PAPER

Male pre- and post-pubertal castration effect on live weight, components of empty body weight, estimated nitrogen excretion and efficiency in Piemontese hypertrofic cattle

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Abstract

To evaluate the effect of sexual neutering and age of castration on empty body weight (EBW) components and estimated nitrogen excretion and efficiency, a trial was carried out on 3 groups of double-muscled Piemontese calves: early castrated (EC, 5th month of age), late castrated (LC, 12th month of age) and intact males (IM, control group). Animals were fed at the same energy and protein level and slaughtered at 18th month of age. Live and slaughtering performances and EBW components were recorded, whereas N excretion was calculated by difference between diet and weight gain N content. In live and slaughtering performances, IM showed higher final, carcass and total meat weight than EC and LC ($P<0.01$). In EBW components, IM showed higher blood and head weight than EC and LC ($P<0.01$ and 0.05 respectively), and differences were found between EC and LC for head weights ($P<0.01$). IM showed higher body crude protein (BCP) than EC and LC ($P<0.01$ and 0.05 respectively), but BCP/EBW ratio was higher only in IM than EC ($P<0.05$). Estimated N daily gain was higher in IM than EC and LC ($P<0.01$). Only LC showed higher excretion than IM ($P<0.05$), and N efficiency was higher in IM than EC and LC ($P<0.05$ and 0.01 respectively). In conclusion, for the Piemontese hypertrophied cattle castration significantly increases N excretion (+7%) and reduces N efficiency (-15%), leading to a lower level of sustainability.

Introduction

The European Community legislation has ruled the nitrogen (N) pollution from agriculture and livestock practices by mean of a specific Directive (EU Council Directive 91/676/EEC; European Council, 1991), considering the N as the main livestock pollutant. The manure nitrogen content depends on several factors such as species and breeds reared, productive system, feed and feeding systems adopted, or animal physiological conditions (Giustini *et al*., 2007).

In cattle, physiology is certainly conditioned by sexual neutralization for the different amounts of androgen hormones, with testosterone having the major effect. In fact, castration modifies live and slaughtering performances between bulls and steers, as well as between steers castrated at different ages (Knight *et al*., 1999, 2000; Parrassin *et al*., 1999), modifying average daily weight gain (ADG), feed conversion rate (FCR), body conformation and allometric growth or proportion of dissected carcass tissues (Biagini and Lazzaroni, 2007; Lazzaroni and Biagini, 2008). Bulls' higher efficiency in producing leaner carcasses than steers has not exactly been physiologically determined, as well as the direct mechanism by which castration alters protein turnover remains unclear (Morgan *et al*., 1993), even if these facts have certainly effect on nitrogen excretion. In fact, androgen hormones promote muscular development and then increase nitrogen retention (Galbraith *et al*., 1978; van Tienhoven, 1983). Therefore, a trial was carried out to verify the effect of sexual neutralization and age of castration on empty body components to determine the exact N retention, estimated nitrogen excretion and efficiency in intact, pre- and post-pubertal castrated males.

Materials and methods

The trial was carried out on 24 hypertrophied Piemontese calves of the same initial age and weight (157±19 d and 162±19 kg), homogeneously divided into 3 groups according to age and weight: early castrated (EC, 5th month of age); late castrated (LC, 12th month of age), intact males (IM, control group).

Sexual neutralisation, carried out by a veterinarian according to the European and national welfare legislations (Council Directive 98/58/EC and Regulation 99/1804/EC) which do not forbid the castration even in the organic livestock (European Council, 1998; 1999), was obtained after local anaesthesia by Burdizzo's pincer, by pressing the scrotum and determining the spermatic and blood vessel cord interruption. This is the most diffuse technique among local farmers. In fact, this practice has little influence on steer growth capacity and behaviour (Biagini *et al*., 2001), particularly in young calves (Biagini and Lazzaroni, 2007).

