

REVIEW

COMMENTS ON OPTIMIZATION
OF CATTLE BREEDING SCHEMES :
BEEF BREEDS FOR SUCKLING HERDS (1)
A REVIEW

F. MÉNISSIER

*Station de Génétique quantitative et appliquée,
Centre national de Recherches zootechniques, I. N. R. A.,
78350 Jouy en Josas (France)*

SUMMARY

Optimization of selection of beef breeds for suckling herds is little developed within the *European Economic Community (E.E.C.)* because of the small proportion of suckling cows and the very different systems of management of the latter. These various situations of selection are defined by the female populations involved and their genetic improvement objectives. We have distinguished between 3 types of populations : specialized beef breed herds, hardy herds used in crossing for their maternal abilities, herds composed of F₁ females : dairy × beef. The selection goals of beef breeds necessary for these different systems depend on the fate of the female offspring of the chosen (selected) sires.

Optimization of selection requires a better knowledge of the genetic parameters concerning breeding qualities of beef breeds both for their paternal contribution (direct effects) and for their maternal contribution (direct and maternal effects). According to the performances recorded in the *Charolais* breed, a general reduction of breeding qualities and notably of fitness can be observed, as well as an increasing muscle development. The reduction of calving ability is due both to an increase in the size of the animals and to an improvement of their musculature. With respect to mothering ability, the antagonism generally observed between direct and maternal effects would rather be of environmental than of genetic origin. In addition, selection on muscle development in Europe is made in conditions where natural selection on breeding qualities are less and less involved. As the artificial insemination is proportionally more developed in Europe than anywhere, it is possible to set up integrated selection schemes on breeding qualities of beef breeds. Artificial insemination is used to optimize the choice of breeding animals (selection on progeny) and to accelerate the diffusion of genetic change to all the herds (natural mating). Optimization of these schemes is confronted with difficulties arising from the distribution of the costs (supported by the AI) and the returns (obtained by natural matings).

Beyond this approach, it would be advisable to consider the improvement of beef cattle for suckling herds within the enlarged scope of the *E.E.C.* and for the coming 10 or 20 years.

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Optimum selection systems risk might to exceed the means, *i.e.* the actions undertaken within each breed or each country; one of the objectives of the *European Economic Community* would be perhaps to facilitate the selection of this future breeding stock.

In the *European Economic Community* (*E.E.C.*), the proportion of suckling cow herds is small. The situations observed in the various countries are extremely varied and the number of artificial inseminations is very often restricted in these herds as compared to dairy herds. For that reason, the studies made to define optimum selection schemes have not progressed as much as those concerning the dairy schemes and beef schemes for industrial crossing. We are therefore only going to point out the conditions and objectives of selection for suckling cow herds as well as the genetic parameters pertaining to their principal abilities; we will thereafter attempt to analyse how to complete and coordinate these parameters with the aim of optimizing the selection for suckling herds.

I. — CONDITIONS AND OBJECTIVES OF SELECTION OF BREEDS FOR SUCKLING COW HERDS

The suckling cow herds within the *E.E.C.* can be divided into three types according to the female population concerned and to the part they play with respect to selection (VISSAC, 1975; MÉNISSIER *et al.*, 1974) :

1. *Specialized beef breed herds.* They are composed of three main ethnic groups: british breeds of small size and characterized by very early fattening (*Aberdeen-Angus*, *Hereford*), continental breeds traditionally exploited for beef production in suckling cow herds (*Charolaise* and *Limousine*), local and hardy breeds characterized by numerous abilities and which, after suppression of milking and utilization of the animals for draught, have been converted into beef breeds (*Piemontaise*).

2. *Herds of hardy breeds* which have not been used as mentioned above; the purebred or crossbred females are used in terminal-like crossing with sires of beef breeds (*Aubrac*, *Gasconne* and *Sarde*).

3. *Herds composed of « F₁ females » : « dairy × beef »,* from industrial crossing in dairy herds. This type of herds belongs to the same category as the previous one as the females come from hardy breeds formerly subjected to milking. The development of beef production in Western Europe then appears as a by-product of dairy selection (ANONYME, 1972; MÉNISSIER *et al.*, 1974). The reduction of milk production primarily leads to development of crossing between milked females and beef sires, then suppression of milking and extension of the industrial crossing (VISSAC, 1975).

As far as the production conditions are concerned, the herds corresponding to the former and the latter types (specialized beef breeds and F₁ females) are generally exploited in regions with a high grassland production; conversely, the hardy breeds are currently used in areas with a poor grass production and their ability of exploiting these environmental conditions becomes reponderant (CASU *et al.*, 1975).

As a matter of fact the selection objectives in these various situations will depend on the fate of the female offsprings of the sires from the breeds involved (MÉNISSIER *et al.*, 1974). This fate is characterized by the proportion of females maintained for reproduction, by the length of the reproductive life of these females and by the utilization of the products of this female progeny for reproduction (table 1). If the male progeny is always intended for slaughter, the utilization of the reproductive performances and maternal abilities of the female offsprings varies considerably. In the case of male lines of terminal crossing, these traits are not used at all, whereas in female lines of terminal crossing or maternal strains, they are used to a maximum.

