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CICLO: XXII

GENETICS OF AUTOCHTHONOUS ITALIAN BEEF CATTLE BREEDS

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[…]
To’ …. quel vitello – al cui grande occhi appari
immensa, con un lento albero in mano,
quando con una vetta tu lo pari –

guarda stupito, nuovo, al monte , al piano:

tutto una selva, il monte; la costiera
sembra un velluto tenero di grano.

Egli che non sapea la primavera,
la dura coda svincola, saluta il mondo bello.
Prima, esso non c’era: ci si ritrova: fiuta l'aria, fiuta
la terra: all'aria sobbalzando avventa
le brevi corna della fronte bruta;
e con le zampe irrequïete tenta
la terra. […]

….. guardi nella valle,
per vederlo passare anche una volta. […]

Tratto da “Il Torello”, Giovanni Pascoli 1899

…..a Riccardo

INDEX

ABSTRACT

This thesis has aimed to analyse both management aspects of performance testing traits in many Italian breeds, including Italian beef cattle breeds, to analyse and update heritability values in performance test traits of Italian beef cattle breeds and evaluate a possible implementation of slaughter data as selection tools for the three main diffused Italian beef cattle breeds (i.e, Chianina, Marchigiana and Romagnola breeds).

The Introduction aims with all Italian cattle breeds, considering both beef, dual purpose and dairy breeds and describes the selection of Italian cattle breeds. In the 60'-70' the management of the Herd Book, since that held by State, has been delegated to several National Cattle Breeder Association, which have been recognized, in addition to competence in genealogical records, including that relating to the assessments of morphological traits and breeding values. For each cattle breed exist a National Cattle Breeder Association that is established to promote and implement all type of initiatives aimed towards improving, developing and valorisation. After the report of the EAAP working group on performance testing for young bulls to be used in artificial insemination (AI) programs was to established a recommendations for performance testing of beef, dual purpose and dairy prior to their use in AI. The Performance test, as method of evaluation, has become the main selection tool for both dual purpose and beef cattle breeding programmes. Station performance testing allows for the comparison of beef bulls from different herds under standard conditions to identify genetically superior bulls for use in commercial herds.

The second chapter encloses over that an extract of this report, the results of a survey to review the present Italian situation as regard to the specific activity on performance testing of young bulls across National Cattle Breeders Association. A specific form was designed to collect data on performance test and given to Italian cattle breeders associations across the period 2007-2009. Data collected concerned national herd books' statistics (i.e., registered and controlled population), structures available at the genetic centres to know the main characteristics of performance testing and its organisation, traits analysed and selection indexes obtained on bulls tested.

The third chapter regarding an explanation for breeding system of Italian Beef Cattle Marchigiana, Chianina and Romagnola and its evolution in the last 20 years and the estimate heritability and genetic correlations of main slaughter data (carcass weight, slaughter age and carcass average daily gain) of these breeds.

After years of selection based on Bull Selection Index for the three Italian Beef Cattle Marchigiana, Chianina and Romagnola, Chapters four aimed to obtained new estimates of heritability for traits included in the Selection Index on test station in Perugia. The bull selection index (BSI) that is used a selection criteria at the end of test, account for genetic index of both

average daily gain (ADG) measured till weaning and average daily gain realized during the test. Other trait computed in BSI is fleshiness at the end of test. Heritability for ADG in test showed higher value than ADG in pre performance, as expected, and more closer to values reported in literature. Heritability of fleshiness resulted more variable between breeds. Simple correlation analysis was carried out on ranks between previous performance test indexes and global index (BSI) and the newest obtained with the heritability estimates.

The fifth chapter deals with the study of an new estimates of genetic parameters for Maremmana and Podolica breeds using performance test data, after about fifteen years from the beginning of the activity. For these breeds the bull selection index (BSI) used as selection criteria at the end of test, accounts for genetic index of both average daily gain (TADG) realized during the test, and morphological score at end of test. The study carried out in chapter five involved also fleshiness evaluated at the end of test, aiming to obtain genetic correlations among all considered traits. The analysis produces h^2 estimates greater than those obtained for the three main breeds at test station as regard the daily gain. Positive genetic correlations among traits were estimated for Maremmana, although milder correlations were obtained for Podolica.

RIASSUNTO

L'obiettivo di questa tesi è stato quello di analizzare sia gli aspetti di gestione del performance test di molte razze italiane, tra cui le razze bovine da carne, e analizzare e ri-stimare i valori di ereditabilità dei caratteri di performance test delle razze di bovine italiane da carne (ANABIC) e valutare una possibile implementazione con i dati di macellazione, come ulteriore strumento di selezione per le tre principali razze bovine italiane da carne (Chianina, Marchigiana e Romagnola).

Nell' Introduzione vengono descritte le principali caratteristiche dei bovini italiani, considerando le razze da carne, quelle a duplice attitudine ed infine da latte. Infatti, il primo Capitolo, descrive la selezione ed il miglioramento genetico delle razze bovine italiane. Negli anni 60/70 la gestione dei Libri Genealogici, detenuti dallo Stato, è stata delegata alle diverse Associazioni Nazionali Allevatori (ANA) di Bovini, che si occupano oltre che della competenza dei Libri Genealogici, anche delle valutazioni morfologiche e del miglioramento genetico. Per ogni razza bovina esiste una propria ANA, che si prefigge di promuovere e realizzare ogni tipo di iniziativa volta al miglioramento, allo sviluppo ed alla valorizzazione della razza ad essa delegata. Dopo il report del gruppo di lavoro dell'EAAP sul Performance Test per i giovani tori da utilizzare nella fecondazione artificiale, è stato stabilito un programma con una serie di raccomandazioni specifiche atte a testare le attitudini produttive dei bovini da carne, da latte e quelli a duplice attitudine. Il Performance test, come metodo di valutazione, è diventato quindi lo strumento principale di selezione nei piani di selezione, vuoi per i bovini da carne che per quelli a duplice attitudine. Il Centro Genetico consente la comparazione in condizioni standard dei torelli, provenienti da allevamenti diversi, per identificare i tori migliori geneticamente de destinare alla riproduzione.

Nel secondo Capitolo sono riportati i risultati del monitoraggio effettuato presso le Associazioni Nazionali al fine di effettuare uno screening sulla situazione attuale italiana per quanto attiene alla attività di selezione attraverso il Performance test di giovani tori. Al riguardo, è' stato predisposto uno specifico questionario per raccogliere tutte le possibili informazioni presso le Associazioni durante il periodo 2007-2009. I dati raccolti hanno riguardato le statistiche dei Libri Genealogici Nazionali (i bovini registrati e sotto controllo), le strutture disponibili presso i Centri Genetici – allo scopo di conoscere le caratteristiche principali del Performance test e la sua organizzazione – ed infine i caratteri in selezione analizzati e gli indici di selezione ottenuti sui torelli testati.

Il terzo Capitolo descrive la situazione del sistema di allevamento dei bovini da carne delle razze Marchigiana, Chianina e Romagnola e la sua evoluzione negli ultimi 20 anni e la stima di ereditabilità e le correlazioni genetiche dei principali dati di macellazione (peso carcassa, età di macellazione e l'accrescimento medio giornaliero in carcassa) di queste razze.

Dopo anni di selezione delle razze bovine italiane da carne Marchigiana, Chianina e Romagnola sull'Indice Selezione Toro, lo studio presente nel quarto Capitolo ha avuto lo scopo di ottenere nuove stime di ereditabilità per i caratteri inclusi nella Selezione del Centro Genetico di Perugia, quali: accrescimento medio giornaliero (ADG) pre-performance e in performance e la muscolosità ottenuta a fine test. Il valore di ereditabilità dell' ADG in test è risultato essere, come previsto, più alto rispetto a quello del carattere pre-performance, e simile ai valori riportati in letteratura. L'ereditabilità del carattere muscolosità invece è risultata essere più variabile tra le razze. Sono state effettuate anche analisi di correlazione tra gli Indici precedenti e quelli stimati di nuovo.

Il quinto Capitolo, invece, presenta lo studio di nuove stime dei parametri genetici di Performance test dei torelli di razza Maremmana e Podolica, dopo circa quindici anni dall'inizio dell'attività dei Centri Genetici. Anche per queste razze, l'Indice di selezione toro (BSI) è usato come criterio di selezione alla fine del test e comprende l'Indice Accrescimento medio giornaliero (ADG) realizzato durante il test ed il punteggio morfologico a fine della prova. Lo studio ha coinvolto anche il carattere di muscolosità valutata a fine test al fine di analizzare anche le correlazioni genetiche tra i caratteri in analisi. Le stime di ereditabilità ottenute per l'accrescimento in test sono risultate essere buone e migliori rispetto alle altre tre razze principali. Le correlazioni genetiche sono risultate positive per la Maremmana e mediamente inferiori per la Podolica.

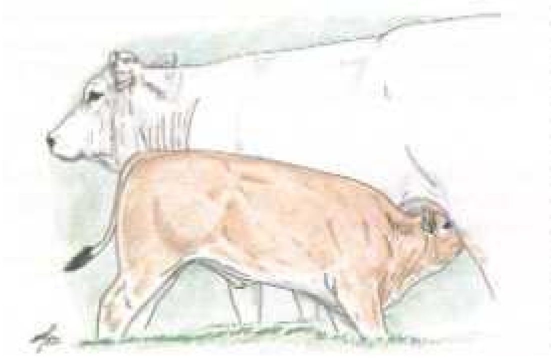
CHAPTER 1

INTRODUCTION

1.1 ITALIAN CATTLE BREEDS

ITALIAN BEEF CATTLE

The Italian Chianina, Marchigiana, Romagnola, Maremmana and Podolica beef-cattle breeds, which descended from the same original stock, are now widespread throughout all of Italy and are found predominantly in the central and southern regions. The farms, which follow the cow-calf line, are small- to middle-sized and most for them are located in hilly or mountainous areas. The autochthonous breeds currently number a total of 150,000 head of cattle currently involved in selection activities. Their outstanding productive and reproductive traits, as well as the excellent quality of their meat, have made them famous all over the world, where both purebreds and crossbreds are raised successfully.



Marchigiana

This Podolica-origin breed descended from the Asiatic cattle that reached Italy during the fourth century AD following the barbarian invasions. In order to improve the original stock, the Marchigiana was crossed with the Chianina and then with the Romagnola. In 1928, all types of crossbreeding were stopped so that the breed's extrinsic traits could be fixed through morphological and functional selection. Nowadays Marchigiana is a cattle breed type that has a significant somatic development and is characterized by a high growth capacity and outstanding precocity. It has a white coat that may have some gray shading in the males. The skin and mucosa ores have a black pigmentation. The Marchigiana has a light head with short horns. It has a long cylindrical trunk with excellent muscle development, particularly in the buttocks and thighs. The cows have excellent maternal capabilities and calving is natural, with the calves weighing an average of 45 kg at birth. It also has an excellent growth capacity and in the best specimens weight gain can peak at 2 kg a day. The cows weigh between 700 and 900 kg while males range from 1200 to 1500 kg. Being a precocious breed, it reaches its ideal slaughter weight at the age of 15-16 months, for a yield as high as 67%. The Marchigiana breed is widespread throughout Marche, Lazio, Abruzzo and Campania.

Chianina

The Chianina, an ancient breed that dates back to Umbro-Etruscan times, has been raised in Umbria, Tuscany and Latium for over twenty-two centuries. It has a porcelain-white coat with slate-gray skin and black pigmentation around the natural orifices. Its head is light and expressive and it has short horns. The Chianina has a long cylindrical trunk with thick wide back and loins, a broad horizontal rump, long convex-shaped thighs and buttocks, a solid but lightweight skeletal structure and correct perpendicularity. Calves are wheat-coloured at birth, but by the age of three-four months their coat becomes the colour typical of this breed. In this breed, which is renowned for its somatic gigantism, calving is completely spontaneous - even for calves weighing up to 50 kg - thanks to the Chianina's typical dolichomorphic structure. Cows weigh an average of 800-900 kg and weight can often go as high as 1000 kg. The most famous Chianina bulls have reached truly outstanding sizes of 1700 kg in weight, with a height of two meters at the withers. Growth potential in the best subjects can exceed 2 kg a day. Ideal slaughter weight is 650-700 kg at an age of 16-18 months, for a yield of 64-65%. Chianina beef is famous for its excellence as well as for its good nutritional value.

Romagnola

Over the years, this descendent of the Podolica breed has taken on the characteristics of modern beef-cattle types thanks to intelligent selection work (Falaschini A. and Canestrari G., 2009). The Romagnola has a white coat with gray shading towards the front, and black apical pigmentation. It has a significant somatic development and a harmonious structure that tends to be brachymorphic. The trunk is particularly well-developed in the transverse diameters, with particular emphasis on the hindquarters, where the thighs and buttocks reveal a broad, convex and markedly inclined musculature. This breed's short sturdy legs and strong feet have made it an ideal grazing animal. Calving takes place without any difficulty and the cows give birth to wheat-colored calves that weigh an average of 40-45 kg. The Romagnola has an outstanding growth capacity that is comparable to the Chianina and Marchigiana. The cows weigh between 600 and 900 kg, whereas adult males reach 1200-1500 kg. They are slaughtered when they reach a weight of 650 - 700 kg, at the age of 16-18 months. Average slaughter yield is 62-63%. The Romagnola is raised in the provinces of Forlì, Bologna and Ravenna.

Maremmana

A direct descendent of the gray Asiatic breed, the Maremmana has a gray coat that is darker in males and lighter-colored in females, with blank apical pigmentation (Giorgetti et al., 2009). As seen in other breeds of Podolica descent, calves are wheat-colored at birth and then at around three months they turn to the characteristic colour of the breed. The horns are long and have typical half-moon shape in the males, whereas the females have lyre-shaped horns. The Maremmana has an impressive skeletal structure that gives the adult a very solid and robust appearance. This very large sized cattle has extremely solid legs, exceptionally hard hooves and, in general, perfect perpendicularity. The cows have a well-shaped udder and an abundant supply of milk that ensures daily weight gains of over 1 kg of the calves. The Maremmana is an extraordinarily rustic and long-lived breed that can reach an age of 15-16 years. Calving is spontaneous and the calves weigh 30-40 kg at birth. They reach a weight of 180-220 kg by the age of six months, thus confirming the cow's milk-producing capacity. Adult females weigh about 600-800 kg whereas the males reach a weight of 1000-1200 kg. This breed is widespread in Tuscany and Latium.

Podolica

Its origin can be traced to the Bos Taurus Primigenius, the ancient forerunner of all the cattle breeds that descended from the Podolica. It has been present in Italy for a very long time and represents yet another example of successful biological adaptation to a hostile environment. The breed is widespread over a rather vast area that includes all of southern Italy. As a result, this has caused a great deal of variability in its size and in the colour of its coat, which can range from white to dark gray. Pigmentation is black. The Podolica has a lightweight skeletal structure with slender legs, excellent perpendicularity and strong feet. A robust and frugal breed comparable to the Maremmana, it is capable of exploiting grazing areas covered with shrubs, stubbles and thickets. It is characterized by its docile nature, outstanding maternal capability and long reproductive career. Calves are born spontaneously and weigh an average of 30 kg at birth. Cows reach a weight of 400-500 kg by adulthood and produce plenty of milk rich in fat, which in some areas is used to make highly prized soft cheese ("Caciocavallo Silano"). Adult bulls weigh from 600 to 800 kg. (ANABIC, website 2009).

Piemontese

The Piemontese cattle breed is a beef breed of medium size that converts forage into meat very well and has a high dressing out percentage. The quantity of commercial cuts is higher than that of bigger-sized breeds. It has very fine bones, a fine and elastic skin, a low quantity of external fat and lean and tender, but tasty meat. The bulls have a grey or pale fawn coat, with black hairs on the head (especially around the eye sockets), on the neck, the shoulders, the distal regions of the limbs and sometimes on the lateral sides of the body and the hind limbs. The cows have a white or pale fawn coat with shades of grey or pale fawn. At birth the coat of the calves is of a deep pale fawn colour. The tongue, the palate and the external mucosae are black. The cows are of a medium size (550 - 600 kg), at birth the calves weigh on average 40 to 45 kg. The male fattening calves are ready for slaughtering at a weight of 550-650 kg when they are about 15 -18 months old, the females at about 350-450 kg when they are about 14-16 months old. Considering their size, the weight gain of Piemontese cattle is high, reaching 1.4 kg a day in the calves between weaning and slaughtering, when feeding and environmental conditions are optimal. The indexes of food conversion are extremely high and confer to the Piemontese breed a feeding efficiency which is definitely superior to all the other beef breeds. The dressing out percentage is very high, on average 67-68% in the fattening calves, with peaks of 72%, thanks to the extremely fine bones and the low quantity of external fat. The conformation of the carcasses is excellent: they are always classified S and E of the S-EUROP classification. The milk production of the Piemontese is sufficient to suckle the calf; this is a consequence of the double-purpose selection applied on the breed in the past. Some of the Piemontese breeders use the milk for cheese production. The cheeses "Castelmagno", "Bra", "Raschera" and many of the "Tome" coming from the valleys of the region Piemonte are produced with Piemontese milk. (ANABORABI, website 2009).