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In order to compensate the low number of heads per group, the animals were reared in straw-bedded pens (8×6.5 m each) with lock-in stanchion, under the same environmental conditions to reach the statistical reliability required (power of the experiment = 0.95). The cattle were reared for an average of 405±9 days and fed for a daily weight gain of 1.2 kg with hay (2 kg/day) and with an increasing but rationed amount of concentrate (similar for all groups) to meet the energy and protein requirements, according to the INRA scheme for bulls of late maturing beef breeds (Garcia *et al*., 2007). In the trial, a two-phase feeding system was used. The concentrate (0.95 UFV/kg) for the growing period (7 months) was made up of maize (45%), barley (17%), soy bean meal (18%), bran (14%), carob (*Ceratonia siliqua* fruits; 3%), minerals and additives (3%), and for the finishing period (6 months) of maize (60%), barley (15%), soy bean meal (10%), bran (9%), carob (2%) and minerals and additives (4%). Feed characteristics are reported in Table 1.

During the trial, the individual feed intake was recorded, as well as the individual live weights at the beginning (one day before EC group calves castration, 5th month of age), at the middle (one day before LC group calves castration, 12th month of age), and at the end of the trial (one day before slaughtering, 18th month of age). Thus, it was possible to split the rearing phase into 2 periods: the 1st period (5-12 month of age); and the 2nd period (12-18 months of age).

The animals were slaughtered, in a commercial abattoir, at the same age (about 18 months) and degree of fattening, as visually evaluated by expert butchers, according to market requirements. After 7 days of ageing at a temperature of 2±2°C, the carcass sides were weighted and dissected. At slaughterhouse and during dissection, blood, head, shanks, hide, empty rumen, stomach and intestine, offal, carcass, total meat, fat and bones weights were recorded.

Data were used to calculate the actual final empty body weight (aEBW) and the weight and percentage of body crude protein (BCP), then the nitrogen excretion. The aEBW was utilised to verify the reliability for the Piemontese bulls and steers of the empirical equation to predict EBW starting by SBW proposed by the National Research Council (1996):

$$EBW=0.891\ SBW$$

where:
EBW is the empty body weight;
SBW is the shrunk body weight measured after an overnight without feed.

After verification, the formula has been utilised to estimate the empty body weight at the 5th (EBW_5), 12th (EBW_{12}) and 18th (EBW_{18}) month of age for the N excretion appraisal. BCP was calculated using EBW components weight and N content of the respective part (INRAN, 2009; Destefanis *et al*., 2003).

Nitrogen excretion was calculated according to the final report of the European Commission Directorate General XI (ERM/AB-DLO, 1999) that established the criteria for the assessment of N content in animal manure and N excretion. The general equation to estimate N excretion is:

$$N_{excretion} = N_{diet} - N_{gain}$$

where:
$N_{excretion}$ is the amount of N excreted in total by growing-finishing cattle during a certain period (kg);
N_{diet} is the amount of N contained in feed consumed for the same period (kg);
N_{gain} is the amount of N contained in empty body weight gain of growing-finishing cattle for the considered period (kg).

N content in the diet was calculated by dividing the CP of total feed intake by 6.25. N gain has been estimated with the equation of Simpfendorfer (National Research Council, 1996), previously used by Guo *et al*. (2004) to predict N excretion in growing-finishing Piemontese, Holstein and Piemontese x Holstein cattle.

The equation to calculate N gain in the body during a certain period (t_1–t_2) is:

$$N_{gain}=0.0376\ (EBW_2-EBW_1)-0.0000208\ (EBW_2^2-EBW_1^2)$$

where:
EBW_1 is the empty body weight at the beginning of the period (t_1; kg);
EBW_2 is the empty body weight at the end of the period (t_2; kg).

The relationships between EBW (kg) and BCP (kg) differ, depending on breed, age and sex (National Research Council, 1996). For a comparison between Piemontese steers and bulls and other cattle genetic types and categories, the relationship between EBW_{18} and BCP in Piemontese EC, LC and IM was calculated.

All data collected and estimated were analysed, after testing their normal distribution (Shapiro-Wilk test), by GLM ANOVA (SPSS, 1999) procedure with the following model:

$$y=\mu+\alpha_i+\varepsilon_{ij}$$

where
μ = general mean;
α_i = age of castration effect;
ε_{ij} = random error effect.

Differences in mean values were tested by Duncan's multiple range test, using a first class error α=0.05 to accept the differences as significant.

The relationship between EBW_{18} and BCP in Piemontese EC, LC and IM was calculated with a linear regression equation (SPSS, 1999).

Results

The evolution of live weight and the average daily feed intake for all animals are reported in Table 2. The effect of sexual neutralisation started to be evident at the middle of the trial (12th month), when LC showed higher live weight than EC (P<0.05), and increased at the end of the trial, when the live weight was higher in IM than EC and LC (P<0.01).

