calves from the East Europe were much lighter. Among them, FR calves were lighter than SI ones (295 vs 331 kg, $P < 0.001$).

Weight of animals at slaughter was on aver-

age close to 650 kg, but breed category strongly affected this trait. Charolaise young bulls, with an average of 703 kg BW, were the heaviest group, and comparison with other genetic groups was always significant ($P < 0.001$) with the exception of IRCR. Among the other French purebreds, LI young bulls were slaughtered at a much lower BW than CH (591 vs 703 kg, $P < 0.01$), and SA at a slightly lower BW (675 kg). Also slaughter BW of crossbreds imported from France was lower with respect to CH, and FRCR were lighter than crosses from hardy breeds. As expected, slaughter BW of dual purpose young bulls imported from Eastern Europe was much lighter than that of CH young bulls, particularly when FR was taken into account. Last, the lowest BW at slaughter was exhibited by CHF, which did not reach on average 530 kg BW at the end of fattening.

The length of the fattening period was on average close to 220 d. Salers young bulls among the French genetic types and FR among the Eastern European breeds showed the longest fattening period (252 and 236 d, respectively). Only CHF evidenced a fattening period lower than 7 months (198 d). Average daily gain (ADG) was close to 1.30 kg/d, but variation due to genetic type was great. Charolaise young bulls evidenced the greatest ADG (1.40 kg/d) and performed significantly better when compared to all other genetic groups. Crossbred cattle imported from France or from Ireland showed ADG close to 1.30 or 1.35 kg/d, respectively, whereas purebred LI and SA were characterized by weight gain

close to 1.20 kg/d. Among Eastern cattle, FR young bulls exhibited the lowest value. As expected, the gender exerted an effect even larger than that of breed, and growth rate of CHF was nearly 30% lower than that of their male counterparts. Incidence of animal losses during fattening within batch ranged between 1.9 and 2.9% in young bulls and averaged only 1.2% in CHF. Due to the high residual variation in the model of analysis, the only significant difference ($P < 0.001$) was found in the comparison between CH and CHF.

Economic performance of young bulls and beef heifers according to their genetic type

Economic traits of young bulls and beef heifers were all significantly affected by genetic type ($P < 0.001$). As shown in Table 4, the average purchase price per kg of CH stock calves was: i) nearly 15% lower than that of LI calves, which evidenced the greatest values among all categories; ii) slightly greater than that of crossbred stock calves imported from France, which showed significant differences within their category; iii) considerably greater than that of SA or East Europe purebred stock calves or IRCR, with a price-gap ranging between 10 and 34% with respect to IRCR or FR, respectively; iv) nearly 6% greater than the average price paid at purchase for CHF. The purchase price per head, resulting from variation in purchase price per kg and BW at arrival, ranged between 572 and 1045 €/head for FR

Table 2. ANOVA analysis of P values of model effects for performance and economic traits of young bulls and beef heifers.

	P value					R ²	RMSE
	Herd	Genotype	Year	Month	Batch		
Live weight, kg							
At purchase	<0.0001	<0.0001	<0.0001	<0.0001	0.03	0.65	32.67
At sale	<0.0001	<0.0001	<0.0001	<0.0001	0.002	0.89	24.38
Length, d	<0.0001	<0.0001	<0.0001	<0.0001	0.15	0.40	25.59
ADG, kg/d	<0.0001	<0.0001	<0.0001	<0.0001	0.008	0.74	0.08
Losses, %	<0.0001	0.0010	0.004	0.07	0.60	0.17	2.30
Purchase price							
€/kg	<0.0001	<0.0001	<0.0001	<0.0001	0.80	0.79	0.16
€/head ⁻	<0.0001	<0.0001	<0.0001	<0.0001	0.02	0.78	74.20
Sale price							
€/kg	<0.0001	<0.0001	<0.0001	<0.0001	0.83	0.67	0.14
€/head ⁻	<0.0001	<0.0001	<0.0001	<0.0001	0.41	0.78	102.26
Net sale gain							
€/d	<0.0001	<0.0001	<0.0001	<0.0001	0.18	0.41	0.47
€/kg	<0.0001	<0.0001	<0.0001	<0.0001	0.67	0.35	0.34
€/head ⁻	<0.0001	<0.0001	<0.0001	0.3	0.11	0.40	111.11

RMSE, root mean square error; ADG, average daily gain. Batch, class of number of animals per batch (class 1: <30 animals; class 2: from 31 to 60 animals; class 3: from 61 to 90 animals; class 4: from 91 to 120 animals; class 5: >121 animals).

