Emergence and Selection

of

the Belgian Blue Breed

Prof. R. HANSET
University of Liege
Belgian Blue Herd-Book
Rue des Champs Elysées, 4
B-5590 CINEY

In honour of the Danish B.B. Herd-Book at the occasion of its 25th anniversary

"Man's power of accumulative selection;
nature gives successive variations : man adds them
up in certain directions useful to him."

Charles DARWIN (1859)
(On the Origin of
Species by Natural Selection)

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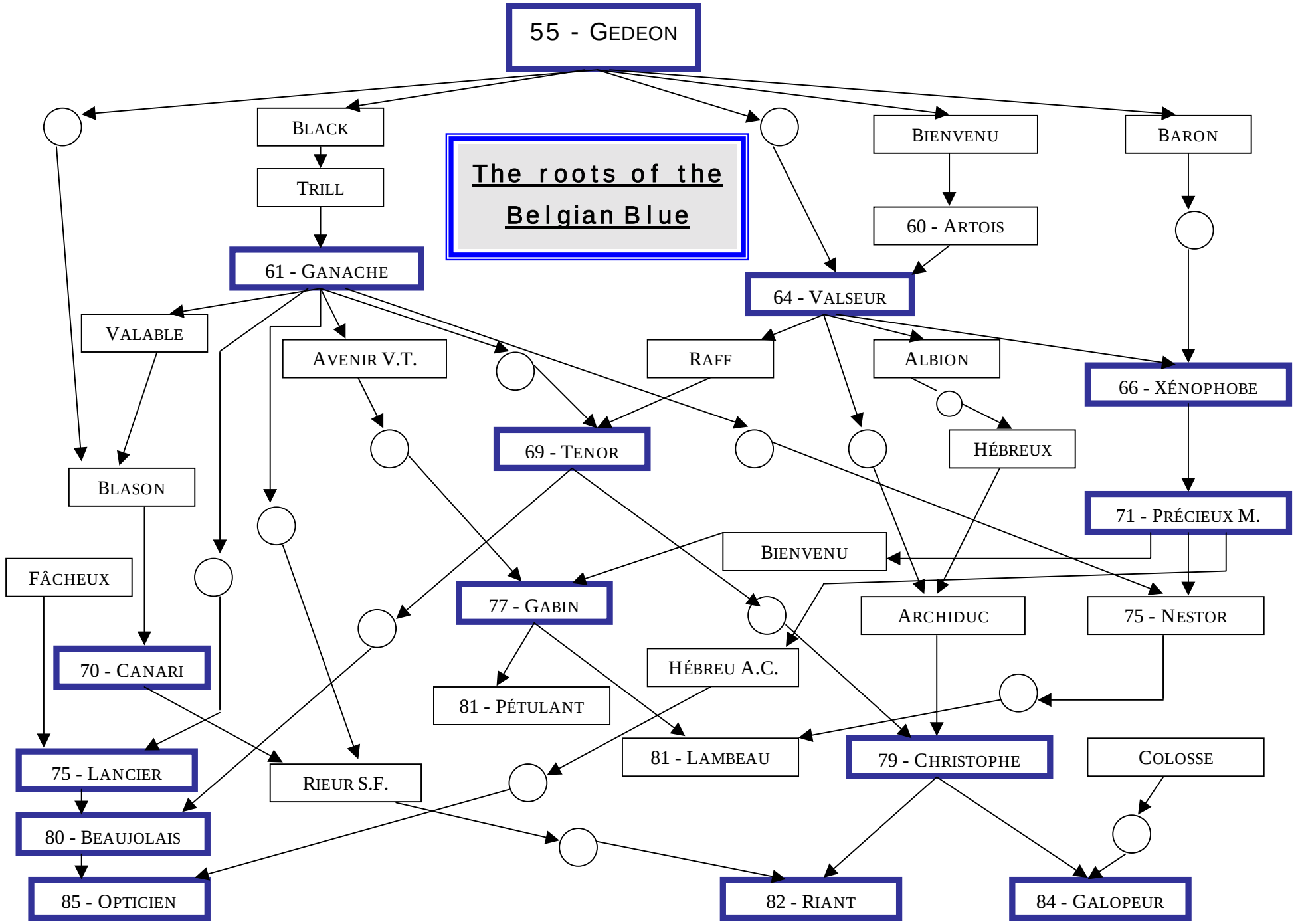
▪ Introduction

A new breed is the outcome of a complex phenomenon with biological, economical and psycho-sociological aspects. The Belgian Blue is no exception to the rule.
Originally, the Belgian Cattle population was characterized by the presence, besides dairy breeds like the Black and White and the Red and White, of dual-purpose breeds : the Red of West Flanders, the White-Red of East Flanders, the White-Blue of Central and High Belgium.