The weight gain was different before and after sexual neutralization as shown by the linear regression coefficient between cattle age (months) and live weight (kg), which in the 1st period were 27.38, 31.67 (+16%) and 32.06 (+17%) in EC, LC and IM respectively, and in the 2nd period 25.59, 21.67 (-15%) and 31.78 (+24%) again in EC, LC and IM respectively.

The non-carcass and carcass-dissected component weights are shown in Table 3. Differences were recorded between EC and LC only for head weight (P<0.05). The IM showed higher non-carcass component weight than EC and LC for blood (P<0.01 and P<0.05, respectively) and for head weight (P<0.01). The IM also has higher hide weight than EC (P<0.01).

EC and LC showed lower total meat weight

Table 1. Chemical composition of feedstuffs used in growing and finishing period.

	Growing period		Finishing period	
	Concentrate	Hay	Concentrate	Hay
DM, %	87.81	87.50	87.61	87.50
CP, % DM	17.76	9.00	14.43	9.00
N, % DM	2.84	1.44	2.31	1.44

DM, dry matter; CP, crude protein; N, nitrogen.

Table 2. Live weight, average daily weight gain and feed intake in early castrated, late castrated and intact Piemontese male cattle (mean ± standard error).

	EC	LC	IM
5th month live weight, kg	163.7±8.3	167.2± 5.7	156.1±6.5
12th month live weight, kg	379.0±7.0^{b}	416.7±8.9^{a}	405.6±12.6^{ab}
18th month live weight, kg	526.7±12.2^{B}	539.0±12.4^{B}	589.2±14.7^{A}
ADG 5-12th month	0.96±0.05^{b}	1.11±0.04^{a}	1.11±0.04^{a}
ADG 12-18th month	0.81±0.06^{b}	0.68±0.06^{b}	1.02±0.03^{a}
5-12th month concentrate consumption, kg/d	4.2±0.3	4.4±0.4	4.3±0.4
5-12th month hay consumption, kg/d	1.8±0.0	1.8 ± 0.0	1.8±0.0
12-18th month concentrate consumption, kg/d	6.4±0.3	6.7±0.3	6.8±0.3
12-18th month hay consumption, kg/d	1.9±0.0	1.9±0.0	1.9±0.0
5-18th month concentrate consumption, kg/d	5.3±0.4	5.5±0.4	5.5±0.4
5-18th month hay consumption, kg/d	1.8±0.0	1.8±0.0	1.8±0.0

ADG, average daily weight gain; EC, early castrated; LC, late castrated; IM, intact males; ^{a,b}P<0.05; ^{A,B}P<0.01.

(P<0.01) and higher total fat weight (P<0.01) than IM. Instead, no significant differences were found in total bone weight even if, once again, it seems to be higher in IM than EC and LC. These differences also influenced the carcass weight, which was higher in IM than EC and LC (P<0.01). Body component weight was used to calculate the aEBW (Table 3), higher in IM than EC and LC (P<0.01). Instead, the aEBW/SBW ratio for EC, LC and IM showed no significant differences between groups, and the average ratio for all the tested animals was 0.890, similar to that proposed by the National Research Council (1996), assuming the equation to be reliability for the Piemontese hypertrophied cattle. Based on these results, the EBW_5, EBW_{12} and EBW_{18} were calculated to estimate nitrogen excretion. No differences were found between the tested groups in EBW_5, but only in EBW_{12} higher in LC than EC (P<0.05), and in EBW_{18} higher in IM than EC (P<0.01) and LC (P<0.05). Similarly the absolute BCP content was also higher in IM than EC (P<0.01) and LC (P<0.05), however the percentage ratio between BCP and EBW_{18} only showed a higher value in IM than EC (P<0.05). Comparison between the empty body components showed a higher percentage for head plus hide and shanks in LC and IM than EC (P<0.05), as well as gastrointestinal tract in EC and LC than IM (P<0.01) and carcass in EC than LC (P<0.05), whereas no differences were found for visceral organs plus blood.