Double muscle factor

The high specialization of this breed is related to the segregation muscular hypertrophy due to a specific mutation in the miostatin coding sequence (Albera A. et al., 2001) better known as the 'double muscle factor'. The double muscle factor appeared at the beginning of last century and spread progressively over the breed up to a point in which nearly all the Herd-book animals possess this characteristic and a very high percentage of the breed as a whole. From a genetic point of view, the double muscle factor has always been considered a natural mutation which can occur in living organs, even if the probability is very low. The spreading of the 'double muscle' over the breed was originally possible thanks to the selection carried out by the breeders and later this has been carried on by ANABORAPI. The Piemontese is a long-living breed that adapts very well to many different climates and that can be bred as easily in a confined rearing system as in an open herding or a semi-open herding system. The calves are usually weaned at an age of 4-6 months when they weigh between 160 and 200 kg. The breeding of the Piemontese cows is traditionally done in stall housing and less frequently in an open housing system. The feeding is very simple and consists mainly in forage, grass or dry feed (or silage), supplemented with feed-stuff that consists mainly of cereals. The traditional stall housing systems for fattening calves are gradually being replaced by open housing in boxes on deep litter. Their feeding is based on feed-stuff made of cereals and hay or straw as a fibre source, often produced on the farm itself. The current breeding goal for the Piemontese breed is the improvement of beef production efficiency and the reduction of dystocia. Selection is performed in two stages: male calves are performance tested for beef production traits at a central station and young bulls selected after performance testing are then progeny tested for direct and maternal calving ease on the basis of birth and calving performance of their progeny. The objective of performance testing in the Piemontese breed is the evaluation of young bulls for growth rate, live fleshiness and bone thinness (Albera A. et al.,2001).

Limousin and Charolaise

Limousin was originally from the Limousin area (province of Limoges - France), west of the Massif Central area characterized by a rather harsh climate, with hot summers, cold winters and abundant rainfall. But the breed has a remarkable facility for acclimatization, and is raised outside the country of origin. In the past it was a dual-purpose breed (meat and work), then has been improved making it more suitable for meat production. In France it is the second breed of meat after the Charolaise. It is bred primarily for grazing. In 1987 it was based in Italy with the National Association Charolaise and Limousin Breeders– ANACLI.

The coat colour is a bright shade of fawn, not too dark, and it's lighter in the ventral and perineal regions; it has depigmentated pink mucous. Horns are lighter, medium-length. Animals are robust, vigorous and rustic. Average live weight is: 6.5 to 8 q females, 10 to12 q males (ANACLI, website 2009).

Charolaise: the area of origin is the Charolles region in France. For its hardiness, its tendency to produce good meat and its easy adaptation, it is bred in many other countries, and is primarily used as a cross breed. In the past it was a dual-purpose breed (meat and work), but over time has been selected mainly for meat production. It is a precocious breed, prolific and a harmonious development of different regions of the body. It's the first beef breed in France. The coat colour is creamy white or off-white, the depigmentated mucous membranes are pink; the head is small and short (especially in males), with a large forehead, and short horns. It is a massive animal, with good muscle mass development and of medium build. Live weight is 7-9 q for females and 12-13 q for males; it has postpartum lactating cows and calves, and milk production is sufficient to weaning (6-7 months). This breed in Italy is used for the production of young bulls of 16-18 months of age and live weight of 600-650 kg.

ITALIAN DUAL PURPOSE CATTLE

Simmental

Italian Simmental is a dual purpose breed that's bred in all of Italy; the main reason for it being so widespread is that it represents a secure investment for the farmer, since it has a good milk production from both a quantity and quality point of view; at the same time it offers an appreciable added value with the sale of its meat. It is also adaptable to the most difficult and hard farming and breeding conditions, which makes this cattle easy to manage. In the last years it has spread above all in Piemonte and Sicily. The average production for this breed was 6.612 Kg, 3.89% fat and 3.43% protein; these results are achieved with a very low ratio of N° cows/herd (about 10) often located in mountainous regions (60% of the farms). Thanks to the fat and protein content, the high frequency of the genotype B of the K casein, and a low cell somatic count, the Italian Simmental demonstrates its exceptional dairy properties. In the best farms, where the unifeed technique is applied, it is quite common to find cattle herds with an average of 3.60% protein. In 2008 the best 60 farms produced an average of 9,104 kg of milk with 3.90% fat and 3.55% protein; this just goes to show that the real productive potentiality of the breed has yet to be fully exploited.

Meat production: The trait that makes it so different from other milk breeds is the production of meat, which leads to a further income for the farmer. The calves reach a price at weaning which is quadruple that of other milk breeds. Fatted calves of the IS breed are highly regarded on the market and we may confidently say that IS cattle is collocated between R+ and R on the EUROP grid, with a value which is considerably higher than that of other breeds. The average daily gain of fatted calves is approximately 1,350-1,450 kg/day. There is an increasing tendency to use IS cows to wet-nurse 2-3 calves. This is due to the high capacity of the breed to wean several calves, even of different breeds, due to its extraordinary motherly instinct (ANAPRI, website 2009).

Rendena

The area of origin is the Rendena Valley (Trentino). Today this breed is mainly spread in the provinces of Padua, Trento, Vicenza, Verona and other provinces of northern Italy. Very rustic, it is suitable to the most difficult grazing areas or the mountains. It is now slightly increasing after the 80's decrease. It is a very long lasting breed. Coat colour: different shades of brown, darker almost black in the bulls. Harmonious animals, medium-small size and height; straight hair, dorsal line with lighter dorsal stripe. Black mucosa, wide black muzzle. Light horns with black and white tips. Height: 130 cm; weight: 500-550 kg. Ivory hairs in the auricles. Economic characteristics: either suitable for milk and meat, mainly milk though, with an average production of over 46 q. with minimum quantity of concentrates even in difficult grazing areas (agraria website, 2009).

Valdostana

This is the autochthonous breed from Valle d'Aosta, where almost all heads are bred (85%). It is either bred for milk or meat, with a fairly good milk production considering the size of the animals (on average 500 kg alive), it is a frugal breed with a quite good meat production and good slaughter yield. There are three breeds which differ by their morphological characteristics, coat, milk and meat production and temperament. These are: Valdostana Pezzata Rossa, Valdostana Pezzata Nera and Castana. There are two genealogical books, one to register Valdostana and Pezzata Rossa heads and the other to register either Valdostana Pezzata Nera or Castana heads. In 1937 the National Association of Valdostana Breeders was founded - A.N.A.Bo.Ra.Va (ANABORAVA, website 2009).

<u>Valdostana Pezzata Rossa</u>

It is the most common breed in Val d'Aosta. It is marked by a red Pied coat shading from a light to a dark red with white head, abdomen, parts of limbs and tail. Like all red pied breeds grazing in the Mount Blanc valleys, this one comes from red pied cattle dating back to the end of the fifth century (Burgundi). It is one of the typical Italian dairy breeds which is appreciated for its quality meat and its strength. Particularly docile and strong, it is very apt to harsh climates and it is also resistant to ordinary pathologies. Long-lived, frugal, this breed is able to live on coarse forage.

Valdostana Pezzata Nera – Castana

Valdostana Pezzata Nera and Castana together with the Swiss Hérens belong to the autochthonous cattle which originated in the Alps, coming probably from 'Bos brachyceros'. Brachycephalic breeds stand out for their lively temperament, their rusticity. They both belong to the same Genealogical Book, but they are different in the coat. Milk production is lower than in the Valdostana Pezzata Rossa. The coat of Pezzata Nera has a black and white pigment to build up the typical pied, while Castana has a uniform black and red pigment shading from black to tawny. It has similar features as the Pezzata Rossa, but it is usually less developed, more rustic, stronger and more harmonious (agraria website, 2009). These animals show a lively, almost aggressive temperament when grazing: they establish a sort of hierarchy within the herd by fighting (not cruelly). It is just by exploiting this peculiarity that since 50 years breeders organize fights between their heifers (Batailles de Reines) in order to establish the strongest and give it the title of queen, Reìna in original language (Mantovani et al., 2007).

Alpine Grey

Breeding of the Alpine Grey/Grauvieh in Italy is traditionally widespread in Alto Adige and in the Dolomite valleys of Trentino and Bellunese. In the last few years new breeding centres have emerged even outside this area, such as in the provinces of Udine, Como, Torino and Campobasso. The National Association of Breeders of Grey Alpine cattle - A.N.A. ALPINE GREY - was founded on 19 June 1980. This breed represents the link between the mountain environment and its resources and a product of quality. The animals are of medium size and weight and have a correct locomotor apparatus with very strong hooves. The Alpine Grey is a typical mountain cattle breed that gives an excellent production of milk and meat. They are rustic, frugal, have a strong instinct for finding their own food, and are able to convert even coarse vegetation efficiently. The Alpine Grey is a breed with a long life expectancy and excellent fertility.

Milk - The quality of milk produced by the Alpine Grey Breed makes it suitable both for transformation into cheese and for direct consumption. Functional controls carried out in 2007 gave an average production of 5,150 kg of milk with 3.72% fat and 3.36% of protein. This production should be regarded as good, considering the medium size and weight of the animals and the non-intensive breeding farm conditions.

Meat - The Alpine Grey has good "weight gaining" qualities. This is especially marked with medium-to-heavy bulls, which have an average daily gain of about 1,200 g, very good carcass shape characteristics, slaughter production of around 58% and excellent meat quality (agraria website, 2009).

ITALIAN DAIRY CATTLE

Friesian

The origin area is the Pianura Padana. Italian Friesian derive from Dutch and North-America types. Colour of coat is black and white but also red and white. Large in size (130-150 cm); expressive head, distinct and vigorous, straight upper profile, bright eyes, highly mobile ears, large nostrils, broad muzzle and strong jaws. Front: harmonious long neck, thin and rich in skin folds, shoulder tightness, strong and broad chest. Upright and well spaced forelimbs. Strong standing, with high sole. Topline straight with strong loins. Udder firmly attached, prominent and tortuous abdominal veins, the mammary vein is not too large and branched, spongy and elastic tissue. Adult female weighing 550 to 900 kg (height 130-150 cm).

Brown

The Italian Brown breed gives outstanding milk production of high quality - with cheese yields certainly above average and particularly fitted for the production of typical cheeses - good meat yields and high environmental adaptability.

Not only in Italy, but also in the other European countries, the Brown Race is extremely adaptable to the most varying agricultural and climatic conditions - both in the mountains and on the plain - and it's particularly important for safeguarding the environment in difficult areas: milk cattle breed can in fact solve the socio-economic problems in marginal areas, where the presence of man to protect the environment is of primary importance. The 20 best herds have an average production of around 10,607 kg with 3.69% average protein. This data shows the measure of the genetic potential of the Bruna italiana; the best breeders are able to produce more milk and more protein. In fact, the genetic potential for protein percentages is very high and those who are able to make the most of environmental conditions, feeds, health status, and so on, may have herds that reach very high levels (ANARB, website 2009).

1.2 SELECTION AND IMPROVEMENT IN ITALY: BREEDING GOALS OF ITALIAN CATTLE BREEDS

Direct selection is a technique of genetic improvement of a population for which the choice of sires is made on their estimated genetic value for one trait that corresponds with a trait to improve (Bittante G. et al, 1999).

Genetic Progress

The Genetic Progress of a population for a quantity trait depends primarily on the choice of sires and those used; that influence determinates the genetic value of future generation. *In fact the choice of the reproducer is the selection (Pagnacco G., 2008).*

Genetic Progress estimated for a year is obtained from the following formula (Van Vleck L.D., 2003):

$$\Delta g \equiv \frac{r_{ti} \cdot i \cdot \sigma_a}{L}$$

r_{ti} = accuracy of estimated genetic values

i = selection intensity

σ_a = genetic standard deviation of trait

L = generation interval (years)

In the 60'- 70's the management of the Herd Book, held by State until then, was delegated to several **N**ational **C**attle **B**reeder **A**ssociations, which have been recognized for various competences in genealogical records, including that relating to the assessments of morphological and genetic breeding. For each cattle breed mentioned above, a **N**ational **C**attle **B**reeder **A**ssociation exists, that is established to promote and implement all types of initiatives aimed towards improvement, development and evaluating the breed.

Table 1. Venue of Genetic Centre and of Offices of Italian Cattle Breeds.

Breed	Venue of Genetic Centre or Performance test station	Venue of Offices	Acronym	Year of begin acitvity
Marchigiana	S. Martino in Colle (PG)	S. Martino in Colle (PG)	ANABIC	1969
Chianina	S. Martino in Colle (PG)	S. Martino in Colle (PG)	ANABIC	1969
Romagnola	S. Martino in Colle (PG)	S. Martino in Colle (PG)	ANABIC	1969
Podolica	Laurenzana (PZ)	S. Martino in Colle (PG)	ANABIC	1969
Maremmana	Alberese (GR)	S. Martino in Colle (PG)	ANABIC	1969
Piemontese	Carrù (CN)	Carrù (CN)	ANABORAPI	1976
Limousin	Verano di Podenzano (PC)	Roma	ANACLI	1987
Rendena	Bassano (VI)	Trento	ANARE	1980
Simmental	Fiume Veneto (PN)	Udine	ANAPRI	1971
Alpine Grey	Bolzano	Bolzano	ANAGA	1982
Valdostana	Gressan (AO)	Gressan (AO)	ANABORAVA	1982
Brown	Loc. Ferlina - Bussolengo (VR)	Loc. Ferlina - Bussolengo (VR)	ANARB	1968
Friesian	Loc. Migliaro	Loc. Migliaro (CR)	ANAFI	1968

The selection program essentially expresses the overall activities performed on livestock enrolled in the Herdbook in order to pursue the selection objectives that have been identified. Even selection goals have changed over time:

- the Post War years were characterized by selection of production milk for dairy breeds, and for growth rate for beef breeds;
- in the first half of the 80’s, in conjunction with the Community surpluses and the introduction of payment systems increasingly linked to quality issues, evaluation and selection based on the quality has begun (fat and protein for milk, dressing percentage, estimated carcass conformation in vivo for the meat). This procedure started and the first results were seen at the beginning of the 90s;
- in the second half of the 80’s selection indexes were taken and obtained combining various characters;
- in the first half of the nineties we began to introduce the morphology in the indexes of selection of specialized dairy breeds, and in the second half we have conducted studies to determine the role of morphology in the influence of the longevity of cows;
- always in the second half of the 90’s all beef breeds and dual purpose breeds adopted "beef index" based on BLUP genetic evaluation animal model, and characters were followed in the performance testing;

- in dual-purpose breeds, finally, the overall indexes were adopted to take account of both productive attitudes.

The trend in Italy, as in the rest of the world, therefore, is to evaluate the animal as a whole, giving more attention to the secondary traits, including longevity, resistance to mastitis, maternal and direct effects on the calving difficulty, fertility and temperament (“Le Scienze animali al servizio dell’uomo” Alcuni scritti di Mario Bonsembiante, 2003).

For beef cattle selection programmes are usually focused on the improvement of productive traits (i.e. average daily gain, weight, etc.). However, also functional traits play an important role in the efficiency of animal production. Among these traits: calving performance, affecting stillbirth of calves, the fertility of cows, animal welfare and the consumers’ perception of products are particularly relevant for specialized beef cattle breeds. (Albera A., 2006). Also longevity in beef cattle is an important economic trait; this trait when included in a breeding scheme increases profit and also has a positive impact on the well-being and welfare of the animal (Forabosco et al., 2006).

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CHAPTER 2

SURVEY ON CATTLE GENETIC CENTRES IN ITALY

Part of the results are presented at ASPA Congress, Communication Palermo, 2009.

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2.1 PERFOMANCE TESTING

Survey of Performance testing on bulls in the report of a Working group of the Commission on cattle production.

The report of Andersen B. et al. (1981) summarised the results of a survey about information of performance testing from 14 Western European countries (63 stations with 7947 places) and five Eastern European countries with comparable testing conditions having a total of 6460 places, mostly in state-owned farms.

The number of breeds participating to the Performance tests were: 57 dairy/dual purpose breeds and 50 beef breeds.

The aim of this report of the EAAP working group on performance testing for young bulls to be used in artificial insemination (AI) programs (Andersen et al., 1981), was to establish recommendations for performance testing of beef, dual purpose and dairy bulls prior to their use in AI. In this report the basic objective of selection through performance testing in dairy/dual purpose and beef breeds was to improve the efficiency of lean-meat production.