Since the 50's, the price scale for beef cattle became wider and included very attractive prices for animals of extreme conformation (double-muscled – DM). Some butchers specialized in the cutting-up of the carcasses of such animals, the latter being still very few at the start and born sporadically, mainly from White and Blue parents of normal conformation (recessivity).
The caesarean section was introduced at that time and allowed the proper delivery of living DM calves.
The meat trade cheered as these animals fulfilled the butcher's dream of a carcass with an exceptional yield of lean and tender cuts.
Following this market's appeal, strong debates arose among breeders concerning :
1.- the future orientation of the breed
2.- the respective roles of the state-administration and of the breeders in the decision's taking.

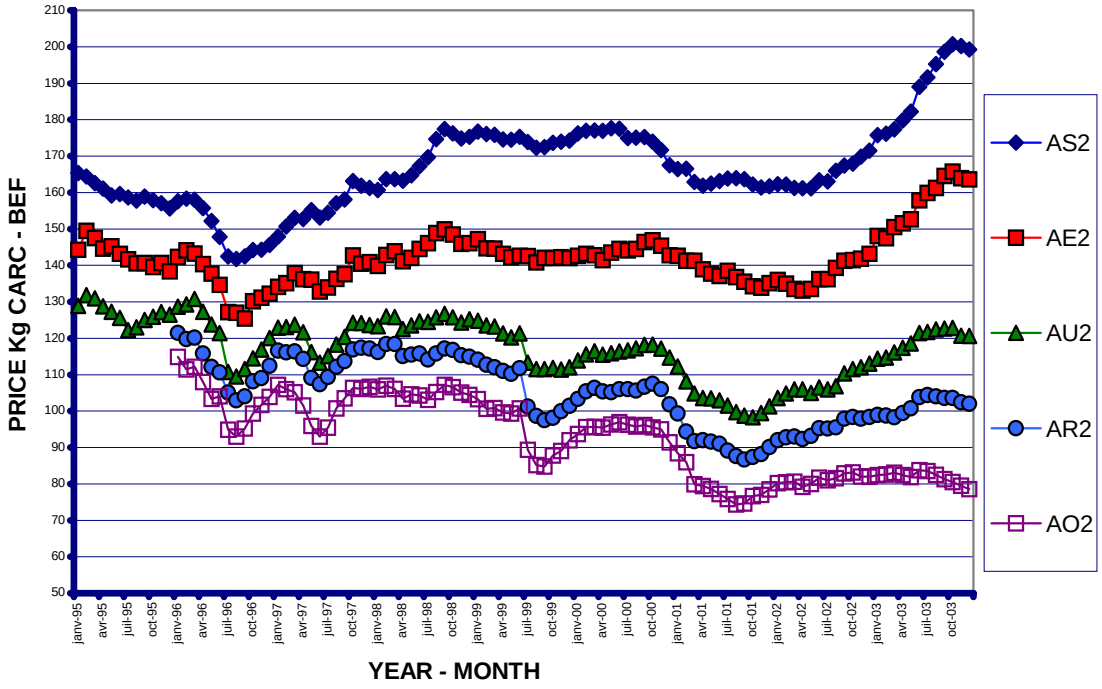
But the facts didn't wait. Some breeders of the White-Blue of Central and High Belgium, followed afterwards by more and more breeders, responded to the incentives of the market and gave preference to better muscled breeding animals (probably heterozygous – see below) (e.g. : Gédéon, a founding father born in 1955) and the frequency of DM calves increased. During the 60's, DM bulls (homozygous – see below) entered A.I. (e.g.: Ganache 1964, grand grandson of Gédéon), with as a consequence a further increase of the frequency of DM calves. Soon after, females with rounded shapes were also used for breeding and the fixation (homozygosity) of the "meaty type" made rapid progress within top breeding herds.
But the controversy was not yet appeased and, in 1969, it was still recommended to exclude the extreme animals from reproduction and to maintain the option of a dual-purpose breed.
But the facts were running faster than the rules. Full responsibility was granted to the breeders. Innovation ensues from freedom to act.