The importance of maternal performances depends on two factors :

— Primarily, on the breeding system : the maternal performances are less important in purebreeding systems (or rotational crossbreeding) where the reproduction of the females merely ensures the maintenance of the stock of this population, most of the females being then fattened like the males. Conversely, in systems including terminal crossing, just the strictly necessary amounts of females for terminal crossing are produced for the renewal of the herd ; generally, their reproductive abilities are exploited to a maximum.

— Secondly, on the carcass value of the female and its variation with age : in the continental beef breeds, slaughtering of young females after some few reproductive cycles is not only accepted but also often advised because of their high carcass value (extreme cases in double muscle beef breeds). Conversely, the females of British beef herds or of hardy breeds are used as long as possible for reproduction.

TABLE I

*Characteristics and selection goals for main systems
of commercial use of selected beef cattle*
*Caractéristiques et objectifs de sélection
des principaux systèmes d'utilisation commerciale des bovins sélectionnés
pour la production de viande*

Systems of commercial use of selected beef breeds ⁽¹⁾	Use of female calves				Main goals of selection			
	Proportion for		Longevity (number of reproduction years)	Number of generation of use	Calf crop D : fertility C : survivability ⁽²⁾	Calving ability D : calving facility C : birth weight	Prewearing growth D : maternal ability C : weaning weight	Post-weaning growth D : maintenance cost C : beef value
	Breeding	Fattening						
Terminal sire line	0	100 %	00	0	• 000	• 000	• 000	• 000
Beef breed	25 %	75 %	n (3 to 5)	N	00 00	00 00	00 00	0
Terminal maternal line	100 %	0	N (5 to 10)	1	000 •	000 •	000 •	000 •

⁽¹⁾ May be either pure or synthetic breed.

⁽²⁾ The above symbol is for dam (D) ; the below symbol is for calf (C), Number of symbols indicates the relative importance of each goal according to different systems ; Size of symbols (0, 0, 0) indicates the relative value of different goals within the system of commercial use.

Since some traits of the females are related to age (sexual precocity, calving ability) the relative importance to be imputed to these traits in the selection will naturally vary according to the proportion of heifers used in the herds. Moreover, in the case of traits being expressed according to one or several thresholds, the objectives of the selection of breeds intended for crossing will depend on the relationships between the components of the traits related to the mother and those related to the calf, *i.e.* on the complementary (calving ability and pre-weaning growth).

This presentation of the selection objectives has been made with reference to the situation existing within the *E.E.C.* (populations, types and systems of production). A more theoretical and global approach might be obtained by applying systems or models for the analysis of the economic efficiency to these different situations; these models of analysis have already supplied valuable results in the case of similar production systems (LEIGH *et al.*, 1972; LONG, 1972; CARTWRIGHT *et al.*, 1975; FITZHUGH *et al.*, 1975; LONG *et al.*, 1975; MORRIS *et al.*, 1975; PARKING *et al.*, 1975; WILTON et MORRIS, 1975). Independently of the human constraints, the application of these models would allow to define more accurately the relationships between the different traits and the parameters used (see the communication of CARTWRIGHT).

II. — GENETIC VARIABILITY OF THE PRINCIPAL, MATERNAL, TRAITS

After determination of the importance of the traits relatively to the paternal contributions (direct effects) and maternal contributions (direct and maternal effects), the estimation of the overall genetic value assumes knowledge of the genetic parameters concerning these different contributions. In the light of our most recent results about the *Charolais* breed, we are only going to present the most interesting aspects of the maternal contributions, those concerning the paternal contribution having been developed elsewhere (see communications of FOULLEY and LINDHE). The following points will be considered successively : numerical productivity, calving ability, mothering ability.

TABLE 2

Heritability estimates of maternal traits for numerical productivity in Charolais breed :
Progeny testing results in station, for maternal abilities in AI bulls (MÉNISSIER et al., 1975)
Héritabilités estimées de la composante maternelle
de la productivité numérique en race Charolaise :
résultats du contrôle de descendance en station pour les qualités maternelles des taureaux d'IA

Characters ⁽¹⁾		Number of Heifers		Mean values		Heritabilities (confid. limits for $p = 0.05$)
		Total	per sire	Average \pm Stand. deviation	c.v. (%)	
Analytical characters	Age of 1st AI	990	18.0	457 \pm 1 day	6	51.3 % (31.4/82.6)
	Date of 1st AI . . .	990	18.0	29 may \pm 1 day	3	
	Mated heifers (by AI) (%)	1 067	19.4	93.1 \pm .7 %	27	5.1 % (— 2.7/18.7)
	Pregnant heifers/ inseminated (%)	990	18.0	79.9 \pm 1.2 %	50	13.5 % (2.9/31.6)
	Calving heifers/ pregnant (%) ..	796	14.4	96.4 \pm .6 %	19	9.2 % (— 1.9/28.1)
	Weaned calves/cal- ving heifers (%)	758	13.6	82.3 \pm 3.7 %	47	< 0 (— 17.2/16.5)
Synthetic characters ⁽²⁾	Pregnant hei- fers (%)	1 067	19.4	74.4 \pm 1.3 %	59	7.3 % (— 1.1/22.0)
	Calving heifers (%)	1 067	19.4	71.7 \pm 1.3 %	63	9.3 % (.3/24.8)
	Calf crop (%) . . .	1 067	19.4	58.0 \pm 1.0 %	84	4.3 % (— 3.3/17.5)

⁽¹⁾ AI on natural oestrus, during about 70 days, for 1st calving at 2 years old 55 sires.