(the cheapest price per kg and the lightest stock calves at arrival) and CHAU crossbreds (the heaviest stock calves at arrival).

For all categories, the average price at sale was lower than that at purchase when expressed per unit weight and, obviously, greater when expressed per head (Table 4). The price at sale per unit weight of CH young bulls was nearly 10% lower when compared to that paid for LI young bulls, slightly lower (-2%) when compared to that paid for CHF, similar to that obtained for crossbred stock calves imported from France, and greater than that paid for IRCR (4.8%) or East Europe pure-bred stock calves (on average 22%). When expressed per head, CH young bulls showed the greatest value, and the differences with other groups ranged between 4 and 43% when compared with the group of crossbreds imported from France or that of dual purpose young bulls imported from East Europe, respectively. The NSG per head was on average roughly one third of the sale price per head (Table 4). Cattle genetic type or category significantly influenced all economic traits ($P < 0.001$). Due to the different trends in price between purchase and sale, in fattening duration, and in ADG, LI young bulls evidenced, with respect to CH, significantly lower ($P < 0.001$) head and daily NSG but greater ($P < 0.001$) NSG per unit

Table 3. Least squares means of performance traits of young bulls and beef heifers according to their genetic type.

	BW, kg		Length, d	ADG, kg/d	Losses, %
	Purchase	Sale			
Genetic type					
CH	394	703	224	1.40	2.31
LI	317	591	228	1.21	2.06
SA	377	675	252	1.19	2.18
CHSA	391	684	225	1.31	2.08
CHAU	410	689	220	1.28	2.28
FRCR	372	663	224	1.30	2.25
IRCR	387	686	222	1.35	2.67
SI	331	620	219	1.30	1.92
FR	295	570	236	1.17	2.90
CHF	325	527	198	1.02	1.24
R ²	0.65	0.89	0.40	0.74	0.17
RMSE	32.67	24.37	25.58	0.08	2.30
P value of breed effect	***	***	***	***	***
Contrasts, P					
CH <i>vs</i> LI	***	***	**	***	ns
CH <i>vs</i> SA	**	***	***	***	ns
CH <i>vs</i> (CHSA+CHAU+FRCR)	ns	***	ns	***	ns
(CHSA+CHAU) <i>vs</i> FRCR	***	***	ns	ns	ns
CHSA <i>vs</i> CHAU	***	ns	ns	**	ns
CH <i>vs</i> IRCR	***	ns	ns	***	ns
CH <i>vs</i> (SI+FR)	***	***	ns	***	ns
SI <i>vs</i> FR	***	***	**	***	ns
CH <i>vs</i> CHF	***	***	***	***	***

BW, body weight; length, duration of the fattening period; ADG, average daily gain; CH, Charolais; LI, Limousine; SA, Salers; CHSA, Charolais×Salers; CHAU, Charolais×Aubrac; FRCR, French crosses; IRCR, Irish crosses; SI, Eastern Simmental; FR, Polish Friesian; CHF, Charolais, heifers; RMSE, root mean square error. *** $P < 0.001$; ** $P < 0.01$; ns, not significant.

Table 4. Least squares means of economic traits of young bulls and beef heifers according to their genetic type.

	Purchase price		Sale price		Net sale gain		
	€/kg	€/head	€/kg	€/head	€/head	€/d	€/kg
Genetic type							
CH	2.56	1001	2.19	1540	539	2.45	1.76
LI	2.95	930	2.44	1438	508	2.26	1.86
SA	2.13	800	1.98	1339	539	2.18	1.80
CHSA	2.46	960	2.15	1474	514	2.31	1.75
CHAU	2.53	1045	2.19	1514	469	2.17	1.69
FRCR	2.60	956	2.18	1450	494	2.19	1.68
IRCR	2.32	892	2.09	1441	549	2.49	1.84
SI	2.24	734	1.90	1177	443	1.99	1.53
FR	1.91	572	1.69	984	412	1.71	1.46
CHF	2.40	785	2.24	1198	413	2.05	1.99
R ²	0.79	0.78	0.68	0.77	0.40	0.41	0.35
RMSE	0.16	74	0.14	102	111	0.47	0.35
P value	***	***	***	***	***	***	***
Contrasts, P							
CH <i>vs</i> LI	***	***	***	***	***	***	***
CH <i>vs</i> SA	***	***	***	***	ns	**	ns
CH <i>vs</i> (CHSA+CHAU+FRCR)	*	**	ns	***	***	***	ns
(CHSA+CHAU) <i>vs</i> FRCR	***	***	ns	**	ns	ns	ns
CHSA <i>vs</i> CHAU	**	***	*	*	*	*	ns
CH <i>vs</i> IRCR	***	***	***	***	***	***	*
CH <i>vs</i> (SI+FR)	***	***	***	***	***	***	***
SI <i>vs</i> FR	***	***	***	***	ns	***	ns
CH <i>vs</i> CHF	***	***	**	***	***	***	***