55 - GEDEON
The roots of the Belgian Blue
BLACK
TRILL
61 - GANACHE
BIENVENU
60 - ARTOIS
64 - VALSEUR
BARON
VALABLE
AVENIR V.T.
RAFF
ALBION
66 - XÉNOPHOBE
69 - TENOR
HÉBREUX
BLASON
71 - PRÉCIEUX M.
BIENVENU
FÂCHEUX
77 - GABIN
ARCHIDUC
75 - NESTOR
70 - CANARI
HÉBREU A.C.
81 - PÉTULANT
75 - LANCIER
RIEUR S.F.
81 - LAMBEAU
79 - CHRISTOPHE
COLOSSE
80 - BEAUJOLAIS
85 - OPTICIEN
82 - RIANT
84 - GALOPEUR

In 1973, to indicate that the breed had acquired a distinct phenotype and for a lot of breeders was no longer a dual-purpose breed, the milked cows becoming suckling cows, the breed was renamed "*Blanc-Bleu Belge*" and a national Herd-Book society, the present-day "*Herd-Book de la race Blanc-Bleu Belge*" was established and in charge of the definition of the selection goals, of the selection criteria and responsible for the genetic management of the breed. It was immediately decided to divide the B.B.B. breed into two branches with distinct selection goals : "the meaty type" (without anymore requirement regarding milk yield) and "the dual purpose type" that imposed milk recording as in the original breed. Of these two branches, the meaty one was by far the most important. Meanwhile, in the meaty type, caesarean section became generalized and is now performed systematically at an early stage of the parturition which brings minimum stress to the dam and to the foetus as attested by the low perinatal mortality. In this way, was removed the problem of difficult calving associated with double-muscling. In Belgium, caesarean doesn't raise any ethical question. Any outside coercive measure aimed at reducing its incidence would be opposed by the breeders because this couldn't go without jeopardizing the specificities of the breed and the welfare of the dam and her calf. In addition, it would go against the principle of subsidiarity asserted in the "Protocol on the protection and welfare of the animals" of the Treaty of Amsterdam.
In our country, the Belgian Blue of the meaty type overshadows the other breeds (50 % of the cattle population) and gives its stamp to the Belgian beef industry. The B.B. contributes 65 % of the total beef production and 75 % of the red meat. It is the reverse in the E.U. where 2/3 of beef come from the dairy herd. Moreover, 68 % of young cattle fall in the S and E classes (of the European classification system) (1,2 % in Denmark, 5,1 % in France) while in the other E.U. countries, the majority belongs to the U, R and O classes.

As fifty years ago, the price differential in favour of the meaty type is still present, as shown in Fig. 1, in spite of market's fluctuations due for instance to the successive crises: BSE, dioxine, FMD (1 € = 40,3399 BEF). The carcasses of the S and E classes are typical of the Belgian Blue. The cutting system, at the beginning, a speciality of a few butchers was taught in the training schools for butchers and was taken up by the hypermarkets whose beef supplies consist mainly of B.B. carcasses. In addition, it appeared that the productivity of the work required for cutting and meat preparation was definitely higher for an heavy carcass (500 Kg) of the S class.

Figure 1 : PRICE per Kg CARCASS - MALES - SEUROP SCALE



▪ Genetics of the Belgian Blue

In Belgium, cattle registration and selection started at the end of the 19th century from an heterogeneous population, a mixture largely influenced by black and white, red and white and Shorthorn blood. The Shorthorn breed carried the roan gene (R+) and produced the blue phenotype when crossed with black cattle (EE). The White-Blue breed of Central and High Belgium emerged slowly from this blend while discarding the propensity inherited form the Shorthorn ancestor to lay down an excess of fat.

The present-day B.B.B. has retained from the ancestral breeds : early maturity, quiet temperament and the colour polymorphism of the Shorthorn (white, roan, red) but with a black background instead of the red one of the Shorthorn (R^+R^+EE = white; R^+rEE = blue; rrEE = black).

There was enough genetic variation within the breed of Central and High Belgium to allow the transformation of that dual-purpose breed into this hyper-muscled breed known for its exceptionally high killing-out percentage, lean / fat and lean / bone ratios, proportion of 1st quality and tender cuts.