⁽²⁾ By breeding heifers.

A. — Numerical productivity

(or number of calves weaned per female kept for reproduction)

The heritability of this criterion is generally low ($h^2 = 0$ to 5 p. 100) as for most of the reproductive performances (MAIJALA, 1964); even in the case of heifers tested at the station, we only observe 4 p. 100 (table 2). As a matter of fact, the numerical productivity represents a synthetic complex criterion resulting from the incidence of very different physiological functions: conception, gestation and viability of the calves. Separately, these traits may have different heritabilities (table 2): those connected with conception or gestation being more heritable than the maternal component of the survival rate of the calves.

In *Charolais* heifers, where we have reduced as much as possible the variance depending on the environment, the heritability of conception or gestation rates ranges around 10 p. 100. This rather high value has been confirmed by the findings of DEARBORN *et al.* (1973) for *British* breeds ($h^2 = 0.22 \pm 0.17$). As compared to growth and conformation at 18 months of these heifers (table 3), fertility is phenotypically independent (ADG 9 to 18 months) or positively related (weight at 18 months) to growth; On the other hand it appears to be genetically in opposition to these criteria (-0.07 to -0.53). Analogous trends can be observed with respect to conformation and especially with respect to muscle development and subjective judgment of the breed qualities (the two latter criteria are related genetically: $r_g = 0.62$). These genetic

TABLE 3

Genetic (r_g) and phenotypic (r_p) correlations between numerical productivity and growth or conformation score in Charolais breed:
Progeny testing results in station,
*for maternal abilities in AI bulls (MÉNISSIER *et al.*, 1975)*
Corrélations génétiques (r_g) et phénotypiques (r_p) entre la productivité numérique et la croissance ou la conformation en race Charolaise:
résultats du contrôle de descendance en station
pour les qualités maternelles des taureaux d'IA

		Growth and conformation score (heifers at 18 months old)					
		Weight (at 18 months old)	Daily gain (9 to 18 months old)	Muscle development (°)	Skeletal development (°)	Breed qualities (°)	Total score (°)
Heritabilities		33 % (18/58)	21 % (9/42)	48 % (29/78)	31 % (16/56)	14 % (4/32)	25 % (12/47)
Numerical productivity (as maternal character) (4)	Mated heifers (%) ..	— .07 (3)	— .53	— .04	— .08	— .36	— .18
	Pregnant heifers (%)	.29	— .01	.05	.14	.08	.13
	Calf crop (%)	— .25	— .18	— .41	— .10	— .68	— .57
		.18	— .00	— .01	.08	.02	.04
		(5)	(5)	(5)	(5)	(5)	(5)
		— .06	.02	— .04	— .01	— .01	— .03

(1) By breeding heifers.

(2) Linear combination of score for various characters.

(3) The above figure is the genetic correlation r_g the below figure is the phenotypic correlation r_p .

(4) Calving heifers at 2 years; 1 067 heifers sired by 55 bulls.

(5) $\widehat{\sigma}_g^2 < 0$.

relationships might confirm the opposition between muscle development and breeding qualities generally observed between genotypes. A more thorough analysis of these relationships should be made.

Even, when distinguishing between the mortality of the calves during their foetal life, at birth and after, we did not notice any genetic variability for the maternal component. This result does not exclude the probable existence of direct genetic effects (VAN DIETEN, 1963; CLOPPENBURG, 1966; MAIJALA, 1964; BAR-ANAN, 1972; PHILIPSON, 1975); besides, the genetic variability of the latter is low and partly related to calving difficulties (direct effect). Independently of the mortality, we have observed some heritability of the maternal component vigour of the calves at birth ($h^2 = 27$ to 37 p. 100); besides, it is genetically related to calving easiness ($r_g = +0.3$ to $+0.5$). The recent results of PHILIPSON (1975) about the mortinatalité in dairy herds, confirm the low heritabilities of the direct effects ($h^2 = 0.01$) and maternal effects ($h^2 = 0.01$ to 0.08) as well as the absence of genetic correlation between these effects ($r_g = +0.02$). The viability of the calves is one of the criteria that should be particularly considered in selection, both for industrial crossing as well as for suckling herds, in relation with the degree of maturity at birth.