Net sale gain, value at sale less value at purchase; CH, Charolais; LI, Limousine; SA, Salers; CHSA, Charolais×Salers; CHAU, Charolais×Aubrac; FRCR, French crosses; IRCR, Irish crosses; SI, Eastern Simmental; FR, Polish Friesian; CHF, Charolais, heifers; RMSE, root mean square error. *** $P < 0.001$; ** $P < 0.01$; * $P \leq 0.05$; ns, not significant.

of BW gain. Despite the much lower price at purchase and sale, SA young bulls yielded a NSG per head and per kg weight gain not different than that of CH, whereas their daily NSG was significantly lower because of their lower ADG. The individual and daily NSG evidenced by FRCR crossbred young bulls were significantly lower than those shown by CH, whereas the NSG per kg was not different between these categories. Moreover, the differences among crossbred young bulls imported from France were mostly insignificant. Irish crosses was the only category that yielded significantly greater figures than CH for all NSG traits. Conversely, the dual purpose young bulls imported from East Europe, and especially the FR, were characterized by lower economic return than the specialized beef breeds, whenever it was expressed. Last, CH heifers, despite the low total and daily NSG, exhibited the highest NSG per kg gained.

Variation in fattening and economic performance due to the herd effect

As expected, farm significantly affected all production and economic traits, even after including in the model breed category, year, and month effects. Descriptive statistics of least squares (LS) means of herds for performance and economic traits are given in Table 5. Variation among herds, expressed by the coefficient of variation (CV) of LS means of fattening farms, was greater in average batch weight at arrival when compared to that at sale (6.82 vs 1.92%), and ranges of LS means were 168 and 65 kg for BW at purchase and at sale, respectively. The length of the fattening period exhibited the greatest variation among herds, with a CV equal to 10.2% and a range of LS means close to 150 d, as a consequence of differences among herds for BW at purchase and for ADG. Also LS means of herds for prices tended to be more variable at purchase than at sale, both when expressed per unit of BW and per head. However, differences among LS means of herds were much greater for NSG than for purchase or sale price, as CV ranged between 7.6 and 9.6% for the former and between 2.1 to 4.5% for the latter traits.

Trend of fattening and economic performance due to year effect

Despite year highly affected all traits of concern, the magnitude of year by year variation was limited both for BW at purchase or sale and for ADG. Initial and final BW (Figure 1a) tended to increase slightly during the years investigated. Also the year by year variation of ADG was very limited (Figure 1b), and it

ranged between 1.24 and 1.28 kg/d in the time interval considered. The time variation of prices at purchase and at sale was larger than that of growing performance because it was affected by international market fluctuation. Both prices, when expressed per kg, tended to

increase during the first part of the decade, whereas the trend appeared stable in the last years (Figure 1c). The year-by-year variation of the NSG per kg gain was larger than that of prices and BW, which were the components of NSG. However, no long period congruent trend was evident for NSG (Figure 1d).

Table 5. Descriptive statistics and coefficient of variation of least squares means of herds for performance and economic traits from a model including herd, genotype, year, month and batch effects.

	Mean	CV, %	Minimum	Maximum
BW, kg				
At purchase	360	6.82	269	437
At sale	641	1.92	606	671
Length, d	225	10.22	182	325
ADG, kg/d	1.25	4.62	1.14	1.38
Losses, %	2.18	42.83	0.56	4.73
Purchase price				
€/kg	2.41	4.48	2.09	2.88
€/head	868	3.35	783	918
Sale price				
€/kg	2.10	2.06	2.01	2.20
€/head	1356	2.97	1266	1449
Net sale gain				
€/head	488	9.12	407	666
€/d	2.18	9.55	1.84	2.81
€/kg	1.74	7.64	1.55	2.20

CV, coefficient of variation; BW, body weight; ADG, average daily gain; net sale gain, value at sale less value at purchase.