In 1985, it was definitely demonstrated that the B.B. was homozygous for a major gene of muscular hypertrophy (the mh gene, partially recessive). Based on this knowledge, a pedigree was constructed in such a way that the segregation of the two specific genes : R^+ and mh could be followed.

Co-segregation studies involving 213 DNA markers were carried out by Professor Georges and his team in our University. It was shown that the mh gene was located on chromosome 2 and the R^+ gene on chromosome 5 of the bovine genome (Charlier 1995-1996).

In 1997, the same research team discovered that the double-muscled phenotype in the B.B. was due to the homozygosity for a deletion (11 base pairs – del 11) in the gene encoding myostatin (MSTN), a protein that regulates the multiplication of myoblasts (Grobet).
This remarkable scientific breakthrough occurred twenty years after our breeders had unknowingly achieved the fixation of the mh gene as a result of their selection on muscular development. It is known that, when selecting for a quantitative trait determined by several genes, the gene with the largest effect will be fixed in the first place.
But, for our breeders, that fixation was not the end of the story. In fact, selection didn't stop, not even slow down and the genetic improvement of muscular development continued (see below the genetic trends).
Other genes, besides the mh gene, are thus involved. They are still unknown in number, location and function.
The B.B. is more than simply a double-muscled.
Summing-up, the genetic components of the B.B. are :

- the original gene pool (with the R^+ gene)
- the gene pair mh/mh
- the other genes accumulated during the recent selection and acting on muscular development in the presence of the mh/mh pair.

Any animal resulting from a single cross with a B.B. parent will inherit a sample half of these genes.

The dual-purpose type

A few breeders (25-30 against 2500/3000 for the meaty type) didn't take the bend and went on breeding the old dual-purpose type (now considered as a protected breed). This small population of about 2000 cows reminds of the Central and High Belgium breed of the 50/60's. Analyses at the DNA level showed that the three genotypes at the MH locus were still present : +/+; mh/+ and mh/mh, the latter with the mildest expression of the double-muscled condition.

▪ Selection of the Belgian Blue

The selection of the B.B.B. went off within a classical pedigree breeding scheme. Belgium has a long tradition of pedigree breeding with shows and contests organized at the regional, provincial and national levels. Such a system fits well the selection of the B.B.B..
The main selection criteria are visible and relatively heritable traits expressed in both sexes, at an early age.
In this case, the phenotype is indicative of the genotype. Moreover, high selection intensity and short generation intervals are inherent advantages of phenotypic selection. An animal bred for beef displays the amount of meat he will supply. It is particularly true for the meat yield expected from a B.B. animal compared to subjects of other breeds.
In these conditions, visual assessment (phenotype) plays an essential role.
I don't know of any successful breeder who wouldn't have a gift for the observation and the memorization of the morphological characteristics of bulls and cows. In this context, the bulls enjoy a great visibility and good opportunity for commercial transactions (individual breeders, A.I. organizations).
The new crop of yearling bulls, registered at birth and born from Herd-Book parents is exhibited and submitted to ranking within age classes at the occasion of well attended provincial "shows-markets" held each year in January. Afterwards, during spring, the official inspections of young bulls (with parentage testing) leading to the admission to the Herd-Book are organized with the support of the state throughout the country.

Ranks and categories are assigned. The selection criteria are muscular and skeletal conformation, height of withers, leg soundness, locomotion, absence of mouth defects.
About 1.000 bulls enter the Herd-Book at these occasions but 24.000 were registered at birth.

Concerning the females,36.000 calves are registered at birth and 30.000 are admitted to the Herd-Book (from the age of 10 months) after inspections carried out on the farms during the winter period.

Artificial Insemination

About 63 % of the registered births are from A.I. (males : 67,8 %; females : 60,62 %), an exceptionally high level for a beef breed. Very soon, our breeders discovered the genetic potential of A.I. which became well integrated into their way of doing. The same applied to E.T., a few years later.
Since the 50's, A.I. is the main vector of genetic improvement. The A.I. organizations have their own committee of top breeders in charge of buying new bulls (on the farms, at the shows, at the auctions of the Performance Testing Station). The bulls selected have the best pedigree and a superior phenotype. There is no restriction of use and no waiting period.
Most of these young bulls are sons of the most popular A.I. sires. There is no special planning regarding the number of young bulls and the number of sires to breed bulls. 74 bulls born in the year 2000 entered A.I.. They were the sons of 33 sires (S), themselves sons of 18 sires of sires (SS), themselves sons of 16 SSS which were sons of 12 SSSS.
As the contributions of the sires, of the SS, ... were unequal, the "statistically efficient" numbers of S, SS, ... were respectively : 16,5 S instead of 33; 8,12 SS instead of 18; 5,68 SSS instead of 16 and 3,41 SSSS instead of 12.
Such a concentration on very few ancestors led necessarily to inbreeding, the inevitable corollary of selection. The average level of inbreeding of the A.I. bulls born in 2002 is about 4 %.