B. — Calving ability (as maternal trait)

The heritability of the maternal contribution of this criterion is relatively higher than that of the previous criteria (BRINKS *et al.*, 1973; COUTEAUDIER *et al.*, 1971; HANSEN, 1975). In the *Charolais* breed we have obtained from 15 to 20 p. 100 (table 4) these values are higher

TABLE 4

*Heritability estimates of maternal calving ability in Charolais breed :
Progeny testing results in station,
for maternal abilities in AI bulls. (MÉNISSIER *et al.*, 1975)*
*Héritabilités estimées pour l'aptitude maternelle au vêlage en race Charolaise :
résultats de contrôle de descendance en station,
pour les qualités maternelles des taureaux d'IA*

Characters (1)	Number of heifers		Mean Values		Heritabilities (confid. limits for $p = 0.05$)
	Total	per sire	Average \pm stand. deviation	c.v. (%)	
<i>Calving difficulties (2)</i>					
- Score (increasing-1 to 4)	753	13.6	2.53 \pm .03 points	39	18.2 % (.6/42.3)
- Difficult calving (%)	753	13.6	48.1 \pm 1.7 %	104	14.9 % (— .0/38.3)
<i>Calf (2)</i>					
- Birth weight	753	13.6	37.3 \pm .2 kg	16	16.7 % (— .7/40.5)
- Gestation length ..	753	13.6	283.7 \pm .2 days	2	18.6 % (.9/42.8)
<i>Dam</i>					
- Calving weight	405	8.8	494 \pm 2 kg	11	47.0 % (15.2/88.6)
- Calving preparation (% good score)	719	13.0	78.7 \pm 1.5 %	52	13.7 % (— 3.9/37.6)

(1) 1st calving at 2 years. 55 sires.

(2) As a maternal trait.

than those generally estimated for direct effects ($h^2 = 0.05$ about ; MÉNISSIER, 1974), but they are mostly obtained under conditions where the environmental variability is reduced (Stations or experimental herds) and where the genetic variability is expressed to a maximum (calving of the heifers). This maternal ability is directly related with the size of the calf ($r_g = + 0.67$ and $r_p = + 0.59$) and much less with the gestation length ($r_g = - 0.07$ and $r_p = + 0.21$). Although these two traits have a maternal component as heritable as that of calving ability, they are more subjected to direct effects than to maternal effects (PHILIPSON, 1975) and depend more on the genotype of the calf than on that of the mother. Furthermore, the genetic correlation of their direct and maternal effects is naught or negative (table 7 ; KOCH, 1972 ; PHILIPSON, 1972) which might be the expression of a competition between the mother and the foetus regarding their requirements in the case of animals with a high growth potential. The genetic opposition is less evident in the case of calving ability ($r_g = - 0.19$; PHILIPSON, 1975), but let us recall with respect to this that a greater number of traits are involved (MÉNISSIER, 1975).

The morphological traits of the mother at calving (weight and pelvic opening) are the most heritable criteria (table 4 and COUTEAUDIER *et al.*, 1971). With respect to the weight at calving,

TABLE 5

Genetic (r_g) and phenotypic (r_p) correlations between maternal calving ability and growth or conformation score in Charolais breeds :

Progeny testing results in station,

*for maternal abilities in AI bulls (MÉNISSIER *et al.*, 1975)*

Corrélations génétiques (r_g) et phénotypiques (r_p)

entre l'aptitude maternelle au vêlage et la croissance ou la conformation en race Charolaise : résultats de contrôle de descendance en station, pour les qualités maternelles des tauraeux d'IA

	Growth and conformation score (heifers at 18 months old) :							
	Weight (at 18 months old)	Daily gain (9 to 18 months old)	Muscle development (3)	Skeletal development (3)	Breed qualities (3)	Total score (3)	Calving weight	
Héritabilités (%)	33	21	48	31	14	25	47	
Calving ability (4)	Calving difficulties (2) Score (increasing 1 to 4) . . . . .	.09 (4) — .01	.08 .18	.33 — .01	— .12 .09	.26 .07	.24 .08	.51 — .08
	Difficult calving (%) . . . . .	.21 — .01	.14 — .04	.51 — .01	.30 .26	.37 — .10	.64 .04	.75 — .03
	Calf birth weight . . . . .	.47 .05	.61 .03	.01 — .05	.32 .04	.12 .06	.23 .19	.33 .26
	Gestation length . . . . .	.15 .04	.29 .01	— .05 .03	— .02 .29	.13 .03	— .00 .04	.05 — .08
	Calving weight . . . . .	.75 .78	.47 .23	1.33 .30	— .11 .54	.69 .07	1.04 .48	. . . . .

(1) 1st calving at 2 years, 753 heifers sired by 55 bulls.

(2) As a maternal trait.

(3) Linear combination of score for various characters.