Differences appear in average N in daily diet (Table 4), appraised in accordance with the Simpfendorfer equation (National Research Council, 1996). Castration reduced the N daily gain in steers for all the considered trial periods. In fact, EC showed lower values than LC and IM (P<0.05) between 5^{th} and 12^{th} month of age, as well as EC and LC showed lower values than IM (P<0.01) between the 12^{th} and 18^{th} month. Consequently, also the whole period N daily gain was lower in EC and LC than IM (P<0.01). Analysing the N daily excretion, no differences were found in the 1^{st} period, but only in the 2^{nd} ones when the considered parameter was higher in LC than EC and IM (P<0.01). On the other hand, considering the whole period, only LC showed higher N daily excretion than IM (P<0.05).

As showed in Table 4 N efficiency was higher in IM and LC than EC (P<0.05) in the 5-12^{th} month period and higher in IM than EC (P<0.05) and LC (P<0.01) in the 12-18^{th} month period. In the latter, EC also showed higher N efficiency than LC (P<0.05) whereas IM showed higher N efficiency than EC (P<0.05) and LC (P<0.01) for the whole fattening period.

Relationships between EBW (kg) and BCP (kg) was calculated, giving the following linear regression equations:

EC: $BCP=0.2251\ EBW_{18}-10.6498$ (R^2=0.992)

LC: $BCP= 0.1939\ EBW_{18}+5.4245$ (R^2=0.977)

IM: $BCP=0.1991\ EBW_{18}+3.6419$ (R^2=0.997)

Discussion

Sexual neutralisation, and the consequent reduction of the androgen hormones effect, leads calves not only to a lower live weight, but also to an intermediate morphological type, with a body conformation intermediate between male and female aspects (Lazzaroni *et al*., 2002) and consequently with peculiarity in body conformation and differences in body components. In fact, castration affects the masculine somatic characteristics (secondary sexual traits) and calves assume a neutral morphological type owing to a reduced development of fore body muscles (Biagini and Lazzaroni, 2007). The IM showed a higher muscle development, affecting the carcass weight, and a lower fat deposit than EC and LC,

Table 3. Empty body fractions, actual empty body weight, empty body weight/shrunk body weight ratio, empty body weight at different age and body crude protein in early castrated, late castrated and intact males Piemontese male cattle (mean ± standard error).

	EC	LC	IM
Carcass, kg	356.5 ± 10.7^{B}	356.6 ± 7.0^{B}	397.7 ± 11.0^{A}
Total meat, kg	291.4 ± 9.3^{B}	290.7 ± 4.8^{B}	333.9 ± 9.7^{A}
Total fat, kg	16.7 ± 1.4^{A}	16.3 ± 0.9^{A}	10.6 ± 0.6^{B}
Total bones, kg	48.4±1.5	49.6±2.0	53.2±1.8
Blood, kg	13.1 ± 0.3^{Bb}	13.4 ± 0.3^{ABb}	14.7 ± 0.4^{Aa}
Head, kg	21.0 ± 0.4^{Bb}	22.9 ± 0.6^{Ba}	25.4 ± 0.5^{Aa}
Shanks, kg	9.7±0.3	9.9±0.3	9.9±0.3
Hide, kg	27.0 ± 2.4^{B}	32.3 ± 1.1^{AB}	37.0 ± 1.4^{A}
Empty rumen, kg	10.7±0.9	11.0±0.5	9.6±0.4
Empty stomachs and guts, kg	15.8±0.7	16.3±0.6	15.2±0.6
Offal, kg	15.4±0.2	15.5±0.7	15.6±0.4
aEBW, kg	469.3 ± 13.1^{B}	478.0 ± 9.4^{B}	525.2 ± 12.8^{A}
aEBW/SBW	0.890±0.009	0.887±0.004	0.891±0.004
EBW_5, kg	145.9±7.4	149.0±5.1	139.1±5.04
EBW_{12}, kg	337.7 ± 6.2^{b}	371.3 ± 11.2^{a}	361.4 ± 7.9^{ab}
EBW_{18}, kg	469.3 ± 10.8^{Bb}	480.2 ± 11.1^{ABb}	525.0 ± 13.1^{Aa}
BCP, kg	95.1 ± 3.0^{Bb}	98.1 ± 2.5^{ABb}	108.2 ± 1.8^{Aa}
BCP/EBW_{18}, %	19.46 ± 0.67^{b}	20.00 ± 0.48^{ab}	22.06 ± 0.60^{a}
Relative empty body fraction			
Visceral organs + blood, %	6.11±0.15	6.06±0.12	5.78±0.04
Head, hide and shanks, %	12.28 ± 0.32^{b}	13.62 ± 0.32^{a}	13.80 ± 0.38^{a}
Gastrointestinal tract, %	5.66 ± 0.23^{A}	5.71 ± 0.15^{A}	4.73 ± 0.08^{B}
Carcass, %	75.94 ± 0.37^{a}	74.61 ± 0.36^{b}	75.70 ± 0.39^{ab}