The most important potential measurable traits for testing and selection in performance tests were: growth rate, feed efficiency, appetite, quantitative carcass properties, functional traits.

Recommendations in relation to the performance testing procedure must be based on knowledge of the genetic parameters of the traits of interest, and the biological consequences of different selection strategies and the various aspect of testing system. Typical values for heritability coefficient and genetic correlations for some important traits were reported by Andersen. et al. (1981) in Table 1.

The number of traits undergoing selection, together with various aspects of the testing system, can have a significant influence on the response to selection based on performance-test results. These aspects, reported by Andersen B . et al (1981) are:

- **Adaptation period**: this should be sufficiently long to allow compensatory growth to equalize the body conditions of the animals. This is particularly important for the beef breeds, which are generally older when they enter the test station;
- **Age at start, and length of test period**;
- **Selection for growth rate and correlated responses**,
- **Feeding system and feeding regime.**

Table 1. Heritability estimates (on diagonal) and genetic correlations for some important traits[1].

	BW	DG	W12	FC	FC\G	MW	L\B	L\F	DP
BW	*0.44*	0.40	0.64	-	-0.46	0.89	-0.04	0.55	-0.05
DG		*0.54*	0.98	0.64	-0.95	0.40	-0.34	0.52	-0.61
W12			*0.42*	-	-	-	-	-	-
FC\G					*0.36*	-	0.27	-0.53	0.46
MW						*0.57*	0.05	-	-
L\B							*0.52*	0.25	0.56
L\F								*0.50*	-0.12
DP									*0.58*

[1] Abbreviations: BW= birth weight; DG= daily gain; W12= weight at 12 months, FC= feed consumed; FC\G= feed consumed/kg gain; MW= maturity weight; L/B= lean/bone ratio; DP= dressing percentage.

And the other report on performance testing of bulls for efficiency and traits in dairy and dual purpose cattle (Averdunk et al., 1988) described a review and an exchange of results and experiments about performance testing bulls in dairy and dual purpose breeds with experts from different countries and explained some recommendations for testing procedures.

The Performance test, as method of evaluation, has become the main selection tool for both dual purpose and beef cattle breeding programmes (Mantovani et al., 1999).
Station performance testing allows the comparison of beef bulls from different herds, under standard conditions, to identify genetically superior bulls for use in herds. For accurate evaluation of growth potential of beef bulls, it is necessary to identify important factors that affect the growth of bulls on test.
Some studies were carried out to evaluate the effects that influence potential growth of young bulls, including: M. F. Liu and M. Makarechian (1993). In order to compare records of performance (ROP) tested bulls and make selection of herd sires as effective as possible, it is necessary to know the influence of both environmental and inherited factors. The purpose of their study was to determine the cause of variation observed from bull to bull for several traits of economic importance and to estimate the relative magnitude of their effects.

At present, the performance test represents the main tool used for the genetic evaluation of beef cattle, but it is widespread also in dual purpose and dairy cattle, despite the different aims among countries and breeds due to the specific selection objectives (Bittante et al., 1999; Bittante G., 2007). In Italy, almost all national breeders associations have adopted this method

for young bulls' evaluation, but differences exist among performance tests according to the selection goals, the population size and breeds' characteristics.
In fact, in Italy, cattle selection is based on individual productive aptitudes controlled in specific control stations, "Genetic Centres"; at the same time animals are homogeneous for age, weight and nutritional conditions when compared. The animals are collected in Genetic Centres where, previously, they are submitted to an adaptation period and then pass to a *performance test* phase.

During the performance test all animals are kept in the same environment, reared with the same technique and fed with same feed because one of mainly characteristic is the preservation of *standard condition.*

Performance test is therefore a relatively quick technique of animal genetic evaluation, it is economic and efficient and it is adaptable for all traits that satisfy the following conditions:

a) Medium-high heritability ;
b) Show phenotype on animals (generally males) submitted to control;
c) Show phenotype on live animals at an age compatible with destination for reproductive carrier.

2.2 SURVEY PERFORMANCE TESTING ON BULLS IN ITALY

In literature there are no more informations about performance test in Italy and other countries, in spite of the fact that it is a main tool for genetic evaluation for cattle.
Bittante G. (2007) describes the selection situation of beef and dual purpose cattle breed in Italy. The breeds considered were: Piemontese, Chianina, Marchigiana, Romagnola, Maremmana, Podolica, Charolais, Limousin, Italian Simmental, Valdostana and Rendena. For each breed the evaluation objectives, the main characteristics of performance test, the heritability of the traits were evaluated and, for Piemontese and Italian Simmental, the genetic relationship among them are described. The genetic progress of the main traits is very good for the majority of the breeds even though the generation interval is generally too long.
For this reason the aim of this study was to review the present Italian situation especially regarding the specific activity on performance testing of young bulls across National Cattle Breeders Association.

***N**ational **C**attle **B**reeder **A**ssociation (**NCBA**)*

These are for beef cattle:

- **ANABIC** (Marchigiana, Chianina, Romagnola, Maremmana and Podolica breeds)
- **ANABORAPI** (Piemontese breed)
- **ANACLI** (Charolaise and Limousin breeds)

These are for dual purpose cattle:

- **ANARE** (Rendena breed)
- **ANAPRI** (Simmental breed)
- **ANABORAVA** (Valdostana breed)
- **ANAGA** (Alpine Grey breed)

These are for dairy cattle:

- **ANARB** (Brown breed)
- **ANAFI** (Friesian)

A specific form was designed to collect data on performance test carried out and was given to Italian cattle breeders associations across the period between 2007-2009.

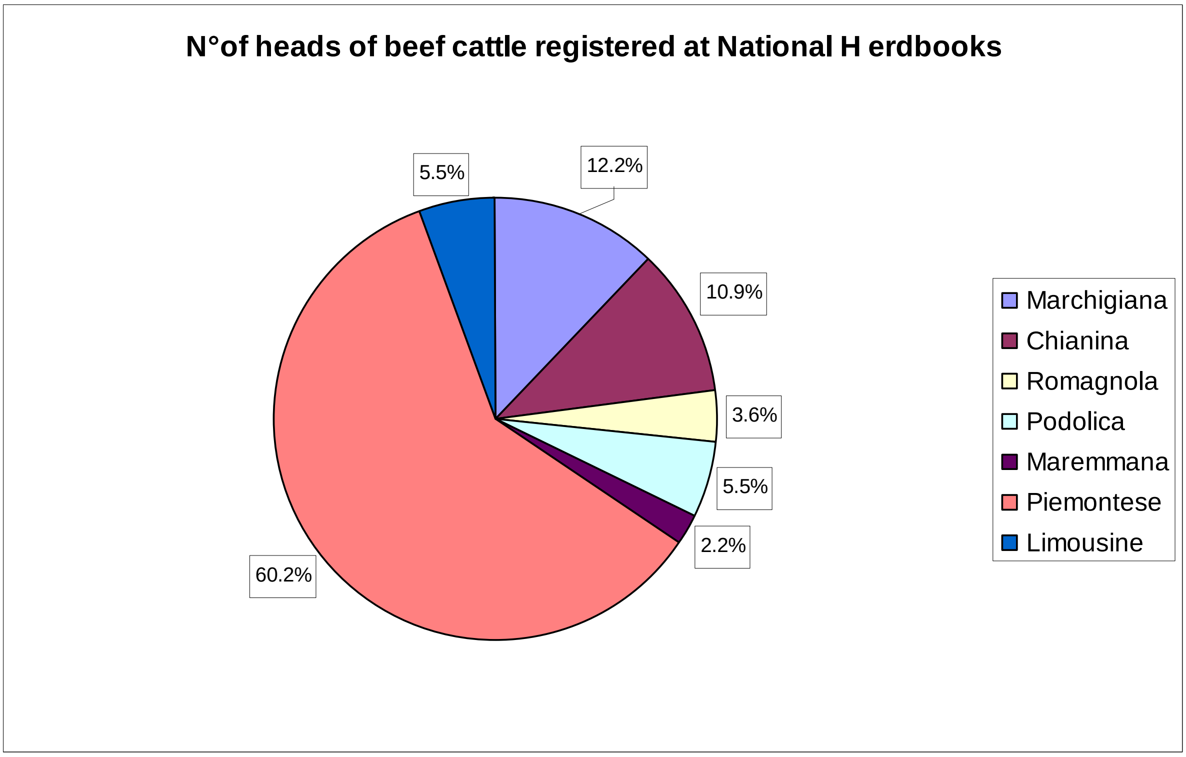
Data collected concerned national herd books' statistics (i.e., registered and controlled population), structures available at the genetic centres to know the main characteristics of performance testing and its organisation, traits analysed and selection indexes obtained on tested bulls.

In particular, the survey was organised in order to obtain data on the procedure for bulls' admittance at genetic centres, the number of yearly tested bulls and the people employed at the centres. Other data regarded the schedule of performance testing and its phases, if there were more than one, the feeding system, the data recorded on young bulls and the destination of bulls after selection at the end of test. Moreover, the number of selected bulls was collected in order to assess the different intensity of selection adopted among breeds. Herd Book Statistics show how the differences exist between the breeds, for a specific characteristic, in particular on number of head and herds, and also in term of localization of cattle in all regions in Italy.

Table 2. General statistic of National Herd Book at 31-12-2009

	N° heads	N° cows	N° heifers	N° bulls	N° young stock	N° herds	cow/ heads	N° heads/herd
Marchigiana	52,344	24,303	6,675	648	29,718	2,498	9.73	*20.95*
Chianina	46,553	22,062	5,775	884	17,832	1,549	14.24	*30.05*
Romagnola	15,416	7,943	1,755	512	5,372	512	15.51	*30.11*
Podolica	23,370	15,374	4,602	196	3,198	622	24.72	*37.57*
Maremmana	9,212	5,181	1,903	181	1,947	185	28.01	*49.79*
Piemontese	257,600	11,7953	13,326	1,977	24,344	4,002	29.47	*64.37*
Limousin	26,157	12,361	3,417	590	9,789	457	27.05	*57.24*
Rendena	6,298	4,098	1,205	85	942	225	18.21	*27.99*
Simmental	94,778	50,568	16,191	210	27,809	5,644	8.96	*16.79*
Alpine Grey	17,524	9,053	/	49	8,422	1,457	6.21	*12.03*
Valdostana	34,263	16,699	6,371	420	10,773	1,109	15.06	*30.90*
Brown		101,071	58,038		61,000	7,646	13.22	*0.00*
Friesian	1800,000	1103,453	700,000	30,00		14,069		

Figure 1. Statistic of beef cattle registered on Herdbook in 2009



For beef cattle, 60% of Herd Book population is represented by Piemontese localised mainly in Piemonte Region, 34% by the five Italian beef cattle breeds, localised through Central Apennine and a few in other parts of Italy (i.e. Veneto region or South region of Italy), while the remaining part is represented by Limousin (5.5%) (Figure 1). For dual purpose cattle the main breed is mainly represented by Simmental (Figure 2).

Figure 2. Statistics of dual purpose cattle registered on Herdbook in 2009

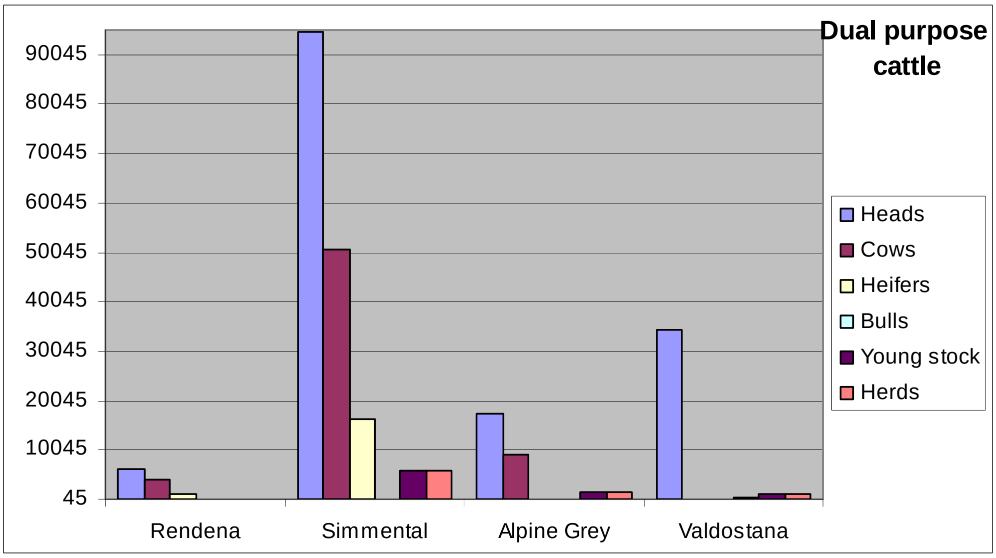
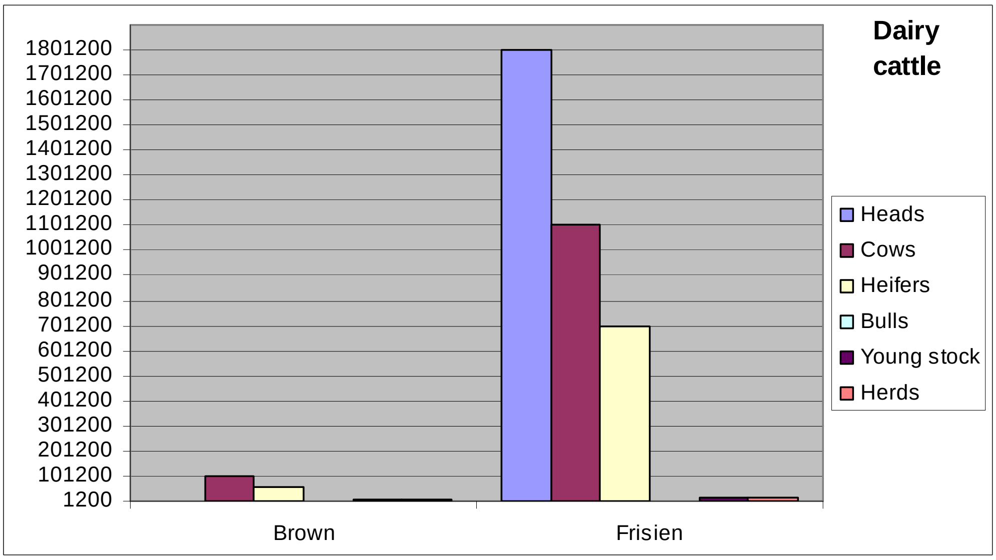


Figure 3. Statistics of dairy cattle registered on Herdbook in 2009



Obviously, the main dairy breed is represented by Friesian, that corresponds to about 75% of all cattle population in Italy (registered in a Herd Book) (Figure 3).

There are also differences regarding the position/location of Genetic Centres, in terms of localisation of the stall of Performance; generally all of them are not near urban centres.

Table 3. Location and position of Genetic Centres surveyed.

Breed	Location of Genetic Centres	Esposition		Sea level meters
Marchigiana	Hill	south/west-facing	SW	260
Chianina	Hill	south/west-facing	SW	260
Romagnola	Hill	south/west-facing	SW	260
Podolica	Mountain	south/est-facing	SE	1100
Maremmana	Plain	West	W	0
Piemontese	Plain	South	S	380
Limousin	Plain	South	S	100
Rendena	Plain	north-/south-facing	NS	200
Simmental	Plain			30
Alpine Grey	Hill	north-/est-facing	NE	600
Valdostana	Mountain – Valley	est/west	EO	600
Brown	Plain	nord/south	NS	0
Friesian	Plain		\	0

ORGANIZATION OF PERFORMANCE TEST

ADAPTATION PERIOD OR QUARANTENE

This period is present for all breeds, because the isolation at the arrival of calves at Genetic Centres is very important to avoid sanitary problems and for adaptation to the new conditions (life within a new group, new feeding, new environment, etc).

The age at the entrance at genetic centres results higher for beef and dairy breeds (excepted Piemontese breed), with an average value of 7 months (Limousin is about 10 months), while it is about 30 d for dual purpose breeds and Piemontese. Another main difference among breeds is the number of groups tested yearly, with monthly entrance for the most popular beef breeds, while the smaller breeds (i.e., rustic breeds and autochthons dual purpose breeds) are conditioned by seasonal calving and therefore by a lower number of groups (1 to 6). As far as the dairy breeds are concerned, the Brown breed has a bimestrial entrance and Friesian has basically a weekly “continuous” bull’s admittance to the genetic centre (Sbarra et al., 2009). (Table 4 and 5). Health controls on animals at the genetic centres aim to diagnose the absence of Tuberculosis (TBC), Brucellosis (BRC), Blue Tongue (BT), Infectious Bovine Rinotracheitis (IBR) and Bovine Viral Diarrhoea (BVD) in almost all breeds. The only exception is represented by Alpine Grey and Valdostana that do not allow the introduction of animals from any other part of the country. Therefore, they are officially certified and, for this reason do not need the testing for IBR and/or BVD.