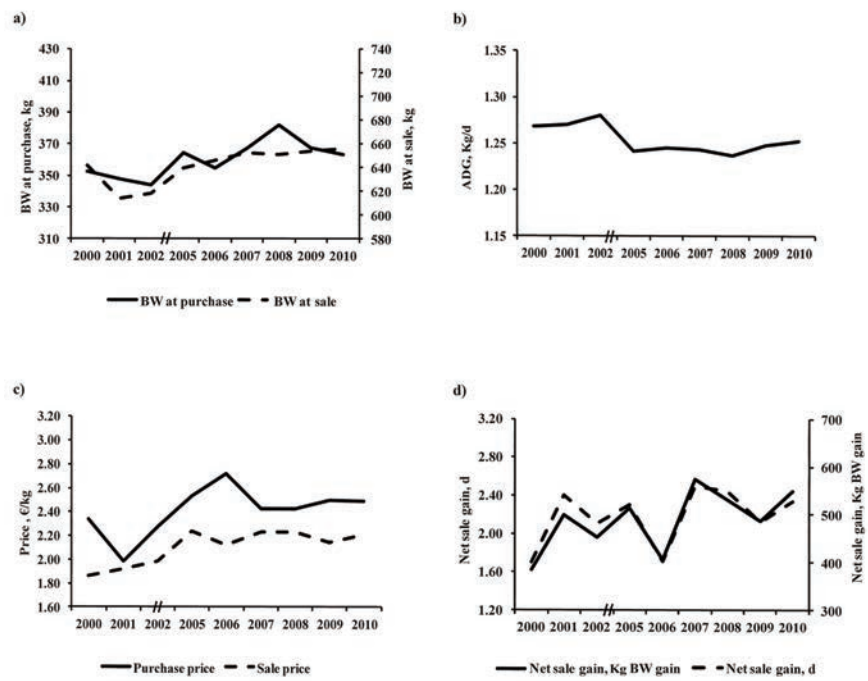


Figure 1. Trend of least squares means of years for body weight (BW) at purchase and at sale (a), average daily gain (ADG) (b), purchase and sale price (c), and net sale gain per day and per kg BW gain (d).

Discussion

The intensive beef farming system of the Veneto region

Stock calves fattened in the Veneto region are mostly imported from other European countries, and the present survey confirmed the dominant role as supply market of France, which accounted for nearly 90% of animals fattened. Ireland and Eastern European countries also contributed to stock calves supply, and in the surveyed herds importation from Ireland tended to increase during the last decade, whereas that from Eastern European countries diminished in the same time period (data not shown).

The present survey included intensive specialized fattening centres with different farm size. In these herds the housing system is typically based on closed or open barn with multiple pens and fully slatted floor or permanent bedding, which are usually both present in the same fattening unit. In general, fatteners tend to allocate middle-sized animals, leaner genotypes, and heifers on barns with slatted floor, whereas they prefer permanent bedding barns for heavy genotypes, more sensitive to lameness (Cozzi *et al.*, 2005). In the present study, individual batches were identified for fattening farm, but not for barn and floor type within farm, so that the comparison of different genetic types and genders are affected also by different proportion of housing system. Anyway, previous studies evidenced that the floor type did not represent a major cause of variation of beef performance in this kind of herds (Sturaro *et al.*, 2005).

Regarding the feeding regime, the Veneto fattening system is based on total mixed ration (TMR) with a high proportion of concentrate (Cozzi *et al.*, 2009). Maize is the main feedstuff used, and it is fed under different form: corn silage, ground corn grain, and, with a lesser extent, ground ears silage or ground grain silage, gluten feed or distillers. Usually corn silage represents the base humid feed for the preparation of TMR, and is included in an increasing proportion moving from beef breeds to crossbreds to dual purpose breeds. Dry or pressed ensiled sugar beet pulps are also sometimes used as non-starchy energy feeds. Conversely, dry mixed feedstuffs moisturized with addition of water are seldom used in these herds. Wheat straw is the most frequent source of long fibre, and soybean meal is the most frequent source of protein, followed by extruded or toasted soybean, sunflower meal, and some byproducts. Mineral and vitamin supplementations are always present in

typical young bulls diets, and different proportions of feedstuffs are used in the mixer wagon according to the genotype/gender/fattening phase category.