EC, early castrated; LC, late castrated; IM, intact males; aEBW, actual empty body weight; SBW, shrunk body weight; EBW, empty body weight; BCP, body crude protein; ^{a,b}P<0.05; ^{A,B}P<0.01.

Table 4. Nitrogen average daily gain, excretion and efficiency in early castrated, late castrated and intact Piemontese male cattle (mean ± standard error).

	EC	LC	IM
N in daily diet $_{5-12}$, g	163±9	168±10	165±10
N in daily diet $_{12-18}$, g	154±6	161±8	163±9
N in daily diet $_{5-18}$, g	159±10	165±11	164±11
N daily gain $_{5-12}$, g	40.6 ± 1.8^{b}	47.9 ± 1.7^{a}	47.5 ± 1.9^{a}
N daily gain $_{12-18}$, g	39.7 ± 2.8^{B}	33.4 ± 2.8^{B}	50.8 ± 2.0^{A}
N daily gain $_{5-18}$, g	40.2 ± 2.1^{B}	41.4 ± 1.7^{B}	49.0 ± 1.7^{A}
N daily excretion $_{5-12}$, g	122.1±1.8	119.9±1.7	117.8±1.9
N daily excretion $_{12-18}$, g	114.1 ± 2.8^{B}	127.8 ± 2.8^{A}	112.1 ± 2.0^{B}
N daily excretion $_{5-18}$, g	118.5 ± 2.1^{ab}	123.4 ± 1.7^{a}	115.2 ± 1.7^{b}
N efficiency $_{5-12}$, %	24.95 ± 1.12^{b}	28.53 ± 0.99^{a}	28.74 ± 1.16^{a}
N efficiency $_{12-18}$, %	25.83 ± 1.85^{ABb}	20.74 ± 1.71^{Bc}	31.19 ± 1.25^{Aa}
N efficiency $_{5-18}$, %	25.33 ± 1.33^{ABb}	25.14 ± 1.06^{Bb}	29.82 ± 1.01^{Aa}

EC, early castrated; LC, late castrated; IM, intact males; N, nitrogen; $^{a-c}$P<0.05; ^{A,B}P<0.01.

probably due to the masculine hormones effect (particularly testosterone) on muscle protein anabolism (Morgan *et al*., 1993). On the contrary, sexual neutralisation determines a lower muscle thickness and a higher peri-muscular and sub-cutaneous fat deposition and infiltration into muscular tissue, the latter being due to thyroid insufficiency and consequently oxidative process slowdown. Furthermore, bone growth is also modified in steers vs. bulls, above all the head and limb long bones showing a different or a prolonged growth. However, these differences could be pointed out only at the end of the growing period. Therefore, in our trial the recorded differences in head weight might be due to sexual neutralization.

The differences recorded in the empty body components, as well as in blood and hide weights, between the three tested groups partially modify the N retention and utilisation efficiency.

Several physiological factors influence nitrogen utilisation efficiency and thus the live weight gain in growing animals. Analysing the live weight and feed intake in the three studied experimental groups, the IM showed higher efficiency in feed conversion rate, since intake did not change in the three experimental groups. These data are in accordance with results obtained by Solanas *et al*. (2005), who found statistic differences in the final weight but not in total DM intake of Friesian calves. The effect of castration on live weight was evident after puberty and increased with age (Bretschneider, 2005). In fact, after few weeks from the sexual neutralization the observed differences were between the not yet castrated LC and EC, however, at the end of the trial, IM showed higher live weight than EC and LC, with higher significance and LC showed the worst live performance compared to the other groups.

As shown by carcass components, the differences recorded in live weight were imputable to a different growth ratio between meat and fat tissues, then in N gain, higher in IM than in EC and LC. This affects the efficiency of feedstuffs conversion into saleable animal products, above all into protein products, averaging only 20-30% for meat production in growing cattle (Wessels and Titgemeyer, 1997), and the well-known high energetic cost of protein synthesis (15-20 MJ per kg of protein synthesized in accordance with the species; Lobley, 2003).