For beef breeds the bull’s owner remains the farmer (excepted for the Piemontese breed where NCBA owns some bulls), while for dual purpose breed the owner is always the NCBA. On the other hand AI Centres own all tested bulls belonging to dairy breeds.

Table 4. Organisation of adaption period in Italian Cattle Breeds.

Breed	Bull recognize	Lenght (d)	Automatic feeder	Distribution on
Marchigiana	Collar and chip	30	Yes	Weight
Chianina	Collar and chip	30	Yes	Weight
Romagnola	Collar and chip	30	Yes	Weight
Podolica	Collar and chip	30	No	Weight
Maremmana	Collar and chip	30	No	Weight
Piemontese	Collar and chip	90	Yes (*)	
Limousin	identification number pt	30	Yes	Adg
Rendena	identification number pt	/	/	/
Simmental	Collar	34	Yes	Needs
Alpine Grey	Identification number pt and progressive number	150	No	feeding plan
Valdostana	Collar and chip	30	No	
Brown	Collar and chip	28	No	
Friesian	Collar and chip	35	No	group and age

(*) artificial milk

Table 5 . Some characteristics of organisation of starting Performance Test

Breed	groups	Mean Age at entrance (d)	Weaning phase
Marchigiana	12	150	NO
Chianina	12	150	NO
Romagnola	12	150	NO
Podolica	1	270	NO
Maremmana	1	270	NO
Piedmontese	12	50	YES
Limousin	1	300	NO
Rendena	5	40	YES
Simmental	12	34	YES
Alpine Grey	6	28	YES
Valdostana	3	40	YES
Brown	6	210	NO
Friesian	50	225	NO

PERFORMANCE TEST

In table 6 some specific characteristics of performance testing organization are summarized; for beef and dual purpose breeds (except for Piemontese, Simmental and Rendena), testing length is about 6 months. The main trait measured by all NCBA over the test is the weight, with differences in the frequency of weightings that range from 21 to 42 d among breeds. In some cases, together with the weights, some body measurements are taken, but not used to construct selection indexes. These measurements are "indicators" of the body conformation of bulls. However, the dairy breeds submitted to a lesser number of weightings, due to the different aim of testing for this breed compared with beef or dual purpose ones.

Table 6. Some characteristic of organisation of Performance Test

Breed	length of test (d)	Months on test	Age at end of test (m)	No. weighing	Frequency (d)	Body measurements	Assessors final evaluation
Marchigiana	180	6	12	9	21	2	3
Chianina	180	6	12	9	21	2	3
Romagnola	180	6	12	9	21	2	3
Podolica	180	6	14-15	9	21	NO	3
Maremmana	180	6	14-15	9	21	NO	3
Piedmontese	280	10	12	11	28	1	3
Limousin	120	4	15	6	28	1	1
Rendena	330	11	12	11	30	11	2+3
Simmental	294	7	12	7	42	2	3
Alpine Grey	168	6	12	6	28	6	3+3
Valdostana	180	6		6	30	6	3
Brown[(a)]	120	6	12.5	2+1		3	1
Friesian[(b)]	120	3		3		1	0

[(a)] Weightings at first semen collection and after one month; [(b)] Weightings at entrance, end of adaptation and end of test.

As far as feeding is concerned, during the performance test 7 testing stations on total uses the automatic feeder, and hay is usually given separately from concentrates. The only exception is for Simmental breed, being submitted to a total mixed ratio feeding system.

For ANABIC breeds and Simmental electronic balances are used, while Piemontese breed also use a mechanic balance (also Rendena and Alpine Grey breeds).

As regards the use of selected young bulls and their distribution among herds, almost all breeds provide to the semen training and collection, with the exception of Maremmana, Podolica, Limousin, Alpine Grey and Friesian.

In some cases (i.e., Piemontese, Simmental and Valdostana) the NCBA also provides for the distribution of semen, while in many cases, young bulls are sold by auction after the test.

About Rendena, it must be said that the modest selection pressure obtained at the end of the performance test is justified by the fact that all the bulls are eligible for Artificial Insemination and will be on Natural Service; there are no other bulls for Natural Service and this is essential in such as small a breed to retain the highest genetic variability (Bittante, 2007) (Table 7).

Table 7. Selection on tested young bulls in beef and dual purpose Italian breeds.

Breed	young bulls	AI [(a)]	AI [(b] a/t	NS [(b)]	NS a/t [(d)]	RE	IA as[(f)]	NS as[(g)]
Marchigiana	60	20	33.3%	16	26.7%	40%	18	14
Chianina	61	26	42.6%	12	19.7%	38%	25	12
Romagnola	61	24	39.3%	18	29.5%	31%	15	6
Podolica	51			19	37.3%	63%		17
Maremmana	23			15	65.2%	35%		11
Piedmontese	213	40	18.8%	137	64.3%	17%	40	71
Limousin	37	6	16.2%	24	64.9%	18.9%	0	20 (+ 10 a fixed price)
Rendena	57	30	52.6%			47.4%	30	
Simmental	213	18	8.5%	76	35.7%	55.9%	0	0
Alpine Grey	30	13	43.3%	5	16.7%	40.0%	13	5
Valdostana	59	28	47.5%	31	52.5%	0.0%	28	14

[(a)]Approved young bulls for Artificial Insemination

[(b)]Approved young bulls for Artificial Insemination/tested young bulls

[(c)]Approved young bulls for Natural Service;

[(d)]Approved young bulls for Natural Service/tested young bulls

[(e)] Rate of bulls elimination

[(f)] Approved young bulls for Artificial Insemination Sold

[(f)] Sold Approved young bulls for Natural Insemination Sold

The number of tested young bulls depend by the number of bull calves born during the year and by the structure of Genetic Centres; the percentage of approved young bulls for Artificial Insemination ranged from 8.5% to 52.6% (this is case of Rendena in which all the tested bulls are approved for Artificial Insemination). Another important difference is that for Maremmana and Podolica breeds, there is only Natural Service approbation, due the characteristics of their breeding system (farms are open pasture).

FINAL EVALUATION

As regards the Morphological evaluation, the basic is the "linear description" of the different body areas of an animal through numbers that have a range between the biological extreme of the traits. This method allows the statistic elaboration of the Genetic Indexes. (ANABORAPI, 2010)

At the end of the test, for the five Italian beef breeds, three breed assessors carry out a individual linear evaluation (27 traits for Muscle Development, Body Size, Structure and Legs, Fineness and Reproductive traits). In this case any single trait is evaluated using five classes (from 1 to 5). Also for the Piemontese breed the breed assessors carry out an individual linear evaluation. In the Simmental breed measurement, evaluation, size, structure and legs are taken into consideration.

Limousin breed carries out a morphological evaluation, while Rendena bulls are evaluated both for linear type trait and commercial carcass conformation (EUROP grade) and dressing percentage estimated in vivo (Anon, 2004).

Also Alpine gray bulls are evaluated for linear type traits and commercial carcass conformation (EUROP grade) and dressing percentage estimated in vivo by a commission of assessors. For Valdostana breed bulls a linear type of evaluation is carried out by a commission.

SEMEN ANALYSIS AND TESTICULAR MEASUREMENTS

Before operating a selection on bull reproductive potential fertility, it is necessary to know the mean reproductive characteristics and their variability within a specific bovine population (Sylla et al., 2005). Currently the best way to predict bull potential fertility, specially yearling, consists in a general physical examination, semen collection and analysis, dealing to exclude from breeding programs bulls with either congenital or acquired abnormalities which can adversely affect breeding efficiency (Carson & Wenzel, 1997). Some reproductive characteristics related to fertility are inherited (Calisti and Monaci, 1988). Testicular growth is conditioned by breed, age, body weight and season (Fields et al., 1979). Scrotal circumference is positively correlated to gonad weight and daily sperm output and to semen quality (Sylla et al., 2005).

Semen analysis represents an essential step in the evaluation of bull potential fertility.

In a study of Sylla et al. 2007 sperm concentration was also positively related to testicular length, diameter and Scrotal circumference in Marchigiana, Chianina and Romagnola breeds.

Some NCBA have a Semen Production Station that produces exclusively semen of the their breed (i.e. Piemontese and ANABIC for Marchigiana, Chianina and Romagnola breeds).

For Marchigiana, Chianina and Romagnola breeds, at the end of performance test (for young bulls approved for IA) there is a control of semen characteristics (volume, concentration, progressive motility, head abnormalities, tail abnormalities, midpiece abnormalities, detached heads, total abnormalities) and testicular measurements (scrotal circumference, testicular length, testicular diameter). Furthermore for these breeds a previous service before the collection is carried out. This training consists in accustoming the bull to service on the dummy with the help of an artificial vagina handled by an operator. Since the beginning of 2010 semen collection was currently carried out by ANABIC for the three specialised breeds (a limited number of semen straws collected). Also Rendena and Valdostana breeds carry out this controls, while Piemontese and Simmental breeds carry out only semen analysis and training for Artificial Service at service but don't effect testicular measurements.
Table 8 resumes the system of semen collection and selling system for young bulls.

Table 8. Semen collection system of NCBA of Italian Cattle breeds.

Breed	Training to semen collection	Semen Collection	Selling system of young bulls
Marchigiana	YES	YES	Auction
Chianina	YES	YES	Auction
Romagnola	YES	YES	Auction
Podolica	NO	YES	Auction
Maremmana	NO	NO	Auction
Piedmontese	YES	YES	Direct
Limousin	NO	NO	Auction
Rendena	YES	YES	Auction
Simmental	YES	NO	NO
Alpine Grey	NO	NO	Direct
Valdostana	YES	YES	NO
Brown	YES	YES	Direct
Friesian	NO	NO	Direct

In the survey, information about people that work in Genetic Centres with bulls is also collected: for almost all NCBA, nationality is Italian, except in some cases where there is European and Extra-European nationality.

GENETIC EVALUATION

From data collected during performance test each NCBA compute Selection Indexes according to selection goals. As can be seen in table 8 for Marchigiana, Chianina and Romagnola the Bull Selection Index (BSI) is based on the traits controlled during performance test. In particular the 50% of average daily gain is considered, also including the pre-test average daily gain (from birth till the beginning of the test) (Bittante, 2007) and the other 50% is reserved for fleshiness at the end of the test (Sbarra et al., 2009). For rustic breeds such as Maremmana and Podolica, bulls are selected through average daily gain during the test (50%) and the final score of morphological evaluation (50%) (Migni, 2002). The breeding goal for Piemontese breed is the improvement of beef production and the reduction of dystocia (Albera et al., 2001). In this breeding program, sequential selection of sires is applied: young bulls are first selected on the basis of their own performance testing on station for beef traits, and subsequently progeny-tested for calving performance using birth records of their progeny and calving records of their daughters (Albera et al., 2004). In fact, Piemontese breed uses two different indexes of selection: “beef” and “herd”: both reserve 40% of the weight to the traits directly assessed on the young bulls during the performance test, in particular, it 20% is reserved for fleshiness, 14% for average daily gain and 6% to feet and legs; 60% is reserved for calving ease.

For Limousin breed genetic evaluation are computed in France; 84% of total of Index is composed by traits collected during performance test while the remaining 16% is reserved for calving ease. For dual purpose breeds it is not surprising that one-half to three quarters of the total Index is reserved to milk yield and functional traits. For example Simmental and Valdostana reserve 25% of total Index to beef traits (with some differences on traits considered) while Rendena reserves 25% of the total of Index to beef traits including evaluation of EUROP and estimated dressing out *in vivo*. For Alpine Grey there aren’t beef traits in the computation of Selection Index, but ANAGA collects phenotypic data during performance test. (Table 9).

Table 9. Percentage weight of traits included in Bull Selection Index on beef and dual purpose breed.

Breed	Daily Gain	Fleshiness	Size	Legs	Direct calving ease	Maternal Calving ease	Milk Yield	Others
Marchigiana	50	50						
Chianina	50	50						
Romagnola	50	50						
Podolica	50							50
Maremmana	50							50
Piedmontese "Beef"	14	20		6	40	20		
Piedmontese "Herds"	14	20		6	20	40		
Limousin [a]	24	41	19		16			
Rendena	5	20					65	10
Simmental	18 [*]						44	38
Valdostana		25					70	5

[a] France; [*] 18% of total index: performance test beef traits.

Table 10 shows the Bull Selection Index in the Italian beef cattle. The Bull Selection Index (BSI) for Chianina, Marchigiana and Romagnola used as selection criteria at the end of test, account for genetic index of both average daily gain (ADG) measured from weaning in the farm of origin up to 5 mo. of age – (PAGD) and ADG realized during the test period at the genetic centre (from 6 up to 12 mo. of age - TADG) (Sbarra et al., 2009). Indeed, previous studies (Mantovani et al., 1999) have indicated possible bias in BSI not accounting for PADG index due to compensative growth. However, BSI also accounts for a fleshiness genetic index (FLESH) evaluated by 3 classifiers at the end of test (Bittante et al., 2001). Frequency computation is every three months (four times per year). BSI is also currently used in Maremmana and Podolica breeds (BSI), but despite the other breeds ANABIC, traits considered are ADG in test and the score (MORPH) is assigned by experts at the end of test, using the linear evaluation system (Migni, 2002). For these breeds, ANABIC does the calculation once a year .

Piemontese breed, as mentioned above, has two Indexes (beef and herds) and ANABORAPI carries out computation each month (twelve times/year) (ANABORAPI, website 2010).

For dual-purpose breeds is necessary to explain the relationship between traits related to milk production and the specific meat characteristics. The IDA (dual purpose Index) for Simmental breed includes milk traits and performance test traits (18% includes average daily gain, size, legs and fleshiness of bulls). About this breed, ANAPRI does the calculation each month, at the end of the performance test cycle. For Rendena breed, ANARE effects a computation with a “multiple” index including milk quality (ILQ), Average Daily Gain in Performance Test, yeld in vivo (RE) x EUROP yeld in vivo (EU), fleshiness evaluation, udder evaluation. (Five times per year for beef traits and once per year for milk trait). ANABORAVA compute an index once a year (in july) that contains Cheese yield and type (IRCM). Alpine Grey Association computes an Index that includes milk quality traits (fat and proteins).

Table 10. Bull Selection Index of beef and dual purpose Italian Cattle.

Breed	Name of Index	Frequency (beef traits) in the year	Frequency (milk traits) in the year	Standardisation
Marchigiana, Chianina and Romagnola	BSI (Bull Selection Index)	4	\	Yes
Podolica and Maremmana	BSI (Bull Selection Index)	1 (summer)	\	Yes
Piemontese "Beef"	Beef Index	12	\	Yes
Piemontese "Herds"	Herd Index	12	\	Yes
Rendena	ILQM	5	1 (summer)	Yes
Simmental	Dual purpose Index	12	3	Yes
Alpine Grey	ILQ		2	No
Valdostana	IRCM	1 (summer)	1 (summer)	Yes

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CHAPTER 3

GENETIC PARAMETERS OF SLAUGHTER DATA ON ITALIAN BEEF CATTLE

Part of the results are presented at EAAP Congress, Poster
Vilnius, 2008.

BOOK OF ABSTRACT
(Vol. 14: 127)

3.1 THE LIVESTOCK SYSTEM OF ITALIAN BEEF CATTLE

The livestock systems for beef cattle in Italy reflect two main types: 1) fattening farms and 2) suckling cow farms. These types are usually well defined and reflect two separated management system, although some interactions between them are often reported. The discriminating factor between the farming systems is usually in the context of agriculture where the activity fits: the fattening systems are spread in areas with intensive agriculture, while, on the other hand, suckled-cow herds, are located in marginal areas of extensive agriculture. Given the morphology of the Italian territory, it is obvious that intensive breeding systems have risen to a greater extent in the Po Valley. It is common practice, in dairy farms, to inseminate the cows with lower genetic value with beef sires to produce crossbreeds for fattening destination and this allows to target the category of veal light, although maintaining a good quality of meat. The extensive systems are usually located at the foot of the Alps, Central Apennines, South and Islands. In these areas one or more breeds are raised (Tiezzi F., 2008).
In central Italy there are three main breeds of beef cattle, whose origin is closely linked to the history of the area: Chianina, Marchigiana e Romagnola.

From ISMEA data (2009) the Beef Italian sector was composed by:

Table 1. Production and consume of meat in Italy.

	(tonne of carcass * 1000)
National production	891
Animal importation	28
Meat importation	450
Consume	1370

Self sufficiency rate: about 65%

Breeding system of Italian Beef Cattle Chianina, Marchigiana and Romagnola.