Specialized French beef breeds (Charolais and Limousine)

Charolais young bulls were by far the dominant category of animals reared in the Veneto beef system, and this region still remains a main market destination of stock calves for central France beef breeders. Apart from their accessibility, being the most represented beef breed in France (Bouquet *et al.*, 2009), CH stock calves are preferred because of the availability of uniform batches of animals, selected and grouped according to the age/weight interval, conformation/fleshiness, and gender. Moreover, the distance between production and fattening areas complies with a direct lorry transport without intermediate stops, according to EU regulations. It is well known that CH bullocks are able to utilize well the TMR based on corn silage, because of their intake capability (Rioni Volpato *et al.*, 1979; Clarke *et al.*, 2009). In the present study the French white beef breed confirmed its well-known growth potential (Hickey *et al.*, 2007; Alberti *et al.*, 2008; Clarke *et al.*, 2009), and average slaughter BW observed in these specialized fattening units was close to that reported by Chriki *et al.* (2013) for CH in BIF-beef data base. Moreover, CH young bulls are appreciated for their feed efficiency (Williams *et al.*, 1995; Renand *et al.*, 1996; Pfuhl *et al.*, 2007). The high weight at a young age, combined with hoofs often considered sensitive to lameness, lead most farmers to house CH young bulls in barns with permanent bedding (Cozzi *et al.*, 2005). Charolais young bulls are the category of fattened cattle preferred by Italian retail chains, which usually require carcass weight of at least 400 kg, fleshiness and fatness score of U and 2, respectively, according to the SEUROP scale of the EU (European Commission, 2006). Even if the CH young bulls were characterized by one of the highest NSG per head and per day of fattening, the NSG per kg ($1.76 \text{ €} \times \text{kg}^{-1}$) was only about two thirds of the purchase price per kg paid.

French LI young bulls were the second most widespread category of animal found in the Veneto fattening system. In the present survey this breed confirmed the lower growth rate and slaughter weight with respect to CH (Alberti *et al.*, 2008; Clarke *et al.*, 2009). Although LI young bulls are appreciated for the valuable dressing percentage, muscularity of the carcass and retail cuts yield and quality (Alberti *et al.*, 2008), their average NSG per day was lower when compared to CH NSG.

Hardy French dual purpose breeds (Salers and Aubrac) and their crosses with Charolais

The hardy dual purpose French breeds, such as SA, Aubrac, Gascon, are well known since many decades by Veneto fatteners (Rioni *et al.*, 1979; Bittante, 1984). They are appreciated for their resistance to diseases and lameness (Bonsembiante and Bittante, 1984) and for their adaptability to different housing, feeding and management conditions (Piedrafita *et al.*, 2003; Jurie *et al.*, 2005). However, their use in Veneto specialized fattening units as pure-breeds has been very limited in this last decade, and concerned mainly SA young bulls, which exhibited a significantly lower ADG when compared to CH young bulls. This lower potential of growth with respect to CH has been previously reported by others (Liènard *et al.*, 2002), likewise lower dressing percentage and retail cuts value when compared to specialized beef breeds (Bonsembiante and Bittante, 1984; Listrat *et al.*, 1999; Renand *et al.*, 2002). This explains the moderate purchase and sale prices attained by SA young bulls in this study, which resulted in a nearly - 11% NSG per day of rearing when compared to CH young bulls.

The crossbred stock calves sired by CH bulls mated to cows belonging to hardy breeds, mainly SA and AU, appeared more popular among Veneto specialized fatteners than purebred hardy French animals, and accounted for nearly 9% of batches and 7% of young bulls surveyed. These calves are characterized by production traits intermediate between the sire and the dam breeds, and intermediate is also their reputation for adaptability and resistance by fatteners. From an economic point of view, the average purchase and sale price per kg were very similar to those registered for CH breed, and the different value for head with respect to CH relies mainly on the different slaughter BW. The positive sale price per kg gained by these crossbreds may be explained considering that slaughter performance is reputed similar to that of CH, and consequently their carcasses are often commercialized together with CH carcasses. However, the NSG per day of these crossbred young bulls were on average significantly lower than those of the CH, because of their nearly 10% slower growth rate.

French and Irish crossbred calves of different origin

French crosses refer to calves obtained from dairy and dual purpose cows mated to beef bulls, maintained indoor and fed milk replac-

ers. Only first quality calves are weaned for beef production, whereas the second quality calves are assigned to veal production. The most represented crossbreds in Veneto specialized herds are those obtained from CH bulls mated to Holstein Friesian cows (uniform or spotted grey coat) and to Montbeliarde or other Simmental derived breeds (uniform or spotted blonde coat with the white head). Otherwise, but infrequently in Veneto Region, they originate from LI bulls mated to Holstein Friesian (solid black coat) or red spotted cows (solid red coat with the white head).