(4) The above Figure is the genetic correlation (r_g), the below figure is the phenotypic correlation (r_p).

there is no, or a slightly negative, phenotypic correlation with calving difficulties, whereas there is a very high positive genetic correlation ($r_g = + 0.5$ to $+ 0.8$). The relationships with growth and the conformation of the heifers at 18 months confirm this genetic opposition (table 5). As a matter of fact, several phenomena have to be mentioned. Primarily, the increase in size of the mothers (weight) is connected with an increase in birth weight of the calves. Proportionally, this increase would be greater than that of the size of the mothers (MONTEIRO, 1969) or of their pelvic opening related with the larger size of the dams (TAYLOR *et al.*, 1975); consequently, there would be more calving difficulties in large-sized breeds. Increase in calf weight/mother weight ratio would signify a higher maturity of the calves at birth; there is an apparently discrepancy between this and the observations of FITZHUGH and TAYLOR (1971). In addition, we do not know the respective share of the direct effect and maternal effect in the increase of weight at birth. The second phenomenon to be mentioned for the increase of calving difficulties, is the improvement of muscle development. We have noticed that muscle development causes more difficulties at calving ($r_g = + 0.51$) without however increasing the weight of the calves ($r_g = + 0.01$). The effect of muscle development consists probably more in changing the morphology of the calves and especially in reducing the pelvic opening of the mothers relatively to their size. This phenomenon has been described in connection with studies on the double muscle trait (VISSAC *et al.*, 1973; MÉNISSIER, 1974 a). In beef breeds, calving difficulties might be a consequence of their size and/or of their muscle development (MÉNISSIER *et al.*, 1974 b). It would be necessary to examine more thoroughly the incidence of their present selection on this ability.

C. — *Mothering ability*

The variability of the maternal contribution on the preweaning growth of the calves is better known than in the case of the previous abilities; 15 to 30 p. 100 of this variability are of genetic origin (table 6 and KOCH, 1972). It is also a complex criterion since it closely depends

TABLE 6
Heritability estimated of mothering ability in Charolais breed :
Progeny testing results in station,
for maternal abilities in AI bulls
Héritabilités estimées de l'aptitude à l'allaitement en race Charolaise :
résultats de contrôle de descendance en station,
pour les qualités maternelles des taureaux d'IA

Characters ⁽¹⁾		Number of heifers		Mean Values		Heritabilities (confid. limits for $p = 0.05$)
		Total	per sire	Average ± stand. deviation	c.v. (%)	
Milk production at 4-5 months of lactation		511	11.0	5.4 ± .1 kg by day	33	41.1 % (15.7/75.6)
Calves at 4 months old ⁽²⁾	Weight	525	10.8	144.1 ± .7 kg	13	14.3 % (— 7.4/44.8)
	ADG from birth	525	10.8	877 ± 6 g/day	16	18.5 % (— 3.8/49.8)
	Beef conformation score .	525	10.8	15.9 ± .2	25	< 0 (— 19.9/26.8)
	Beef value (weight × score)	525	10.8	2 323 ± 33 kg × points	32	6.5 % (— 13.9/35.5)

(1) 1st calving at 2 years. 48 sires.

(2) As a maternal trait.

TABLE 7

Genetic variability of direct (O) and maternal (m) effects on the preweaning growth.
Results of literature (according to FOULLEY and MÉNISSIER, 1974)
Variabilité génétique des effets directs (O) et maternels (m) sur la croissance avant sevrage :
résultats bibliographiques

Characters	Heritabilities (%)		Genetic correlations $r_{\theta(O, m)}$	Number and genetic type	Reference
	Total (²) h^2_{θ}	Direct effect h^2_{θ}				Maternal effect $h^2_m$
Birth weight	42	35	≥ 0	4 553 Hereford	Koch and Clark (1955)
	49	45	{ -.00 (¹) .14 (²)	4 060 Hereford		Koch (1972)
	56	44	{ -.56 to -.89	1 962 Hereford	Vesely and Robison (1971)
	48	72		1 064 Holstein		Everett and Magee (1965)
	2	22		4 to 15	789 Hereford		Brown and Galvez (1969)
36	56	30	932 Angus		
17	14	25			
Growth from birth to weaning	12	21	-.65	4 553 Hereford	Koch and Clark (1955)
	32	20	{ -.05 (¹) .41 (²)	4 060 Hereford		Koch (1972)
	42	26	{ -.00 .73	725 Brahman	Deese and Koger (1967)
	25	48		466 Brahman X	
	17	40		Shorthorn	
Weaning weight	32	44	-.32	717 Hereford	Hill (1965)
	42	32	-.46	1 692 Hereford		Vesely and Robison (1967)
	17	37	{ -.73 to -1.07	2 618 Hereford	Hohenboken and Brinks (1974)
	28	23	-.28 (¹)			Foulley et Méniissier (1974)
	8	23	-.79 (²)	228 Charolais	
32	14	-.07 (¹)			
—	14	64	-.14 (²)		

(¹) Without offspring-dam relation.

(²) With offspring-dam relation.

(³) Estimation according to WILLHAM (1973).

on the maternal environment ; for example, milk production of beef breeds accounts for 20 to 70 p. 100 of the variance of the calves preweaning growth (BIBE et HIVERT, 1975).