The three Italian cattle breeds (Marchigiana, Chianina and Romagnola) are the main assets indigenous livestock of central Italy. These three breeds have strong ties with the territory and the breeding techniques have evolved in harmony with the natural environment and social-economic tissue. Those breeds were selected for the dual attitude before the advent of mechanization in agriculture, and house-kept for farming operation. After World War II, with the changes that took place in the society and then in agriculture, loose housing became more and more popular. In recent years the exploiting of marginal areas with semi-wild breeding system is the most common for the sucker-cow line. The technique of feeding for the three “white” breeds involves the use of fodder cereals preferably produced on the farm. Suckling is natural and the weaning is between 4 and 6 months of age. (ANABIC website, 2009). Noteworthy are the farms that are investing in facilities for processing and marketing directly the animal born and fattened in the farm. This system allows for a short-chain at farm level that represents an important opportunities for the enhancement of farm profit, permitting also a greater quality of products sold.

3.2 EVOLUTION OF BREEDING SYSTEM OF ITALIAN BEEF CATTLE

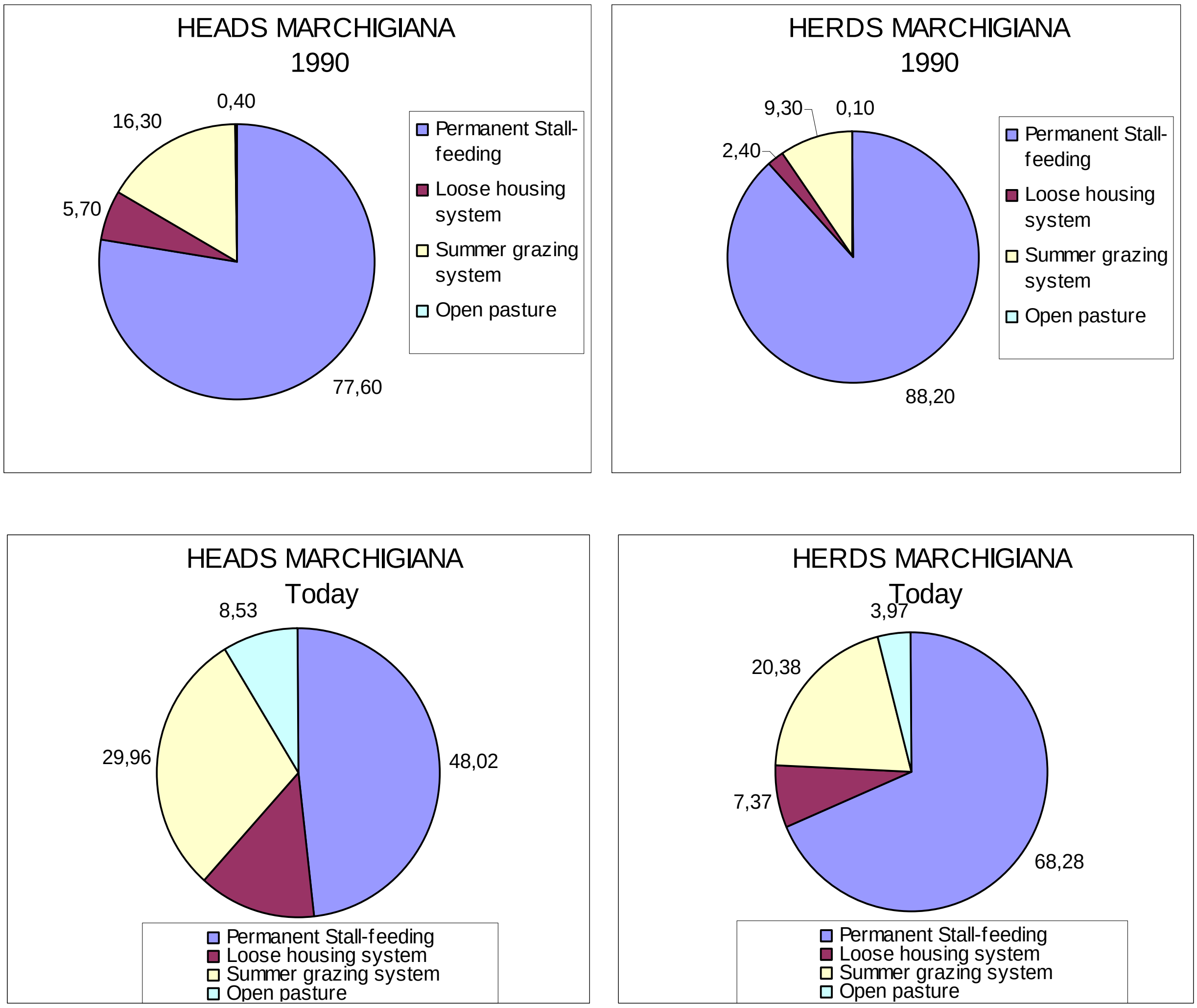
Data of year 1990 and actual data.
Statistics from ANABIC Herd Book

To investigate the state of the herds and fattening farms, an initial check was made on the type of breeding system employed by the registered herds, in particular for Marchigiana and Chianina cattle.

In regard to the Marchigiana breed, for which a permanent stall-feeding system has historically been used, in 1990 the 88% of the farms were classified as this type, with 77% of the livestock raised in such way; on the other hand, about 22% of the animals were raised on open pasture or summer grazing system. Today, the breeding system of this breed has undergone to important changes and permanent stall-feeding system involves about 68% of the total herds, 20% less compared to 20 years ago.

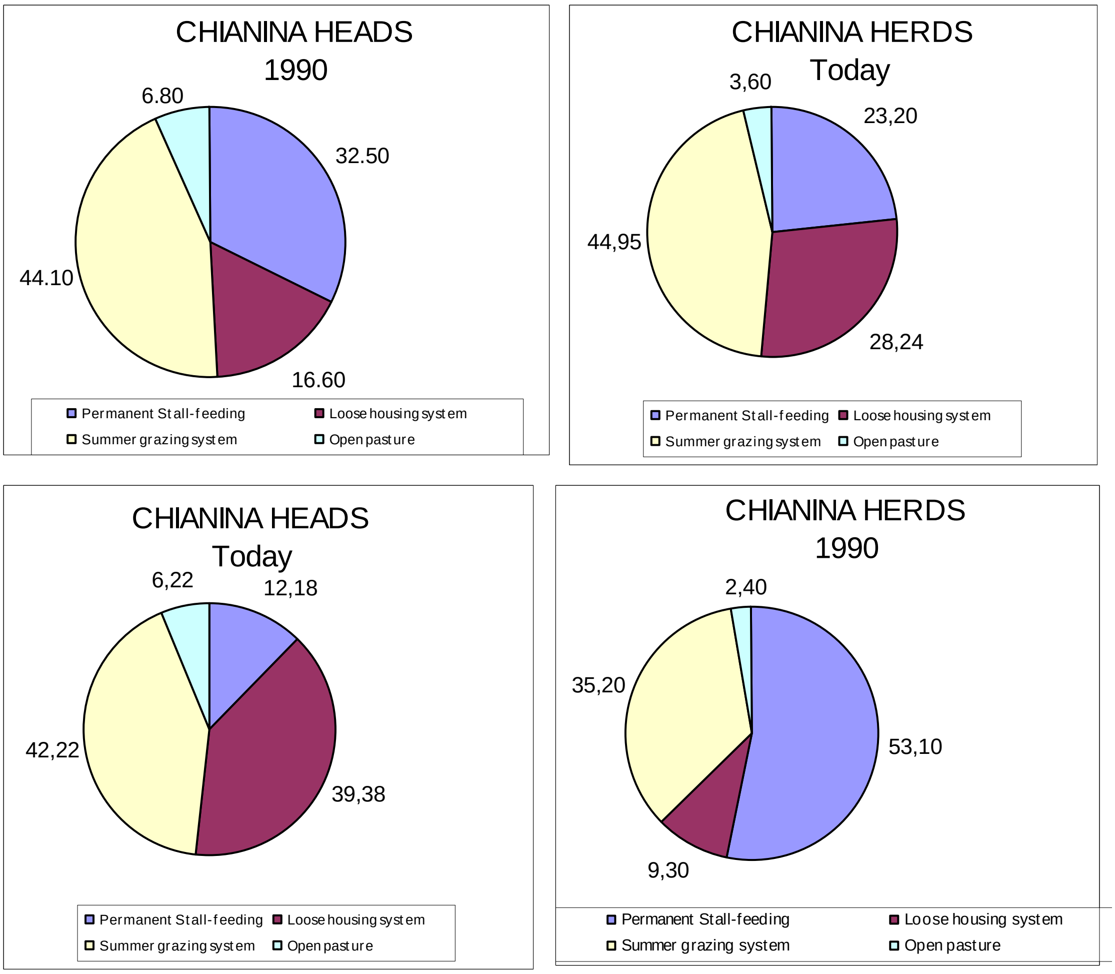
In figure 1 are represented percentages of breeding system in Marchigiana breed and their evolution considering a number of herd and number of heads registered at Herd Book.

Figure1. Evolution of breeding system in Marchigiana cattle.



In figure 2 is represented the evolution of breeding system in Chianina Cattle. About this breed, in 1990 extensive systems were used by 44% of the farms, involving 60% of the animals, while permanent stall feeding was used by 53% of the farms, accounting for 32% of animals. At present, the situation has greatly changed and 72% of the farms and about 80% of cattle are under extensive system; on the other hand, permanent stall feeding account to only 23% of farm and to 12% of animal.

Figure 2. Evolution of breeding system in Chianina cattle.



For Romagnola breed, open pasture and summer grazing systems are used by 51% of the farms and for as high as 69% of the animals.

3.3 GENETIC PARAMETERS OF SLAUGHTER DATA ON BEEF CATTLE

Beef cattle genetic improvement programs have traditionally focused primarily on live animal growth traits. However, as consumers become more concerned with diet-health issues and as the beef industry focuses more on value-based marketing, then emphasis on body composition traits is expected to become increasingly important in the design of breeding programs (Marshall D.M. 1994).

An exhaustive review of estimates of heritability for a broad spectrum of beef production traits published in the scientific literature was conducted by Koots et al. (1994), but their review did not include other important carcass traits (i.e. yield grade, fat weight). Later, Bertrand et al. (2001) re-examined genetic parameters with emphasis on reports from others authors since 1981 until 2000: collecting some carcass parameters, as well as carcass weight but also longissimus muscle area, fat depth, marbling scores, etc.

Riòs Utrera and Van Vleck (2004), have reported heritability values of carcass parameters for some beef breeds and crossbreeds (steers, cattle, heifers, etc) analyzing seventy-two papers published in the scientific literature from 1962 to 2004 reporting estimates of heritability for carcass traits in cattle. The number and the unweighted means of estimates of heritability for each carcass trait by slaughter end point (slaughter age, slaughter weight, backfat thickness) were obtained. The number, the unweighted means, and the ranges of estimates of heritability over the three different end points were also calculated. Standard errors were not reported for many heritability estimates and several different methods of estimation were used (e.g., animal model, son on sire regression, paternal half-sib covariance). Therefore, weighted means of heritability were not calculated. Papers that did not specify at which end point animals were slaughtered or to which end point carcass traits were adjusted were not included in this review. Traits included were carcass weight, dressing percentage, backfat thickness, longissimus muscle area, kidney, pelvic, and heart fat percentage, marbling score, yield grade, predicted percentage of retail product, retail product weight, fat weight, bone weight, actual retail product percentage, fat percentage, and bone percentage. On average, heritability value resulted 0.42 correcting for age, 0.37 correcting for weight, and 0.35 correcting for backfat. Table 2 represents some results of heritability values for carcass weight compared.

Table 2. Heritability of carcass weight in some breeds. (Riòs Utrera and Van Vleck, 2004)

Authors	Year	Breed	Constant in the model	h^2
Wilson et al.	1993	Angus	Age	0.31
Wheeler et al.	1993	Some beef breeds	Age	0.15
Oikawa et al.	2000	Japanese Black	Age	0.15
Benyshek et al.	1981	Hereford	Weight	0.19
Benyshek et al.	1988	Hereford	Weight	0.19
Arnold et al.	1991	Hereford	Weight	0.24
Crews Jr. and Kemp	2001	Simmental	Weight	0.38
Morris et al.	1990	Crossbreed	Fat thickness	0.17
Gilbert et al.	1993	Hereford	Fat thickness	0.26
Wulf et al.	1996	Crossbreed	Fat thickness	0.10
Elzo et al.	1998	Angus	Fat thickness	0.39

Only three studies that compared estimates of heritability for carcass weight adjusted for age or for backfat thickness were found. The differences in estimates of heritability obtained with these two adjustments were variable across studies. For crossbred steers representing 11 cattle breeds that were slaughtered at 20 months of age, Morris et al. (1990), found that hot carcass weight adjusted to a constant age had a larger estimate of heritability than hot carcass weight adjusted to a constant backfat thickness (0.28 vs. 0.17). In a recent study, Devitt and Wilton (2001), using crossbred steers, also obtained differences between age and backfat thickness-constant estimates of heritability for carcass weight, but the estimate adjusted for backfat thickness was larger than the estimate adjusted for age (0.57 vs. 0.47). The reduction in the estimate of genetic variance caused by age adjustment relative to that for backfat thickness (522 vs. 1,051 kg2) could mainly explain this difference, because phenotypic variances were not much different with these two adjustments. In contrast, Shanks et al. (2001), found no significant difference between age and backfat thickness-constant heritabilities (0.32 vs. 0.33) for carcass weight of Simmental and percentage Simmental steers (Riòs Utrera and Van Vleck, 2004).

About Hereford breed, Benyshek (1981, 1988), conducted a study in order to estimate the heritability of average growth and carcass traits of steers and heifers. Heritability was estimated from covariance among paternal half sibs on an age constant basis and also with carcass weight held constant. Feedlot was a technique of fattening.

The estimate of heritability for hot carcass weight for steers (0.54) is similar to the estimates reported by other authors.

In Ireland, Hickey et al. (2007), conducted a study in order to estimate heritability of carcass average daily gain and other carcass parameters evaluated under EUROP system across several breeds and crossbreeds animals. Data collected included crossbreed (F1 dairy cows with beef or dairy bulls) slaughtered an age ranged from 300 to 875 days. The heritability of carcass traits obtained by Irish Authors are resumed in Table 3. Carcass fatness traits shows a lower value of heritability than other carcass traits. In regard to the genetic correlations between this traits in Holstein sire breed group, the values for carcass weight with carcass conformation and carcass fatness was respectively 0.11 and 0.26, while the genetic correlation between carcass conformation and carcass fatness was 0.44.

Table 3. Heritability of carcass trait for each breed (sire group) reared in Ireland. Hickey et al. (2007).

Breed group	Carcass Weight	Carcass Conformation	Carcass Fatness Class
Aberdeen angus	0.17	0.12	0.23
Belgian Blu	0.17	0.33	0.15
Charolais	0.65	0.09	0.24
Friesian	0.06	0.04	0.13
Hereford	0.18	0.13	0.00
Holstein	0.18	0.20	0.02
Limousin	0.20	0.36	0.00
Simmental	0.54	0.10	0.40

3.4 PROCTED GEOGRAPHICAL INDICATION: the Italian Beef Cattle of Central Apennine: Chianina, Marchigiana and Romagnola.

The Chianina, Marchigiana and Romagnola beef cattle breeds, which descended from the same original stock, are now widespread throughout all of Italy and are found predominantly in the central and southern regions. The herds, managed as suckling cow farms, are small- to middle-sized and most of them are located in hilly or mountainous areas, providing in many cased directly the fattening of young calves.

The National Association of Italian Beef-Cattle Breeders (ANABIC) was established to promote and implement all types of initiatives aimed towards improving, developing, ad spreading the autochthonous Italian cattle breeds: Marchigiana, Chianina, Romagnola, and other two ancient breeds as the Maremmana and the Podolica. ANABIC, which derives by merging the previously existing National Breeders Associations, has taken on the herd books' responsibilities as far as selection is concerned, setting up a single National Herd Book for the five aforementioned Italian beef-cattle breeds. In addition to its main activity focusing on genetic improvement, ANABIC also carries out numerous promotional initiatives, collaborates with competent government structures and university institutes on research and test programs, and offers technical assistance to international operators involved in raising the Italian beef cattle breeds (ANABIC website, 2008). In recent years, an increased attention of consumers to food safety has led to the setting up and development of appropriate legislation in Europe aimed to provide legal protection to regional foods. This has been mainly accomplished through the 'PGI' (Protected Geographic Indication) and 'the PDO' (Protected Designation of Origin) labels (European Union Regulation (EEU) 2081/92). These two labels represent two distinct level of protection of regional food products. Indeed, the PGI are products produced, processed and prepared in a specific geographic area using defined materials and methodology. Nevertheless, the PDO are products in which at least one stage of the production is covered by the geographical protection. In both cases the geographic component is the key aspect of the protection. The aims of this legislation were: to support diversity in agricultural production, to protect consumers by giving them information on the specific characteristic of the product and to protect product names against fraud and imitation (Ilbery and Kneafsey, 2000; Parrott at al., 2002).

