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PRINCIPLES OF AN A.I. BREEDING PROGRAMME WITH SPECIAL REFERENCE TO THE USE OF HOLSTEIN FRIESIANS IN THE GERMAN BLACK AND WHITE CATTLE BREED

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Artificial insemination (A.I.) has brought about a breakthrough of population genetics in cattle breeding. Several authors have discussed the advantages which A.I. offers compared to natural service. Reference is made to papers published by Robertson and Rendel (1950. 1954), Skjervold (1963), Skjervold and Langholz (1964), Henderson (1953, 1954), VanVleck (1964), Specht and McGilliard (1960), Cunningham and Cleaves (1965), Lindhé (1968). A.I. has improved "selection accuracy" and "selection intensity", two factors which determine breeding progress. If all facets of a modern A.I. breeding program are optimized, selection progress can be expected to be twice to three times higher than that attained in the past.

In this connection the different selection intensity between the female and the male cattle should be considered. In the average breeding herd a relatively high percentage of all female calves have to be reared as replacements. In the Federal Republic of Germany this is about 60%. The attainable selection differential on the female side is therefore relatively low while on the male side, especially under conditions of A.I., the possibilities are better. It is more accurate to estimate the breeding value of a bull on the basis of many daughter records compared to that of a cow on the basis of her own performance.

Considering the higher selection intensity among the sires, the higher accuracy in estimating the breeding values of bulls and finally the higher reproduction rate of a bull compared to a cow, it is clear that the bull has a greater influence in determining breeding progress. Several authors have estimated the relative importance of the four possible paths determining breeding progress, (see Table 1).

The path from sire to son has the greatest influence. The influence of the path from sire to daughter is also relatively great. From this it must be concluded that the bull has to be a point of main effort in our modern breeding work, since, according to the calculations, 60 to 70% of the selection progress is due to the sire.

Basic concepts of an A.I. breeding program

Model calculations (VanVleck, 1964; Lindhé, 1968; Fewson, 1963) as well as practical experience show that the development maintenance of an A.I. breeding program is very expensive. Therefore, for a program concentrating on practical viewpoints, income has to be maximised and costs have to be minimized. This requires a systematic organization of all steps within the program. In an A.I. breeding program the most important decisions are made when test bulls are selected. In many publications it is shown that the greatest genetic progress is obtained by using sons of the best proven sires (Robertson and Rendel, 1950; Specht and McGilliard, 1960; VanVleck, 1964; Skjervold and Langholz, 1964).

Our own 21 years of experience show that the best possible young bulls are provided when a central organization exists which is equipped with the necessary competence and with sufficient financial resources (Schwarz, 1969). This organization has to plan the production of the next young test bull generation systematically in advance. Following this tight program conflict with individual decisions of breeders and A.I. stations cannot always be avoided.

Table 1

Share of the 4 selection paths in determining selection progress

Authors	sire to son	sire to daughter	dam to son	dam to daughter
Robertson and Rendel (1950)	46	18	33	6
Skjervold (1963)	46	24	24	6
Syrstad (1966)				
a)	35	11	49	5
b)	41	10	45	4
Lindhé (1968)				
a)	40,9	25,5	27,7	5,9
b)	41,9	25,0	27,3	5,9
c)	42,8	24,2	27,1	5,9
d)	43,5	24,2	26,4	5,9
e)	44,2	24,1	25,7	5,9
Kräusslich et al. (1970)	43	28	29	0

Emphasis of such a program has to be on:

1. *Creating large breeding units*

Robertson and Rendel (1950), Skjervold (1953), Fewson (1963) show that there is a correlation between the rate of selection progress and the population size. In this case only the active part of the population has to be taken into consideration, which are the cows under milk test. Smaller insemination units have a smaller test capacity. Therefore, they are not able to select as intensively as larger units. They also need more time to carry out the test inseminations. Rate of genetic improvement is, therefore, slower and more costly. Due to the fact that they are able to test only a limited number of young bulls each year, they carry a higher risk. To optimize an A.I. breeding program, Fewson (1963) recommends pooling at least 50 000 active cows in one breeding unit. Therefore, A.I. centres which cannot fulfill this requirement are strongly advised to cooperate with other A.I. stations at least in the bull testing program.

2. *Organization of planned matings*

Only a small percentage of cows out of the total herdbook population is eligible as potential dams of A.I. bulls, while only the best progeny tested bulls are eligible as sires. The selection of the sires and dams must be done centrally since the individual breeder is not in a position to assess the total population.

a) *Selection of dams*

In the Federal Republic of Germany the selection of dams takes place in two steps. First the deviation as a contemporary comparison in milk and butterfat yield of each herdbook cow is computed and all the animals are ranked. These deviations are calculated for the first 5 lactations. If results of more lactations are available, the arithmetic average is used. About 8% of all herdbook cows are selected in the first step.