A rather great number of authors (table 7) have estimated for the growth of the calves, the respective share of genetic variability in the direct effects and maternal effects : the heritability of the maternal effects often exceeds that of the direct effects. An antagonism between these two types of effects is generally observed. If we do not take into account the inaccuracy in the estimations of the covariance and the omission of the dominance effects, this negative relationships would be of environmental rather than of genetic origin, indeed, young females placed in a very favourable environment (on account of the age of the mother, year or season, herd management) and which have shown a high early growth, produce thereafter lighter calves at weaning than heifers having exhibited normal growth (CHRISTIAN *et al.*, 1965 ; VOGT et MARLOWE, 1966 ; TOTUSEK, 1968 ; KOCH, 1969 ; MANGUS et BRINKS, 1971 ; KRESS et BURFENING, 1972) ; This might be due to a deterioration of their dairy abilities (SWANSON, 1960 and 1967). If the preweaning

TABLE 8

*Genetic (r_g) and phenotypic (r_p) correlations between mothering ability and growth or conformation score in Charolais breed : progeny testing results in station, for maternal abilities in AI bulls (MÉNISSIER *et al.*, 1975)*

Corrélations génétiques (r_g) et phénotypiques (r_p) entre l'aptitude à l'allaitement et la croissance ou la conformation en race Charolaise : résultats de contrôle de descendance en station, pour les qualités maternelles des taureaux d'IA

		Growth and conformation score (heifers at 18 months old)					
		Weight (at 18 months old)	Daily gain (9 to 18 months old)	Muscle development (3)	Skeletal development (3)	Breed qualities (3)	Total score (3)
Heritabilities (%)		33	21	48	31	14	25
Mothering ability (1)	Milk production (4-5 months of nursing).....	-.04 (4)	.43	.11	-.32	-.98	-.81
		.04	.08	.01	.00	.05	.01
	Calf weight at 4 months (2)	(5)	(5)	(5)	(5)	(5)	(5)
		.14	.05	.14	.19	.08	.21
	Calf daily gain from birth (2) ..	.03	-.98	.75	-.32	.24	.95
		.08	.01	.11	.12	.08	.16
	Beef conformation score of calf at 4 months (2)	(5)	(5)	(5)	(5)	(5)	(5)
		.03	.04	.12	.01	.16	.14
	Beef value of calf (weight × score) (2).....	(5)	(5)	(5)	(5)	(5)	(5)
		.08	.75	.13	.08	.14	.18

(1) 1st calving at 2 years, 511 heifers sired by 48 bulls.

(2) As maternal trait.

(3) Linear combination of scores for various characters.

(4) The above figure is the genetic correlation (r_g) ; the below figure is the phenotypic correlation (r_p).

(5) $\hat{\sigma}_g^2 > 0$.

growth superiority of heifers is of genetic origin (paternal or maternal lines for instance, KRESS et BURFENING, 1972 ; MANGUS et BRINKS, 1971), the deteriorating effect on mothering ability is less obvious. As regards the preweaning growth of *Charolais* heifers, we have not found any evident opposition (table 8) ; only conformation score appears to be negatively related to milk production, without any repercussion on the growth of the calves. Similar trends have been reported by FREY *et al.* (1972) for Aberdeen-Angus.

Thus, all results pertaining to the genetic variability show the necessity of pursuing the analysis of the variations and covariations in the direct and maternal effects in order to optimize selection. The most obvious genetic oppositions appear between muscle development and each of the maternal components : this corresponds to the observations that can be made both in *France* and in the whole World on the abilities of the various strains of *Charolais* « individualized » since the beginning of the century : increase in muscle development leads to reduction of fitness and adaptation traits (VISSAC *et al.*, 1973 a ; VISSAC *et al.*, 1972 ; VISSAC et MÉNISSIER, 1974).

III. — SELECTION SCHEMES FOR SUCKLING COW HERDS

Up to the present time these schemes concerned herds kept in rather extensive systems with natural mating. Mass selection of males and females on conformation and growth criteria (especially weaning weight) appeared to be sufficient, as the extensive conditions favoured natural selection with respect to the fitness trait. The situation in the *E.E.C.* differs for two reasons :

— Primarily, the selection concerns in particular the muscle development with animals from small family farms (well supervised herds) and with more intensive systems (management and feeding). In these conditions the natural selection on breeding qualities intervenes less and less.

— In addition, 20 to 60 p. 100 of these herds according to cases, are subjected to artificial insemination. It therefore seems logic to use this technique, on the one hand, in order to optimize the choice of the selected animals on the basis of their breeding qualities (selection on progeny) and, on the other, in order to accelerate the diffusion of genetic change to all suckling herds.