Legislation of appropriate methods to ensure ''traceability" is indeed essential and plays a key role in any modern food safety control and verification system for food products. An effective traceability system contributes to prevent frauds, provides an effective method for the assessment and management of food risk, facilitates disease control procedures and contributes to consumer confidence in product safety. DNA-based methods offer the possibility to identify animals and single part of their body or their products, guaranteeing the full traceability of a product all along the food chain.

Protected Geographical Indication (PGI)

At EU and World level, Italy is the leader in PGI and PDO foods, with 145 total recognized labels. Italy is followed in this particular ranking by France, Portugal, Spain and Greece. Considering their economical value, due to the fact that PGI and PDO carry on the values of high quality, history and traditions, both these labels represent at EU level an interesting way to maintain and develop livestock systems in the less competitive areas of the country. This give also an idea about why researchers are focusing on geographic traceability topics. (Dalvit, 2007). As regard the meat industry, both Italy and Spain have obtained PGI labels for beef from some native breeds: Chianina, Marchigiana, and Romagnola breeds for Italy, and Pirenaica for Spain (Arana et al., 2002)

The Protected Geographical Indication (PGI) is one of the two systems adopted by the European Union to recognize and protect agro-food products of excellence coming from the various areas of the European Union. The PGI for the Italian beef cattle breeds started in 1992 with EC Regulation no. 2081/92. With the approval of this regulation (i.e., EC 2081/92), the farmers and beef producers of the Italian cattle breeds have understood the importance of the labelling system, that allows an official European recognition for quality of their product, particularly in recent years, when the mad cow disease was widespread all along the old continent (Mengoli, 2005).

Officially, in 1993 the PGI recognition of the “Vitellone Bianco dell’Appennino Centrale” was activated by the Italian Ministry of Agriculture and the European Commission for the Chianina, Marchigiana or Romagnola breeds. Within the PGI animals have to be slaughtered at an age between 12 and 24 months, born, raised and slaughtered within the typical area of production and fattened following the specific production regulations.

Under the EU beef carcass classification (SEUROP) scheme, each carcass is assessed and classified at the weighing point on the slaughter line (Anon, 2004). In regard to this, each PGI “Vitellone Bianco dell’Appennino Centrale” carcass must fall within the following values:

- carcass conformation score not lower than letter “R”;
- carcass fattening class equal to 1 and no greater than 3.

Moreover, the colour of carcass exposed parts need to be within the carcass normal colour, avoiding abnormal magenta or tangentially black colours (vitellonebianco website, 2009).

This traceability system for cattle meat products has become a key aspect of food quality assurance and the first priority within EU countries, to meet consumer demand for comprehensive and integrated food safety policies (Negrini et al., 2008).

Accounting for this, new selection purposes have been introduced in many EU countries, particularly taking into account also the quality aspects of the carcasses, focussing on the carcass fleshiness and carcass fatness. These traits have been considered within the progeny or the performance testing schemes by many beef breeders associations. For example, the current genetic evaluation of genetic parameters of carcass traits in Swedish beef breeds considers only growth traits, although correlations with field-recorded growth traits and carcass traits are taken into account (Eriksson et al., 2003). From this point of view, also the ANABIC has enrolled in recent years a system for evaluating bulls not only for growth traits, but accounting also for quality characteristics of growth in performance tested animals. (Sbarra et al., 2009).

3.5 GENETIC ANALYSIS OF SLAUGHTER AGE AND OF CARCASS WEIGHT AND WEIGHT GAIN OF MARCHIGIANA, CHIANINA AND ROMAGNOLA YOUNG BULLS

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ABSTRACT

In 1993 the request for PGI recognition of the "Vitellone Bianco dell'Appennino Centrale" (White young bull of the Central Apennines) made by the Italian Ministry of Agriculture was approved by the European Commission for the meat produced from young bulls and heifers of the Marchigiana, Chianina or Romagnola breeds. Today, animals slaughtered at an age between 12 and 24 months, born, raised and slaughtered within the typical area of production in Central Italy are within the PGI system. The slaughter data obtained within the PGI were used in this study. Variables considered were the slaughter age (SA, d) and carcass weight (CW, kg) of young bulls slaughtered between 2004 and 2007. Carcass average daily gain (CWG, kg/d) was also calculated. After editing, 20,872 records, complete for SA and CW and pertaining to fixed herd-year with at least two observations, and 50,865 ancestors, were used. Single trait analysis carried out produced h^2 estimates greater for SA in all the breeds analyzed, ranging from 0.28 for Chianina, to 0.38 for Romagnola breeds. The CW shows heritability values lower than SA in all the breeds, changing from 0.14 for Chianina to 0.24 for Romagnola young bulls. Adjusting CW by SA increases slightly the heritability values of CW in all breeds. The trait to be used as endpoint is implicitly assumed to be an environmental factor to be taken into account, especially when it is the age of animals. But if the endpoint trait is heritable, its inclusion in the models for slaughter traits analyses can lead to biases in the estimation of genetic parameters and of genetic values of animals, and the importance of these biases is depending mainly on the sign and entity of genetic correlations between the endpoint trait and the analyzed traits. While the

phenotypic correlations between CW and SA, as expected, were moderate and positive for all breeds, the genetic correlations resulted low and negative. This means that animals with a greater genetic value for CW (fast growing ones) tended to be slaughtered earlier than animals with the lower genetic value for CW. However, the correlation between ranks of EBV derived from the analysis of CW and CW adjusted by SA showed greater values in Marchigiana (0.967) and Romganola (0.945), while in Chianina breed greater changes in rankings among sires evaluated by slaughter data are possible accounting or not for the SA, because of the lower correlations observed (i.e., 0.853).

Key words: age at slaughter, carcass weight, carcass growth, Italian beef cattle breeds.

3.5.1 INTRODUCTION

Beef cattle genetic improvement programs have traditionally focused primarily on live animal growth traits and conformation recorded at farm level or at test stations on young candidate bulls (Andersen et al., 1981; Albera et al, 2001). However, data from slaughterhouses have been considered to analyze genetic components of carcass traits (Koch et al., 1982; Rìos-Utrera, 2004). In recent years, large datasets relative to cattle slaughter performance at population level have been used to study genetic components in *post mortem* traits (Reverter et al., 2000; Shojo et al., 2006; Hickey et al., 2007; Boukha et al., 2009; Mc Hugh, et al., 2011; Carnier et al., 2011). The increased availability of data at slaughter could be related to both the traceability regulations (animal passports) introduced by European Union after the BSE outbreaks and to the increasing number of beef products that achieve special labelling like the Protected Designation of Origin (PDO) or the Protected Geographical Indication (PGI), which requires the monitoring of all the production chain at individual animal level.

The possible effects of using these large datasets for the genetic improvement of beef breeds are not yet well documented. If environmental variations are generally taken into account including in the statistical models the effect of herd, year and season, some doubts can arise from the proper addressing of the individual variability of the age at slaughter. In fact, recently, Bittante et al. (2011) outlined the possible biases in the estimation of genetic value for live weight (LW) of calves sold at auction if the model adjusts for age at auction, either through a linear covariate or age classes. Moreover, Bittante et al. (2011) reported a moderate heritability of age at selling and a strong negative genetic correlation between age and weight of the calves. The possible explanation of such a result could be related to the fact that breeders decide to sell earlier the fast growing animals, keeping longer on fattening the slow growing subjects. In this condition a univariate model of analysis of LW including age as fixed factor lead to underestimate the best animals ant to overestimate the worst, while a bivariate model with both LW and age allows a more correct estimation (Bittante et al., 2011; Penasa et al., 2011).

The Italian Marchigiana, Chianina and Romagnola beef-cattle breeds are now widespread throughout Italy and are found predominantly in the central and southern regions. The National Association of Italian Beef-Cattle Breeders (ANABIC) was established to promote and improve these breeds (ANABIC website, 2011).

In 1993 the request for PGI recognition of the "Vitellone Bianco dell'Appennino Centrale" (White young bull of the Central Apennines) made by the Italian Ministry of Agriculture was approved by the European Commission for the meat produced from young bulls and heifers of the Marchigiana, Chianina or Romagnola breeds. This PGI involve all purebred animals slaughtered at an age between 12 and 24 months, born, raised and slaughtered within the typical area of production in Central Italy, and obtained following the appropriate production regulations for management and feeding (Mengoli, 2005).

The aim of this study was to analyze the genetic parameters and relationships of slaughter age, carcass weight and carcass weight gain of Marchigiana, Chianina and Romagnola young bulls using the slaughter database of the Consortium for PGI "Vitellone bianco dell'Appennino Centrale"

3.5.2 MATERIAL AND METHODS

Animal Care and Use Committee approval was not obtained for this study because the data were from an existing database. The authors did not have direct control over the care of the animals included in this study.

Data and editing procedure

Data used in the study were slaughter age (SA, d) and carcass weight (CW, kg) of the three autochthonous Italian beef cattle breeds Marchigiana, Chianina and Romagnola slaughtered between 2004 and 2007. Dataset was obtained from the Consortium of PGI "Vitellone Bianco dell'Appennino Centrale" and pedigree information was supplied by ANABIC (Italian Beef cattle Breeder Association, San Martino in Colle, Perugia, Italy). Carcass average daily gain (CWG, kg/d) was calculated as a ratio between CW and SA.

After editing, 20,872 records, complete for SA and CW and pertaining to herd-years having at least two observations, and 50,865 ancestors were retained for further analysis. In table 1 are summarised the number of animals with phenotypic observations, ancestors, herd-year levels and slaughterhouses included in the analysis and separated by breed.

The GLM procedure (SAS Inst. Inc., Cary, NC) was used for fitting the following model:

$Y_{ijk}=\mu + HY_j + S_i + a_{ijk} + e_{ijk}$

Single trait analysis was carried out to estimate heritability of SA, CW, CW adjusting with SA and CWG traits. In order to obtain the best estimation as possible of the (co)variance among CW and SA, a bi-trait REML analysis was additionally carried out (Mistztal, 2002).
The correlation analysis was carried out on ranks between EBV derived from CW and CW adjusting with SA. To carry out a homogenous comparison among breeds 80 sires were chosen for each breed ordering animals on the basis of the number of offspring in the slaughter dataset and keeping sires with the greater number of offspring.

Standard error (SE) for estimates for heritabilities were approximated using the following formula (Falconer, 1989)

$$SE_{h^2} = 4\sqrt{\frac{2(1-t)^2[1+(k-1)t]^2}{k(k-1)(s-1)}}$$

Where t is the intraclass correlation approximated by $h^2/4$ for paternal half-sib estimates, k is the average number of offspring per sire, and s is the number of sires. Approximated SE for estimates of genetic and phenotypic correlations were computed using the following formula (Falconer, 1989):

$$SE_r = \frac{1-r}{\sqrt{2}}\sqrt{\frac{SE\,h^2{}_1 SE\,h^2{}_2}{h^2{}_1 h^2{}_2}}$$

Where r are the estimated genetic and phenotypic correlations, h_1^2 and h_2^2 are the estimates of heritability, and SE $h^2{}_1$ and SE $h^2{}_2$ are the SE of the estimated heritabilities.

3.5.3 RESULTS AND DISCUSSION

Table 2 shows some descriptive statistic of all considered traits for each breed: mean age at slaughter was very similar among breeds, resulting in about 21 mo., with a coefficient of variation slightly greater than 10%. The mean CW was higher for Chianina young bulls than for the other two breeds (+10.6%). As a result, the carcass average daily gain ranged from 0.768 kg/d for Chianina breed to 0.693 and 0.675 kg/d for Marchigiana and Romagnola young bulls, respectively. The coefficient of variation were around 13% for CW and 15% for CWG, with the exception of the Romagnola breed that exhibited a lower variability coefficient (12,6%). These data confirms that Chianina breed has a superior growth capacity than the two other breeds non only under performance testing at central station of ANABIC (Sbarra et al., 2009), but also in field conditions.

In table 3 are summarised the genetic parameters estimated from animal model analysis for SA, CW and CWG traits. The SA shows a good heritability in all analyzed breeds, ranging from 0.28 in Chianina, to 0.38 in Romagnola young bulls. This result seems to indicate that the age at slaughter is not only an environmental factor but that it is also influenced by genetics. More specifically, there is a genetic component also for precocity of the breed with a different magnitude among the three breeds analysed. Comparing our results with other studies, the heritability estimated in the present study are much greater than heritability values found on Brown Swiss young calves sold at auction (Bittante et al., 2011; Penasa et al., 2011).

Carcass weight shows heritability values lower than SA in all the breeds changing from 0.14 in Chianina to 0.24 in Romagnola young slaughtered bulls. Adjusting CW by SA increases slightly the heritabilities of CW in all breeds, like in the case of LW of calves sold at auction analysed by Bittante et al. (2001), but didn't reach the values found for SA. The values estimated in the present paper are within the range reported in the review of Rìos-Utrera (2004), or in other studies (Shojo et al., 2006; Hickey et al., 2007). Particularly, Rìos-Utrera (2004) outlined that in the large majority of paper examined the heritability values reported were relative to slaughter weight adjusted by age at slaughter and that few studies, those with inconsistent results, have compared estimates of heritability and genetic correlations for carcass traits adjusted to different slaughter endpoints (Lee et al., 2000; Shanks et al., 2001; Rumph at al., 2007; Choy et al., 2008). The trait to be used as endpoint is implicitly assumed to be an environmental factor to be taken into account, especially when it is the age of animals. But if the endpoint trait is heritable, its inclusion in the models for slaughter traits analyses can lead to biases in the estimation of genetic parameters, not reflecting an actual breeding value for the animals. The magnitude of such biases is depending mainly on the sign and entity of genetic correlations between the endpoint trait and the analyzed traits, as indicated by Bittante et al. (2011).

In regard to the phenotypic correlations between CW and SA, as expected, the estimates obtained were moderate and positive in all breeds. On the other hand, the genetic correlations resulted close to zero and negative. This means that animals with a higher genetic value for CW (fast growing ones), tended to be slaughtered earlier than animals with the lower genetic value for CW (Table 4). The choice for the right moment of slaughtering is a complex decision pertaining to farmer and is strongly influenced by market characteristics and seasonality. To understand what really means a genetic value for the SA, further researches are needed, especially considering possible interactions with feed efficiency on one side, and with muscle development and fat deposition on the other side. Furthermore, the direct or indirect effect of selection for precocity of slaughter animals should also take into account indirect effects on conformation and reproduction precocity of both males and females (Cammack et al., 2009; Santana et al., 2010; Mantovani et al., 2010).

A strong negative genetic correlation between age and LW was also found on calves sold at auction (Bittante et al., 2011).

Because of the main objective of adjusting CW by SA is a correct evaluation of the of growth potential of the animal, an alternative way to obtain this is by using the carcass daily gain, obtained dividing CW by SA. From table 3 it is evident that this trait is characterized, in all the three breeds studied, by a heritability value greater than those obtained for CW (adjusted or not) and very close to that found for SA.

Figure 1 represents rank correlations related to EBV obtained from the analysis of CW and CW adjusting with SA showed. With the exception for Chianina breed, due probably to the greater negative genetic correlation between CW and SA, in the two other breeds the changes observed were very small, indicating that accounting or not for SA do not produce great changes in breeding values of sires.

Table 1. Number of animals and of fixed effects for Marchigiana, Chianina and Romagnola breeds.

Breed	Marchigiana	Chianina	Romagnola
Animals:			
with phenotypic data	5,440	10,658	4,774
Ancestors	13,579	24,070	13,216
Total	19,019	34,728	17,990
Fixed factors levels:			
HY	1,120	1,356	357
S	22	22	7

Table 2. Descriptive statistics for the SA, CW and CWG of the Marchigiana, Chianina and Romagnola young bulls.