Performance Recording

Performance recording was encouraged and financially supported by the State. The criteria are defined and periodically adapted by the Herd-Book.
The technicians in charge of performance recording belong to the inter-provincial associations (A.W.E. for Walloony and V.R.V. for Flanders). They are "authorized" by the Herd-Book and under its supervision.

Performance Testing in Stations

Performance recording started in 1973 with the opening of the Testing Station of Ciney. A second Station opened in Ath in 1993.
227 bulls finished the test in 2002. Their dams have to fulfil minimum requirements concerning age at calving and linear scores (height, muscling, meaty type, leg soundness, general appearance). Their sires are either A.I. bulls of the 1st category (qualification obtained after the special inspection of the A.I. bulls carried out by the Herd-Book) or

private bulls of the 1st category (assigned at the time of the official inspections).
The traits recorded at the testing stations are : weight at 7 months (beginning of the test period) and at 13 months (end of the test), height, price per Kg liveweight, feed consumption, scrotal circumference, linear scores.
At the end of the test, a category is assigned to each bull :

- admitted to the auction (61,7 % in 2002) ;
- only admitted to the Herd-Book (16,8 %) ;
- discarded (21,6 %).

Of the 140 bulls admitted to the auctions, 10 were bought by Belgian A.I. organizations and 20 by foreign A.I. centres.

Progeny-Test on the farm

Progeny-test on the farm of A.I. bulls started in 1978. The progeny of the A.I. bulls are inspected at birth and at 14 months.
The number of inspections at birth in 2001 was : 45.937 (45,8 % males; 54,2 females) – 76,4 % of the calves were born in pedigree herds and 23,6 % in non-pedigree herds.
For the animals inspected at 14 months, 15.648 were born in 2001 (17,8 % males; 82,2 % females). 82,5 % were born in pedigree herds and 17,5 % in non-pedigree herds.

The traits recorded are :

at birth	→	birth weight (estimate), gestation length, conformation score, leg and mouth defects, ability to drink, vitality, mortality.
at 14 months	→	height, weight (estimated from the heart girth), price for Kg liveweight, leg and mouth defects, mortality.

Linear Scores

A special linear scoring system was developed for the B.B.. It was introduced on a limited scale in 1988 and then extended, since 1994, to all the registered cows (age : 15 to 56 months).
Bulls are also scored at the occasion of the official inspections, in stations, in A.I. centres and occasionally on the farm.
25 characteristics are scored. (the height is measured)
Some cows are scored several times since all the herd is scored. About 34.000 cows are classified each year.
The number of scored cows per year of birth is constant at about 22.000 (period 1995 to 2000). These cows are born from A.I. or from natural service. 7 well-trained classifiers perform this work.

▪ Sire Evaluations

The data collected on a regional basis (A.W.E. and V.R.V.) are centralized at the Herd-Book where the genetic analyses and the sire evaluations are performed on a national basis.
This centralization at the Herd-Book means : proximity of the breeders, permanent exchanges between theory and practice, immediate availability to the board of the information required for the genetic management of the breed, a better chance of a profitable coexistence between the "empirical" approach and the "numerical approach".
Contrary to the situation prevailing in the dairy world, it is difficult to sell a beef bull or its semen only on the basis of figures which moreover are coming late or aren't available at the right moment.
A.I. organizations can not do without setting up the A.I. bulls' presentations which attract thousands of breeders.
In fact, the two approaches complement each other. Not all traits are visible and sufficiently heritable. This is particularly true for functional and fitness traits whose importance increases into highly selected breeds.
All traits recorded lead to sire evaluations obtained by the classical methodology of mixed model equations (BLUP estimates – EBVs).
These genetic evaluations and their precision (r^2) are published by the Herd-Book at regular intervals :

- birth trait : twice a year,
- traits at 14 months, linear scores, traits recorded at the testing stations : once per year.