Moreover, the different physiological response of each animal to castration stress and the influence of castration age, which affect live weight gain in the subsequent weeks, influenced feeding efficiency as well as N excretion, particularly higher in LC than EC and IM in the 2nd period. The sudden changes of the N excretion might affect manure composition, increasing the potential environmental impact (N loss and conversion of urea to ammonia and its subsequent volatilization that modified N:P ratio below plant requirements; Firkins and Reynolds, 2005).

In our trial, Piemontese steers and bulls might consume approximately 1 kg/d of apparent digestible crude protein (N * 6.25), but retain approximately 0.25 and 0.30 kg/d respectively (both about 28% of daily weight gain). Lobley (2003) has found that it achieves 2.7 kg/d in finishing beef steers, i.e. about 3% of total body protein. The direct mechanism by which castration alters protein turnover remain unclear, nevertheless, this practice influences endogenous proteinase activity and myofibrillar protein turnover. Morgan *et al*. (1993), comparing bulls and steers, have found that intact males were heavier and more efficient in feed conversion, besides having higher calpastatin and cystatin muscle activity and excreting less N-methylhistidine. Moreover, they displayed lower fractional degradation rates. Comparing the relative body components of empty body weight found in our trial with other breeds, Piemontese cattle showed higher carcass weight, lower weights as regards head plus hide and shank, visceral organs plus blood and gastrointestinal tract than 14 month old Hereford, Charolais and Simmental heifers (Buckley *et al*., 1990). Furthermore, Piemontese cattle have a prevalence of higher protein tissue content with potential consequences on N efficiency. On the other hand, the studied animals showed similar ratios with Marchigiana steers and bulls (Mantovani, 1961).

Data analysis of carcass and carcass components showed opposite and predictable differences between the two groups of steers (EC and LC) and IM. In fact, possibly as a result of masculine hormones effect on muscle protein anabolism (Morgan *et al*., 1993), muscle thickness and fat deposition.

Comparing the relationship between EBW and BCP in other breeds, at the same EBW Piemontese cattle showed higher BCP than Angus and Holsetin non-double muscled bulls and steers (National Research Council, 1996), and then different N efficiency and requirements. The difference in N efficiency is also due to the higher feed efficiency in double-muscled animals (Menissier, 1982; Michaux *et al*., 1982) with lower feed intake and higher growth rate (Hanset *et al*., 1989; Clinquart *et al*., 1995; Keane, 2000).

These findings suggest that hypertrophied Piemontese steers and bulls required more attention as to the N, protein and energy supply. In particular, it is well know that optimising ruminal fermentation and providing high quality sources of abomasal amino acids could significantly increase nitrogen balance and protein accretion. Moreover, the different ratio between muscle and others carcass and non-carcass parts that characterise hypertrophied cattle could increase N efficiency, so as castration modifies calf behaviour and physiology, as well as the protein metabolism, thus inevitably *limiting* the maximal efficiency that could be achieved.

Conclusions

Considering the peculiarity of the Piemontese hypertrophied cattle, this trial examined the effect, not yet widely studied, of sexual neutralization and age of castration on Piemontese double muscled calves (practice recently used again to obtain high quality meat used for local, typical and traditional productions) first on empty body components (no data are available for Piemontese hypertrophied bulls and steers) and then the consequences on the nitrogen excretion and efficiency of intact, pre- and post-pubertal castrated males. The trial showed that both pre- and post-pubertal castration of Piemontese calves reduce the muscle tissue synthesis, increase the fat deposition and modify the weight of some body components affecting the N retention under the same feeding conditions, getting worse N daily gain and then N efficiency. The differences among pre- and post-pubertal castration groups showed that would be preferable to conduct early castration rather than delaying the procedure.

These results confirm how accuracy of the protein really intake and prediction on its retention is fundamental to assume different strategies for N excretion reduction in accordance with the specific head characteristics. Particularly it is possible modify protein and energy supply splitting the herd in homogeneous groups using several criteria including gender.

In conclusion the trial showed as the management strategies could have different environmental effects on the level of sustainability and confirm how the increasing attention given to animal production for these aspects imposes an appropriate evaluation of the different productive processes.

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