Even though FRCR originate from environment (closed barns *vs* pasture), feeding regime (milk replacer, concentrates and dry roughage *vs* maternal milk, grass and creep feed), and health background very different with respect to the aforementioned crossbreds with hardy breed cows, in this survey these two crossbred categories provided similar production performance, and differences registered on economic performance were due to the greater price per kg paid for FRCR with respect to CH-hardy crossbreds at purchase, but not at sale.

Irish crosses have a genetic background more variable than that of French crossbreds, as several continental European beef breeds have been imported into Ireland to be evaluated for crossing on Irish Friesian dairy cows and cows of other breeds and breed combinations (Keane and Allen, 2002). However, the breed composition changed gradually year by year, and Italy has become a main importer of live Irish cattle (Department of Agriculture, Food and Fisheries, 2011). The calves imported in the Veneto region are currently sired mainly by Belgian Blue, CH, LI, and SI bulls mated to Friesian and crossbred dairy, dual purpose, and beef cows. In this survey IRCR provided production performances only slightly lower than those observed for purebred CH, whereas economic performance were slightly greater in term of NSG both per kg and per head, because of their favourable purchase price per kg.

Dual purpose breeds from Eastern Europe (Simmental and Polish Friesian)

The extent of importation of beef calves from Eastern European countries has decreased in the last decades. This is probably due firstly to the difficulty to provide a regular availability of large groups of calves uniform for age and weight. Moreover, native Polish Black and White breed, a dual-purpose type with lower dairy and higher meat traits as compared with Holstein Friesian cattle (Litwinczuk *et al.*, 2012), has been progressively crossbred or substituted with specialized

dairy breeds (Gołębiewski and Brzozowski, 2011). Therefore, batches of young bulls of these breeds accounted for less than 3% of those produced by surveyed herds in the last decade. In agreement with previous studies (Chambaz *et al.*, 2001; Alberti *et al.*, 2008; Litwinczuk *et al.*, 2012), when compared to CH or other specialized beef breeds, SI and FR young bulls evidenced lower slaughter weight and growth rate. However, they may partially compensate this drawback with a good adaptability to different housing conditions and to less concentrated diets, thus explaining why some batches of these animals are still imported despite their low NSG per day with regard to other breeds.

Beef heifers (Charolais)

The fattening of beef heifers represents a small but important branch of Veneto fattening system, and involves mainly CH calves imported from France, but sometimes also purebred LI or crossbred calves. With respect to their male counterparts, CHF are imported at a similar age and, consequently, at a lower average BW, and generally they are fed diets characterized by a lower energy content to avoid an excessive fattening. Nevertheless, the duration of fattening was about one month shorter in CHF than in CH, and losses due to death or injuries was nearly halved. Average BW at slaughter and ADG observed for CHF in the present survey were consistent with data of others (Zahradkova *et al.*, 2010; Bureš and Bartoň, 2012). These herd performance allows to obtain typical carcass weight of nearly 300 kg and fatness score ≤ 3 according to SEUROP grade. In the northern Italy market the price per kg is greater for carcasses from heifers than from young bulls of the same breed and SEUROP category. Although the NSG per head or per day of fattening showed by CHF were much lower than those observed for CH, the NSG per kg of BW gained by CHF was the highest among all the cattle categories compared. As heifers are characterized by lower final BW than young bulls, the number of heifers per pen may be higher than that of young bulls, and consequently the weight gain produced and the NSG per pen can be similar or even greater in heifers than in young bulls. Moreover, average feed intake tends to be lower in heifers than in young bulls (Schiavon *et al.*, 2013), so that even the total consumption per pen can be similar between genders.