1. — Choice of the breeding animals

For that purpose, integrated selection schemes of French beef breeds for production of breeding females have been developed the last few years (VISSAC, 1970 ; MÉNISSIER *et al.*, 1974 ; VISSAC et MÉNISSIER, 1974 ; MÉNISSIER, 1975 ; BOYAZOGLU, 1975). These schemes (fig. I and table 9) are based on two main steps :

a) The most original step is the progeny testing on breeding qualities on daughters of A.I. sires. This testing was made with a sample of 20 purebred daughters/sire, kept for two years at the station, from weaning till the second gestation. Not only their growth, but also their fertility, calving ability and maternal mothering ability at first calving when 2 years old, were estimated. Although it represents one of the selection objectives, this early first calving was retained in particular in order to reduce the duration of progeny testing and to permit a better expression of the genetic variability of the maternal abilities. This assumes a good repeatability of these abilities (the value of which is perhaps not always as high as claimed : CUNNINGHAM et HENDERSON, 1965 ; BOSTON *et al.*, 1975).

b) The second step consists in a combined choice on ancestry and individual value of the young bulls, after having planned rational matings on a nucleus of elite cows (or « sire mothers »). The choice of sire mothers distributed in a great number of herds, is made from performances

recorded on the farm. At the level of the overall controlled population, these performances are generally elaborated in form of « female index » (or estimation of the « Most Probably Producing Ability » ; REGIS, 1974), thus leading to rather large selection pressures. The young males produced are subjected to performance testing before they are chosen for the subsequent steps.

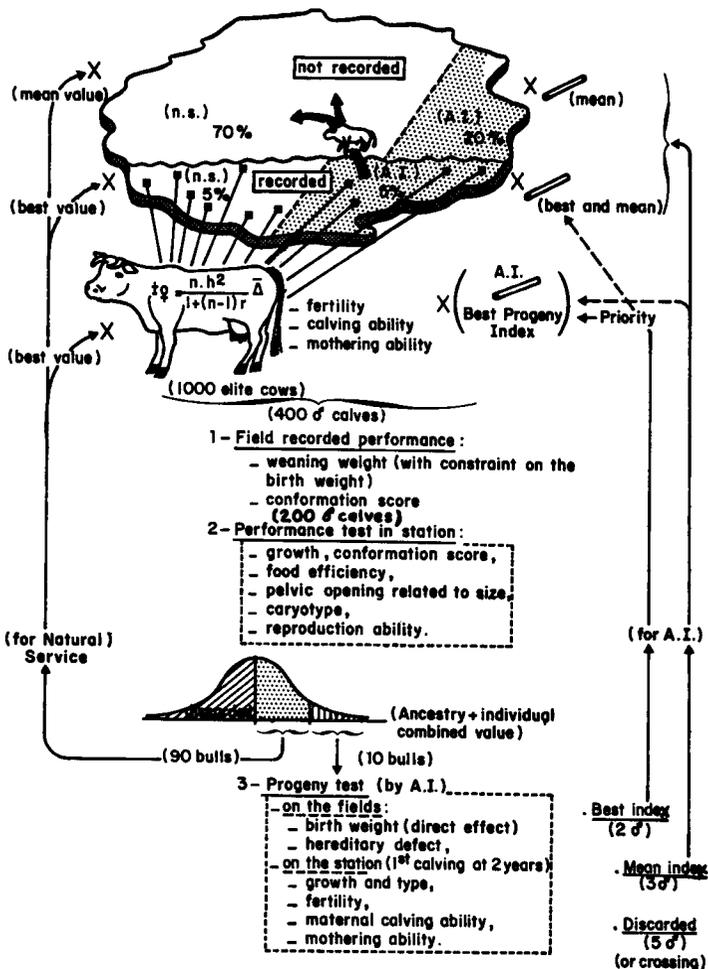


FIG. 1

Integrated selection scheme for beef breeds in beef herds : an example.

Schéma de sélection intégrée pour les races à viande dans les élevages à viande : un exemple.

In this scheme, the efficiency of the choice of breeding animals depends on the quality of the estimations of their genotypic value at each stage. It might be improved by a better combination of the available informations (the taking into account of the oppositions between direct and maternal effects for preweaning growth, for instance ; MANGUS et BRINKS, 1971) as well as by the utilization of early selection criteria. These criteria might as well be chromosomal aberrations or hormonal levels (LH and prolificacy, oestrogenes and mothering ability) as morphological traits such as the pelvic opening of the young bulls (MÉNISSIER et VISSAC, 1971) relatively to their size (TAYLOR *et al.*, 1975).

TABLE 9

Characteristics of progeny testing stations for selection of sires in French beef breeds on growth and maternal abilities of their daughters (MÉNISSIER, 1975)
 — 20 daughters per sire are purchased on the farm at weaning and reared for 1st calving at 2 years.
 — all heifers are mated by the same bull for each Station.

Caractéristiques des stations de contrôle de descendance pour la sélection des taureaux de races à viande françaises, sur la croissance et les aptitudes maternelles de leurs filles.