Subsequently a scoring for type and conformation, udder and milkability is carried out. After the second selection step 2 to 3% of all herdbook cows remain in the dam register. The number of dams within a closed breeding unit which have to be selected for the production of the proposed number of test bulls is influenced by the number of the available test places which are on one hand determined by the size of the active breeding part of the total population and on the other hand by the required selection intensity after finishing the test. Furthermore, it depends on the number of planned matings which have to be organized in order to produce one testworthy young bull. Based on our own experience 15 to 20 cows should be selected for one young bull finally sampled. This figure is identical with reports from Carter (1967) for the region of the A.I. Centre Eastern Breeders, New York.

In order to shorten the generation interval the dams should already be selected after finishing the first lactation. This seems justified since the heritability of milk yield and butterfat content decreases in the following lactations (Alps and Averdunk, 1972; Förster, 1971).

b) *Selection of sires*

When selecting appropriate sires, all bulls within the breed must be taken into consideration regardless of the breeding area in which they are. However, limitations have to be set where the methods of bull testing are of doubtful validity. In these cases it is advisable to investigate the testing system before taking breeding stock in.

With regard to the desirable shortening of the generation interval the sires should be selected in short intervals. As soon as a sire appears to be superior he should be used immediately.

c) *Organizing of planned matings*

In order to obtain a desired distribution per selected sire on a given number of dams the matings have to be planned and the animal owner, the A.I. technician and the staff of the A.I. centre have to communicate with each other. The coordinator of these three can only be successful if the prospective calving data of the cows included in the breeding program are known.

Another requirement is the uncomplicated semen exchange between the A.I. stations and the guarantee of the semen delivery at the right time to every place. This is only assured when deep frozen semen is routinely used.

3. *Rearing of bull calves*

In the Federal Republic of Germany the majority of bull calves resulting from planned matings are reared on the farm and are offered for sale at auctions. Large-scale performance testing is presently done only in South Germany and includes the breeds Fleckvieh and Gelbvieh.

4. *Progeny test*

The selecting of young test bulls which undergo the progeny test on A.I. stations is based on their predicted value, which is calculated from their dams' and sires' information. The predicted breeding values and the final progeny test results of 176 Fleckvieh bulls are compared in table 2. There is good agreement for both milk and butterfat yield.

In all breeding areas of the Federal Republic of Germany a uniform system for the progeny test, for milk and butterfat yield is used. The data for easy calving, type and conformation scoring, milkability and beef and carcass value are collected in a modified way in the different breeding areas.

The use of Holstein Friesians

In order to increase the genetic variation of certain production traits, top proven sires of the same breed but of a different population are often used in breeding pro-

Table 2

Comparison of predicted breeding value and performance of milk and butterfat yield of 176 Fleckvieh bulls

Pred. breed. value class kg milk		sires n	milk yield			fat yield	
			x daugh-ters	b	breed. value	breed value	fat %
up to	199	53	46	1,51	+ 47	+ 1,9	4,01
200 to	349	70	49	1,53	+ 116	+ 4,5	4,03
350 to	499	41	35	1,40	+ 141	+ 4,7	3,97
over	500	12	45	1,50	+ 369	+ 11,8	3,94

grams. This is being done in the German Braunvieh population by introducing Brown Swiss bulls and in the German Friesian (DSB) population by introducing Holstein Friesian (HF) bulls from Canada and the United States.

These programs were initiated mainly to improve milk production and udder characteristics more rapidly. There were many discussions about the introduction of Holstein Friesians into the German Black and White breed. The low butterfat content of Holstein Friesians, and their lower carcass value as well as the imbalance of the total milk and beef production within the European Common Market, were pointed out. However, continually, increasing production costs of milk, and the fact that the net profit of milk production has a positive relation to the herd level necessitated a continual increase in milk production. In individual cases therefore private economic considerations are given preference to those referring to the national economy.

In the meantime, Germany and a number of other European countries have collected comparative figures of the most important breed characteristics of Holstein Friesians and European Friesians. When screening these figures the following points have to be considered:

Holstein Friesians and European Friesians have the same origin but during the past 50 years the two populations have been selected in different directions. While the European Friesians has become a dual purpose breed, the HF's have been selected to become a single purpose breed. When using HF sires for crossbreeding heterotic effects can be expected, which complicates an objective comparison between the two populations.