A comparison of past and present production traits in the Veneto fattening system

The system of beef production in Veneto has

developed during the last four decades with the aim of improving the added value of local agriculture. This has been achieved mainly exploiting the large availability of maize of the region and connecting northern regions of Europe with large availability of beef calves (France, Ireland, Germany, Poland, Czech Republic, Slovakia, Hungary, Croatia) with regions characterized by a demand of beef meat exceeding the local production (mainly Central and Southern Italy). The growth of this system during the sixties and seventies was supported by four factors: i) the discovery of maize silage; ii) the development of management procedures derived by North American feedlots; iii) the rapid increase of the domestic beef meat demand due to the industrialization of the country; and iv) the creation and enlargement of a common market following the development of European Community/European Union. At the beginning, the moderate price of imported stock calves supported the development of specialized fattening herds in Veneto, even if the losses due to death, injuries and diseases were much higher than nowadays (Bonsembiante and Bittante, 1984), because of the lack of a common veterinary organization, of inappropriate or absent conditioning of calves before and after importation, and of frequent mixing of animals imported from different countries and farming systems. Nowadays, the progressive decline of beef consumption in Italy is a growing challenge facing the Veneto beef system. It is further exacerbated by the contextual increase of consumption of imported low-price beef (ISMEA, 2010), with the combined effect of progressively depressing the demand of national-produced beef. Moreover, the tendency of a growing proportion of consumers to identify animal raised in good welfare condition with pasture farming systems (Hocquette and Chatellier, 2011; Brscic *et al.*, 2013) may impact the appeal of Veneto beef, considered as industrialized and felt as unnatural and, consequently, unsafe. In general, consumers lack knowledge on the food production system, and the provision of impartial information, traceability, and a labeling format clear and informative could support highly organized production systems such as the specialized Veneto beef sector, and may be an effective way to preserve the image and to valorise the high level of the Veneto beef meat with respect to anonymous products.

The trend in the performance of the Veneto fattener system can be appraised by comparing (Table 6) main production data of the present survey with the figures of some breeds comparison studies published about three decades ago (Rioni *et al.*, 1979; Bittante, 1984;

Bonsembiante and Bittante, 1984). The sources of stock calves did not evidence large changes in the last 30 years. Main differences in the breeds availability concern: the progressive reduction of appeal of FR, concomitant with the holsteinization of the breed in Poland and with the growing request of Italian market for carcasses of high quality; the replacement of the German Fleckvieh with other Simmental strains imported from East European countries; and the more recent growth of importation of crossbred calves from Ireland, due to a progressive increase of prices of stock calves from France. The availability of stock calves is expected to decrease and their purchase price to further increase, due to: i) the progressive trend of French beef breeders toward delaying the sale of calves and fattening directly their animals; ii) the forthcoming abolition of milk quotas, that could favour the increase of milk herds at the expense of suckler cows ones in countries like France and Ireland (Hocquette and Chatellier, 2011); and iii) to the perspective of a growing beef demand in some developing countries, which will affect export policies of stocker calves producers. A possible way to increase the availability and the self-supply of stock calves may rely upon the full exploitation of the use of X sexed semen in dairy and dual purpose cows, which allows to increase the number of dairy cows beyond the replacement needs that could be inseminated with conventional semen of beef bulls. Double-muscling breeds (Boukha *et al.*, 2011) seem particularly appropriate for this use, because crossbred calves obtained are appreciated both for veal and beef production, are characterized by high prices (Dal Zotto *et al.*, 2009), and may give production performance similar to those obtained with purebred CH cattle (Schiavon *et al.*, 2013). Moreover, the aforementioned rising price of stocker calves could support an increase of the cow-calf farms also in confined barns and in the intensive rearing areas.

In the past, the average BW of calves at arrival was lower than now (Table 6), because with time breeders of suckler cows have improved their productive organization by using creep feed till weaning, by retaining the calves longer before selling, and by preparing the calves for exportation with the aim of increasing their weight and price. Also the BW at slaughter showed a progressive increase during the last decades, probably due to: i) the increase of average BW at purchase; ii) the need to dilute the negative differential between purchase and sale prices per kg in a higher BW gain; iii) the genetic improvement of mature size as an indirect response to selec-

Table 6. Comparison between the average production traits obtained in the present study with those from an early survey (Bittante, 1984) and two experimental studies (Rioni *et al.*, 1979; Bonsembiante and Bittante, 1984) carried out in the fattening units of the Veneto region.