Breed	Marchigiana	Chianina	Romagnola
SA (d):			
mean	631.1	628.2	645.9
s.d.	72.0	66.1	66.5
Min	450.0	451.0	450.0
Max	766.0	780.0	775.0
CW (kg):			
mean	432.9	479.0	433.3
s.d.	58.0	65.3	52.9
Min	203.0	226.0	240.0
Max	645.0	713.0	623.0
CWG (kg/d):			
mean	0.693	0.768	0.675
s.d.	0.107	0.112	0.085
Min	0.367	0.342	0.386
Max	1.102	1.183	1.010

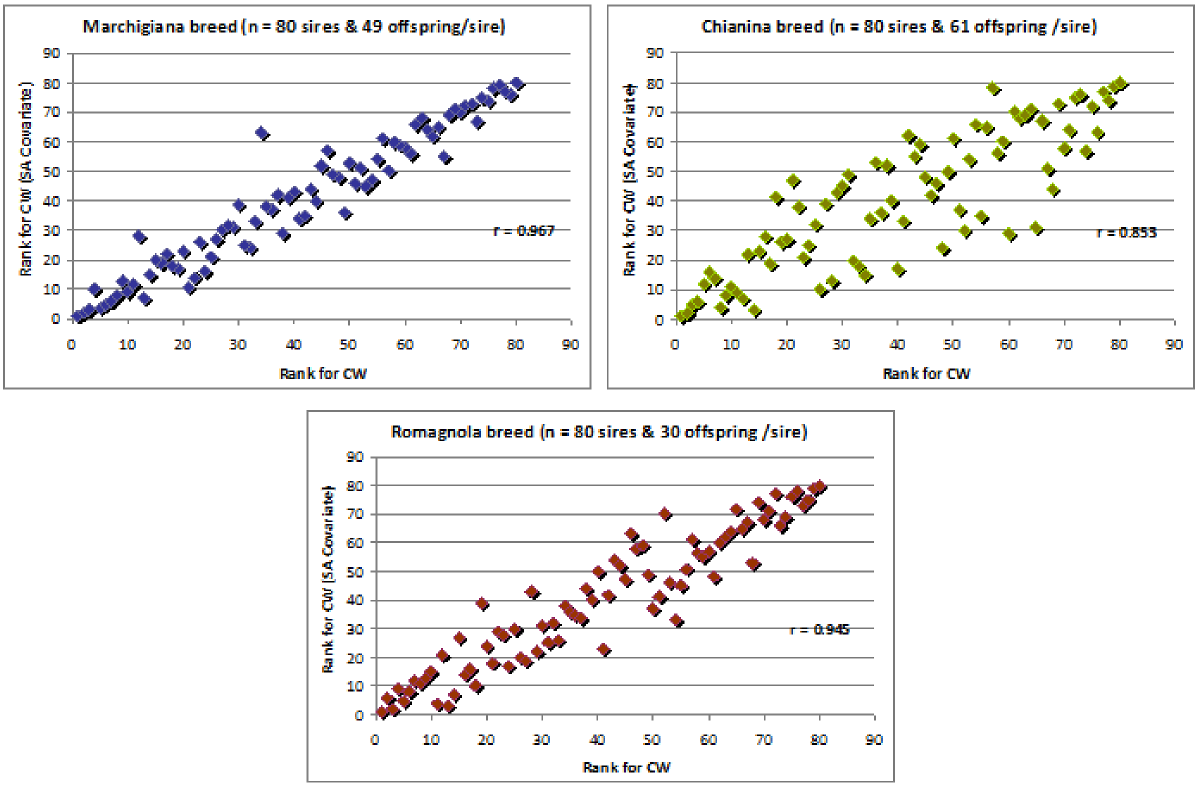
Table 3. Genetic and phenotypic standard deviation and heritability for Slaughter Age, Carcass Weight, Carcass Weight with Slaughter Age as covariate and Carcass Weight Gain (Single trait Reml) for Marchigiana, Chianina and Romagnola breeds.

	Marchigiana	Chianina	Romagnola
SA (d):			
s_A	27.4	23.2	29.5
s_E	36.6	37.6	37.5
h^2	0.36 (0.04)	0.28 (0.03)	0.38 (0.05)
CW:			
s_A	20.5	18.1	21.5
s_E	39.4	45.3	38.5
h^2	0.21 (0.03)	0.14 (0.02)	0.24 (0.04)
CW (SA as covariate):			
s_A	21.9	20.8	23.1
s_E	35.6	42.3	35.8
h^2	0.25 (0.04)	0.20 (0.02)	0.29 (0.04)
CWG (kg/d):			
s_A	0.048	0.043	0.047
s_E	0.062	0.071	0.056
h^2	0.37 (0.04)	0.27 (0.03)	0.41 (0.05)

Table 4. (Co)variances, genetic and phenotypic correlations for Slaughter Age and Carcass Weight for Marchigiana, Chianina and Romagnola breeds.

	Marchigiana		Chianina		Romagnola	
(co)variance	SA	CW	SA	CW	SA	CW
genetic	716.9	421.8	516.7	303.3	880.3	460.6
residual	1,372	1,552	1,432	2,072	1,398	1,482
r_A	-0.12 (0.10)		-0.28 (0.23)			-0.08 (0.13)
r_P	0.21 (0.13)		0.26 (0.09)			0.25 (0.13)

Figure 1. Rank correlation between EBV of Carcass Weigth and Carcass Weight adjusted with Slaughter age in Marchigiana, Chianina and Romagnola breeds.



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CHAPTER 4

HERITABILITY OF PERFORMANCE TEST TRAITS IN CHIANINA, MARCHIGIANA AND ROMAGNOLA BREEDS.

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4. HERITABILITY OF PERFORMANCE TEST TRAITS IN CHIANINA, MARCHIGIANA AND ROMAGNOLA BREEDS.

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ABSTRACT – Performance testing is the main method of selection used for Marchigiana, Chianina and Romagnola breed since 1985. The young bulls are tested in a common central station for 6 months period, starting from age of about 6 months. The bull selection index (BSI) that is used a selection criteria at the end of test, account for genetic index of both average daily gain (ADG) measured till weaning (PAGD) and ADG realized during the test (TADG). Other trait computed in BSI is fleshiness (FLESH) at the end of test. Data of 2422 young bulls (735 Marchigiana, 863 Chianina, 824 Romagnola) were used to estimate heritability of performance test traits. For PADG trait for breeds h^2 values estimates was from 0.02 to 0.20 while for PADG trait h^2 values was similar between breeds (from 0.28 to 0.34); for FLESH trait h^2 values resulted more variable between breed (from 0.19 to 0.55). Also simple correlation analysis was carried out on ranks between previous performance test indexes and global index (BSI) and the newest obtained with the heritability estimates. Correlation ranged from 0.71-0.95, indicating sometimes high rank changes.

Key words: performance test, heritability, Italian beef cattle.

4.1 INTRODUCTION

In spite of the long time since its introduction, performance testing of young bulls for beef characteristics still represents the main tool used for the genetic evaluation of beef and dual purpose cattle (Averdunk G. et al. 1988). It consists on verifying individual performance of young male along a tests period in which animals are kept under standard conditions in specially-designed control stations (Bittante et al., 1999). For Italian cattle breeds Marchigiana, (M), Chianina (C), and Romagnola (R), performance test is carried out at the Genetics Centre in San Martino in Colle (Perugia), where 4 batches/breed/year of the three breed are tested. A specific aspect of performance testing of M, C and R, not common in other test-stations, is that young bulls enter the genetic centre at about 5 month of age (Sbarra et al., 2009). For this reason, the bull selection index (BSI), used ad selection criteria at the end of test, account for genetic index of both average daily gain (ADG) till the beginning of test (i.e. mostly in the farm of origin - PAGD) and ADG realized during the test period at the genetic centre (from about 6 to 12 mo. of age - TADG). Indeed, previous studies (Mantovani et al., 1999) have indicated possible bias in BSI not accounting for PADG index due to compensative growth. BSI account also for a fleshiness genetic index (FLESH) evaluated by 3 classifier at the end of test (Mantovani et al., 1999). After years of selection based on BSI, this study has aimed to obtained new estimates of heritability for traits included in the BSI of M, C and R bulls on test station.

4.2 MATERIAL AND METHODS

Data of 2422 performance tested bulls born from 1988 and February 2006 were extracted from ANABIC data-base. Data regarded 735 Marchigiana bulls tested in 185 contemporary groups (G), 863 Chianina in 196 G, and 824 Romagnola in 194 G. As in a previous study (Mantovani et al., 1999), the herd of origin was reported for each tested bull and herds with single observation were grouped on the basis of a common rearing system. At the end of editing were counted 46 herds (H) for Marchigiana, 46 for Chianina and 36 for Romagnola. Traits included in the analysis were PADG (g/d), TADG obtained regressing weights on age (g/d) and mean FLESH evaluated at the end of test (points x 100). Data were preliminarily analysed by ANOVA (SAS, 1999) to identify the fixed non genetic factor to include in the model. For all traits and breed G and H resulted significant, but other factors not always affected significantly the traits. Therefore, at the end of the preliminary analysis common models were adopted for the three breeds, although different depending on the trait considered. Indeed, for all traits the model accounted for the fixed effects of G and H, but for PADG the parity (P) of the dam was also considered as fixed effect (4 classes: 1st parity, 2nd parity, 3rd-5th parity, and >5th parity), while for FLESH, the age (in days) at end of test was included as linear covariate. Single trait REML analysis (Misztal et al., 2002) was carried out including all available pedigree information (i.e., 3658 for M, 4829 for C and 3653 for R). Simple correlation analysis was carried out on ranks between previous performance test indexes and BSI and the newest obtained with the estimated heritability.

4.3 RESULTS AND CONCLUSIONS

Table 1 shown variance components estimates for three performance test trait in each breed. As regard PADG, the obtained estimates yielded generally low value of h^2, particularly in Marchigiana breed, where h^2 was equal to 0.02. This extremely low value could be influenced by data structure, since Marchigiana is mainly reared in very small farms accounting for only few animals. Indeed, almost all variability was not assigned to a genetic component in this breed, and residual variance was the highest among breeds. As regard the other two breeds, the h^2 estimates were a bit higher than for M, but still lower than h^2 value reported by Mantovani et al. (1999). As regard the TADG, heritability ranged from 0.28 to 0.34, depending on the breed, and also in this case lower than previous estimates, i.e., 0.28-0.56. The situation among breed has resulted more homogeneous in this case, due to the high controlled conditions of the test station, despite the different genetic structure of data: 4.2 sons/bulls sire for M, 3.2 for C and 3.9 for R. As regard to FLESH, h^2 resulted more variable between breed, with only the C breed that reached a value correspondent to the expectation. Probably, the lower variability on raw data among the other two breeds could have influenced the estimates obtained for M and R, that were quite different form those obtained in the previous study. Table 2 represents rank correlations related to indexes obtained with the new and older estimates of h^2. With the exception of PADG for M breed, in all situations changes were small, particularly in BSI that account for the three traits indexed after the test. However, correlations for BSI in C and R, in spite of the high value reached, indicate sometime wide changes in animal rankings for a quite large amount of animals.

Table 1. Variance component estimates for performance test traits in M, C and R breeds.

Item	Marchigiana	Chianina	Romagnola
Pre test ADG:			
- Genetic Variance	341.1	2,325.0	3,499.0
- Residual Variance	20,500.0	17,060.0	14,100.0
- Heritability	0.02	0.12	0.20
Test ADG:			
- Genetic Variance	6,925.0	8,446.0	5,891.0
- Residual Variance	17,150.0	16,050.0	15,413.0
- Heritability	0.29	0.34	0.28
Fleshiness at end of test:			
- Genetic Variance	1,266.0	1,577.0	437.7
- Residual Variance	2,048.0	1,297.0	1,829.0
- Heritability	0.38	0.55	0.19

Table 2. Rank correlations between previous and new indexes on performance test traits and BSI as results of latest heritability estimates.

Trait:	Marchigiana	Chianina	Romagnola
Pre test ADG	0.706	0.889	0.953
Test ADG	0.926	0.859	0.851
Fleshiness at end of test	0.907	0.811	0.778
Bull Selection Index	0.946	0.867	0.844

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CHAPTER 5

GENETICS PARAMETERS OF PERFORMANCE TESTED TRAITS IN MAREMMANA AND PODOLICA BREEDS

Abstract in submission at ASPA Congress 2011

5. GENETICS PARAMETERS OF PERFORMANCE TESTED TRAITS IN MAREMMANA AND PODOLICA BREEDS

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ABSTRACT – Performance testing is the main method of selection used for Maremmana and Podolica since 1996. The young bulls are tested in a common central station for a period of 6 months, starting from about 6 months of age. Data of 300 and 457 performance tested bulls of Maremmana and Podolica breeds respectively, born from 1996 to 2009 were extracted from ANABIC database and were used to estimate heritability of performance test selected traits: Average Daily Gain during test (TADG) and Morphological Score at the end of test (MORPH).

As regards TADG test, the obtained estimates of h^2 in Maremmana breed was 0.54, while in Podolica was equal to 0.32. The heritability of Morphological Score was 0.34 for Podolica and 0.46 for Maremmana. The study involved also Fleshiness (FLESH) that is assessed at the end of test using an assessment system with five linear classes (1 for low development to 5 for high development) on 8 different muscle regions. The h^2 for this trait resulted similar with TADG ; in fact the obtained estimates yielded a higher value of h^2 in Maremmana breed (0.49), while in Podolica it reached a value of 0.26. The information were used to estimate h^2 for TADG, MORPH and FLESH with bi-traits combinations. Heritability in this case ranged from 0.51 to 0.62 in Maremmana breed (higher than single trait estimates) and 0.28 to 0.38 in Podolica breed (equal to single trait).

The genetic correlations between the three traits in Maremmana breed were positive and strong ranging from 0.68 to 0.91. The Podolica breed has shown instead milder correlations (from -0.29 between TADG and MORPH to.0.53 between TADG and MORPH).

Keywords: Maremmana, Podolica, performance test, heritability.

5.1 INTRODUCTION

After the report of the EAAP working group in the 80's on performance testing for young bulls to be used in artificial insemination (AI) programs (Andersen B. et al., 1981), this method of evaluation has become the main selection tool for both dual purpose and beef cattle breeding programmes (Sbarra et al., 2009). It consists on verifying individual performance of young males along a test period in which animals are kept under standard conditions in specially-designed control stations (Bittante et al., 1999). Since 1961, ANABIC (Italian beef cattle breeds national association) has been operating for genetic improvement and promotion of the Italian Chianina, Marchigiana, Romagnola, Maremmana and Podolica beef cattle breeds, keeping the National Herdbook, doing genetic evaluations, and all else that is useful towards the promotion and spreading of these breeds (Guarcini, 2009). The selection plan for Chianina, Marchigiana and Romagnola revolves around the Performance Test carried out at Genetic Centres of ANABIC (Italian beef cattle breeds national association) in Perugia (Umbria) (Sbarra et al., 2009). In fact, the present selection scheme adopted for these breeds is based on the selection of bulls through a Performance Test trial that involve evaluation of average daily gain measured both from birth till the beginning of the test (about 6 months of age) and at the test station (from 6 up to 13 months of age) and the fleshiness evaluation made at the end of the performance test (Mantovani et al., 2005).

In the autumn of 1996 the Performance Test of young bulls began for Maremmana and Podolica breeds too. The performance test stations were seated in the territories of origin of the breeds: Grosseto (Tuscany) for Maremmana and Potenza (Basilicata) for Podolica (Forabosco, 2000). Maremmana and Podolica are rustic breeds and they have always been reared using summer grazing or open pasture system, with such system comprising 95-97% of the farms and animals (ANABIC, website 2010). The organisation of Performance test is the same of the other three Italian Cattle breeds: six months of duration with nine weightings at 21 days intervals and final linear evaluation. Because of the different type of environment and breeding system, the aim of Maremmana and Podolica selection plan is to increase productivity (TADG) while preserving the ability to be raised in tough conditions typical of their territories: MORPH, that includes fleshiness and other traits in its evaluation (see below), expresses this attribute of the breeds.

The beginning of performance test in controlled environments represented the opportunity to define the selection objectives for the five Italian beef cattle breeds (Migni, 2002).

The aim of this study is to ri-evaluate genetic parameters of Maremmana and Podolica Performance test traits after about fifteen years from the beginning of the activity.

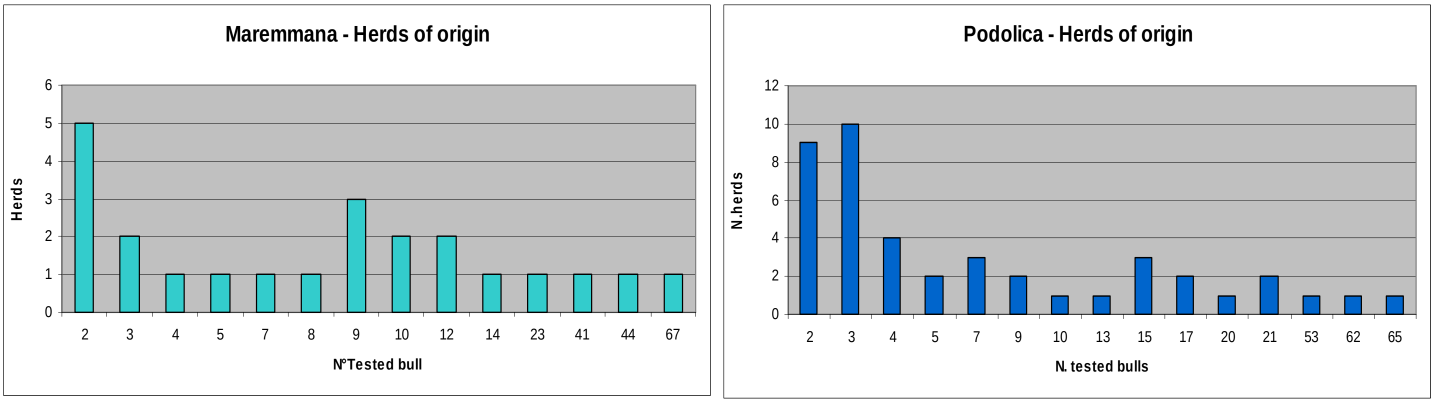
5.2 MATERIAL AND METHODS

Data of 300 Maremmana bulls and 457 Podolica bulls born from 1996 to 2009 were extracted from ANABIC database. At the end of editing were counted 23 herds of origin (H) for Maremmana and 43 for Podolica. Figure 1 represents the number of calves for each farm of origin.