Usually only semen from the top plus-proven HF sires has been used. These bulls were usually mated to the best cows of European origin. Therefore, the random sample character necessary for an objective comparison does not exist. Another complicating factor is that only the special breeding value was known for some of the selected HF sires because they were only tested in natural service or in a few specially selected test herds.

1. *Differences in milk and fat performance and in protein content*

Genetic differences between Holstein Friesians and German Friesians were investigated by several authors (see table 3 and 4). The unanimous conclusion is the superiority of Holstein Friesians in milk and butterfat yield and an inferiority in percent fat and protein content.

Table 3

Comparison of milk, butterfat and protein production between HF- and DSB-cows

Author	cows n	milk yield kg	fat yield kg	fat content %	protein content %
Ernst (1968)		+1647	+ 54	– 0,11	
Langlet and Ernst	37	rel. 126%	rel. 125%	rel. 100%	rel. 94%
(1971)	37*F_1	rel. 115%	rel. 121%	rel. 105%	rel. 98%
Franz et al. (1972) zit. n.	51	+1884	+ 61	–0,20	
Kräusslich (1973)	43	+1777	+ 47	– 0,38	
Werhahn (1972) zit. n. Kräusslich (1973)	201*F_1	+ 839	+ 28	– 0,16	
Kräusslich (1973)	progeny of 8 bulls	+ 661	+ 23	– 0,06	
Huth (1972)	103*F_1	+ 839	+ 28	– 0,16	
Schönmuth et. al. (1973)	20	1615	41	–0 ,37	–0,28

*) F_1 cows

Table 4

Progeny test results of HF-sires on F_1 cows

Author	n sires	n daughters p. sire	breeding value	
			milk kg	butterfat kg
Vogt-Rohlf (1973)	4	92	+ 646	27,0
Bayern: 1971	8	84	+ 686	27,6
1972	6	110	+ 700	28,8
1973	12	98	+ 624	22,2
zit. n. Kräusslich (1973)				
Kräusslich (1973)	8	138	+ 537	18,8
Gravert (1974)	4	46*	+ 337	12,0

*) deviation to CC

Kräusslich and Osterkorn (1973), concluded that the use of Holstein Friesian bulls causes an increase in production which is independent of the herd level. They could not find any sign of a genotype environment interaction. Daughters of Holstein Friesian bulls show the same relative increase in production in herds on a low production level as in herds on a high level. Kräusslich and Osterkorn – assuming a 100% additive inheritance – conclude that F_1 cows produce 800 kg milk and 27 kg butterfat more than comparable German Friesian cows. Purebred Holstein Friesian cows showed a relatively high variation in fat content.

Künzli (1972) compared 20 Holstein Friesian cows with Simmental and Brown Swiss cows and observed a superiority of + 1200 kg milk of the Holstein Friesian cows. The protein- and fat content was below that of the two European breeds. According to Huth (1972) net returns from milk sales were DM 160. –– per year higher for Holstein Friesian cows compared with German Friesians.

Genetic differences between Canadian and U.S-American Holstein Friesians have been investigated by Hinks and Zarnecki (1973) and by Gravert (1974). Based on a reciprocal test of proven Holstein Friesian sires from the two populations in both countries Hinks and Zarnecki (1973) showed the superiority of US sires in milk production. The differences in fat content appeared to be of none genetic origin. The comparison of daughters of US-American and Canadian Holstein Friesian sires out of Friesian cows in Germany and Denmark showed the same result. Gravert (1974) calculated the genetic differences between US-American and Canadian Holstein Friesians to be 200 kg milk and 8 kg butterfat in favour of US-Friesians.

2. *Differences in meat performance*

Several investigations on fattening and carcass performances of Holstein Friesian cattle and crossbreds demonstrated more or less unanimously that the average daily gain to a weight of 450 kg is equal or slightly superior to the average daily gain of German Friesian cattle (Huth, 1972; Gravert, 1973 and 1974; Grothe, 1973; Langlet and Ernst, 1971; Schönmuth, Wilke, Rackwitz, Michulitz, Zelfeld, Brauns, 1973; Pappstein, Markmann, Otto, Tielsch, 1973). If fattened cattle were carried to higher final weights of 550 to 600 kg the average daily gains appears to be in favour of the German Friesians. All authors found that Holstein Friesian cattle had a dressing percentage which was 0,5 to 1,5% lower. The absolute figures vary between 56,3% (Gravert, 1974) at a final weight of 450 kg and 62,9% (Huth, 1972) at a final weight of 579 kg. Langlet and Ernst (1971) found that 54 HF bulls carried to a final weight of 550 kg, had a superiority in average daily gain of 4% compared to contemporaries, but were inferior by 2% as far as dressing percentage was concerned. All authors report that monetary returns were lower for Holstein Friesians than for German Friesian slaughter cattle. This is true for sales on the hoof as well as on the hook. The lower prices for animals sold on the hoof is caused by the not very pronounced muscling of Holstein Friesians.