Breeds	Manager of the programme; Localisation of station	Type of selection		
		Choice of bulls to be progeny-tested	Year of opening ; number of sires ; number of testing groups	Number of selected bulls
<i>Charolaise</i>	« Union nationale de Testage de la race Charolaise. » 03 Agonges	— partial performance tested, and progeny tested for calf production (direct effet) in pure breeding.	1968 7 to 10 bulls per year 5	4 to 5 bulls per year
<i>Limousine</i>	« Union Auvergne-Limousin et Charentes » 19 Uzerche	— progeny tested for veal or baby beef production in cross and pure breeding.	1972 10 bulls per 2 years 1	4 bulls per 2 years
<i>Blonde d'Aquitaine</i>	« Midalest » 47 Casteljaloux	— progeny tested for veal or baby beef production in cross breeding.	1972 6 bulls per year 1	2 bulls per year

2. — Utilization of breeding animals

Lastly, the optimization of such selection schemes requires a rationalization of the utilization of breeding animals chosen at each step ; with the aim of obtaining a rapid diffusion of genetic change to the overall population. In particular, the sires selected by this scheme, after progeny testing, should in priority be kept for planned matings (by AI) with the elite females, in order, on the one hand, to procreate the following generation with the best elite mothers and, on the other, to produce young males with the other elite cows for the natural services in the recorded or unrecorded commercial herds. Before being used, these young males should be performance tested. Such an integration of the selection schemes at the level of the population, is difficult at the present time because of the difficulty in the distribution of the costs (supported by the AI) and the returns (obtained by natural matings).

CONCLUSIONS

With the aim of determining an optimum breeding scheme for beef herds, the various local and national situations with their specific restrictions chiefly concerning the environments, the production systems and market requirements, the sociological place of traditional breeders and pro-

ducers, should be considered. In this limited but realistic context, partial results have been obtained by several teams of research workers : breeding goals and production systems (U.S.A., Canada, United Kingdom, France, ...) as well as the genetic variability traits, for example, calving ability (France, ...) and preweaning growth (U.S.A., ...). It would now be necessary to confront the results in order to elaborate optimum selection models fitted to the existing situation.

Beyond this approach, it is also important to consider the improvement of beef cattle for suckling herds in the enlarged scope of the *European Community* and for the coming 10 or 20 years. It appears that suckling herds will chiefly develop from beef crosses coming from the dairy herds (grassland and cultivated lowland areas with medium sized farms) and in difficult environments of mountainous or arid zones from adapted breeding types. We have now to find the optimum production system, the place of beef breeds in each of them, the breeding goals of these breeds and hardy breeds, using analysis models of efficiency from beef production.

These goals and optimum breeding schemes which will result from such analysis (selection of maternal lines for example) may be different from those of existing breeds in purebreeding with an average early culling. To reach these goals, it might be interesting to select for special strains from a synthetic population (from a gene pool) Creation of such adapted beef strains, overstepping the schemes of each breed in the imposed local and national context, is naturally a too large enterprise considering the facilities and responsibilities of each country. To be achieved such a goal, could be a stimulating challenge for *European Economic Community*.

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RÉSUMÉ

COMMENTAIRES SUR L'OPTIMISATION DES SCHÉMAS DE SÉLECTION DES RACES A VIANDE POUR LES TROUPEAUX DE VACHES ALLAITANTES, UNE REVUE

Dans la *Communauté économique européenne* (C.E.E.) l'optimisation de la sélection des races à viande pour les troupeaux allaitants est peu avancée du fait de la faible proportion de vaches allaitantes et de la diversité de leurs conditions d'exploitation. Ces diverses situations de sélection se définissent par les populations femelles concernées et leurs objectifs d'amélioration génétique. Nous avons distingué 3 types de populations : les élevages de races à viande spécialisées, les races rustiques utilisées en croisement pour leurs aptitudes maternelles, les troupeaux de femelles F_1 lait \times viande. Les objectifs de sélection des races à viande nécessaires à ces divers systèmes, dépendent du devenir des descendants femelles engendrés par les taureaux sélectionnés.

L'optimisation de la sélection nécessite une meilleure connaissance des paramètres génétiques concernant les qualités d'élevage des races à viande, tant pour leur contribution paternelle (effets directs) que pour leur contribution maternelle (effets directs et maternels). A partir des performances en race *Charolaise*, nous observons une réduction générale des qualités d'élevage et notamment de « fitness », avec un accroissement du développement musculaire. La réduction de l'aptitude au vêlage résulte aussi bien d'une augmentation de la taille des animaux que d'une amélioration de leur musculature. Pour l'aptitude à l'allaitement, l'antagonisme généralement observé entre effets directs et maternels serait plutôt d'origine environnementale que génétique. Par ailleurs la sélection sur le développement musculaire se réalise, en Europe, dans des conditions

où la sélection naturelle sur les qualités d'élevage intervient de moins en moins. Comme l'IA y est proportionnellement plus développée qu'ailleurs, il est possible de mettre en place des schémas intégrés de sélection sur les qualités d'élevage des races à viande ; l'IA est utilisée pour optimiser le choix des reproducteurs (sélection sur descendance) et pour accélérer la diffusion du progrès génétique à l'ensemble des troupeaux (par monte naturelle). L'optimisation de ces schémas se heurte aux difficultés de répartitions des coûts (supportés par l'IA) et des recettes (obtenues par m.n.)

Par delà cette approche, l'amélioration génétique des bovins à viande devrait être plus considérée dans le cadre élargi de la C.E.E. et dans une perspective de 10 à 20 ans. Les systèmes optimaux de sélection risquent de dépasser les actions entreprises au niveau de chaque race ou pays ; c'est peut être un des objectifs de la C.E.E. que de faciliter la sélection de ce futur matériel génétique.

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