Maremmana bulls were tested in 13 contemporary groups (G) and Podolica in 14 groups. Traits included in the analysis were Average Daily Gain (TADG) obtained regressing weights on age (g/d) utilising data from the 9 weights observed during the test, Fleshiness (FLESH) evaluated at the end of test and morphological score (MORPH).

Data were preliminarily analysed using ANOVA (SAS, 1999) to identify the fixed non genetic factor to include in the model. For both breeds and all traits, G and H resulted significant. At the end of the preliminary analysis common models were adopted for the two breeds: for all traits the model accounted for the fixed effects of G and H, while, for FLESH and MORPH, the age (in days) at the end of test was also included as linear covariate. Single trait REML analysis (Misztal et al., 2002) was carried out including all available pedigree information furnished by ANABIC: 1,959 animals for Maremmana breed and 2,251 for Podolica breed. Bi-trait GIBBS analysis and genetic correlations between considered traits were carried out (Misztal, 2008).

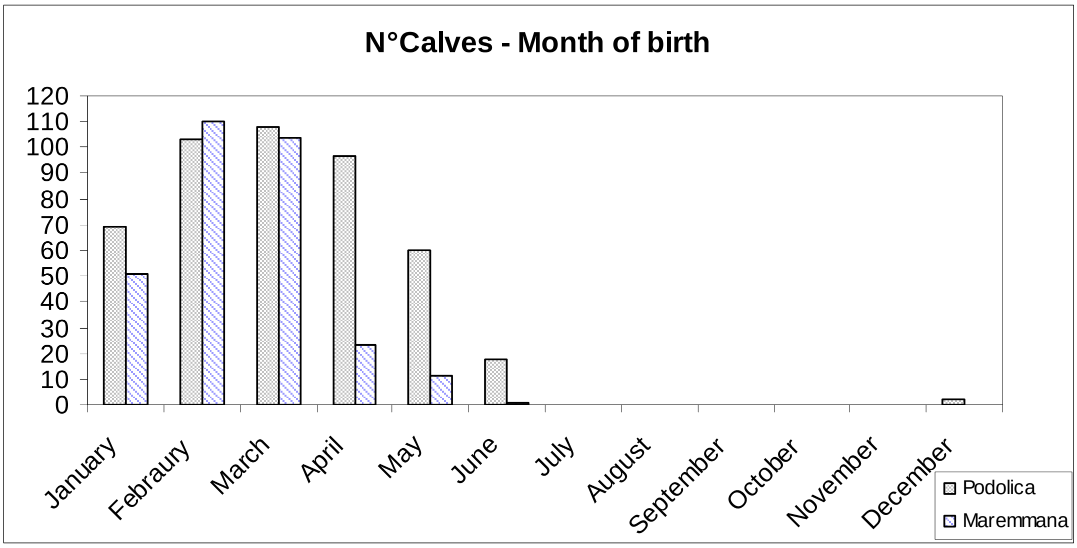
Figure 1. Distribution of tested bulls (n) and herds provenience.



5.3 RESULTS AND CONCLUSIONS

In both Test Station, the entrance of bulls is made once per year (one group) because of seasonality of calving (births from January to June), typical of these breeds (Figure 2). The animals are not brought in a monthly basis (as is the case for Marchigiana, Chianina and Romagnola breeds), but all at once in November.

Figure 2. Distribution of calves on birth months during the year.



In table 1 descriptive statistics of information recorded during the Performance Test are summarised. The mean age and weight at beginning of the test is about 300 days and 322 kg for Maremmana breed and 286 days and 242,3 kg for Podolica. The bulls of both breeds at the end of Performance test were at an age between 12 to 19 months (depending on age of entrance), Maremmana bulls with a mean age of 473 days and a mean weight of about 550 kg; the mean TADG was about 1,377 g ranging from 0.719 to 1,921 g. Podolica young bulls have reported similar values for TADG, despite the average weight at the beginning of the test that was about 90 kg lower than Maremmana calves.

Figures 3 and 4 represent the number of calves per sire and per performance tested sire; in Maremmana breed about 45% of sires (51 of 115) have only one tested calf and about 50% of calves have a performance tested sire (41 tested sires in total). In Podolica breed about 30% of sires have 1 tested calf (32 of 110 sires in total) and about 43% of calves have a tested sire (41 tested sires in total) .

The low number of calves per sire is due to the fact that in these breeds artificial insemination is unused so bulls have a limited number of sons (Figure 3).

Table 1. Descriptive statistics of Maremmana and Podolica young tested bulls.

	MAREMMANA					PODOLICA				
Variables	Obs	Mean	St[(a)]	Min	Max	obs	Mean	St[(a)]	Min	max
Age start test (d)	300	306.7	38.0	202.0	423.0	457	286.4	44.2	176.0	414.0
Weight start test (kg)	300	322.1	57.3	177.3	468.3	457	242.3	59.7	107.5	464.5
Age end test (d)	300	473.0	38.02	369.0	591.0	457	447.6	43.28	330.0	582.0
Weight end test (kg)	300	549.4	65.18	374.5	719.5	457	443.7	63.38	278.0	680.5
TADG (g)	300	1,377.2	190.52	719.0	1,921.0	457	1,259.1	150.19	820.0	1,700.0
Fleshiness	300	3.54	0.73	1.87	5.0	457	3.35	0.69	1.32	5.00
Morphological scores	300	82.9	2.37	77.7	88.0	457	81.9	2.13	75.0	88.0

[(a)] *Standard Deviation*

Figure 3. Maremmana breed: Number of calves per bull and per tested bull.

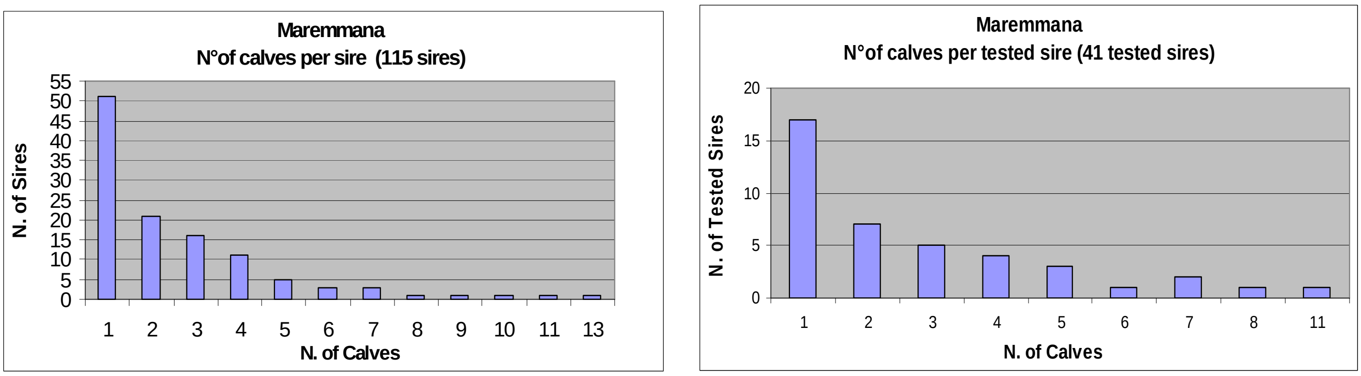


Figure 4. Podolica breed: Number of calves per bull and per tested bull.

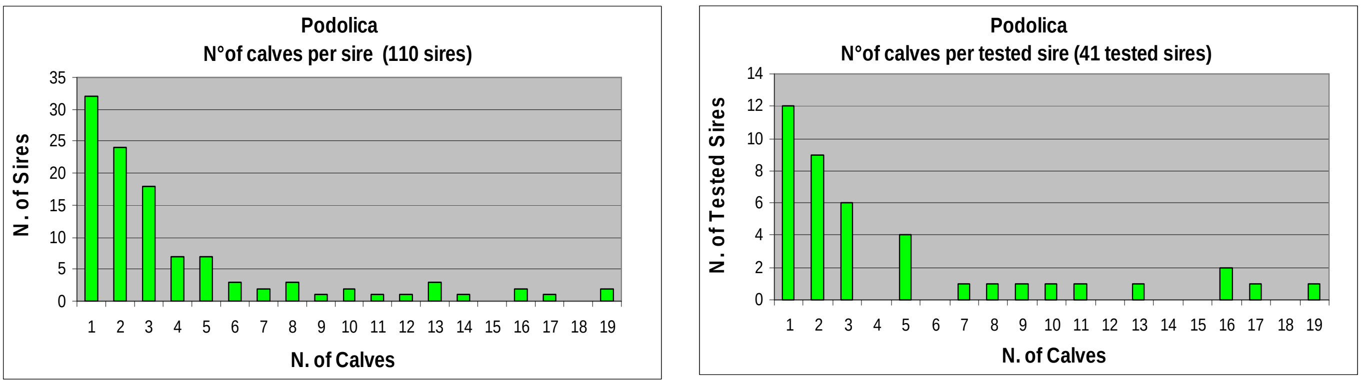


Table 2 shows variance components estimates for the three performance test traits of each breed calculated using single traits. As regard TADG, the obtained estimates yielded a higher value of h^2 in Maremmana breed (0.53), while in Podolica h^2 was equal to 0.32. The heritability of MORPH was 0.34 for Podolica and 0.46 for Maremmana. For FLESH the obtained estimates yielded a higher value of h^2 in Maremmana breed (0.49), while in Podolica h^2 was 0.26.

Table 2. Variance component estimates for performance test traits in Maremmana and Podolica breeds (single trait).

Item	Maremmana	Podolica
TADG		
- Genetic Variance	15,070.00	4,596.00
- Residual Variance	12,990.00	9,801.00
- Heritability	0.54	0.32
MORPH		
- Genetic Variance	2.24	1.40
- Residual Variance	2.65	2.70
- Heritability	0.46	0.34
FLESH		
- Genetic Variance	0.19	0.09
- Residual Variance	0.20	0.26
- Heritability	0.49	0.26

Table 3 represents the results of heritability for the three traits with bi-traits combination, considering the traits two by two and genetic and phenotypic correlations among considered traits. These heritability ranged from 0.51 to 0.62 in Maremmana breed, a bit higher than in single trait estimates, and from 0.28 to 0.38 in Podolica equal to single trait.

In Maremmana breed estimated genetic correlations between TADG and other traits of Performance Test ranged from 0.67 to 0.75 while genetic correlations between FLESH and MORPH were very high (0.91) because Fleshiness is a part of total Morphological scores in linear assessment. Phenotypic correlations among three traits ranged from 0.36 to 0.72. In Podolica breed TADG with other traits has shown milder genetic correlations (-0.29 to 0.21); estimated genetic correlations between FLESH and MORPH was 0.53. Also phenotypic correlations in this breed were lower than Maremmana ranging from 0.13 to 0.59.

The negative correlation between TADG and MORPH and the lower correlation between MORPH and FLESH is probably due to the fact that Podolica breed has a higher phenotypic variability in the tested calves. This particularity of the breed causes the phenotypic value of MORPH to be strongly affected by the other components of linear assessment (breed traits – in a very important way, body size, structure, legs, fineness and reproductive traits).

Table 3. Heritability estimates, Genetic (above diagonal) and Phenotypic correlations (below diagonal) for performance test traits in Maremmana and Podolica bulls.

Trait:	Maremmana			Podolica		
	TADG	MORPH	FLESH	TADG	MORPH	FLESH
TADG	**0.62**	0.68	0.75	**0.28**	-0.29	0,21
MORPH	0.37	**0.51**	0.91	0.17	**0.38**	0.53
FLESH	0.42	0.72	**0.57**	0.13	0.59	**0.31**

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CHAPTER 6

GENERAL CONCLUSIONS

GENERAL CONCLUSIONS

This thesis have treated various topics regarding the five Italian beef cattle breeds managed in as a single herd book by ANABIC (i.e., Marchigiana, Chianina, Romagnola, Maremmana and Podolica).

The Performance testing, as method of evaluation, has become the main selection tool for both dual purpose and beef cattle breeding programmes. The growth ability, considering the average daily gain during the test, and fleshiness are objectives of selection in almost all Italian cattle breeds. The most important goal is to make more efficient the selection plan through a quick and focused semen distribution in population of tested bulls. This gives an increase of selection pressure and the decrease of generation interval, allowing a sped up of the genetic progress. In literature there are no more information about performance test in Italy and other countries, in spite of the fact that it is the main tool for selection of young candidate bulls.

For this reason, in the second chapter of the thesis, a review of the present Italian situation especially regarding the specific activity on performance testing of young bulls across National Cattle Breeders Association have been carried out. The results of the survey here reported have the final aim of exploiting actual organization of selection processes carried out in Italy for beef, dual purpose and dairy cattle breeds through performance test. The most relevant differences discovered among breeds is the age at the entrance at the genetic centres, that resulted greater for beef and dairy breeds (7 months on average) as respect to the Piemontese and other dual purpose breeds, that had a mean age at entrance at the test station of 30 d. Another main difference among breeds is the number of groups tested yearly, with monthly entrance for the most popular beef breeds, while the smaller breeds (i.e., rustic breeds and autochthons dual purpose breeds) are conditioned by seasonal calving and therefore by a lower number of groups (1 to 6). For beef breeds the bull's owner remains the farmer (except for the Piemontese breed where NCBA owns some bulls), while for dual purpose breeds the owner is always the NCBA. On the other hand, breeding companies own all tested bulls belonging to dairy breeds. About genetic evaluation, for all beef and dual purpose cattle the most important selection criterions are growth traits and in vivo fleshiness evaluation at the end of test.

The use of slaughter data, however, could be a useful integration of performance data for speeding up genetic progress in Italian beef cattle breeds. The meat quality traits have a strategic importance and could be a useful supplement to the actual quantitative genetics selection methods based on performance test at station. Therefore, In chapter three, the results of slaughter data in Marchigiana, Chianina and Romagnola were considered and analysed. Results obtained confirms the greater growth capacity of the Chianina breed as compare to the other breeds, resembling results obtained during the performance test at the central station of

ANABIC. The slaughter age shows a good heritability in all the breeds analyzed, meaning that age at slaughter is not only an environmental factor but it is influenced by genetics. The phenotypic correlations between carcass weight and slaughter age were moderate and positive for all breeds, but the genetic correlations were low and negative. This means that animals with a greater breeding value for carcass weight tended to be slaughtered earlier than animals with the lower genetic value for this trait. The choice of the right moment for slaughtering of animals is a complex decision pertaining to farmer and is strongly influenced by market characteristics and seasonality.

After years of selection based on Bull Selection Index (BSI) in all five Italian cattle breeds of ANABIC, a study (chapter four and five) aimed to obtain new estimates of heritability for traits included in the BSI bulls on test station was conducted. The update of heritability values on performance testing of the three main breeds allows a more efficient selection of all Italian beef cattle breeds, particularly for the two rustic breeds that had new heritability values estimated for the first time considering a sufficiently great dataset.

In an overall overview of selection methods in beef cattle, however, the functional traits are not yet included in specific breeding programs. The only exception is the Piemontese breed, for which calving traits are considered. However, longevity and fertility have great economic impact and should be studied and implemented in appropriate selection plan.

In view of this, the ANABIC is studying new traits related to morphology and longevity as a criterion for the selection of bull dams. A further improvement could be the systematic use of slaughter data to obtain breeding values of bull sires also from field data rather than from performance test station only.

Other functional trait under evaluation to be used in selection programmes is the mothering ability, aiming to select females on the basis of their ability to bring the calf to the weaning phase autonomously and at the greatest as possible body weight. It is thus an indicator of the production of the milk necessary for this function. This indicator, considering the evolution of the type of breeding farm that is increasingly oriented toward open pasture or summer grazing systems, becomes extremely important in the herd management politics.

At the same time, however, it is important to ensure the maintenance of biodiversity providing a high level of genetic variability. In regard to this, possible optimization of reproduction within the selection schedule of ANABIC breeds should be probably taken into account.

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