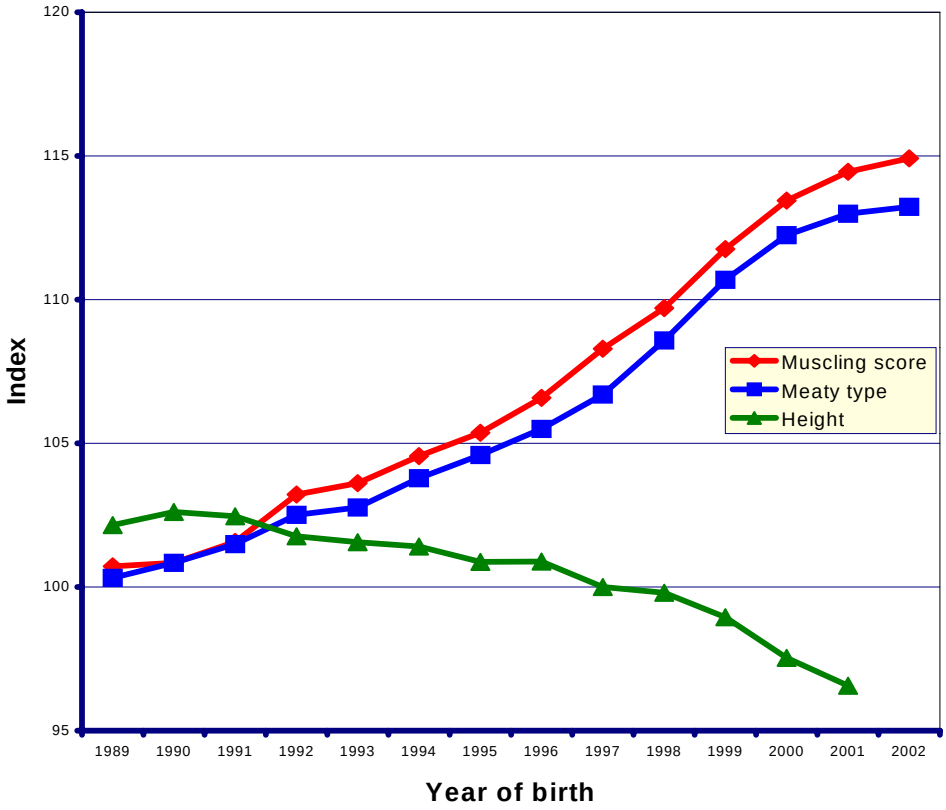
Over-information and large amounts of figures can become unappealing to the breeders. Special efforts are made to synthesize the numerous genetic evaluations and to give of them a more attractive presentation.

▪ Genetic Trends

The efficiency of a system is judged on its results.
The genetic trends give the answer.
A genetic trend represents the change, year of birth after year of birth, of the average genetic level for the trait considered and is a by-product of the genetic evaluations.
Such trends (period 1989 – 2002) are shown for some morphological traits of B.B. cows.
The genetic levels are computed from standardized EBVs.

Fig. 2 illustrates the continuous improvement of two synthetic scores : "muscling score" and "meaty type" and the decrease of the height (antagonistic traits).

Figure 2 : MUSCLING - MEATY TYPE - HEIGHT - GENETIC TRENDS - COWS



The changes of the individual components of the muscling score (muscling of the shoulder, of the top, of the thighs – side and rear view) are illustrated in Fig. 3 and in Fig. 4 the changes of the individual components of the "meaty type" (pelvis width, rib shape, chest width, rump (slope), tail set, pelvis length, body length).

Fig. 3 shows some decrease of the rate of improvement in muscular development during the last two years, more so for the top.

Seven skeletal traits are considered in Fig. 4.

An S-shape curve, similar to that of Fig. 3, is found for pelvis width, rib shape (rounder), chest width. Rump slope and tail set exhibit a moderate improvement while pelvis and body lengths show a slight decrease.

Summing-up, these curves demonstrate a significant response to selection for better muscling and skeletal width (better carcass quality) and negative correlated responses for height and length traits (body and pelvis length).

Obviously, the genetic trend is a useful management's tool. It is highly appreciated by the breeders. It indicates unequivocally the orientation taken by the breed and the possible corrections.