According to Ernst, Langlet and Martin (cited from Grothe, 1974) under the present price-cost-relationships in the Federal Republic of Germany, F_1 females have to produce 350 kg FCM more and purebred HF females have to produce 500 kg FCM more than German Friesians in order to compensate for the lower returns for slaughter cattle. Differences in body measurements and weights between animals of Holstein Friesian and German Friesian origin were found in height at withers, length of rump, chest depth and total weight. Grothe (1903) compared purebred Holstein Friesians with German Friesians and found a 6% greater height at withers, an 8% longer rump and a 10% higher weight of Holstein Friesians. Corresponding figures for F_1 animals are: +4%, +5% and +6%. Schönmuth (1973) found a superiority in height at withers of 12% which corresponds very well with the findings of Huth (1972) and Langlet et al. (1971).

Feed conversion figures in the literature show a slight superiority of Holstein Friesians mainly to a weight of 450 kg (Huth, 1972; Schönmuth, 1973; Langlet et al., 1971).

3. *Differences in age at first calving, milking ability, fertility and calving ease*

All available publications express a lower age at first calving for Holstein Friesian heifers. Schönmuth (1973) reports a difference of 35 days as compared to German Friesian heifers; Huth (1972) of one month; Grothe (1973) of two to three months and Künzli (1972) of 7 months compared to Simmentals and of 9 months compared to Brown Swiss.

In spite of the higher milk production of HF cows no reports were found of a greater frequency of infertility or conception anormalities. There are some indications that Holstein Friesian cows show very pronounced signs of heat and the average semen quality of males seems to be better.

An improvement of shape of udders and teats and of position of teats is generally stressed. The milking tests tend to indicate an improvement of the average milk flow rate and percent milk in fore udders (Schönmuth, 1972; Kräusslich, 1973; Witt, Andrea, Kallweit, Pfleiderer, Rappen, von Schutzbar, Werhahn, Röseler and Selhausen, 1971).

Gravert (1974) reports that gestation length for Holstein Friesian calves was 1 day shorter and birth weights were 5 to 8% (2 to 3 kg) higher.

These observations correspond to those of Pappstein et al. (1973), who found birth weights which were 6 to 8% higher and a higher percentage of still birth as well. The following figures for still births were summarized from own material (see table 5).

Table 5

Percentage Stillbirth

bull group	n bulls	heifers		cows	
		n calving	% stillbirth	n calving	% stillbirth
100% HF	9	1721	2,0	5102	0,8
75% HF	10	1237	1,5	2999	0,5

Discussion

The use of Holstein Friesian bulls has become common in all German Friesian herdbook societies. The proportion of first inseminations with Holstein Friesian bulls varies very much from area to area. The proportion is 14,1% in Lower Saxony with the largest Friesian population in Germany and is approximately 90% in Bavaria with a relatively small Friesian population. For the following reasons one may expect a further intensification of the use of Holstein Friesians.

1. Because of a genetic superiority in milk and butterfat performances Holstein Friesian sires normally have better progeny results in these two traits than bulls of German origin. If Holstein Friesian bulls are included in a bull testing program, one is soon confronted with the fact that bulls from the original population do not pass the progeny test as proven sires. Hence, A.I. stations are led to use only Holstein Friesian bulls. Only when beef characters and carcass value is given more emphasis could this be prevented.

2. The agricultural structure of small farm holdings in the Federal Republic of Germany does not allow a specialization in milk or beef production. For the average German farmer, the returns from cattle production are composed of 55% from milk sales and of 45% from sales of slaughter cattle. But economic calculations have shown that an increase of prices for slaughter cattle will favour dairy cattle production by 70% and cattle fattening by only 30%. The reason is that there is a very high positive correlation between prices for slaughter cattle and prices for feeder calves. This is again an explanation why genetic improvement of the milk yield is given so much emphasis.

3. Meanwhile, in North America some thoughts are spent on how the fattening performance of dairy breeds, especially of Holstein Friesians, could be used more economically. Calo, VanVleck, McDowell and Miller (1973) show in model simulations that a simultaneous selection on milk and meat would be more economical than the one-sided consideration of milk production only. In the meantime purebred and crossbred Holstein Friesians are fed in many North American feed lots. Biases against these animals on the slaughter market are going to be reduced. A convergence of the breeding aims in the Holstein Friesian and German Friesian population can be expected.

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