	Genetic type					
	CH	LI	CH×AU	SA	SI ^o	FR
BW at purchase, kg						
Present study, 2014	394	317	410	377	331	295
Bittante, 1984	320	277	318	-	253	260
Rioni <i>et al.</i> , 1979	197	212	-	-	188	221
Bonsembiante and Bittante, 1984	310	288	314	310	267	246
BW at sale, kg						
Present study, 2014	703	591	689	675	620	570
Bittante, 1984	608	573	582	-	522	431
Rioni <i>et al.</i> , 1979	543	568	-	-	498	456
Bonsembiante and Bittante, 1984	559	549	585	557	500	463
Fattening length, d						
Present study, 2014	224	228	220	252	219	236
Bittante, 1984	233	267	216	-	239	138
Rioni <i>et al.</i> , 1979	264	282	-	-	217	204
Bonsembiante and Bittante, 1984	233	239	239	233	226	175
ADG, kg/d						
Present study, 2014	1.40	1.21	1.28	1.19	1.30	1.17
Bittante, 1984	1.25	1.10	1.29	-	1.16	1.28
Rioni <i>et al.</i> , 1979	1.32	1.29	-	-	1.43	1.15
Bonsembiante and Bittante, 1984	1.09	1.08	1.13	1.07	1.03	1.07

CH, Charolais; LI, Limousine; CH×AU, Charolais×Aubrac; SA, Salers; SI, Simmental; FR, Polish Friesian; BW, body weight; ADG, average daily gain. ^oIn earlier studies the Simmental young bulls were imported from Bavaria and not from Eastern European countries.

tion for increased growth rate (Perry and Arthur, 2000); iv) the delayed tendency for fat deposition caused by increased muscular development potential (Renand *et al.*, 1996; Sbarra *et al.*, 2013). The only partial exception to this regard concerned LI young bulls, that evidenced only a slight increase of final BW in the last 30 years. Therefore, in early studies CH and LI showed a comparable BW at slaughter, whereas currently the difference in final BW between the two breeds approaches 100 kg. The length of fattening period appeared different within breed in early studies, and tended to be shortened in the case of French beef breeds and conversely extended for FR when compared to current data. In comparison with previous studies, ADG observed in the present survey evidenced an increase in French specialized beef breeds, probably due to their genetic improvement and to an increased energy concentration of diets, induced by the change of relative prices of different feedstuffs in favor of the cereals grains. Further changes in the feeding of fattening bulls are expected in the next future, due to concerns about environmental sustainability of herds and the related rules from EU, which may advantage extensive herd systems (Hocquette and

Chatellier, 2011). In the recent past, constraints imposed to the number of animals herded by environmental legislation such as Nitrate Directive (EEC, 1991) led to underutilization of facilities, machinery, labour, and expertise of specialized fatteners herds. An increase of self-supply of feedstuffs seems to be a prospective aim of future EU livestock models (Hocquette and Chatellier, 2011), and this can be a threat for fattening herds of Veneto, where feed production relies mainly on corn silage. There is a need to develop new feeding strategies focused on improving both herd self-supply and efficiency of nutrition, thus limiting feeding costs and reducing harmful emission, and applied research targeted at these issues may play an important role (Schiavon *et al.*, 2012).

Conclusions

Data from this survey, based on a nearly 10-years collection of performance data of young bulls and beef heifers from 44 Veneto fattening herds, allowed to compare the technical and market performance of 2806 batches of almost

200,000 young bulls and heifers of 10 purebred and crossbred genetic type. The results confirm firstly that France still maintains a dominant role as supplier of stock calves for specialized beef herds of Veneto, providing animals of different breeds and crosses. However, popularity differs widely among genetic types, and Charolais young bulls appeared the category still now largely preferred, because of their superiority in growth performance and their greater differential between the value at sale and that at purchase in comparison with the other French genetic types. Among beef cattle of other origin, Irish crosses gave growth and economic performance comparable to those provided by purebred Charolais, and evidenced an increase in popularity and appreciation by fatteners in the last years of this survey. Variation in growth performance due to the herd effect was generally moderate, suggesting a common standard of feeding and management procedures among fattening centres that allows to increase animal uniformity, which is a growing requirement of beef processors and retailers. Growth performance of beef cattle observed in the present survey appeared higher than that reported some decades ago for the same specialized fattening system and for stock calves of the same origin, confirming the enhancement of technical level of this intensive beef production system.

The beef supply chain is still a traditional branch of agriculture of this region, but it must face several issues that are endangering its viability. The progressive erosion of herd profitability, the growing requirements for environmental sustainability and animal welfare, the expected detrimental changes in common agricultural policy, the need to add value to meat produced in relation to consumers requirements and concerns, are some main challenges that specialized Italian beef sector shall cope with. Innovative strategies are then needed, and they can be attained only consolidating the relationships and the cooperation between beef producers organizations, agriculture institutions and scientific research.

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