Figure 3 : MUSCULAR DEVELOPMENT - GENETIC TRENDS - COWS

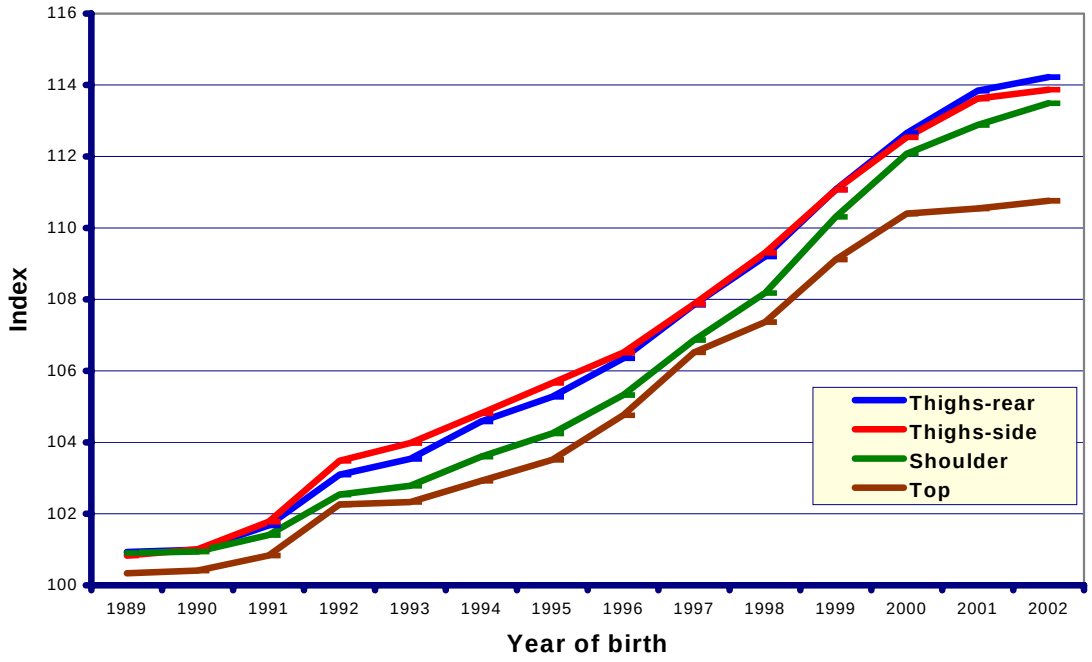
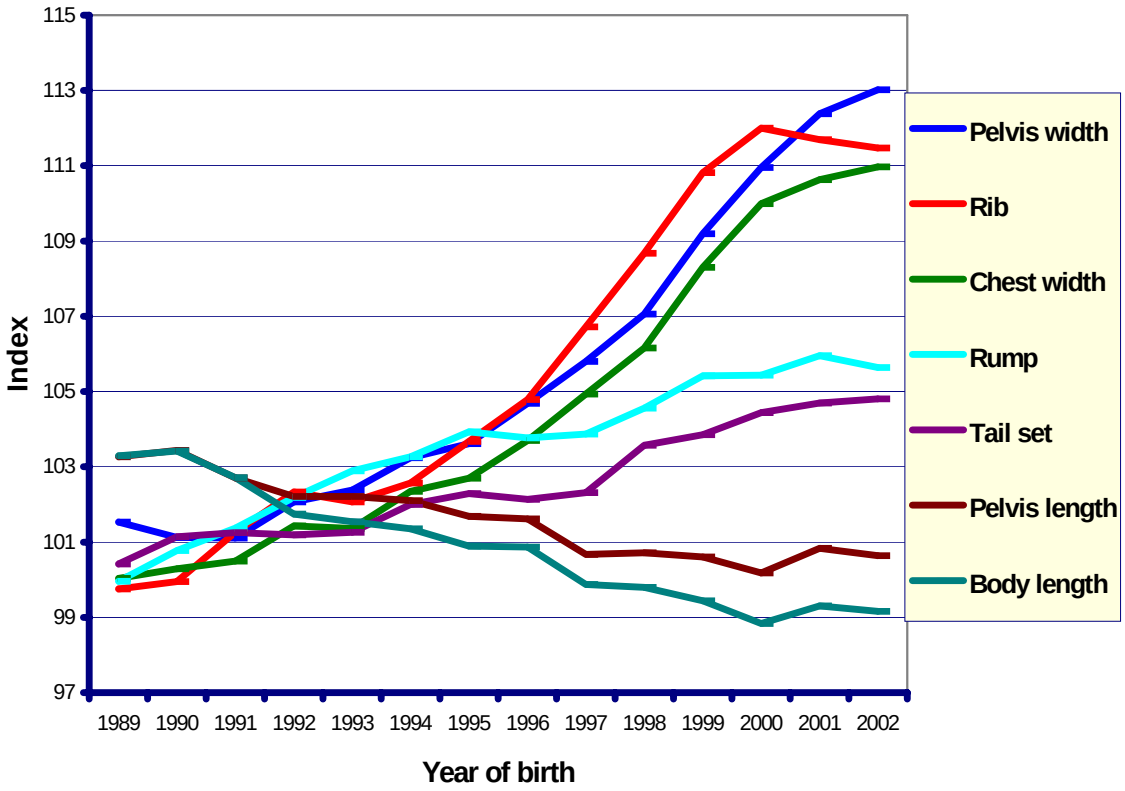


Figure 4 : SKELETAL CONFORMATION - GENETIC TRENDS - COWS



▪ The Belgian Blue bull as terminal sire

In a crossbred animal, one expects an improvement of the body composition compared to that of the maternal breed which is bred for its own characteristics : milk yield (e.g. : Holstein) or adaptation to a particular production system : ranching, extensivity, arid zones, tropical areas (e.g. : Angus, Hereford, Brahman, Nelore, ...).
When the terminal sire is a B.B., while coloured (R^+R^+), the product is "colour marked" (blue, R^+r), has better muscling, less fat, better lean/fat and lean/bone ratios.
According to a British source, this advantage is best expressed in females on a high energy diet.
Moreover, this crossbred animal carries only one copy of the mh gene and although its muscular development is improved, its conformation remains that of a conventional animal. This explains why natural calving is the rule in contrast to the pure bred B.B.B..
According to American scientists, the B.B.B. appears among the best terminal breeds.
In fact, the B.B. has gained considerable popularity in some countries for use in crossing.

▪ Conclusions

The market forces that favoured the emergence of this biological type, fifty years ago, are still at work. The selection objectives are chosen accordingly. What the Belgian breeders achieved, demonstrates once more that in the field of animal selection : "man can do more than he knows".
As it was already the case at the time of Charles Darwin, these artisans of genius are ahead of science. This remains true in spite of the tremendous scientific progress.
The method of animal improvement followed by our breeders is now a blending of tradition and modernity, taking the best of each and it works !
During the period considered – half a century – we could attend not simply the evolution of that particular breed but well a real co-evolution of : animals, farm structure, production system, way of life, mass marketing, scientific knowledge.

The Belgian Blue is well rooted in our high quality beef market as well as in the Belgian society. There is no concern about animal welfare resulting from the generalization of the caesarean section, nor about its ethical aspect. But this makes problem in some countries.
"Truth on this side, error on the other side"
Selection is a never ending process. New challenges arise (inbreeding, lethal gene, unwanted correlated responses, ...)
Most of the time, selection is a question of compromise. Any living being carries in its genome good and less good genes and a given gene can have at the same time favourable and unfavourable effects.
Therefore, the most appropriate answer is rarely either white or black.
The breed was created and then continuously improved.
When will this improvement reach an end ?
This question is asked since the beginning of the breed.
Our breeders have always been receptive to the light of science.
The hypothesis of a recessive gene with large effects on muscular growth underpinned the division, in 1973, of the breed into two branches with their distinct selection goals : the meaty type (homozygous for the recessive gene and "breeding true") and the dual-purpose type (with the tow other genotypes).
The first BLUP evaluations of sires for beef traits were obtained in 1985. Methodological refinements came afterwards.
In addition, it was from a collaboration with Professor Georges

- that the mh gene was identified, assigned to chr. 2 and sequenced
- that the dual-purpose population was DNA-typed for the mutation (Euro-mh project)
- that a research work is under way to find a DNA marker of a lethal condition.

More aid will come in the future from molecular genetics.
Nevertheless, when practical decisions are to be taken, the responsibility falls naturally to the breeders because they have a better perception of the situation as a whole.
The breed represents their asset and their source of income.
Fortunately, complete responsibility was granted by the state to the breeders and their Herd-Book at the critical moment.
Freed from different kinds of constraints, they had finally the last word.
Such a breed would not exist if non breeders had to take the capital decision.